Review Article

DOI: 10.7860/JCDR/2020/46510.14254

# A New Phase of Healthcare: COVID-19 and Medical Advancements

Public Health Section

OSHIN PURI[1], VYAS KUMAR RATHAUR[2], NITISH PATHANIA[3], MONIKA PATHANIA[4]



## ABSTRACT

Corona Virus Disease (COVID-19) was, declared a global pandemic by the World Health Organisation (WHO) on 11th March 2020, which has posed innumerable challenges for the medical fraternity. To overcome these obstacles healthcare professionals, engineers and industries like robotics, Artificial Intelligence (AI), 3 Dimension (3D) printing etc., are coming up with innovations that can assist them in administering critical care to COVID patients, restart health services for non-COVID patients, combat the spread of the disease, restart elective services and above all protect themselves while treating others. This article is a narrative review of the developments in the field of robotics and AI, improvements in ventilators and critical care facilities, measures taken to spread awareness and the need of such innovations, their benefits and effectiveness in relation to the current scenario. Articles regarding advancements during COVID months of March-May 2020 were searched on the internet and references giving medical evidence of the suitability of these innovations were added from PubMed and Google Scholar search engines, wherever necessary. Knowing the need and principles of such medical innovations which can help in improving the current practices or replace them with even better technologies are the need of the hour.

**Keywords:** Aarogya, Artificial intelligence, Hand sanitisation, Innovations, Ventilators

## INTRODUCTION

COVID-19 has proven to be one of the greatest challenges to the healthcare sector. The WHO declared this outbreak of Severe Acute Respiratory Syndrome (SARS) a Public Health Emergency of International concern on 30th January and soon a global pandemic on 11th March, 2020 [1]. Although the pandemic has put forward numerous challenges but couldn't detour the zeal and motivation of health sciences to rise from the ashes. Rapid public spread and the increased need for critical care necessitated innovation that revolutionised medical practise to adopt to the new normal. Curious minds are coming up with newer ideas and innovations to bridge the gap between demand and availability of critical care and to minimise and mitigate the spread.

### 1. Contactless Sanitisation Facilities: Prevention is Better than Cure

**Airlens minus corona-** Indian Institute of Technology (IIT) and All India Institute of Medical Sciences (AIIMS) alumni Debayan Saha and Shashi Ranjan developed "Airlens Minus Corona", a device that automatically travels through public spaces, sterilises the surroundings by spraying ionised water droplets [2]. There is both biochemical and electronic evidence that increasing the surrounding pH to 8.0 using ionised water induces conformational changes in coronavirus spike glycoprotein E2 (S protein). These changes result in loss of viral infectivity, aggregation of virions and increased virus-induced cell fusion [3]. Airlens Minus Corona exploits this principle for effective sterilisation of the surroundings.

**Foot-operated wash basins-** Foot-operated wash basins earlier limited to the scrub rooms of surgical settings are being employed as contactless handwashing facilities in almost all parts of the world. To name a few, the Jammu and Kashmir Police, Talegaon Dabhade Municipal Corporation, Barwadih Wagon Care Centre of the Dhanbad Division and the Indian Railways have also shifted to washbasins modified to touchless technology [4,5].

**Automatic mist based sanitiser dispensing unit-** As a continuum of the touchless cleaning mission, Centre for Fire Explosive and Environment Safety (CFEES), Delhi has developed an automatic mist-based sanitiser dispensing unit which detects hands using infrared sensors and dispenses sanitiser. CFEES, Delhi along with High Performance Organisation (HPO), used their expertise in fire suppression by mist technology, to develop an automatic mist based sanitiser dispensing unit. Being a contactless sanitiser dispenser it sprays alcohol based hand rub solution for sanitisation of hands at the entrance of buildings/office complexes, etc. Based on water mist aerator technology, it was developed for water conservation. It operates through an ultrasonic sensor in a contactless technology. A fluid nozzle with low flow rate generates aerated mist and dispenses the hand rub sanitiser, sanitising hands within minimum wastage by using only 5-6 ml sanitiser in one operation as a cone spray over both palms [6].

