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KEY UPDATES
Updated December 2021

Updates have been made throughout the entirety of this handbook. Please especially note the following list, bolded items, and the Appendices.

1. Guidance on Use of Occupational Spirometry During the COVID-19 Pandemic has been updated and included at the start of this handbook.
2. The 2019 ATS/ERS Standardization of Spirometry Update has been incorporated throughout this BTMed Handbook4.
   a. Section III. Relative Contraindications is expanded.
   b. Pre-test procedures updated.
   c. Testing procedures updated.
3. The 2020 ACOEM Guidance Statement on Spirometry in Occupational Health has been incorporated throughout this BTMed Handbook5.
4. Test procedures have been updated. Of note, procedure #10 has been updated.
   a. There is no longer a minimum length of exhalation. Rely on the curve shape; no exhalations greater than 15 seconds.4,5
5. Best practices updates include ensuring patient data is recorded appropriately. Use sex at birth when choosing whether reference values should be male or female.10
   a. APPENDIX 2 – BTMed Spirometry Screening Form has been updated to reflect this change.
6. Spirometry test quality has changed. FVC and FEV1 Quality Grade for adults now use the same scoring system but are graded separately. A new grade of U is included, which indicates that only usable but not acceptable measurements were obtained.4
GUIDANCE ON USE OF SPIROMETRY DURING COVID-19 PANDEMIC

This guidance is based on recommendations of several professional organizations. Most comes from guidance from the July 20201 and August 20212 updates from the American College of Occupational and Environmental Medicine (ACOEM). As new recommendations are made available, this guidance document may change to concur.

**Absolute contraindications to spirometry**

A patient with COVID-19 symptoms or flu-like symptoms should **not undergo spirometry**. In general, patients who have tested positive recently for SARS CoV2 should not be tested for 30 days post infection.1 Specifically, however, testing should not occur until at least 10 days have passed – or 20 days for patients with severe COVID-19 or who are severely immunosuppressed - since first onset of symptoms and symptoms have resolved, or since the first positive test for those who tested positive but are asymptomatic3.

**Precautions Guidance**

NOTE: See APPENDIX 1 – This appendix is an excerpt from the ACOEM 2021 Interim Recommendations for Protective Measures by Risk Tier2. This figure outlines the different exposure control strategies for spirometry testing, along with either serious (yellow) or strong (red) recommendation for use. BTMed believes these are appropriate recommendations for safely performing spirometry during the COVID-19 pandemic as of November 2021.

Organizational

- Weigh the risks and benefits of spirometry. Screen patient referrals and prioritize patients for essential tests only.1-3
  - Only perform spirometry tests that are essential for immediate diagnostic or treatment of current illness.
  - You may consider completing testing for patients not considered vulnerable if the lab has implemented the following significant safety precautions for the protection of other patients and clinic staff.
- Triage patients carefully for COVID-19 status.
  - Screen patients and caregivers telephonically or through the EMR for COVID19 symptoms, previous exposure, and prior COVID19 testing.
  - Pre-screen patients as they arrive at the clinic.
    - Postpone testing if patient is showing any symptoms of COVID19.
- Reorganize waiting areas.
  - If able use separate waiting rooms for symptomatic vs. well patients.
  - Consider accepting only one patient at a time if unable to provide separate waiting rooms.
- Reorganize testing rooms and staff offices to minimize transmission of the virus.
- Reorganize testing schedules to include extra time for post-test cleaning/decontamination procedures of the surfaces of the test equipment and environment, **allow at least 30 minutes**
to ventilate the room (open windows, closed doors) and for personal protective equipment (PPE) donning and doffing. Recalibrate the lung function equipment after decontamination.

