NCPD 2.5 HOURS
Continuing Education

Respiratory Assessment

Respiratory illnesses often require acute care admissions and are a leading cause of death globally, thus creating a financial burden for healthcare systems. Home healthcare clinicians can significantly reduce morbidity and hospital readmissions by becoming proficient at respiratory assessment. This article aims to assist homecare clinicians in performing a respiratory assessment in a logical and structured approach, including inspection, palpation, percussion, and auscultation. This article reviews the anatomy and physiology of the respiratory system and describes subjective and objective respiratory assessment. It is anticipated that becoming adept at these skills will enable home healthcare clinician to assess and identify those patients at risk for deterioration and readmission.

According to the World Health Organization (WHO, 2022), the category of severe respiratory illness ranks among the top 10 causes of death worldwide. One in seven adults suffers from lung disorders (Centers for Disease Control and Prevention, 2022), leading to high admission rates to acute care facilities. Home healthcare clinicians care for many patients with respiratory illness and must excel in respiratory assessment to detect problems before they become emergencies. This article describes respiratory assessment including vital signs, breathing patterns, cough, skin color, and lung auscultation, leading to critical evaluation of an adult patient. Advanced practice assessment is denoted with an asterisk. Pediatric considerations can be found in the sidebar.

Anatomy and Physiology of the Lungs

Breathing is a vital physiological function that contributes to acid/base balance and is involved in homeostasis. Its primary function is gas exchange between the environmental air and circulating blood through ventilation, diffusion, and perfusion. The physiology of oxygenation consists of inspiration, expiration, and intact lung structures. Any lung tissue alteration can decrease the body's ability to take in oxygen and release carbon dioxide (Bickley, 2020). Examples of respiratory diseases commonly encountered in home healthcare are chronic obstructive pulmonary disease (COPD), bronchitis, asthma, and pneumonia.

Control of ventilation occurs through voluntary and involuntary mechanisms. Voluntary control of the muscles of respiration is regulated through the central nervous system, which enables individuals to maintain conscious control over their breathing rate. Involuntary ventilation is controlled by the medulla oblongata and pons (Moutlana, 2020). The respiratory center transmits impulses to the respiratory muscles, causing them to contract and relax. Carbon dioxide levels can also influence the respiratory center and involuntary ventilation.

In a thorough examination of the respiratory system, clinicians must assess the upper and lower airway, including the nasal passages, sinuses, pharynx and larynx, trachea, bronchi, lung, bronchioles, and alveoli. The nares humidify and warm inhaled air. The air is then propelled toward the pharynx, which transports air to the larynx and trachea, marking the beginning of the lower respiratory tract. The trachea then divides into the right and left bronchi and terminal bronchioles and alveoli. The right lung has three lobes, the left has two lobes (Bickley, 2020).

Inhalation of air expands the thorax, and the lungs fill, then compress passively for exhalation. The diaphragm is an active participant in the ventilatory process, functioning as an inspiratory muscle. The medulla within the brain initiates inspiration, sending impulses to the phrenic nerve to stimulate the diaphragm to contract and flatten (Jarvis, 2020). The airways transport inspired air until it reaches the terminal bronchioles and alveoli where gas exchange takes place. The alveoli contain surfactant, which lowers the surface tension for optimal lung compliance.

