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Vitalograph Aerosol Inhalation Monitor

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Objectives

1. Review the technique errors and functional barriers that can prevent successful inhaler use
2. Describe Vitalograph Aerosol Inhalation Monitor (VAIM) testing
3. Explain the utility of VAIM testing in optimizing inhaler therapy

Background

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Henry Ford Hospital (HFH), Detroit, MI

- 877 bed teaching hospital
- Level 1 trauma center
- Includes inpatient pulmonary medicine floor (F2)
  - General medicine unit, primarily pulmonary patients

Inhaler Technique

- **Adherence to inhaler medications and correct inhaler device technique** are crucial to successful asthma and chronic obstructive pulmonary disease (COPD) management
  - Poor inhaler technique results in marked **decreases in drug deposition within the lungs**

Global Initiative for Asthma (GINA): inhalers should be prescribed only after patients have been trained to use them properly

Global Initiative for Chronic Obstructive Lung Disease (GOLD): essential to ensure that inhaler technique is correct and to re-check at each visit and for each change of inhaler device

Global Initiative for Chronic Obstructive Lung Disease 2024.
Global Initiative for Asthma 2024.

Inhaler Technique

Studies show high rates of error

- One study showed 50% error for Handihaler up to 83% for Turbuhaler (Sriram et al.)
- 1 in 117 patients demonstrated perfect inhaler technique at baseline (Jolly et al.)
- Errors involving inhaler technique recur within 4 to 6 weeks after initial teaching (Nixon et al.)

Patients with poor technique have poor control

Hands on education/demonstration significantly increased number of patients with proper inhaler technique (Jolly et al.)

Sriram et al. Chron Respir Dis 2016.
Jolly et al. Indian J Chest Dis Allied Sci 2015.
Nixon B, et al. J Pharm Technol 2024.

40 Years of Inhaler Technique: A Systematic Review

- Meta-analysis conducted from 1975-2014
- Articles reporting direct observation of inhaler technique by trained personnel
  - 144 articles; 54,354 subjects
- Overall prevalence of correct technique: 31%
  - No significant difference between first and second 20-year periods

Sanchis J, et al. CHEST 2016.

Common Errors with Inhalers

Inhaler Type	Common Errors
Any Inhaler	Not holding breath long enough Forgetting to exhale before or exhaling into device Not using maintenance inhaler when asymptomatic Using a device with zero on the counter
Metered-Dose Inhaler (MDI), with or without spacer	Not shaking Wrong inhalation technique Inhaling foreign object from uncapped device Dirty/damaged spacer valves limiting amount of drug
Dry Powder Inhaler (DPI), Breath Activated	Failure to load device Holding device wrong after loading Failure to draw drug out of device
DPI, Loading or Capsule Piercing Required	Forgetting to pierce capsule or remove old capsule Failing to take 2nd breath to receive full dose Swallowing capsule Putting capsule in mouthpiece instead of holding chamber

The Effects

- Inadequate control of asthma and COPD
- Symptoms don't alleviate
- Increased exacerbations
- More hospitalizations
- Overuse of rescue medication
- Lower quality of life

It’s Not Always JUST About Technique

- Efficacy and compliance are improved with proper technique education, but education alone **does not address all barriers to correct inhaler use**

Inability to Use Inhalers

Inhaler Type	Patient Factor
MDI, with or without spacer	Inability to actuate device (arthritis, paralysis, Parkinson's, etc.) Inability to form a good seal around the mouthpiece of the inhaler or spacer (e.g. person with cognitive impairment or facial weakness)
DPI, Breath Activated	Inability to form a good seal around the mouthpiece of the inhaler (e.g. person with cognitive impairment or facial weakness) Inability to inhale deeply
DPI, Loading or Capsule Piercing Required	Poor manual dexterity (e.g. weak hands or osteoarthritis) Inability to form a good seal around the mouthpiece of the inhaler or spacer (e.g. person with cognitive impairment or facial weakness) Inability to inhale deeply

