

# Recent Advances Of Lab Testing Of COVID 19

Amirtha varshini<sup>1</sup>, Leslie Rani. S\*<sup>2</sup>, M.P. Brundha<sup>3</sup>, Lakshminarayanan Arivarasu<sup>4</sup>

**Type of manuscript :**Review

**Running title :**Recent advances in the lab testing of COVID-19

<sup>1</sup>Saveetha Dental College and hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu,

<sup>2</sup>Lecturer, Department of General pathology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu.

<sup>3</sup>Associate professor, Department of General Pathology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu.

<sup>4</sup>Assistant Professor, Department of Pharmacology, Saveetha Dental College, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu.

Email :<sup>1</sup>[151801067.sdc@saveetha.com](mailto:151801067.sdc@saveetha.com), <sup>2</sup>[leslieranis.sdc@saveetha.com](mailto:leslieranis.sdc@saveetha.com),  
<sup>3</sup>[brundha.sdc@saveetha.com](mailto:brundha.sdc@saveetha.com), <sup>4</sup>[lakshmin.sdc@saveetha.com](mailto:lakshmin.sdc@saveetha.com)

**Abstract:** A cluster of pneumonia cases infected with a completely unique coronavirus was reported in Wuhan, a city in Hubei province of China in December 2019. The acute respiratory illness is understood as coronavirus disease 2019 or COVID-19. The virus that caused this disease is designated severe acute respiratory syndrome coronavirus 2 or SARS-CoV-2. Workflows for COVID-19 laboratory diagnosis by screening and confirmation steps by molecular method have been designed and validated, with the utilization of synthetic nucleic acid technology. Diagnosis of COVID-19 depends on a mixture of epidemiological criteria, presence of clinical symptoms additionally as laboratory testing and clinical imaging based tests. COVID-19 includes analysing examples that demonstrate the present or past nearness of SARS-CoV-2. Tests for viral presence are utilized to analyze current ailment and to permit public health specialists to distinguish and contain flare-ups as fast as could reasonably be expected. The test can be done on samples obtained by various methods, including a nasopharyngeal swab, throat swabs, deep airway material via suction catheter or saliva. As evidenced by previous epidemics, including SARS and MERS, exceptionally delicate and explicit lab diagnostics are basic for case distinguishing proof, contact following, creature source finding, and productive and sane regulation measures. This study reviews the recent advances within the lab testing of covid 19

**Keywords :** Covid -19, lab testing, diagnosis, recent advances, assays

## 1. INTRODUCTION:

COVID-19 is a communicable disease caused by coronavirus. Most people who are affected by COVID-19 virus suffer mild to moderate respiratory illness. COVID-19 virus spreads essentially through droplets of saliva or release from tainted individual hacks or sniffles. SARS-CoV-2 could be a large positive sense single-stranded RNA virus that consists

of 4 structural proteins, i.e., nucleocapsid protein that holds the viral RNA, spike protein, envelope protein, and membrane protein, that make the viral envelope. It has a width of 50–200 nm and has spikes on its surface that give it the crown-like appearance which is a quality of coronaviruses. The lung disease caused by SARS-CoV-2 was given the name of COVID-19 by the World Health Organisation (WHO) on Feb 11, 2020 [1]. Like different coronaviruses, SARS-CoV-2 particles are round and includes proteins called spikes projecting from their surface. These spikes latch onto human cells, at that point experience a basic change that permits the viral film to consolidate with the cell layer. The viral genes would then be able to enter the host cell to be replicated, creating more infections. Ongoing work shows that, just like the virus that caused the 2002 SARS outbreak, SARS-CoV-2 spikes bind to receptors on the human cell surface called (ACE2) angiotensin-converting enzyme 2. As the COVID-19 situation evolves, the outbreak characteristics a country faces will change. A similar case such as The 2014-2016 Ebola outbreak in West Africa, studied by [2] began in a rural setting of southeastern Guinea, spread to urban areas and across borders within weeks, and became a global epidemic within months which resulted in at least 28638 suspected cases and 11315 confirmed deaths.

