SPIROMETRY FOR ALL!
Spirometry is the lungs’ check-up

Spirometry is a simple test which is used to measure the air that each individual can breathe. It is the check-up of the proper functioning of the lungs which everyone should do, just as the state of the car is checked. It is considered a vital sign like the heart rate, the body temperature, the blood pressure and the respiratory rate.
Spirometry, a simple but fundamental test: a vital sign

The subject must inhale deeply and immediately exhale as fast as possible into the mouthpiece of a small instrument, called a spirometer. He/she must employ the same kind of effort used many times to blow out the candles of a birthday cake.
The flow/volume curve =
everybody’s digital impression of the lungs

The test results in a particular "sail-like" curve named Flow / Volume curve that plots the velocity of exhalation against the volume of exhaled air. This curve is compared with a theoretical normality curve obtained from the values measured in a population of healthy subjects with equal weight, height, ethnicity, gender and age. Consequently, the flow-volume curve is like a unique "fingerprint" of the lungs for each subject that provides a simple, accurate and highly predictive actual and "future" assessment of our lung function.
The lung age tells us how "aged" the lungs of a subject are

The test also provides simple measurements which, always compared with the theoretical normality of a population with the same characteristics, indicate the "lung age" of a subject. The lung age is a way of making the spirometry results more comprehensible, by indicating the "age" level of the lungs in relation to an individual's age. Put simply, in a healthy subject, the lung age corresponds to the true age. On the other hand, in a person exposed to risk factors or already with lung diseases, the lung age will be that much higher than the true age, the more compromised the lungs are.
Use of lung age a novel resource for better inform the patients

Lung age has for years been the most effective instrument in making people stop smoking, widely used for example by general practitioners (GP). For many individuals with asthma or COPD undergoing inhalation therapy, the progressive reduction of the lung age which gets closer to the true age one, indicates that some improvement has been achieved and represents the main stimulus to continue the therapy!
Spirometry also has an incredible diagnostic-predictive power. For example, when all other exams such as a chest radiography are still normal, spirometry already shows some slight alterations (borderline, slight obstruction) in subjects with asymptomatic COPD or who have only modest non-specific symptoms such as cough or sputum.
Predictive power of spirometry vs symptoms

Spirometry is able to anticipate the diagnosis of COPD by at least 5-10 years in relation to symptoms such as dyspnoea appearing, which, as is known, is evident when the lung disease is already in an advanced stage with irreversibly compromised respiratory function and at risk of progressing to oxygen therapy.
Predictive power of spirometry vs lung disease

The predictive power of spirometry is not just that of anticipating the diagnosis of certain respiratory diseases. The relationship between smoking and the decline in respiratory function has been known for 50 years. By periodically performing spirometry checks, over the years we can predict the degree of disability that a smoker faces and his/her life expectancy. This chart shows another fundamental concept: at whatever point an individual stops smoking, his/her quality of life and life expectancy improve!
The predictive power of spirometry also extends to non-respiratory problems! The father of spirometry [or the inventor of the spirometer], John Hutchinson, in 1846, intentionally called "vital capacity" one of the measurements of spirometry, because it was related to the survival of the individual subjects. More recent studies such as "The Framingham Study" have confirmed that a person with a reduced vital capacity has a greater likelihood of premature mortality due to non-pulmonary causes. Even if it seems incredible, spirometry is superior to ECG in predicting a cardiac death (hearth attack).
Spirometry is key in asthma management

Spirometry has other potentialities in addition to the predictive diagnostic power. In 1999, in one of his unforgettable articles "SPIROMETRY IS KEY IN ASTHMA MANAGEMENT", Tom Petty re-launched the role of spirometry in the management of respiratory diseases such as asthma. As blood glucose, blood pressure and ECG need to be measured to prescribe antidiabetic, antihypertensive and antiarrhythmic drugs, so spirometry should be essential for prescribing bronchodilator medications.
Spirometry is fundamental in self-management

