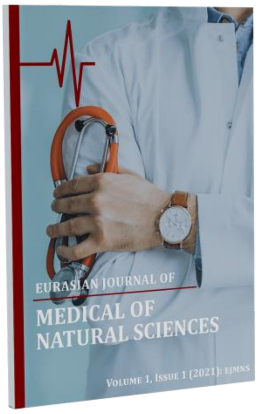
EURASIAN JOURNAL OF MEDICAL AND NATURAL SCIENCES
Innovative Academy Research Support Center
UIF = 8.3 | SJIF = 5.995 www.in-academy.uz



RESPIRATORY SYSTEM

Kamalova Aysulu
Abdukhalikova Nozima
Djurayeva Barno Gulomovna

https://www.doi.org/10.5281/zenodo.10579036

ARTICLE INFO

Received: 22th January 2024
Accepted: 28th January 2024
Online: 29th January 2024

KEY WORDS

Respiratory system, Anatomy, Upper respiratory tract, Lower respiratory tract, Gas exchange, Alveoli, Respiration, Inspiration, Expiration, Diaphragm, Breathing regulation, Central respiratory centers, Peripheral chemoreceptors, Respiratory diseases, Asthma.

ABSTRACT

This article provides a comprehensive exploration of the respiratory system, covering its anatomy, mechanics, and the regulatory processes involved in breathing. It delves into the significance of respiratory health, including common disorders and preventive measures. The aim is to offer readers a thorough understanding of the intricate symphony that sustains life through the continuous exchange of gases in the respiratory system.

Introduction. The respiratory system is a marvel of biological engineering, orchestrating the exchange of gases crucial for sustaining life. From the intricate anatomy of the lungs to the rhythmic process of respiration, this article delves into the multifaceted workings of the respiratory system. By exploring its anatomy, functions, and the significance of respiratory health, we aim to unravel the intricate symphony that ensures the continuous flow of life-giving oxygen and the expulsion of carbon dioxide.

Human respiratory system, the system in humans that takes up oxygen and expels carbon dioxide. The respiratory tract conveys air from the mouth and nose to the lungs, where oxygen and carbon dioxide are exchanged between the alveoli and the capillaries.

The human gas-exchanging organ, the lung, is located in the thorax, where its delicate tissues are protected by the bony and muscular thoracic cage. The lung provides the tissues of the human body with a continuous flow of oxygen and clears the blood of the gaseous waste product, carbon dioxide. Atmospheric air is pumped in and out regularly through a system of pipes, called conducting airways, which join the gas-exchange region with the outside of the body. The airways can be divided into upper and lower airway systems. The transition between the two systems is located where the pathways of the respiratory and digestive systems cross, just at the top of the larynx.

The upper airway system comprises **the nose and the paranasal cavities (or sinuses)**, the pharynx (or throat), and partly also the oral cavity, since it may be used for breathing. The lower airway system consists of the larynx, the trachea, the stem bronchi, and all the airways ramifying intensively within the lungs, such as the intrapulmonary bronchi, the bronchioles, and the alveolar ducts. For respiration, the collaboration of other organ systems is clearly essential. The diaphragm, as the main respiratory muscle, and the intercostal muscles of the chest wall play an essential role by generating, under the control of the central nervous system, the pumping action on the lung. The muscles expand and contract the internal space of the thorax, the bony framework of which is formed by the ribs and the thoracic vertebrae. The contribution of the lung and chest wall (ribs and muscles) to respiration is described below in The mechanics of breathing. The blood, as a carrier for the gases, and the circulatory system (i.e., the heart and the blood vessels) are mandatory elements of a working respiratory system

Morphology of the upper airways.The nose.

The nose is the external protuberance of an internal space, the nasal cavity. It is subdivided into a left and right canal by a thin medial cartilaginous and bony wall, the nasal septum. Each canal opens to the face by a nostril and into the pharynx by the choana. The floor of the nasal cavity is formed by the palate, which also forms the roof of the oral cavity. The complex shape of the nasal cavity is due to projections of bony ridges, the superior, middle, and inferior turbinate bones (or conchae), from the lateral wall. The passageways thus formed below each ridge are called the superior, middle, and inferior nasal meatuses.

