Practical considerations for Spirometry during the COVID-19 outbreak: Literature Review and Insights

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Abstract

**Background:** As the Coronavirus disease 2019 (COVID-19) is spreading worldwide, countries are dealing with different phases of the pandemic. Lately, scientific evidence has been growing about the measures for reopening respiratory outpatient services during the COVID-19 pandemic. We aim to summarize the key differences and similarities among recommendations by different national and international organizations.

**Methods:** We searched on Google and Pubmed for recently published National and International Recommendations/Guidelines/Position Papers from professional organizations and societies, offering a guidance to physicians on how to safely perform pulmonary function testing during COVID-19 pandemic. We also searched for spirometry manufacturers' operational indications.

**Results:** Indications on spirometry were released by the Chinese Task force, the American Thoracic Society, the European Respiratory Society, the Thoracic Society of Australia and New Zealand, the Société de Pneumologie de Langue Française, the Spanish Societies (Sociedad Espanola de Neumologia y Cirugia Toracica, Sociedad Espanola de Alergologia e Inmunologia Clinica, Asociacion de Especialistas en Enfermeria del trabajo, Asociacion de Enfermeria Comunitaria), the Sociedade Portuguesa de Pneumologia, the British Thoracic Society/Association for Respiratory Technology & Physiology, the Irish Thoracic Society, the Sociedad Uruguaya de Neumologia, the Italian Thoracic Society and the Italian Respiratory Society, Cleveland Clinic and Nebraska Medical Center. Detailed technical recommendations were found on manufacturers' websites.

We found several similarities across available guidelines for safely resuming pulmonary function services, as well as differences in criteria for selecting eligible patients for which
spirometry is deemed essential and advice which was not homogenous on room ventilation precautions.

**Conclusions:** This study shows a synthesis of national/international guidelines allowing practicing physicians to adapt and shape the way to organize their outpatient services locally. There is generally good agreement on the importance of limiting pulmonary function testing to selected cases only. However, significant differences concerning the subsets of candidate patients, as well as on the management of adequate room ventilation, were observed.

**Abbreviations:**

ACH: air changes per hour  
ARTP: Association for Respiratory Technology and Physiology  
BTS: British Thoracic Society  
COVID-19: Coronavirus disease 2019  
WHO: World Health Organization  
ANZSRS: Australian and New Zealand Society of Respiratory Science Ltd  
AET: Asociacion de Especialistas en Enfermeria del trabajo  
AEC: Asociacion de Enfermeria Comunitaria  
ATS: American Thoracic Society  
CLEVELAND: Respiratory Institute Cleveland Clinic  
COPD: Chronic obstructive pulmonary disease  
ERS: European Respiratory Society  
HCWs: health care workers  
ITS: Irish Thoracic Society  
IRS/SIP: Italian Respiratory Society/Società Italiana di Pneumologia  
ITS/AIPO: Italian Thoracic Society/Associazione Italiana Pneumologi Ospedalieri
PFTs: pulmonary function tests
PPE: personal protective equipment
SEAIC: Sociedad Espanola de Alergologia e Inmunologia Clinica
SEPAR: Sociedad Espanola de Neumologia y Cirugia Toracica
SPLF: Société de Pneumologie de Langue Française
SPP: Sociedade Portuguesa de Pneumologia
SUNEUMO: Sociedad Uruguaya de Neumologia
TSANZ: Thoracic Society of Australia and New Zealand
UV: ultraviolet

**Keywords:** COVID-19, SARS-CoV-2, pulmonary function test, spirometry, outpatient clinic, safety, guidelines.
INTRODUCTION

Coronavirus disease 2019 (COVID-19) has spread worldwide, becoming a public health emergency of international concern, officially designated as a pandemic by World Health Organization (WHO) on March 11. COVID-19 has had a high impact on the health care system, necessitating unprecedented measures for containing the infection, shutting down all the outpatient activities and providing treatment only for emergency cases.

The infection is mainly transmitted by respiratory droplets and close contacts, so both pulmonologists and their patients are at high risk of COVID-19 transmission during the outpatient visit and the pulmonary function testing procedures.

