



Review of FeNO health economics data

June 2021

1. Berg J, Lindgren P. *Respir Med* 2008; 102: 219-231.
2. Price D, et al. *Allergy* 2009; 64: 431-438.
3. Bukstein D, et al. *Allergy Asthma Proc* 2011; 32: 185-192.
4. Laforce C, et al. *Ann Allergy Asthma Immunol* 2014; 113: 619-623.
5. Honkoop PJ, et al. *J Allergy Clin Immunol* 2015; 135: 682-688.
6. Beerthuisen T, et al. *Thorax* 2016; 71: 607-613.
7. Sabatelli L, et al. *J Investig Allergol Clin Immunol* 2017; 27(2): 89-97.
8. Arnold RJG, et al. *Allergy Asthma Proc* 2018; 39(5): 338-344.
9. Brooks EA, Massanari M. *Manag Care* 2018; Jul 27(7): 42-48.
10. Brooks EA, et al. *ClinicoEcon Outcomes Res* 2019; 11: 301-307.
11. Darba J, et al. *ClinicoEcon Outcomes Res* 2021; 13: 289-297.
12. Buendia JA, et al. *Cost Eff Resour Alloc* 2021; 19: 33.
13. Buendia JA, et al. *J Investig Allergol Clin Immunol* 2021 Apr 13; doi: 10.18176/jiaci.0690 (online ahead of print).

- Berg J, Lindgren P. Economic evaluation of FeNO measurement in diagnosis and 1-year management of asthma in Germany. *Respir Med* 2008; 102: 219-231 (supported by Aerocrine).
- Objectives: To assess the cost-effectiveness of FeNO measurement in asthma diagnosis and management using NIOX MINO at a reimbursement price of €34.

• Results:

	Standard Diagnostics and Guidelines	Use of FeNO
Cost of diagnosis per patient	€26	€38
Cost of management per patient (mild to severe asthma)	€981	€949

- Conclusions: Asthma diagnosis based on FeNO measurement alone costs €12 more per patient than standard diagnostic methods, while offering improved accuracy. The use of FeNO measurement in treatment decisions is less costly than management based on standard guidelines and provides similar health benefits.

- Price D, et al. An economic evaluation of NIOX MINO airway inflammation monitor in the United Kingdom. *Allergy* 2009; 64: 431-438 (supported by Aerocrine).
- Objectives: To determine the cost-effectiveness of FeNO measurement for asthma diagnosis and management in the UK using a NIOX MINO, at a reimbursement price of £23.

• Results:

	Standard Diagnostics and Guidelines	Use of FeNO
Cost of diagnosis per patient	£72	€29
Cost of management per patient (mild to severe asthma)	£1007	£666
Cost of management per patient (moderate to severe asthma)	£1181	£628

- Conclusions: Diagnosis based on FENO measurement with NIOX MINO alone is less costly and more accurate than standard diagnostic methods, and management is less costly with similar health benefits.



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- Bukstein D, et al. Exhaled nitric oxide as a tool in managing and monitoring difficult-to-treat asthma. *Allergy Asthma Proc* 2011; 32: 185-192 (supported by Aerocrine).
 - **Objectives:** To determine the potential US payer cost savings resulting from an asthma specialist incorporating fractionated exhaled nitric oxide (FeNO) as an asthma management or monitoring tool to guide treatment of difficult-to-treat asthma patients.
 - **Results:**
 - The most likely clinical scenario assumes a 5% reduction in hospitalization and emergency department costs only.
 - The inclusion of FeNO measurements to the asthma management strategy would essentially reach parity with the current standard of care, despite the additional cost of FeNO measurements.
 - Additional scenarios were examined, all showed cost and use reduction across all medical resource categories.
 - **Conclusions:** Use of FeNO measurement to guide asthma management, maintenance, and control in difficult-to-treat asthma would almost certainly result in cost savings to the payer.

- **Laforce C, et al. Impact of exhaled nitric oxide measurements on treatment decisions in an asthma specialty clinic**
Ann Allergy Asthma Immunol 2014; 113: 619-623 (supported by Aerocrine).
- **Objectives: To determine whether the use of FeNO in the specialist management of asthma results in more effective and cost-effective treatment decisions.**
- **Results:**
 - Without FeNO, the clinician's assessment of airway inflammation was incorrectly classified in 50% of subjects.
 - FeNO results substantially altered treatment decisions in more than one third of subjects, notably medication augmentation in 10 (20%) and medication decreases in 8 (16%).
 - Use of FeNO in addition to standard of care was estimated to save \$629 per subject per year.
- **Conclusions: Measurement of FeNO augments routine clinical assessment of asthma by measuring airway inflammation. Knowledge of FeNO affects medication treatment decisions (augment or decrease pharmacotherapy), which has the potential to lower the costs and morbidity associated with asthma exacerbations.**