On each side, the intranasal space communicates with a series of neighbouring air-filled cavities within the skull (the paranasal sinuses) and also, via the nasolacrimal duct, with the lacrimal apparatus in the corner of the eye. The duct drains the lacrimal fluid into the nasal cavity. This fact explains why nasal respiration can be rapidly impaired or even impeded during weeping: the lacrimal fluid is not only overflowing into tears, it is also flooding the nasal cavity.

The paranasal sinuses are sets of paired single or multiple cavities of variable size. Most of their development takes place after birth, and they reach their final size toward age 20. The sinuses are located in four different skull bones—the maxilla, the frontal, the ethmoid, and the sphenoid bones. Correspondingly, they are called the maxillary sinus, which is the largest cavity; the frontal sinus; the ethmoid sinuses; and the sphenoid sinus, which is located in the upper posterior wall of the nasal cavity. The sinuses have two principal functions: because they are filled with air, they help keep the weight of the skull within reasonable limits, and they serve as resonance chambers for the human voice.

The nasal cavity with its adjacent spaces is lined by a respiratory mucosa. Typically, the mucosa of the nose contains mucus-secreting glands and venous plexuses; its top cell layer, the epithelium, consists principally of two cell types, ciliated and secreting cells. This structural design reflects the particular ancillary functions of the nose and of the upper airways in general with respect to respiration. They clean, moisten, and warm the inspired air, preparing it for intimate contact with the delicate tissues of the gas-exchange area. During expiration through the nose, the air is dried and cooled, a process that saves water and energy.

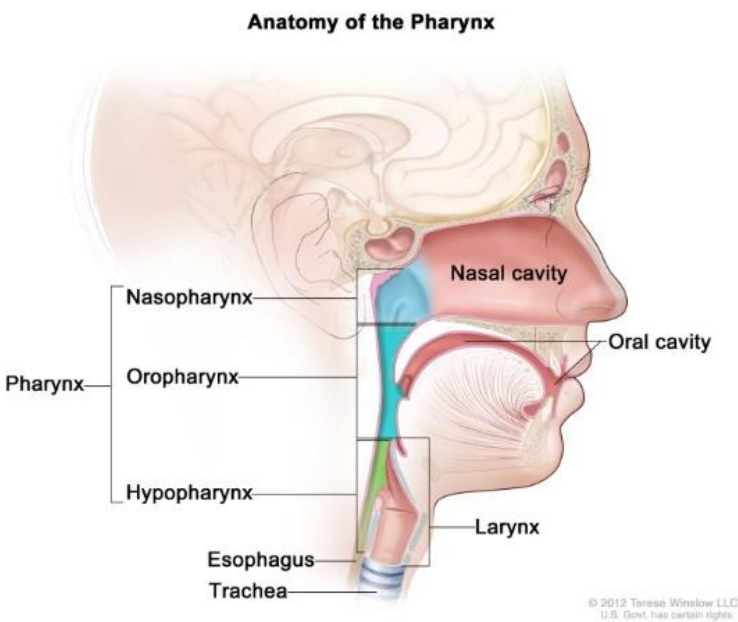
Two regions of the nasal cavity have a different lining. The vestibule, at the entrance of the nose, is lined by skin that bears short thick hairs called vibrissae. In the roof of the nose, the olfactory bulb with its sensory epithelium checks the quality of the inspired air. About two dozen olfactory nerves convey the sensation of smell from the olfactory cells through the bony roof of the nasal cavity to the central nervous system.

The pharynx.

For the anatomical description, the pharynx can be divided into three floors. The upper floor, the nasopharynx, is primarily a passageway for air and secretions from the nose to the oral pharynx. It is also connected to the tympanic cavity of the middle ear through the auditory tubes that open on both lateral walls. The act of swallowing opens briefly the normally collapsed auditory tubes and allows the middle ears to be aerated and pressure differences to be equalized. In the posterior wall of the nasopharynx is located a lymphatic organ, the pharyngeal tonsil. When it is enlarged (as in tonsil hypertrophy or adenoid vegetation), it may interfere with nasal respiration and alter the resonance pattern of the voice.

The middle floor of the pharynx connects anteriorly to the mouth and is therefore called the oral pharynx or oropharynx. It is delimited from the nasopharynx by the soft palate, which roofs the posterior part of the oral cavity.