Therefore, in the early phases of the pandemic some International Societies such as the Chinese expert consensus, the American Thoracic Society (ATS), the Thoracic Society of Australia and New Zealand (TSANZ/ANZRS), the Sociedade Portuguesa de Pneumologia (SPP), the Société de Pneumologie de Langue Française (SPLF), the Spanish Societies [Sociedad Espanola de Neumologia y Cirugia Toracica (SEPAR), Asociacion de Enfermeria Comunitaria (AEC), Asociacion de Especialistas en Enfermeria del trabajo (AET), Sociedad Espanola de Alergologia e Inmunologia Clinica (SEAIC)] and the Irish Thoracic Society (ITS), recommended stopping or postponing pulmonary visits and pulmonary function tests (PFTs) during the pandemic surge unless deemed clinically essential.

Nevertheless, PFTs cannot be delayed for a long time in some patients’ groups. Moreover, a respiratory follow-up of patients who recovered from COVID-19 pneumonia is crucial in the monitoring of a possible fibrotic complication of the disease which could lead to a reduction of the pulmonary function.

Entering the second phase of the COVID-19 pandemic, we need to consider that the infection will remain endemic and we have to coexist with the disease, which will
become a part of the routine practice. Therefore, hospitals have to be prepared to safely bring back regular ambulatory services and PFT labs, especially to assess patients suffering from pre-existing chronic respiratory diseases, to prevent their risk of mortality and disability.

To date, several official Recommendations/Guidelines from National and International Societies, hospitals or professional organizations have been released on this topic with operational indications during the COVID-19 surge. Some Organizations updated their own documents, and other Societies, such as the European Respiratory Society (ERS), the British Thoracic Society/Association for Respiratory Technology & Physiology (BTS/ARTP), the Sociedad Uruguaya de Neumología (SUNEUMO), the Italian Thoracic Society (ITS/AIPO), and the Italian Respiratory Society (IRS/SIP), as well as renowned medical centers such as Cleveland Clinic, recently published statements.

We aim to summarize the available official recommendations on the use of spirometry in the context of COVID-19 infection and to compare them, reviewing in detail the most important aspects, such as eligible patients, health-care workers’ and patients’ protection, equipment, and environmental management to prevent COVID-19 transmission. These results will help practicing physicians make decisions on how to safely reshape and reopen ambulatory services, tailoring measures to the specific context of their needs, and organizational issues.

**METHODS**

We searched and reviewed all recent Guidelines, Consensus documents, Statements, and Position Papers from National and International Societies or local policies of medical centers on how to perform spirometry during COVID-19, published on official websites in four languages: English, Italian, French and Spanish.
To increase the search strategy's sensitivity, we also searched on Google the websites of the spirometer manufacturers using the following terms: COVID-19, Sar-Cov-2, spirometry, pulmonary function test.

RESULTS

We considered the challenging issues related to performing spirometry and the solutions that may be adopted, as suggested by official Recommendations.

Table 1 summarizes Societies' Recommendations on performing PFTs.

Eligible patients

There was an overall good agreement among Guidelines on limiting PFTs to patients really needed them, weighing the benefits of ongoing care and clinical evaluation with "exposure risk" to COVID-19 for individuals coming to the hospital. Nevertheless, we found heterogeneous indications on the subgroup of patients considered a priority.

The ATS 6 and ERS 17 Recommendations generically advise performance of PFTs when they are essential for immediate treatment decisions of the current illness. At the same time, SPP 16, SPLF 9 and BTS/ARTP guidelines 12 strongly encourage performing essential procedures only in cancer patients or in cases of pre-operative assessments for urgent surgery. In contrast, the recent update of the Australian Guidelines 14 suggests that asymptomatic patients might undergo PFTs, especially in cases of a pre-operative evaluation for elective surgery. The ITS 11 Guidelines recommend performing PFTs in patients with cystic fibrosis and rapid access lung cancer and in those needing a pre-operative assessment for emergency surgery. Furthermore, they recommend spirometry in immunocompromised patients for urgent treatment (e.g. bone marrow transplant, lung transplants, pre-chemotherapy treatments), suggesting testing them first on the day. Conversely, the Chinese expert Recommendations 5 limit PFTs only to patients needing them; moreover, they specify that in patients with asthma and chronic obstructive
pulmonary disease (COPD), the test might be suspended unless urgently needed for diagnosis and treatment, suggesting the use of a peak flow meter for self-monitoring the lung function. Similar indications come from the Position Paper of the ITS/AIPO Italian Society \(^{19}\), which also prioritizes patients needing thoraco-abdominal surgery. The latest released IRS/SIP Recommendations \(^{20}\), provide more broad indications, including the diagnosis of COPD and asthma and interstitial lung diseases, the follow-up and the antifibrotic drugs prescription. Cleveland \(^{21}\) is the only Organization that also mentions patients with pulmonary hypertension, while SUNEUMO \(^{18}\) also takes into account patients with pneumoconiosis and respiratory drug toxicity. Finally, the SEPAR/AEC/AET/SEAIC\(^{10}\) Recommendations suggest performing PFTs in negative rooms and postponing them unless urgently needed.