HFH Study: Optimization of Patient-Specific Inhaler Regimens

- Conducted in the ambulatory care setting
- 1-group, pre-test/post-test quasi-experimental study from October 2015 to March 2016
  - 44 patients with a 4-week follow-up
- Findings:
  - **27 (61%) of patients were not on an appropriate device after Vitalograph Aerosol Inhalation Monitor (VAIM) testing**
  - After medication optimization, there was significant improvement in asthma control test (ACT)/COPD assessment test (CAT) scores, patient-reported inhaler use, and patient adherence

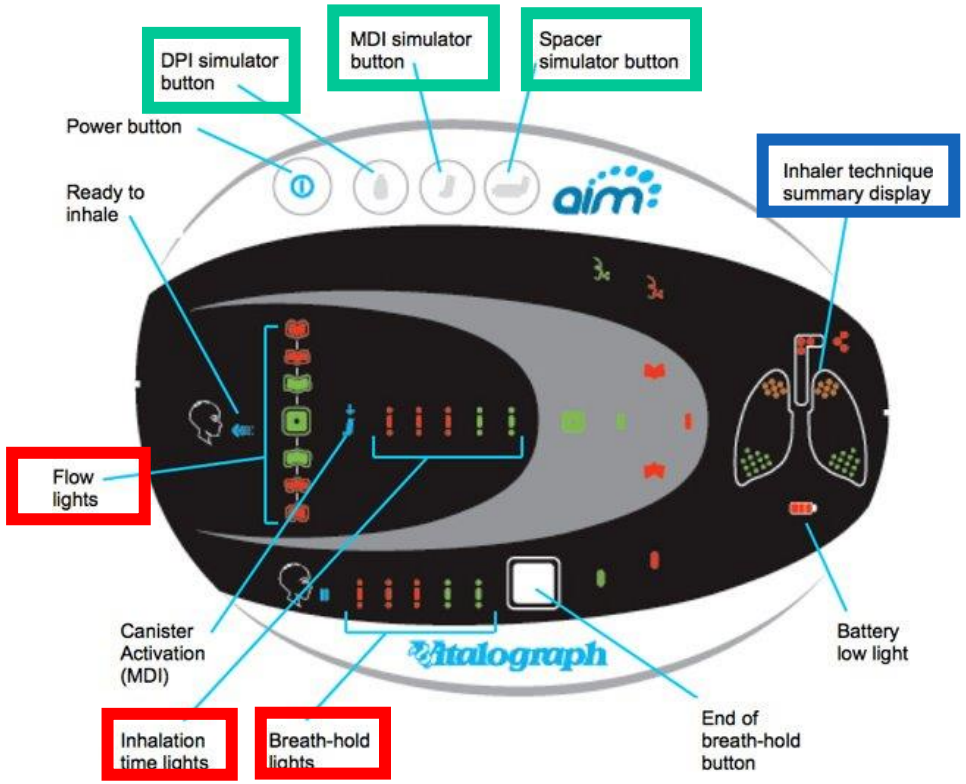
Blum E et al. J Am Pharm Assoc 2019.

Vitalograph Aerosol Inhalation Monitor (VAIM)

- Purpose: an objective tool for training and assessing inhaler technique to help ensure accurate drug delivery
- Intended to be operated by the patient under the supervision of a healthcare provider
- Allows individualization of a patient's pulmonary regimen:
  - Cognitive and physical abilities
  - Ease of use
  - Patient preference

Vitalograph Aerosol Inhalation Monitor (VAIM)

- Three different settings
  - Dry powder inhaler (DPI)
  - Metered-dose inhaler (MDI)
  - MDI with spacer
- Machine assesses:
  - Inspiratory rate
  - Inhalation time
  - Breath hold time at end of inhalation
  - Canister activation (for MDI)
- Results determine what areas the patient fails, is suboptimal in, or passes



Vitalograph.

