Review Article

# Tele-Intensive Care Unit Networks: A Viable Means for Augmenting Critical Care Capacity in India for the COVID Pandemic and Beyond

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## Abstract

The COVID-19 pandemic has enormously stressed global healthcare systems compelling new approaches to care, especially by leveraging telehealth. In India, the timely release of the Telemedicine Practice Guidelines by the Government has enabled health providers to deliver essential medical evaluation, diagnosis, and triage remotely. Patients with COVID-19 present with a range of symptoms, and some need intensive care. The management of critically ill patients is resource-intensive and requires partnership between humans and machines. Monitoring vital physiology is key to effective critical care. In many countries, including India, the distribution of intensivists is skewed and tends to be predominantly based in urban tertiary care hospitals. Hospitals without on-site intensivists may benefit from tele-intensive care unit (ICU) services wherein electronic systems connect ICU patient data with intensivists at remote locations as part of a collaborative network. The tele-intensivists provide real-time data and audiovisual monitoring, diagnostic, and intervention services and work together with bedside teams bridging the critical care gap. This article is a practical guide for the logistics of telemedicine-based critical care in India for patients with COVID-19 and other conditions. In addition, this paper also suggests methods to expedite care. Information is provided for immediate use by physicians who have not practiced telemedicine in the ICU. As the number of patients affected increases around India rapid deployment of tele-ICU services will be essential to save lives. Caregiver stress can be minimized by remote care providers who can assist at any time.

**Keywords:** COVID-19, critical care, intensive care, telehealth, tele-intensive care unit, telemedicine

## Introduction

According to the Ministry of Health and Family Welfare, Government of India,[1] the number of active cases of COVID-19 under medical supervision in the country as on August 13, 2020, is 653,622, and the case fatality rate has declined to 1.96%. The total number of recovered COVID-19 patients is 1,695,982. Government of India sources mention that there are 1488 dedicated COVID Hospitals (DCHs) with 249,358 isolation beds, 31,639 intensive care unit (ICU) beds and 109,119 oxygen supported beds, 16,678 ventilators. There are also 3231 dedicated COVID Health Centres (DCHCs) with 207,239 Isolation beds, 18,613 ICU beds, and 74,130 oxygen supported beds and 6,668 ventilators that have been operationalized. In addition, 10,755 COVID Care Centres with 1,002,681 beds are now available to combat COVID-19 in the country.[2]

Access this article online

Quick Response Code:

Website: www.apollomedicine.org

DOI: 10.4103/am.am_104_20

The Ministry of Health and Family Welfare in India released guidance documents to enable the delivery of essential health services and appropriate management of suspect/confirmed cases during the COVID-19 outbreak. One of the core objectives was to put in place standard operating procedures to ensure optimal utilization of available resources like ICU beds and ventilators and thereby providing appropriate critical care to the growing number of COVID-19 patients. These guidance documents[3-5] provide the algorithm for isolation of suspect/confirmed cases of COVID-19 and specify three categories of public health facilities

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**Submitted:** 14-Aug-2020 **Accepted:** 25-Aug-2020
**Published:** 16-Sep-2020

**How to cite this article:** Haranath SP, Udayasankaran JG. Tele-intensive care unit networks: A viable means for augmenting critical care capacity in India for the COVID pandemic and beyond. Apollo Med 2020;7:209-16.

dedicated for COVID-19 case management. Among these, the DCHs are those that offer comprehensive care for severe cases. These hospitals have fully equipped ICUs, ventilators and beds with assured oxygen support and will serve as referral centers for the other two categories of COVID health facilities-the DCHC for moderate cases and the Dedicated COVID Care Centre (DCCC) for mild/very mild or COVID suspect cases. These facilities have separate areas for suspected and confirmed cases. Every DCCC is mapped to one or more DCHC and at least one DCH for referral purpose. These three categories of facilities are interlinked by the Integrated Disease Surveillance Programme, a national program aimed to detect and respond to outbreaks quickly via a distributed network of surveillance units in the country. Tele-ICU assistance seems relevant at various points in the above-mentioned 3-tier infrastructure established for triaging and treatment.

About 15% of the patients are likely to require hospitalization, and an additional 5% expected to require critical care and ventilator management.[5] To avoid overcrowding of hospitals and prevent transmission of SARS-CoV-2 virus during travel or in health facilities, the guidance document[3] suggests triaging of suspected COVID patients and other patients requiring ambulatory care via tele-platforms to determine the need to visit the appropriate health facilities and referral mechanisms based on clinical severity.

