PROFESSIONAL GUIDELINES

THE STANDARDS FOR THE PERFORMANCE AND INTERPRETATION OF OFFICE SPIROMETRY IN SINGAPORE

CHAPTER OF RESPIRATORY PHYSICIANS

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1. PURPOSE AND DEVELOPMENT OF THE GUIDELINE

Singapore has embarked on the Healthier SG journey to transform healthcare delivery, shifting emphasis towards actively promoting health[1]. The Healthier SG strategy aims to empower every individual to adopt a healthier lifestyle, go for regular health screens, and seize opportunities for early intervention to arrest disease progression.

Primary Care is often the first critical touchpoint in a patient's care journey. A key focus of Healthier SG strategy is to transform and enable Primary Care to be a pillar of the healthcare system. Respiratory symptoms such as dyspnea, cough and wheeze are common reasons for primary care consultations. Respiratory conditions such as Asthma and Chronic Obstructive Pulmonary Disease (COPD) are commonly diagnosed and managed in Primary Care clinics.

Office Spirometry is the most used pulmonary function test in the Primary Care setting to evaluate respiratory symptoms and patients with Asthma and COPD[2]. With Primary Care as the key healthcare pillar for our population with respiratory conditions, widespread use of office spirometry is anticipated. There are currently several international guidelines on spirometry and chronic respiratory conditions that differ in their recommendations on spirometry interpretation, potentially leading to confusion and variation in office spirometry interpretation and reporting[3–5]. It is therefore crucial, at this juncture, to have a Professional Guidance in Singapore on the standards for the performance and interpretation of office spirometry. These recommendations aim to raise the standards of office spirometry and respiratory diagnosis, challenge current performance and serve as an aspirational guide for delivery of this service.

The Chapter of Respiratory Physicians of the College of Physicians, Academy of Medicine Singapore ('The Chapter'), initiated the formation of a workgroup to develop the guidelines. Chapter member representatives, who are the lead and directors of the pulmonary function laboratory for their respective institution, from each healthcare cluster were invited to be part of the workgroup. Feedback from members of the Chapter of Respiratory Physicians and Chapter of Family Physicians were solicited during the development of the guidelines to ensure that the guidelines are practical for implementation nationally.

2. INDICATIONS AND CONTRAINDICATIONS

There are several indications for the performance of spirometry, such as diagnosing, monitoring, assessing disability and prognosticating respiratory related conditions. At the Primary Care setting, office spirometry is commonly used to evaluate patients presenting with dyspnea, cough and wheeze. Office spirometry is typically used to identify and monitor obstructive airway diseases such as Asthma and COPD.

Guidelines on contraindications are largely based on expert opinion[3,6,7]. In general, the guiding principle is that the information obtained from the office spirometry should be of high quality, of benefit to the patient and outweighs the risk of performing it. High quality results that are acceptable and reproducible are important pre-requisites for interpretation for clinical use. Hence office spirometry should not be ordered for patients, such as young children or patients with dementia, who cannot be instructed to perform the test appropriately.

Spirometry is a very safe procedure with minimal risk to most patients[7,8]. Some people may experience shortness of breath, lightheadedness, or dizziness during or immediately after the procedure. These side effects are usually transient and resolve uneventfully. There are several relative contraindications, mostly attributable to the forced expiratory manoeuver during performance of the spirometry test[3,6]. The medical conditions that may be adversely affected by the forced expiratory manoeuver can be broadly classified into 2 categories:

(1) Conditions that are affected by increase in myocardial demand or changes in blood pressure.

These include conditions such as acute myocardial infarction, hypotension, severe hypertension, decompensated heart failure, significant arrythmias, acute pulmonary embolism and acute cor pulmonale. These conditions should be resolved or stabilized for at least a month before the performance of office spirometry.

(2) Conditions that are affected by increase in intracranial, ocular, intrathoracic, intra-abdominal, sinus and middle ear pressures.

These include cerebral, thorax or abdominal conditions that are affected by increased pressures, for example, cerebral aneurysms and aortic aneurysms, recent surgery (within a month) of the brain, the thorax or abdomen; and recent surgery (within a

week) of the eye, sinus or middle ear[6]. Performance of office spirometry during pregnancy, especially late term pregnancy is also not recommended.

Another risk during spirometry is the potential transmission of infection. Spirometry is considered as an aerosol generating procedure due to the forced expiratory maneuver and potential coughing during test performance[9,10]. Patients with infectious diseases, such as active pulmonary tuberculosis and active covid-19 infection, should undergo testing only when they are deemed non-infectious.

Recommendations
• Office spirometry should be considered in patients with respiratory symptoms suggestive of airway diseases such as Asthma and COPD. • A review of contraindications should be performed prior to spirometry testing.

