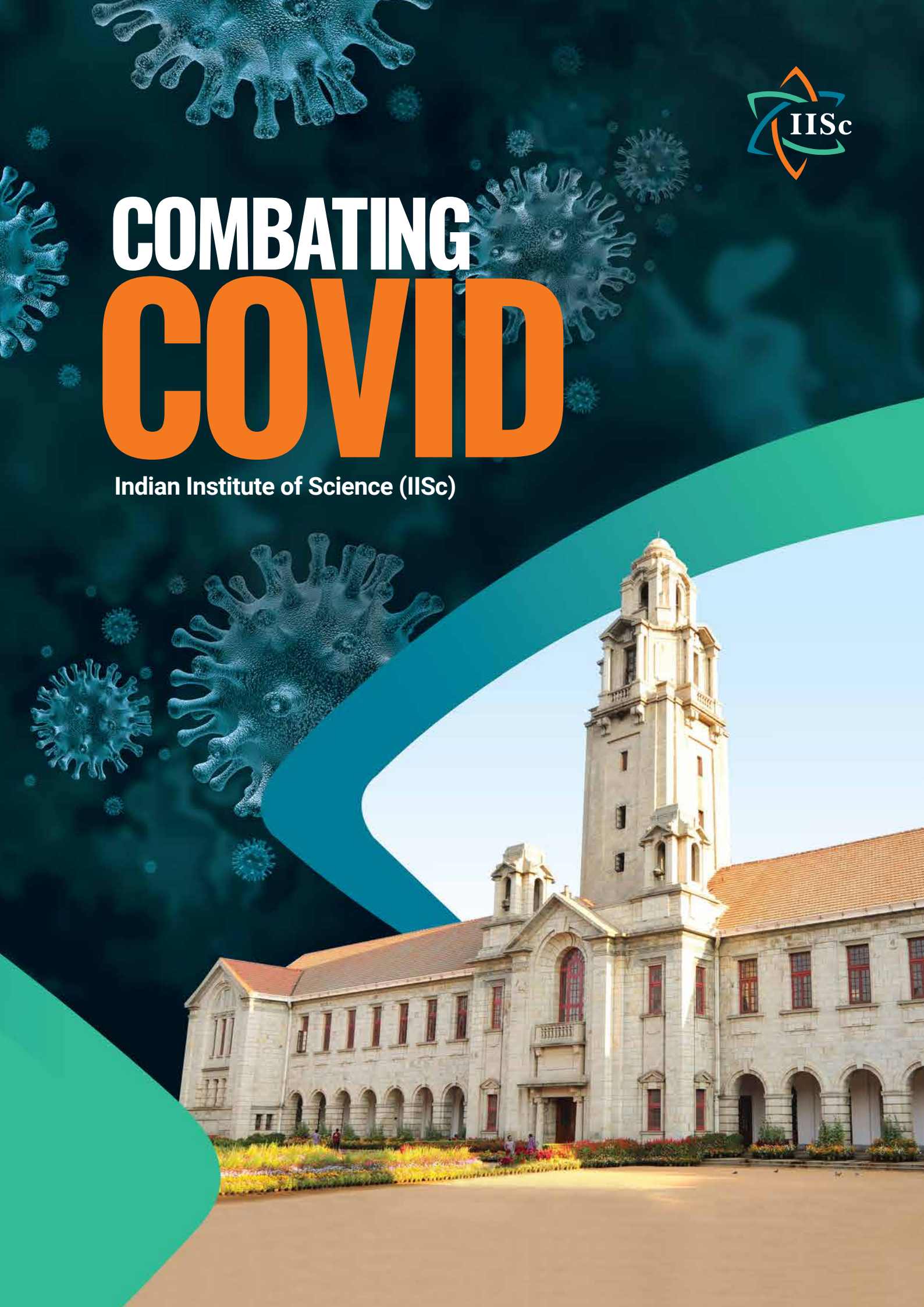
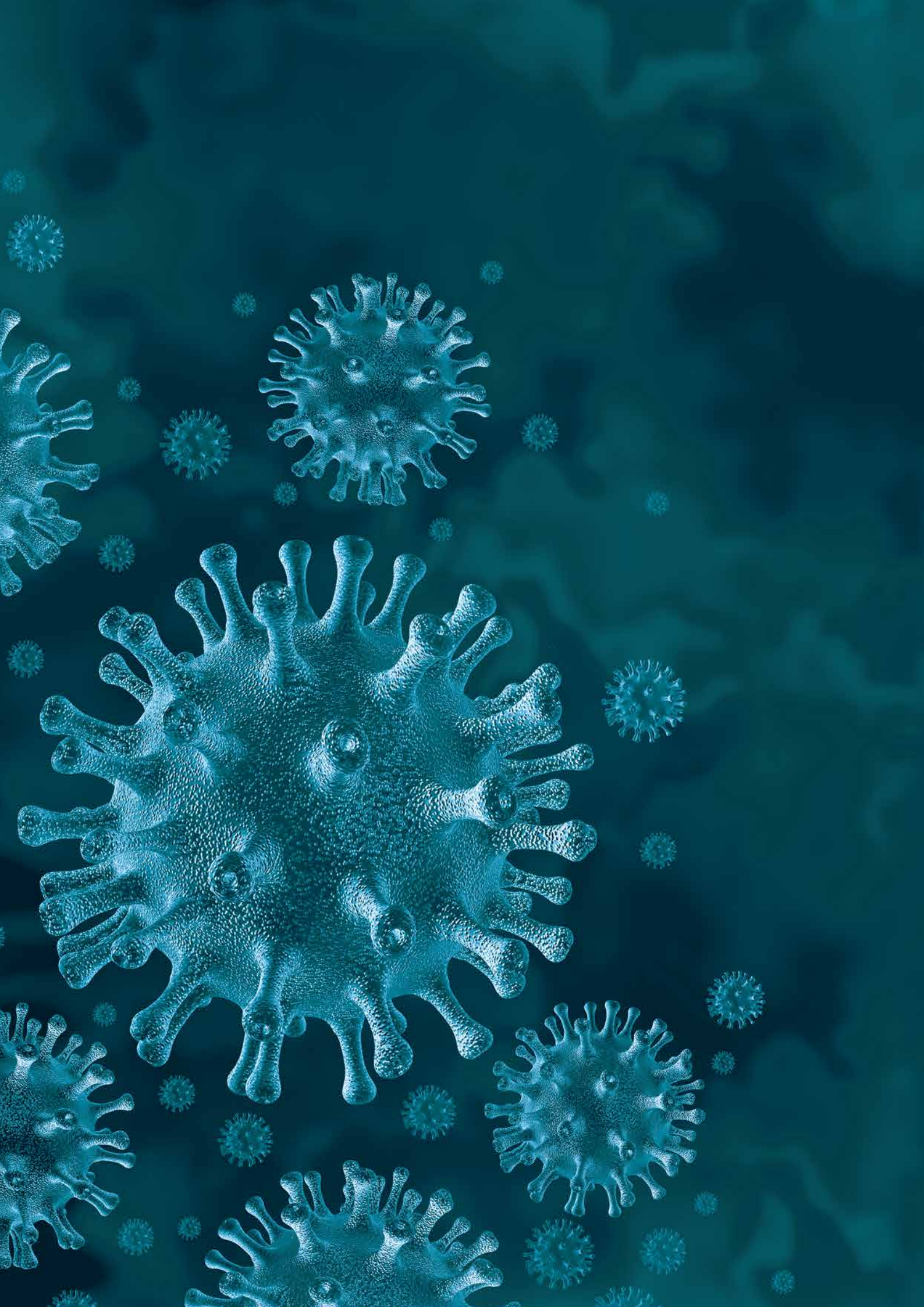
COMBATING COVID