Petty also underlined that the systematic use of spirometry was critical in assessing the severity of respiratory diseases, the efficacy of the therapy, and the clinical outcome. In short, he had high-lighted the concept of functional monitoring in order to verify the health status and therapeutic efficacy over time, integrating it with that of management, i.e. an integrated approach to the disease, aimed at improving the results and services offered but within a perspective of cost rationalisation. Technological progress has led to increasingly precise, small and economic spirometers: this has led to "self-measurement", i.e. to the possibility of self-measuring at any moment and in any place, and, consequently, to the "self-management" of chronic respiratory diseases. Petty summarised these concepts in his statement "NO ONE CAN MANAGE ASTHMA ADEQUATELY WITHOUT A SPIROMETER".
Measuring the breath is important as well as measuring the body temperature

Spirometry is not a medical test which is only required for patients with chronic respiratory diseases. Few people know that common respiratory virus diseases (flu, bronchitis) can cause a **20% decrease in respiratory function** in 60% of healthy subjects. Even some **non-asthmatic subjects** may have episodes of **bronchospasm** which, if left untreated, may evolve into a **chronic bronchitis** similar to asthma. In any case after flu, the **complete recovery** of the respiratory function takes place after **2-4 months**, sometimes even **after a year**. It follows that, after the emergency and once the **thermometer** has been stored away, a **spirometer** should be used!
A disposable flowmeter: your beauty case should never be without one

Technological development has not only led to smaller and more precise instruments. Disposable flowmeters have been available for some years, ensuring maximum precision together with maximum hygiene. It is no longer necessary to use bulky antibacterial filters at the doctor’s to avoid the risk of respiratory infections. And at home everyone can measure their breathing safely, each with their own meter just like their own toothbrush!
Not only asthma and COPD: autoimmune diseases and lungs

But lungs do not become sick only with COPD and asthma! Spirometry has a key role in the diagnosis and follow-up of pulmonary fibrosis, pulmonary interstitial disease, occupational diseases and environmental pollution.
And unfortunately, it does not end here. Many systemic diseases become highly disabling and sometimes deadly once they hit the lungs. One example consists of autoimmune diseases, such as scleroderma which causes skin hardening. But the big problems arise if the lungs begin to "harden" (pulmonary fibrosis). In this case, spirometry allows following the progress of the disease, foreseeing complications and avoiding the excessive repetition of invasive tests such as the Computed Tomography of the thorax.
Neuromuscular diseases, both neurological and neurodegenerative, such as multiple sclerosis, ALS and myasthenia gravis, also become severely disabling, sometimes fatal, when they involve respiratory muscles. Where the involvement of leg and arm muscles leads to physical impairments and to the necessity of wheelchairs and walkers, that of the respiratory muscles leads to respiratory failure. Two spirometric parameters - vital capacity and peak flow (FVC and PEF) - may for all practical purposes be considered “biomarkers” of the respiratory complications of neuromuscular diseases. The vital capacity allows monitoring the progressive reduction of the lung volumes and the weakening of the diaphragm. The peak expiratory flow is an excellent indicator of respiratory muscle involvement and of the impaired cough mechanism which favours the onset of pneumonia.
Pathological processes can affect the bronchi (chronic bronchitis or bronchial asthma) causing a so-called "obstructive" defect, i.e. limited expiratory airflow (or emptying of the lungs). Other diseases reduce the "elasticity" of the entire lung (such as pulmonary fibrosis), causing the shrinking or "miniaturisation" of the lung itself with "restrictive damage", i.e. limited filling. Sometimes the restrictive damage can occur because of the alteration of the rib cage elasticity (as in neuromuscular diseases).
Get to know your lungs with only 3 parameters

Spirometry essentially measures three parameters: the vital capacity (forced and slow), the FEV1 and the Peak expiratory flow. The Vital Capacity measures the volume of air which can be exhaled from lungs which are completely filled with air. FEV1 represents the maximum volume which a person can breathe out in the first second: this parameter also contains “the concept of timed vital capacity” or “the concept of flow”. The peak expiratory flow (PEF) represents the maximum expiratory rate at which a subject can expel air from the lungs after a full inhalation. Normally a healthy adult subject manages to exhale at least 75-80% of his/her Forced (FVC) or Slow (VC) Vital Capacity. This concept is well expressed by the FEV1/FVC% index which must be at least 75-80%. As stated, the FEV1, FVC and PEF measurement allows tracing a particular curve called "Flow/Volume Curve" which relates the expiratory speed (expiratory flow) to the volume of exhaled air.
The immediate analysis of the flow/volume curve