- Roster staff to provide support to fellow staff for donning / doffing procedures.
- Signs/Screening should be at entry and at the front desk informing patients of protocols / masking.
  - Protocols/masking should be discussed with patients during pre-visit screening call.¹

Testing and Equipment

- Spirometry should be performed in a separate room or isolation tent. Allow for sufficient time between patients to allow the ventilation system to adequately clear respirable particles. While the actual amount of time will vary depending on the specific environment, waiting a minimum of 30 minutes after test for the next patient in an environment with 12 air changes per hour and HEPA filtration would be appropriate².
- Exercise testing, nebulization, bronchial challenge tests, and other aerosol generating procedures should be limited to specific equipment and testing rooms.
- Test should always be carried out with a high specification disposable in-line bacterial and viral filter in place (We recommend filters with minimum proven efficiency for high expiratory flow of 600 to 700 L/min). Use of disposable combined mouthpieces/sensors is not recommended at this time. The exception would be where an additional filter can be added to the patient circuit and not degrade the measurements.¹⁻³
- Where reusable items are utilized, they should be managed carefully and should be thoroughly cleaned as recommended by local infection control policy.

Protection of Staff Performing PFTs

- We recommend the use of N95 respirators or equivalent/higher level of respiratory protective device²⁻³. The duration of use of protective masks should comply with local policy.
- Hand hygiene protocols for patient and staff as per local policy, before and after glove use.
- Only the patient and technician should be in room when testing is conducted.
- Maintaining social distancing should continue between tech and patient as best able.
  - Tech should remain out of direct plume of exhaled air.

Cleaning and Infection Control

- Patients should wear masks and sit a minimum of 6 feet from the next person or as guided by local policy.
- Patients and staff should wash hands for 20 seconds or use sanitizing gel (greater than 70% alcohol) prior to and at the end of testing.
  - Hand sanitizing stations should be made available for patient use to include common areas.
• Implement strict infection control and cleaning protocols as per local policy. Between each patient wipe down the spirometer, all cables, and all high touch surfaces with sanitizing wipes.
  o Please consider that patients with lung disease can be sensitive to strong odors in cleaning products.
  o Recalibrate equipment after decontamination, if appropriate.
• Adequate room ventilation (negative pressure in testing areas if available). Close door and let room air be exhausted.

Recommendations from professional organizations

American College of Occupational and Environmental Medicine Guidance
• 2021 - ACOEM Guidance Statement on Occupational Spirometry and Fit Testing in the COVID-19 Era
• 2020 - ACOEM Guidance Statement on Occupational Spirometry and Fit Testing in the COVID-19 Era

American Thoracic Society (ATS)
• Guidance: Restoring Pulmonary and Sleep Services as the COVID-19 Pandemic Lessens
• Pulmonary Function Laboratories: Advice Regarding COVID-19
  https://www.thoracic.org/professionals/clinical-resources/disease-related-resources/pulmonary-function-laboratories.php
BACKGROUND

Participants in the BTMed national screening program have worked in jobs where they potentially experienced exposure to a variety of different respiratory hazards that include asbestos, silica, beryllium, and welding fumes, among others. These exposures can result in conditions such as Chronic Obstructive Pulmonary Disease (COPD), Asbestos-related lung disease (including Asbestosis), Silicosis, Chronic Beryllium Disease, or even lung cancer. Spirometry is a useful tool to understand whether there are any signs of these conditions, which can prompt referral for additional evaluation and may also help a participant in evaluation for possible benefits under the Department of Labor’s Energy Employees Occupational Illness Compensation Program Act (EEOICPA).

Spirometry is used to measure lung function volume during forced breathing maneuvers. The important measurements include forced vital capacity (FVC) or the greatest volume of air exhaled from a maximal inspiration to a complete exhalation, the forced expiratory volume in one second (FEV1) or the volume of air exhaled in the first second of a FVC maneuver, and the ratio between these two values (FEV1/FVC).

BTMed expects its spirometry providers to maintain high quality spirometry equipment, capable of performing at the levels expected to be in line with recommended guidelines for technique and interpretation. All procedures will conform to current American Thoracic Society (ATS) guidelines. Test results will be compared to predicted and lower limit of normal values determined from the third National Health and Nutrition Examination Survey (NHANES III) also known as Hankinson 1999 reference equations.