**UV sanitisation box and Hand-held UV device-** Regular sanitisation of hands is futile unless belongings like mobile phones, cash and keys are also disinfected. Defense Institute of Physiology and Allied Sciences, Institute of Nuclear Medicine and Allied Sciences and Defence Research and Development Organisation laboratories in Delhi decided to address the concern and came up with Ultraviolet-C (UV-C) light-based sanitisation box which can sanitise personal belongings using UV-C light with a wavelength of 254 nanometres (nm). The radiation warps the Ribonucleic Acid (RNA) structure preventing viral particles from replicating and killing the microbes quickly. UV-C light based sanitisation helps in avoiding harmful effects of chemicals used for disinfection and thus makes the method of sanitisation environment friendly. SARS Co-V-2 is deactivated by UV-C light in about one minute spaced equidistantly in a box with UV dose of 100 mJ/cm$^2$ producing ozone and takes care of unexposed areas of the object surfaces. This measure reduces transmission of corona virus in office and public environment [6].

**Immunotouch-** A different approach to tackle the same issue was employed by Slightly Robot, a Seattle based company which decided to redesign their ongoing wristband (to reduce frequent nail biting and skin-picking) project into Immunotouch. The device was coded to signal the users by producing sounds whenever the user tried to touch his/her face. In such times demanding serious hygiene [7], such a device can be a breakthrough and might help prevent transmission event after a contact [8].

### 2. Avoiding Contact, Avoiding Spread-Era of Robotics

**Milagrow Humanoid Elf-** Controlling the infection among healthcare professionals by minimising direct contact with positive

patients, AIIMS, Delhi tried out "Humanoid Elf" in its COVID-19 wards. This 92 cm tall robot can move automatically at a speed of 2.9 km/h. Milagrow Humanoid Elf developed by home-grown robotics company uses light detection, simultaneous localisation and mapping technologies to detect objects in its path, which helps it to avoid collisions. It records all activities using its in-built 3D and High Definition (HD) cameras and enables doctor-patient interactions remotely. The add-on to help patients overcome isolation related mental health issues, Humanoid Elf aids communication between patients and their family members through a 10-inch screen. It is equipped with at least 60 sensors and runs on a battery lasting up to eight hours, with an auto-charge feature [9].

**Milagrow iMap 9-** AIIMS Delhi has deployed Milagrow iMap 9. It is a floor-cleaning robot that does not require a human intervention to sanitise floors. It uses sodium hypochlorite solution to kill any COVID-19 spores on floor surfaces. Milagrow's patented Real-Time Terrain Recognition Technology (RT2RT) scans 360-degree angles six times per second making a floor map in real-time. This enables the iMap 9 to perform sanitisation successfully in the first attempt instead of 2 to 3 attempts other currently operating robots take [9].

**Nightingale-19-** The district COVID-19 centre in Ancharakkandi in Kerala's Kannur has deployed robots, called Nightingale-19, to assist health workers. The robot has been designed by students of Vimal Jyoti Engineering College in Chemberi, Kannur. It carries food and water, weighing up to 25 kg at a time and can be controlled from a distance of one km [10].

**KARMI-Bot-** Kochi-based Asimov Robotics has also built an autonomous robot, which has now been deployed in hospitals to assist COVID-19 patients. It dispenses food and medicine, collects trash disposed of by patients, performs disinfection and enables video calls between the doctor and patients. It also addresses the issues of shortage of Personal Protective Equipment (PPE) kits and exposure of healthcare professionals to the pathogen by minimising both. It is connected via a distributed sensor network and uses AI and machine Learning to come to a decision, based on which it responds and operates [11]. Another Jaipur based hospital is using robots to deliver medicines and food to patients in isolation wards [12].

**Stethoscope equipped Tele-consultation-** Hospitals in the United States use AI-based robots that allow doctors to communicate with patients via a screen, some of which were also equipped with a stethoscope to take a patient's vitals [13].

**Spot robot-** Spot robot, manufactured by Boston Dynamics, is in use at a Boston hospital to help with coronavirus treatment. Brigham and Women's Hospital of Harvard University has also been using a Spot for suspects. Boston Dynamics, owned by Japanese communications giant SoftBank, is deploying Spot as a telemedicine machine [14].

**Little peanut-** A Shenzhen company called Multicopter has now employed robots to transport medical samples. A robot called Little Peanut delivered food to passengers on a flight from Singapore to Hangzhou (China) [15].

**ATRIS, AIMBOT and Cruzr robots-** UBTECH Robotics' All-Terrain Patrol Robot for Intelligent Security (ATRIS), Autonomous Indoor Monitoring Robot (AIMBOT) and Cruzr robots work at a Shenzhen hospital treating COVID-19 patients. The robots were originally used for retail and hospitality purposes. These robots provide video conferencing services between patients and doctors, monitor body temperatures of visitors and patients and disinfect [16].

