2021 11th International Conference on Cloud Computing, Data Science & Engineering (Confluence) | 978-1-6654-1451-7/20/$31.00 ©2021 IEEE | DOI: 10.1109/Confluence51648.2021.9377180

A proposed model of a semi-automated sensor actuator resposcopy analyzer for 'covid-19' patients for respiratory distress detection

Pushan Kumar Dutta
Department of Engineering, Amity School Engineering and Technology, Amity University Kolkata, Kolkata, India
pkdutta@kol.amity.edu

Protyush De
Department of Engineering, Amity School of Engineering and Technology, Amity University Kolkata, Kolkata, India
protyush.de@s.amity.edu

Ahona Ghosh
Department of Computational Science, Brainware University, Kolkata
ahonaghosh95@gmail.com

Madjid Soltani
Department of Mechanical Engineering, K.N.Toosi University of Technology, Tehran, Iran Department of Electrical and Computer Engineering, University of Waterloo, ON, Canada Centre for Biotechnology and Bioengineering(CBB), University of Waterloo,Waterloo, Ontario, Canada
msoltani@uwaterloo.ca

Abstract— **COVID19 patients have been admitted to hospitals based on the reports of clinical symptoms associated with pulmonary disease identification. Reducing human intervention as much as possible, we prepared this model that will be able to keep an eye on the parameters related to the symptoms of COVID-19. In corona infected patients the proposed study is used to develop a formulate treatment entitled as 'RESPOSCOPY' to ease out this situation and increased the life expectancy of the patients. In order to observe distraction and effect of blood pressure and to reduce BOD (Biological Oxygen Demand) for chest cavity treatment. There are no proper methods of electronic tools to identify the pathology and physiology of COVID19 patients who undergo acute respiratory issues. Hence there should be a screening method for identifying acute to moderate breathing disorder for patients which can cause a significant rise in pulmonary failure like a COVID19 disorder. The method proposed by us is called as auscultation that is used to transport an electronic stethoscope in the lungs without causing medical infection. Identification of changes associated with Tracheal, bronchial, broncho-alveolar and alveolar breath sounds to identify characteristic of pneumonia for auscultator percussion for general use in areas with limited medical infrastructure. Rapid detection of semi rigid chest wall using sensors reduces the false negative output associated with RT-PCR tests as the proposed electronic sensors can give better pre test analysis which are recorded as measurable signals. The tests performed using electronic probes.**

Keywords— Novel Corona Virus, Covid-19, Sensor-actuator system, Concentration of water, Multi organ failure

I. INTRODUCTION

It was identified in April 2020 by Bat-Call (Nesher, Israel) to help COVID-19 patients recover through early diagnosis and treatment of chronic respiratory and cardiovascular disorders using auditory digital diagnostic system that gives full spectrum body hearing auscultation in case of different pulmonary diseases including chronic obstructive pulmonary disease (COPD) and congestive heart failure (CHF), which can be detected using sensors. Understanding the basic physiological processes for the clinical characteristics of the disorder can improve the efficiency of treatment approaches and eliminate certain unfortunate consequences. [1].In order to diagnose the cause of the disease, it is essential to find out the main characteristics associated with coronavirus symptons with electronic sound analysis carried across the trachea and the upper part of the lungs. This systematic procedure is known as auscultatory percussion which is a new method of physical examination developed by Guarino [2]. The ambient noise developed by the vibration seen between patient and the stethoscope is a high-energy extrapolation on the time-frequency chart. The illustration can be clearly displayed to track the future respiratory changes. The usage of Nano robotics in this field will enable to provide an effective way to deal with the communications within the medical staffs involved in treating this disease and a modernized way to look after the patients suffering from such a contagious virus. The interpleural pressure (Ppl= -4) is normally negative that keeps the lungs inflated. It was found from a study that interpleural pressure becomes zero in case of pneumothorax, the chest wall ruptures. A decrease in pressure occurs from this rise in height, enabling outside air to flow in. The diaphragm returns to the original position while exhaling, and the muscles relax the decrease in thoracic & lung volume & increase in pressure, pushing air into the lungs. The