Nadine Wodwaski, DNP, MSN-ed, CNS, RN, and Elaine Webber, DNP, PPCNP-BC, IBCLC

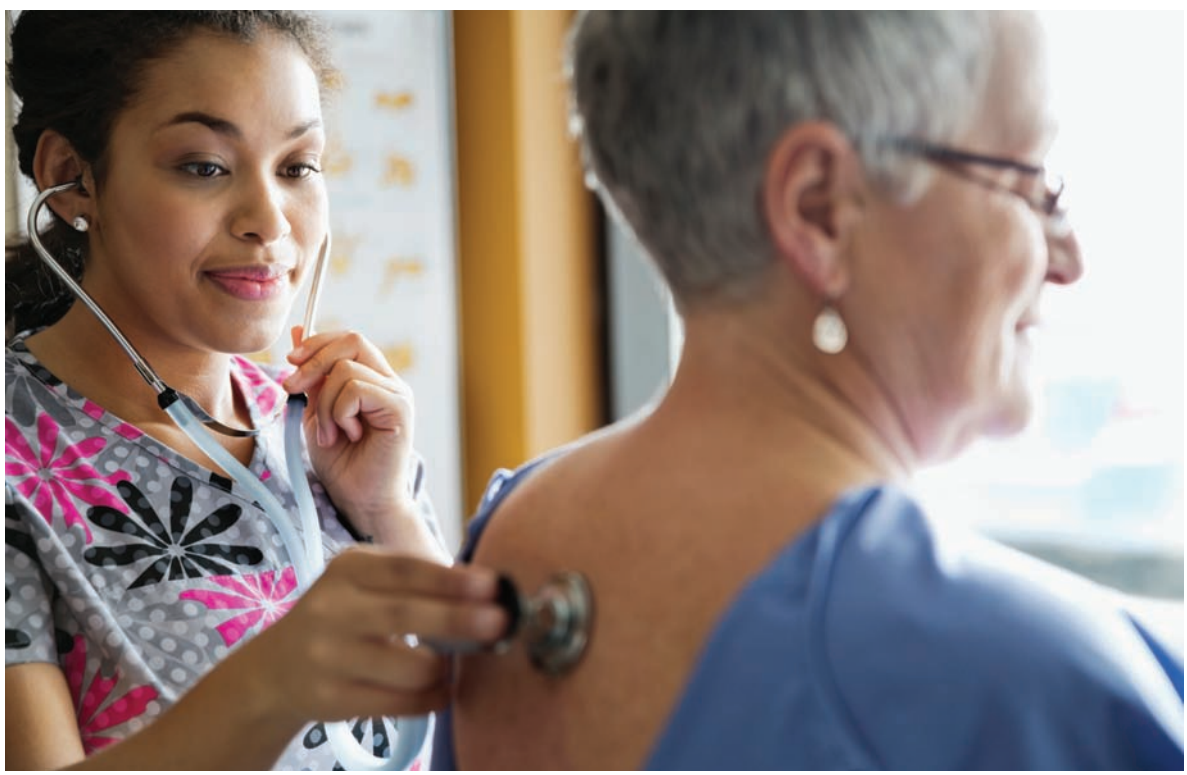
Health History

During the health history, the patient tells their story, including current complaint, history of presenting complaint, past medical history, current medications, family history, psychosocial history, and a review of systems (Bickley, 2020). Identifying the main symptom(s) is imperative, and may include cough, wheezing, shortness of breath, or lethargy. Question the patient about time of day or night symptoms that occur and duration of symptoms, along with aggravating and alleviating factors.

Inquire about previous or current illnesses and diseases affecting other organs, such as the cardiovascular system, especially if the patient complains of breathlessness. This can be an indication of heart failure and may be the underlying cause of symptoms rather than a respiratory illness. Assess the patient's medications as some medications have pulmonary side effects such as beta blockers and ACE inhibitors which can cause a cough. Ask about family history. This will highlight potential genetic conditions such as alpha one antitrypsin deficiency or cystic fibrosis. Social history such as smoking or illicit drug use should also be addressed. Inquire about the patient's occupation, as they may have been exposed to environmental hazards on the job. Assess living arrangements such as type of housing (single story or stairs), use of household or walking aids, and how far the patient can walk before becoming breathless and whether they live with someone or alone. Inquire about recent travel that included sitting for an extended period in a car or airplane which can increase the risk for pulmonary embolism. Ask about birds as pets as they are a source of bird fancier lungs (pneumonitis related to repeated exposure to birds), whereas dogs and cats can trigger asthma.

Have the patient describe airway symptoms, including productive and nonproductive cough, breathlessness, changes in breathing pattern and nasal symptoms such as nasal obstruction, rhinorrhea, nasal discharge, nose bleeds, and sneezing. Inflammatory conditions can cause symptoms of the pharynx and larynx, so ask about hoarse voice, snoring, stridor, and pain. Encourage the patient to discuss any other symptoms they may have. For example, lung cancer patients may present with fatigue, night sweats, and anorexia instead of breathlessness or cough (McCance & Huether, 2018).