Considering the rapid pace of increase in COVID cases, and the need to augment capacities for isolation beds, the government has plans to utilize modified coaches from the Indian Railways as COVID Care Centres if states have exhausted the other facilities. Indian Railways has its own medical service and has been operating the Lifeline Express, the world's first hospital-on-a-train since 1991.[6] RailTel from the Indian Railways is one of the largest neutral telecom infrastructure providers in the country and has pan-India optic fiber network covering 70% of the population.[7] With their experience in providing medical services as well as managed telecom services like telepresence, the Indian Railways seems well suited to bring telemedicine services too to the coach based COVID Care Centres if the need presents itself.

## Background

### The demand and supply conundrum in critical care

Along with COVID, several noncommunicable and infectious diseases may also need intensive care. India has a disproportionately high burden of chronic respiratory diseases, with a third of the total global health loss from chronic respiratory diseases occurring in India. India has recorded over 55.3 million chronic obstructive pulmonary disease (COPD) patients and 37.9 million with asthma, cough, and shortness of breath in 2016.[8] India accounts for approximately one-quarter of the world's tuberculosis burden.[9] There are over 10,000 intensive care trained doctors in India who are members of the Indian Society of Critical Care Medicine, which has brought out guidelines for the current crisis.[10] Telemedicine was listed as a means for quality assurance in this guideline, but there are few examples at scale.

### Tele-critical care networks in COVID scenario in India

Collaborative networks of intensive care units can help promote a quality-improvement agenda across an entire system or region. Proposed advantages include targeting a greater number of patients, sharing of resources, and common measurement systems for audit and feedback or benchmarking.[11] Tele-ICU deployed at scale connects a team of highly trained critical care specialists with ICUs across the country, ensuring the gold standard of care to a greater number of patients while enabling rapid learning. With the bedside clinicians having an additional set of eyes to support them, ventilation management and Advanced Cardiac Life-Support are some of the many areas where tele-ICU support can make a significant difference.[12] Tele-critical care support networks help extend the reach and expertise of intensivists in the management of COVID-19 related cases and become force multipliers in the national efforts, minimizing the need for transfer of patients between facilities, thereby limiting exposure. One premise is that critical care truly can be required at any place anytime. A practical, user-friendly guide is a necessity in this context and may help COVID-dedicated facilities from both public and private sector commence telemedicine practice in the ICU. India has a vast geography and terrain. Critical care in India can capitalize on large numbers of experts, advanced private and public health facilities, and widespread connectivity. A hub and spoke model with training, communication as well as technical upgradation will allow millions to benefit. However, it is the interpretation of the data, conversion of information into actionable intelligence as well as clinical integration of material from diverse sources that will allow expert level evidence-based critical care. To do this effectively, trained personnel are critical and remote intensive care can offer cognitive expertise. This model has been successfully used in United States tele-ICU systems and there are proposals to recreate a national network for the current and future situations where a surge in demand for critical care services occurs.

In the United States (US),[13] ratios approximate one physician to 100 patients and one nurse per 30–40 patients with most data updates and charting done by the tele-ICU nurse. Currently most ICUs in India probably have one trained intensivist for every 15–20 beds, but that may be overestimating in the absence of data. In the authors personal experience, the quantum of work, day of the week and the nature of coverage determines the patient load that can be handled safely. Expecting a 50% drop in efficiency with newly established tele-critical care systems, a lower ratio 30–60 patients for physicians, and 15–30 patients for nurse monitoring and problem triage might be reasonable.[14]

## Technique

### Possible tele-intensive care unit models

Tele-ICUs have various levels of involvement, including episodic discontinuous advice for complex patients and

subspecialty teleconsultation. As noted in Table 1, there are advantages and disadvantages primarily related to continuity of care. Many systems only offer nocturnal coverage even from overseas using time zone advantages. The use of virtual triage for anytime on-demand service by teams of tele-intensivists and nurses is common. Video solutions with medical records for data capture are feasible. Patients in isolation can be monitored either proactively or on-demand. Sub-specialist access and procedural supervision are available. Business and staffing need often determine the model choice. Hospital structures influence tele-ICU ecosystems. In tertiary care systems, the tele-ICU supports bedside intensivists and offers patient coverage during breaks assisting with complex ventilator care, proned patients, interpreting arterial blood gas/labs and can update staff and family. Research protocols can also be assisted. Several complications can be detected by responding to alarms. Graduates of Pharm. D programs can help with medication lists, dosing, and detecting drug interactions.