When compared with a theoretical overlapping normality curve, the Flow/Volume curve immediately indicates whether an individual is healthy or whether there is an obstructive or restrictive respiratory defect, also suggesting its severity (qualitative analysis). The analysis of the three parameters (FEV1, FVC and PEF) and of the FEV1/FVC index in relation to the (expected) theoretical values provides quantitative information on the current state of the lungs, on the lung age, on life expectancy. In particular, it allows identifying and quantifying (quantitative analysis) a respiratory defect: obstructive, restrictive or mixed (the presence of both defects).
Obstructive ventilatory disorder

As mentioned, some pathologies cause an obstructive deficit, i.e. an individual’s difficulty to empty his/her lungs well and quickly. The person is no longer able to empty 75-80% of the lungs during the first second of fast exhalation as occurs in a healthy person. This defect is identified by the spirometry if the FEV1/FVC% index is lower than the minimum normal value (LLN). When the FEV1 / FVC% ratio is lower than 70%, it is an alternative criterion to LLN in order to identify the obstruction. Currently, the guidelines for spirometry analysis prefer the FEV1/vital capacity <LLN obstruction criterion, while the COPD GOLD guidelines use the FEV1/vital capacity <70% after administering a bronchodilator. Once the presence of the obstruction has been defined, its severity is verified on the basis of the level of FEV1 reduction compared with the expected theoretical value.

Restrictive ventilatory disorder

"Restrictive" diseases however cause a defect in the filling of the lungs due to their reduction. It can be identified if the vital capacity is <LLN or <85% of the expected theoretical value. Further confirmatory tests are required such as a complete analysis of the respiratory function and a chest CT. The severity of the restriction is verified on the basis of the level of reduction of the vital capacity compared with the expected theoretical value.
Mixed ventilatory disorder

Sometimes both obstruction and restriction defects can coexist and then we talk about a mixed deficit that, for example, can be found in subjects with obesity and asthma or fibrosis and pulmonary emphysema.

Finally, there are non-pulmonary diseases which can create restrictive defects: for example, neuromuscular diseases. In these cases, in addition to the reduction of the vital capacity, a significant alteration of the Peak Flow is observed, which correlates well with the degree of neuromuscular compromise.
Early diagnosis

As mentioned concerning the predictive power, spirometry shows COPD damage when the subject is still asymptomatic (or has nonspecific symptoms) and other exams such as chest X-rays are normal. Spirometry makes it possible to identify a problem early on also in many other cases. For example, it is able to identify an asthmatic exacerbation or the lung involvement in diseases such as scleroderma. So much so that in subjects who have received lung transplantation the impairment of some spirometry indices is the earliest indicator of a possible rejection. However, even today many doctors tend to prescribe too few and too late spirometry exams even when a subject has respiratory symptoms. This translates into a diagnostic and, obviously, therapeutic delay, with heavy repercussions on respiratory pathologies and on the quality of life and life expectancy. Therefore, it is necessary to strongly reaffirm the primary role of spirometry in the early diagnosis of respiratory diseases.
Primary, secondary and tertiary prevention in preventive healthcare

In modern health promotion and protection programs, a three-phase (primary, secondary and tertiary) prevention is of primary importance. **Primary prevention** acts at a very early stage by eliminating risk factors before a disease can develop: for example, vaccinations or campaigns against alcoholism. **Secondary prevention** is instead the **early diagnosis** of a disease that has already started but is still asymptomatic, which, in addition to the removal of risk factors, provides for starting the therapy to stop the disease’s progression. Finally, **tertiary prevention** intervenes on a clinically manifested disease (i.e. symptomatic) with therapies and rehabilitation procedures to limit further progression and possible complications with a view to social recovery or at least to maintaining a good quality of life.
The role of spirometry in primary, secondary and tertiary prevention

Spirometry has always played a key role in Tertiary prevention programs understood as the diagnosis, therapy and follow-up of respiratory diseases. It is included, for example, in the guidelines of bronchial asthma, COPD, idiopathic fibrosis both as a diagnostic and staging tool and as a follow-up and exacerbation identification instrument.