Indian Institute of Science (IISc)





Foreword

Early in March 2020, the Indian Institute of Science (IISc) began shutting most of its operations in response to the growing COVID-19 crisis. But its researchers did not stop working. Many of them immediately turned their attention to developing devices, technologies and solutions that will help healthcare workers, government agencies and institutions respond better to the crisis. These efforts have also brought together faculty members from diverse disciplines to work together, reflecting the interdisciplinarity that is enshrined in the Institute's ethos.

There are currently over 30 ongoing projects related to COVID-19 in five broad areas: hospital assistive devices to support overburdened healthcare systems; modelling, simulation and analysis tools to track epidemic spread; low-cost and innovative diagnostic tools to rapidly detect the disease; vaccine development and drug repurposing approaches; and various products and systems that improve sanitisation and disinfection.

This booklet aims to provide a snapshot of these projects. Our researchers are continuing to work closely with industry partners and government agencies to quickly scale up and deploy these solutions for widespread benefit.

Hospital Assistive Devices

PRAANA: Indigenous electro-mechanical ventilator

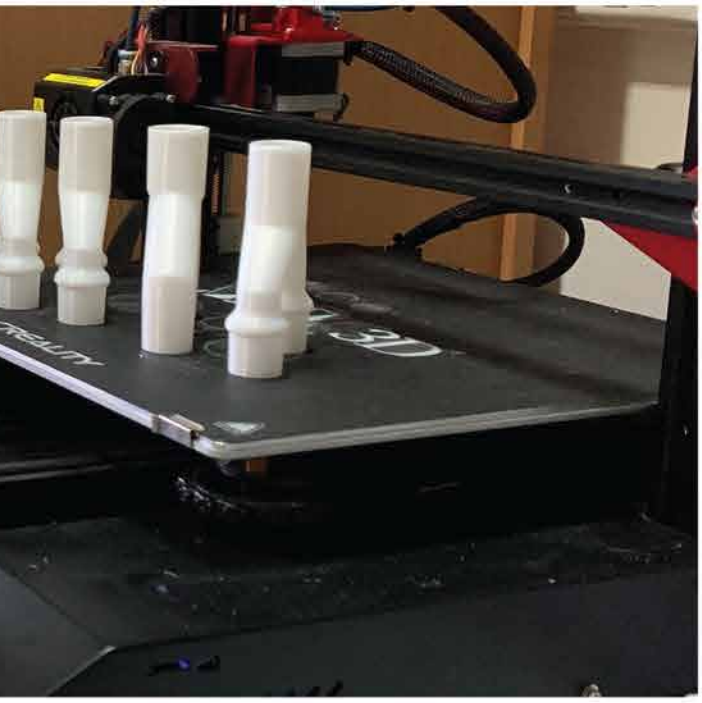
An ICU-grade ventilator, built entirely from components made in India or easily available in domestic supply chains. It uses customised algorithms and techniques to blend air and oxygen in the desired ratio, and has fine-grained control of patients' respiratory parameters.

