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The Importance of Intra- and Inter-Institutional Networks for Capacity Building in Severe Acute Respiratory Syndrome Coronavirus 2 Reverse Transcription Polymerase Chain Reaction Services: Experience from an Oncology Centre in Eastern India

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Abstract

High-throughput, accurate, cost-effective and rapid testing for severe acute respiratory syndrome coronavirus 2 (SARS CoV-2) is the need of the hour in face of the global coronavirus disease pandemic. This target is achievable, within a relatively short time through capacity building of reverse transcription polymerase chain reaction (RT-PCR) tests by utilising the strengths of intra and inter institutional networks. These networks act as force multiplier for vital resources which are required for capacity building, namely, leadership, expertise, equipment, space, infection control inputs and human resources. In this article, we report the experience of capacity building for delivery of RT-PCR tests for SARS CoV-2 from a cancer hospital in Eastern India. The relevance, mode of operation and value addition of this essential public health service are discussed in the context of inter departmental collaboration and interaction with other institutes through the existing diagnostic, surveillance and infection control networks. This networking model for service development and delivery could be used by other centres.

Keywords: Capacity building, coronavirus disease, equipment, human resource, networks, reverse transcription polymerase chain reaction, severe acute respiratory syndrome coronavirus 2

INTRODUCTION

The first case in India of the novel coronavirus disease (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-Cov-2) was reported from the Thrissur district of Kerala on 30 January 2020. Since that first report, more than 2.5 million tests have been performed and nearly 108,000 infections have been detected, with 3303 deaths and ~ 61,000 active cases (as of 20 May 2020). Testing for SARS-CoV-2 is required for many reasons including case detection in suspected cases, as part of quarantine protocols, in patients recovering from COVID-19 and in health-care workers after high-risk exposure. Testing is also indicated after international travel and is being considered as screening before major medical interventions, especially in patients from high

endemism areas. Of note, around 70% of the ~3300 deaths reported in India till May 20, 2020 was in patients with comorbidities. Between January and February 2020, only a handful of laboratories were equipped to perform reverse

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transcription polymerase chain reaction (RT-PCR)-based testing for SARS-CoV-2. Measures were taken later to increase the number of testing laboratories within India in view of its large population and wide geographic expanse. As of 19 May 2020, 555 operational laboratories were reporting to the Indian Council of Medical Research (ICMR) on testing for SARS-CoV-2, including 391 government laboratories and 164 private laboratories. This included conventional RT-PCR testing in 431 laboratories, (government, 293; private, 138), the True Natmicro RT-PCR test system in 77 laboratories (government, 73; private 4) and the cartridge based nucleic acid amplification test (CBNAAT) system in 47 laboratories (government, 25; private 22). As of 18 May 2020, the government of India reported that 108,233 samples were tested for SARS-CoV-2.^[1-4]

THE REQUIREMENT AND CHALLENGES OF CAPACITY BUILDING FOR SEVERE ACUTE RESPIRATORY SYNDROME CORONAVIRUS 2 TESTING

The COVID-19 pandemic has resulted in an unprecedented need for large-scale testing for SARS-CoV-2 infection. A number of laboratories have been identified by the government in both the public and private sector to manage this diagnostic challenge. There is an urgent need for capacity building in both sectors for the testing and timely reporting of results. In this context, a European consortium reported in January 2020 that the common problems associated with capacity building with regard to SARS-CoV-2 molecular testing included lack of adequate positive controls; lack of personnel trained in molecular biology, lack of primers/probes; lack of appropriate quality control panels to test specificity of primers/probes against other corona viruses; difficulty in implementing standards as per ISO15189; lack of adequate number of commercial tests and difficulty in their procurement; lack of adequate training; equipment shortage and inadequacy of adequate level of biosafety laboratories.^[5] In the case of RT-PCR testing, Corman *et al.* discussed candidate SARS-CoV-2 gene targets, including genes encoding the envelope (E), membrane (M), nucleocapsid (N), open reading frame, RNA-dependent RNA polymerase (RdRp) and spike (S) proteins.^[6] With RT-PCR testing, a challenge highlighted by Konrad *et al.* is the uncertain significance of amplification curves around the cycle threshold of 40.^[7] RT-PCR on nose and throat swab samples is not the only method for detection of SARS-CoV-2 infections. As reported by Carter *et al.*, diagnostic approaches for COVID-19 include (a) integration of computed tomography imaging of chest with results of RT-PCR testing (b) rapid IgM-IgG combined antibody testing for SARS-CoV-2 (c) diagnosis from faecal specimens in patients with the characteristic respiratory syndrome (d) digital droplet PCR for more sensitive and accurate detection of SARS-CoV-2 in low viral load specimens (e) rapid SARS-CoV-2 detection using a CRISPR-Cas12-based lateral flow assay.^[8] Peter *et al.* had reported previously from Botswana and Ethiopia along