**Others-** China, the epicenter of COVID-19 has been using Robots to carry out most of the necessary tasks to minimise contacts namely- deliver groceries, meals and medicines to quarantined households, cleaning and sanitising the public places and hospitals periodically and patrolling for monitoring social distancing. In China, hospitals are using robots from the Danish company UV Disinfection (UVD) Robots that can disinfect patient rooms. The robots are remotely controlled by a device operated by a health worker [17].

Indian Army corps of electronics and mechanical engineers created a remote-controlled trolley equipped with a washbasin and dustbins to be used for delivering essential items to frontline healthcare staff [18].

## 3. Ventilators- The Lifeline during the Pandemic

**Prana vayu-** Prana Vayu (literally Pran- life, Vayu- air from Hindi), the brainchild of IIT, Roorkee and AIIMS, Rishikesh has proven to be one of its kind. One of the cheapest and most rapidly manufactured ventilators, Pran Vayu is highly effective and reliable to be used in open areas converted into Intensive Care Units (ICUs) to combat COVID-19. It restores normal lung function even in vulnerable groups like infants and the high-risk population like the overweight adults [19] but does not require compressed air, which makes it portable. Equipped with a real-time spirometer and alarm, it automatically limits high pressures and opens the circuit to the atmosphere in case of failure, thus preventing choking. Remote monitoring by healthcare professionals, single touch control of all parameters, moistener and temperature control are other add ons which make this device desirable [20].

**COVID emergency ventilator-** A similar successful attempt by Dr. Rhys Thomas, from Glangwili Hospital, Carmarthen, United Kingdom led him to design the "COVID Emergency Ventilator" in just three days. Although it cannot replace the ICU ventilators, this machine is capable enough to support COVID patients and has an air-purifying effect, ensuring the supply of only purified air to the already critical patients. In addition to being a survival aid for critical patients, it limits the spread of opportunistic respiratory infections among SARS patients, without demanding extra effort on the part of the medical fraternity [21].

**A 3-D printed ventilator splitters-** The University of Michigan approached the same problem in a different way. Instead of trying to increase production, they managed to increase the productivity of already available ventilators. Sharing of ventilators posed a serious problem of the spread of potential pathogens among patients but, to combat this issue, University of Michigan designed "Personalised Ventilator Splitters" using 3D-printing technology. More than being able to contribute itself, this idea opened a new horizon of ventilator sharing [22].

**Splitter that can ventilate nine patients at a time-** Institutes around the globe have been trying similar ways of using a ventilator for two or more patients, but the breakthrough in this field was by Dr. Alain Gauthier, an Anaesthetist in Perth and Smiths Falls District hospital in Ontario who rugged up a ventilator with "Do it yourself mechanics" to treat nine patients with similar lung capacities and ventilator requirements simultaneously [23]. This has helped to meet the large disparity between the availability and demand without necessitating increased production.

**Ruhdaar-** Engineers at the Design Innovation Centre of Islamic University of Science and Technology, with engineering students from IIT Bombay, created a low-cost ventilator named 'Ruhdaar'. Currently working in laboratory settings, it's in-vivo efficacy is yet to be evaluated by medical experts at Sher-E-Kashmir Institute of Medical Sciences, Jammu and Kashmir, India [24].

**Jeeva setu-** REVA University, Bengaluru has launched a low-cost, oven-sized and portable ventilator named 'Jeeva Setu' with residents to enhance the availability of medical infrastructure in the country. It delivers 500-600 ml of air per breath and 15-18 breaths per minute, as specified for COVID-19 patients. Along with that they also made masks to support the community [25].

**Digital medical respiratory system-** A step ahead, students from the Moroccan School of Engineering Sciences (EMSI) have developed three innovations to ease medical check up and healthcare

processes in the fight against COVID-19 during a competition named Hackathon Virtual Maro COVID-19 competition. One of the three innovations is a Digital Medical Respiratory System that sends detailed information concerning the patients' respiratory status to doctors and enables them to adjust pressure and respiratory flow in critical situations remotely [26].

## 4. Testing of Suspects: Easier, Faster and Safer

**India's first COVID-19 test kit-** Mylab, a Pune, India based company prepared India's first "COVID-19 Test Kit", in a record time of six weeks. This Real Time- Polymerase Chain Reaction (RT-PCR) based kit has been approved by the Indian Council of Medical Research (ICMR) for its use in the current scenario. Furthermore, this kit gives results in 2.5 hours instead of the 7.5 hours needed with previous protocols [27].