When patients complain of breathlessness, assess if the onset is gradual or sudden, how long it lasts, what exacerbates or alleviates it, and if there is orthopnea or cough. The length of breathlessness may suggest underlying conditions such as



iStock/Hero Images

anxiety, infection, asthma, COPD, pneumonia, pleural effusion, or anemia, to name a few. Coughing is an involuntary action the body utilizes to protect the airway from infections, smoke, or dust. Ask if the cough is productive or nonproductive and assess aggravating or alleviating factors. Ask about hemoptysis or associated symptoms such as fever/chills or night sweats. If the cough is productive, ask about sputum color, consistency, odor, and amount. Because older adults are at a greater risk for respiratory complications because of decreased lung tissue elasticity and reduced lower lung oxygenation, ask specifically about weight loss, fatigue, dyspnea on exertion (also referred to as shortness of breath), orthopnea, as well as flu, pneumonia, and COVID vaccine status.

Sidebar: Pediatric Consideration for Respiratory Assessment

As it is difficult to auscultate breath sounds in a crying or uncooperative child, respiratory assessment in infants and young children can be a challenge. Start your assessment from least invasive to most invasive. The assessment is best conducted with the infant or child resting comfortably in the arms of a trusted caregiver.

Begin with observation:

- Observe the infant or child's behavior, skin color, and general comfort level.
- Obtain the respiratory rate watching the chest rise and fall—this can be assessed again during the "hands on" auscultation later in the assessment.
- Observe chest movement during inspiration and expiration, looking for equal movement on both sides of the chest.
- Prior to using a stethoscope, listen for sounds such as grunting, snoring, wheezing, stridor, or coughing. Make note of the quality of the cough if present; include whether the cough is productive or nonproductive.

Move into the "hands on" component of the exam.

- With younger children, allow them to play with the stethoscope or integrate the use of toys during the exam to develop trust and encourage compliance.
- Allow infants and young children to stay in their caregiver's arms, when possible, to enhance cooperation and keep the child comfortable and quiet.
- If the infant/child is still resting quietly without crying, count respirations again using the stethoscope to auscultate inspiration and expiration. Compare to the previous findings of watching the chest rise and fall during the observation phase of the assessment.
- Ask the child to take deep breaths and blow out through their mouth. Tow tactics to enhance cooperation is to ask the child to pretend to blow up a balloon or blow out candles on a birthday cake. This encourages deep inhalations and expirations to better assess breast sounds.
- Auscultate the chest, comparing breath sounds as you move the stethoscope down the chest.
- Note any sounds such as wheezing or crackles on both the inspiratory and expiratory phases of the respiratory cycle.
- Document your findings and be sure to indicate if the infant was at rest or crying during the examination. See Table 3 for normal respiratory rate and heart rate parameters.

Observe for symptoms of respiratory distress such as:

- Tripod positioning
- Paradoxical abdominal breathing
- Absence of crying
- Drooling
- Cyanosis
- Retractions in the tracheal, supra-costal, substernal, or subcostal areas.

ALERT: A "silent chest" is considered a medical emergency. This is suggestive of little to no air exchange and is a warning that respiratory failure may be imminent (Hockenberry et al., 2022).

Both respiratory rate and heart rate are dependent on the child's age.

Objective Assessment

Start with vital signs—blood pressure, pulse, respirations, pulse oximetry, and temperature. Pulse oximetry (SpO_2) measures oxygenation at the tissue level and hemoglobin saturation in arterial blood. A patient with no lung disease or anemia should have an SpO_2 reading of 97% to 100% (Jarvis, 2020). Conversely a patient with an SpO_2 level less than 94% is considered hypoxic. If this is a new finding or the SpO_2 is <90, the primary care provider should be notified (Myatt, 2017). If a patient is on home oxygen, SpO_2 should be assessed with the patient wearing oxygen supplementation.

Measure the respiratory rate by counting for one full minute while the patient is unaware they are being observed, as knowing their breathing is being measured could alter their breathing pattern. Record the rate, rhythm, and depth (shallow, deep, or labored). A summary of respiratory rates and patterns is provided in Table 1.

General Survey

While assessing vital signs, note the patient's physical presentation, including facial expression and level of consciousness, and whether they are alert and oriented to person, place, time, and situation. Assess whether the patient is confused, lethargic, drowsy, interacting appropriately and cooperative, or are they distrustful, hostile, or distressed. A restless or agitated patient may show signs of hypoxia (Bickley, 2020).