This handbook is meant to serve as a guide for performance of spirometry for BTMed participants. The guidance here is based on current field spirometry practices of the National Institute for Occupational Safety and Health (NIOSH), with references to the recommendations of the ATS and the American Association for Respiratory Care (AARC). If any of the contraindications or performance characteristics at an individual spirometry lab are more conservative than those mentioned in the guide, please contact the BTMed Medical Director to discuss those discrepancies.
INDICATIONS

Spirometry is used to detect obstructive, restrictive, and mixed lung function patterns. Additionally, it enables measuring the effect of a disease on lung function, monitoring disease course or the result of therapeutic interventions, and determining a prognosis for many pulmonary conditions.4

ABSOLUTE CONTRAINDICATIONS – DO NOT PERFORM SPIROMETRY

1. Systolic Blood Pressure >180 or Diastolic Blood Pressure >110 mmHg or pulse rate >110 beats per minute.7
2. Unstable angina8,9(cardiac chest pain at rest or escalating; angina not controlled with medication).
3. Current hemoptysis of unknown origin (coughing up blood).8,9
4. Unrepaired brain arterial aneurysm.8,9

RELATIVE CONTRAINDICATIONS4 – Consider seeking physician guidance prior to performing Spirometry

1. Due to increases in intrathoracic and intraabdominal pressure:
   a. Current Pneumothorax (collapsed lung) – Can be performed 2 weeks after successful treatment.9
   b. Recent thoracic, abdominal, or brain surgery within the last 1-2 months – Adequate healing may require up to 6 weeks. Perform at least 6 weeks postoperatively.9
   c. Abdominal surgery within 4 weeks
   d. Late-term pregnancy
2. Due to increases in intracranial and intraocular pressure:
   a. Recent eye surgery within the last 3 months – Eye surgery may require 6-12 weeks for optimal recovery, depending on surgical procedure. For LASIK surgery, spirometry can occur after 1 month.9
   b. Repaired and stable prior cerebral aneurysm
   c. Brain surgery within 4 weeks
   d. Recent concussion with continuing symptoms
3. Due to increases in myocardial demand or changes in blood pressure:
   a. Systemic hypotension
   b. Significant atrial/ventricular arrhythmia
   c. Noncompensated heart failure
   d. Uncontrolled pulmonary hypertension
   e. Acute cor pulmonale
   f. Clinically unstable pulmonary embolism
   g. History of syncope related to forced expiration/cough
4. Due to increases in sinus and middle ear issues:
   a. Sinus surgery or middle ear surgery or infection within 1 week
5. Infection control issues:
a. Active or suspected transmissible respirator or systemic infection, including tuberculosis
b. Physical conditions predisposing to transmission of infections, such as significant secretions or oral lesions or bleeding
6. Patient experiences pain during the spirometry procedure
7. Patient who is unable to understand or follow directions

NOTE: See APPENDIX 2 for a BTMed Spirometry Screening Form that can be used to document screening for contraindications.

CONDITIONS THAT MAY AFFECT OPTIMAL TEST PERFORMANCE
Test can be completed, but if able to schedule at a time when the condition is resolved, results may be of higher quality.

1. Acute disorders including chest, back or gastrointestinal (GI) distress/discomfort – May indicate an underlying acute issue or affect subject performance during testing.
2. Oral or facial pain exacerbated by a mouthpiece – May interfere with an air-tight seal.
3. Stress incontinence – Performance of a forced maneuver may trigger an episode of incontinence.
4. Dementia, altered mental status, confusion – May be unable to make an optimal effort for adequate testing.
5. Recent use of medication that affects the airway. Per the American Thoracic Society, “The decision to withhold long- and short-acting bronchodilators before testing is a clinical one determined by the referring healthcare professional. If the study is performed to diagnose an underlying lung condition, then withholding bronchodilators before testing is useful” (p.e76)  

ATS recommends the following withholding times for inhaled medications⁴:
- Short-acting beta agonists (ex. Albuterol) – 4-6 hours
- Short-acting muscarinic antagonists (ex. Ipratropium) – 12 hours
- Long-acting beta agonists (ex. Salmeterol, formoterol) – 24 hours
- Ultra-long-acting beta agonists (ex. Indacaterol, vilanterol) – 36 hours
- Long-acting muscarinic antagonists (ex. Tiotropium, umeclidinium) – 36-48 hours

The technician should ask the subject if any of these contraindications are present and document in the subject’s medical record. If any of the absolute contraindications are present, the technician should NOT proceed with the test. If a relative contraindication is present, the technician will determine if there is a significant health risk that would limit optimal testing before proceeding with the test.