with the US Centers for Disease Control (CDC) the importance of capacity building to combat Ebola outbreaks in Africa.^[9] Similar were the findings of Phommasack *et al.* from Laos in the case of influenza.^[10] The African Field Epidemiology Network demonstrated similarly the importance of networking in building laboratory capacity among resource-poor African countries.^[11]

In a detailed analysis, Gupta *et al.* from the ICMR elaborated on various methods for laboratory capacity building with India for COVID. These include (a) increase in working hours, (b) redeployment of RT-PCR machines in research institutes for COVID-19 diagnostic work, (c) use of RT-PCR machines from the National AIDS Control Organization centres, (d) redeployment of nucleic acid amplification testing (NAAT) equipment of the National Tuberculosis Elimination Programs, (e) procurement of automated high-throughput RT-PCR testing platforms and nucleic acid extraction systems and (f) using a combination of testing kits.^[12] Similarly, Mourya *et al.* in another publication from ICMR detailed the various basic biosafety requirements for the laboratories.^[13]

CAPACITY BUILDING MEASURES FOR REVERSE TRANSCRIPTION POLYMERASE CHAIN REACTION TESTING FOR SEVERE ACUTE RESPIRATORY SYNDROME CORONAVIRUS 2 IN INDIA

For each laboratory, the average number of samples that require testing may vary from a handful to 1000 each day.^[2,4] At the beginning of the COVID-19 pandemic, clinical samples in each state were sent to designated Government laboratories/hospitals with RT-PCR testing capability. Soon, it became clear that centralised testing at a state/district level is not feasible on a large scale, given the size of the Indian population, its density in select areas, the wide geographical spread and the related logistical challenges. Thus, both the Central and State governments have enabled additional laboratories in both the public and private sectors to perform RT-PCR based testing for SARS-CoV-2.

This in turn raises the question of total quality management of SARS-CoV-2 testing facilities [Figure 1]. In the case of private laboratories, the essential requirement to carry out viral RT-PCR testing is to possess accreditation for such testing with the National Accreditation Board for Testing and Calibration Laboratories.^[3] This however is not a mandatory requirement for government laboratories. In Figures 2 and 3 we have depicted the number of samples tested at Tata Medical Center, Kolkata, and in the state of West Bengal [Figure 3] while capacity building was in progress. Additionally, capacity building for SARS-CoV-2 testing involves developing and sustaining facilities in the following sectors:^[1-3]