Posterior Inspection

To prepare for inspection, ensure the room is warm because the patient should be without upper body clothing for an accurate assessment. Evaluate the patient's skin. Healthy skin is warm, dry, intact, uniform, and consistent with ethnicity. Patients with COPD often have under-oxygenated blood that induces purple or red skin discoloration (Jarvis, 2020). Examine the patient's mouth and lips for cyanosis which suggests hypoxia.

Cyanosis in patients with light skin creates a blue-tinged appearance. With dark skin tones, cyanosis can appear darker blue and dull (Jarvis, 2020). Inspect the patient's nail beds for shape and color. Nailbeds should be pink with brisk capillary refill and the angle between the nail base and skin should be 160 degrees. Cyanotic or pale nails can indicate hypoxemia and clubbing of the nails can occur with chronic hypoxemia (Bickley, 2020).

Assess for signs of respiratory compromise, such as tachypnea, pursed lip breathing, air hunger, and/or use of accessory muscles (sternocleidomastoid, trapezius, external intercostals, pectoralis major). Use of accessory muscles during respiration should prompt quick intervention, as this suggests a medical emergency. Observe the chest wall for shape and configuration. The spinous process should appear straight, with a symmetrical thorax, downward sloping ribs, and symmetrically scapulae. Ribs, clavicles, and sternum are usually flat and free of deformity (Jarvis, 2020). If asymmetry is noted, the thoracic cage may be limited by skeletal deformities such as scoliosis or kyphosis (McCance & Huether, 2018). Assess the anteroposterior (AP) diameter, which should be less than the transverse diameter. Anteroposterior and transverse diameters are often equal in COPD patients, making the chest "barrel" shaped and the ribs horizontal. Evaluate the patient's position. Sitting in the tripod position (sitting up and leaning forward with arms on knees) opens the chest allowing for better lung expansion and is commonly seen in patients with COPD. As a patient ages, the chest size increases, increasing the AP diameter, and there may be an outward curvature of the thoracic supine, known as kyphosis (Winn et al., 2020).

Palpation

Assess for symmetrical expansion by placing warm hands on the posterolateral chest at the level of T_9-T_{10}. With thumbs together, slide hands medially and pinch the skin between thumbs* (Figure 1). Ask the patient to breathe in and out slowly and observe if hands and thumbs move equally on both sides. Unequal movement of hands can indicate atelectasis or pneumonia, and if accompanied by pain may suggest pleural effusion (McCance & Huether, 2018). It should be noted that chest expansion in older adults may decrease due to increased costal cartilage calcifications or loss of musculature, but it should be symmetrical (Jarvis, 2020).

Palpate for tactile fremitus by using the ulnar side of one hand or the palmar base of the fingers*. Start at the apices of the lungs and palpate for vibrations when the patient says, "blue moon" or "ninety-nine" (Figure 2). Fremitus is prominent where the bronchi are closest to the chest and decreases as hands progress down the chest because of increased tissue which may be related to obesity or increased musculature. Decreased fremitus may suggest conditions such as obstructed bronchus, pneumothorax, emphysema, or pleural effusion (Booth, 2023). Increased fremitus occurs with lung consolidation which can be caused by pneumonia, excessive mucus production, or atelectasis. Bronchial or rhonchal fremitus is felt when patients have thickened bronchial secretions. When the pleura is inflamed, pleural friction fremitus may be detected (Booth, 2023). Palpate the entire chest wall for tenderness, skin temperature, moisture, lumps/masses, or lesions. If crackling or a coarse sensation (crepitus) is noted, this may be caused by air escaping the lungs and entering the subcutaneous tissue. It should be noted that bony prominences may be palpable as the patient ages due to the decrease in subcutaneous fat.

Table 1. Summary of respiratory rates and patterns

Name	Description
Normal respiratory rate	12–20/minute
Bradypnea	<10 respirations/minute
Tachypnea	>20 respirations/minute
Hypoventilation	Irregular shallow pattern
Cheyne-Stokes	Increased rate and depth with brief periods of apnea
Biot's	Series of 3–4 normal respirations followed by periods of apnea

Adapted from Jarvis (2020).