Countries could encounter at least one of these situations at the sub-national level and should adjust and tailor their approach to the local context and prepare for potential subsequent phases. As the transition from sporadic cases to community transmission can be extremely rapid, WHO strongly advises all countries to prepare even before the first case has been detected [3]. The Laboratory Assessment Tool (LAT) is explicitly planned to evaluate limits of existing labs which have intended to execute COVID-19 infection testing. It addresses both core capacities of a laboratory and specificities related to COVID-19 virus testing. Diagnostic techniques that involve oral fluids are mainly of interest as they are relatively easy to use, lower in cost and non-invasive [4]. The progressing episode of the as of late developed novel coronavirus represents a test for general wellbeing research facilities as infection secluded are inaccessible while there is developing proof that the flare-up is more across the board than at first idea, and global spread through voyagers does as of now happen [5]. There have been tremendous advances in in vitro diagnostic (IVD) assays for COVID-19 caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). This not only involves physical examination but also screening tests to prevent the onset of disease or worsening of existing disease [6]. Interpreting a lab report is generally aided by the known standard value which is compared to that of the observed report value, and then the condition is analyzed to be normal or abnormal [7]. Over the course of the current Covid-19 emergency, the significance of solid, available testing to screen for the illness has gotten progressively obvious. Development of a vaccine can prevent the spread of COVID-19. Vaccination is the process of administration of a vaccine to enable the immune system to create security from an illness [8]. Vaccination is the procedure of organization of an antibody to empower the resistant framework to make security from an ailment. Although concern about the safety or necessity of vaccination is not a new phenomenon [9]. Building a strong immune system also prevents several diseases. Addition of probiotics in diet improves host's gastrointestinal mucosa and immune system [10]. The aim of the study focuses on reviewing the recent advances in the lab testing of COVID-19.

## **2. MATERIALS AND METHODS :**

This study included 51 articles from various search engines. The search engines used for the present study include PUBMED, Google scholar, cochrane, MESH, etc. The articles were searched based on the keywords which include COVID-19, lab testing, assays etc. The articles were collected from the duration of 2000 - 2020.

#### Epidemiological characteristics :

The city of Wuhan in China is the focal point of worldwide consideration because of a flare-up of a febrile respiratory sickness because of a coronavirus 2019-nCoV. In December 2019, there was an outbreak of pneumonia of unknown cause in Wuhan, Hubei province in China [11]. Pneumonia is an microbial infection caused by microbial agents. The respiratory system is colonized with commensal bacteria and it is continuously exposed to a variety of bacteria [12]. Coronaviruses are encompassed RNA infections that are circulated comprehensively among people, different well evolved creatures, and winged animals and that cause respiratory, enteric, hepatic, and neurologic diseases. 2019-nCoV is the seventh member of the family of coronaviruses that infect humans [13]. Chinese analysts discovered its cause in bats, yet the middle hosts for SARS-CoV-2 have not yet been recognized. The aged population (age above 65 years), and persons having decreased immunity or chronic diseases, such as diabetes mellitus, cardiovascular diseases, and lung disease, cancer [14] are at a higher hazard for creating serious COVID-19 in the event that they are contaminated with SARS-CoV-2. Diabetes mellitus is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both [15]. It is a major health problem in India [16]. PCOS is associated with insulin resistance and risk of developing Type 2 diabetes mellitus [17]. The complications also include respiratory problems such as acute respiratory distress syndrome [18,19]. Hypertension that is otherwise referred to as high blood pressure is a persisting medical condition, wherein the blood pressure in the arteries remains elevated [20], is also a complication for COVID-19. Nocturia is common in people with heart failure, liver failure, poorly controlled diabetes mellitus etc [21]. The SARS-CoV-2 infection presents particular challenges and dangers to patients with anemia [22,23]. There are also alterations in the hemoglobin value [24]. Therefore, they must take special precautions to prevent the infection. In suspected or documented cases of COVID-19, surgery such as hysterectomy etc should be postponed [25]. The crude mortality rate is 2.8% for men and 1.7% for women [26]. The number of affected population is predominantly men [27]. The mode of transmission is thought to happen chiefly by means of respiratory beads, taking after the spread of flu. With droplet transmission, infection discharged in the respiratory emissions when an individual with disease hacks, sniffles, or talks can taint someone else in the event that it reaches the mucous layers; contamination can likewise happen on the off chance that an individual contacts a tainted surface and, at that point contacts their eyes, nose, or mouth. Patients who have contracted the new coronavirus may have eye symptoms [28]. Droplets typically do not travel more than six feet (about two meters) and do not linger in the air [29].

