

# Perception and practice regarding infection control measures in Radiology department during pre-COVID and COVID times—A survey among radiologists and a review of current concepts and literature

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## Abstract

**Aim:** In this study, we aim to evaluate the perception and practice of IPC measures by Radiologists during pre-COVID and present COVID times, while conducting a thorough review of current concepts and literature, to provide a standard operating procedure (SOP) for radiology operations. **Methods:** This study was conducted by Department of Radiodiagnosis and Imaging, Kasturba Medical College, MAHE, Mangalore. After obtaining approval from the institutional ethics committee, and other required permissions, the Google form questionnaire was sent to 350 Radiologists via email and text during the period of May 2020. Data was collected by time-based sampling in the period of fifteen days during the end of the total lockdown time. **Results:** 54% ( $n = 152$ ) reported never attending a training session on (Infection Prevention & Control) IPC prior to the COVID-19 outbreak. The perception regarding IPC were found to be good among radiologists as majority of the respondents were correctly able to answer questions regarding IPC. 86% ( $n = 152$ ) of the respondents believed that their knowledge on IPC has improved during the COVID-19 pandemic. However, it was revealed that majority of the respondents only started to practice appropriate contact and droplet / procedural precautions only after the COVID-19 outbreak. **Conclusion:** The present COVID-19 scenario coupled with the lack of knowledge and training regarding IPC amongst radiologists evident from the results of our survey, highlights the need for proper training and establishing standard operating procedures and best practices in IPC pertinent to modern radiology practice

**Key words:** COVID-19; empirical precautions; infection prevention and control; procedural precautions; radiology; source control; standard operating procedure; standard precautions; triage

## Introduction

Knowledge and training regarding infection prevention and control (IPC) is lacking among radiologists, and as

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modern Radiology practice evolves into its more clinical role, the implementation of standardized IPC measures becomes increasingly relevant.<sup>[1]</sup> This was evident in a study conducted by Reddy *et al.*,<sup>[2]</sup> wherein, an online infection control survey for the members of Society of Interventional Radiologists (SIR) was conducted which revealed that only a small percentage of interventional radiologists practised proper infection control measures in their practice. The recent COVID-19 pandemic has taken the world by storm, being the third severe coronavirus outbreak over the past 20 years.<sup>[3,4]</sup> Due to its high transmissibility (R0) and a relatively lower mortality rate (2%),<sup>[5]</sup> over 6 million people have been infected, with over 370,000 deaths at the time of writing this article.<sup>[6]</sup> COVID-19 may be transmitted via droplets, contact, and possibly airborne transmission.<sup>[5]</sup> The potential risks of such disease transmission exist in the radiology department as the diagnosis of COVID-19 often relies heavily upon imaging and should be prevented with the implementation of proper IPC measures.<sup>[7]</sup> Strategies to reduce the risk of acquiring and transmitting COVID-19 due to close patient contact and invasive patient care in the Radiology department is essential.<sup>[8]</sup> In a report of 44,672 COVID-19 cases in China, 1,716 (3.8%) were health care workers (HCWs), wherein, 14.8% of confirmed cases among HCWs were classified as critical, observing a total of five deaths.<sup>[9]</sup> Similarly, there are reports of several radiology staff who were infected as a result of improper isolation protocols for patients suspected or confirmed of COVID-19.<sup>[7]</sup>

In this study, we aim to evaluate the perception and practice of IPC measures by radiologists during pre-COVID and present COVID times, while conducting a thorough review of current concepts and literature, to provide a standard operating procedure (SOP) for radiology operations in the present context.

## Methodology

This descriptive cross-sectional study was conducted by the Department of Radiodiagnosis and Imaging, Kasturba Medical College, MAHE, Mangalore. A structured proforma (questionnaire) was built on “Google Forms” for this purpose based on literature review and inputs from experts in medical radiology, infection control, epidemiology, and medical education. The Google forms questionnaire was pilot tested and modified accordingly, as needed. After obtaining the approval from the institutional ethics committee and also the other required permissions, the Google form questionnaire was sent to the study participants via social media, specialty groups, personal contacts, or email. The study participants comprised of consultant radiologists, residents, and postgraduates working in clinics, diagnostic centers, and hospitals involved in performing ultrasound, reporting cross-sectional imaging, and performing procedures in interventional radiology (IR) suites who consented to

participate. Data was collected by time-based sampling in a period of 15 days during the end of the total lockdown time.