3D printed valves for split ventilator use

Valves that enable the use of a single ventilator for multiple patients, made using 3D printing. Preliminary designs were fabricated and tested in a hospital setting using simulated lungs.

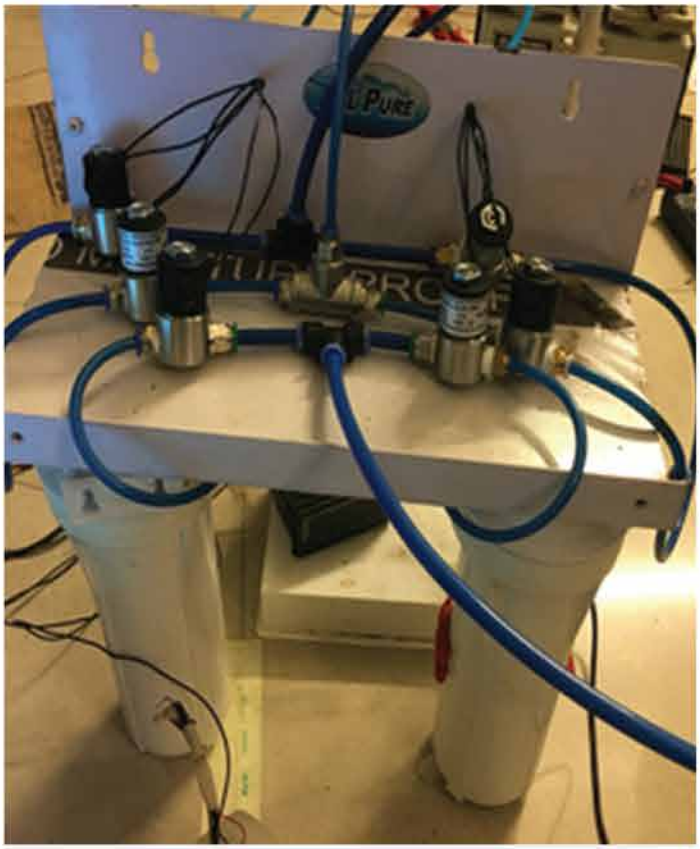
Low-cost ventilator using inexpensive electronics

A ventilator system that uses basic electronics and can easily interface with existing hospital infrastructure in the absence of a full-fledged ventilator. Advanced versions offer fine-tuned control of pressure and volume.



Aerosol shield for intubation and anaesthesia

A transparent box that can be placed around a patient while putting them on a ventilator or under anaesthesia to reduce the risk of infection for doctors and healthcare workers. Initial designs have been developed and tested at NIMHANS, Bengaluru.



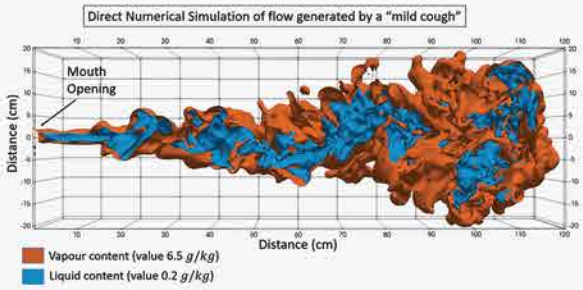
Oxygen concentrator

Low-cost oxygen concentrators that can be coupled with ventilators to ensure reliable oxygen supply for patients. Atmospheric air is pumped through mineral sieve beds that preferentially absorb nitrogen, in order to increase oxygen concentration.

Medical oxygen generator

An oxygen generation system for small-scale medical requirements using low power. Oxygen is separated from ambient air using a twin-bed vacuum swing adsorption system integrated with a discharge vessel and various safety systems.

