

---

## Changes in Respiratory Rate Before and After Oxygen Administration Among Patients With Bronchial Asthma in the Emergency Department of Assyifa Islamic Hospital, Sukabumi, Indonesia

Fitri Septiyani Suparma<sup>1\*</sup>, Ratna Fithriyah Solihany<sup>2</sup>

<sup>1,2</sup>Yapkesbi Health Polytechnic, Indonesia

*Correspondence Author, Email: igdfitri1987@gmail.com*

---

### ABSTRACT

**Background:** Asthma is a chronic inflammatory airway disease characterized by variable airflow limitation and respiratory symptoms. During acute exacerbations, increased respiratory rate may reflect respiratory distress. Supplemental oxygen may be administered as part of emergency management when clinically indicated; however, changes in respiratory rate cannot necessarily be attributed to oxygen administration alone.

**Objective:** To describe changes in respiratory rate before and after emergency management involving supplemental oxygen among patients with bronchial asthma.

**Methods:** This quantitative study employed a single-group, uncontrolled before–after design. The study was conducted in the Emergency Department of Assyifa Islamic Hospital, Sukabumi, Indonesia, in May 2026. Twenty-three participants were selected through purposive sampling from a reported population of 30 patients. Respiratory rate was assessed before and after the management episode and categorized into predefined intervals. Descriptive statistics were used to summarize participant characteristics and respiratory rate distributions.

**Results:** Before management, 18 participants (78.3%) had respiratory rates of 21–25 breaths/min, while five (21.7%) had rates of 26–30 breaths/min. Following management, 22 participants (95.7%) had respiratory rates of 15–20 breaths/min, and one (4.3%) had a rate of 21–25 breaths/min.

**Conclusion:** Respiratory rate categories shifted toward lower values following emergency management involving supplemental oxygen. However, the absence of a control group and incomplete documentation of concurrent interventions prevent the observed changes from being attributed independently to oxygen administration.

**Keywords:** bronchial asthma; respiratory rate; supplemental oxygen; emergency department; before–after study.

---

### INTRODUCTION

Asthma is a heterogeneous chronic inflammatory disease of the airways characterized by variable respiratory symptoms, airway hyperresponsiveness, and fluctuating expiratory airflow limitation. The underlying disease process involves complex interactions among airway inflammation, bronchial smooth muscle contraction, mucus production, and structural changes that may contribute to respiratory obstruction. Patients commonly experience wheezing, coughing,

chest tightness, and breathlessness, with symptom intensity varying according to environmental exposures, respiratory infections, medication adherence, and individual disease characteristics. Although effective pharmacological management can reduce symptoms and prevent exacerbations, acute episodes remain an important cause of emergency department attendance and hospitalization. The Global Initiative for Asthma (GINA, 2025a) emphasizes that appropriate diagnosis, assessment of disease severity, and timely treatment are fundamental

to reducing asthma-related morbidity and preventing potentially life-threatening respiratory deterioration.

The global burden of asthma demonstrates the continuing importance of improving respiratory care and evaluating clinical outcomes. According to the World Health Organization (WHO, 2026), approximately 363 million individuals were affected by asthma in 2023, and the disease was associated with an estimated 442,000 deaths. Asthma-related morbidity extends beyond acute symptoms because uncontrolled disease may interfere with daily activities, occupational productivity, sleep quality, and overall well-being. Disparities in healthcare access, availability of essential inhaled medications, and continuity of disease management can further increase the burden of preventable exacerbations. These challenges emphasize the importance of emergency healthcare services, where healthcare professionals must rapidly identify respiratory deterioration, initiate appropriate treatment, and reassess patient responses using clinically meaningful parameters. Consequently, respiratory monitoring remains a fundamental component of asthma care, especially when patients present with acute breathing difficulties.