NOTE: If the technician is considering cancelling the test, they should discuss this with the supervising clinician.
DESCRIPTION OF EQUIPMENT MAINTENANCE

Spirometry should be conducted in a private space, and the ambient temperature will be maintained between 17 and 40°C (62.6-104°F).4

At the test site

1. Calibrate spirometers per manufacturer recommendations and verify them to be in correct operating condition. Verify that software parameters are correctly defined.
2. Set up equipment and connect cables; connect power cords to grounded electrical receptacles.
3. Record room temperature and barometric pressure.
4. Perform volume calibration and leak check per NIOSH recommendations either automatically or manually using 3-Liter syringe (repeat after every 4 hours of testing) according to specifications according to the manufacturer recommendations.10
5. Perform biological control test at beginning and end of each testing session.

PRE-TEST PROCEDURE

1. Measure and record height and weight of subject (preferably without shoes).
2. Measure and record blood pressure and pulse rate of. Record blood pressure.
   a. If blood pressure or pulse rate is a contraindication for spirometry (Systolic Blood Pressure >180 or Diastolic Blood Pressure >110 or pulse rate > 110 beats per minute), explain to the subject that their blood pressure or heart rate is too high to safely perform the test currently7. Advise the subject to seek guidance from their physician.
   b. If blood pressure or pulse rate are elevated (Systolic Blood Pressure between 120 and 180, or Diastolic Blood Pressure between 80 and 110, or pulse rate between 100 and 110 beats per minute) and the test can still be performed – do perform the test7. Advise the subject to recheck their measurements within a week and, if still elevated, to seek guidance from their physician.
3. Perform and document pre-test screening for contraindications. An optional form is provided for this in Appendix 2.
4. Do not perform test if any absolute contraindications are present.
5. Ensure testing is performed in a quiet and comfortable environment.
   a. Drinking water should be made available.4
6. Tissues or paper towels should be offered to help patients deal with secretions.4

TEST PROCEDURES

1. Explain the purpose of the examination and the need for maximal effort from the subject to get accurate results. Tell the subject, ‘I want to measure how much air you can blow out and how fast you can blow it out.’
2. Ask the subject to loosen any tight clothing.
3. Perform spirometry in an erect seated position in a chair with arms (to prevent falling sideways should syncope occur), with the shoulders slightly back and chin slightly
4. Demonstrate a deep inspiration and proper placement of the mouthpiece.
5. Blast out a full breath of air in a demonstration of the effort and length of time you expect the subject to blow.
6. Prepare the spirometry system for collection.
7. Place nose clip on subject’s nose. Clips may be removed between trials. If the nose clip falls off or is uncomfortable, ask the subject to hold their nose during the FVC maneuvers.
8. Encourage the subject to sit up straight and not lower chin or bend over. Emphasize not straining with the neck but pushing from the belly and diaphragm.
9. Give the following instructions (enthusiastic coaching is required, shouting is not):
   a. ‘Take the largest breath of air that you can inhale.’
   b. ‘Quickly blast your air into the tube as hard and fast as you can.’
   c. ‘Keep on blowing out the same breath of air until I tell you to stop or for as long as you can.’
   d. Coach: ‘Keep blowing, keep going, almost there,’ until a plateau is observed.
   e. ‘You can stop now.’
   f. ‘Okay, now catch your breath.’
10. Review the procedure and correct any problems at the end of each trial. Flow-volume curves should have sharp peak flows and volume-time curves must have a plateau and after exhalation. Record your impression of the subject’s effort at the end of each trial.
   a. NOTE: There is no longer a minimum length of 6 seconds for exhalation. ATS now uses the term “end of forced expiration” (EOFE) to describe how to assess what previously was termed “end of test” (EOT). To meet EOFE criteria now, exhalation should either:
      i. Plateau (meaning that there is ≤25 ml/s of flow)
      ii. Be stopped at 15 seconds (if exhalation still has not plateaued)
      iii. Have a repeatable FVC (within 150 ml)