History of Current Inpatient Process at HFH

- Previously, VAIM testing occurred only in the ambulatory care clinic
- Outpatient VAIM was so well received that providers requested testing inpatient
- Pharmacy is the only service that provides VAIM inpatient
- Inpatient pharmacist assesses patient inhaler technique via VAIM
- Pharmacist provides therapeutic recommendations to team and documents patient findings

EMR Documentation Template

☐ Asthma ☐ COPD ☐ Other_____

Pre-Admission Inhalers:

Inhaler	Dose	Frequency

VAIM Results:

	DPI	MDI	Spacer
Flow rate	Pass/Fail	Pass/Fail	Pass/Fail
Inhalation time	Pass/Fail	Pass/Fail	Pass/Fail
Breath Hold	Pass/Fail	Pass/Fail	Pass/Fail

Comments:_____

_____

Recommendations:

☐ Continue current regimen

☐ Switch _____ to _____

☐ Add _____

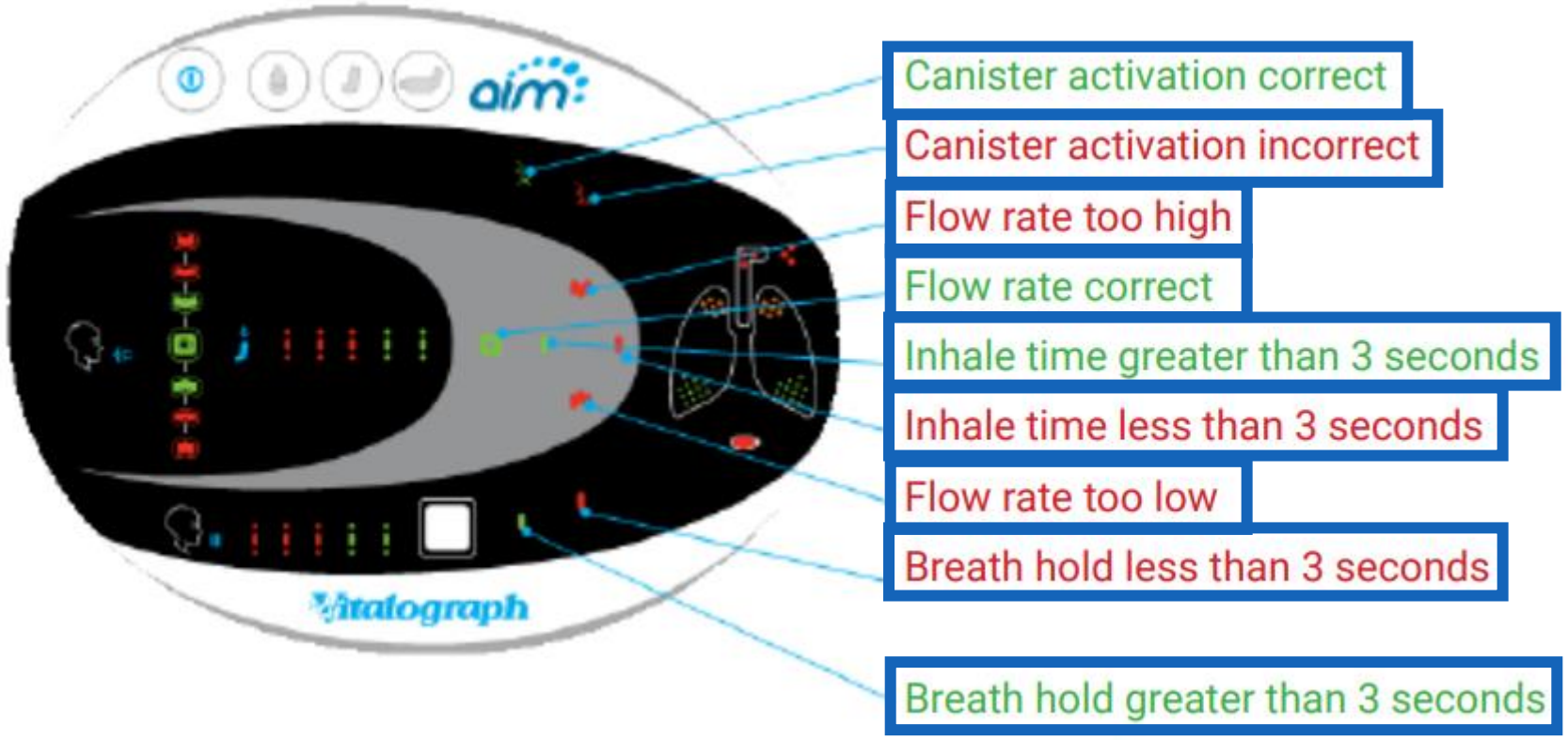
☐ Discontinue _____

Recommendations communicated to team: ☐ Yes ☐ No ☐ Pharmacist

Recommendations accepted: ☐ Yes ☐ No If no, reason why:_____

Time spent on assessment and documentation: ☐ Less than 15 minutes ☐ 15-30 minutes ☐ >30 minutes