1. Sample collection, transport, packaging
2. Molecular Laboratory set up
3. Equipment
4. Test kits and reagents

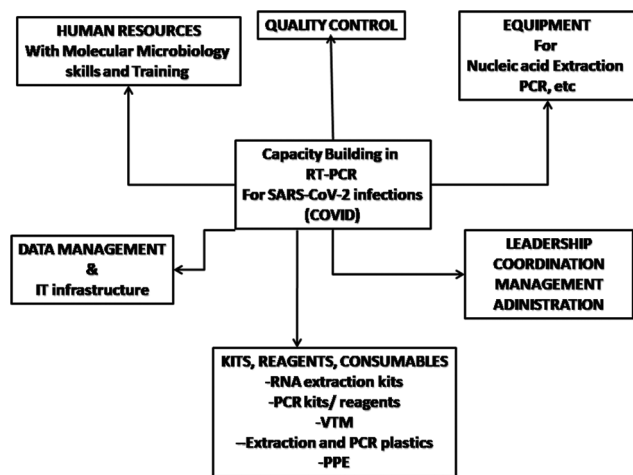


Figure 1: Components of capacity building for severe acute respiratory syndrome coronavirus 2 reverse transcription polymerase chain reaction

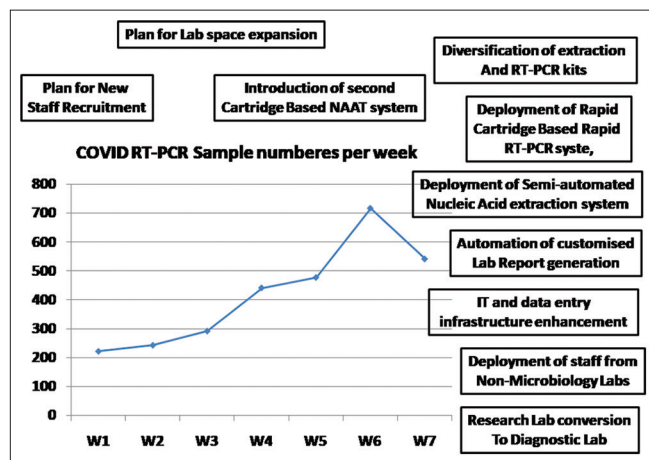


Figure 2: Sample numbers for severe acute respiratory syndrome coronavirus 2 reverse transcription polymerase chain reaction and capacity building components at Tata Medical Center, Kolkata

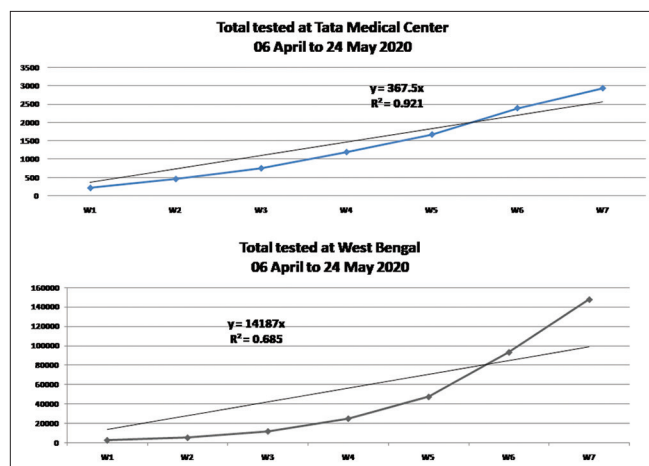


Figure 3: Severe acute respiratory syndrome coronavirus 2 reverse transcription polymerase chain reaction testing trends in Tata Medical Center and in the West Bengal state

5. Storage facility for samples, kits and consumables
6. Human resources
7. Data entry and information technology (IT) infrastructure
8. Total quality management
9. Administration, management and leadership.

SAMPLE COLLECTION

Essential components to deliver and expand the capacity for sample collection include well-trained staff, robust systems for sample identification including use of a standardised sample requisition form and the ICMR-approved RT-PCR app developed by the National Informatics Centre and using designated areas for sample collection to ensure safe and efficient collection of respiratory samples. Adequate supply of viral transport medium (VTM) and appropriate swabs to manage the expected sampling load, along with logistical planning for the labelling, packaging, storage and transport of the collected samples is critical. Multiple collection points, including field-based collection using the RT-PCR app will help in enhancing sample collection capacity.