The lower floor of the pharynx is called the hypopharynx. Its anterior wall is formed by the posterior part of the tongue. Lying directly above the larynx, it represents the site where the pathways of air and food cross each other: Air from the nasal cavity flows into the larynx, and food from the oral cavity is routed to the esophagus directly behind the larynx. The epiglottis, a cartilaginous, leaf-shaped flap, functions as a lid to the larynx and, during the act of swallowing, controls the traffic of air and food.

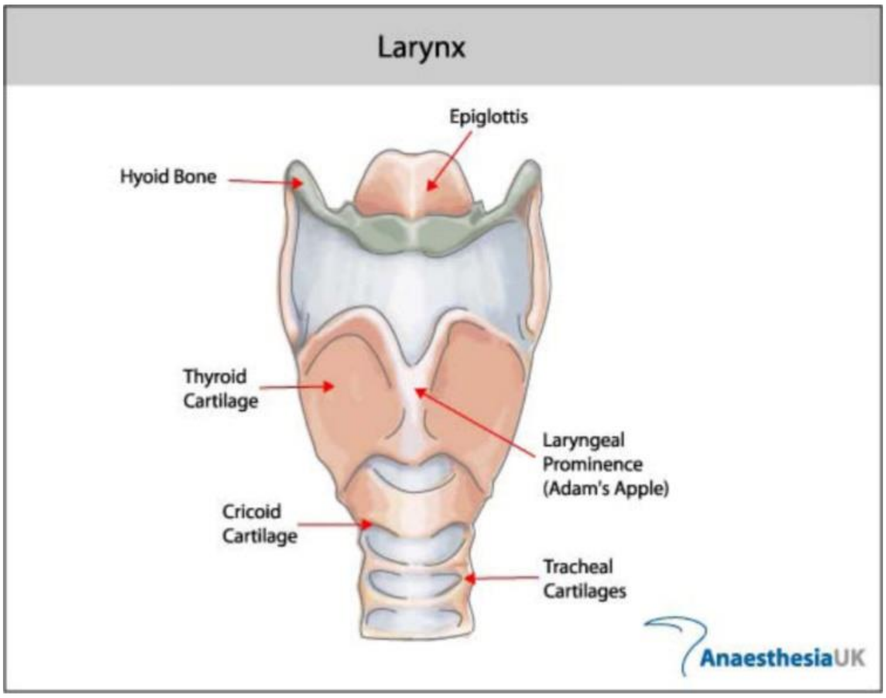


Morphology of the lower airways. The larynx

The larynx is an organ of complex structure that serves a dual function: as an air canal to the lungs and a controller of its access, and as the organ of phonation. Sound is produced by forcing air through a sagittal slit formed by the vocal cords, the glottis. This causes not only the vocal cords but also the column of air above them to vibrate. As evidenced by trained singers, this function can be closely controlled and finely tuned. Control is achieved by a number of muscles innervated by the laryngeal nerves. For the precise function of the muscular apparatus,

EURASIAN JOURNAL OF MEDICAL AND NATURAL SCIENCES
Innovative Academy Research Support Center
UIF = 8.3 | SJIF = 5.995 www.in-academy.uz

the muscles must be anchored to a stabilizing framework. The laryngeal skeleton consists of almost a dozen pieces of cartilage, most of them very small, interconnected by ligaments and membranes. The largest cartilage of the larynx, the thyroid cartilage, is made of two plates fused anteriorly in the midline. At the upper end of the fusion line is an incision, the thyroid notch; below it is a forward projection, the laryngeal prominence. Both of these structures are easily felt through the skin. The angle between the two cartilage plates is sharper and the prominence more marked in men than in women, which has given this structure the common name of Adam's apple.