#### Recent advances in lab testing :

With the emergence of SARS-CoV-2 and the related Coronavirus sickness 2019 (COVID-19), there is a basic requirement for analytic tests that can recognize the disease. Diagnosis is based on different clinical parameters which involves detailed examination [30]. Morphological identification plays a vital part in understanding pathology and comprehending the pathogenesis of a particular lesion or structure [31,32]. The principle IVD examines utilized for COVID-19 utilize constant converse transcriptase polymerase chain response (RT-PCR) that takes a couple hours. At present, polymerase chain reaction (PCR) and antibody testing are the dominant ways that global healthcare systems are testing citizens for Covid-19. PCR tests are utilized to straightforwardly distinguish the nearness of an antigen, as opposed to the nearness of the body's safe reaction, or antibodies. By distinguishing viral RNA, which will be available in the body before antibodies structure or side effects of the sickness are available, the tests can tell whether somebody has the infection right off the bat.

It is likewise obvious that the current continuous converse transcriptase polymerase chain (RT-PCR) measures can't identify the COVID-19 in the beginning periods of contamination, and there are reports where it has given false negatives in subjects for as long as about fourteen days. The reason for false negative results by RT-PCR could be due to the improper extraction of nucleic acid from clinical materials and insufficient cellular material for detection. This is indicated in the study by [33] that RT-PCR testing for 2019-nCoV may be falsely negative due to laboratory error or insufficient viral material in the specimen and a chest computerized tomography (CT) scan act as a complementary diagnostic tool that viably distinguish COVID-19 contamination in a few such RT-PCR false negative cases. Hence a typical CT findings can help early screening suspected cases and may predict severe complications such as acute respiratory diseases. Researches are going on under stem cells against COVID-19 [34]

SARS-CoV-2 IgG-IgM combined antibody test detect immunoglobulin M (IgM) and IgG antibodies 15 minutes that can detect patients at different infection stages. The SARS-CoV-2 quick IgG-IgM consolidated counter acting agent test pack is planned and made by Jiangsu Medomics Medical Technologies, situated in Nanjing, China. It is a lateral flow qualitative immunoassay for the rapid determination of the presence or absence of both anti- SARS-CoV-2-IgM and anti- SARS-CoV-2-IgG in human specimens (whole blood, serum, and plasma) [35]. This new develop test kit, has sensitivity of 88.66% and specificity of 90.63%. It has several advantages. Compared to RT-PCR, it saves time and it does not require equipment, it is simple to perform and only requires minimal training. It can be performed at the bedside, in a clinical laboratory, at airports or at railway stations [36]

Abbott IS Now™ COVID-19 test is the latest advancement IVD measure that recognizes SARS-CoV-2 in only 5 min. It is a molecular POC test that utilizes the isothermal nucleic acid amplification technology for the qualitative detection of viral RNA from SARS-CoV-2. Designed for near patient testing in a variety of healthcare environments, Direct example types incorporate Nasal, Throat, and Nasopharyngeal swabs, Facilitates powerful patient administration.

The most conspicuous IAs are computerized chemiluminescent IA (CLIA), manual ELISA, and quick parallel stream IA (LFIA), which distinguish the immunoglobulin M (IgM) and immunoglobulin G (IgG) delivered in people in light of SARS-CoV-2 contamination.

ELISA tests could be a more secure decision at this phase of the pandemic. POC tests (LFIA), that are progressively appealing for huge seroprevalence examinations showing high particularity yet lower affectability. Likewise, IgM ELISA distinguished a larger number of cases than polymerase chain response (PCR) on day 5.5 of sickness. The combination of IgM ELISA in addition to PCR identified 98.6% of cases versus 51.9% with a solitary PCR [37].