As regards patients recovered from COVID-19 experiencing persistent or evolving respiratory complications, BTS/ARTP \(^{12}\) Guidelines propose a detailed follow-up: all patients recovered from a severe (hospitalized in Intensive Care Unit/High Dependency Unit, or necessitating protracted dependency on a high fraction of inspired oxygen or noninvasive ventilation during the hospital stay, or discharged with oxygen or with significant ongoing respiratory symptoms) or a mild to moderate pneumonia, or clinically improved patients with persistent changes in the chest X-ray 12 weeks post-discharge, should undergo PFTs.

Patients with a previous COVID-19 pneumonia are also mentioned by the ERS\(^{17}\) Guidelines that only specify that these patients must not be tested for a minimum of 30 days post-infection. The ITS/AIPO \(^{19}\) Position Paper recommends a documented negative swab test 48-72 h before PFTs or arranging dedicated post-COVID PFTs lab facilities, while IRS/SIP \(^{20}\) Guidelines state that these patients need to be tested without specifying any strategy. No specific indications for PFTs in COVID-19 recovered patients are mentioned by the other Guidelines.
**Patient management: measures to ensure social distancing**

To safely restart PFTs services, it is mandatory to appropriately assess each outpatient, considering everyone as a potential symptomatic or asymptomatic COVID-19, avoiding at the same time denying access to many patients. All Guidelines are generally encouraging similar strategies to guarantee health safety, are implementing measures to warrant social distancing and to identify suspected patients for limiting the transmission of the infection, are ensuring the safety of health-care workers (HCWs) with adequate personal protective equipment (PPEs), because subclinical patients may still transmit the virus.

**Patient visit**

Chinese, ITS/AIPO, IRS/SIP, and Irish Recommendations particularly emphasize that patients should be scheduled for a visit at a specific date and time, in order to avoid early arrival of the patient and crowded waiting rooms.

The Irish Thoracic Society specifies that patients booked for a visit should wait in their own car, entering the department for testing only after a phone call by the administrative team. No mention of scheduled visits was formulated by ATS, BTS/ARPT, TSANZ/ANZSRS, SSP, SUNEUMO, SPLF, SEPAR/AEC/AET/SEAIC Societies.

**Waiting rooms**

The Recommendations generally encourage patients to come to the visit alone, without accompanying persons, when possible, or limited to one caregiver if they need support. Maintaining a minimum of 2 meters distance between sitting patients is recommended by Irish, Chinese, ITS/AIPO, ERS, and BTS/ARTP Societies, while SEPAR/AEC/AET/SEAIC limit the distance to at least 1 meter.

Furthermore, the Chinese task force, and ITS/AIPO Position Paper suggest making a demonstration video focused on the maneuvers for correctly performing spirometry and to project it in the waiting area, enabling patients to be prepared before the visit, while SEPAR/AEC/AET/SEAIC Societies recommend to use educational posters.
Patient entrance

ERS 17 and ITS/AIPO 19, IRS/SIP 20, Portuguese 16, SPLF 9 and Nebraska medical center 15 Guidelines specify that patients coming to their visit should wear a mask, stressing that patients without a mask will not be allowed to enter the outpatient facility.

SEPAR/AEC/AET/SEAIC 10 Societies suggest wearing a mask only if patients have respiratory symptoms.