## Results

During the period of May 2020, a total of 350 radiologists were requested via email and text to participate in our 66-item questionnaire, of which 152 completed the full survey. The survey comprised of three sections – A) Demography, B) Perception of Infection Prevention and Control (IPC) measures among radiologists, and C) Impact of COVID-19 on the practice of IPC measures among radiologists. The questions were aimed at assessing the perception, knowledge, attitude, and practices in infection control measures within the Radiology department.

### A. Demography

Of all the respondents, performing ultrasound (70%) and reporting cross-sectional imaging (76%) were the most frequently reported predominant areas of radiology practice. A majority of the respondents (54%) reported *never*

**Table 1: Demography**

Characteristics	Number of respondents	Percentage
Sex (n=152)		
Male	94	62%
Female	58	38%
Age (n=152)		
20-29	44	29%
30-39	48	32%
40-49	39	26%
50-59	15	10%
≥60	6	4%
Class level/designation (n=152)		
Postgraduate	35	23%
Senior Resident	16	11%
Consultant	75	49%
Private Consultant	26	17%
Predominant area of radiology practice (n=152)		
Ultrasound	106	70%
Cross-sectional imaging reporting	115	76%
Interventional procedures in the cath lab	21	14%
Nonvascular interventions	55	36.18%
Intensive care and related areas	27	17.76%
Have you ever attended a training session on ipc prior to the covid-19 pandemic? (n=152)		
Yes	70	46.05%
No	82	53.95%
If yes, what form of training did you receive? (n=119)		
Seminar	11	9.24%
Lecture	32	26.89%
Workshop	3	2.52%
CME/Web-based training	21	17.65%
N/A	52	43.70%

attending a training session on infection prevention and control (IPC) prior to the COVID-19 pandemic. For further details on demographic characteristics, refer to “Table 1”

**B. Perception of infection prevention and control (IPC) measures**

The general knowledge and perception regarding IPC were found to be good among the respondents. Majority of the respondents were able to correctly answer the questions regarding disease transmission, standard precautions, and personal protective equipment (PPE). However, majority of the respondents (57.2% (n = 152)) perceived “Use of leak-proof plastic containers” as a part of standard precautions by CDC. Although, considered as an important specimen-handling precaution<sup>[1]</sup> in IPC, the use of leak-proof plastic containers, is not a part of the “Standard Precautions by CDC”. On average, approximately 31% (n = 152) of the respondents *incorrectly* identified the sequence of *donning* and *doffing* of PPE. Additionally, 86% of all respondents (n = 152) believed that their knowledge of IPC has improved during the phase of COVID-19 pandemic.

The questions and percentile answers aimed at the knowledge of the principles of IPC and PPE are listed in Tables 2 and 3. Awareness of standard precautions and the Spaulding classification system are listed in Tables 4 and 5, respectively.

**(C) Assessing the practice of IPC measures and the impact of covid-19 on the practice of IPC measures among radiologists**

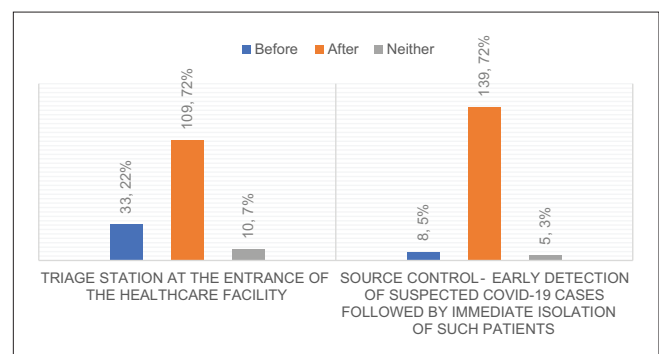
This section was broadly divided into the following subsections – “Triage, Early recognition & source control,” “Standard Precautions (CDC),” “Contact and Droplet Precautions,” “Procedure Precautions,” and “Future Plans.” Various practices of IPC were mentioned under each subsection and the participants were asked to indicate

whether those practices were practiced *since before the COVID-19 outbreak, started practicing after the COVID-19 outbreak or if NOT practiced at all*, by checking “Before”, “After,” OR “Neither,” respectively.