Patients who are young, have restrictive impairment, or small thoracic cavities may exhale less than 6 seconds due to their high elastic recoil. This should not be considered a quality violation. With software upgrade those curves will now be marked as “acceptable”.
11. Continue testing until at least three acceptable trials are completed and the repeatability criteria are met (where the top two highest values for FEV1 and FVC are within 150 ml of each other) up to a maximum of eight trials have been performed, or until the subject cannot or should not continue - whichever comes first (see Appendix 3 for acceptability and repeatability criteria). Examples of acceptable maneuvers and common errors can be viewed at https://www.cdc.gov/niosh/docs/2011-135/. Additional technical resources are included in the section ONLINE SPIROMETRY QUALITY AND TRAINING RESOURCES of this handbook.
QUALITY ASSESSMENT

Equipment

Each testing site is responsible for maintaining equipment and calibration. BTMed recommends that sites maintain records of calibration results, equipment repairs or modifications, dates of software and hardware changes, and the dates and location of equipment use. Periodically, the accuracy and repeatability of the spirometers should be evaluated over a range of mechanically-simulated exhalation maneuvers.4

Test Quality

If automatic quality grading is available on the spirometer, please activate it and report it. The goal is to obtain A and B level quality spirometry, according to current NIOSH specifications. The grades are often assigned using the following definitions:4

- FVC and FEV1 Quality Grade for adults now use the same scoring system but are graded separately:
  - A = at least three acceptable trials, highest two values match within 150 ml (or within 50 ml if highest from last trial)
  - B = two acceptable trials, highest two values match within 150 ml
  - C = at least two acceptable trials, highest values match within 200 ml
  - D = at least two acceptable trials, highest values match within 250 ml
  - E = at least two acceptable trials, highest values greater than 250 ml
    - Or only one acceptable trial
  - U = 0 acceptable AND at least one usable trial
  - F = no acceptable trials and no usable trials

NOTE: Although some maneuvers may be acceptable or usable at grading levels lower than A, the overriding goal of the operator must be to always achieve the best possible testing quality for each patient.

The quality of all spirometry tests is reviewed by BTMed staff. Quality control reports are generated and provided to spirometry clinical sites. If coaching deficiencies are identified during this review, clinical site directors should consider providing additional training to their technicians.

NOTE: See Quality Assessment in APPENDIX 3 for information about test acceptability, usability, and repeatability, and for a helpful graphic see APPENDIX 4 – Quality Assessment Criteria Graphic.

SAFETY PROCEDURES

1. To prevent electrical shock, all equipment will be plugged into a grounded electrical outlet.
2. Infection control measures:
a. When a volume spirometer is used, a clean hose or mouthpiece filter will be used for each subject.
b. Only disposable mouthpieces should be used.
c. Mouthpieces are handled only by the subject.
d. Spirometers and accessories will be cleaned and disinfected daily.

3. Ideally, technicians will have successfully completed a NIOSH spirometry training course or be a Certified Pulmonary Function Technician through the National Board of Respiratory Care and will have been supervised while testing 20 subjects by a trained and experienced technician.

4. Subjects in wheelchairs may perform the test while seated in their wheelchairs. Wheelchair wheels must be locked prior to testing.

5. Encourage subjects to sit for the test, the expected practice for BTMed participants.

EMERGENCY PROCEDURES

1. Spirometry clinical sites should have an emergency plan in place to handle patient care issues requiring an escalated level of care. This should include:
   a. Instructions to call 911.
   b. Arrangement information for transportation to the nearest hospital.
   c. Address and telephone number for the nearest hospital emergency room.