In secondary care rural/urban hospitals with an ICU trained manpower is scarce. Patients need stabilization before transferring to a higher level of care. More remote district hospitals where the infrastructure is minimal can be used as staging and stabilizing locations. Patients too sick to move will need remote guidance.

The Command Center structure can be distributed geographically with intensivists and nurses at various locations. It would be ideal in a surge to create virtual pools of providers supporting command centers.

## Illustrative Examples of Tele-Intensive Care Unit Solutions

- A 68-year-old male smoker with dyspnea consulted the first author by telemedicine from almost 1600 km away and had features suggestive of acute exacerbation of COPD. A triage decision was made that the patient was unsuitable for telemedicine and maybe COVID-19 infected despite history, not indicating high risk. The patient was instructed to immediately call an ambulance, and the receiving doctor was informed. The patient was intubated in the emergency room and responded well to treatment and was discharged after a week. This was one meaningful and successful use of remote technology and forward triage
- The Apollo Hospitals backed "eACCESS" tele-ICU service,[15] functional since 2013 has remotely managed over 3200 ICU patients in the last 3 years in several Indian hospitals. Continuous round the clock monitoring using remote technology as well as training and treatment recommendations to bedside teams is ongoing. Electrocardiogram triage from regional centers is also done, and they recently pioneered monitoring of patients in isolation with potential COVID infection. About 12.9% of their patients had respiratory infections. Others included organophosphate poisoning (7.1%), stroke (10.9%), road traffic accidents (8.9%), COPD (7.29%), coronary disease (11.92%), diabetic emergencies (3.35%), chronic kidney disease (5.08%), asthma (2.37%), obstetric emergencies (0.71%) and tropical diseases including dengue (2.89%) and malaria (1.59%). As shown in Figure 1, tele-ICU workflows can be quickly learnt
- Since November 2018, over 500 primarily inpatients have used subspecialist tele-consultations through the eACCESS program and saved travel cost and time away from work and home. Tele-consultations have been widely adopted due to current travel restrictions. Video triage can overcome health illiteracy, as seen in the case discussed earlier, where the illness severity was unrecognized. Training remote sites in the management of triage and safe airway care using existing tele-ICU

**Table 1: Tele-intensive care unit models and their relative advantages and disadvantages**

| Type of Tele-ICU | Advantages | Disadvantages |
|---|---|---|
| Episodic; 50 years old diabetic admitted with acute kidney injury due to sepsis. The remote site doctor wants input on managing the blood pressure medications which include ACE inhibitors | As needed help is taken especially for complex disease needing expert advice<br>More cost-effective<br>May be used for subspecialty inpatient consultation | Cannot have full spectrum of connectivity of clinical data<br>Lack of continuous information may prevent fully informed consultation<br>Commitment to maintain service depends on adequate volume |
| Continuous: 30 years old with COVID-19 ARDS needing prone ventilation for P/F ratio below 150 | Ability to assess course of illness and understand impact of intervention<br>Rapport and team building between bedside team and remote team<br>Quality projects, research and training more easily accomplished | Costs higher<br>Difficult to exit contracts<br>Bedside becomes dependent on remote site for nonurgent issues |
| Capacity building: Tertiary care ICU trying to improve length of stay in ICU for ventilated patients initiates early extubation readiness assessment program by remote teams | Existing fully staffed ICU can use for capacity building and lower workload during busy times<br>Quality improvement projects can be more detailed<br>Hybrid bedside and remote providers can enhance capacity | Financial implications may be excessive for many centers<br>Redundancy and dilution of responsibility<br>Increased chance of conflict in decision making |

ACE: Angiotensin converting enzyme, ARDS: Acute respiratory distress syndrome, P/F ratio: $PaO_2/FiO_2$ ratio, ICU: Intensive care unit