Molecular biology laboratory design and set-up

The minimum requirement to initiate molecular biology-based diagnostics for SARS-CoV-2 testing is a biosafety cabinet class II type A2 and PCR machines. The lab outlay and the type of PCR machine will depend on the chosen methodology of testing. In the case of conventional RT-PCR, organisation of the laboratory will involve having separate areas for RNA extraction, PCR master mix preparation, PCR set-up and nucleic acid amplification.

CBNAAT for SARS-CoV-2 may be carried using Cepheid’s GeneXpert, Qiagen’s QIAstat-Dx and Biomeriex’s Biofire FilmArray systems. CBNAAT systems have minimal footprints, requiring only a table-top to accommodate the instrument and the accompanying laptop. These systems will need to be positioned adjacent to a BSC-IIA2 and require suitable electrical supply. By contrast, conventional RT-PCR-based diagnostics requires at least 3 separate work areas, one each for nucleic acid extraction, PCR master mix preparation and viral nucleic acid template addition. At least one BSC-IIA2 and a refrigerated centrifuge is required in the nucleic acid extraction room, while a dead air box and/or laminar flow box may be sufficient in the other 2 rooms. The choice between CBNAAT and conventional RT-PCR testing is usually based on the test needs of the centre. CBNAAT will obviously need fewer personnel, occupies less space and is less labour-intensive, but carries the major disadvantage of low throughput. When large-scale or field testing of samples is the need of the day, testing by conventional RT-PCR is the more appropriate option.

Equipment for the molecular biology laboratory

The list of equipment for conventional RT-PCR is extensive and includes:

1. BSC-IIA2, dead air boxes and laminar flow cabinets for sampling handling

2. RT-PCR instruments including Qiagen’s Rotor Gene Q (convection-based heating using a centrifugal rotary design) or Applied Biosystems’ Quant Studio systems and ABI 7500 (conduction-based heating using heated plates)
3. Freezers and refrigerators for storage of samples, template nucleic acid and reagents; reagents are typically stored at -20°C; extracted viral RNA is stored at -80°C; samples are stored short term at 2°C–8°C and long term at -80°C
4. Refrigerated centrifuge (operating at 2°C–8°C) with centrifugation speeds of at least 14,000 rpm
5. Small equipment including dedicated set of pipettes, spinfuges, vortex mixers
6. Equipment for automated nucleic acid extraction including Qiagen’s QIAcube and QIASymphony, Thermo Scientific’s Kingfisher and HiMedia’s Insta NX.
5. Sample types (blood, tissue, respiratory sample, bacteria, virus, etc.)
6. Extraction principle: magnetic bead/vacuum column/spin column extraction
7. Throughput (number of samples per run)
8. Run time (time required for extraction)
9. Pre-processing time
10. Equipment cost
11. Cost per sample PCR reaction (reagent plus plastic ware)
12. Decontamination methods
13. Quality control methods
14. Service, maintenance and troubleshooting support
15. Warranty period
16. Availability of reagents, consumables.

RT-PCR machines differ in speed and throughput. The Rotor Gene Q requires approximately 150 min to complete a run of 72 reactions (alternatively 36 reactions per run using a smaller ring), while the plate-based ABI 7500 or Quant Studio systems can handle 96 reactions per run. However, The PCR run time also depends on the PCR cycling parameters (which may differ with kits). There are protocols on Rotor Gene Q which can be finished within 100 min. The sample handling capacity may be enhanced by choosing plate-based machines with a higher ramp rate (rate of change in temperature over unit time). For instance, the Rotor Gene Q peak ramp rates, in air, >15°C/s heating, >20°C/s cooling The Quant Studio 3 has a ramp rate between 6.5 to 9°C/s depending on the reaction volume. Other approaches to enhance instrument capacity is to use automated nucleic acid extraction machines with batch systems and use of liquid handling systems for automated mixing of template and PCR master mix (e.g., Qiagen’s QIAgility).