ease of contraction of the lungs is overturned by lung compliance. Good lungs, like a small balloon is easy to inflate, typically having better conformity and have high resistivity. Lung compliance decreases as it becomes rigid in conditions that trigger tissue scarring or fibrosis, so it becomes difficult to inflate. In reality, it is necessary to remember the ratio of time spent breathing (inspiration) to exhaling (expiratory) while considering a single breath duration, so more energy is needed. because more energy is required to completely exhale and avoid over-inflation (i.e. breath piling or auto-PEEP). Inhalation step length may be adjusted by changing the inhalation to exhalation ratio (I: E) of the ventilator while a particular respiratory rate (bpm) is used. To maintain the 'open lung,' positive end-expiratory pressure (PEEP) is used to prevent alveolar collapse and thereby maximise the movement of gas and reduce atelectrauma (repeated opening and collapsing of alveolic atelectasis may also trigger damage; the effect of which is referred to as atelectrauma). In addition , due to the homogeneity of the lung tissues, positive pressure ventilation can contribute to regional over-distention of alveoli (volutrauma and barotrauma) which may hinder the flow of gas and likely more harm to the diseased lung. Regional variations in pulmonary compliance are complex and dramatically alter and over period of a patient's treatment, as long as the patient or machine decides each of the above parameters , different ventilation modes are established. The clinical incidence of pneumonia decreases where there are focus abnormalities such as fracturing or asymmetry between lung fields. In this case , the following methods have historically been used to manage pneumonia and may be of interest to coronavirus asymptotic patients. Some of the auscultation and rhythm methods are typical aspects of the physical test, with no evidence on predictive accuracy or reproducibility. No single manoeuvre is both extremely responsive and unique to the diagnosis of pneumonia; thus, a variety of manoeuvres are typically conducted to improve the precision. There are some pitfalls of physical inspection, including poor precision and high inter-observer error. The creation of a proof-of-concept non-invasive system to recognize the concentration of fluid in the lungs (consolidation) characteristic of pneumonia has solved this diagnostic gap. This unit uses auscultative percussion technique to act as a percussive instrument; a percussive feedback sound[3] is emitted through the chest and recorded using a wireless stethoscope for examination. The most relevant screening procedures for pneumonia are physical examination and chest x-rays. Although other methods can be used for diagnostic purposes, such as ultrasound and computed tomography (CT), they are less common in clinical practise [4,5]. The latest clinical procedure for diagnosis is the chest X-ray, which tests the concentration of protein-rich inflammatory fluid (exudate) in the lungs. Managed studies have shown that auscultative tapping, a physical examination technique in which the doctor taps the chest of the patient and listens to the back of the patient with a stethoscope, is a method capable of recognizing multiple pneumonia presentations[6]. By testing pulmonary acoustics with automatic input and output instruments, we recommend diagnosing pneumonia. Past research has focused on fully automatic monitoring of pneumothorax [7,8] or partially automated monitoring of pneumonia [9,10]. Pneumonia occurs when a microbe enters the lungs and is not eliminated by the immune system due to either a lack in host immunity, exposure to a particularly virulent microbe or micro-aspiration. [11]. Swelling and build-up is caused by lung infection. The acoustics of the respiratory system, especially the vibration, absorption and transmission of sound through the chest cavity, are tested by pulmonary physical testing techniques. Resonance corresponds to the natural frequency at which, when activated by an impulsive force, a body will begin to vibrate; this characteristic of the chest depends on the size of the thorax[12]. The impulse reaction is a very short, rapid feedback that imitates physical measuring output.

II. FUNCTIONAL ANALYSIS OF SENSOR –ACTUATOR IN COVID-19 TESTING

Acute Respiratory Distress Syndrome (ARDS) induces fluids in the lungs to fill in small air bags or alveoli, where oxygen from the skin diffuses through the tissue [13]. When the lungs overflow with air, they get weaker and stiffer, and people's chest and stomach muscles tend to function harder to extend and compress the lungs to breathe. It is primarily defined by the distribution of damage to the lungs and the development of an alveoli membrane to function properly and the signs involve quick coughing , shortness of breath or bluish shading of the eyes with a Positive End Expiratory Pressure(PEEP)[14]of more than 5cm of H_2O.In our suggested method, ARDS can be stopped when focusing through the lens incorporated in the optical fibers. As long as the sensor identifies the existence of moisture in alveoli, the actuator can begin the cycle of absorption.The following are the areas where a resourceful method can be proceeded to manage the situations:

I. Hypoxia Management for patients kept in ventilation

II. Worsening dyspnoea for a symptomatic

management
III. Airway function management in a condition of pulmonary oedema &ARDS
IV. Sepsis management as a more crucial effect
V. Cardiac arrest management as a last effort to increase the survival chanceof the patient
The change in image can be a data in this regard to observe the process associated with it.Covid-19 this upcoming medical pandemic is causing ARDS as one of its primary effect leading to mechanical ventilation and ultimately death. Absorption of water from alveoli can prevent such a major dreadful effect and will be an effective weapon against Covid-19.

II.1 AIM OF WORK

A person with weakened immunity may get obstruction due to the bended protein membrane, severe complications may lead to the accumulation of fluids in tiny airy sacs present in the lungs known as alveoli. Non- invasive ventilation with require PEEP and FiO2 level has been provided to control the situation for persons staying in ventilation. Lung protective strategy is associated with low tidal volumes to decrease barotraumas depending on patient's body weight.
The following system will perform four main functions:-
Initial tidal volume: 6-8 cc/kg of predicted body weight(PBW) is calculated from the presence of moisture in the alveoli and prevent a condition known as ARDS. Will give an inner view of the respiratory tract through an endoscope to detect any barriers or hurdles leading to respiratory disorders. Investigate cases related to pulmonary edema and will determine the amount of chest expansion and contraction. Inhalation procedures to clear the pathway and provide effective treatment to the lungs. Scientists at the University of Bath[16] are designing endoscopic optical fibre construction devices intended to enter the narrow airways deep inside the lungs of a person to locate any barriers or obstacles leading to respiratory problems by means of an endoscope[17]. A hair-sized probe, which can measure key markers of tissue damage deep within the lungs, has been designed by scientists to help track the progression of diseases such as pneumonia[18].

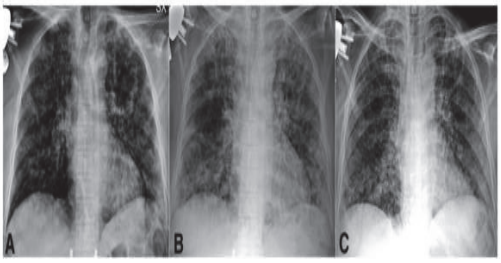

FIGURE 1. A)Chest X Ray showing pulmonary effusion. The distribution pattern is mainly peripheral. (B) Chest X-ray again 14 days later to identify the branching and effusion of fluid(C) Chest X-ray taken as a radiological data identified after Day 25 to find the change of the fluid accumulation in areas of the chest.

The findings of auscultation in patients with COVID-19 affected pneumonia were consistent with the results of pathology and imaging, indicating that pulmonary symptoms were not specific in patients with COVID-19 infectious - disease with other pulmonary inflammations.

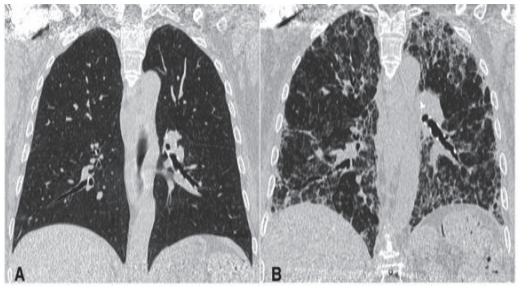

Figure 2. Chest computed tomography coronal reconstructions: (A) executed in 2019, showing no abnormalities; (B) executed in 2020, after COVID-19 infection. Diffuse lung architectural distortion is visible.

The technique, developed by researchers from the University of Heriot-Watt[19] and the University of Edinburgh in the United Kingdom, paves the way for detailed tissue monitoring in places where current technologies are unable to access them. The respiratory tract measures using the sensor circuit developed for these purposes. The measurement of the signal to noise ratio would provide the definition of any barrier present in the direction and will approximate the affected region of the lungs side by side.