Modelling, Simulation and Analysis

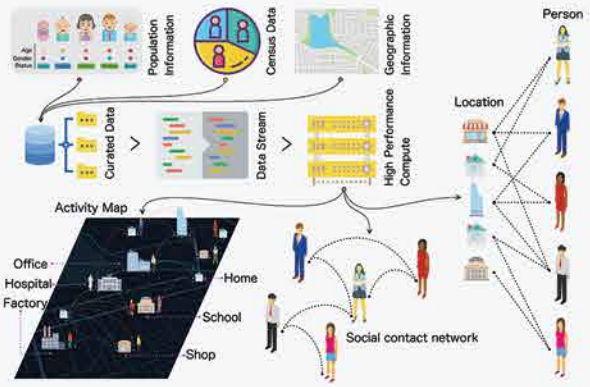


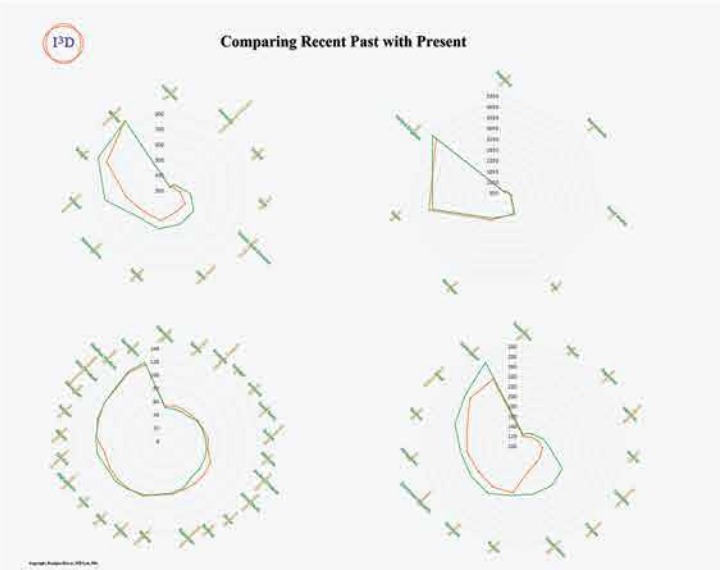
Simulating cough/sneeze flows

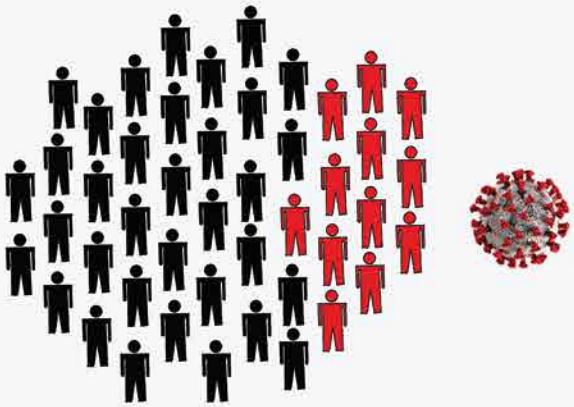
A direct numerical simulation code for studying "cough/sneeze flows" by applying principles from computational analysis of atmospheric clouds. Highly-resolved simulations are being run on IISc's CRAY XC40 (SahasraT) supercomputer.

Modelling epidemic spread in cities

City-scale simulations to evaluate the impact of post-lockdown scenarios. The agent-based model mimics various interaction spaces such as households, schools and workplaces, where infections are tracked under different intervention scenarios.





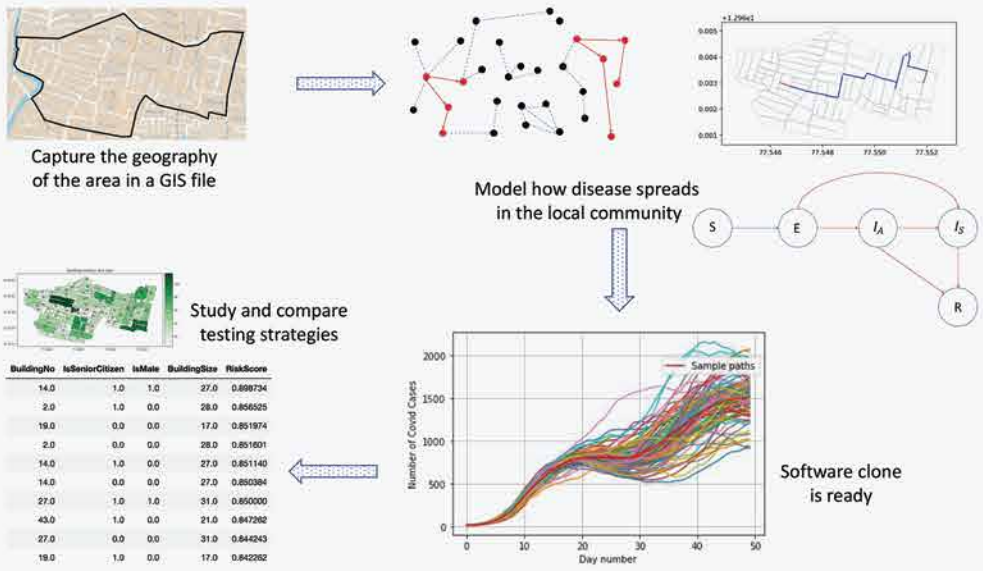


Estimating infection spread

A reliable estimator to gauge infection rate within a target population. The estimator takes as input the time series formed by the number of hospitalised cases that test positive each day.

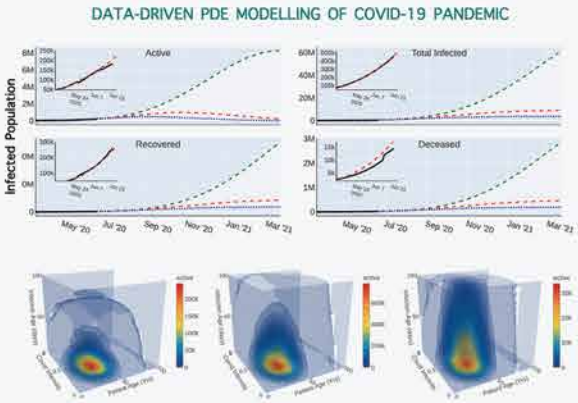
Studying testing strategies

An agent-based simulation framework to evaluate and compare various testing strategies and policies. These include random symptomatic testing, contact tracing and spatially aware sampling of hotspots, as well as interventions such as lockdowns.



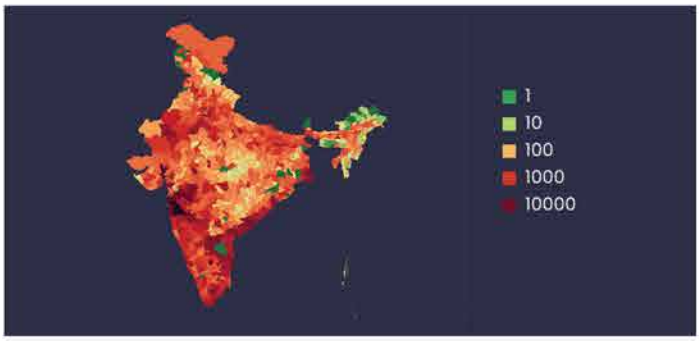
Visualising phases of spread

A new interactive visualisation system to represent and compare phases of spread of COVID-19 across different countries. It uses a knee detection algorithm that divides the exponential spread into multiple linear components.