Equipment and system selection for a molecular microbiology laboratory

Selection of appropriate systems, equipment and processes is critical for capacity building. This may be done using checklists so that essential points for consideration are not missed during system selection [Tables 1-3]. Some examples are as follows:

Checklist for the selection of an automated nucleic acid extraction system

1. Open or closed system
2. Random access or batched testing
3. Sample volume range
4. Elution volume range

Checklist for the selection of a reverse transcription polymerase chain reaction system

1. Open or closed system (CBNAAT is a closed system)
2. Random access or batched testing (CBNAAT is a random-access system)
3. Reaction volume range (this will determine size of PCR tubes)
4. Number and type of optical filters (this will determine compatibility with probe and other dyes used in RT-PCR)
5. Ramp rate (this will determine run time)
6. Heat flux (Peltier heat block or convection heating)
7. Throughput (number of reactions per run)
8. Run time (time required for PCR)-determined by ramp rate, assay type
9. IT Software and hardware support-program and laptop
10. Cost and type of PCR plastic consumables required.

Checklist for the selection of an reverse transcription polymerase chain reaction kit for severe acute respiratory syndrome coronavirus 2 detection

1. Open *versus* closed system kits (CBNAAT cartridges are closed system kits)
2. Cost per reaction and Cost per sample tested
3. SARS-CoV-2 genes detected: E gene/S gene/RDRP gene
4. TaqMan *versus* SYBR chemistry for detection of PCR products and the availability of suitable optical filters for fluorescence detection in the RT-PCR instrument
5. Multiplex, duplex or monoplex format of the PCR (E gene only in a reaction tube; E gene plus internal control in a reaction tube; E gene, S gene and internal control in a reaction tube)
6. Endogenous or exogenous internal control

Table 1: Comparison between Qiagen spin column and thermo magnetic bead manual RNA extraction

Extraction method	Equipment and consumables required	Sample volume (ul)	Elution volume (ul)	Time required (approximate) (min/sample)	Cost of extraction kit/preparation (INR)
Qiagen spin column manual	Centrifuge (refrigerated), pipettes, pipette tips, microfuge tubes	140	60	15	336.00
Thermo magnetic beads manual	Heat block, tube shaker, magnetic stand, pipettes and tips, microfuge tubes	200	50	40	546.00

INR: Indian rupees

Table 2: Comparison of automated extraction systems

Instrument name	Company	Country	Type of System	Preprocessing time (min)	Example for run time	Run time (min)	Technology	Throughput	Extraction time	Per sample cost (including plastic wares) (Rs.)	Open shelf life (days)	Elution volume (ul)	Comment	Approximate nonnegotiated cost (Can vary)
QIA symphony SP	Qiagen	Germany	Closed	Depend on sample type and number	30 min for 24 samples	90-120	Magnetic bead based	96	240-300 for 96 samples	600	30	50	During breakdown same extraction kit cannot be used for manual extraction	Rs. 50 lakhs + GST
Qiacube HT	Qiagen	Germany, Malaysia	Closed	Depend on sample type and number	30 min	90-140	Vacuum based	96	90-140 for 96 samples	400	365	50	During breakdown same extraction kit cannot be used for manual extraction	Rs. 22 lakhs + GST
Kingfisher Flex	ThermoFisher scientific	USA	Open	Depend on sample type and number	30 min for 96 samples	30	Magnetic bead based	96	30 for 96 samples	200	365	50	Yield somewhat less as compared to bead based assays	Rs. 33 lakhs + GST
Insta NX	Himedia	India	Closed	Depend on sample type and number	15 min	75	Column based	12	75 for 12 samples	500	365	50	During breakdown same extraction kit cannot be used for manual extraction	Rs. 10 lakhs + GST
AS8500 Maxwell RSC 48	Promega	USA	Closed	Depend on sample type and number	10 min incubation at 56°C	30-45	Magnetic bead based	48		800	365		During breakdown same extraction kit cannot be used for manual extraction	47 lakhs + GST