During an acute asthma exacerbation, airway narrowing increases resistance to airflow and may produce substantial changes in respiratory mechanics. Bronchial smooth muscle contraction, airway wall inflammation, and mucus accumulation can limit expiratory airflow, promote air trapping, and increase the work required for ventilation. Patients may consequently develop tachypnea, accessory respiratory muscle use, prolonged expiration, or other signs of respiratory distress. Respiratory rate is among the most accessible physiological measurements used during initial assessment because it can be obtained rapidly without specialized diagnostic equipment. Nevertheless, respiratory rate does not provide a complete evaluation of pulmonary function or exacerbation severity. Long and Rezaie (2022) emphasized that emergency assessment of obstructive airway exacerbations requires integration of clinical symptoms, respiratory effort, oxygenation, airflow measurements when available, and response to treatment.

Similarly, Dabbs et al. (2024) described repeated clinical assessment as an essential component of acute asthma management, particularly because respiratory deterioration may occur despite initially reassuring physiological observations.

An important consideration in respiratory assessment is the distinction between respiratory rate and subjective dyspnea. Respiratory rate represents an objective measurement of breathing frequency, whereas dyspnea refers to a patient's subjective experience of breathing discomfort. Although both may occur during acute airway obstruction, they represent different dimensions of respiratory function and should not be treated as interchangeable clinical outcomes. A patient may report severe breathlessness without marked tachypnea, while an elevated respiratory rate may occur for reasons unrelated to airway obstruction, including anxiety, pain, fever, or metabolic disturbances. Howell et al. (2024), in a systematic review of outcome measurements used in asthma attack treatment trials, highlighted the variability of outcomes selected to evaluate treatment responses. This finding underscores the need for clearly defined and appropriately measured study outcomes. Accordingly, respiratory rate should be reported as a physiological variable rather than interpreted as a validated measure of perceived dyspnea unless a suitable symptom assessment instrument has been used.

Emergency management of acute asthma generally involves several complementary interventions targeting different components of the underlying respiratory disturbance. Inhaled short-acting beta<sub>2</sub>-agonists are commonly administered to relieve bronchoconstriction, while systemic corticosteroids are used when indicated to reduce inflammation and lower the risk of continued deterioration. In some clinical situations, anticholinergic bronchodilators and additional supportive interventions may also be required. Supplemental oxygen serves a different therapeutic purpose by addressing inadequate oxygenation when clinically indicated. GINA (2025b) recommends controlled oxygen administration with monitoring of oxygen saturation, alongside appropriate bronchodilator and corticosteroid

treatment. Evidence concerning asthma pharmacotherapy further demonstrates the importance of distinguishing individual therapeutic components. Rayner et al. (2025) reported clinically meaningful differences among inhaled reliever strategies, while Roche et al. (2024) identified heterogeneity in patient characteristics and treatment outcomes across trials of inhaled corticosteroid-containing regimens. Although these studies do not directly evaluate oxygen-related changes in respiratory rate, they demonstrate why outcomes observed during asthma treatment should be interpreted in relation to the broader therapeutic context.

Oxygen saturation monitoring represents another important component of respiratory assessment because the physiological effects of supplemental oxygen are primarily related to oxygen availability rather than direct reversal of bronchoconstriction. Current GINA guidance recommends titrating oxygen, when necessary, toward a peripheral oxygen saturation target of approximately 93%–95% for adults and adolescents. However, achieving an appropriate oxygen saturation does not necessarily demonstrate that airflow obstruction has resolved, nor does a reduction in respiratory rate independently establish improvement in oxygenation. Furthermore, pulse oximetry measurements require careful interpretation. Shi et al. (2022) identified differences in pulse oximetry accuracy across skin pigmentation groups, while Cabanas et al. (2022) described several technical and physiological factors that may affect oxygen saturation measurement. These considerations reinforce the importance of combining respiratory rate, oxygen saturation, clinical symptoms, and other available observations when evaluating patient status.