Majority of the respondents reported establishing a *triage station* and practicing *source control* after the COVID-19 outbreak [Figure 1]. Almost all the respondents reported the practice of “Standard Precautions (CDC)” either since before or after the COVID-19 outbreak. Majority (51%) of the participants reported the practice of “strict hand hygiene” before and after contact with each patient and/or with potentially infectious material. “Prevention of needle stick or sharp injuries” was reported by 92% of the respondents since before the COVID-19 outbreak. However, upon inquiring on “proper handling, cleaning, and disinfection of patient care equipment,” “providing patient education on respiratory hygiene,” and “use of appropriate PPE,” majority of the respondents reported the practice of these standard precautions only after the COVID-19 outbreak (72%, 53%, and 77% respectively) [Figure 2]. On inquiring upon practice of “Contact and Droplet precautions,” it was revealed that majority of the respondents started to practice these precautions only after the COVID-19 outbreak, whereas, some respondents even reported not practicing these precautions at all. A much greater portion of respondents (n = 152) reported practicing contact and droplet preventive protocols related to isolation only after the COVID-19 outbreak such as “placement of patients in properly ventilated single room(s)” (64%), “assigning a designated team of HCWs to provide care for those under isolation” (90%), “appropriate donning and doffing of PPE” (84%), and “using a new set of PPE for a different patient” (59%). Similarly, preventive protocols related to transportation of patients were also reported to be practiced majorly after the COVID-19 outbreak. Only 25% (n = 152) of the respondents reported regular cleaning and disinfection of all surfaces the patients may be in contact with, since before the COVID-19 outbreak. However, the “use of disposable/dedicated equipment,” including the “use of dedicated portable X-ray/diagnostic equipment” were the only preventive measures listed under “contact

**Table 2: Perception of Radiologists regarding disease transmission in Radiology Departments**

Questions and responses	Number of respondents	Percentage
Which areas of the radiology department are most likely for pathogen exposure? (n=152)		
Common waiting area	107	70.39%
Procedure holding area	100	65.79%
Examination rooms	103	67.76%
On procedure units (e.g.: Radiography table/CT scanner)	129	84.87%
Storage room	19	12.50%
What are the primary modes of transmission in a Radiology department? (n = 152)		
Direct/Indirect contact route	132	86.84%
Droplet route	143	94.08%
Airborne route	101	66.45%
Bloodborne route	25	16.45%
Vector-borne	3	2%



**Figure 1: Triage, Early Detection & Source Control (n=152)**

**Table 3: True or false statements**

	True		False	
“COVID-19 transmits mainly via Droplet route and Contact route, and possibly Airborne transmission” (n=152)	136	89%	16	11%
<b>ASEPSIS, DISINFECTION &amp; STERILIZATION</b>				
“ASEPSIS is the state of being free from all disease-causing organisms” (n=152)	131	86%	21	14%
“DISINFECTION is the reduction of microorganism burden without elimination of all microorganisms” (n=152)	130	86%	22	14%
“STERILIZATION is the elimination of all microorganisms from a surface but NOT spores” (n=152)	28	18%	124	82%
“DISINFECTION does NOT eliminate spores” (n=150)	127	85%	23	15%
<b>Personal Protective Equipment (PPE) (n=152)</b>				
“Gloves, Isolation gowns, face masks, particulate respirators, eye protection - all are forms of PPE”	143	94%	9	6%
“Gloves provide protection against direct and indirect contact transmission”	111	73%	41	27%
“Cuffs of the glove must overlap the cuffs of the gown”	149	98%	3	2%
“Isolation gowns provide varying levels of fluid and microbe imperviousness”	131	86%	21	14%
“Lab coats/Aprons are a suitable substitute for isolation gowns”	17	11%	135	89%
“Surgical/Isolation face masks provide varying degrees of particulate filtration and fluid imperviousness”	132	87%	20	13%
“Use of respirators (N95, FFP2) requires regular fit checks”	133	88%	19	13%
“Eye-glasses and contact lenses are suitable substitutes for eye protection”	21	14%	131	86%

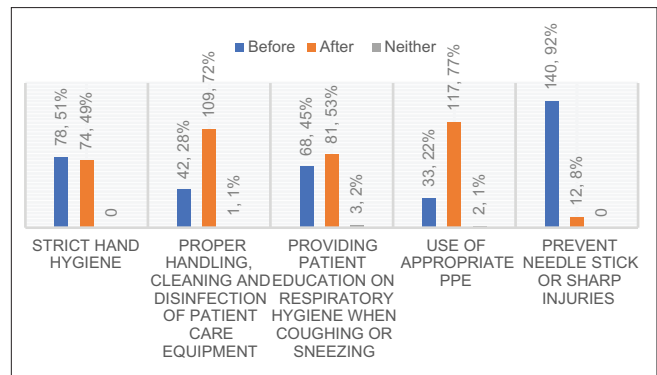
**Table 4: Are the following part of ‘Standard Precautions’ by CDC (Yes/No/Not Sure) (n=152)**