Modelling infection distribution

A six-dimensional population balance predictive computational model for an epidemic. Unlike existing models, it predicts the distribution of infected population across region, age, days since infection and severity of infection over a period of time.



Projecting medical inventory

A dashboard that forecasts medical inventory such as PPEs, ventilators, oxygen and masks, across districts and states. A robust algorithm for estimating asymptomatic patients and predicting the medical inventory required is also being developed.

Modelling cities as small world communities

Modelling cities as multi-lattice small world networks where each ward is modelled as a 2D lattice and nearby wards are connected together. The model simulates several post-lockdown interventions on such networks to study their effectiveness.

Diagnostics and Surveillance

RNAWrapr: Secure transportation of RNA samples

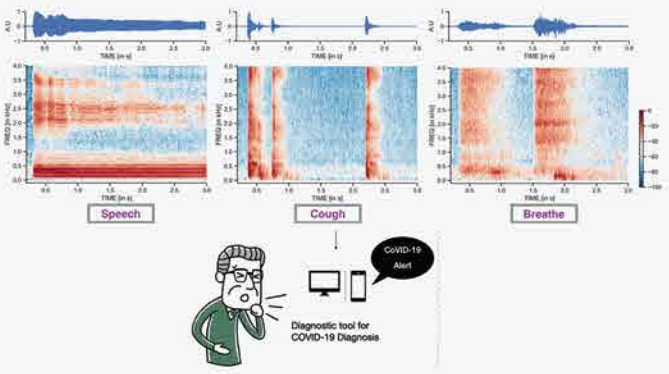
A viral transport medium that does not need refrigeration, thereby greatly reducing the cost of transporting samples for RT-PCR testing. RNAWrapr also inactivates the virus to some extent, reducing the risk of infection and protecting the RNA from degradation.

Mobile diagnostic labs

A fleet of BSL2+ compliant, ICMR-approved mobile diagnostic labs that can travel to and operate in remote areas. The mobile labs allow healthcare workers to collect, process and test samples using RT-PCR onsite, and upload results directly to the ICMR portal.

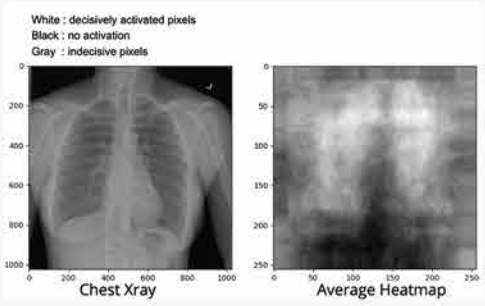
GoCoronaGo: Contact tracing app

An app to help identify people who may have crossed paths with COVID-19 positive subjects by tracking their interactions in the past using Bluetooth and GPS. It also provides alerts on isolation and proximity scores, and helps enhance social distancing.



Coswara: Sound-based diagnostics

A tool for diagnosing COVID-19 based on respiratory, cough and speech sounds. As the major symptoms include respiratory problems, it aims to detect and quantify biomarkers of the disease in the acoustics of these sounds.

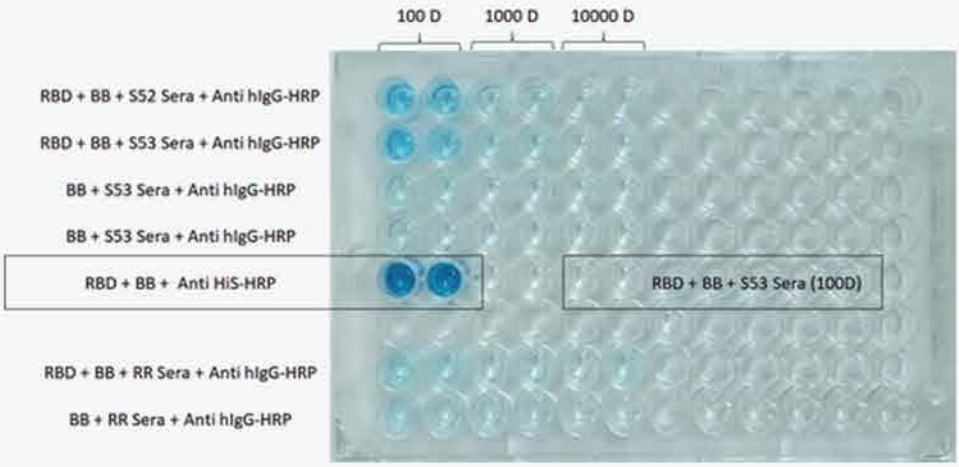


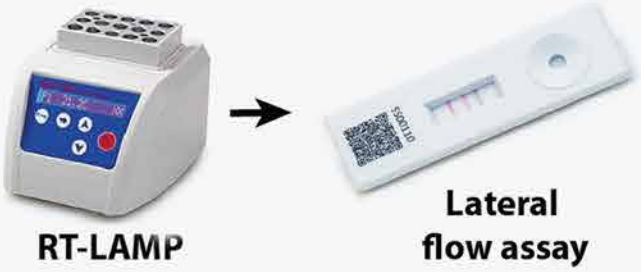
COVID-SWIFT: X-ray based diagnostics

A deep learning model that detects COVID-19 based on chest X-rays. The results of the test derived from the model can be obtained easily and quickly, especially in rural areas. A pilot WhatsApp-based service called "COVID-SWIFT" through which doctors can quickly receive machine-generated reports is currently being tested.