Serologic tests can improve early diagnosis of COVID-19. Reverse Transcription Loop-Mediated Isothermal Amplification (RT-LAMP) RT-LAMP has been developed as a rapid and cost-effective testing alternative for SARS-CoV-2. RT-LAMP requires a set of four preliminaries explicit for the objective quality/locale to improve the affectability and consolidates LAMP with an opposite interpretation venture to take into consideration the identification of RNA [38] Transcription-Mediated Amplification (TMA) TMA is a protected single cylinder, isothermal enhancement innovation demonstrated after retroviral replication which can be utilized to enhance explicit districts of either RNA or DNA substantially more proficiently than RT-PCR [39]. Buccal smear is useful for diagnosing malignancy, fungal infection and viral infection [40]

Need for recent advances in lab testing :

Due to the false negative results of RT-PCR, there is a need for developing better in vitro diagnostic (IVD) assays that can detect the SARS-CoV-2 infection reliably in persons even at

the initial stage [41]. The particular biomarkers required during the beginning period of COVID-19 contamination ought to be explored and utilized for the advancement of diagnostics. The accurate diagnosis of people infected with the SARS-CoV-2 is essential to curb the global spread of COVID-19. The fact that asymptomatic persons are potential sources of 2019-nCoV infection poses increased need for the advances in the lab testing [42]. Since COVID-19 shows a scope of clinical indications, from gentle influenza like manifestations to dangerous conditions, it is imperative to have productive testing during the beginning periods of disease to recognize COVID-19 patients from those with different ailments. This maintains a strategic distance from pointless isolates of negative people and the spread of contamination by constructive people. Early determination licenses doctors to give brief mediation to patients who are at higher hazard for growing progressively genuine intricacies from COVID-19 ailment [43].

#### Testing priorities :

The order of priority follows Hospitalized patients with symptoms, health care facility workers, residents in long term care facilities or other congregate living settings, including prisons and shelters with symptoms, persons with symptoms of a possible infection with COVID-19 including fever, cough, shortness of breath etc., persons without symptoms who are prioritised by health departments or clinicians for any reason. Emergency department staff are vulnerable to industrial exposure to contagious body fluids[44]. The non priority group includes the individuals without symptoms. The first priority ensures ideal consideration alternatives for all hospitalized patients, reduces the danger of human services related contaminations, and keeps up the honesty of the social insurance framework. The second priority Ensures those at most elevated danger of difficulty of contamination are quickly distinguished and suitably triaged. The third priority, As resources allow, test individuals in the surrounding community of rapidly increasing hospital cases to decrease community spread, and ensure health of essential workers [45].

#### Diagnostic challenges :

One major challenge in the novel coronavirus pandemic has been the availability of test kits and the reagents required to use those kits. Reliable methods to confirm the diagnosis of COVID-19 are essential to the successful management and containment of the virus. Current diagnostic options are limited in type, supply, and reliability [46]. There is a need for manufacturers to rapidly gather data on sensitivity and specificity as their tests are potentially being used to [47]inform decision making for patients, providers, and policy makers. The Quality of sample collected poses a major challenge in the diagnosis of COVID- 19 [48]. Unintentional variations in the collection process, such as “air swabs,” would cause lack of sample (nucleic acid materials), which in turn produces errors in test results (false negatives). Shortages of personal protective equipment [47] and access to test kits and supplies are hampering hospitals’ ability to diagnose and treat patients during the COVID-19 pandemic, as are a host of other challenges [49]. Other issues that need to be addressed are the safety of healthcare personnel collecting, storing and transporting the samples and laboratory personnel handling and processing the potentially infectious samples [50,51]