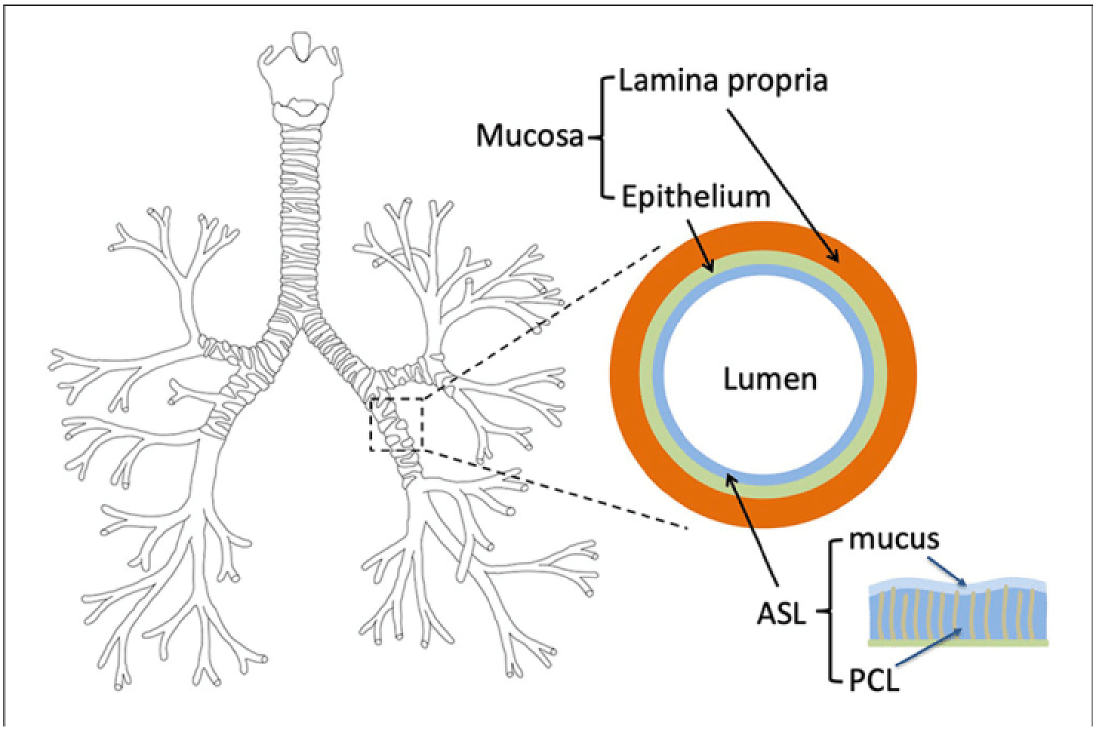
The trachea and the stem bronchi. Below the larynx lies the trachea, a tube about 10 to 12 cm (3.9 to 4.7 inches) long and 2 cm (0.8 inch) wide. Its wall is stiffened by 16 to 20 characteristic horseshoe-shaped, incomplete cartilage rings that open toward the back and are embedded in a dense connective tissue. The dorsal wall contains a strong layer of transverse smooth muscle fibres that spans the gap of the cartilage. The interior of the trachea is lined by the typical respiratory epithelium. The mucosal layer contains mucous glands.

At its lower end, the trachea divides in an inverted Y into the two stem (or main) bronchi, one each for the left and right lung. The right main bronchus has a larger diameter, is oriented more vertically, and is shorter than the left main bronchus. The practical consequence of this arrangement is that foreign bodies passing beyond the larynx will usually slip into the right lung. The structure of the stem bronchi closely matches that of the trachea.

The hierarchy of the dividing airways, and partly also of the blood vessels penetrating the lung, largely determines the internal lung structure. Functionally the intrapulmonary airway system can be subdivided into three zones, a proximal, purely conducting zone, a peripheral, purely gas-exchanging zone, and a transitional zone in between, where both functions grade into one another. From a morphological point of view, however, it makes sense to distinguish the relatively thick-walled, purely air-conducting tubes from those branches of the airway tree structurally designed to permit gas exchange.

Structural design of the airway tree.

The structural design of the airway tree is functionally important because the branching pattern plays a role in determining air flow and particle deposition. In modeling the human airway tree, it is generally agreed that the airways branch according to the rules of irregular dichotomy. Regular dichotomy means that each branch of a treelike structure gives rise to two daughter branches of identical dimensions. In irregular dichotomy, however, the daughter branches may differ greatly in length and diameter. The models calculate the average path from the trachea to the lung periphery as consisting of about 24–25 generations of branches. Individual paths, however, may range from 11 to 30 generations. The transition between the conductive and the respiratory portions of an airway lies on average at the end of the 16th generation, if the trachea is counted as generation 0. The conducting airways comprise the trachea, the two stem bronchi, the bronchi, and the bronchioles. Their function is to further warm, moisten, and clean the inspired air and distribute it to the gas-exchanging zone of the lung. They are lined by the typical respiratory epithelium with ciliated cells and numerous interspersed mucus-secreting goblet cells. Ciliated cells are present far down in the airway tree, their height decreasing with the narrowing of the tubes, as does the frequency of goblet cells. In bronchioles the goblet cells are completely replaced by another type of secretory cells named Clara cells. The epithelium is covered by a layer of low-viscosity fluid, within which the cilia exert a synchronized, rhythmic beat directed outward. In larger airways, this fluid layer is topped by a blanket of mucus of high viscosity. The mucus layer is dragged along by the ciliary action and carries the intercepted particles toward the pharynx, where they are swallowed. This design can be compared to a conveyor belt for particles, and indeed the mechanism is referred to as the mucociliary escalator