Continuing the legacy, IIT Delhi's Kusuma School of Biological Sciences developed a probe - free RT-PCR test kit validated to have a sensitivity and specificity of 100% by the ICMR [28].

**Phonebooth-style testing center for COVID-19 suspects-** A hospital in South Korea introduced a "Phonebooth - style testing center for COVID-19 suspects" where the consulting doctor and the patient inside the booth are separated by a partition to keep the air from leaking and saves a lot of time but can communicate via a telephone connecting the two sides. The only communication between the two sides are the two armholes guarded by arm length gloves making it possible for the doctor to collect swabs and samples of patients without any real contact. Post-consultation the booth is swiftly disinfected and ventilated. Indeed, it protects the frontline healthcare professionals from falling prey to the pandemic and can help curtail the unnecessary burden of COVID-19 positive doctors [29].

**AbC-19-** UK Rapid Test Consortium (UK-RTC), a partnership between Oxford University and leading UK diagnostics companies launched AbC-19, a rapid finger-prick COVID-19 antibody test kit that delivers results with 98.6% within 20 minutes. It captures IgG antibodies from the blood sample with the full-length spike protein [30].

Today, the world is suffering with a shortage of PPE, medical equipment and drugs to help fight COVID-19. Even as the global tally spikes innovators across the globe, are using technology to help the spread of the pandemic. Germ trap masks, protective plastic capsules, smart helmets, sanitising UVD robots, airport cleaning robots, hands-free door openers are just a few of the many other innovations that countries have come up with.

**A 3D-printed reusable mask-** The Louisiana State University Dental School, US designed a "3D-printed reusable mask". Such an innovation does not only save resources and make masks available for all but also help us keep our healthcare professionals safer. Another unit of Louisiana State University, the Biomedical Engineering unit has initiated "3D-printing of ventilator parts" to enhance the production of this necessity during the pandemic [31].

**COVID bus: COVID-19 test bus-** The COVID-19 Test Bus based on indigenous Kodoy Technology Stack, is the first vehicle with onboard genetic testing, AI-based teleradiology and contactless sample collection facilities. The IIT C19 Test Bus has been executed by partner organisations led by IIT alumni. The Kodoy architecture has employed automated e-vehicles for sample selection and for telemedicine administration, algorithm-based pooled genetic testing and indigenous mega labs with each lab capable of performing 5 million monthly. The medical equipment on board comprises a low dosage digital X-ray, real-time teleradiology, contactless swab collection and instant RNA testing. The bus has been configured keeping in mind extremes of weather and has 384 sq.ft of lab space onboard. It is also equipped with a wireless robotic teleoperated ultrasound lung probe and a nanopore gene sequencer. The COVID bus visits slum locations and effectively isolates the high-risk suspects. It has also reduced the cost of testing by over 80% without compromising on accuracy [32].

**COVISAFE-** Doctors in Nagpur, Maharashtra, India innovated COVISAFE to ensure the safe transport of COVID-19 patients. The box fits over medical stretchers and is completely airtight. Emergency oxygen and ventilator like facilities can be installed on the box easily. Most importantly, whatever air the patient breathes, comes out of the box after getting filtered. Thus, keeping doctors and other frontline healthcare professionals from getting infected [33].

**African saviour-** Among the three medical inventions developed by students from the École Marocaine des Sciences de l'Ingénieur (EMSI) during Hackathon Virtual MaroCovid-19 competition the second one is African Saviour - an app based system that employs drones to deliver nasal swab test kits to people showing COVID-19 symptoms allowing testing without putting healthcare professionals at risk [26].

An Indian Navy Doctor has developed a low-cost PPE with the National Research Development Corporation, under the Ministry of Science and Technology which has been validated by ICMR too. Made up of a special fabric with high 'breathability', it is suitable for hot and humid conditions prevalent in India. Mass production of this PPE set is ongoing, facilitated by a team of innovators from the Navy working in close coordination with Intellectual Property Facilitation Cell [34].

## 5. Aware! To Beware

To fight such a pandemic, awareness of nearby cases can make the population more vigilant and encourage the practice of precautionary measures more extensively. With quarantine, since social media is the only available platform to spread necessary information. If exploited to its full potential, it can surely be used to make a difference.

**Corontime-** With this thought, IIT Bombay developed the "Corontime" application that can track cases and provide real-time information regarding nearby cases and deduce the rapidness of spread in an area. It can help people to trace whether they have had any primary or secondary contact with the patient or its family and thus get screened at early stages to avoid spread and getting into critical situations [35].