Screening

All the Guidelines besides ATS 6, TSANZ/ANZSRS 14 and BTS/ARTP 12 recommend administering a symptoms screening questionnaire to patient on arrival and checking body temperature, in order to verify if they are likely to have a COVID-19 infection. A sample screening questionnaire is provided by ERS 17, ITS/AIPO 19 and IRS/SIP 20 documents. ITS/AIPO 19, IRS/SIP 20, Irish 11 and Chinese task force 5 specify that the questionnaire, when possible, might also be administered by telephone (tele-screening) 48-72 hours before the visit. Body temperature detection alone is recommended only by TSANZ/ANZSRS 14 Guidelines: if the temperature is greater than 37.3°C, the visit will be suspended. No information on PPE to be used by the personnel during the triage is provided by any Guidelines.

ITS/AIPO 19 and IRS/SIP 20 Guidelines strongly recommend a documented negative swab test 48-72 h before PFTs for suspected cases, while ITS/AIPO 19 Guidelines encourage physicians to arrange dedicated post-COVID-19 PFTs lab facilities.

Patient preparation

After this screening phase, the patient will perform careful hand hygiene and enter the PFTs operative room; ITS/AIPO 19 Guidelines specify that patients need to wear gloves too.

HCWs protection
There is a lack of evidence about whether the PFTs should be considered aerosol-generating procedures. Nevertheless, HCWs assigned to PFTs lab should adopt all the precautionary measures suggested by WHO, since the procedure needs close contact with the patient and can induce coughing, similar to that induced by collecting diagnostic respiratory samples (e.g. nasopharyngeal swab). All Societies cautiously recommend PPEs use for HCWs performing PFTs, specifying that HCWs should wear filtering facepiece respirators FFP3 or, when not available, FFP2 and eye protection. Only SPLF Guideline states that HCWs can use a simple surgical mask. Changing disposable gloves between patients is highly recommended and rigorous hand hygiene is essential.

BTS/ARTP Guidelines further specify that HCWs also need to wear a fluid-resistant gown and a disposable plastic apron, while IRS/SIP, SPLF, and SEPAR/AEC/AET/SEAIC Guidelines mention only the gown. However, the Chinese task force and Portuguese Guidelines recommend the use of overshoes and surgical hats and replacing masks, gloves, and protective glasses if contaminated with saliva, sputum, and other secretions.

Furthermore, Chinese task force, SEPAR/AEC/AET/SEAIC, and ITS/AIPO Position Paper for an additional level of safety consider it appropriate that the chair direction of the PFTs operator should sit beside the patient, facing the same way, and recommend avoiding sitting face to face.

**Equipment management**

Spirometry systems are not designed to be sterile. There are three main potential sources of cross-contamination when performing the test: skin contact, aerosolized particles and saliva/body fluids; therefore, hygiene measures to protect users are crucial.

**Filter**

The ERS, BTS/ARTP, SEPAR/AEC/AET/SEAIC, and ITS/AIPO Guidelines specify that in-line bacterial/viral filters should be used to protect the whole circuit from
contamination with exhaled microorganisms, and the patient from inhaling particles from the circuit, while ATS\textsuperscript{6}, ITS\textsuperscript{11} and TSANZ/ANZSRS\textsuperscript{14} Guidelines do not specify any precaution in this regard.

To ensure the protective effect, BTS/ARTP\textsuperscript{12} Guidelines recommend using in-line filters with a high-quality filtration performance against viruses but with proven evidence of not altering function measurements. Similarly, ITS/AIPO\textsuperscript{19} and the Chinese Task force\textsuperscript{5} state that verification of the total resistance of the filter and lung respiratory tube function instrument should be \(< 1.5 \text{ cmH}_2\text{O} \) at a flow rate of \(0-14 \text{ L/s} \cdot \text{L}^{-1} \cdot \text{s}^{-1}\), in order to not affect the results of the lung function test. At the same time, ERS\textsuperscript{17} Guidelines suggest selecting a filter with a minimum proven efficiency for a high expiratory flow of 600 to 700 L/min.

Interestingly, only the SPLF\textsuperscript{9} Guidelines recommend performing PFTs in a plethysmography boot with a shut door.

**Bronchodilator**

As far as bronchodilator challenge is concerned, TSANZ/ANZSRS\textsuperscript{14} Societies suggest using the patient’s own salbutamol inhaler or a single-use inhaler, while ITS\textsuperscript{11} Guidelines recommend considering the use of Turbohaler or an aerosol holding chamber (spacer) device (i.e. aerochamber), the latter also endorsed by the Portuguese Society\textsuperscript{16}.