2. A subject who feels faint during testing will be allowed to rest in a seated position and encouraged to lower their head towards their knees and to breathe slowly and deeply until recovered.

3. Contact BTMed to notify the national office if a medical emergency occurs in the context of performing spirometry at 1-888-464-0009 (Kim Cranford, RN) or 1-800-866-9663 (Anna Chen).
ONLINE SPIROMETRY QUALITY AND TRAINING RESOURCES

General Guidance on Performance of Spirometry

- AARC Clinical Practice Guideline
  https://www.aarc.org/resources/clinical-resources/clinical-practice-guidelines/
  o This document describes spirometry procedure, indications, contraindications, hazard / complications, and assessment of test quality.

- ATS/ERS Task Force: Standardisation of Spirometry 2019 Update.
  o This document describes the standards of spirometry testing for both the American Thoracic Society (ATS) and the European Respiratory Society (ERS). It includes a description of the measured values, quality control measures, and flow loop examples.

- ACOEM Guidance Statement: Spirometry in Occupational Health 2020
  o This document provides useful information for all users of spirometry test results and discusses equipment performance, conducting tests, comparing results with reference values, and evaluating results over time.

- Update on Contraindications for Lung Function Testing, Thorax 2011
  https://thorax.bmj.com/content/66/8/714
  o A publication that discusses different absolute and relative contraindications for Spirometry.

Training Guidance

- NIOSH Spirometry Poster
  o This document provides concise information on how to identify and correct technical and equipment errors encountered during spirometry testing. Graphic examples and descriptive text enable easy identification of testing problems.

- NIOSH Spirometry Quality Assurance: Common Errors and their Impact on Test Results
  https://www.cdc.gov/niosh/docs/2012-116/default.html
  o This booklet describes technical criteria for normal spirometry testing procedures, quality assurance guidelines, and 12 common errors of testing. Each error includes a description of the problem, typical values, identification criteria, implications for test results, and solution.
• NIOSH Spirometry Training Program
https://www.cdc.gov/niosh/topics/spirometry/training.html
  o This website lists all the approved NIOSH-sponsored spirometry courses throughout the United States, has additional training materials, and links to essential components of a quality spirometry program.

• NIOSH Spirometry Training Guide
https://www.cdc.gov/niosh/docs/2004-154c/
  o This guide is intended for individuals who are responsible for conducting spirometry in the workplace, including physicians, nurses, and other health professionals. It is an adjunct training guide that is not a self-instructional package.

• NIOSH Spirometry Training Courses
https://www.cdc.gov/niosh/topics/spirometry/training.html
  o This website provides a list of NIOSH-approved spirometry courses, locations, and schedules.

• NIOSH Learning Curves Spirometry Testing Training Video
https://www.cdc.gov/niosh/docs/video/2017-167/
  o This spirometry training video provides information on how to correctly administer a spirometry test using current guidelines, recognize errors, and report valid test results.

References from Professional Organizations and Predictive Values

• AJRCCM Spirometric Reference Values from a Sample of the General U.S. Population
  o This document, sometimes referred to as ‘Hankinson,’ discusses the establishment of reference values for three different race groups: Caucasians, African-Americans, and Mexican-Americans.

• NIOSH Spirometry Reference Tables
https://www.cdc.gov/niosh/topics/spirometry/nhanes.html
  o References the values for FEV1, FEV6, FVC, PEF, PEF25-75, FEV1/FVS, and FEV6/FVC for Men and Women of African-American, Caucasian, and Mexican-American descent. NHANES III reference values are the most appropriate comparison group for occupational testing in the U.S.