**Arogya setu-** Arogya Setu application launched by the Ministry of Electronics and Information Technology of the Government of India on 2nd April, 2020 to help augment the efforts of limiting the spread of COVID-19. The app is available in 12 languages and on Android as well as iOS platforms. It became the world's largest contact tracing application reaching over 11 crore 40 lac people in 40 days with the use continuously increasing due to its privacy and security settings. It enables people to assess the risk of catching the corona virus infection. It calculates this risk based on their interaction with others, using cutting edge Bluetooth technology, algorithms and AI. It is designed to keep citizens informed, in case she or he crosses paths with someone who has tested positive. Digital tracing rapidly notifies users if they have been in proximity with a medically diagnosed COVID-19 patient. By design, these systems have layers of privacy protection [36]. Digital tracing detects proximity, avoiding centralised databases of where smartphone users have travelled. Downloading and using the application is however, voluntary. The technique for determining proximity relies on anonymous signals (called "chirps") sent back and forth between phones. Chirps contain anonymous information and reveal an individual's COVID-19 diagnosis to the public health authorities only [37].

**Digital surveillance and contact tracing-** Strategies in China, Singapore, South Korea, and Taiwan have supplemented traditional manual approaches with digital surveillance through smartphone

applications. In fact, South Korea, with 2015 amendments of their personal information protection act allowed the government to use phone location details, credit and debit card transactions, medical and prescription records, immigration records, transit pass records for public transportation, closed-circuit television footage and personal identification information except the name to prepare and release a time-wise list of the areas of danger on government websites so that the general public can trace if they had been at any of these places. In March 2020, Korean Center of Drug Control launched the COVID-19 Epidemiological Survey Prompt Support System for enhanced contact tracing which helped South Korea to crush the curve instead of just flattening it [38].

**Remote health monitoring system-** Patient health metrics, with patient location, regularly uploaded to a centralised Command and Control Centre (CCC) set up under the "Remote Health Monitoring system" developed by AIIMS, Rishikesh and Bharat Electronics (BEL). The patient can himself upload the data or alternatively integral Global System for Mobile Communications (GSM) Subscriber Identification Module (SIM) is used. It also graphically maps the geo-distribution of COVID-19 suspects/patients in the state helping the hospital in visualising the hot spots and taking necessary action to isolate these areas to check the spread [39].

### 6. The Holistic Approach

AIIMS, Rishikesh and BEL have developed a health monitoring system to remotely assess the health of COVID-19 patients quarantined in homes and hospitals. This system reduces spread along with reducing the demand for PPE and logistics. BEL developed the "Proof of Concept" model of a system integrating non-invasive health monitoring sensors to measure critical parameters such as temperature, pulse rate, $SPO_2$ (Saturated Oxygen level) and respiration rate. A mobile app/web browser enrolls people with AIIMS-Rishikesh once they show symptoms of COVID-19. Clinical experts then assess the condition of the patient and a health monitoring kit is handed over to the patient for periodical monitoring of the critical parameters. Alerts are sent to medical officers and healthcare workers when the health parameters exceed the threshold. Along with this, the CCC, set up under this scheme caters to providing real-time necessary information and suffices the need for awareness [39].

**Moroccan electronic perspective-** Third in the triad of innovations contributed by students from the EMSI was digitising medical prescription, which is an exceptional example of telemedicine. The Moroccan Electronic Perspective, equips doctors with an app to send prescriptions directly to the pharmacy post-teleconsultation. The pharmacy generates a unique QR code which can help the patient to directly identify his pharmacy and collect the necessities. It not only protects the healthcare professionals, but also reduces interpersonal interaction frequency and time which is the need of the hour during these tough times [26].

## CONCLUSION(S)

The unforeseen challenges of COVID-19 posed before the medical fraternity gave a stimulus for inventors and innovators which has accelerated the growth of healthcare exponentially. Robots, which were decades away till 2019, are now being employed for many hospital duties. Shortage of critical care services which cost lives of thousands till date, is now being overcome with ventilator splitters. Arguably, use of such splitters has been proposed in the past as well, but it was only COVID-19 during which its age-old drawback of infection spread could be overcome. Industrial lockdown has taught the medical fraternity to be independent in days of crisis, by using 3-D printers. Institutions around the globe have printed reusable masks, ventilator splitters, ventilator parts, robot parts etc., to make up for the slow production due to lockdown. Techniques to minimise contact while maintaining the accuracy of testing has led to invention of efficient and safe COVID-19 testing technologies. COVID-19 might have affected other sections like economy, education, social wellbeing and mental health for the worst, but the healthcare advancements it has brought along must also be acknowledged for their benefits.