	Yes	No	Not sure
Hand hygiene	152 (100%)	0 (0.00%)	0 (0.00%)
Avoid patient transportation	34 (22.4%)	85 (56.0%)	33 (21.7%)
Use of appropriate PPE	149 (96.8%)	1 (0.66%)	2 (1.32%)
Respiratory hygiene and cough etiquette	134 (88.2%)	3 (1.97%)	15 (9.87%)
Use of leak-proof plastic containers over glass containers	87 (57.2%)	29 (19.1%)	36 (23.7%)
Safe injection practices	131 (86.2%)	8 (5.26%)	13 (8.55%)

**Table 5: “Spaulding Classification” for Disinfection of reusable medical items**

Questions and responses	Percentage
Are you aware of the Spaulding classification system? (n=152)	
Yes	30%
No	70%
If Yes, how does it classify reusable medical items? (n=66)	
Correct (Critical, Semi-critical, and Non-critical items)	66%
Incorrect	34%

and droplet precautions” that were reported practiced since before the COVID-19 outbreak by approximately 61% (n=152) [Figure 3]. Regarding “Procedure Precautions,” it was revealed that only few certain precautions such as using US guidance for vascular access, careful handling of sharps, and steam sterilization of critical reusable medical items were practiced since before the outbreak by majority of the respondents. Whereas, maximum procedural precautions were either reported to be practiced only after the COVID-19 outbreak, or less often, *not* practiced at all. The practice of performing central venous catheter (CVC) placement in an isolation room with an US unit and a C-arm, along with the “use of single-use sterile US gel” and



**Figure 2: Standard precautions (CDC) (n=152)**

“double-bagging of US unit and transducer & C-arm” was reported not practiced by majority of the respondents (39%, 64%, and 58%, respectively). Although, reported to be practiced, a major bulk of the procedural precautions related to disinfection were reported to be practiced only after the COVID-19 outbreak, including, disinfection of all workstations and procedural rooms after each use (71%), mandatory cleaning undertaken at least four times per day (70%), etc., (For further details on the practice of procedural precautions among radiologists, please refer to Figure 4).

## Discussion

Based on the questionnaire on perception and practice, a quick review of the current concepts is presented below.

### Broad Guidelines

1. Establishment of efficient central coordination between hospital infection prevention and control and the radiology department
2. Screening, Early Detection, and Source Control –

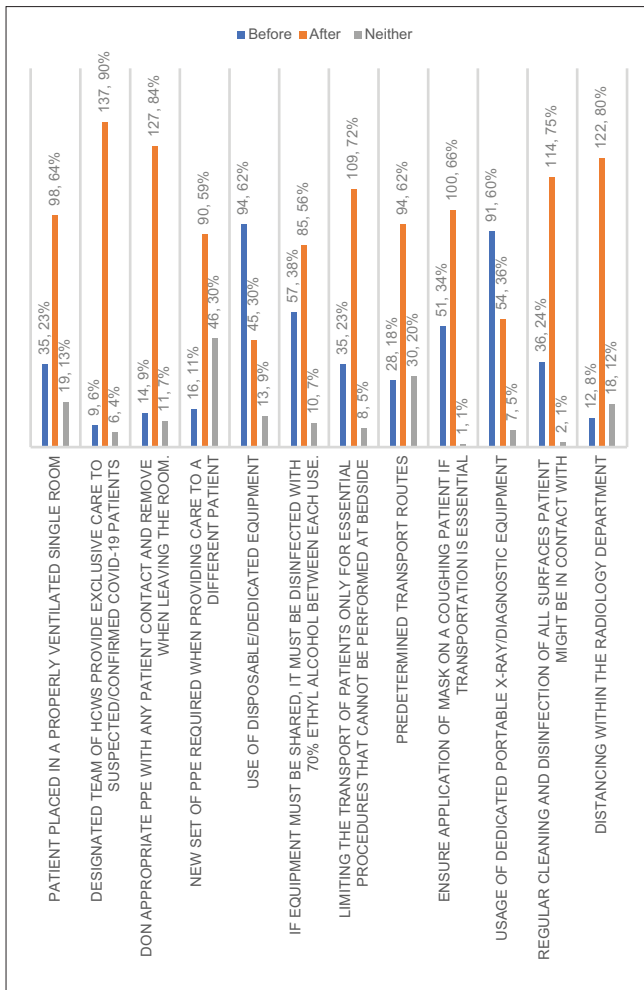


Figure 3: Contact and droplet precautions (N=152)