Despite the established importance of respiratory monitoring in acute asthma, the interpretation of physiological changes following emergency management remains methodologically challenging when multiple treatments are administered during the same clinical episode. Before–after observations may demonstrate differences between assessment periods, but they cannot determine whether a particular intervention independently caused those differences without an

appropriate comparison strategy and sufficient treatment documentation. The original dataset from Assyifa Islamic Hospital contained respiratory rate observations obtained before and after emergency management involving supplemental oxygen among patients with bronchial asthma. However, documentation concerning oxygen delivery parameters, baseline oxygen saturation, concurrent pharmacological interventions, and measurement intervals was incomplete. Therefore, the present investigation addresses a descriptive rather than causal question, focusing on the respiratory rate distributions documented during the emergency-care episode.

Based on these considerations, this study aimed to describe changes in respiratory rate categories before and after emergency management involving supplemental oxygen among patients with bronchial asthma at the Emergency Department of Assyifa Islamic Hospital, Sukabumi, Indonesia, in May 2026. By reporting respiratory rate as the measured physiological outcome and interpreting the findings within the limitations of an uncontrolled before–after design, this study seeks to provide a transparent account of observed respiratory changes while avoiding unsupported conclusions regarding the independent effectiveness of supplemental oxygen or improvement in subjective dyspnea.

## METHODS

### Study Design and Setting

This study employed a quantitative, single-group, uncontrolled before–after design to describe respiratory rate observations obtained at two assessment periods during emergency management of patients with bronchial asthma. The research was conducted at the Emergency Department of Assyifa Islamic Hospital, Sukabumi, Indonesia, in May 2026. The original investigation described its design as quasi-experimental with a one-group pretest–posttest structure. However, because there was no concurrent control group receiving an alternative management strategy, the design was interpreted as an uncontrolled before–after investigation. This distinction is methodologically important because changes recorded between two assessment periods may

be influenced by clinical progression, concurrent medications, supportive care, measurement conditions, and other factors. Consequently, the study was structured to describe the observed respiratory rate distributions rather than estimate the independent causal effect of oxygen administration.

### Population and Sampling

The reported source population consisted of 30 patients diagnosed with bronchial asthma who attended the emergency department during the study period. From this population, 23 participants were included using purposive sampling. The sample consisted of both male and female patients across the age groups presented in the study results. The original research documentation identified bronchial asthma as the underlying diagnosis but did not specify the diagnostic criteria, detailed inclusion and exclusion requirements, recruitment flow, or reasons for excluding seven individuals from the reported population. Similarly, no prospective sample-size calculation was documented. Therefore, the final sample was considered a purposively selected group of patients rather than a statistically representative sample of all emergency department patients with asthma. The available documentation also did not permit assessment of selection bias or evaluation of whether excluded patients differed systematically from those included.

### Clinical Management and Respiratory Assessment

The clinical management episode was described in the original research as involving supplemental oxygen administration. Nevertheless, the available documentation did not specify the oxygen delivery device, flow rate, fraction of inspired oxygen ( $\text{FiO}_2$ ), treatment duration, baseline indication for supplemental oxygen, or prescribed oxygen saturation target. Furthermore, the records provided for manuscript revision did not include sufficiently detailed information regarding concurrent inhaled or nebulized bronchodilators, anticholinergic medications, systemic corticosteroids, or other supportive respiratory interventions. These variables are

clinically important because acute asthma management frequently involves multiple treatments with different physiological actions. Therefore, the absence of information concerning concurrent therapies was treated as incomplete documentation rather than evidence that oxygen was administered as the sole intervention.

The outcome evaluated in the present study was respiratory rate, expressed in breaths per minute. Respiratory rate observations were summarized using four predefined intervals: 15–20, 21–25, 26–30, and 31–35 breaths/min. These categories were used exclusively to describe breathing frequency and were not considered validated classifications of dyspnea severity. Respiratory rate distributions were available for assessments conducted before and after the management episode, but the original documentation did not specify the precise intervals between measurements, counting procedures, observer characteristics, or measurement conditions. Oxygen saturation measurements obtained before and after management were also unavailable in the supplied dataset. Accordingly, the outcome assessment was limited to the reported respiratory rate categories, without making assumptions about changes in oxygenation or perceived breathing discomfort.