## REFERENCES


[1] This statement is updated on an ongoing basis, in response to evolving events and common media queries. World Health Organisation [Internet] 27th April, 2020 [Accessed on 20th June, 2020]. Available from https://www.who.int/news-room/detail/27-04-2020-who-timeline---covid-19.

[2] Meet Airlens Minus Corona, device developed by Delhi duo to sterilize the capital. The New India Express [Internet] 21st March, 2020 [Accessed on 10th June, 2020]. Available from https://www.newindianexpress.com/cities/delhi/2020/mar/21/meet-airlens-minus-corona-device-developed-by-delhi-duo-to-sterelise-capital-2119709.html.

[3] Sturman LS, Ricard CS, Holmes KV. Conformational change of the coronavirus peplomer glycoprotein at pH 8.0 and 37 degrees C correlates with virus aggregation and virus-induced cell fusion. J Virol. 1990;64(6):3042-50.

[4] Kunal G. COVID-19: Innovative Foot-operated Washbasins Encourage Social Distancing. Republicworld.com [Internet]. 6th April, 2020 [Accessed on 10th June, 2020]. Available from https://www.republicworld.com/india-news/general-news/covid-19-municipal-corporation-comes-up-with-washbasin-that-operates.html.

[5] Coronavirus | Northern Railway develops hands-free washbasins for contactless experience. The Hindu [Internet] 25th April, 2020 [Accessed on 10th June, 2020]. Available from https://www.thehindu.com/news/national/other-states/northern-railway-develops-hands-free-washbasins-for-contactless-experience/article31433182.ece.

[6] DRDO Introduces two new products to enable COVID-19 disinfection process. Ministry of Defence [Internet] 17th April, 2020 [Accessed on 14th June, 2020]. Available from https://pib.gov.in/PressReleasePage.aspx?PRID=1615331.

[7] How to Protect Yourself and Others. Centres of Disease Control and Prevention [Internet][cited 2020 June 30]. Available from https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention-H.pdf.

[8] Gaur V, Seven Tech Inventions and Ideas That Are Taking Covid-19 Head-on. Express Computer [Internet] 8th May, 2020 [Accessed on 30th June, 2020]. Available from https://www.expresscomputer.in/artificial-intelligence-ai/seven-tech-inventions-and-ideas-that-are-taking-covid-19-head-on/55208/.

[9] AIIMS Delhi to deploy robots at its advanced COVID-19 ward. Express Computer [Internet] 26th April, 2020 [Accessed on 11th June, 2020]. Available from https://www.expresscomputer.in/indiaincfightscovid19/aiims-delhi-to-deploy-robots-at-its-advanced-covid-19-ward/54055/.

[10] COVID-19 | A robot to fight virus in Kannur. The Hindu [Internet] 20th April, 2020 [Accessed on 11th June, 2020]. Available from https://www.thehindu.com/news/national/kerala/covid-19-a-robot-to-fight-virus-in-kannur/article31391486.ece.

[11] Dhawan B. COVID-19: Kudos! Mohanlal's Viswasanthi Foundation donates 'KARMI-Bot' to Kochi hospital; how it works. Financial Express [Internet] 30th April, 2020 [Accessed on 11th June, 2020]. Available from https://www.financialexpress.com/lifestyle/health/covid-19-kudos-mohanlals-viswasanthi-foundation-donates-karmi-bot-to-kochi-hospital-how-it-works/1944155/.

[12] Coronavirus | Jaipur's Sawai Man Singh hospital tests serving robot. The Hindu [Internet] 26th March, 2020 [Accessed on 11th June, 2020]. Available from https://www.thehindu.com/news/national/other-states/coronavirus-jaipurs-sawai-man-singh-hospital-tests-robot-to-assist-covid-19-patients/article31170301.ece.

[13] Roy S. Robots to the rescue: As the number of COVID-19 cases rise, it's become important for health workers. The financial express [Internet] 3rd May, 2020 [Accessed on 10th September, 2020]. Available from https://www.financialexpress.com/lifestyle/robots-to-the-rescue-as-the-number-of-covid-19-cases-rise-its-become-important-for-health-workers/1946351/.

[14] Statt N. Boston Dynamics' Spot robot is helping hospitals remotely treat coronavirus patients. The Verge [Internet] 23rd April, 2020 [Accessed on 12th June, 2020]. Available from https://www.theverge.com/2020/4/23/21231855/boston-dynamics-spot-robot-covid-19-coronavirus-telemedicine.