• NIOSH Spirometry Reference Value Calculator
https://www.cdc.gov/niosh/topics/spirometry/RefCalculator.html
  o This online calculator provides the percent predicted spirometry values based on gender, age, race, and height.
• OSHA Spirometry Testing in Occupational Health Programs
    ○ This publication describes spirometry testing, interpretation of test results, quality assurance reviews, procedures, and recordkeeping.
REFERENCE LIST


Table 1. Framework for Hazard Tiers

<table>
<thead>
<tr>
<th>Tier</th>
<th>Rates (County,* Local)</th>
<th>Patient Group; Employer/Workplace</th>
<th>Clinic Hazard Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – Background; no elevated risk</td>
<td>No unusual elevation</td>
<td>—</td>
<td>Standard precautions</td>
</tr>
<tr>
<td>1 – Low risk</td>
<td>Low</td>
<td>Low risk</td>
<td>Well-established comprehensive program</td>
</tr>
<tr>
<td>2 – Probable increased</td>
<td>Moderate</td>
<td>Higher rates than surrounding county</td>
<td>Program in place</td>
</tr>
<tr>
<td>3 – Significantly elevated risk</td>
<td>Substantial</td>
<td>Elevated risk activity or rates significantly above county rates</td>
<td>Limited program</td>
</tr>
<tr>
<td>4 – High risk</td>
<td>High or unknown but of very significant concern</td>
<td>High risk activity, extensive travel, or high consequence of infection</td>
<td>Minimal programmatic protection</td>
</tr>
</tbody>
</table>

This table provides a framework for classifying hazard level tiers (see accompanying text for details). It considers both the county rates and the characteristics of the worker population served. The clinic hazard level is based upon the clinic’s protective measures in relation to the hazard level.


Table 2. Protective Measures by Risk Tier

<table>
<thead>
<tr>
<th>Tier</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>0*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient screening/exclusion:</td>
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<tr>
<td>Defer testing</td>
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<td>Patient viral testing</td>
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<td>Symptom screening</td>
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<td>Testing facility environment:</td>
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<tr>
<td>Adequate room ventilation</td>
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<td>Expert HVAC consultation</td>
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<tr>
<td>Freestanding HEPA air filter (if ventilation inadequate)</td>
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<tr>
<td>Air disinfection (e.g., UVGI)</td>
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<tr>
<td>Dedicated area</td>
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<tr>
<td>Room configuration</td>
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<tr>
<td>Room decontamination between patients</td>
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<td>Test procedures:</td>
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<td>Bacterial/viral filters</td>
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<tr>
<td>Equipment cleaning (between patients)</td>
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<tr>
<td>End-of-day cleaning</td>
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<tr>
<td>Clinical Operations</td>
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<tr>
<td>Staff vaccination</td>
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<tr>
<td>Staff N95</td>
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<tr>
<td>Face shield &amp; gloves</td>
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<tr>
<td>Staff single use gown</td>
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<tr>
<td>Dedicated technician</td>
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<tr>
<td>Reroute higher risk staff</td>
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<tr>
<td>Written protection plan</td>
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<tr>
<td>Staff education</td>
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<tr>
<td>Designated responsible manager</td>
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<tr>
<td>Compliance with OSHA ETS</td>
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<tr>
<td>Written policies</td>
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</tr>
</tbody>
</table>

This table indicates categories of preventive measures and suggests in which tiers of hazard they are recommended. Those shown in red are strongly recommended, and those shown in yellow cross-hatched should be seriously considered. More detailed descriptions of the methods are in the text [part 2]. Column “0” refers to the future when there is no outbreak, pandemic, or epidemic.
APPENDIX 2 – BTMED SPIROMETRY SAFETY SCREENING FORM

Use of this form is optional.

<table>
<thead>
<tr>
<th>Name</th>
<th>Race</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Birthdate</th>
<th>Age</th>
<th>Sex at birth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Height (nearest ½ inch)</th>
<th>Weight (pounds)</th>
<th>Blood Pressure</th>
<th>Pulse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Current Medications/Eye Drops/Inhalers *(Note also if patient has taken inhaled medications within the last 24 hours):*