Figure 1. Assessing chest expansion

Figure 2. Locations for palpating fremitus

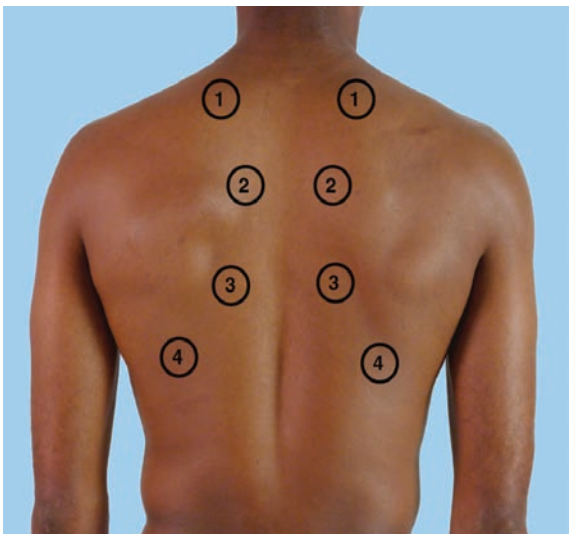


Figure 3. "Ladder" pattern for percussion and auscultation

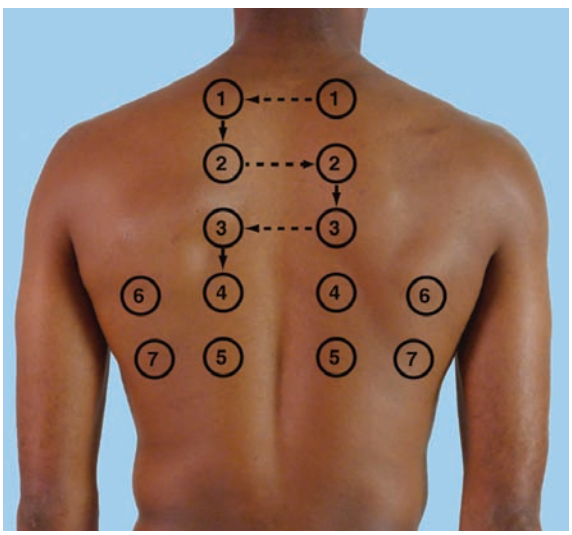
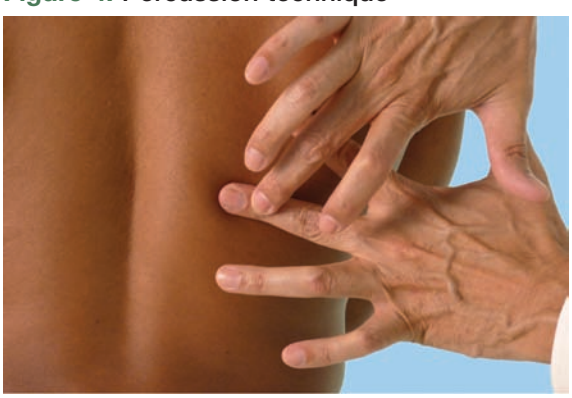


Figure 4. Percussion technique



Percussion

Perform percussion on the posterior chest by starting at the apices, alternating side to side to compare sounds* (Figure 3). Keep the middle finger firmly on the chest wall along the intercostal spaces (Figure 4) and tap the chest over the distal interphalangeal joint with the middle finger of the opposite hand. The movement of tapping should come from the wrist. Tap two to three times in a row, but do not leave the percussing finger on the chest because it will dampen the sound (Bickley, 2020). As you strike the intercostal spaces, note the feel of percussion and resonance. Resonance is a clear, hollow, low-pitched sound noted over normal lung tissue; dull tones are muffled sounds signifying density, which is often found over bones. If dullness is noted in intercostal spaces, this may indicate abnormal density, such as pleural effusion, atelectasis, pneumonia, or tumor. Hyperresonance is a booming, low-pitched sound found when too much air is present such as in patients with emphysema (Bickley, 2020).