[15] Cuthbertson A. Coronavirus: Little Peanut Robot delivers food to people in quarantine in China. Independent [Internet] 29th March, 2020 [Accessed on 12th June, 2020]. Available from https://www.independent.co.uk/life-style/gadgets-and-tech/news/coronavirus-quarantine-robot-china-little-peanut-food-delivery-a9308166.html.

[16] Ismail I. Robots on pandemic frontlines. New Straits Times [Internet] 6th April, 2020 [Accessed on 12th June, 2020]. Available from https://www.nst.com.my/opinion/columnists/2020/04/581958/robots-pandemic-frontlines.

[17] China buys danish robots to fight coronavirus. Hospital and healthcare management [Internet] [Accessed on 13th June, 2020]. Available from https://www.hhmglobal.com/knowledge-bank/news/china-buys-danish-robots-to-fight-coronavirus.

[18] Peri D. Army EME Corps gears up for automation. The Hindu [Internet] 19th May, 2020 [Accessed on 13th June, 2020]. Available from https://www.thehindu.com/news/national/army-eme-corps-gears-up-for-automation/article29674740.ece.

[19] High prevalence of obesity in severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) requiring invasive mechanical ventilation. - Simonnet A1, Chetboun M2, Poissy J1, Raverdy V2, Noulette J2, Duhamel A3, Labreuche J3, Mathieu D1, Pattou F2,4, Jourdain M1,2; Lille Intensive Care COVID-19 and Obesity study group.