3. TEST PERFORMANCE

3.1 Selecting a spirometer

A spirometer measures changes in volume of air during inspiration and exhalation. Spirometry devices utilize various precision technologies in the measurement of air flow and volume. Most spirometers are flow-measuring devices as they are relatively cheaper and more portable compared to volume-measuring devices. There is insufficient data currently to recommend the use of a specific type of spirometry device in the office setting. Key considerations in selecting a spirometer include[3]:

- *Meeting the ISO 26782:2009 Standards*
  Spirometers should meet or exceed the ISO 26782:2009 standards, which specifies requirements for spirometers intended for the assessment of pulmonary function in humans weighing more than 10 kg.

- *Accuracy*
  Spirometers should demonstrate performance with an accuracy of within 3% and maximum permissible error of +/- 2.5%.

- *Test Quality*
  Ideally, real-time graphical display of the spirogram (flow-time curve) and flow-volume loop is recommended. This allows the testing personnel to inspect the

graphs for acceptability. Based on recommendations by the National Lung Health Education Program (NLHEP), office spirometers should also include automated manoeuvre acceptability and repeatability messages[11].

- *Ease of use*
  The spirometer should be easy to use and operate. This would determine the training requirements for the personnel conducting the test. The spirometer should also be easy to perform for a wide range of patients such as children and the elderly.

- *Infection control*
  Equipment disinfection procedures should be considered when selecting a spirometer. For example, the pneumotachograph (airflow measurement unit) would need to be removed and cleaned between patients whereas some manufacturers offer disposable alternatives.

- *Data storage & security*
  Patient data and results should be securely stored in compliance with the data protection act.

3.2 Conducting the spirometry test

- *Calibration*
  All office spirometers should undergo calibration checks or regular preventive maintenance to ensure accuracy of results. Syringe calibration checks may be required depending on device. If required, daily calibration check should be done before the start of the first test scheduled for the day. At least 3 different flow rates, ranging from 0.5L/s to 12L/s should be evaluated, ideally with a 3L-syringe. Spirometers must have a maximum permissible error of ±2.5% when tested with a 3-Litre calibration syringe. Some of the newer commercial spirometers come with disposable sensors which are pre-calibrated at time of manufacture and therefore do not require daily calibration by the operator. In these cases, we recommend that syringe linearity checks be performed based on the manufacturer's recommendations.

- *Test environment*
  Patients should perform the test in a quiet and comfortable environment that is

separate from other patients. The chair should be without wheels and adjusted to a height such that the patient's feet will be flat on the floor. The chair should also have support at the sides to prevent patients from falling. Ideally, a weather station is recommended to monitor the testing environment's temperature, humidity, and barometric pressure. These values should be entered into the spirometer's system daily (where available). All spirometry results should be recorded at BTPS (body temperature, ambient barometric pressure, saturated with water vapour).

- *Preparing the patient for the test*

  Before proceeding with the test, ensure that the patient is not unwell and there are no contraindications to performing spirometry. The test preparation should then follow:

  - Measure the patient's height (without shoes) and weight. For patients who are unable to stand upright, arm span can be used as a surrogate. This information will be used to obtain the relevant reference values for test parameters.
  - Enter the patient's height and weight, as well as their date of birth, birth sex and race into the spirometer software.
  - The patient should be seated erect, with shoulders pulled back and chin elevated to a horizontal position. A nose clip should be applied and if unavailable, the patient should manually occlude his/her nostrils.

- *Performing the test*

  There are three distinct manoeuvres during spirometry testing and must be performed to achieve a certain quality, i.e., *Acceptability* criteria, as described below:

  - Maximal inspiration

    The test begins with the patient breathing normally through the mouthpiece with the lips tightly sealed around the mouthpiece. After a series of normal breaths, the patient should be instructed to rapidly inhale to total lung capacity (TLC).

- Forceful (“a blast”) and maximal expiration

  The patient should then be coached to exhale with maximal effort rapidly (“a blast of expiration”) until no more air can be expelled. This manoeuvre measures the total volume of air exhaled, i.e., forced vital capacity (FVC). The volume of air that is forcefully exhaled during the first second of the FVC manoeuvre is known as the FEV_1. Of note, there should be minimal hesitation (< 2s) before exhalation begins. Full expiration is considered when either plateau is achieved (defined as $\leq$ 0.025L volume change in last 1 second) or expiration for a maximum of 15 seconds[3].

- Maximal Inspiration at maximal flow

  To complete the test, the patient then inspires with maximal effort back to TLC. This last manoeuvre measures forced inspiratory vital capacity (FIVC). The FIVC manoeuvre together with the FVC manoeuvre generates the flow-volume (FV) loop. Of note, if the FIVC is greater than the FVC by more than 0.100L or 5% of FVC, this suggests that the patient did not inhale fully prior to exhalation and hence FVC is likely to be underestimated[3].