Auscultation

The air passing through the tracheobronchial tree generates distinct sounds that may vary if there is an obstruction in the passageway. Auscultate posterior breath sounds directly on skin, not over clothes which could produce either muffled breath sounds or additional sounds. While in a sitting position, instruct the patient to lean slightly forward, arms resting at the side, and breathe in through the mouth. Hold the stethoscope's diaphragm firmly on the chest wall and listen for one full inspiration and expiration in each location, starting at the apices to the bases (T_{10}) and laterally from the axilla to the 7th/8th rib (Figure 3). Compare side to side, listening intently. Normal breath sounds include tracheal, bronchial, bronchovesicular, and vesicular sounds (Table 2). Tracheal breath sounds are normally heard over the trachea and are characterized as high pitch, loud amplitude, harsh, and hollow, with the duration of inspiration less than expiration. Bronchial breath sounds are heard over the larger airways and are loud with a relatively high pitch. Bronchovesicular sounds are heard over the main bronchi and have a moderate pitch and amplitude, with the duration equal between inspiration and expiration. Vesicular sounds are heard over most of the peripheral lung field and have a low pitch and soft amplitude, sounding like rustling with the duration of inspira-

Table 2. Characteristics of Breath Sounds from Bickley (2020)

	Duration of Sounds	Intensity of Expiratory Sound	Pitch of Expiratory Sound	Locations Where Heard Normally
Vesicular* 	Inspiratory sounds last longer than expiratory sounds.	Soft	Relatively low	Over most of both lungs
Bronchovesicular 	Inspiratory and expiratory sounds are almost equal.	Intermediate	Intermediate	Often in the first and second interspaces anteriorly and between the scapulae
Bronchial 	Expiratory sounds last longer than inspiratory ones.	Loud	Relatively high	Over the manubrium (larger proximal airways)
Tracheal 	Inspiratory and expiratory sounds are almost equal.	Very loud	Relatively high	Over the trachea in the neck

*The thickness of the bars indicates intensity; the steeper their incline the, higher the pitch.

Sources: Loudon R, Murphy LH. *Am Rev Respir Dis*. 1994;130:663; Bohadana A et al. *N Engl J Med*. 2014;370:744; Wilkins RL et al. *Chest*. 1990;98:886; Schreur HJW et at. *Thorax* 1992;47:674; Bettancourt PE et al. *Am J Resp Crit Care Med*. 1994;150:1921.

tion greater than expiration (Bickley, 2020). Breath sounds are considered normal only in the areas specified; if detected elsewhere they are considered abnormal. A silent chest indicates no air movement and is an ominous sign. Absent or diminished sounds indicate an obstruction which may be due to mucus plugs, secretions, foreign objects, or any condition which prevents free movement of air. Patients with emphysema have hyperinflated lungs, loss of lung tissue elasticity, and diminished inspiratory breath sounds (McCance & Huether, 2018). If breath sounds are loud, the patient may have lung consolidation which occurs when the alveoli and bronchioles are filled with fluid, pus, infection, or malignant cells. Consolidation enhances the transmission of sound. If the patient is obese or muscular, breath sounds may be difficult to hear. Deep breathing may be difficult for older adults, particularly those with chronic lung disease, causing fatigue; offer rest as needed during the examination.

Adventitious Breath Sounds

Adventitious sounds are added or superimposed over normal breath sounds caused by air colliding with secretions in the tracheobronchial passageway. Note the chest wall location and when it was heard during the respiratory cycle (inspiration or expiration). If abnormal sounds are heard during auscultation, have the patient cough, clearing the lungs. Then listen again and note any changes.

Discontinuous sounds include fine and coarse crackles, atelectatic crackles, and pleural friction rub. Fine crackles heard during inspiration are high-pitched crackling or popping sounds and can be caused by air colliding with deflated airways that open (Bickley, 2020). Crackles can be heard with pneumonia, interstitial fibrosis, heart failure, or may be caused by changes in position from sitting to supine (postural induced crackles). Expiratory fine crackles are caused by sudden airway closing. These are often heard with asthma, chronic bronchitis, and emphysema (Kim et al., 2022).

Course crackles are caused when air collides with tracheal or large bronchi secretions and sound like a low-pitch, loud gurgling that starts with inspiration and may be present with expiration as well. These sounds can be heard with pneumonia, pulmonary edema, pulmonary fibrosis, and patients with a depressed cough reflex (McCance & Huether, 2018). Suctioning or deep coughing may decrease crackles, but they will reappear shortly afterward. Atelectatic crackles are caused by alveoli not fully aerated due to secretions. These sound like fine crackles, but they do not last, and disappear after a few deep breaths. Atelectatic crackles are often detected in patients confined to bed. A pleural friction rub is caused when the pleura is inflamed and loses its lubrication. It triggers the surfaces to rub together and sounds coarse, low-pitched, and superficial, heard with pleuritis (Jarvis, 2020).