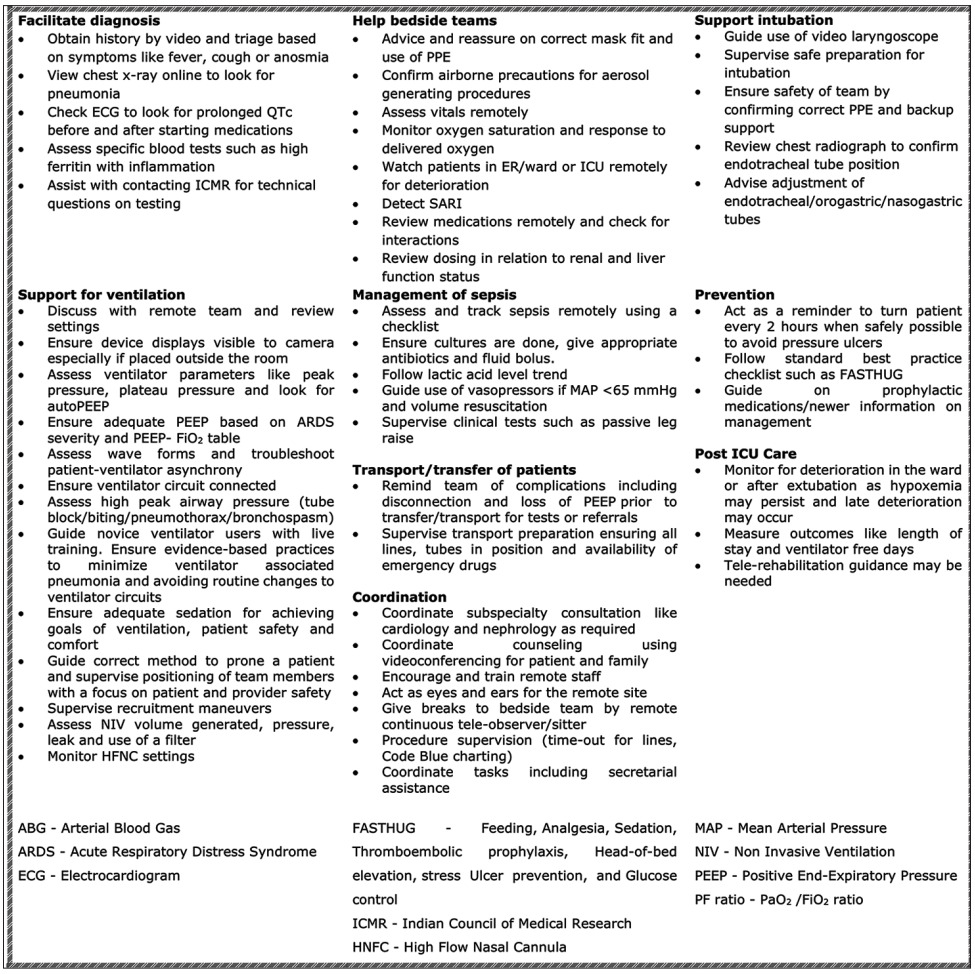


**Figure 1:** Tele intensive care unit based support roles in COVID-19 management

connectivity are ongoing. The treatment of COVID-19 syndrome has brought various aspects of critical care to the forefront. Most of these clinical features can be evaluated remotely as noted in Table 2. Postpandemic with the expected surge of non-COVID-19 diseases, which have dropped to unusually low numbers globally, training in evidence-based critical care is paramount

- Several areas can be managed using the tele-ICU infrastructure, including second opinions, imaging, stroke, diabetic ketoacidosis, hypertensive emergencies and tele-counseling for anxiety. Chest pain triage, EKG review for atrial fibrillation using smart watches[16] and ventilator management are practiced in many tele-ICU systems. In the COVID era, remote rehabilitation may help and there has been precedent in India. It will require scaling up staff and technical infrastructure[17]
- Cardiopulmonary resuscitation is regularly guided using tele-ICU in India[18] and the US. In COVID-19, modifications to prevent aerosols are necessary, such as not disconnecting the ventilator during chest compressions and such information can be communicated to remote teams. End of life discussions and allowing natural death conversations are feasible using remote technology. It is beneficial for the treating team and the patients' family to discuss at any time critical aspects of care[19]
- Health workers in hospitals or the field can be remotely advised, and vital signs acquired remotely. Tele-ICU guidance can establish and maintain best practices through alerts and impactful teachable moments. Frontline providers can be guided by specialty experts and intensivists on current COVID-19 care or sepsis, for example. Trainee physicians and nurses get experience, confidence, and practice safely while managing complex illness. We can rapidly upskill subspecialists outside their domain expertise. A urologist managing acute respiratory distress syndrome may need assistance with ventilator graphics or a cardiologist with diabetes care. Several nonintensivists may manage non-COVID-19 diseases like diabetic ketoacidosis or myocardial infarction. Informal provider networks within hospitals can use social media to interact and learn. Medico-legal safety, patient privacy, and confidentiality remain vital[20]
- While private/public healthcare systems are managing COVID-19; there are shortages of personal protective equipment (PPE) and trained medical/paramedical resources. The tele-ICU solution can triage and manage