### 3. CONCLUSION :

The primary test has involved directly detecting SARS-CoV-2 viral RNA through quantitative reverse transcriptase PCR tests (RT-qPCR). Most recently used IAs include automated chemiluminescent IA (CLIA), manual ELISA, and rapid lateral flow IA (LFIA), The SARS-CoV-2 IgG-IgM is a rapid combined antibody test. It can detect immunoglobulin M (IgM) and IgG antibodies simultaneously against SARS-CoV-2 virus in human blood

within 15 minutes which can detect patients at different infection stages and also Isothermal Amplification (RT-LAMP) RT-LAMP has been developed as a rapid and cost-effective testing alternative for SARS-CoV-2. Abbott IS Now™ COVID-19 test is the latest advancement IVD that distinguishes SARS-CoV-2 in only 5 min. The ongoing research endeavors and advances in correlative innovations will give rise to new tests in the coming months.

#### 4. ACKNOWLEDGEMENT:

The authors are thankful to Saveetha Dental College and Hospitals for providing a platform to express their knowledge.

#### **Authors contribution :**

Amirthavarshini executed the research work, collected data and drafted the manuscript. Dr. Leslie Rani. S, contributed to validating the collection of data as well as did the proof reading of the manuscript. Dr. Lakshmi Narayanan contributed to literature search. Dr. M.P. Brundha was involved in revision and proofreading of the review.

#### **Conflict of interest :**

The authors declare that there is no conflict of interest

#### 5. REFERENCES :

- [1] Vashist SK. In Vitro Diagnostic Assays for COVID-19: Recent Advances and Emerging Trends. *Diagnostics* (Basel) 2020;10. <https://doi.org/10.3390/diagnostics10040202>.
- [2] Hemashree S, Rubini KR, Lohala S, Nithya S. Ebola Virus-A Review. *J Adv Pharm Technol Res* 2016;9:617.
- [3] World Health Organization. Laboratory testing strategy recommendations for COVID-19: interim guidance, 21 March 2020. World Health Organization; 2020.
- [4] Sareen A, Tandon S, Ramachandran A, Srimathi R. Saliva as A Diagnostic Tool for Detection of the Viruses: A Review. *J Adv Pharm Technol Res* 2018;11:4739.
- [5] Corman VM, Landt O, Kaiser M, Molenkamp R, Meijer A, Chu DKW, et al. Detection of 2019 novel coronavirus (2019-nCoV) by real-time RT-PCR. *Eurosurveillance* 2020;25:2000045.
- [6] Hui DS, Azhar EI, Madani TA, Ntoumi F, Kock R, Dar O, et al. The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health — The latest 2019 novel coronavirus outbreak in Wuhan, China. *International Journal of Infectious Diseases* 2020;91:264–6. <https://doi.org/10.1016/j.ijid.2020.01.009>.
- [7] Varshini A, Rani SL, Brundha MP. Awareness of annual doctor checkups among general population. *Drug Invention Today* 2020;14.
- [8] Dhivyadharshini J, Brundha MP. Comparison of effects of interpretation of lab reports among the undergraduate dental students. *Drug Invention Today* 2020;14.
- [9] Swetha G, Rani SL, Brundha MP. Awareness of the side effects of vaccination among general public. *Drug Invention Today* 2020;14.
- [10] Sarvesh Kumar J, Brundha MP. Awareness about childhood vaccination among parents with children below 15 years of age. *Drug Invention Today* 2018.
- [11] Ananya B, Rani SL, Brundha MP. Knowledge and attitude of probiotics among outpatients visiting dental operator. *Drug Invention Today* 2020;14.
- [12] Chellammal MR. Bacterial Pneumonia. *Research Journal of Pharmacy and Technology* 2014;7:942–5.
- [13] Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, et al. A Novel Coronavirus from Patients with Pneumonia in China, 2019. *N Engl J Med* 2020;382:727–33.