- *Repeatability*

  The test is considered repeatable if the difference between the two largest FVC values is within 0.150L, and the difference between the two largest FEV1 values is within 0.150L[12]. There should be a minimum of 3 good spirometry attempts which are within the repeatability threshold. The maximal number of consecutive manoeuvres should not exceed 8 attempts for each test session to avoid fatigue.

- *Test Quality*

  The spirometry results should meet the minimal acceptability and repeatability criteria. Most spirometers provide an automated quality grading of the test results. Test results graded A, B and C can be used for interpretation.

- *Bronchodilator Response Testing*

  In bronchodilator response (BDR) testing, 4 puffs of 100mcg salbutamol are administered via a spacer and the spirometry test is repeated at least 15 minutes after. In general, the Chapter recommends BDR testing to be performed for the diagnosis of suspected airway disease (see Section on Interpretation).

3.3 Reporting and displaying of results

Spirometers should record and display values for FEV_1, FVC, FEV_1/FVC ratio in standard units and with appropriate reference values. Spirometers should also display the test quality grading. Some office spirometers may report FEV_6 as a surrogate for FVC. We recognise this as an acceptable alternative in office spirometry due to the high accuracy and concordance of FEV_1/FVC with FEV_1/FEV_6 for the diagnosis of airway obstruction[13]. The FV loops should be displayed in the following format:

- *X-axis: Volumes recorded at 1 L/unit distance with a scale factor of 10 mm/L.*
- *Y-axis: Flow recorded at 2 L/sec/unit with a scale factor of at least 5 mm/L/sec.*

The office spirometry reports should display the demographics and reference values (see section on Interpretation). In addition, a summary narrative report should be included. (See Figure 1)

3.4 Infection control and transmission of infection

Spirometry is considered an aerosol generating procedure[9,10]. A patient with suspected or confirmed pulmonary infection should defer spirometry testing until he or she is no longer infectious.

Both the operator and patient should adhere to hand hygiene practices throughout the procedure. The operator should wear disposable gloves when handling the mouthpiece, filters, and nose clips. We recommend the use of at least a surgical face mask for the operator during spirometry testing.

We encourage the use of nose clips, mouthpiece and filters that are single use and disposable. Majority of the in-line bacterial/viral filters are usually part of the mouthpiece. A filter with a minimum proven efficiency for high expiratory flow of 600-700L/min is recommended for spirometry testing during the COVID-19 pandemic and should be adhered to where relevant[10]. When utilised, high specification filters are highly effective (>99%) in the prevention of microbial transfer to the equipment and cross-contamination. Reusable parts of the spirometer should undergo cleaning and disinfection as per manufacturer's recommendations and instructions. Where applicable, the prevailing institution and/or Ministry of Health infection control guidelines should be adhered to.

Recommendations
• Office spirometry should be performed using a portable spirometer with visual display. • The selected spirometry device should be compliant with the standards for device specification and performance accuracy. • Spirometry procedure performance should achieve the acceptability criteria. • A minimum of 3 acceptable and repeatable performances should be attained. • Bronchodilator response testing should be performed in the diagnosis of airway disease. • Demographics, selected reference values, quality grading, numerical and graphical (FV loop) test results, and a summary narrative should be included in the spirometry report.

4. INTERPRETATION

4.1 Selecting the appropriate reference values

The Chapter recommends adopting the Global Lung Function Initiative (GLI) reference values for spirometry interpretation in Singapore.

Reference values of a test refers to the range of values that would be expected when the test is performed on a healthy individual. Reference values of lung function depend primarily on age, height, birth sex and ethnicity. Reference values have been generated from population studies involving healthy non-smoking individuals and individuals with respiratory illness or occupational exposures[12,14,15]. Some of these studies also provide ethnic-specific reference values[16–18]. The best available and most applicable reference values based on the patient's demographics should be selected for each patient undergoing office spirometry. At present, a universal set of reference values that is applicable to all races in Singapore is not available.

The Chapter recommends the use of the GLI reference values as the standard reference value of choice currently. The GLI reference values were generated from the largest number of spirometry records of people aged 3 to 95 years old with different ethnic backgrounds[17,19]. The most appropriate GLI ethnicity category should be selected for each individual undergoing spirometry. There are 5 ethnicity categories,

and these includes “Caucasian, Black, North-East Asian, South-East Asian and Other/mixed” categories. For individuals of Chinese ethnicity in Singapore, the GLI “South-East Asian” category should be selected. For individuals of Malay, Indian or Eurasian ethnicity, the GLI “Other/mixed” category should be selected. If the ethnicity of the individual is unknown, uncertain or not well represented by any of the 4 population-specific categories, then GLI “Other/mixed” category should be selected.

It is important that a consistent set of reference values is used in Singapore so that meaningful comparisons can be made longitudinally as well as across test sites.

