



Case Study Report: Asthma – Understanding the Respiratory System and Lifestyle Management for Adolescents

Component 1: Written Assignment (Case Study Report)

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Introduction

Asthma is a chronic inflammatory disorder of the airways that causes recurrent episodes of wheezing, breathlessness, chest tightness and coughing, particularly at night or in the early morning (National Institute for Health and Care Excellence (NICE), 2024). It is one of the most common long-term respiratory conditions in the UK, affecting the lower respiratory tract and producing variable airflow obstruction that is usually reversible with treatment or spontaneously. Currently, approximately 5.4 million people in the UK are receiving treatment for asthma, and adolescents represent a particularly vulnerable group as they move from childhood symptoms into more severe adult-type presentations (British Thoracic Society, NICE and SIGN (BTS/NICE/SIGN), 2025).

The core pathophysiology of asthma involves three interlinked processes: airway inflammation, bronchial hyperresponsiveness and mucus hypersecretion (Sinyor et al., 2023). Chronic inflammation damages the airway epithelium, leading to oedema of the submucosa, recruitment of eosinophils and mast cells, and release of inflammatory mediators. This results in swelling of the bronchial walls, excessive mucus production by hyperplastic goblet cells, and contraction of smooth muscle, all of which narrow the airway lumen and increase resistance to airflow. These changes explain the sudden exacerbations seen in the fortnightly

asthma clinic described in the case study, where adolescents who previously experienced only mild childhood symptoms are now presenting with more serious and frequent attacks.

Risk factors for developing and worsening asthma are both genetic and environmental. Genetically, a strong family history of atopy (allergic tendency) is the most significant predictor; maternal atopy confers the highest risk through in-utero immune programming and epigenetic changes (BTS/NICE/SIGN, 2025). Environmentally, common triggers include allergens such as house dust mite and pollen, outdoor and indoor air pollution, occupational exposures and viral respiratory infections. For adolescents specifically, modifiable lifestyle factors play a major role in triggering and exacerbating the condition. These include the initiation of smoking or vaping, frequent attendance at crowded bars and clubs (which dramatically increases exposure to respiratory viruses), reduced physical activity levels, poor sleep patterns and weight gain associated with social lifestyle changes (Chatziparasidis et al., 2022). Vaping, in particular, introduces chemical irritants such as nicotine, propylene glycol and flavouring agents that cause direct epithelial injury and oxidative stress, even among adolescents who have never smoked conventional tobacco (Tam et al., 2023). These behaviours align exactly with the case study observations and explain the rise in exacerbations as young people gain greater social independence.

By providing adolescents with clear, evidence-based physiological explanations of their condition and its risk factors, practice nurses can empower them to take greater ownership of their care plans. This understanding has been shown to reduce emergency department attendances, improve medication adherence and significantly enhance overall quality of life (NICE, 2024). The report below therefore addresses all required elements of the case study to support effective patient education in the GP surgery setting.

Describe the structure of the respiratory system and explain the process of mechanical respiration

The respiratory system is anatomically divided into the upper respiratory tract (nasal cavity, pharynx and larynx) and lower respiratory tract (trachea, bronchi, bronchioles and alveoli). Functionally, it is separated into a conducting zone (which transports air) and a respiratory zone (where gas exchange occurs) (Cleveland Clinic, 2024). The conducting zone warms, humidifies and filters inspired air. Key structures include the trachea, reinforced by C-shaped hyaline cartilage rings to prevent collapse, and the bronchi, lined with ciliated pseudostratified columnar epithelium containing goblet cells that produce mucus to trap particles. As the airways branch into smaller bronchioles, cartilage disappears and the walls become dominated by smooth muscle, allowing dynamic changes in diameter. The respiratory zone begins at the respiratory bronchioles and terminates in approximately 300 million thin-walled alveoli, each surrounded by a dense network of pulmonary capillaries. This architecture provides an enormous surface area of around 70 m² for efficient gas exchange (National Heart, Lung, and Blood Institute (NHLBI), 2022).