### Statistical Analysis

Participant characteristics and respiratory rate observations were summarized using descriptive statistics. Age and sex were presented as frequencies and percentages, while respiratory rate was reported according to predefined categories for the two assessment periods. Percentages were calculated using the total sample of 23 participants as the denominator. The original manuscript reported a Wilcoxon signed-rank test and displayed a  $p$ -value of 0.000. However, individual paired respiratory rate observations, the number and direction of nonzero paired differences, and the corresponding statistical software output were not available for independent verification. Because marginal frequency distributions cannot reproduce a Wilcoxon signed-rank test or determine the precise magnitude of individual respiratory rate changes, the present revision does not rely on that inferential result.

The findings are therefore presented descriptively, without reporting an unverified effect size, confidence interval, or statistical significance claim.

### Ethical Considerations

The provided research documentation did not specify the approving research ethics committee, ethical approval number, approval date, or procedures used to obtain informed

consent from participants. These details could not be independently established from the available materials. Consequently, ethical approval and consent were not presumed. Verification of institutional ethical authorization and participant consent documentation remains necessary before the manuscript can be submitted for publication..

## RESULT

### Demographic Characteristics

A total of 23 patients with bronchial asthma were included in the study. The participants were distributed across age groups ranging from 10–20 to 71–80 years. The largest age group was 51–60 years, comprising 10 participants (43.5%), followed by the 61–70-year age group with four participants (17.4%).

Three participants (13.0%) were aged 41–50 years, while the remaining participants were distributed across the younger and older age categories. Regarding sex, 12 participants (52.2%) were female and 11 (47.8%) were male. These findings describe the composition of the study sample but do not establish demographic risk factors for asthma severity or treatment response

Table 1. Demographic Characteristics of Patients With Bronchial Asthma (n = 23)

| Characteristics    | Frequency (n) | Percentage (%) |
|--------------------|---------------|----------------|
| <b>Age (years)</b> |               |                |
| 10–20              | 1             | 4.3            |
| 21–30              | 1             | 4.3            |
| 31–40              | 2             | 8.7            |
| 41–50              | 3             | 13.0           |
| 51–60              | 10            | 43.5           |
| 61–70              | 4             | 17.4           |
| 71–80              | 2             | 8.7            |
| <b>Sex</b>         |               |                |
| Female             | 12            | 52.2           |
| Male               | 11            | 47.8           |
| Total participants | 23            | 100.0          |

*Note. Age and sex represent separate distributions of the same 23 participants. Percentages may not sum to exactly 100.0% because of rounding.*

### Respiratory Rate Categories Before and After Management

Before emergency management, all 23 participants had respiratory rates above 20 breaths/min. The majority, comprising 18 participants (78.3%), had respiratory rates of 21–25 breaths/min, while five participants (21.7%) had respiratory rates of 26–30

breaths/min. None of the participants was recorded within either the 15–20 or 31–35 breaths/min category at the initial assessment. Following the management episode involving supplemental oxygen, the distribution shifted toward lower respiratory rate intervals. Twenty-two participants (95.7%) were recorded within the 15–20 breaths/min category, while one participant (4.3%)

remained within the 21–25 breaths/min category. No participants were recorded in the

26–30 or 31–35 breaths/min categories after management

Table 2. Distribution of Respiratory Rate Before and After Emergency Management (n = 23)

| Respiratory rate (breaths/min) | Before, n (%) | After, n (%) |
|--------------------------------|---------------|--------------|
| 15–20                          | 0 (0.0)       | 22 (95.7)    |
| 21–25                          | 18 (78.3)     | 1 (4.3)      |
| 26–30                          | 5 (21.7)      | 0 (0.0)      |
| 31–35                          | 0 (0.0)       | 0 (0.0)      |
| Total                          | 23 (100.0)    | 23 (100.0)   |