4.2 Defining normality

Interpretation of spirometry is based on comparing the patient’s spirometry results with the expected normal range in the majority (e.g., 90%) of the population of similar demographics. Hence determining the normal range is important in defining an abnormal spirometry result. It is important to note that people with a result that is lower than the normal range could be normal. If we define 90% of the normal population spirometry results as “normal”, 5% of the normal population will have results below the normal range and 5% of the normal population will have results above the normal range, assuming the results are normally distributed. In interpreting abnormal spirometry results, we are concerned only with determining the lower limit of the normal range.

There are presently two methods to determine normality of the patient’s spirometric values:

- *Fixed FEV_1/FVC ratio and percent predicted values of FEV_1 and FVC*
  The fixed FEV_1/FVC ratio of 0.70 and thresholds of 80% predicted for FEV_1 or FVC are traditional cut-offs used to determine normality[20]. International guidelines on airway disease, such as the Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2023 Report[21], and the ACE (Agency for Care Effectiveness) Clinical Guidance on COPD[5], currently use fixed FEV_1/FVC ratio for identification of obstructive abnormality and percent predicted values for severity classification.

- *Lower Limit of Normal (LLN) for all spirometry indices*
  For any given patient, a normal range of values can be determined from a reference population with similar demographics. Spirometry results that are below the normal

range, i.e., below the Lower Limit of Normal (LLN) are considered abnormal. The normal range for that specific patient can be auto determined in current office spirometers once the demographics are keyed in and relevant reference values (i.e., GLI) is selected. Hence FEV_1/FVC ratio, FEV_1 or FVC values lower than the LLN are considered as abnormal.

Of note, healthy lung function is normally distributed. Statistically, the midpoint of this normal distribution is the predicted value of the person's lung function. The standard deviation (SD) from this midpoint is expressed as the Z-score. Another way of determining the LLN is having a Z-score value less than a value of -1.64. This corresponds to -1.64 SD from the predicted value, i.e., lowest 5% of the normal population. Current office spirometers report the Z-score in addition to the lower limit value for that patient. Hence to determine abnormality using LLN method, one can either compare the patient's values with the lower limit value or a Z-score that is less than -1.64.

4.3 Recommendations for the use of "Lower Limit of Normal" method

International guidelines on lung function testing[4] as well as the Global Initiative for Asthma (GINA) guidelines[22] recommend LLN method for spirometry interpretation. This contrasts with the GOLD 2023 report that recommends the fixed ratio and precent predicted values method for spirometry interpretation[21].

It is important as we embarked on HealthierSG, with anticipated widespread use of office spirometry, that the medical community is congruent in our methodology so that meaningful comparisons can be made across test sites and across time.

The Chapter recommends the LLN in the interpretation of FEV_1, FVC and FEV_1/FVC ratio, in line with the latest ATS/ERS recommendations[4]. The Chapter recognizes that the use of fixed ratio and percent predicted has been used with familiarity in Singapore for many years. While the Chapter acknowledges the use of the fixed ratio and percent predicted methodology, the Chapter cautions the use of the fixed FEV_1/FVC ratio of 0.7 and the 80% predicted FEV_1 and FVC threshold to define abnormality as this methodology is prone to erroneous classification of spirometry results. For example, fixed ratio of 0.7 may potentially result in under-diagnosis of airflow obstruction in younger patients with asthma and over-diagnosis of airflow obstruction in older patients without COPD[19].

4.4 Approach to spirometry interpretations

- *STEP 1: Assess test quality.*
  The spirometry results should meet the minimal acceptability and repeatability criteria as outlined above.

- *STEP 2: Assess the presence of airflow obstruction.*
  In office spirometry, the emphasis is first placed on determining the presence of airflow obstruction. FEV_1/FVC ratio below LLN (or z-score <-1.64) confirms the presence of airflow obstruction. FEV_1/FVC ratio above LLN excludes airflow obstruction.

- *STEP 3: Assess presence of any other abnormal ventilatory pattern.*
  FVC that is below LLN suggests either possibly restrictive or non-specific pattern. In this situation, further clinical correlation with lung volumes testing may be required. Of note, lung volumes cannot be measured on the office spirometer. If an individual's measured FVC is above or equal to LLN, there is no restrictive or non-specific pattern.