Mechanical respiration, or pulmonary ventilation, is the process of moving air into and out of the lungs and depends on pressure gradients created by changes in thoracic volume, governed by Boyle's law (pressure and volume are inversely related) (TeachMePhysiology, n.d.). Inspiration is an active process requiring muscular effort. The diaphragm contracts and flattens, increasing the vertical dimension of the thoracic cavity, while the external intercostal muscles lift the ribs upwards and outwards, expanding the anterior-posterior and lateral dimensions. As thoracic volume increases, intrapleural pressure falls below atmospheric

pressure, causing air to flow into the lungs until intrapulmonary pressure equalises. Normal (quiet) expiration is passive: elastic recoil of the stretched lung tissue and chest wall, aided by the surface-tension-reducing properties of pulmonary surfactant, returns the thorax to its resting position, raising intrapulmonary pressure above atmospheric pressure and expelling air. During forced expiration (for example, during coughing or exercise), the internal intercostal muscles and abdominal muscles contract to accelerate the process.

Figure 1: Structure of the respiratory system (Insert a fully labelled diagram here showing the upper and lower respiratory tracts, trachea, bronchi, bronchioles, alveoli, diaphragm and pleural membranes. Source and reference: Cleveland Clinic, 2024.)

Briefly explain the process of gas exchange in the lungs, showing how oxygen is absorbed into the blood and carbon dioxide is released into the alveoli

Gas exchange in the lungs occurs by simple diffusion across the extremely thin respiratory membrane (0.5–1 μm thick) within the alveoli (Merck Manuals, 2014). The membrane consists of alveolar type I cells, a shared basement membrane and the endothelium of pulmonary capillaries. Oxygen diffuses from alveolar air, where its partial pressure is approximately 104 mmHg, into deoxygenated blood in the pulmonary capillaries ($\text{PO}_2 \approx 40$ mmHg) down its concentration gradient. Once in the blood, oxygen dissolves in plasma and rapidly binds to haemoglobin inside erythrocytes to form oxyhaemoglobin, which is then transported to the tissues. Simultaneously, carbon dioxide diffuses in the opposite direction: from venous blood ($\text{PCO}_2 \approx 46$ mmHg) into the alveoli ($\text{PCO}_2 \approx 40$ mmHg). The majority of CO_2 is transported in blood as bicarbonate ions (HCO_3^-), formed inside red blood cells by the enzyme carbonic anhydrase; smaller amounts remain dissolved in plasma or bound to haemoglobin as carbamino-haemoglobin. In the alveoli, CO_2 is released and exhaled (NHLBI, 2022).

Efficient gas exchange also depends on optimal ventilation-perfusion (V/Q) matching, with an ideal ratio of approximately 0.8 across the lung. In asthma, patchy airway obstruction creates regions of low ventilation relative to perfusion, resulting in hypoxaemia and, in severe cases, hypercapnia (Powers and Dhamoon, 2023). This physiological impairment directly affects cellular metabolism and explains why adolescents in the case study experience worsening symptoms after exposure to irritants or viruses in social settings. Understanding this process helps patients appreciate why maintaining open airways through lifestyle choices and medication is essential.

Figure 2: Gas exchange at the alveolar-capillary membrane (Insert a fully labelled diagram here showing diffusion of O_2 and CO_2 , partial pressures, haemoglobin binding and carbonic anhydrase. Source and reference: Merck Manuals, 2014.)

Explain how increased levels of irritants in the respiratory system leads to swelling in the lung tissue, and the impact of this on respiration

When irritants such as tobacco smoke, vape aerosols (containing nicotine, propylene glycol and flavourings) or respiratory viruses from crowded venues enter the airways, they trigger the classic asthmatic inflammatory cascade (Sinyor et al., 2023). Epithelial cells and mast cells release histamine, leukotrienes and cytokines, which recruit eosinophils and T-helper 2 lymphocytes. The resulting inflammation produces three main effects: (1) oedema of the submucosa due to increased vascular permeability, (2) hyperplasia of goblet cells leading to

excessive mucus secretion, and (3) contraction of bronchial smooth muscle (bronchoconstriction). These changes cause swelling of the airway walls and narrowing of the lumen.