*Note. Values represent respiratory rate categories at two assessment periods. Individual paired respiratory rate measurements were not available for calculating the precise change experienced by each participant*

The findings demonstrate a substantial difference between the respiratory rate distributions recorded before and after emergency management. In particular, the proportion of participants within the 15–20 breaths/min category increased from 0% to 95.7%, while the proportion with respiratory rates above 20 breaths/min decreased from 100.0% to 4.3%. These differences represent changes in the marginal distributions of respiratory rate categories and should not be interpreted as an estimate of the independent effect of supplemental oxygen. Furthermore, because individual paired measurements were unavailable, the mean or median respiratory rate reduction and an independently verified statistical significance level could not be determined.

## DISCUSSION

### Changes in Respiratory Rate Following Emergency Management

The present study demonstrated a shift toward lower respiratory rate categories among patients with bronchial asthma following emergency management involving supplemental oxygen. Before management, all 23 participants had respiratory rates above 20 breaths/min, whereas 95.7% were recorded within the 15–20 breaths/min category afterward. These findings suggest an improvement in the observed respiratory rate distribution during the clinical management episode. Similar observations regarding the importance of respiratory monitoring during

acute asthma treatment have been discussed by Long and Rezaie (2022) and Dabbs et al. (2024), who emphasized that respiratory rate should be interpreted alongside clinical severity, respiratory effort, and treatment response. Nevertheless, the observed changes cannot be attributed exclusively to supplemental oxygen because the study did not include a control group or complete documentation of concurrent interventions.

### Clinical Interpretation and Comparison With Previous Research

The observed respiratory rate changes should be considered within the broader context of acute asthma management, which commonly involves supplemental oxygen, bronchodilators, and systemic corticosteroids when clinically indicated. GINA (2025) emphasizes that supplemental oxygen primarily supports oxygenation, whereas bronchodilators and corticosteroids address airway obstruction and inflammation. Dabbs et al. (2024) similarly highlighted the importance of combining appropriate treatments during acute exacerbations. Furthermore, Rayner et al. (2025) demonstrated the importance of pharmacological treatment selection in improving asthma-related outcomes, although their findings concerned inhaled reliever strategies rather than immediate respiratory rate changes. Because the present study did not adequately document oxygen delivery parameters or concurrent medications, the contribution of individual treatments to the observed respiratory changes remains uncertain.

An additional consideration is the distinction between respiratory rate and subjective dyspnea. Although increased respiratory frequency may accompany breathing discomfort, it cannot independently determine dyspnea severity. Howell et al. (2024) emphasized the importance of clearly defined outcomes in asthma treatment research. Therefore, the present findings should be interpreted as changes in an objective respiratory parameter rather than evidence of reduced subjective breathlessness. Similarly, because oxygen saturation measurements were unavailable, the study cannot establish whether oxygenation improved following management. This reinforces the importance of distinguishing changes in respiratory frequency from improvements in oxygenation or patient-reported symptoms.

#### **Interpretation of Participant Characteristics**

The largest proportion of participants was aged 51–60 years (43.5%), while females accounted for 52.2% of the sample. These findings describe the demographic composition of patients included in the study but do not establish relationships between age, sex, and asthma severity. Although demographic characteristics may influence asthma presentation and management, the present investigation did not examine these factors as predictors of respiratory rate changes. Therefore, the demographic findings should be interpreted descriptively without drawing unsupported conclusions regarding age-related or sex-related susceptibility.