In practice, the 2 indices, i.e., FEV_1/FVC ratio and the FVC (STEP 2 & 3) are interpreted together to arrive at 4 spirometry patterns (See Figure 2):

- normal ventilatory pattern (normal FEV_1/FVC ratio & normal FVC)
- possible restriction or non-specific pattern (normal FEV_1/FVC ratio & low FVC)
- obstruction (low FEV_1/FVC ratio & normal FVC)
- possible mixed disorder (low FEV_1/FVC ratio and low FVC)

- *STEP 4: Grade the severity of the observed abnormal spirometry indices*
  The severity of spirometry abnormality is recommended to be determined based on the z-score of the measured FEV_1. Severity grading is divided into 3 grades: mild (z-score of -1.65 to -2.5), moderate (z-score of -2.51 to -4.0) and severe (z-score below -4.0). This grading system supersedes the 2005 international guidelines that was based on the FEV_1 %predicted[12]. (See Table 1)

At present, most office spirometers can display Z-scores in their spirometer's displayed report. However, there could still be some spirometers that cannot display Z-scores, thus limiting the use of the 3-scale system for severity grading. Thus, until Z-scores are routinely available in all spirometers, it is our opinion that it would still be reasonable

to adopt either the 2005 or 2021 severity grading if the clinician remains consistent in the grading scale chosen when reporting the spirometry. (See Table 1)

Some examples of conclusion statements at the end of Step 4.

- "Spirometry shows mild airflow obstruction."
- "Spirometry shows moderate ventilatory limitation which appears restrictive in pattern."
- "Spirometry shows very severe ventilatory limitation which appears mixed in pattern."

- *STEP 5: Visual inspection of the flow-volume loop*
  If visual display is available, the FV loop should be reviewed to look for patterns suggestive of fixed airway obstruction, variable airway obstruction, biphasic airway obstruction and sawtooth pattern as these patterns indicate possible lesions affecting the large airways and warrants a referral. (See Figure 3)

- *STEP 6: Assess the post-bronchodilator response (Optional)*
  The 2005 BDR criteria required the presence of both an absolute (>200mLs) and relative (>12%) increase in the post-bronchodilator FEV_1 and/or FVC when compared to pre-bronchodilator values in a single test session[12]. These criteria have been adopted by GINA[22]. However, the latest 2021 guidelines recommends that a significant BDR be defined as >10% increase in the post-bronchodilator FEV_1 and/or FVC relative to the predicted value[4]. Mathematically, the 2021 BDR criteria can be easily determined by subtracting the pre-bronchodilator FEV_1 (or FVC) % predicted from the post-bronchodilator FEV_1 (or FVC) %predicted. The approach avoids misinterpretation of BDR in relation to the magnitude of the baseline lung function, which is associated with age, height, and sex.

However, as some office spirometers are unable to automatically display the 2021 criteria, it is our opinion that it would still be reasonable to adopt either the 2005 or 2021 BDR criteria for determining presence of a significant BDR if the clinician remains consistent in the criteria chosen when reporting the BDR and is aware of the potential limitations of either BDR criteria.

Examples of conclusion statements on BDR:

- "There is no significant bronchodilator response to 400mcg inhaled salbutamol

(2021 criteria).

- "There is significant bronchodilator response to 400mcg inhaled salbutamol (2005 criteria).

Note: the clinician can additionally choose to specify the 2005 or 2021 BDR criteria used (in brackets) for clarity and for future reference when subsequent spirometry is performed.

If BDR testing is performed, it is important to also apply STEP 2 and 3 in the interpretation of post-BDR spirometry results.

Some examples of conclusion statements that includes both pre and post BDR testing spirometry results:

- "Both pre- & post-bronchodilator spirometry show mild airflow obstruction."
- "Both pre- & post-bronchodilator spirometry show severe and mild airflow obstruction respectively."
- "Pre-bronchodilator spirometry shows moderate ventilatory limitation which appears restrictive in pattern while post-bronchodilator spirometry is within normal limits."
- "Pre-bronchodilator spirometry shows very severe ventilatory limitation which appears mixed in pattern while post-bronchodilator spirometry shows mild airflow limitation."

Recommendations
• The Global Lung Initiative (GLI) reference values should be used for our local population. • The lower limit of normal (LLN) method is recommended for the determination of abnormality in FEV_1/FVC ratio, FEV_1 and FVC. • The severity of spirometry abnormality is recommended to be determined based on the z-score of the measured FEV_1. • A step-by-step approach to spirometry interpretation is recommended. • Recommended criteria for positive bronchodilator response is >10% increment in post-bronchodilator FEV_1 or FVC relative to predicted value.

5. FOLLOW UP

It is recommended to perform spirometry testing for patients with stable COPD at regular intervals, e.g., annually, to identify patients whose lung function is declining rapidly. The decision to perform a spirometry subsequently is also guided by clinical needs, e.g., assessment of patient's symptoms and prognosis[21]. In patients with asthma, an interval spirometry may be performed 3 to 6 months after the initiation of preventer therapy to assess treatment response and to document the patient's best lung function. This can be repeated periodically every 1-2 years for monitoring and ongoing risk assessment[23].

With the recommendation to use GLI reference equations in spirometry, primary care physicians may encounter the situation of different reference values used for spirometry tests that were performed over time. In such a situation, the absolute measured values of FEV_1 and FVC over time can be trended and compared. Using patient's previous absolute measured results as comparison potentially negates the limitations of differing reference values.