- Honkoop PJ, et al. Symptom- and fraction of exhaled nitric oxide-driven strategies for asthma control: a cluster-randomized trial in primary care. *J Allergy Clin Immunol* 2015; 135: 682-688 (devices provided by Aerocrine).
- Objectives: To assess the cost-effectiveness and clinical effectiveness of pursuing partly controlled asthma (PCa), controlled asthma (Ca), or FeNO-driven controlled asthma (FCa).

• Results:

	Partly controlled asthma (ACQ score <1.50)	Controlled asthma (ACQ score <0.75)	FeNO-driven controlled asthma (ACQ <0.75 + FeNO < 25 ppb)
Asthma medication costs per patient per year	\$452	\$551	\$456
Probability of cost-effectiveness at a willingness to pay of \$50,000 per quality-adjusted life year (QALY)	2%	12%	86%

- Conclusions: A symptom- plus FeNO-driven strategy reduces asthma medication use while sustaining asthma control and quality of life and is the preferred strategy for adult asthma patients in primary care.

- **Beerthuizen T, et al. Cost-effectiveness of FENO-based and web-based monitoring in paediatric asthma management: a randomised controlled trial. *Thorax* 2016; 71: 607-613.**
- **Objectives: To assess the cost-effectiveness of web-based monthly monitoring (ACT) and 4-monthly monitoring of FeNO as compared with standard care in managing children with asthma.**
- **Results:**
 - No statistically significant differences were found in QALYs and costs between the three strategies.
 - The web-based strategy had 77% chance of being most cost-effective from a healthcare perspective at a willingness to pay a generally accepted €40 000 per QALY.
 - The FENO-based strategy had 83% chance of being most cost-effective at €40 000 per QALY from a societal perspective.
- **Conclusions: Economically, web-based monitoring was preferred from a healthcare perspective, while the FENO-based strategy was preferred from a societal perspective, although in QALYs and costs no statistically significant changes were found as compared with standard care. As clinical outcomes also favoured the web-based and FENO-based strategies, these strategies may be useful additions to standard care.**

- Sabatelli L, et al. Cost-effectiveness and budget impact of routine use of fractional exhaled nitric oxide monitoring for the management of adult asthma patients in Spain. *J Investig Allergol Clin Immunol* 2017; 27(2): 89-97 (supported by Aerocrine).
- Objectives: To evaluate the cost-effectiveness and budget impact of FeNO monitoring for management of adult asthma in Spain.

• Results:

	Standard of Care Alone	Standard of Care + FeNO
Total cost per patient per year	€852.58	€790.05
Quality-adjusted life years (QALY) per patient	0.776	0.802

- Conclusions: Adding FeNO to the treatment algorithm can considerably reduce costs (potential of €129 million) and improve quality of life when used in combination with current treatment guidelines.

- Arnold RJG, et al. Cost impact of monitoring exhaled nitric oxide in asthma management. *Allergy Asthma Proc* 2018; 39(5): 338-344 (supported by Circassia).
- Objectives: To verify the potential cost savings of FeNO use in the management of asthma within a Medicare database.

• Results:

	Before FeNO	After FeNO
Asthma-related hospitalization and emergency department claims per beneficiary per day	0.004	0.002
Asthma-related hospitalization and emergency department charges per beneficiary per day	\$16.21	\$6.46

- Conclusions: FeNO monitoring in beneficiaries with a history of asthma exacerbations was associated with a substantial reduction in asthma-related hospitalization and emergency department claims and charges.

- Brooks EA, Massanari M. Cost-effectiveness analysis of monitoring fractional exhaled nitric oxide (FeNO) in the management of asthma. *Manag Care* 2018; Jul 27(7): 42-48 (supported by Circassia).
- Objectives: To compare estimated 12-month asthma management costs and outcomes using standard of care vs. addition of FeNO to standard of care.

• Results:

	Standard of Care Alone	Standard of Care + FeNO
Per-patient annual expenditure	\$2,637	\$2,228
Per patient annual quality-adjusted life year (QALY)	0.767	0.844

- Conclusions: FeNO monitoring to guide asthma management is cost effective and could result in increased QALYs and decreased health care costs associated with asthma management.