**Equipment Cleaning**

The use of in-line filters does not preclude the necessity for thorough cleaning of the equipment. After each use, equipment cleaning with 75\% ethanol for 3 minutes twice is recommended by the Chinese task force\textsuperscript{17}. SEPAR/AEC/AET/SEAIC\textsuperscript{10} and BTS/ARWP Guidelines\textsuperscript{12} also describe in detail the type of disinfectant solution, as shown in Table 1. A general statement regarding regular equipment cleaning protocol following local policies is advised by IRS/SIP\textsuperscript{20}.

**Nose-clip**
The use of disposable nose clips is strongly recommended by ERS \textsuperscript{17}, BTS/ARTP \textsuperscript{12}, ITS/AIPO \textsuperscript{19}, IRS/SIP\textsuperscript{20} and SEPAR/AEC/AET/SEAIC\textsuperscript{10} Guidelines.

\textit{Environment management}

\textit{Ventilation}

Airborne transmission occurs through the dissemination of droplets from infectious patients; the motion of droplets significantly depends on gravity, direction and strength of local airflow, temperature, and relative humidity. It is crucial, therefore, to perform the spirometry in a properly ventilated room, in order to control any possible cross-infection.

Ventilation is defined as the supply/distribution or removal of air from a space by mechanical or natural procedures. The clearance rate of aerosols in a closed space is dependent on the extent of any mechanical or natural ventilation; therefore, the greater the ventilation rate, expressed as the number of air changes per hour (ACH), the sooner any aerosol will be cleared \textsuperscript{23}. A single air change is estimated to remove 63\% of airborne contaminants: after 5 air changes, less than 1\% of airborne contamination is thought to remain \textsuperscript{24}. A minimum of 20 minutes, that is 2 air changes, in hospital settings, where most of these procedures occurs, is considered pragmatic \textsuperscript{25}.

Nevertheless, the issue of adequate ventilation was considered only by ERS \textsuperscript{17}, ITS/AIPO \textsuperscript{19}, BTS/ARTP \textsuperscript{12}, Chinese task force \textsuperscript{5}, SUNEUMO \textsuperscript{18} and Nebraska Medical Center \textsuperscript{15} Recommendations. SEPAR/AEC/AET/SEAIC\textsuperscript{10} and Portuguese\textsuperscript{8} Guidelines generally suggest avoidance of air recycling.

In particular, adequate room ventilation, i.e. at least 15 minutes to ventilate the room (open windows, closed doors), is recommended by SPLF\textsuperscript{9}, ERS \textsuperscript{17} and ITS/AIPO \textsuperscript{19} Guidelines.

Negative isolation rooms with 6-12 ACH or side rooms with 6 ACH are encouraged by BTS/ARTP \textsuperscript{12} Guidelines.

The Nebraska Medical Center \textsuperscript{15} states that the procedure room should remain closed for an hour after the PFTs. The Chinese task force \textsuperscript{5} recommend maintaining the ventilation of
the lung function examination room, ensuring 12 ACH if operating in a negative isolation room or an air flow of at least 160 L/s per patient or hourly in a naturally ventilated room, as well as opening windows as much as possible for natural ventilation.

Chinese, SEPAR/AEC/AET/SEAIC, and ITS/AIPO Guidelines proposed separating the test area from the administrative area of the room. **Room and surfaces cleaning and infection control.**

All the reviewed Guidelines agreed on the importance of cleaning equipment and surfaces; SEPAR/AEC/AET/SEAIC, BTS/ARTP and Chinese Guidelines also recommend the type of cleaning solution to be used, Table 1. Disposable cleaning wipes were strongly recommended by SEPAR/AEC/AET/SEAIC, BTS/ARTP, ITS, and Cleveland Clinic Guidelines, but only TSANZ/ANZSRS and SEPAR/AEC/AET/SEAIC Guidelines expressly recommend the presence of minimal furnishings that can be easily cleaned and disinfected.

As regards PFTs operating room cleaning, ERS, BTS/ARTP, ITS/AIPO, and IRS/SIP Guidelines suggest the use of UV light or ozone room decontamination at intervals, compliant with local infection policies, while more detailed precautions are provided by the Chinese task force.