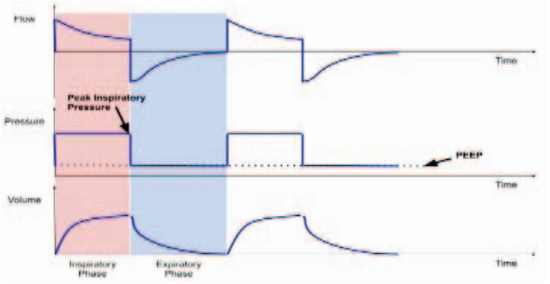

Figure 3: Breathing pattern of the breathing cycle for a Covid-19 patient

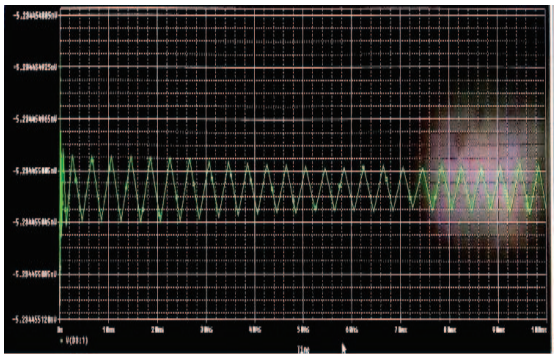

Figure 4: Analog Signal generated in the sensor circuit when designed in orcadpspice software

III PROPOSED DESIGN

The endoscope that would be used to image the inner section of the lungs is the first. While non-intrusive ventilation (NIV) techniques the role of such techniques in acute hypoxemic respiratory failure (AHRF) in acute exacerbations of congestive heart failure and cardiogenic pulmonary edoema has been established. In our diagnosis the suction pumper is mainly used in Root canal treatments of deep rooted cavity along with required stainless probe sensors and actuators, thirdly a place to incorporate inhalers to boost the damage portion of lungs using inhalation drugs along with small water pipe systems to drain out the excess water in lungs. The internal structure of this instrument consists of stainless probe sensors along with an electronic sensor to generate spikes-based signals and monitor the vicinity affected area of the lungs[21,22]. Electro-optical examination of nose, throat or breath samples identified by Prof. Gabby Sarusi of the Ben-Gurion University of the Negev[23] can find the asymptomatic and infected COVID-19 virus carriers. This is the result of spikes[24] that will help to analyse the region minutely and identify the respiratory system has already been impacted. SARS-CoV-2 does not induce extreme lung inflammation, but induces alveolar epithelial tissue desquamation. “The epithelial cells die after being infected, fall into the alveolar lumen and leave the basement membrane exposed”. The organism’s defense system believes that the region is raw or ulcerated and assumes there’s a risk of hemorrhage, triggering a storm of interleukins [proteins that act as immune signalers] and what we call a ‘coagulation cascade’. The platelets begin clumping together to form clots and ‘plug the leak’.”The clots block the lung’s small blood vessels and cause micro infarcts (cellular death or tissue necrosis). The regions of tissue that die due to a lack of blood supply are replaced by scar tissue in a process called fibrosis. In addition, micro thrombi at the alveolar-blood vessel interface prevent the passage of oxygen to smaller arteries. “This explains why COVID-19 patients may not have difficulty breathing even though their oxygen saturation is low. Many come to hospital walking and talking and very soon have to be intubated,”[25].If the intravascular clotting is not rapidly treated, micro infarcts and fibrosis tend to spread throughout the lungs. Opportunistic bacteria and fungi may infect the damaged tissue and cause pneumonia, as SARS-CoV-2 leads to a decrease in the number of immune cells (lymphopenia). The patient may develop acute respiratory distress at the end of this process. To observe the pulmonary edema and its adverse effect in a human anatomy the diagnostic involves to send spikes using snubber based power electronic sensor circuits to the thoracic cavity and the sternum. This spike has been compared with some spike generated signals obtained from a ventilation system. The spikes will ensure the concentration of water and an endotonic aspirator[26] used in root canal treatment can be used to suck out the water getting flooded in the lungs. Endoscopes are slender and tubular structure which are usually made compatible with the diameter of the food pipe present in human anatomy and is used to view the inner portion of the digestive system. This spike generated signal when compared with the heart beat graph of a patient obtained in echocardiography test [27]. A metered dose inhaler is a device that is used to provide effective drugs directly into the patient’s heart in the form of outburst of sprays. A basic metered dose inhaler consists of three main components the canister-which is the aluminum container on which the formulation resides, the metering valve-This is used to measure the amount of drug administrated into the patients lungs and finally an actuator which allows to pass a definite amount of spray into the respiratory system with each actuation for the ease operation by the patient.