- Brooks EA, et al. Cost-effectiveness of fractional exhaled nitric oxide (FeNO) measurement in predicting response to omalizumab in asthma. *ClinicoEcon Outcomes Res* 2019; 11: 301-307 (supported by Circassia).
- Objectives: To examine the cost-effectiveness of using FeNO to help identify patients with moderate-severe asthma who will respond to treatment with omalizumab.

• Results:

	12-Week Trial of Omalizumab Only	FeNO Screen + Omalizumab Trial
Per-patient costs during the trial period and initial 12-month treatment period	\$13,703	\$10,943
Expected cost per responder during the trial period	\$7,786	\$4,326

- Conclusions: The use of FeNO to identify omalizumab responders reduced expected per-patient costs almost 50% during the trial period, and cost savings continued through the initial treatment period of 12 months. This analysis may serve as a model for policy and clinical practice and has widespread implications for payers.



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- **Darba J, et al. Economic evaluation of the use of FeNO for the diagnosis and management of asthma in patients in primary care in Sweden. *ClinicoEcon Outcomes Res* 2021; 13: 289-297.**
 - **Objectives: To determine the economic impact of FeNO in asthma diagnosis and management in primary care in Sweden using an economic model.**
 - **Results:**
 - Adding FeNO measurement in asthma diagnosis resulted in cost savings of SEK672 per patient by the fourth year.
 - The use of FeNO testing in asthma management proved to be a dominant strategy when compared with each other test except methacholine challenge test.
 - Sensitivity analyses confirmed the robustness of the results.
 - **Conclusions: Introducing FeNO testing in clinical practice for the diagnosis and management of asthma in primary care in Sweden is less costly than standard methods while providing similar health benefits.**

- **Buendia JA, et al. Cost utility of fractional exhaled nitric oxide monitoring for the management of children asthma. *Cost Eff Resour Alloc* 2021; 19: 33.**
- **Objectives: To evaluate the cost-effectiveness of asthma management using FeNO monitoring in patients between 4 and 18 years of age.**

• **Results:**

	Standard Care Alone	Standard Care + FeNO
Per-patient costs during the 12-month modelling period	\$1452	\$1333
Quality-adjusted life years (QALY) per patient	0.92	0.93

- **Conclusions: Asthma management using FeNO monitoring was cost-effective for treating patients between 4 and 18 years of age with mild to moderate allergic asthma.**

- Buendia JA, et al. Budget impact analysis of fractional exhaled nitric oxide monitoring for the management of childhood asthma: the Colombian National Health System perspective. *J Investig Allergol Clin Immunol* 2021 Apr 13; doi: 10.18176/jiaci.0690 (online ahead of print).
- Objectives: To evaluate the budget impact of asthma management using FeNO monitoring in patients between 4 and 18 years of age in Colombia.

• Results:

	No FeNO	FeNO
5-year costs in the base-case analysis	€ 480.485.149	€ 469.904.130

- Conclusions: FeNO was cost-saving in emergency settings for infants with persistent asthma. This evidence can be used by decision-makers in our country to improve clinical practice guidelines and should be replicated to validate their results in other middle-income countries.

1. **Berg & Lindgren 2008: Asthma diagnosis is more accurate but slightly more costly. Asthma management is less costly with FeNO.**
2. **Price et al. 2009: Asthma diagnosis and management are less costly with FeNO, especially moderate-severe.**
3. **Bukstein et al. 2011: FeNO in management of difficult-to-treat asthma should result in cost savings.**
4. **Laforce et al. 2014: Clinicians alter treatment when FeNO known, with potential to lower costs and reduce exacerbations.**
5. **Honkoop et al. 2015: Addition of FeNO reduces medication use while sustaining control and quality of life.**
6. **Beerthuisen et al. 2016: FeNO-based management strategy was preferred from a societal perspective.**
7. **Sabatelli et al. 2017: Addition of FeNO to asthma management can reduce costs and improve quality of life.**
8. **Arnold et al. 2018: Addition of FeNO can reduce asthma hospitalization and emergency department claims in patients at risk for exacerbations.**
9. **Brooks & Massanari 2018: Addition of FeNO can reduce costs of management and improve quality of life.**
10. **Brooks et al. 2019: Addition of FeNO to identify omalizumab-responders can reduce the cost of treatment.**

- 11. Darba et al. 2021: In primary care FeNO is less costly and provides similar health benefits as standard methods for the diagnosis and management of asthma.**
- 12. Buendia et al. 2021A: Asthma management with FeNO was cost-effective for treating pediatric patients with mild to moderate allergic asthma.**
- 13. Buendia et al. 2021B: FeNO is cost-saving in emergency settings for infants with persistent asthma.**