**Table 2: Rapid tele-intensive care unit based evaluation of COVID-19 patients**

| Clinical feature | Remote detection by video or bedside communication |
|---|---|
| Respiratory failure | Oxygenation |
| | P/F ratio |
| | Work of breathing |
| | Cyanosis |
| Hypotension | Mean arterial pressure |
| | Passive leg raise evaluation |
| | Pneumothorax |
| | Volume depletion |
| | Cardiogenic shock |
| Hematologic | Hyperferritinemia |
| | Thrombotic tendency and need for therapeutic anticoagulation |
| | Ensure prophylactic anticoagulation |
| Inflammatory | Cytokine release syndrome |
| Cardiac | ECG QTc |
| | Cardiomyopathy by exam/echo |
| Renal | AKI/need for renal replacement/manage acidosis and hyperkalemia |
| Gastrointestinal | Ensure stress ulcer preventive measures present |
| | Diarrhea can be seen in COVID-19 infection |
| Infection control | Donning and doffing training and observation |
| | Antibiotic review for timing as well as type |
| Best practices | Ventilator associated pneumonia prevention with head of bed elevation, chlorhexidine mouth cleaning |
| | DVT prophylaxis |
| | FASTHUG components as noted here and in other sections of this table |
| Neurologic | Many CNS COVID-19 presentations noted including stroke |
| Resuscitation | Guide families and patients with decision making on escalation of care |
| | Guide bedside teams with resuscitation and act as a virtual time-out team |
| Radiology | Confirm supportive device positioning including endotracheal tubes and enteral tubes |
| | Detect emergent conditions like pneumothorax quickly |

AKI: Acute kidney injury, CNS: Central nervous system, DVT: Deep venous thrombosis, FASTHUG: Feeding, analgesia, sedation, thromboembolic prophylaxis, Head-of-bed elevation, stress ulcer prevention, and glucose control, P/F ratio: $PaO_2/FiO_2$ ratio, QTc: Corrected QT interval

patients in isolation-conserving PPE, avoiding infection and optimizing human resources with constant remote monitoring. Close range telemedicine called "ePPE" has evolved and uses tablets to communicate with patients who can be physically attended to immediately if needed.[21] Innovations to monitor patients include placing ventilator displays and intravenous pumps outside patient rooms[22]

- As per the guidelines,[23] postdischarge from DCHs, domiciliary management of patients under the guidance of critical care/other physicians for continuity of care is possible. Simple solutions like telephonic interactive voice response system or video calls are feasible. A communication link between caregivers and hospitals is essential for the entire duration of home isolation. Other hospitalized patients can also use this method
- In the State of Karnataka in India, a tele-critical care network is monitoring critically ill patients in all districts integrating several ICU's onto a single platform. This model of private-public partnership that operationalized rapidly might be replicable in other locations. As on May 4, 2020, 104 COVID-19 patients and 77 cases of Severe Acute Respiratory Infections were being monitored with e-rounds scheduled twice daily to discuss the progression of cases and treatment of patients vulnerable to exacerbation[24,25]
- Around 100 patients undergoing evaluation and treatment for COVID-19 are being monitored in various locations within the Apollo Hospital campus in Hyderabad over the last 5 months. The direct view of the patient and the monitor has allowed many emergencies to be detected early. These include drop in oxygen saturation, disconnected noninvasive ventilator connections as well as alerting nurses about patients who need urgent attention. The vital signs of patients can be remotely monitored too. This system has offered reassurance to patients who are in isolation.