[20] Coronavirus | IIT-Roorkee develops Prana-Vayu, a low-cost ventilator. The Hindu [Internet] 3rd April, 2020 [Accessed on 14th June, 2020]. Available from https://www.thehindu.com/news/national/coronavirus-iit-roorkee-develops-prana-vayu-a-low-cost-ventilator/article31252339.ece.
[21] Wales greenlights emergency ventilation device. Engineering and Technology [Internet] 25th March, 2020 [Accessed on 14th June, 2020]. Available from https://eandt.theiet.org/content/articles/2020/03/wales-greenlights-emergency-ventilation-device/.
[22] Mostafavi B. Personalized device could support multiple COVID-19 Patients from single ventilator. Michigan Medicine Health lab [Internet] 22nd April, 2020 [Accessed on 14th June, 2020]. Available from https://labblog.uofmhealth.org/health-tech/personalized-device-could-support-multiple-covid-19-patients-from-single-ventilator.
[23] Kekatos M. Canadian doctor turns one ventilator into nine with some 'evil genius' DIY mechanics- winning fans, including Elon Musk. Mail Online [Internet] 20th March, 2020 [Accessed on 15th June, 2020]. Available from https://www.dailymail.co.uk/news/article-8136299/Doctors-turns-one-ventilator-nine-genius-DIY-mechanics.html.
[24] Low-cost ventilator built to fight COVID. The Tribune [Internet] 24th April, 2020 [Accessed on 15th June, 2020]. Available from https://www.tribuneindia.com/news/j-k/low-cost-ventilator-built-to-fight-covid-75218.
[25] Varude K. Innovation and technology in the age of Covid-19. Times Now News [Internet] 16th May, 2020 [Accessed on 15th June, 2020]. Available from https://www.timesnownews.com/technology-science/article/innovation-and-technology-in-the-age-of-covid/592598.
[26] Mebtoul T. Moroccan Students Engineer 3 Inventions to Fight COVID-19. Morocco World News [Internet] 2nd April, 2020 [Accessed on 17th September, 2020] Available https://www.moroccoworldnews.com/2020/04/298368/moroccan-students-engineer-3-inventions-to-fight-covid-19/.
[27] PathoDetect COVID-19 detects infection within 2.5 hours: Mylab. future medicine [Internet] 29th March, 2020 [Accessed on 16th June, 2020]. Available from https://www.futuremedicineindia.com/pathodetect-covid-19-detects-infection-within-2-5-hours-mylab/.
[28] Dutt A. IIT-D develops cheaper RT-PCR test, gets ICMR nod. Hindustan Times [Internet] 24th April, 2020 [Accessed on 16th June, 2020]. Available from https://www.hindustantimes.com/delhi-news/iit-d-develops-cheaper-rt-pcr-test-gets-icmr-nod/story-6A20OO4vRdoTre9VgYfamK.html.
[29] South Korea dials up coronavirus testing with hospital 'phone booths'. The Straits Times [Internet] 17th March 2020 [Accessed on 16th June, 2020]. Available from https://www.straitstimes.com/asia/east-asia/south-korea-dials-up-coronavirus-testing-with-hospital-phone-booths.
[30] UK government to launch free finger-prick Covid-19 tests. Medical Device Network [Internet] 20th July, 2020, Last updated 21th August, 2020 [Accessed on 10th September, 2020]. Available from https://www.medicaldevice-network.com/news/uk-government-free-covid-19-tests/.
[31] Rouge B. Protecting the protectors: LSU team supporting physicians, combating COVID-19 by creating masks, ventilator parts. LSU College of Engineering [Internet] 30th March, 2020 [Accessed on 17th June, 2020]. Available from https://www.lsu.edu/eng/news/2020/03/meaganmoorefacemasks.php.
[32] India's first Covid-19 test bus launches in Maharashtra. The Hindu Business Line [Internet] 4th May, 2020 [Accessed on 17th June, 2020]. Available from https://www.thehindubusinessline.com/news/indias-first-covid-19-test-bus-launches-in-maharashtra/article31501366.ece.
[33] COVI-Safe: Transport system for COVID-19 patients made easy. ABP Live [Internet] 4th April, 2020 [Accessed on 17th June, 2020]. Available from https://news.abplive.com/videos/news/india-covi-safe-transport-system-for-covid-19-patients-made-easy-1188141.
[34] Defence Ministry patents low-cost PPE developed by Navy to move towards its mass production. The New Indian Express [Internet] 14th May, 2020 [Accessed on 18th June, 2020]. Available from https://www.newindianexpress.com/nation/2020/may/14/defence-ministry-patents-low-cost-ppe-developed-by-navy-to-move-towards-its-mass-production-2143411.html.
[35] IIT-Bombay Develops App To Track Suspected COVID-19 Patients. NDTV [Internet] 30th March, 2020 [Accessed on 18th June, 2020]. Available from https://www.ndtv.com/mumbai-news/coronavirus-outbreak-iit-bombay-develops-app-to-track-suspected-covid-19-patients-2202624.
[36] Bond S. Getting back to normal: big tech's solution depends on public trust. npr [Internet] 10th April, 2020 [Accessed on 18th June, 2020]. Available from https://www.npr.org/2020/04/14/834460127/apple-google-team-up-to-develop-cellphone-data-contact-tracing.
[37] Ferretti L, Wymant C, Kendall M, Zhao L, Nurtay A, Abeler-Dörner L, et al. Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing. Science. 2020;368(6491):eabb6936. doi:10.1126/science.abb6936PubMedGoogle Scholar.
[38] Park S, Choi GJ, Ko H. Information technology-based tracing strategy in response to COVID-19 in South Korea-privacy controversies. JAMA. 2020;323(21):2129-30. doi:10.1001/jama.2020.6602.
[39] AIIMS-Rishikesh, BEL jointly develop remote health monitoring system. Manufacturing Today [Internet] 10th April, 2020 [Accessed on 19th June, 2020]. Available from https://www.manufacturingtodayindia.com/products-suppliers/7109-aiims-rishikesh-bel-jointly-develop-remote-health-monitoring-system.

**PARTICULARS OF CONTRIBUTORS:**
1. MBBS Student, AIIMS, Rishikesh, Uttarakhand, India.
2. Associate Professor, Department of Paediatrics, AIIMS, Rishikesh, Uttarakhand, India.
3. PG Resident, Department of Kayachikitsa, Sri Sri College of Ayurvedic Science and Kayachikitsa, Bengaluru, Karnataka, India.
4. Associate Professor, Department of Internal Medicine, AIIMS, Rishikesh, Uttarakhand, India.

**NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:**
Dr. Vyas Kumar Rathaur,
Swarn Ganga Appartment, Flat No-405, Rishikesh-249203, Uttarakhand, India.
E-mail: vyasrathaur@gmail.com

**PLAGIARISM CHECKING METHODS:** [Jain H et al.]
- Plagiarism X-checker: Sep 05, 2020
- Manual Googling: Sep 29, 2020
- iThenticate Software: Oct 28, 2020 (21%)

**ETYMOLOGY:** Author Origin

**AUTHOR DECLARATION:**
- Financial or Other Competing Interests: None
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Aug 28, 2020**
Date of Peer Review: **Sep 05, 2020**
Date of Acceptance: **Sep 29, 2020**
Date of Publishing: **Nov 01, 2020**