Table 3. Normal Respiratory Rate (RR) and Heart Rate (HR) Parameters

Age	Normal RR	Normal HR
0–6 months	30–45	100–150
6–12 months	25–40	80–120
1–2 years	20–30	80–125
3–5 years	20–25	70–115
6–11 years	14–22	60–100
>12 years	12–18	55–85

Adapted from Hockenberry et al., 2022; Kliegman et al., 2020.

Continuous adventitious breath sounds include high- and low-pitched wheezes and stridor. High-pitched wheezes are caused by air squeezing through narrow passageways. They sound like musical squeaking, predominately during expiration and are heard with chronic emphysema or acute asthma (Bickley, 2020). Low-pitched wheezing is caused by an airflow obstruction heard with bronchus obstruction or bronchitis (McCance & Huether, 2018). Stridor originates in the larynx or trachea with upper airway obstruction from inflamed tissue or foreign body and sounds high pitched, with a crowing sound that is louder in the neck than the chest. Stridor is heard with croup, epiglottitis, or a foreign body and may indicate a life-threatening condition (Bickley, 2020).

Given that respiratory assessment is a practiced skill, the opportunity to recognize abnormal breath sounds can be limited in the homecare setting. This challenge can be addressed by a wide variety of free websites offering audio lung sound lessons and resources, including http://www.thesimtech.org/audio (Audio, 2023), https://www.easyauscultation.com/lung-sounds (French et al., 2023), and https://www.practicalclinicalskills.com/lung-sounds-audio (Wrigley, 2021).

Anterior Inspection, Palpation, Percussion, and Auscultation

Inspect the position of the sternum, which should be midline and straight. Pectus excavatum or funnel chest is a congenital deformity with a sunken sternum but is not typically a cause for concern. In older patients, it is not uncommon to visualize a prominent sternum or ribs because of decreased subcutaneous fat. To palpate for anterior chest expansion, hands should be placed on the anterolateral wall with thumbs on the costal margins pointing to the xiphoid process* (Jarvis, 2020). Watching the thumbs, ask the patient to take a deep breath, looking for symmetrical thumb movement. Atelectasis or pneumonia create a lag in chest expansion. With pleural friction fremitus, a palpable grating sensation is noted (Kim et al., 2022). Next, assess for tactile fremitus by palpating the tissue over the lung fields, starting at the apices. As the patient says, “ninety-nine” or “blue moon,” compare the vibrations from side to side*. Avoid palpating over female breast as breast tissue dampens the sound.

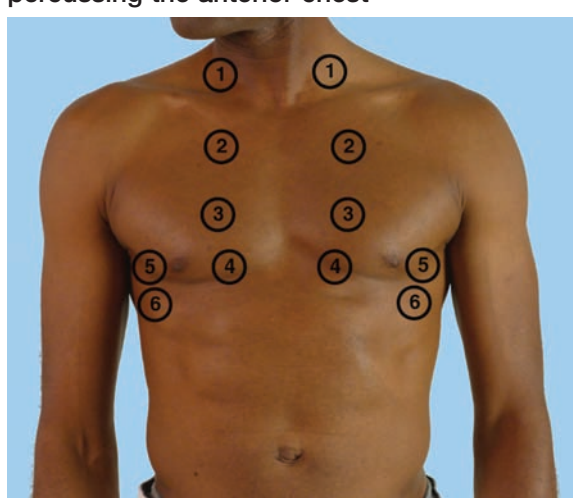
Palpate the anterior chest for tenderness, lumps/masses, skin motility, turgor, temperature, and moisture. Refer the patient to their primary care provider if lumps/masses are found in breast tissue. Percuss the interspaces of the anterior chest starting at the apices, comparing from side to side down the anterior chest* (Figure 5). Shift breast tissue over as it produces a dull note, yielding little helpful information.

Take note of the dullness heard over the heart and liver and tympany over the gastric space (Bickley, 2020). Hyperresonance is usually heard with right middle lobe pneumonia or chronic emphysema; dullness is heard behind the right breast. Auscultate using the same sequence for percussion, starting at the apices, moving down to the sixth rib, alternating from side to side, listening in each location for one full respiration. Again, displace breast tissue and listen over the chest wall. Evaluate breath sounds, noting any abnormality or adventitious breath sounds.