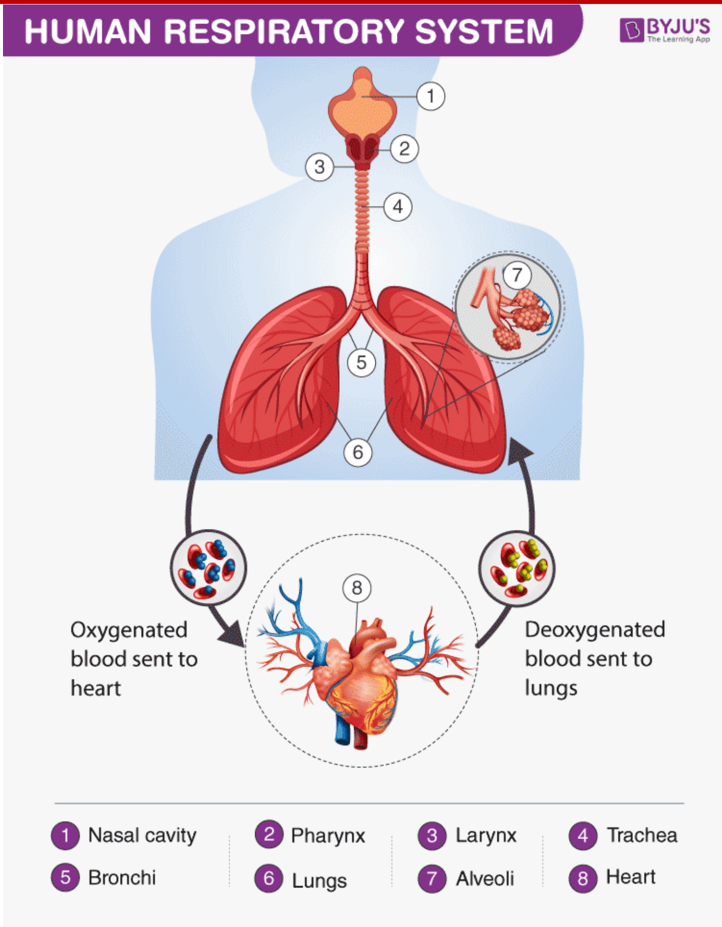


Whereas cartilage rings or plates provide support for the walls of the trachea and bronchi, the walls of the bronchioles, devoid of cartilage, gain their stability from their structural integration into the gas-exchanging tissues. The last purely conductive airway generations in the lung are the terminal bronchioles. Distally, the airway structure is greatly altered by the appearance of cuplike outpouchings from the walls. These form minute air chambers and represent the first gas-exchanging alveoli on the airway path. In the alveoli, the respiratory epithelium gives way to a very flat lining layer that permits the formation of a thin air–blood barrier. After several generations (Z) of such respiratory bronchioles, the alveoli are so densely packed along the airway that an airway wall proper is missing; the airway consists of alveolar ducts. The final generations of the airway tree end blindly in the alveolar sacs.

The lungs.