As stated at the beginning of the discussion, for some years now spirometry has had a fundamental role also in the secondary prevention of diseases such as asthma or COPD before they become symptomatic. For example, screening studies for those at risk because they are smokers or professionally exposed. Or to identify triggering environments for allergic asthma in a subject still unaware of being asthmatic but who has a drop in the spirometry indices in those places compared with previous exams. Secondary prevention = early diagnosis of still asymptomatic respiratory diseases.

More recently, spirometry has also been included in primary prevention programs which envisage the removal of the risk factors in still healthy subjects. For example, the spirometry test data concerning the lung age is one of the tools used by general practitioners (GP) to convince a person to stop smoking. Furthermore, spirometry can help verify whether a working environment can be conducive to the development of forms of reversible professional asthma. Primary prevention = good health or absence of respiratory diseases.
In 1997 Prof. Petty stressed the absurdity of prescribing inhaled bronchodilator and steroid drugs without first performing a spirometry to be reassessed over time. 20 years later, unfortunately, the situation has remained almost the same despite several guidelines and the need for **Appropriateness of Prescriptions in accordance with Evidence-Based Medicine**. Thus, in real life, spirometry is often not performed even in subjects who already have established respiratory diseases. The result is that subjects with asthma or COPD receive an insufficient or an excessive treatment in respect of their actual disease status. Or even, subjects without airway diseases, such as pulmonary fibrosis or heart failure, are prescribed bronchodilators just because they smoke or complain of dyspnoea.

Spirometry remains the simplest and most reliable exam in order not only to diagnose but also to follow the therapeutic response over time of many respiratory diseases.

Currently the **Appropriateness of Prescriptions** is also demanded by the governmental authorities of various states from a **Spending Review** perspective. In fact, many new inhalation drugs display the level of spirometry impairment below which they can be prescribed.
Spirometry for the best possible quality of life (QOL)

The concepts of Predictability, Prevention and Appropriateness are summarised in a more important concept: the quality of life of a subject. This is achieved by removing all risk factors and with the most appropriate treatment. Spirometry is the ideal tool to maintain the best quality of life possible at every severity level of respiratory diseases, from asymptomatic individuals to those most compromised.
The impact, burden and costs, of lung diseases

Chronic respiratory diseases, above all COPD and bronchial asthma, have a very high prevalence, morbidity, mortality and social cost. For example, we estimate (source: Global Initiative for Asthma. Global Strategy for asthma management and prevention, 2017. www.ginasthma.org) that there are 300 million asthmatics worldwide, with an increase of 30% in the last decade and a mortality rate close to 400,000 deaths a year. Asthma affects young and old and is a major cause of absence from school or work with very high social costs: over $ 50 billion in the US and about € 20 billion in Europe. The COPD numbers are even more alarming: at least 250 million of people affected worldwide (source: World Health Organization. Chronic obstructive pulmonary disease (COPD). Fact Sheet N° 315. – Geneva: World Health Organization, 2017), about 10% of subjects aged 40 or over, actually 20% of those over 70 years old. COPD is considered to be the third cause of death in the world: WHO data speak of 3.17 million deaths in 2015 due to COPD (5% of all deaths) with very high socio-economic costs.
Spirometry to limit underdiagnosis and misdiagnosis of lung diseases

However, these diseases are often diagnosed late or inappropriately with incorrect medication prescriptions or are not diagnosed. In about 2/3 of the subjects with COPD, the diagnosis is made the first time on an occasional basis, simply because they have performed a spirometry, perhaps in the workplace or for sports. In fact, and this is even more disturbing, it is estimated that at least 50% of subjects with COPD will never receive the correct diagnosis because of an under-use of spirometry.
In conclusion, a large-scale use of spirometry can allow warding off the main risk factors and, in any case, an early diagnosis of respiratory diseases. Spirometry is a fundamental tool for a drastic improvement in the quality of life of individuals and of the main socio-health indicators and for lowering social costs.