- From the results of our quick survey, it was revealed that establishment of triage stations and the practice of source control was majorly only done after the outbreak of COVID-19 occurred [Figure 1]
- Screening of all patients for COVID-19 should be done prior to all examinations by establishing a triage station with a standardized questionnaire at all the hospital entrances. This provides a systemic approach towards assessment of all patients at the time of admission and early detection of any active or subclinical cases of COVID-19<sup>[10]</sup>
  - The standardized questionnaire should be able to clarify any history of fever and/or signs/symptoms of respiratory illness such as cough, sore throat, breathlessness etc
  - Apart from clinical history, it is also essential to inquire with the patient about any form of contact or travel history.<sup>[11]</sup>
- Temperature screening should be implemented at all hospital entrances to identify anyone with symptoms that may be related to COVID-19<sup>[11]</sup>
- Source Control is the early detection of any

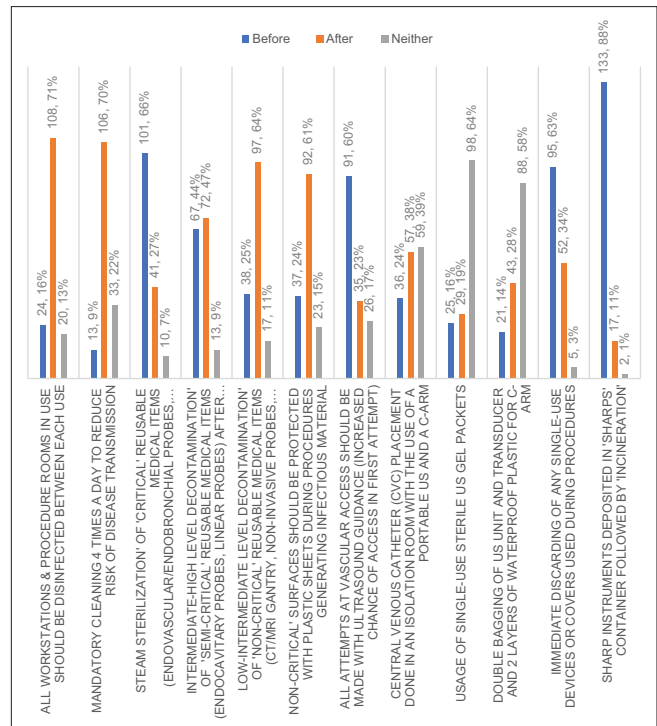


Figure 4: Procedure precautions (n=152)

suspected/confirmed COVID-19 cases followed by rapid isolation of such patients in an area distinctly separate from all other patients.

- Implementation of Standard Precautions (CDC)<sup>[12]</sup> for all patients.
  - Standard precautions advocated by The Center for Disease Control and Prevention (CDC) include –
    - Strict hand hygiene (by either using an alcohol-based hand rub or by washing hands with soap and water for at least 20 seconds),<sup>[11,12]</sup>
    - Use appropriate personal protective equipment (PPE) whenever there is an expectation of possible exposure to infectious material.
 Refer to Table 6 for a brief summary of appropriate PPE requirements according to the level of protection required based on the evidence-based measures in radiology department to limit transmission by Lahoti et al.<sup>[11]</sup>
    - Follow respiratory hygiene/cough etiquette principles,
    - Proper handling, cleaning, and disinfection of patient care equipment/devices and the environment,
    - Follow safe injection practices, and
    - Ensure healthcare worker safety including proper handling of needles and other sharps.
  - The results of our survey clearly indicated that most of the standard precautions mentioned above, except for strict hand hygiene and prevention of needle/sharps injury were practiced by radiologists only

**Table 6: PPE requirements as per the level of protection**

PPE item	Primary protection	Secondary protection	Tertiary protection
	Minimal (low risk)	Suspected case (medium risk)	Confirmed case (high risk)
Surgical mask	✓	×	×
Protective cap	✓	✓	✓
Gloves	✓	✓	✓
Eye protection (goggles OR face shield)	✓	✓	✓
Protective gown	×	✓	✓
Isolation gown	✓	×	×
Disposable shoe covers	×	✓	✓
Particulate respirators (e.g.: N95 or FFP2)	×	✓	✓
Alcohol-based hand rub (ABHR)	✓	✓	✓