The Chinese task force also recommend switching off the central air conditioner, sanitizing the room at least twice a day, using UV light for at least 30 min a day to clean the air and medical air purification devices for air disinfection during lung function tests.

**Waiting time between patients**

The suggested time required between visits by ERS, BTS/ARTP Guidelines is 30 min for a regular side room and 60 min for a negative isolation room. The Portuguese Society recommends a period time of 60 minutes between visits and the Nebraska medical center specifies that the operating room must be closed for 1 hour after the visit.
Interesting suggestions come from ITS/AIPO \textsuperscript{19} and SPLF \textsuperscript{9} Guidelines that recommend a new calibration of the spirometer after the cleaning procedures, and from ERS \textsuperscript{17}, the only Society that takes into account high-risk patients, that suggest performing a remote test with live video instructions in these subgroups of patients.

A plan to manage the respiratory issues of people with acute respiratory symptoms, pre-existing chronic lung diseases or conditions that need adequate pulmonary function assessment to be appropriately diagnosed and treated, is essential to prevent an inevitably indirect effect of COVID-19 on frail patients that could be devastating, increasing death and disability.

\textit{Manufacturers’ policies}

Manufacturers’ policies\textsuperscript{26-29} are summarized in Table 2.

\section*{DISCUSSION}

The COVID-19 pandemic completely changed the routine of providing health-care services, shifting from elective to essential/acute management and limiting several diagnostic resources for chronic respiratory patients such as pulmonary function labs and sleep labs \textsuperscript{30}. We analyzed Society-specific clinical practice Guidelines on how to safely perform PFTs and the recommendation level of consensus for each clinically relevant problem; we found similarities but also several differences. In particular, the Societies’ Guidelines on spirometry during the COVID-19 outbreak differ greatly in relation to the subgroup of patients that need to be prioritized for testing.

The Guidelines agreed about prioritizing patients with urgent need to initiate treatment and pre-operative assessment, except Cleveland \textsuperscript{21}, which takes into account also pulmonary hypertension patients, IRS/SIP \textsuperscript{20}, which also considered patients with a diagnosis of pulmonary fibrosis and follow-up and for therapy prescription, as well as patients with a
diagnosis of asthma and COPD, and Uruguayans\textsuperscript{18} Guidelines, providing indications also for pneumoconiosis and drug toxicity.

We identified a recommendation level of consensus on patient screening, on HCWs protection, and on the use of in-line filters for spirometry, but a little reference to adequate ventilation policies. No details on PPEs that should be worn by the triage personnel were found, as well as no indications on how to safely perform spirometry using point of care portable spirometers with turbines in any National and International Guideline. ERS\textsuperscript{17} and BTS/ARTP\textsuperscript{12} Guidelines provided detailed information on when to perform PFTs in patients with a previous COVID-19 pneumonia, while IRS/SIP\textsuperscript{20} and ITS/AIPO\textsuperscript{19} Guidelines strongly recommend nasopharyngeal swab testing before the visit, probably taking into account only in-patients. The Chinese task force\textsuperscript{5} and ITS/AIPO\textsuperscript{19} Guidelines, interestingly, recommend providing an educational video on how to perform PFTs in the waiting rooms. ERS\textsuperscript{17} is the only Society that suggests the possibility of remote testing in very severely ill patients, “untethering” them from physical sites, promoting decentralized medical services. Manufacturers concentrate on in-detail technical issues, such as the type of in-line filters to be used or the cleaning procedures for the equipment of each product.

This review provides a summary of clinical practice Guidelines/Recommendations/Position Papers on practical problems that might arise worldwide during the safe reopening of respiratory outpatient services during COVID-19 pandemic, with a special focus on spirometry, but does not represent a Guideline itself.

The main strength of this research is that all the reviewed Guidelines were published in the restricted time period of the COVID-19 outbreak, with publication dates ranging from 4, March 2020 to 12, May 2020. Therefore, the scientific evidence available when they were developed was almost the same for them all.
Differences in national healthcare systems, resource availability and different times of epidemic evolution might explain any dissimilarity in terms of consensus. However, the lack of specific COVID-19-related evidence could be another reason for heterogeneity of the Guidelines, mainly based on experts’ opinions rather than evidence-based recommendations. Furthermore, national and international recommendations may overlap due to the contribution of national representatives who possibly served also as the international experts in the Societies’ statement. Finally, although we have searched for national guidelines on spirometry resumption in four common languages (English, Spanish, French and Italian) we might have failed to detect recommendations of some Societies due to language restrictions.