#### **Study Limitations and Clinical Implications**

Several limitations should be considered when interpreting these findings. The uncontrolled before–after design and relatively small purposively selected sample limit causal inference and generalizability. In addition, incomplete documentation of oxygen delivery devices, flow rates, treatment duration, measurement timing, asthma severity, and concurrent pharmacological interventions prevents evaluation of the independent contribution of supplemental oxygen. The absence of SpO<sub>2</sub> measurements

and individual paired respiratory rate values further limits the assessment of oxygenation changes and independent verification of the reported statistical results. Despite these limitations, the study provides descriptive information regarding respiratory rate changes during emergency asthma management. Future investigations should incorporate standardized respiratory assessments, comprehensive treatment documentation, and appropriate comparison groups to strengthen the interpretation of treatment-related outcomes.

#### **CONCLUSION**

This study demonstrated a shift toward lower respiratory rate categories among 23 patients with bronchial asthma following emergency management involving supplemental oxygen at Assyifa Islamic Hospital, Sukabumi, Indonesia. Before management, 18 participants (78.3%) had respiratory rates of 21–25 breaths/min, while five participants (21.7%) had rates of 26–30 breaths/min. Following management, 22 participants (95.7%) were recorded within the 15–20 breaths/min category, indicating a substantial change in respiratory rate distribution between the two assessment periods. However, these findings should be interpreted cautiously because the uncontrolled before–after design, incomplete documentation of concurrent interventions, and absence of oxygen saturation measurements prevent the observed changes from being attributed specifically to supplemental oxygen administration. Furthermore, the study did not assess subjective dyspnea using a validated instrument. Therefore, the findings provide descriptive evidence of respiratory rate changes during emergency asthma management rather than establishing the independent effectiveness of oxygen therapy. Future research should incorporate standardized respiratory assessments, comprehensive treatment documentation, and appropriate comparison groups to strengthen the evaluation of respiratory outcomes.