- [14] Balaji S, Brundha MP, Path DNB. Awareness of About Breast Cancer among Dental Surgeons. *Res J Pharm BiolChemSci* 2016;8:797.
- [15] the Chinese Preventive Medicine Association SEGFC of TE of NCP of. An update on the epidemiological characteristics of novel coronavirus pneumonia (COVID-19). *Zhonghua Liu Xing Bing XueZaZhi* 2020;41:139–44.
- [16] Sowbaraniya SM, Preejitha VB, Brundha MP. Knowledge, awareness, and attitude on dental post-operative complications in diabetes among general population. *Drug Invention Today* 2020;13.
- [17] Preethikaa S, Brundha MP. Awareness of diabetes mellitus among general population. *J Pharm Res* 2018.
- [18] Lakshmi S, Rani SL, Brundha MP. Blow the balloon for the ease--A cross-sectional study on wheezing patients. *Drug Invention Today* 2020;14.
- [19] Shenoy PB, Brundha MP. Awareness of polycystic ovarian disease among females of age group 18-30 years. *Res J Pharm BiolChemSci* 2016;8:813.
- [20] Rexlin PE, Preejitha VB, Brundha MP. Age-related differences of heart rate and respiratory rate in the age group of 45-55 years--A regression analysis. *Drug Invention Today* 2020;14.
- [21] Kumar MD, Brundha MP. Awareness about nocturia-A questionnaire survey. *Research Journal of Pharmacy and Technology* 2016;9:1707–9.
- [22] Shancy Merlin AR, Preejitha VB, Brundha MP. Estimation of salivary pH in hypertensive patients with and without periodontitis. *Drug Invention Today* 2020;14.
- [23] Malay KK, Duraisamy R, Brundha MP. Awareness regarding anemia among 1st year dental undergraduate students. *Drug Invention* 2018.
- [24] Shreya S, Brundha MP. Alteration of Haemoglobin Value in Relation to Age, Sex and Dental Diseases- A Retrospective Correlation Study. *Research Journal of Pharmacy and Technology* 2017;10:1363–6.
- [25] Kalaiselvi R, Brundha MP. Prevalence of hysterectomy in South Indian population. *Research Journal of Pharmacy and Technology* 2016;9:1941. <https://doi.org/10.5958/0974-360x.2016.00398.x>.
- [26] Brundha MP, Pathmashri VP. Quantitative Changes of Red Blood cells in Cancer Patients under Palliative Radiotherapy-A Retrospective Study. *Research Journal of* 2019.
- [27] McIntosh K, Hirsch M, Bloom A. Coronavirus disease 2019 (COVID-19): Epidemiology, virology, clinical features, diagnosis, and prevention. UpToDate, Hirsch, M (Ed), UpToDate, Waltham, MA 2020.
- [28] P Jannathulferdiz BM. Awareness of Stye. *Int J Pharm Sci Rev Res*, n.d.;40:30–2.
- [29] Harsha L, Brundha MP. Prevalence of dental developmental anomalies among men and women and its psychological effect in a given population. *J Pharm Sci* 2017.
- [30] Brundha MP. A Comparative Study-The Role of Skin and Nerve Biopsy in Hansen's Disease. *Res J Pharm BiolChemSci* 2015;7:837.
- [31] Mp B, Brundha MP, Nallaswamy D. Hide and seek in pathology- A research on game-based histopathology learning. *International Journal of Research in Pharmaceutical Sciences* 2019;10:1410–4. <https://doi.org/10.26452/ijrps.v10i2.606>.
- [32] Prashaanthi N, Brundha MP. A Comparative Study between Popplet Notes and Conventional Notes for Learning Pathology. *Research Journal of Pharmacy and Technology* 2018;11:175. <https://doi.org/10.5958/0974-360x.2018.00032.x>.
- [33] Xie X, Zhong Z, Zhao W, Zheng C, Wang F, Liu J. Chest CT for Typical 2019-nCoV Pneumonia: Relationship to Negative RT-PCR Testing. *Radiology* 2020:200343.
- [34] Timothy CN, Samyuktha PS, Brundha MP. Dental pulp Stem Cells in Regenerative Medicine – A Literature Review. *Research Journal of Pharmacy and Technology* 2019;12:4052. <https://doi.org/10.5958/0974-360x.2019.00698.x>.