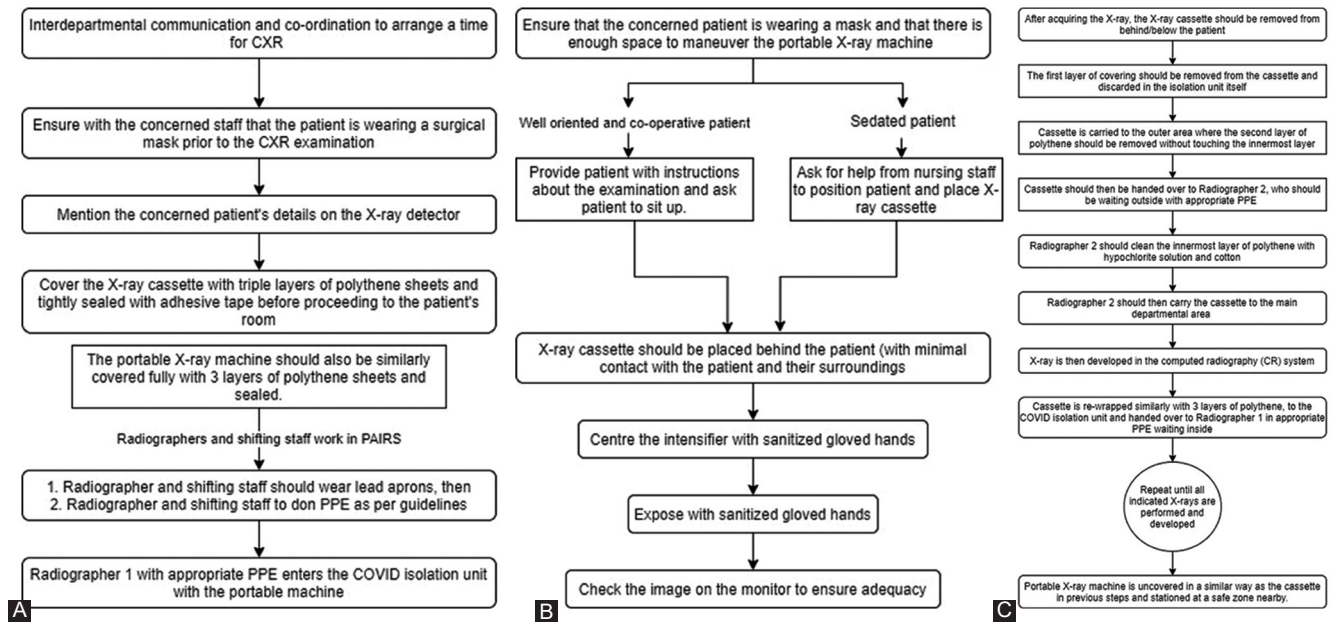
**Table 7: Additional Empirical Precautions**

Contact and droplet precautions	Air-borne precautions
<p>Adequately ventilated single rooms. (In case of unavailability of single rooms, suspect COVID-19 cases should be clubbed together) All patients should be placed at least 1 meter apart. A designated team of HCWs should provide exclusive care to suspected/confirmed patients. Reduce the number of personnel (HCWs, visitors) encountering a suspected/confirmed COVID-19 patient to a minimum. Appropriate donning, doffing, and disposal of PPE according to guidelines. Avoid touching eyes, nose, or mouth with potentially contaminated gloves/hands. Use of disposable (single use) OR dedicated equipment. Use of dedicated portable X-ray/diagnostic equipment. If sharing of equipment is required, it should be disinfected with 70% ethyl alcohol after each use. Avoid transportation of patients unless indicated necessary. If essential, predetermined transport routes should be used and application of a mask on the patient should be ensured. HCWs involved in transportation should follow strict hand hygiene and PPE protocols. Regular cleaning and disinfection of all surfaces patient may be in contact with.</p>	<p>Required when attending to a critically ill patient of COVID-19 or while performing AGPs (aerosol generating procedures). (AGPs are procedures involving patients who are intubated/extubated, on supportive ventilation, requiring active airway suctioning, and procedures that may induce coughing in the patient (lung biopsy, pleural drains, NG tube placement, etc.). Procedures performed in an adequately ventilated room (negative pressure room with at least 12 air changes/hour). (If not equipped with a negative pressure room, a local exhaust ventilation device may be used). Use of particulate respirators such as N95 or FFP2 and eye protection (goggles or face shield) are essential. (HCWs must undergo 'annual fit test' and 'regular fit checks' for using respirators). If the procedure is expected to produce a significant volume of fluids, a fluid resistant long-sleeved gown should also be worn by the HCW.</p>

after the COVID-19 outbreak. This gives an insight into why implementation of standard precautions for all patient care is essential in radiology departments.