## REFERENCES

- Aini, Q., et al. (2024). The effect of oxygen administration using respiratory aids on respiratory rate and oxygen saturation in asthma patients at the emergency department of Yogyakarta City General Hospital. *Jurnal Global Ilmiah*, 1(7), 498–504.  
<https://ar1.ridwaninstitute.co.id/index.php/ar1>
- Alfi, S. (2023). *Pocket guide to nursing diagnosis in clinical practice*. CV Budi Utama.
- Astuti, S. D., & Prihati, D. R. (2026). Pengaruh pemberian oksigen non-rebreathing mask (NRM) terhadap frekuensi nafas dan saturasi oksigen pasien asma di IGD RSUD dr. Soewondo Kendal. *Jurnal Ventilator*, 4(1), 92–113.  
<https://doi.org/10.59680/ventilator.v4i1.2284>
- Ayuda, N., et al. (2022). *Anatomy and [incomplete title]*. Yayasan Kita Menulis.
- Chasanah. (2019). *Bronchial asthma with ineffective airway clearance*.
- Edwin, Finishia, R. D., & Kartikasari, D. (2022). Relationship between gender and the level of asthma control among patients at the pulmonary clinic of Bendan Regional General Hospital, Pekalongan City.
- Faisal, Sangadji, et al. (2024). *Medical-surgical nursing textbook I*. Mahakarya Citra Utama Group.
- Fajar. (2024). Analysis of nursing care for asthma patients with ineffective breathing patterns through oxygen therapy interventions in the emergency department. *Edu Research*, 5(1), 70–80.
- Fitria, R., Maria, R., Waluyo, A., Dasna, & Sinaga, E. (2021). Terapi kipas untuk meredakan sesak napas. *Journal of Telenursing (JOTING)*, 3(2), 651–657.  
<https://doi.org/10.31539/joting.v3i2.2997>
- Harta, L. I., & Nasywa, A. (2025). Ada apa dengan sesak napas. *Indonesian Journal of Sport Science and Technology*, 4(1), 537–548.  
<https://doi.org/10.31316/ijst.v4i1.8312>
- Helitty, Krismiadi, D., & Rahmadania, W. O. (2025). *Medical-surgical nursing textbook: Respiratory system*. NEM Publishers.
- Heny, et al. (2023). The 2023 Indonesian health survey (SKI) in accurate data figures. Ministry of Health of the Republic of Indonesia.
- Khaidir, A., et al. (2019). The relationship between patient characteristics and the severity of bronchial asthma at Andi Makkasau Regional General Hospital in Parepare City. [Journal title unavailable], 1(1).  
<http://jurnal.umpar.ac.id/index.php/makes>
- Kunta, Wibawa, et al. (2022). *Indonesia health profile*. Ministry of Health of the Republic of Indonesia.
- Maria, S., et al. (2023). *Nursing care for families with various health problems*. Nuansa Fajar Cemerlang.
- Maria, Y., et al. (2023). *Emergency nursing care for respiratory system disorders*. Nuansa Fajar Cemerlang.
- Mulyani, I. (2025). Oxygen therapy for emergency patients. *Journal of Nursing Community*.
- Sari, R., & Muharni, S. (2025). *Adult nursing textbook: Nursing care for disorders of the cardiovascular and respiratory systems*. NEM Publishers. †
- Silphia, Nazaruddin, N., et al. (2025). *Respiratory system nursing*. CV Eureka Media Aksara.
- Sugiyono. (2018). *Quantitative, qualitative, and R&D research methods*. †
- Sukmawati. (2020). *Bronchial asthma*. †
- Sulis. (2023). *Scientific paper by a nursing student: A case study on nursing care for clients with bronchial asthma at the Jombang Regional General Hospital*. †
- Sunita, S., & Damayanti. (2024). *Internal medicine*. CV Eureka Media Aksara. †
- Teuku, H., & Simanjuntak, R. F. (2024). *All about shortness of breath*. Syiah Kuala University Press. †
- Tria, F. K., et al. (2023). *Textbook on nursing skills for the five medical-surgical systems*. Mahakarya Citra Utama Group. †
- Wayan, S. (2020). *Comprehensive palliative care*. Airlangga University Press. †
- World Health Organization. (2023). *Asthma*.  
<https://www.who.int/news-room/fact-sheets/detail/asthma>
- Youlanda, & Sidabutar, R. R. (2022). The effect of inhalation therapy and oxygenation on airway patency. *Journal of Midwifery, Nursing, and Health (Bikes)*, 2(1), 50–55. †
- Yulianti, E., et al. (2025). *Pathophysiology*. CV Eureka Media Aksara. †
- Yunus. (2022). *Guide to spirometry testing*. UI Publishing. †
- Cabanas, A. M., Fuentes-Guajardo, M., Latorre, K., León, D., & Martín-Escudero, P. (2022). Skin pigmentation influence on pulse oximetry accuracy: A systematic review and bibliometric analysis. *Sensors*, 22(9), Article 3402.  
<https://doi.org/10.3390/s22093402>
- Chakaya, J., & Ait-Khaled, N. (2022). *Global Asthma Report 2022: A wake-up call to*