CONCLUSION

The review of Guidelines/Recommendations/Position Papers indicate a good agreement in the need to prioritize patients for PFTs, patients screening, HCWs protection, and in the use of in-line filters for spirometry but poor consensus on the subgroup of patients considered a priority, and few indications on the measures to implement for adequate ventilation. We believe that this summary of the available literature may be a useful guide helping HCWs to select appropriate measures, tailored to the highly specific context in which they will be used, to meet the needs of intended users.

Authors’ contribution: CC conceived the content, drafted the manuscript and approved the final version to be submitted. PI drafted the manuscript, approved the final version to be submitted. RC, SN, helped in writing the manuscript and approved the final version to be submitted. AS helped in writing the manuscript, revised it critically for important intellectual content and approved the final version to be submitted. NC conceived the content, revised it critically for important intellectual content and approved the final version to be submitted.

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<table>
<thead>
<tr>
<th>ISSUES</th>
<th>PROPOSED SOLUTIONS</th>
</tr>
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<tbody>
<tr>
<td>CHINESE TASK FORCE</td>
<td>SPLF</td>
</tr>
<tr>
<td>04/03/2020</td>
<td>17/03/2020</td>
</tr>
<tr>
<td>Eligible patients</td>
<td>U/ET tests for Dx of current illness COPD/Asthma: postpone or use PFM</td>
</tr>
<tr>
<td>Post- COVID-19 pneumonia</td>
<td>- Normal BT (&gt; 3d) · - Sx improvement · - Imaging improvement · - 2 consecutive negative swabs</td>
</tr>
<tr>
<td>Social Distancing/ Prevention</td>
<td>Pts wear mask Hand Hygiene</td>
</tr>
<tr>
<td>Trace suspicious cases</td>
<td>Risk assessment questionnaire BT detection</td>
</tr>
<tr>
<td>HCWs protection</td>
<td>PPE: · mask · eye protection · gloves Hand hygiene before and after gloves use Attention to medical staff health</td>
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<tr>
<td>Testing and equipment</td>
<td>1 exam at time Disposable BVF</td>
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Table 1: Issues related to safely performing pulmonary function test and proposed solutions by National/International Organizations.
Technician sit in the same direction, never in front of pts
Separate test/ admin area
Edu program and Telematic report

<table>
<thead>
<tr>
<th>Technician sit in the same direction, never in front of pts</th>
<th>Portable individual patient dedicated spirometers</th>
<th>Telemedicine for high-risk O/P Recalibrate the equipment after decontamination Separate test/ admin area</th>
<th>Disposable nose-clips Technician sit in the same direction, never in front of pts Recalibrate the equipment after decontamination Edu program Separate test/ admin area</th>
<th>BD test: pts' salbutamol inhaler or a single-use inhaler or aero-chamber Separate test/ admin area</th>
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</thead>
</table>

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<tr>
<th>Room ventilation</th>
<th>160 l/s for each pt for hour if natural ventilation 12 ACH for hour if negative room Turn off the A/C</th>
<th>Ventilated rooms to avoid recirculation</th>
<th>Room closed for 1 h after the procedure</th>
<th>30 min for isolation room with 10-12 ACH 60 min for side room with 6 ACH</th>
<th>15 min open windows closed doors 15 min open windows closed doors</th>
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<tr>
<th>Environment and surfaces cleaning</th>
<th>Clean external instruments twice with 75% ethanol for 3 min Sanitize the environment at least BID UV light room decontamination for &gt;30 min</th>
<th>Wiping down surfaces with appropriate cleaners</th>
<th>Wiping down surfaces with appropriate cleaners</th>
<th>Minimal furniture cleaning solutions: Alcohol 60-70 °, 0.5% hydrogen peroxide or disposable wipes, hypochlorite 0.1%</th>
<th>Clean contact parts with appropriate wipes between pts Super Sani-Cloth germicidal disposable wipes (PDI, Woodcliff Lake, N.J) for hard surfaces Sani-Cloth AF3 for glass and other clear surfaces</th>
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</thead>
</table>