<table>
<thead>
<tr>
<th>Absolute Contraindications:</th>
<th>YES</th>
<th>NO</th>
<th>Relative Contraindications:</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic Blood Pressure &gt;180 or Diastolic Blood Pressure &gt;110 mmHg or pulse rate &gt;110 beats per minute</td>
<td>☐</td>
<td>☐</td>
<td>Current Pneumothorax: spirometry can be performed 2 weeks after successful treatment</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Myocardial infarction (MI) within the last 1 month</td>
<td>☐</td>
<td>☐</td>
<td>Recent eye surgery within the last 1-3 months: Eye surgery may require 6-12 weeks for optimal recovery, depending on surgical procedure. For Lasik surgery, spirometry can occur after 1 month.</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Unstable angina</td>
<td>☐</td>
<td>☐</td>
<td>Recent thoracic, abdominal, or brain surgery within the last 1-2 months: Adequate healing may require up to six weeks. Schedule at least 6 weeks post-op</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Current hemoptysis of unknown origin (coughing up blood)</td>
<td>☐</td>
<td>☐</td>
<td>Other relative contraindications (list here) _____________________________ _____________________________</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Unrepaired brain arterial aneurysm.</td>
<td>☐</td>
<td>☐</td>
<td></td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
APPENDIX 3 – QUALITY ASSESSMENT

ATS 2019 Update Table 7– Comparison of Criteria for Acceptability, Usability and Repeatability

Table 7. Summary of Acceptability, Usability, and Repeatability Criteria for FEV\textsubscript{1} and FVC

<table>
<thead>
<tr>
<th>Acceptability and Usability Criterion</th>
<th>Required for Acceptability</th>
<th>Required for Usability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Must have BEV ≤5% of FVC or 0.100 L, whichever is greater</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Must have no evidence of a faulty zero-flow setting</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Must have no cough in the first second of expiration(^*)</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Must have no glottic closure in the first second of expiration(^*)</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Must have no glottic closure after 1 s of expiration</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Must achieve one of these three EOFE indicators:</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>1. Expiratory plateau (≤0.025 L in the last 1 s of expiration)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Expiratory time ≥15 s</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>3. FVC is within the repeatability tolerance of or is greater than the largest prior observed FVC(^\dagger)</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Must have no evidence of obstructed mouthpiece or spirometer</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Must have no evidence of a leak</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>If the maximal inspiration after EOFE is greater than FVC, then</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>FIVC – FVC must be ≤0.100 L or 5% of FVC, whichever is greater(^\ddagger)</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Repeatability criteria (applied to acceptable FVC and FEV\textsubscript{1} values)

Age >6 yr: The difference between the two largest FVC values must be ≤0.150 L, and the difference between the two largest FEV\textsubscript{1} values must be ≤0.150 L

Definition of abbreviations: BEV = back-extrapolated volume; EOFE = end of forced expiration; FEV\textsubscript{0.75} = forced expiratory volume in the first 0.75 seconds; FIVC = forced inspiratory VC.

\(^*\)Occurs when the patient cannot expire long enough to achieve a plateau (e.g., children with high elastic recoil or patients with restrictive lung disease) or when the patient inspires or comes off the mouthpiece before a plateau. For within-maneuver acceptability, the FVC must be greater than or within the repeatability tolerance of the largest FVC observed before this maneuver within the current prebronchodilator or the current post-bronchodilator testing set.

\(^\ddagger\)Although the performance of a maximal forced inspiration is strongly recommended, its absence does not preclude a maneuver from being judged acceptable, unless extrathoracic obstruction is specifically being investigated.
Spirometry Quality Criteria

Acceptability Criteria
- No hesitation or false starts
- No coughing or hiccups in first second
- No glottis closure
- No mouthpiece obstruction by tongue or dentures
- No extra breaths
- No leaks
- The volume of back extrapolation (Vext) < 5% of the FVC, or 150 ml, whichever is greater
- Volume/time curve either:
  a) plateaus
  b) does not exceed 15 sec, or
  c) has FVC within 150 ml of largest prior FVC

All 3 trials should look like this

When you have 3 trials that look like this:
- Compare the 2 largest FVC values – are they within 150 ml?
- Compare the 2 largest FEV1 values – are they within 150 ml?

Repeatability Criteria
- The two largest FVC values should agree within 150 ml
- The two largest FEV1 values should agree within 150 ml