- enhance care and treatment for asthma globally. *The International Journal of Tuberculosis and Lung Disease*, 26(11), 999–1000.  
<https://doi.org/10.5588/ijtld.22.0483>
- Dabbs, W., Bradley, M. H., & Chamberlin, S. M. (2024). Acute asthma exacerbations: Management strategies. *American Family Physician*, 109(1), 43–50.  
<https://www.aafp.org/pubs/afp/issues/2024/0100/acute-asthma-exacerbations.html>
- Global Initiative for Asthma. (2024). Global strategy for asthma management and prevention. <https://ginasthma.org/reports/>
- Global Initiative for Asthma. (2025a). Global strategy for asthma management and prevention. <https://ginasthma.org/reports/>
- Global Initiative for Asthma. (2025b). Summary guide for asthma management and prevention. [https://ginasthma.org/wp-content/uploads/2025/06/GINA-Summary-Guide-2025-WEB\\_FINAL-WMS.pdf](https://ginasthma.org/wp-content/uploads/2025/06/GINA-Summary-Guide-2025-WEB_FINAL-WMS.pdf)
- Howell, I., Howell, A., Ramakrishnan, S., Bafadhel, M., & Pavord, I. (2024). How have we measured trial outcomes of asthma attack treatment? A systematic review. *ERJ Open Research*, 10(1), Article 00660-2023.  
<https://doi.org/10.1183/23120541.00660-2023>
- Khanna, A. K., Beard, J., Lamminmäki, S., Närviäinen, J., Antaki, N., & Yapici, H. O. (2024). Assessment of skin pigmentation-related bias in pulse oximetry readings among adults. *Journal of Clinical Monitoring and Computing*, 38(1), 113–120.  
<https://doi.org/10.1007/s10877-023-01095-1>
- Long, B., & Rezaie, S. R. (2022). Evaluation and management of asthma and chronic obstructive pulmonary disease exacerbation in the emergency department. *Emergency Medicine Clinics of North America*, 40(3), 539–563.  
<https://doi.org/10.1016/j.emc.2022.05.007>
- National Institute for Health and Care Excellence. (2024). Asthma: Diagnosis, monitoring and chronic asthma management (BTS, NICE, SIGN) (NICE Guideline NG245). <https://www.nice.org.uk/guidance/ng245>
- Rayner, D. G., Ferri, D. M., Guyatt, G. H., O'Byrne, P. M., Brignardello-Petersen, R., Foroutan, F., Chipps, B., Sumino, K., Perry, T. T., Nyenhuis, S., Oppenheimer, J., Israel, E., Hoyte, F., Rivera-Spoljaric, K., McCabe, E., Rangel, S., Shade, L. E., Press, V. G., Hall, L., ... Chu, D. K. (2025). Inhaled reliever therapies for asthma: A systematic review and meta-analysis. *JAMA*, 333(2), 143–152.  
<https://doi.org/10.1001/jama.2024.22700>
- Roche, N., Yorgancıoğlu, A., Cruz, A. A., Garcia, G., Lavoie, K. L., Abhijith, P. G., Verma, M., Majumdar, A., & Chatterjee, S. (2024). Systematic literature review of traits and outcomes reported in randomised controlled trials of asthma with regular dosing of inhaled corticosteroids with short-acting  $\beta_2$ -agonist reliever, as-needed ICS/formoterol, or ICS/formoterol maintenance and reliever therapy. *Respiratory Medicine*, 221, Article 107478.  
<https://doi.org/10.1016/j.rmed.2023.107478>
- Shi, C., Goodall, M., Dumville, J., Hill, J., Norman, G., Hamer, O., Clegg, A., Watkins, C. L., Georgiou, G., Hodgkinson, A., Lightbody, C. E., Dark, P., & Cullum, N. (2022). The accuracy of pulse oximetry in measuring oxygen saturation by levels of skin pigmentation: A systematic review and meta-analysis. *BMC Medicine*, 20, Article 267.  
<https://doi.org/10.1186/s12916-022-02452-8>
- Singh, S., Bennett, M. R., Chen, C., Shin, S., Ghanbari, H., & Nelson, B. W. (2024). Impact of skin pigmentation on pulse oximetry blood oxygenation and wearable pulse rate accuracy: Systematic review and meta-analysis. *Journal of Medical Internet Research*, 26, Article e62769.  
<https://doi.org/10.2196/62769>
- World Health Organization. (2026, April 28). Asthma. <https://www.who.int/news-room/fact-sheets/detail/asthma>
- Yamasaki, A., Tomita, K., Inui, G., Okazaki, R., & Harada, T. (2024). Differences in the effectiveness of single, dual, and triple inhaled corticosteroid therapy for reducing future risk of severe asthma exacerbation: A systematic review and network meta-analysis. *Heliyon*, 10(12), Article e31186.  
<https://doi.org/10.1016/j.heliyon.2024.e31186>