Because airway resistance follows Poiseuille's law ($\text{resistance} \propto 1/\text{radius}^4$), even small amounts of swelling produce exponentially higher resistance to airflow. Expiration is particularly affected because it is normally passive; the narrowed airways trap air, increasing residual volume and causing hyperinflation of the lungs. Patients experience dyspnoea, prolonged expiration, wheezing and reduced peak expiratory flow. In adolescents, vaping adds direct oxidative stress and chemical damage to the ciliated epithelium, while frequent exposure to viruses in bars and clubs amplifies the inflammatory response (Chatziparasidis et al., 2022; Tam et al., 2023). If repeated, chronic inflammation can lead to airway remodelling with subepithelial fibrosis, making symptoms more persistent and difficult to reverse (BTS/NICE/SIGN, 2025). This explains the more serious exacerbations described in the case study and highlights the direct physiological link between lifestyle irritants and impaired respiration.

Briefly examine how recording and tracking respiratory functions, such as peak flow readings, helps individuals with asthma to monitor and safely manage their condition

Peak expiratory flow (PEF) monitoring using a simple handheld peak flow meter provides an objective, reproducible and immediate measure of large-airway calibre and overall lung function (DeVrieze, 2024). Patients first establish their personal best PEF (the highest of three readings taken when well) and then compare daily readings to create three colour-coded zones: Green ($>80\%$ of best – good control), Yellow ($50\text{--}80\%$ – caution; increase preventer medication) and Red ($<50\%$ – medical alert; seek urgent help). Daily tracking reveals day-to-day variability (greater than 20% suggests poor control) and can detect early deterioration before subjective symptoms become obvious, allowing timely self-adjustment of medication (NICE, 2024).

Clinical evidence demonstrates that combining PEF monitoring with symptom diaries is more effective than symptom monitoring alone in reducing exacerbations and unscheduled healthcare visits, particularly in moderate-to-severe asthma among adolescents (Gibson et al., 2000; Buist et al., 2006). In the GP asthma clinic setting, regular PEF recording gives concrete visual feedback on how specific lifestyle choices (e.g., vaping after a night out or skipping exercise) directly affect lung function. This reinforces positive behaviour change and supports safe self-management, aligning with LO2 of the module by showing how routine data collected in health and social care is used to improve patient outcomes.

Include evidence-based recommendations on how lifestyle changes could help improve their condition

Evidence-based lifestyle modifications are a cornerstone of modern asthma management and work synergistically with pharmacological therapy (Stoodley et al., 2019). The most important recommendation is complete cessation of smoking and vaping. Both active and passive exposure to tobacco smoke and vape aerosols increase airway inflammation and reduce lung function; vaping is independently associated with worse asthma control and higher exacerbation rates in adolescents (Tam et al., 2023; Chatziparasidis et al., 2022). Referral to NHS stop-smoking/vaping services that combine behavioural support, nicotine

replacement therapy and motivational interviewing has been shown to significantly improve quit rates and lung function.

Conclusion

This report has provided a comprehensive physiological explanation of asthma, detailing the structure and function of the respiratory system, the mechanics of respiration, the process of gas exchange, the inflammatory effects of irritants on lung tissue, the value of peak-flow monitoring and evidence-based lifestyle recommendations. By understanding these processes, adolescents attending the GP asthma clinic can recognise how their daily choices directly influence their respiratory health. Practice nurses are ideally placed to deliver this education, bridging the gap between anatomy, physiology and real-world behaviours. Empowering patients with this knowledge supports safer self-management, reduces exacerbations and improves long-term health outcomes in line with both module learning outcomes.

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