- Standard precautions should be strictly implemented for ALL patients including suspected/confirmed cases<sup>[13]</sup> of COVID-19.
4. Implementation of Additional Empirical Precautions for select patients [Table 7]
- Contact and Droplet Precautions: From the results of our survey, it was revealed that among the radiologists who completed our survey, majority of them only reported implementing these precautions after the COVID-19 outbreak, whereas some respondents even reported not practicing these precautions at all
  - Procedural Precautions (including airborne precautions): The results of our survey indicated that the knowledge and practice of procedural precautions is lacking among radiologists. This implicates the importance of a proper and relevant set of instructions for implementation of appropriate empirical precautions in the setting of a radiology department

- Table 7 represents a summary of the essential contact & droplet and airborne precautions pertaining to radiology departments based on the results of our survey along with a review of current concepts and literature<sup>[1,14-18]</sup>
5. Development and implementation of Standard Operating Procedures (SOPs) for various *imaging modalities* and *interventional procedures* for suspected or confirmed cases of COVID-19.
    - Refer to Figure 5 for a Standard Operating Procedure (SOP) for performing portable chest X-ray for suspected/confirmed patients of COVID-19. *Figure 5A – Procedure before entering a patients room, Figure 5B – Procedure in the patient's room, Figure 5C – Procedure after acquiring patient's X-ray*<sup>[19,20]</sup>
    - Refer to Figure 6 for a Standard Operating Procedure (SOP) for performing CT scan for a suspected/confirmed patient of COVID-19.<sup>[19-21]</sup>
  6. Imaging should only be performed for a COVID-19 patient when imaging will impact the management and outcome of the patient.<sup>[19]</sup>
  7. Decontamination of reusable medical items according to the Spaulding Classification System<sup>[1]</sup> –



**Figure 5 (A-C):** Standard Operating Procedure (SOP) for performing portable chest X-ray for suspected/confirmed patients of COVID-19. (A) Procedure before entering a patients room, (B) Procedure in the patient's room, (C) Procedure after acquiring patient's X-ray

- *Critical items* (contacting normal sterile body surfaces)  
*Example* – Endovascular/endovaginal US probe, reusable surgical instruments  
*Decontamination* – *Heat-resistant items* disinfected by steam sterilization and *heat-sensitive items* disinfected by ethylene oxide gas/hydrogen peroxide gas/plasma/ozone or a liquid chemical sterilant.
- *Semi-critical items* (contacting mucus membranes or broken skin)  
*Example* – Endoscopes, cystoscopes etc.  
*Decontamination* – *High-level decontamination* with chemical sterilant after each use.
- *Non-critical items* (contacting intact skin)  
*Example* – CT/MRI gantry, noninvasive US probes, viewing station keyboard/mouse/surfaces  
*Decontamination* – by *low-intermediate level* disinfectant after each use.