After the Physical Assessment

After completing the respiratory assessment, document your findings. Ensure that the patient is

Figure 5. “Ladder” pattern for palpating and percussing the anterior chest



comfortable and answer any questions. With the data gathered from the general survey, physical assessment, and medical history, home healthcare clinicians now have a complete picture of the patient's respiratory presentation. Clinicians can interpret the clinical findings and respond to any respiratory concerns appropriately.

Conclusion

Many adults suffer from respiratory complications, which is a leading cause of morbidity and mortality. Patients suffering from respiratory compromise are admitted to acute care facilities for acute treatment and discharged to home for continued recovery. It is essential that home healthcare clinicians undertake a comprehensive and systematic respiratory assessment, including inspection, palpation, percussion, and auscultation. Proficiency in respiratory assessment is an essential skill needed to recognize any problems or abnormalities which can hamper recovery or indicate a new or unresolved illness. With early identification of potential complications, early intervention can improve patient outcomes. ⌂

Nadine Wodwaski, DNP, MSN-ed, CNS, RN, is an Associate Professor, McAuley School of Nursing, University of Detroit Mercy, Detroit, Michigan.

Elaine Webber, DNP, PPCNP-BC, IBCLC, is a Professor, McAuley School of Nursing, University of Detroit Mercy, Detroit, Michigan.

The authors declare no conflicts of interest.

Address for correspondence: Nadine Wodwaski, DNP, MSN-ed, CNS, RN, McAuley School of Nursing, University of Detroit Mercy, 4001 W. McNichols Rd, Detroit, MI 48221 (wodwasnk@udmercy.edu).

DOI:10.1097/NHH.0000000000001184

REFERENCES

Audio. (2023). *The SimTech*. http://www.thesimtech.org/audio Bickley, L. (2020). *Bates Guide to Physical Exam and History Taking*. Lippincott ISBN/ISSN: 9781496398178.

Booth, G. M. (2023). Pulmonology. In *Managing Emergencies in the Outpatient Setting: Pearls for Primary Care*. Springer International Publishing.

Centers for Disease Control and Prevention. (2022). *Health, United States, 2020-2021.* https://www.cdc.gov/nchs/hus/data-finder.htm?&subject=Respiratory%20diseases

French, W., Wrigley, D., & Keroes, J. (2023). *Lung sounds.* Easy Auscultation. https://www.easyauscultation.com/lung-sounds

Hockenberry, M., Wilson, D., Rodgers, C., & Wonger, D. (2022). *Wong's Essentials of Pediatric Nursing* (11th ed.). Elsevier.

Jarvis, C. (2020). *Physical Examination and Health Assessment* (8th ed.). W.B. Saunders.

Kim, Y., Hyon, Y., Lee, S., Woo, S.-D., Ha, T., & Chung, C. (2022). The coming era of a new auscultation system for analyzing respiratory sounds. *BioMed Central: Pulmonary Medicine*, *22*(1), 1–11. https://bmcpulmmed.biomedcentral.com/articles/10.1186/s12890-022-01896-1

Kliegman, R., Stanton, B., St. Geme, J., & Schor, N. (2020). *Nelson Textbook of Pediatrics* (20th ed.). Elsevier.

McCance, K., & Huether, S. (2018). *Pathophysiology: The Biologic Basis for Disease in Adults and Children* (8th ed.). Mosby.

Moutlana, H. (2020). Physiological control of respirations. *Southern African Journal of Anaesthesia and Analgesia, 26*(6), S128–S132. https://pdfs.semanticscholar.org/d078/251a7a6cf9b2f103a2f556a7c841e9968a72.pdf

Winn, N., Llopis, E., & Cassar-Pullicino, V. N. (2020). Thoracolumbar spine. In *Measurements in Musculoskeletal Radiology* (pp. 189–236). Springer Publishing.

World Health Organization. (2022). *World health statistics 2022: monitoring health for the SDGs, sustainable development goals.* https://www.who.int/publications/i/item/9789240051157

Wrigley, D. (2021). *Lung sounds; Breath sounds.* Practical Clinical Skills. https://www.practicalclinicalskills.com/lung-sounds-audio