Recommendations
• Interval spirometry testing should be considered in assessing treatment response and disease progression. • Spirometry results should be compared with patient's historical results during follow-up if available.

6. REFERRAL

A normal spirometry result does not exclude the presence of pulmonary disease[24]. Further evaluation with radiology or complex lung function testing may be necessary if clinical suspicion of lung disease is high. For example, in patients with variable respiratory symptoms but repeatedly normal spirometry (documented on at least 2 separate occasions), bronchoprovocation testing such as a methacholine challenge test may be required to diagnose asthma[22].

Spirometry has high sensitivity and specificity in diagnosing COPD[25]. However, spirometry cannot definitively diagnose restrictive lung disease as knowledge of lung

volume subdivisions is required. In individuals with reduced FVC, and especially those with a concomitant preserved FEV_1/FVC ratio, detailed lung volumes and diffusion studies are indicated for the evaluation of possible restrictive lung disease.

In addition, abnormal FV loop pattern where the etiology is unknown, a referral to a respiratory physician for evaluation is recommended. This is especially for patterns that are suggestive of possible central airway obstruction such as variable airway obstructive patterns, fixed airway obstructive pattern, biphasic pattern and sawtooth. (See Figure 3)

In the unusual instance where the patient is unable to perform acceptable or repeatable spirometry or if there is uncertainty of potential contraindications, physicians may refer to the specialist center for consideration of alternative tests.

Recommendations
• Normal spirometry does not exclude significant pulmonary disease. Referral is recommended when there is a high suspicion of pulmonary disease, even in the presence of normal spirometry. • Referral is recommended for abnormal flow-volume loop patterns suggestive of fixed, variable, biphasic obstructive and sawtooth patterns. • Consider referral for lung volume and diffusion studies in individuals with suspected restrictive lung disorder (low FVC).

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8. FIGURES AND TABLES

Figure 1. An example of a spirometry report showing the recommended components: Demographics, Spirometry Values, Quality Grading, Reference Values, Flow-Volume Loop Graph and a Summary Narrative Report