- [35] Li Z, Yi Y, Luo X, Xiong N, Liu Y, Li S, et al. Development and Clinical Application of A Rapid IgM-IgG Combined Antibody Test for SARS-CoV-2 Infection Diagnosis. *Journal of Medical Virology* 2020. <https://doi.org/10.1002/jmv.25727>.
- [36] Singer AJ, Williams J, Taylor M, Le Blanc D, Thode HC. Comprehensive bedside point of care testing in critical ED patients: a before and after study. *The American Journal of Emergency Medicine* 2015;33:776–80. <https://doi.org/10.1016/j.ajem.2015.03.034>.
- [37] Zhao J, Yuan Q, Wang H, Liu W, Liao X, Su Y, et al. Antibody responses to SARS-CoV-2 in patients of novel coronavirus disease 2019. *Clin Infect Dis* 2020. <https://doi.org/10.1093/cid/ciaa344>.
- [38] Hong TCT, Mai QL, Cuong DV, Parida M, Minekawa H, Notomi T, et al. Development and evaluation of a novel loop-mediated isothermal amplification method for rapid detection of severe acute respiratory syndrome coronavirus. *J ClinMicrobiol* 2004;42:1956–61.
- [39] Kacian DL, Fultz TJ. Kits for nucleic acid sequence amplification methods. 5888779, 1999.
- [40] Hannah R, Ramani P, Brundha MP, Sherlin HJ, Ranjith G, Ramasubramanian A, et al. Liquid Paraffin as a Rehydrant for Air Dried Buccal Smear. *Research Journal of Pharmacy and Technology* 2019;12:1197–200.
- [41] Bai Y, Yao L, Wei T, Tian F, Jin D-Y, Chen L, et al. Presumed Asymptomatic Carrier Transmission of COVID-19. *JAMA* 2020. <https://doi.org/10.1001/jama.2020.2565>.
- [42] Rothe C, Schunk M, Sothmann P, Bretzel G, Froeschl G, Wallrauch C, et al. Transmission of 2019-nCoV Infection from an Asymptomatic Contact in Germany. *N Engl J Med* 2020;382:970–1.
- [43] Carter LJ, Garner LV, Smoot JW, Li Y, Zhou Q, Saveson CJ, et al. Assay Techniques and Test Development for COVID-19 Diagnosis. *ACS Cent Sci* 2020;6:591–605.
- [44] Deepika R, Preejitha VB, Brundha MP. Knowledge and awareness of blood/body fluid spill management among the third year dental students. *Drug Invention Today* 2020;14.
- [45] for Disease Control C, Prevention, Others. Priorities for testing patients with suspected COVID-19 infection n.d.
- [46] Hu E. COVID-19 Testing: Challenges, Limitations and Suggestions for Improvement n.d. <https://doi.org/10.20944/preprints202004.0155.v1>.
- [47] Ravichandran H, Brundha MP. Awareness about personal protective equipments in hospital workers (sweepers and cleaners). *International Journal of Pharmaceutical Sciences Review and Research* 2016;40:28–9.
- [48] Chan JF-W, Yip CC-Y, To KK-W, Tang TH-C, Wong SC-Y, Leung K-H, et al. Improved Molecular Diagnosis of COVID-19 by the Novel, Highly Sensitive and Specific COVID-19-RdRp/Hel Real-Time Reverse Transcription-PCR Assay Validated In Vitro and with Clinical Specimens. *Journal of Clinical Microbiology* 2020;58. <https://doi.org/10.1128/jcm.00310-20>.
- [49] Phua J, Weng L, Ling L, Egi M, Lim C-M, Divatia JV, et al. Intensive care management of coronavirus disease 2019 (COVID-19): challenges and recommendations. *Lancet Respir Med* 2020;8:506–17.
- [50] Hong KH, Lee SW, Kim TS, Huh HJ, Lee J, Kim SY, et al. Guidelines for Laboratory Diagnosis of Coronavirus Disease 2019 (COVID-19) in Korea. *Ann Lab Med* 2020;40:351–60.
- [51] Organization WH, Others. Laboratory biosafety guidance related to coronavirus disease 2019 (COVID-19): interim guidance, 12 February 2020. World Health Organization; 2020.