Table 3: Portable and cartridge based systems in capacity building

	Xpert	QiaStatDx	BioFire Film array	Truenat
Company	Cepheid, USA	Qiagen, Germany	Biomerieux, France	Molbio Diagnostics, India
Detects	SARS CoV-2	SARS CoV-2 and 21 other respiratory pathogens	SARS CoV-2 and 21 other respiratory pathogens	Beta Corona virus; needs confirmation for SARS CoV-2
Test duration (min)	30	70	50	60
Sample preparation	Integrated	Integrated	Integrated	Trueprep AUTO Sample Prep Device required
PCR system	GeneXpert Dx; Xpert Infinity	QiaStatDx	FilmArray® 2.0/Torch Instrument Systems	Requires TrueLab: Uno/Duo/Quattro
Genes detected	E and N2	E and ORF1	ORF 1ab; ORF8	E gene
Internal control	Exogenous; sample processing control; probe check control	Exogenous; MS2 bacteriophage	Endogenous; RP2	Endogenous; RNase P

PCR: Polymerase chain reaction, SARS CoV-2: Severe acute respiratory syndrome coronavirus 2

7. Analytical and clinical sensitivity
8. Analytical and clinical specificity
9. Volume of positive controls provided (this determines the number of runs possible with a kit)
10. Number of cycles of PCR (this determines the run time)
11. Is it the kit approved for *in vitro* diagnostics (IVD) or is for research use only?
12. In case of IVD, certification by the FDA, CE, etc.
13. Availability and continuous supply
14. Troubleshooting support.

KITS AND REAGENTS

A key bottleneck regarding molecular diagnostics is the availability and access to indigenous PCR kits and technologies. Currently, Germany and the USA are the leading producers of PCR equipment and reagents. Although domestic kits such as TRUPCR have been marketed by Blackbio, the number of such manufacturers are limited, leading to a wide gap between supply and local demand. Furthermore, critical consumables such as personal protective equipment (PPE), PCR plastics (e.g., pipette tips, columns, microtubes) and VTM may not meet expected quality requirements due to poor manufacturing and quality assurance standards. Therefore, our main goal through capacity building in kits and reagents should be to develop sufficient inventory via imports and stockpiling and expanding local manufacturing of essential consumables to deliver high-quality diagnostic kits in adequate quantity.

STAFFING

Human resource requirements in a molecular biology lab will also depend on the test systems in place. CBNAAT systems are less demanding and require fewer skilled staff. Automation of sections of the conventional RT-PCR process will also reduce the staff numbers. Use of conventional manual intensive systems requires the maximum number of trained personnel. Hence, a good understanding of the lab workflow and systems is vital for staff planning. All staff must be trained in Good Laboratory Practice (GLP) and laboratory safety including biosafety, while prior specific training in molecular techniques would be desirable. To

augment staff capacity, regular training modules in GLP, molecular diagnostics and biomedical waste management, coupled with periodic assessments are necessary. Suitable staff is required in all components of testing from sample collection, through nucleic acid extraction, PCR testing and data management. As example, personnel specification for RT-PCR testing will include:

1. Good knowledge and understanding on:
 - GLP
 - Biosafety
 - Molecular biology.
2. Technical skills in
 - Nucleic acid extraction
 - PCR Master mix preparation and PCR set up
 - Post-PCR analysis.
3. Additional requirements including
 - Rigorous documentation of experimental work, ability to work as part of a team, readiness to work flexibly, equipped with troubleshooting and problem-solving abilities.

MATERIAL STORAGE

Increasing storage capacity in lab needs sufficient space for two types of storage:

1. Dry storage for PCR plastics, extraction kits, PPE, unused VTMs and the paperwork related to testing (sample requisition form, PCR worksheets etc.)
2. Cold storage for samples, templates and reagents.

Short-term storage of samples at 2°C–8°C in a standard refrigerator is feasible while long-term storage of samples and viral nucleic acid templates require a -80°C freezer. Test reagents require -20°C for optimal storage. Large-volume short-term storage may be done using walk-in coolers, thus increasing the available space for cold storage. However, indexing and cataloguing of samples, reagents and consumables is vital to ensure efficient storage and retrieval of material when needed. Therefore, proper labelling and archiving (using paper or electronic means) is paramount to ensure efficient storage and retrieval capacity.