This pandemic has stressed resources even in advanced critical care networks. Workforce sustainability, burnout reduction and limitation of provider infectious exposure will be offshoots of telemedicine-based pandemic responses both in and outside the ICU.[26]

## Discussion

### Overcoming challenges

Business models for tele-ICU in India have been suboptimal without significant profits. The reasons include a lack of

awareness of the utility and the inertia of the status quo. Many locations have concerns about retaining sick patients who cannot afford care or result in violence when outcomes are bad. These real issues need solutions. Referral patterns determine sub-specialist engagement as the tele-ICU team may be different from the hospital patients are being transferred to. Once a tele-ICU is planned, education at all levels becomes key. The monitoring doctor, the bedside nurse, remote site technical team and patients and their family must understand the benefits of care via camera. Communicating with bedside teams can be done directly via video but may need phone access if audio clarity or bandwidth is poor. Interactive handsfree voice activated communication devices have been useful in the ICU.[27] In this pandemic such systems might help decrease infection risk.

## Factors Ensuring Tele-Intensive Care Unit Quality

Tele-ICU has evolved and matured. In India, it is still nascent, and challenges of geography, language, finances and skill gradients can be overcome. As it transforms into a force for care for all, evaluation is needed. This includes factors like care for non-ICU patients without moving to the ICU, ability to handle patients from outside health systems, staffing needs analysis and outcome measures pre- and post-implementation of the tele-ICU. Length of stay, use of critical care best practices and key element documentation are examples.[28] Ergonomics to avoid injury, education, and training for standardization of command center staff and remote staff on current technical and clinical protocols is critical. The COVID-19 crisis has created multiple training opportunities primarily by online courses, including for ventilator training.[29,30] One such course has already trained over 1500 doctors and is playing a vital role in educating frontline doctors who may manage ventilated patients. A basic knowledge about computers and rapidly troubleshooting with the support of an escalation matrix is essential. Connectivity and communication are key aspects of caregiving. The accurate exchange of information between devices, the command center, and the bedside remote team is a priority. Some examples of an approach to managing COVID-19 ICU care remotely are listed in Figure 2.

## Future Considerations

The current pandemic has shown us how important it is for health care to undergo not just tweaking but radical change.[31] Camera-based remote vital signs detection for patients in the ICU, as well as patients in a triage area of an emergency room, would be useful applications. The same technology can be used at home as we transcend geographic barriers to care and truly bring critical care for everyone, everywhere. Remote review and adjustment of ventilator settings is a tremendously useful process if there is adequate safety and backup. There are noninvasive ventilators which can be adjusted via the Internet.[32] A Singapore based company has now created a ventilator that can be remotely controlled. This could be of use where there is a significant shortage of providers who can care for ventilated patients at all levels.[33] The stress and isolation of being critically ill, separated from loved ones and also dealing with a complex medical illness can be devastating. The pain can be eased to some extent by connecting patients and families via video communication. Many hospitals in the past created such systems for patients who were admitted as a means to enhance comfort. Family from anywhere in the world could check-in and speak to the patient. In a recent case of an elderly COVID-19 patient whose family from around the world took turns watching and keeping in touch through the duration of home isolation. In the current pandemic such technology is essential to help bridge the distance in care provision-whether it is ten meters or 10,000 km.[34-36] There are also several apps which have eased communication further and include translator functions.[37] There have been many attempts to enhance knowledge for frontline workers and the All India Institute of Medical Sciences (AIIMS) has started interacting with intensive care units nationally in a program called the "e-ICU." Aimed at reducing mortality, AIIMS has mentored and supported 43 big hospitals in 11 States through shared experiences and technical advice from domain experts in the clinical management of ICU patients. During these virtual sessions that are being conducted twice every week on Tuesdays and Fridays, a specialist team of doctors provides guidance on effective clinical management of COVID-19 patients in the ICUs of different State hospitals through tele/video consultation to reduce the case fatality rate. This facility has boosted the capacity in the treatment of critical care patients according to a press release.[38,39]

## Conclusion

Tele-ICU networks are a viable option for India to manage critical care needs from COVID-19 as well as other diseases. A public-private partnership with compassionate care, quality assurance, and regulatory oversight will be an ideal that seems achievable. We believe a national tele-critical care network will be a game-changer. It will allow expert advice and standardization of critical care protocols to percolate throughout this vast country. The challenges of skewed critical care resource distribution, lack of equipment, and inadequate subspecialist intensivists can be overcome by leveraging the potential of digital health through the National Digital Health Mission. Ultimately, coordinated remote monitoring, mentoring through multiple real-time teachable moments, and management of processes will transform critical care, making it available for everyone, everywhere at any time. Home-based critical care has also shown promise with many projects being released.