Antibody testing kit

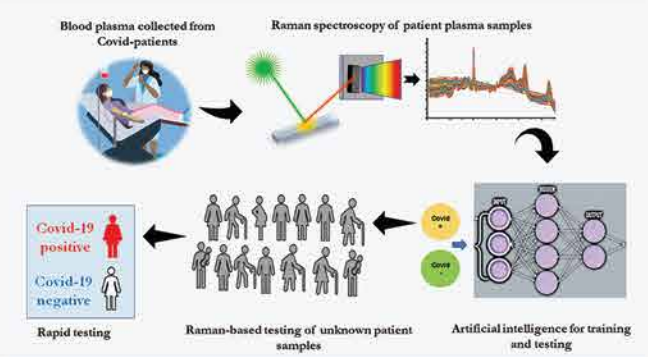
A test to detect antibodies specific to SARS-CoV-2 in blood samples. The assay uses SARS-CoV-2-specific antigens or peptides that bind to human IgG antibodies for detection, and can be used to understand seroprevalence or extent of infection spread.





PCR-free RNA detection test

An RNA-based test that relies on isothermal amplification of nucleic acids instead of PCR, obviating the need for expensive thermal cyclers. It leverages previous research on developing paper-based tests for diseases such as TB.



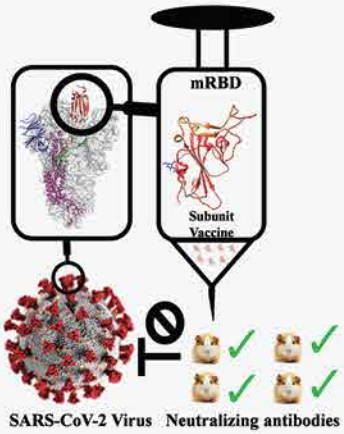
Raman spectroscopy to detect biomarkers

Exploiting Raman spectroscopy, a technique that probes chemical bonds and structures, to identify biomarkers in infected patients' blood plasma. No extraction procedure or reagents are required. The process can be automated using artificial intelligence and deep learning.

CovidWATCH: WhatsApp-based monitoring

A rapid monitoring tool for areas with low smartphone penetration. It offers a basic screening test based on ICMR strategy and a daily symptom tracker, via a multi-language WhatsApp chatbot, specifically built for people with little to no tech expertise.

Vaccines, Drugs and Biological Studies

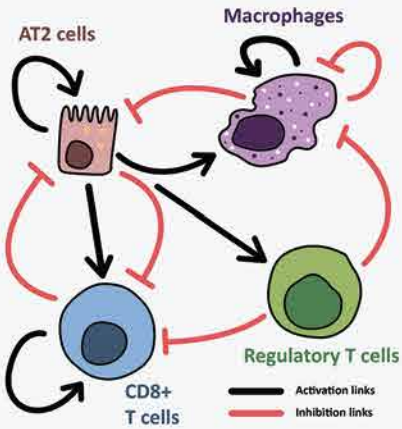


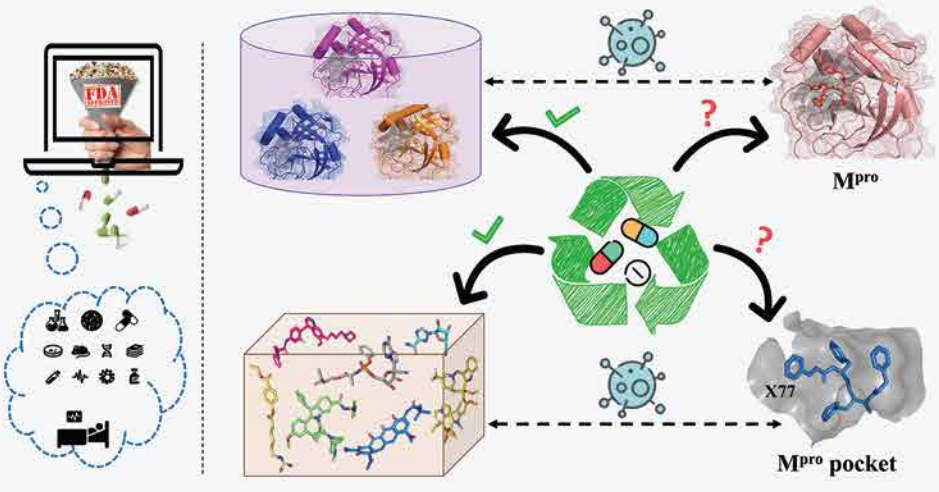
Developing protein-based recombinant subunit vaccine

Developing a rapidly producible vaccine for protection to frontline healthcare workers, senior citizens and individuals with co-morbidities. The vaccine is based on fragments of the spike glycoprotein of the novel coronavirus.