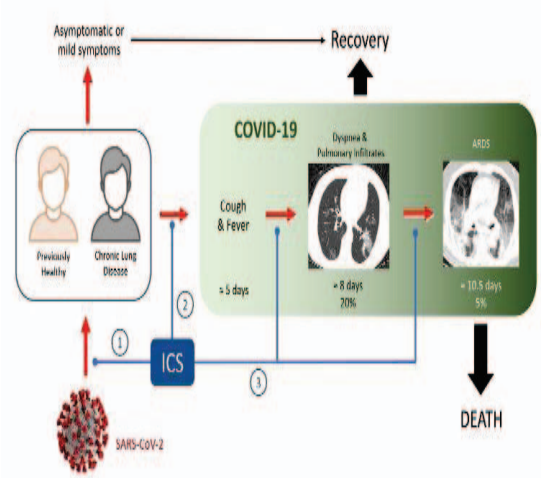

Figure 5: Block diagram of the transition of Covid19 patient from 5 days to 10.5 days

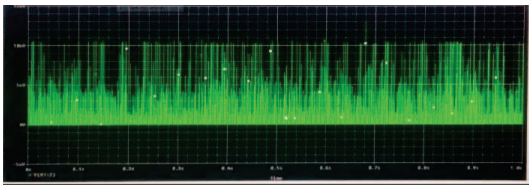

Figure 6: Spikes generated by electronic snubber based circuit

In our system design we have made the diameter of the actuator nozzle aligned with the diameter of the optical cladder to facilitate anti-viral drugs directly into the lungs of the patient. These anti-viral drugs can be compressed in aerosol forms to present an effective weapon in the upcoming Covid-19 effect neutralization.

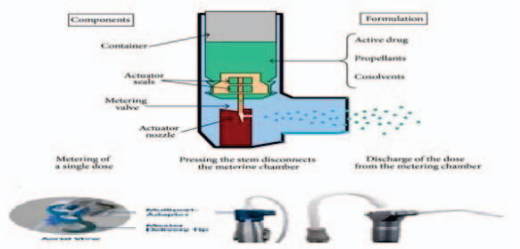

Figure 7: The schematic diagram describing the structure of the various parts of an inhaler

In addition to this our system we try to identify using a sponge test and a waterline pipe system how water soaks and further costs waterline pipe system so that the sucked out water can be extracted and passed out effectively inhibiting the growth of Novel Coronavirus.Another very quality device ratio is the major gain, but it takes a few minutes to perform the scan. The wet sponge acts as a high-pass filter with a reduced absorption of the acoustic source above 200 Hz; remember that larger particles are less amplified than the response of the dry sponge frequency. The results of this model are consistent with observational reports that higher frequency transmission contributes to water accumulation (which reduces acoustic mismatch)[28]. In order to obtain observations of the patient's respiratory behavior and analyze the lower-frequency quality trade-off, the length of the chirp input should be examined from the machine point of view.