Data entry and information technology infrastructure

Building up capacity in the earlier sections is impractical without having an efficient and reliable system for sharing results and notifying the authorities. App-based platforms such as RT-PCR App from ICMR make this accessible and easy. This may be enhanced by linking the app to Lab Information Systems that are integrated with the lab instruments.^[14]

IMPORTANCE OF QUALITY CONTROL IN CAPACITY BUILDING

The importance of quality control in capacity building can hardly be overemphasised. For example, human resource capacity requires careful selection of personnel, training, competence assessment and periodic appraisals. Biomedical equipment used for sample storage, nucleic acid extraction and PCR require regular preventive maintenance, calibration, maintenance contracts (annual or comprehensive). Kits and reagents need to be checked through daily internal quality controls and assessments of precision accuracy. New batches of test kits will need to be reassessed for performance. All pre-analytical factors with regard to sample collection transport and storage will need to be standardised and optimised. Finally, all laboratory techniques will need to be linked to external quality assurance programs.

Leadership and total quality management

Leadership, administrative and managerial support at various levels (test registration, logistics, inventory management, laboratory administration, quality control, biomedical engineering and IT) is critical for capacity building. Effective coordination between various sections is important. Administrative decisions on the suitable laboratory techniques and processes that best meet requirements for throughput, efficiency and cost are crucial for long-term service viability. These decisions will reflect on other variables such as consumables and reagents inventory, staff and equipment requirements. An effective leader is not just a mentor and a visionary but also a manager of man, machine material, method, money, time. Administrative action is critical for capacity building. The medical and laboratory administration decides what is to be done and when it is to be done, whereas the institutional management decides how best to implement the administrative decisions. Administrators have a thinking function, whereas managers have an operational function. The leadership asks questions and mentors provide strategic directions and address roadblocks in implementation. Coordination and integration is required at various levels and sectors: (a) Vertical integration: Establishing synergy within defined areas (e.g., sample collection; inventory management; maintaining IT networks); (b) Horizontal integration: establishing synergy across several functional domains e.g., (sample collection, nucleic acid extraction, RT-PCR, test result reporting); (c) Resource and performance management through management principles such as Lean and Six Sigma which aims at waste elimination and speed (the focus of Lean);

customer satisfaction and accuracy (the focus of Six Sigma whose methodology involves Defining, Measuring, Analyzing, Improving and Controlling).^[15-17]

Recognising psychological aspects of lab workers incapacity building: Distinguishing between fear and danger

Exaggerated fear of acquiring COVID-19 at the workplace can be a significant hurdle in the path to build capacity. Danger is a real phenomenon, whereas; fear is a psychological phenomenon which may be unrelated to the degree of risk. In order to build capacity for testing SARS-CoV-2 addressing staff concerns about contracting infection while working in diagnostic laboratories or in the clinical areas is important. This can be achieved through induction programs, periodic and regular training, staff briefing about best practices, monitoring biosafety and infection trends and making available adequate PPE for all levels of laboratory operations. In select cases, staff may be referred to a psychologist or provided professional counselling about risks, infection prevention measures and risk management.

Value of networks in capacity building and conclusion

Besides access to tangible resources, capacity building requires the development of networks— both intra- and inter-institutional. The cumulative value addition generated by the network is often greater than the sum of its constituent parts [Table 4]. In 2011, ICMR invested in creating a Viral Research and Diagnostics Lab network.^[18] This network was instrumental in providing initial COVID testing support in the country and later worked with the other labs in the country to bring them to speed. The mutually complementary data, information, knowledge, skills, mentorship, leadership and wisdom offered by network members often creates innovative approaches for addressing challenges and a better appreciation of the bigger picture. It is critical in this context of interdependence that we support and reinforce the existing laboratory and infection prevention networks within India.^[19,20]

The existing network of hospitals working on Infection Control and Healthcare Associated Infection (HCAI) surveillance