Modelling SARS-CoV-2 and immune system interplay

A minimalistic yet rigorous model to study host-virus dynamics, immune response and disease progression. The model helps identify key parameters that affect clinical outcomes, and explain the role of risk factors and effects of antiviral drugs (pre-print study).





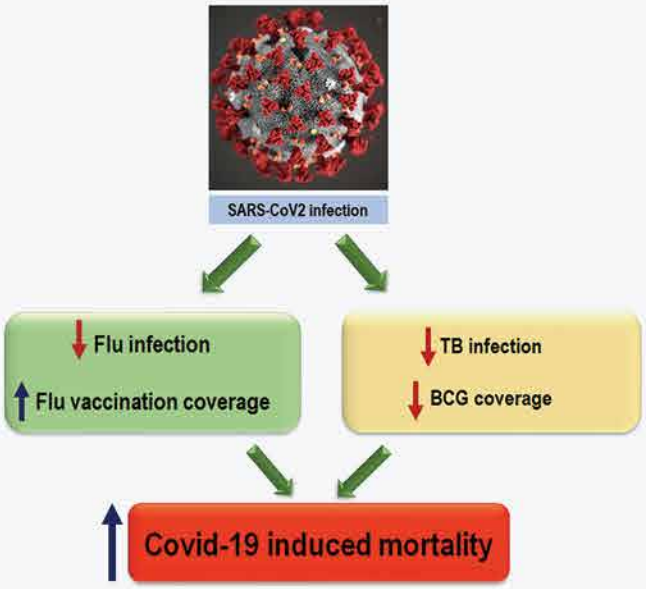
S. Chakraborti, S. Bheemireddy & N. Srinivasan (2020); Mol. Omics (in press)

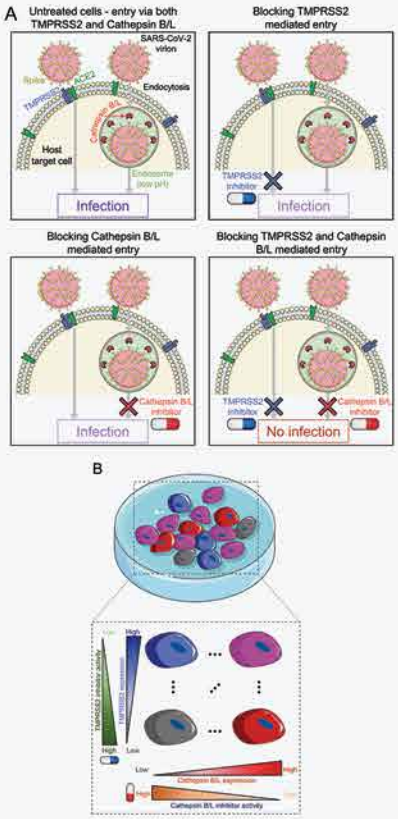
Repurposing drugs to target SARS-CoV-2 main protease

Screening existing drugs to test if they can target the SARS-CoV-2 main protease, a key enzyme in the virus life cycle. More than 20 known drugs or drug candidates that could bind to and block the enzyme have been identified.

Studying role of flu and BCG vaccination

Analysing the link between incidence of tuberculosis and flu with COVID-19 deaths in different countries. Preliminary data shows that countries with higher flu cases and BCG vaccination coverage may have a relatively lower number of COVID-19 deaths (pre-print study).





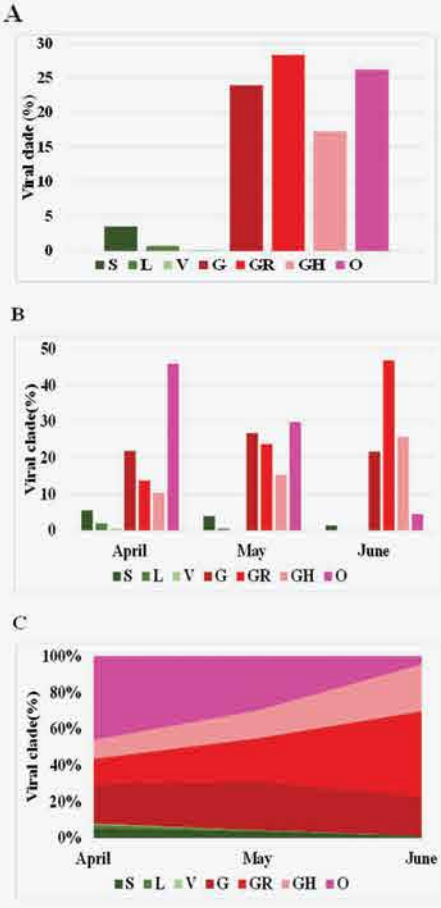
Targeting host proteases to prevent virus entry

Modelling how existing drugs can block host enzymes that play a key role in virus entry. Drugs targeting two key pathways, although independent, displayed strong synergy in blocking virus entry. Exploiting this synergy may improve deployment of drug combinations (pre-print study).