8. STAFF RELATED –

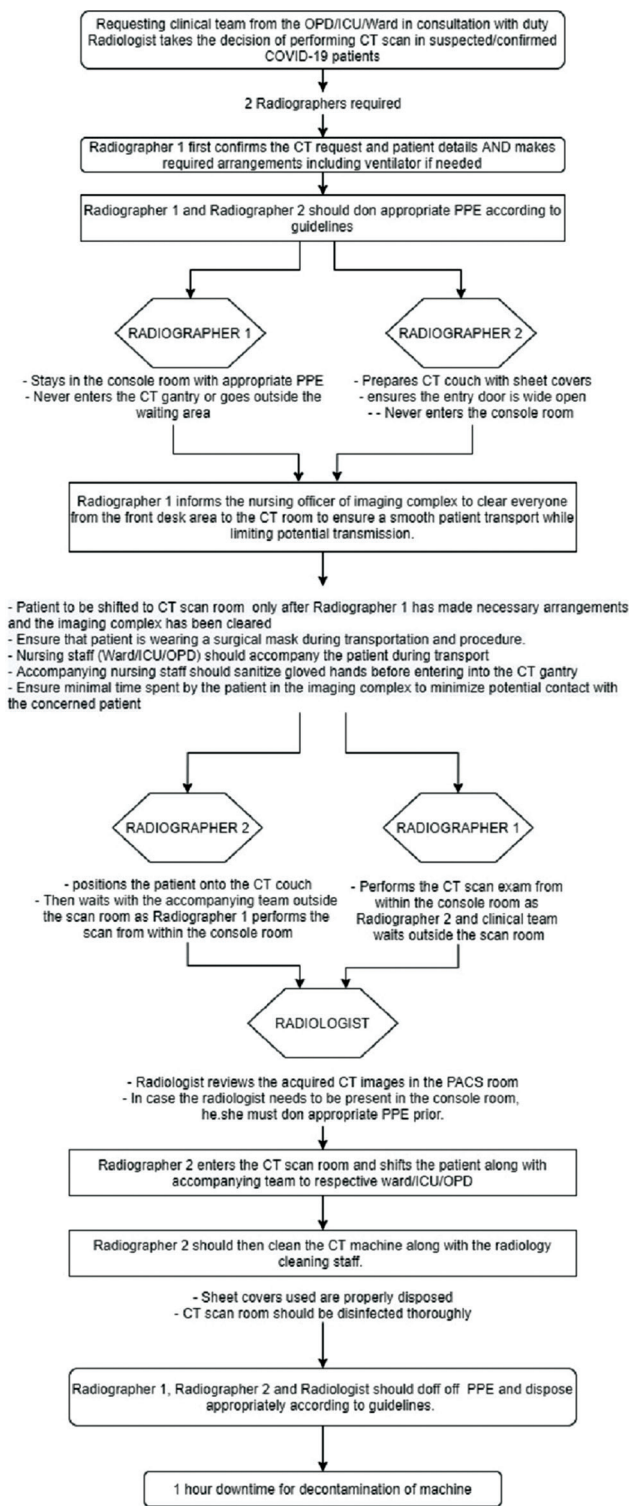
- Staff should be restricted from travelling to any domestic or international destinations for work-related activities.
- Adapting to video-conferences for staff meeting.
- Adapting to remote interpretations in situations where staff may need to go into isolation.

From our quick survey, it was revealed that majority (54%) of the respondents reported not receiving any form of *training* on IPC prior to this COVID-19 pandemic, and 86% of the respondents believed that their knowledge of IPC has improved during this COVID-19 pandemic. 97% of the respondents believed that best practices in

IPC should be continued with same vigilance even after the COVID-19 pandemic, and that IPC should be made a permanent part of the *postgraduate curriculum*. 93.3% of the respondents believed that a “*paperless system*” involving wireless transfer and reporting of images can contribute significantly in IPC in radiology departments. Other suggestions provided by the respondents included mandatory training sessions on IPC for everyone, assigning an IPC officer similar to radiation safety officer (who performs checks on regular intervals, making required adjustments and improvements), and automatic doors that limit contact transmission. A *limitation* of the study was a relatively lower number of responses (*n* = 152), and varied responses from different states/areas.

**Conclusion**

In conclusion, although the COVID-19 crisis continues to persist, it presents us with an opportunity to continue with improved vigilance and refine standard operational procedures to achieve optimum IPC. Although, following all the guidelines may not be possible in every setting, the present COVID-19 scenario coupled with the lack of knowledge and training regarding IPC among radiologists evident from the results of our survey, highlights the need for proper training and establishing standard operating procedures and best practices in IPC pertinent to modern radiology practice. Radiology departments should be well prepared to continue their operations, especially urgent procedures, and essential elective imaging/procedures, during this period of COVID-19 pandemic. The disease burden can also be better handled and staff and patients can be better protected by adopting to the current concepts and



**Figure 6:** Standard Operating Procedure (SOP) for performing CT scan for a suspected/confirmed patient of COVID-19

best practices in IPC by discarding all negative practices, while retaining the good ones. Furthermore, a proper knowledge and training regarding IPC can significantly help in reducing the *fear factor* often associated with imaging COVID-19 patients.

### Declaration of patient consent

The authors certify that they have obtained all appropriate participant consent forms. In the form, the participants have given their consent for their participation in our online Google forms questionnaire. The participants understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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