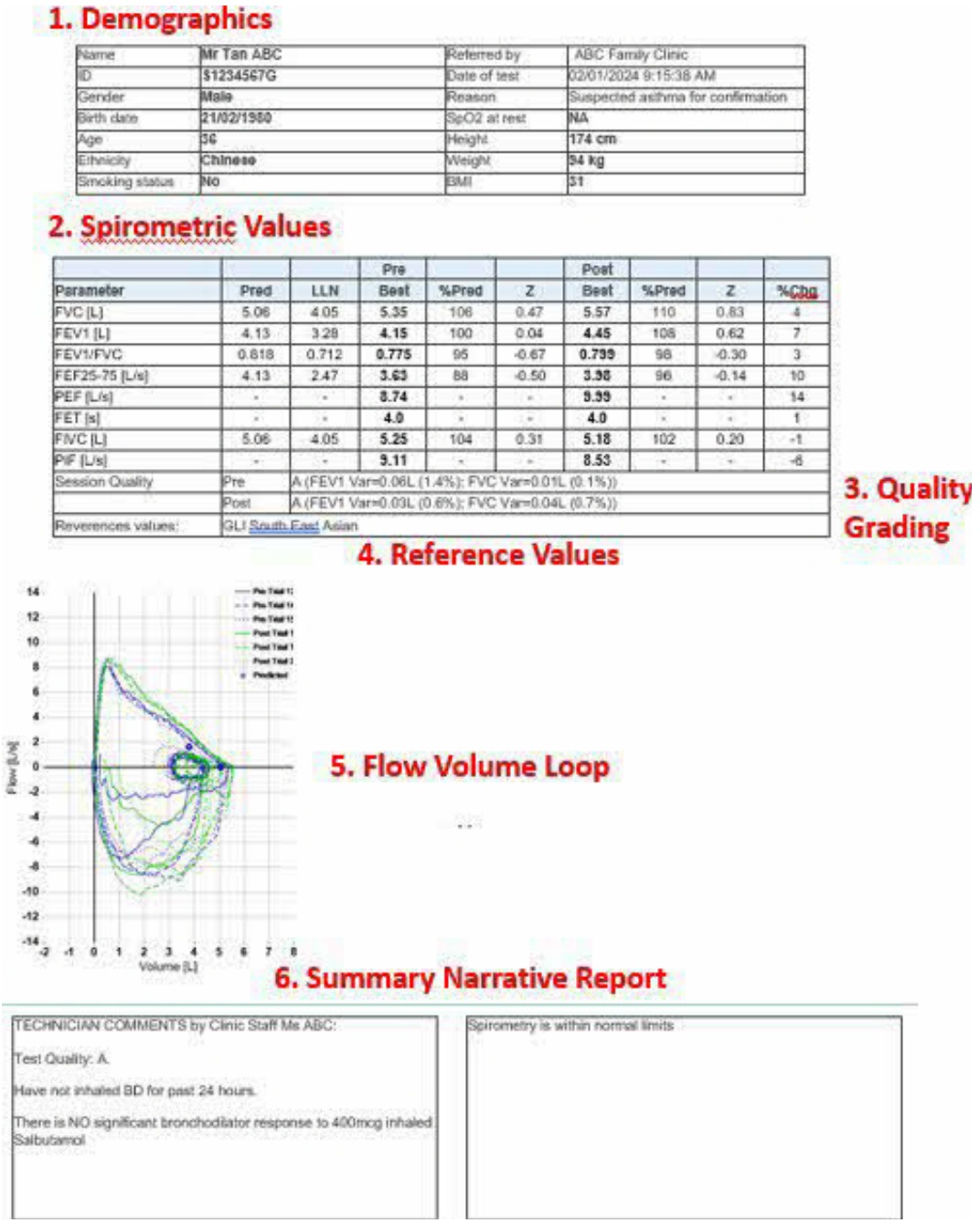

Figure 2. Approach to Spirometry Interpretation

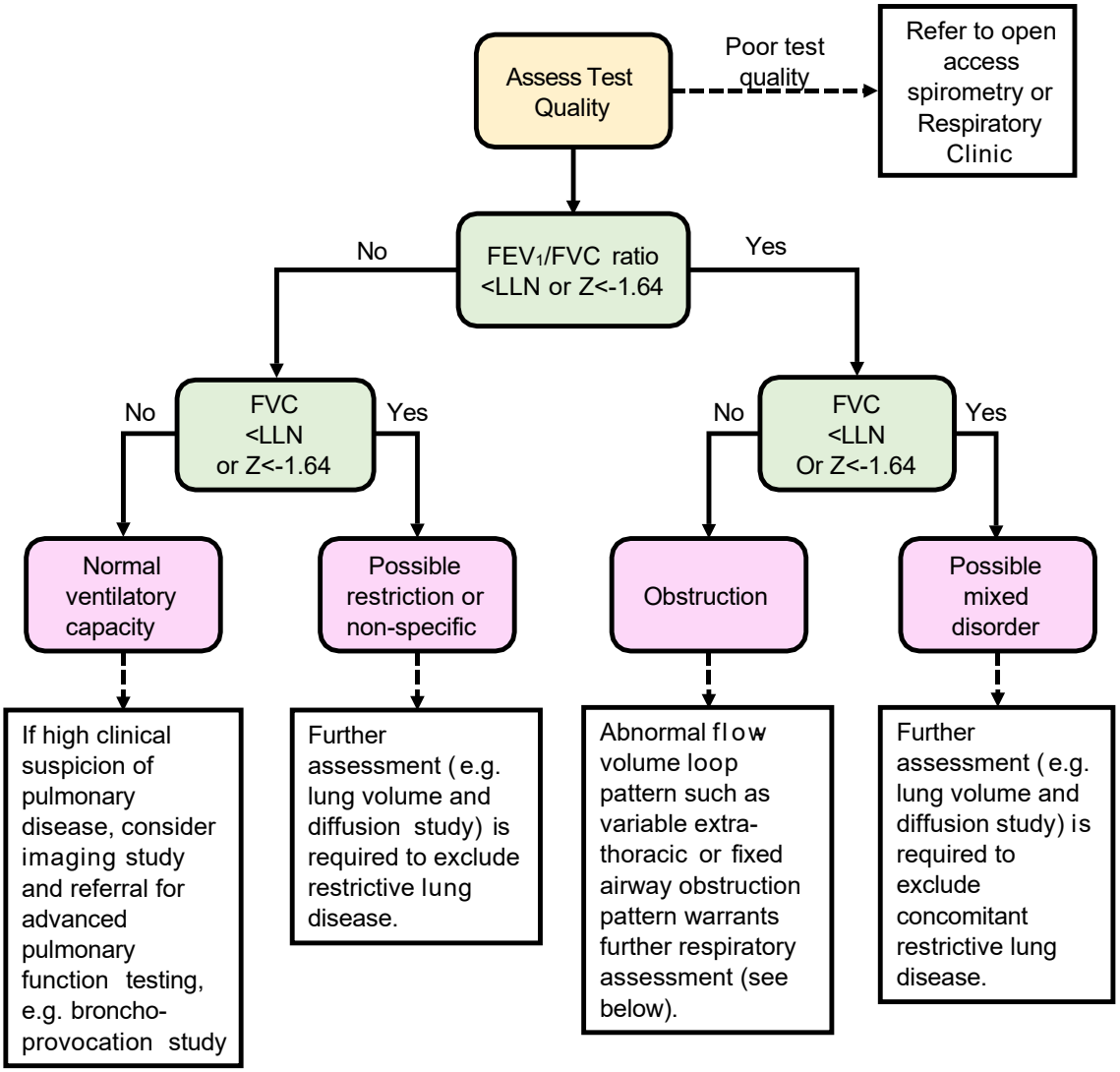

Figure 3. Flow Volume Loops: Flow Volume Loops suggestive of fixed upper airway obstruction, variable extrathoracic and intrathoracic obstruction, biphasic obstructive pattern and sawtooth pattern should be referred for further evaluation.