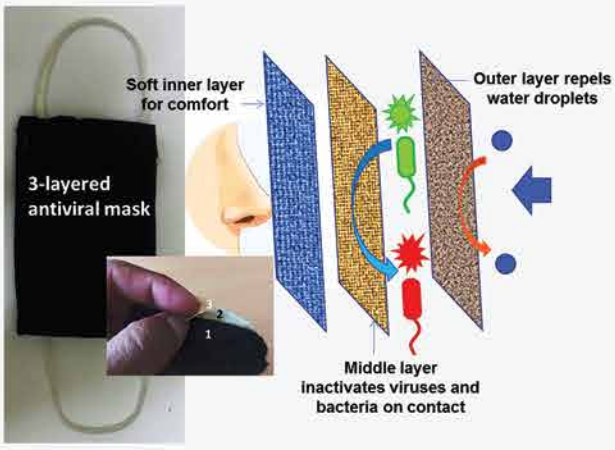
Analysing genomes of Indian SARS-CoV-2 strains

Determining genetic diversity among Indian SARS-CoV-2 strains compared to worldwide strains. More than 600 viral genomes have been analysed to trace the origins of these strains and monitor their dynamics over time.

Distribution of SARS-Cov-2 viral clades in India at July end



Sanitisation and Disinfection



N95 mask renewal and testing

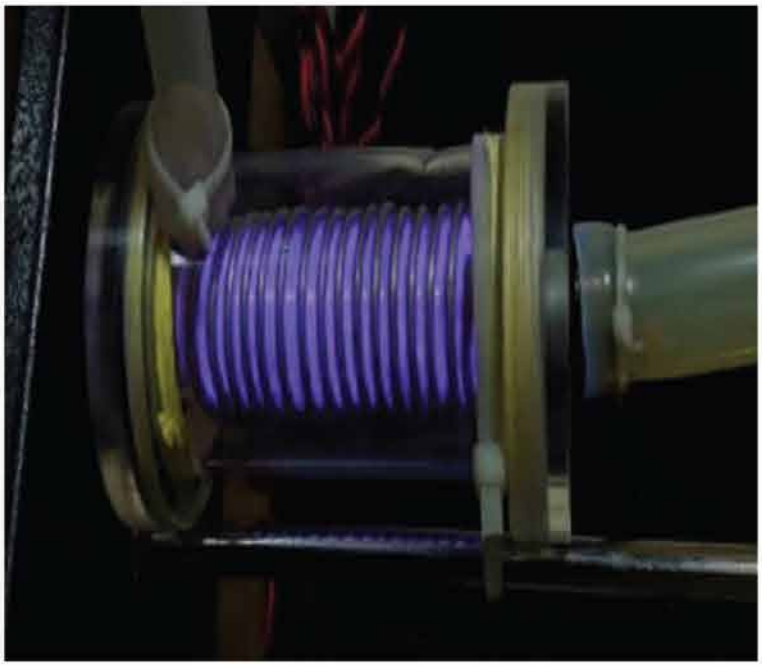
A system to test whether it is safe for healthcare workers to reuse their N95 masks after decontamination, based on breathing resistance and particle filtration efficiency tests. This setup is now being used to test the efficiency of all kinds of masks.

Virucidal composite fabric for PPE

A cost-effective, antiviral and antibacterial three-layered mask based on a nanofibrous polymer membrane. The membrane can also be deposited on the surface of other PPEs such as gloves and lab coats for healthcare personnel.

Plasma sterilisation and disinfection

Rapid plasma-based system for sterilising PPEs such as masks. It uses atmospheric air to generate ozone, a powerful disinfectant that can kill bacteria and viruses, and does not require any special gas preparation system.

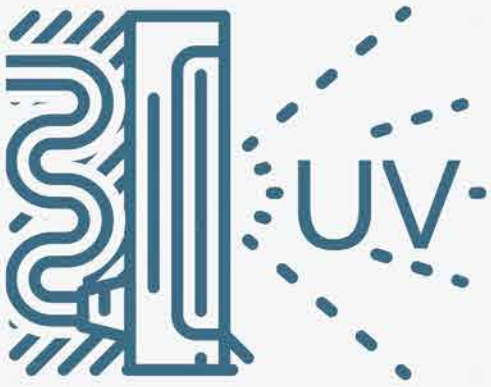


Drones for disinfection

Using drones to spray disinfectants over large areas, especially in places that are hard to reach, in order to reduce risk for sanitation workers. Several key areas in Bengaluru, including outdoor spaces and markets, have been disinfected using these drones.

UV-based disinfecting device

A UV-based disinfection system for public spaces and hospital environments where shorter cleaning cycles are needed. This can also be used to decontaminate reusable PPEs in times of extreme scarcity.



Test Centre for COVID-19

Increasing our testing capacity is crucial in our fight against COVID-19. IISc set up its own COVID-19 test centre towards the end of March 2020 at the Centre for Infectious Diseases Research (CIDR). It was set up within a short span of two to three weeks with support from the Institute and the Government of Karnataka.

The centre has so far tested more than 15,000 samples for the novel coronavirus, SARS-CoV-2.

IISc already has a Bio Safety Level-3 (BSL-3) facility with labs that study infectious diseases such as TB and HIV. The stringent protocols and sophisticated biocontainment equipment in a BSL-3 facility are required for handling highly infectious pathogens.

Personnel who work at the COVID-19 test centre undergo training for two weeks in Standard Operating Procedures (SOPs) specific to working with samples that may contain SARS-CoV-2.

The test centre uses RT-PCR, considered the gold standard for SARS-CoV-2, to detect genetic material of the virus. It employs RT-PCR kits that have been approved by the Indian Council of Medical Research (ICMR).

Several faculty members are involved in managing the test centre along with dedicated research staff members.

भारतीय विज्ञान संस्थान

Office of Communications (OoC)
Indian Institute of Science (IISc)
office.ooc@iisc.ac.in