<table>
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<tr>
<th>Wait time between patients</th>
<th>60 min</th>
<th>30 min</th>
<th>60 min</th>
<th>30-60 min</th>
<th>30-60 min</th>
</tr>
</thead>
</table>

List of Abbreviations:
- 30d: 30 days
- A/C: air conditioner
- ACH: air changes per hour
- Admin: administrative
- AET: Asociacion de Especialistas en Enfermeria del trabajo
AEC: Asociacion de Enfermeria Comunitaria
AS: Asymptomatic
ARTP: Association for Respiratory Technology and Physiology
ATS: American Thoracic Society; ANZSRS: Australian and New Zealand Society of Respiratory Science Ltd
ANZSRS: Australian and New Zealand Society of Respiratory Science Ltd
BD-Test: Post Bronchodilator test
BID: twice a day
BT: Body Temperature
BTS: British Thoracic Society
BVF: Bacterial/viral filter
CA: Cancer Patients
CF: Cystic fibrosis
CLEVELAND: Respiratory Institute Cleveland Clinic
COPD: Chronic Obstructive Pulmonary Disease
CS: Cardiac Surgery
CTX: chemotherapy
Dx: diagnosis
ecdc: European Centre for Disease Prevention and Control
Edu program: Educational program
ERS: European Respiratory Society
ET: essential
FFP: filtering face piece
F/U: follow up
HCWs: Health Care Workers
HEF: High Expiratory Flow
HEPA: High Efficiency Particulate Air filter
I/P: inpatients
ID: Immunocompromised patients
ILD: Interstitial Lung Diseases
IRS/SIP: Italian Respiratory Society/Società Italiana di Pneumologia
IST: Immunosuppressive Therapies
ITS: Irish Thoracic Society
ITS/AIPO: Italian Thoracic Society/Associazione Italiana Pneumologi Ospedalieri
LR: Lung Resection
LTC: long-term conditions
LTP: Lung Transplant Patients
Min: minutes
O/P: outpatients
OS: Oncological Surgery
PAH: Pulmonary Arterial Hypertension
PFM: Peak Flow Meter
PFTs: Pulmonary Function Tests
PneumoTox: Pneumotoxicity
PPE: personal protective equipment
PRE-OP: Preoperative patients
Pt/Pts: patient/patients
q4h: every 4 hour
q6h: every 6 hour
RALC: Rapid Access Lung Cancer Patients
RP: Respiratory Physiologist
SEIAC: Spanish Society of Allergy and Clinical Immunology
SEPAR: Spanish Society of Pneumology and Thoracic Surgery
Sx: symptoms
SPLF: Société de Pneumologie de Langue Française
SPP: Sociedade Portuguesa de Pneumologia (SPP)
SUNEUMO: Sociedad Uruguaya de Neumología
TAS: Thoraco-Abdominal Surgery
TR: Telematic Reports
TSANZ: Thoracic Society of Australia and New Zealand
U: urgent
US: Urgent Surgery
UV: ultraviolet
Wks: weeks
Table 2: Issues related to safely performing pulmonary function test spirometry manufacturers’ proposed solutions.

<table>
<thead>
<tr>
<th>Issue</th>
<th>PROPOSED SOLUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cleaning and infection control</strong></td>
<td><strong>Vitalograph</strong> 26&lt;br&gt;New BVF for each pt&lt;br&gt;Clean the exterior surface with a 70% isopropyl alcohol solution&lt;br&gt;The interior of the patient circuit requires no decontamination between tests&lt;br&gt;If internal contamination is suspected, follow appropriate protocol</td>
</tr>
<tr>
<td><strong>HCWs protection</strong></td>
<td><strong>PPE:</strong>&lt;br&gt;- surgical mask&lt;br&gt;- disposable gloves</td>
</tr>
<tr>
<td><strong>Minimum wait time between patients</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Ventilation</strong></td>
<td><strong>Air ventilation and sterilization</strong></td>
</tr>
<tr>
<td><strong>Critical issue</strong></td>
<td><strong>Measurements are influenced by the filter's resistance.</strong></td>
</tr>
</tbody>
</table>
**List of Abbreviations:**
BVF: Bacterial Viral Filter
HCWs: health-care workers
ID: Immunocompromised patients
PFTs: Pulmonary Function Tests
PPE: personal protective equipment
Pt: patient
References