The lung is parted into two slightly unequal portions, a left lung and a right lung, which occupy most of the intrathoracic space. The space between them is filled by the mediastinum, which corresponds to a connective tissue space containing the heart, major blood vessels, the trachea with the stem bronchi, the esophagus, and the thymus gland. The right lung represents 56 percent of the total lung volume and is composed of three lobes, a superior, middle, and inferior lobe, separated from each other by a deep horizontal and an oblique fissure. The left lung, smaller in volume because of the asymmetrical position of the heart, has only two lobes separated by an oblique fissure. In the thorax, the two lungs rest with their bases on the diaphragm, while their apexes extend above the first rib. Medially, they are connected with the mediastinum at the hilum, a circumscribed area where airways, blood and lymphatic vessels, and nerves enter or leave the lungs. The inside of the thoracic cavities and the lung surface are covered with serous membranes, respectively the parietal pleura and the visceral pleura, which are in direct continuity at the hilum. Depending on the subjacent structures, the parietal pleura can be subdivided into three portions: the mediastinal, costal, and diaphragmatic pleurae. The lung surfaces facing these pleural areas are named accordingly, since the shape of the lungs is determined by the shape of the pleural cavities. Because of the presence of pleural recesses, which form a kind of reserve space, the pleural cavity is larger than the lung volume.

During inspiration, the recesses are partly opened by the expanding lung, thus allowing the lung to increase in volume. Although the hilum is the only place where the lungs are secured to surrounding structures, the lungs are maintained in close apposition to the thoracic wall by a negative pressure between visceral and parietal pleurae. A thin film of extracellular fluid between the pleurae enables the lungs to move smoothly along the walls of the cavity during breathing. If the serous membranes become inflamed (pleurisy), respiratory movements can be painful. If air enters a pleural cavity (pneumothorax), the lung immediately collapses owing to its inherent elastic properties, and breathing is abolished on this side.



Pulmonary segments. The lung lobes are subdivided into smaller units, the pulmonary segments. There are 10 segments in the right lung and, depending on the classification, eight to 10 segments in the left lung. Unlike the lobes, the pulmonary segments are not delimited from each other by fissures but by thin membranes of connective tissue containing veins and lymphatics; the arterial supply follows the segmental bronchi. These anatomical features are important because pathological processes may be limited to discrete units, and the surgeon can remove single diseased segments instead of whole lobes.

Conclusion: In conclusion, the respiratory system serves as the life-sustaining conductor of the human body, orchestrating the delicate balance of oxygen and carbon dioxide. Understanding its anatomy, mechanics, and the factors influencing respiratory health is paramount for fostering a holistic approach to well-being. As we navigate the intricacies of breath, the symphony of the respiratory system continues to underscore the indispensable role it plays in our existence.

References:

1. Hall, J. E., & Guyton, A. C. (2011). Textbook of Medical Physiology. Elsevier Saunders.
2. West, J. B. (2014). Respiratory Physiology: The Essentials. Lippincott Williams & Wilkins.
3. Tortora, G. J., & Derrickson, B. (2017). Principles of Anatomy and Physiology. Wiley.
4. Widdicombe, J. (2006). Lung and Airway Development. Respiration Physiology & Neurobiology, 154(1-2), 291-301.

5. Mason, R. J., Broaddus, V. C., Martin, T. R., King, T. E., & Schraufnagel, D. E. (2015). Murray and Nadel's Textbook of Respiratory Medicine (6th ed.). Saunders.
6. Levitzky, M. G. (2018). Pulmonary Physiology (9th ed.). McGraw-Hill Education.
7. Guzman, J. A. (2015). Disorders of the Respiratory System. Primary Care: Clinics in Office Practice, 42(2), 239-252.
8. Weinberger, S. E., & Cockrill, B. A. (2021). Principles of Pulmonary Medicine (7th ed.). Elsevier.
9. Global Initiative for Asthma (GINA). (2021). Global Strategy for Asthma Management and Prevention. Retrieved from [website link].
10. American Lung Association. (2021). Lung Disease Data. Retrieved from [website link].
11. Wagner, P. D. (2018). The Physiologic Basis of High-Altitude Diseases. Annals of Internal Medicine, 168(9), 677-678.
12. Fabbri, L. M., & Rabe, K. F. (2007). From COPD to Chronic Systemic Inflammatory Syndrome? The Lancet, 370(9589), 797-799.
13. Lundbäck, B., Lindberg, A., Lindström, M., Rönmark, E., Jonsson, A. C., Jönsson, E., ... & Larsson, L. G. (2003). Not 15 But 50% of Smokers Develop COPD?—Report from the Obstructive Lung Disease in Northern Sweden Studies. Respiratory Medicine, 97(2), 115-122.
14. British Lung Foundation. (2021). Occupational Lung Disease. Retrieved from [website link].
15. World Health Organization (WHO). (2021). Ambient Air Pollution: Health Impacts.