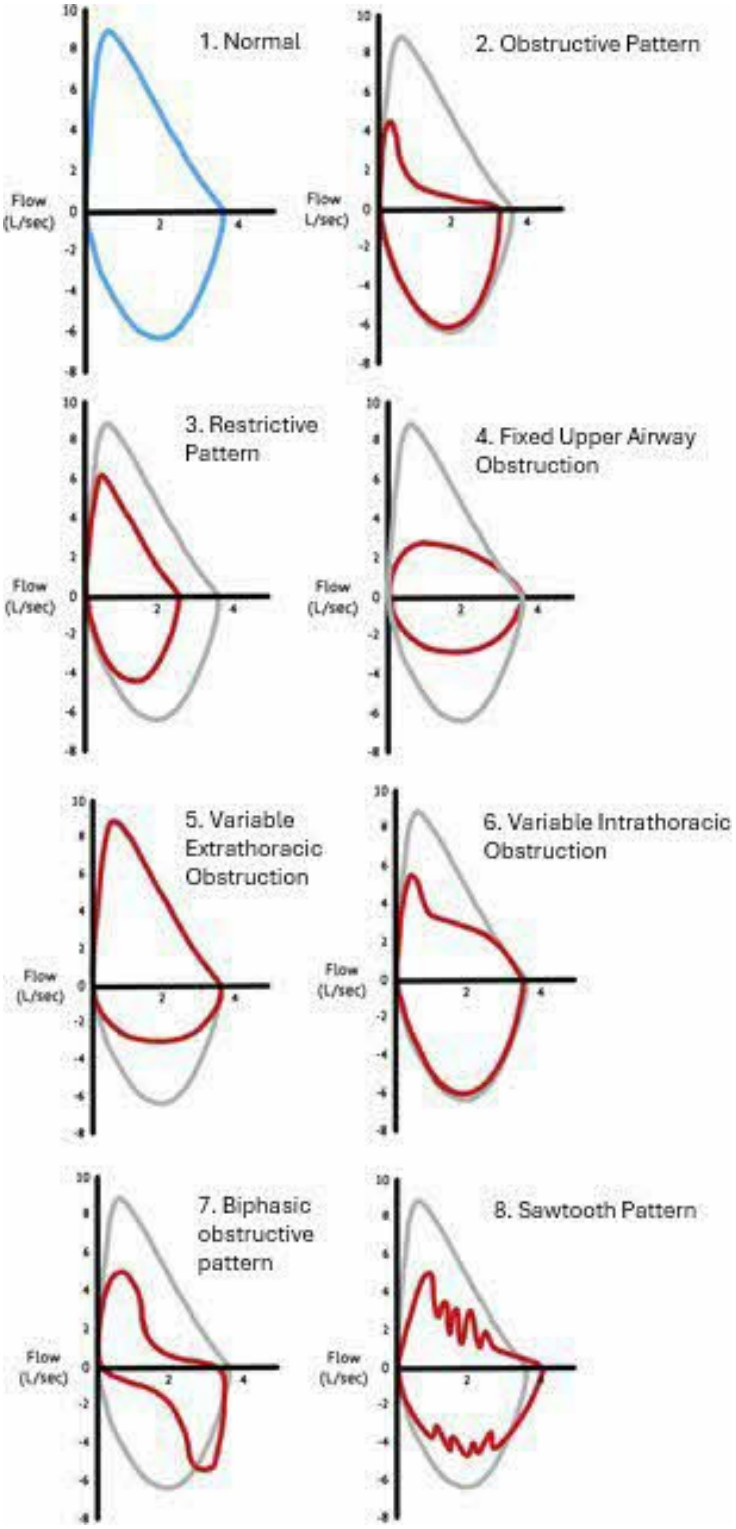

Table 1. Severity grading of spirometry abnormalities.

2005 ATS/ERS statement	2021 ATS/ERS technical standard
Use FEV_1 % predicted values	Use FEV_1 z-score
Mild >70% predicted	Mild: z-score -1.65 to -2.5
Moderate: 60-69% predicted	Moderate: z-score -2.51 to -4.0
Moderate-to-severe: 50-59% predicted	Severe: z-score below -4.1
Severe: 35-49% predicted	
Very severe: <35% predicted	

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