Table 4: Value of networks in capacity building

How inter institutional networks help in capacity building
Linkages with ICMR HQ and ICMR reference labs
Guidance regarding IPC in specialised areas- such as laboratory, sample collection, etc.
Information about best practices and procedures from other centres
Online training in network groups
How intra institutional networks help in capacity building
Reduce redundancy of human resource, equipment and space
Supplement and complement expertise
Help identify institutional priorities and focus resources accordingly
IPC: Infection prevention and control, ICMR: Indian Council of Medical Research, HQ

under the aegis of ICMR-AIIMS and CDC are facilitating trainings of several hospitals. Through these weekly trainings, the hospitals are remotely trained on COVID-related infection control measures, safe handling of specimens and other frequently asked questions (FAQs) [Table 5].^[21]

As resources get prioritised to meet the challenges of pandemic microbiology it is also important that COVID diagnosis capacity building should not compromise the diagnostic systems in bacterial and fungal infections for COVID or non COVID patients. India faces formidable challenges and remarkable opportunities in the domains of Antimicrobial Resistance, Infection Prevention and Control (IPC), Antimicrobial Stewardship Program (AMSP) and Diagnostic Stewardship. The solution requires an integrated approach. If laboratory diagnosis of infections, IPC, non-antibiotic AMSP and non-bacterial or non-infective diagnostic stewardship works together-the problem of multidrug-resistant bacteria and drug resistant fungi can be handled more effectively. This would require capacity building in viral diagnostics, similar to capacity building in fungal diagnostics, HCAI surveillance and antifungal stewardship. Viral pandemic management also benefit from capacity building in bacterial diagnostics and IPC. It may be more resource intensive in the short term, but an

integrated approach eventually is likely to be more rewarding and efficient by reducing redundancy of precious resources.

Creation of sustainable laboratory networks within a country as vast and varied as India takes time, resources and persistence besides a sustained degree of leadership commitment. The COVID-19 pandemic and its ripple effect within India teaches us how existing networks created by ICMR with the help of public and private sector partnership can be put to good use during times of national, regional and international health emergencies. With the SARS-CoV-2 RT-PCR capacity building exercise within India, we are probably steps closer to realising the larger vision of establishing an integrated high-quality molecular microbiology service, research and surveillance network within the country.

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Conflicts of interest

There are no conflicts of interest.

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Table 5: Frequently asked questions

Is a BSL-3 lab required for SARS CoV-2 RT-PCR?
No: A BSL-2 lab with a certified biosafety cabinet of IIA2 variety is sufficient
BSL-3 labs are essential if viral culture work is done. None of the labs should attempt viral culture (ICMR guideline)
Can lower respiratory samples be used for SARS CoV-2 RT-PCR?
Yes: Sputum or BAL or endotracheal secretion may be used
For patients with a productive cough, sputum should be collected. The induction of sputum is not recommended
Where should specimens be collected?
Specimen collection should be performed in a single patient room with the door closed
What are the Aerosol generating procedures in the laboratory?
These include, but are not limited to: Pipetting, sonication, vortexing, centrifugation, preparation of smear, streak inoculation of culture, inserting hot loop into a culture
How to prevent aerosol generation and lab staff exposure?
All manipulations should be performed in appropriately maintained and validated biosafety cabinet
Laboratory personnel performing procedures must demonstrate capability
While centrifuging
Use sealed safety cups and sealed rotors
Open cups inside a biosafety cabinet
Allow cups to sit prior to opening to allow aerosols to settle if no biosafety cabinet available
What disinfectants can be used on smart phones?
Lab staff should avoid using mobile phones during lab work. If used an alcohol wipe with 70% isopropyl can be used by gently wiping the exterior surfaces of the phone
SARS CoV-2: Severe acute respiratory syndrome coronavirus 2, RT-PCR: Reverse transcriptase-polymerase chain reaction, ICMR: Indian Council of Medical Research, BSL: Bio- Safety Level

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