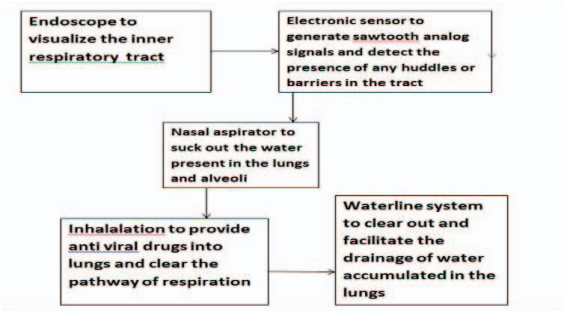

Figure 8:Flowchart design and summary of our system

IV. CONCLUSION

Production of medicines and vaccines has been a serious challenge to the scientists against novel corona virus. To fight out this odds low cost ventilators has been a powerful weapon to fight with this pandemic situation. The length of the input chirp will be analysed from the machine perspective to gather records of the breath operation of the patient and to compare the lower-frequency quality trade-off with shorter records. In order to eradicate the vulnerable effect of this dreadful virus we the engineering community is trying to identify from electronics domain have been motivated to design an integrated system consisting of various electronic components to neutralize pulmonary edema and ARDS as the two most observable outcomes proposed by medical professionals. One of the major drawbacks of this system is that it would be very costly and weighty to carry it from one place to another. So, keeping this in mind we future plan to make it cost effective, light weight and to incorporate the systems in ventilators and dialysis instruments to extract the excess water accumulated in kidneys. As per economic growth is concerned, this system consists of various other instruments to as major components to be manufactured by other biotechnical companies. Considering the present situation manufacturing the individual components will have a huge increase in demand, supply to maintain coordination between buyers and sellers. This will also help to boost up the rapid falling GDP of any country.

References

1. Richard R.Watkins and L.L. Tracy, Diagnosis and management of community-acquired pneumonia in adults. American family physician 83.11: 1299-1306, 2011.

2. John R.Guarino, Auscultatory percussion of the chest. The Lancet 315.8182: 1332-1334,1980.

3. A Rao , J Ruiz,C Bao, S Roy . Tabla: A proof-of-concept auscultatory percussion device for low-cost pneumonia detection. Sensors. Aug;18(8):2689, 2018.

4. A Reissig, A Gramegna, S. Aliberti. The role of lung ultrasound in the diagnosis and follow-up of community-acquired pneumonia. European journal of internal medicine. Jul 1;23(5):391-7, 2012.

5. A Nair , JC Rodrigues , S Hare , A Edey , A Devaraj ,J Jacob , A Johnstone ,R McStay , E, Denton G Robinson . A British Society of Thoracic Imaging statement: considerations in designing local imaging diagnostic algorithms for the COVID-19 pandemic. Clinical Radiology. 2020 May 1;75(5):329-34.

6. David M. G. Halpin, Dave Singh, Ruth M. Hadfield, Inhaled corticosteroids and COVID-19: a systematic review and clinical perspective, European Respiratory Journal, DOI: 10.1183/13993003.01009-2020,2020

7. Esau Mhandu and Y. Danyuo. Development of a Low-cost Biomedical Device to Enhance Pneumonia Diagnosis in Children." MRS Advances 5.26 (2020): 1367-1375,2020

8. H Palnitkar ,BM Henry , Z Dai , Y Peng , HA Mansy , RH Sandler ,RA Balk , TJ Royston . Sound transmission in human thorax through airway insonification: an experimental and computational study with diagnostic applications. Medical & Biological Engineering & Computing. 2020 Oct;58(10):2239-58,2020

9. H. A Mansy., , R. A.,Balk, W. H.Warren, , T. J. Royston, , Z Dai., Peng, Y., & Sandler, R. H. Pneumothorax effects on pulmonary acoustic transmission. *Journal of applied Physiology*, *119*(3), 250-257, 2015.

10. R Mor, , I . Kushnir., J. J Meyer., , J Ekstein., & , I. Ben-Dov Breath sound distribution images of patients with pneumonia and pleural effusion. *Respiratory care*, *52*(12), 1753-1760, 2007.

11. ML Yuliansyah , P Prajitno,DS Soejoko . Computer-Aided Diagnosis (CAD) to Detect Abnormalities in Lung Pediatric Radiography using Particle Swarm Optimization Method. InJournal of Physics: Conference Series 2020 Mar 1 (Vol. 1505, No. 1, p. 012003). IOP Publishing,2020.

12. A.Cohen and A.D.Berstein Acoustic transmission of the respiratory system using speech stimulation. IEEE transactions on biomedical engineering, 38(2), pp.126-132,1991.

13. T.J. Marrie and Jr, T.M.File , Epidemiology, pathogenesis, and microbiology of community-acquired pneumonia in adults. UpToDate. Bond S, editor. Waltam MA.2017

14. ,R. T Sataloff., , Y. D Heman-Ackah., & , M. J .Hawkshaw,Clinical anatomy and physiology of the voice. Otolaryngologic clinics of north America, 40(5), 909-929. ,2007.

15. M. A.,Orsi, G Oliva,., & M Cellina,. The Lungs before and after COVID-19 Pneumonia. *The American Journal of Tropical Medicine and Hygiene*, tpmd200357,2020.