## Clinical Significance

Tele-ICU is a force multiplier that can be rapidly deployed using simple communication tools and enhance the level of

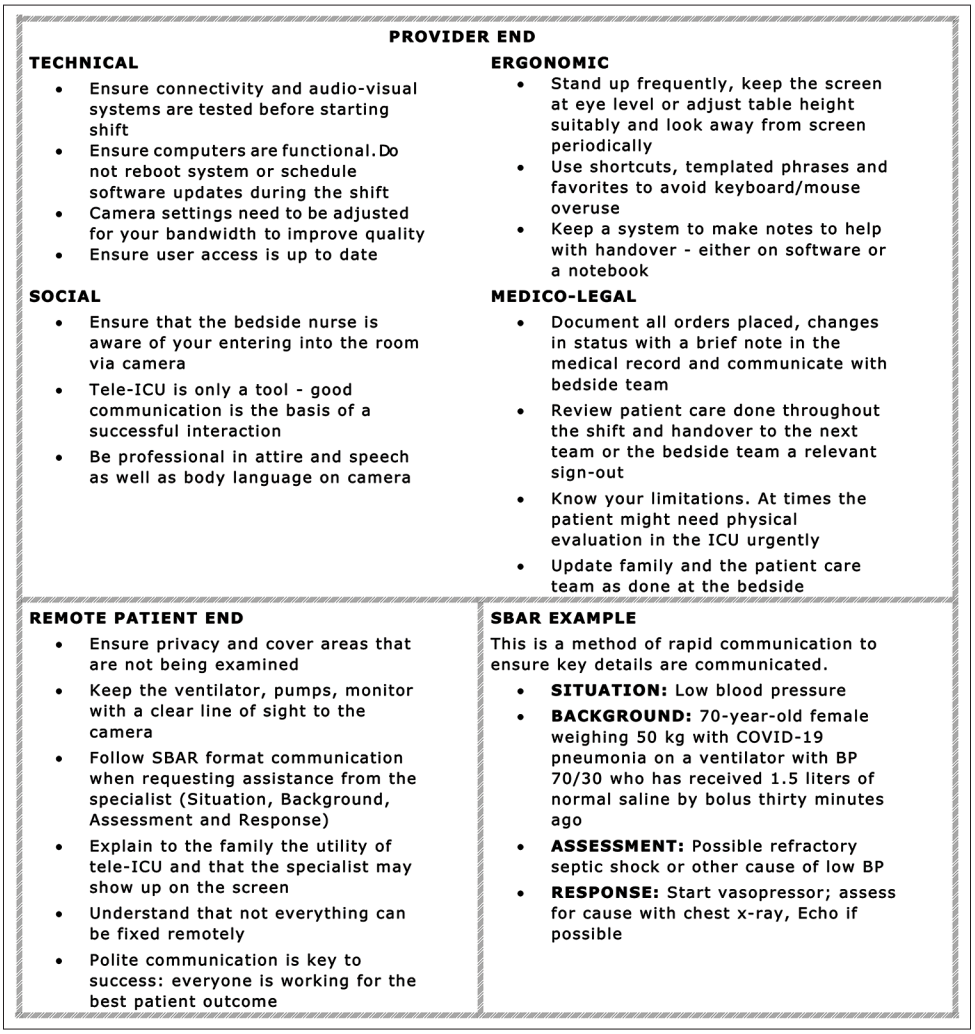


**Figure 2:** Tele intensive care unit workflow tips

care that can be provided in a remotely located ICU. Experts can assist with managing ventilators, titrate medications to assist in sepsis management and allow bedside teams to focus on clinical priorities that require physical presence. The data for the utility of tele-ICU is being rapidly generated in India and globally. As noted in the tables and the illustrative examples, critical care workforce shortages are being overcome with the delivery of relevant evidence-based care. The COVID-19 pandemic has brought these opportunities into sharp focus, and it is essential that we incorporate tele-ICU into our normal workflow.

## Acknowledgments

The authors would like to thank Mr. Pankaj Gautham, Mr. Ramesh Rekala, and Dr. K Subba Reddy of Apollo Hospitals for their assistance in facilitating this manuscript.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

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