16. STOPCOVID,"Scientists at the University of Bath are developing optical fibres and building endoscopic devices designed to access the tiny airways deep within a person's lungs " published online 16 April 2020 Avalaible https://www.bath.ac.uk/announcements/bath-scientists-join-rapid-response-project-to-find-treatments-for-covid-19/

17. Akib Zaman, , Nazrul Islam Muhammad, Zaki Tarannum, and Sajjad Hossain Mohammad. ICT Intervention in the Containment of the Pandemic Spread of COVID-19: An Exploratory Study.*arXiv preprint arXiv:2004.09888* , 2020

18. Photonics21, European photonics scientists are developing an ultrasensitive laser sensor that detects coronavirus at the earliest point of infection from a saliva or nasal swab in minutes. Available online 07thApril, 2020 https://sciencebusiness.net/network-updates/photonics21-develop-saliva-test-detect-covid-19-lasers

19. Paper UK Engineering and Physical Sciences Research Council University of Edinburgh Hair-sized probe can help monitor lung disease: Study Avalaible online 16th June, 2019 https://www.eurekalert.org/pub_releases/2019-06/uoe-tpt061419.php

20. BK Patel, JP Kress and JB Hall. Alternatives to Invasive Ventilation in the COVID-19 Pandemic. JAMA. Published online June 04, 2020. doi:10.1001/jama.2020.9611, 2020.

21. Andres Belalcazar and Aaron Lewicke Monitoring Lung Fluid Using Cardiac Component Of Thoracic Component Of An Impedance- Indicating Signal, Us Patent 8,070,686 B2 Dec.6,2011.

22. DL Ross and BJ. Gabrio Advances in metered dose inhaler technology with the development of a chlorofluorocarbon-free drug delivery system. J Aerosol Med. 1999 Fall;12(3):151-60. doi: 10.1089/jam.1999.12.151. PMID: 10623331,1992.

23. T.D. Cyr, , S.J. Graham, , K.Y.R. Li, et al. Low First-Spray Drug Content in Albuterol Metered-Dose Inhalers. Pharm Res 8, 658–660 (1991) https://doi.org/10.1023/A:1015825311750

24. Ben-Gurion University of the Negev Covid-19 Response Effort, One minute electro-optical coronavirus test developed at Ben-Gurion University, online 27th May, 2020 https://www.eurekalert.org/pub_releases/2020-05/aabu-ome052220.php

25. M Dolhnikoff,, AN Duarte-Neto, RA de Almeida Monteiro, da Silva LFF, de Oliveira EP, Saldiva PHN, Mauad T, Negri EM. Pathological evidence of pulmonary thrombotic phenomena in severe COVID-19. J Thromb Haemost. 2020 Jun;18(6):1517-1519. doi: 10.1111/jth.14844. PMID: 32294295; PMCID: PMC7262093.

26. C. M. Volgenant, CMC Volgenant, IF Persoon, RAG de Ruijter de Soet JJH. Infection control in dental health care during and after the SARS-CoV-2 outbreak. Oral Dis. 2020 May 11:10.1111/odi.13408. doi: 10.1111/odi.13408. Epub ahead of print. PMID: 32391651; PMCID: PMC7272817.

27. MF Konig, M Powell, V Staedtke, RY Bai, DL Thomas, N Fischer, S Huq, AM Khalafallah, A Koenecke, R Xiong, Mensh B, Papadopoulos N, Kinzler KW, Vogelstein B, Vogelstein JT, Athey S, Zhou S, Bettegowda C. Preventing cytokine storm syndrome in COVID-19 using α-1 adrenergic receptor antagonists. J Clin Invest. 2020 Jul 1;130(7):3345-3347. doi: 10.1172/JCI139642. PMID: 32352407; PMCID: PMC7324164.*Investigation*, *130*(7).

28. Researchers at the Swiss Federal Labs for Materials Science (EMPA), ETH Zurich, and Zurich University Hospital, Swiss Researchers Develop Biosensor to Detect COVID-19 Virus in the Air viewed online April 29, 2020 https://www.fierceelectronics.com/sensors/covid-19-swiss-biosensor-could-detect-viruses-air