Results Lights



Technique Summary

MDI activation too early or no activation

Little or no drug administered

Inhalation rate too fast

Drug caught in the mouth or throat

Inhalation time and/or breath hold time too short

Drug not deposited deeply into lungs reducing the efficacy of the drug

Correct

- MDI activation
- Inhalation flow
- Inhalation time
- Breath Hold time

Drug administered at full efficacy

DPI Simulator

- Patient takes forceful deep breath in until their lungs are full
  - Flow lights will light up
- The objective is to get the flow indicator into the green zone or above as quickly as possible, but not to inhale too fast
- The initial forced inhalation is important when using a DPI to correctly deposit drug in the lungs
- Patient should continue to inhale until their lungs are full
  - Inhalation time lights will light up one second at a time

VAIM Results: DPI Simulator

DPI Simulator
Technique Good/Poor Summary

Fail (Red):
Inspiratory flow rate was too low or too slow

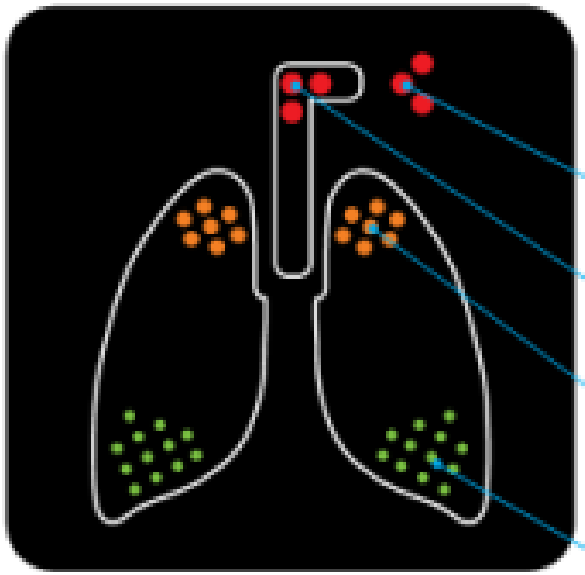
Sub-optimal (Orange):
Breath hold too short or inspiratory flow not forceful enough

Good (Green):
Forceful inhalation with adequate inspired volume and breath hold time

MDI Simulator

- Patient takes a slow steady breath and simultaneously presses the placebo canister
  - Flow lights and the canister activation lights will light up
- The objective is to press the canister as the subject starts to inhale, and to continue to inhale for as long as possible, but not too fast, keeping the flow indicator in the green zone
- VAIM detects activation of the MDI
  - The lights on the device indicate when the inhalation rate is correct to deposit drug in the lungs
  - Patient should continue to inhale until their lungs are full (at least 3 seconds)
  - Inhalation time lights will light up one second at a time

VAIM Results: MDI Simulator



MDI Simulator
Technique Good/Poor Summary

Fail (Red):
Canister activated too early or not at all

Fail (Red):
Inspiratory flow rate was too fast

Sub-optimal (Orange):
Inhalation time and/or breath hold too short

Good (Green):
Correct canister activation, with adequate flow rate, inhale and breath hold time

Vitalograph Aerosol Inhalation Monitor (VAIM)

Common Inhaler Problems	Vitalograph AIM Solution
Coordination of inhaling and MDI actuation[4,5]	✓ Detects correct canister actuation during inhalation
Incorrect inspiratory flow rate for type of inhaler[4,5] ('slow and steady' for MDI vs 'fast and deep' for DPI)	✓ Guides user on correct flow rate.
Not inhaling long enough[5]	✓ Guides user on inhalation duration.
No (or short) breath holding after inhalation[4,5]	✓ Monitors breath hold duration.

You're so VAIM, you probably think this project is about you

Study Purpose: to assess the benefit that pharmacists have on inpatient VAIM testing in COPD patients and hospital readmission rates upon discharge

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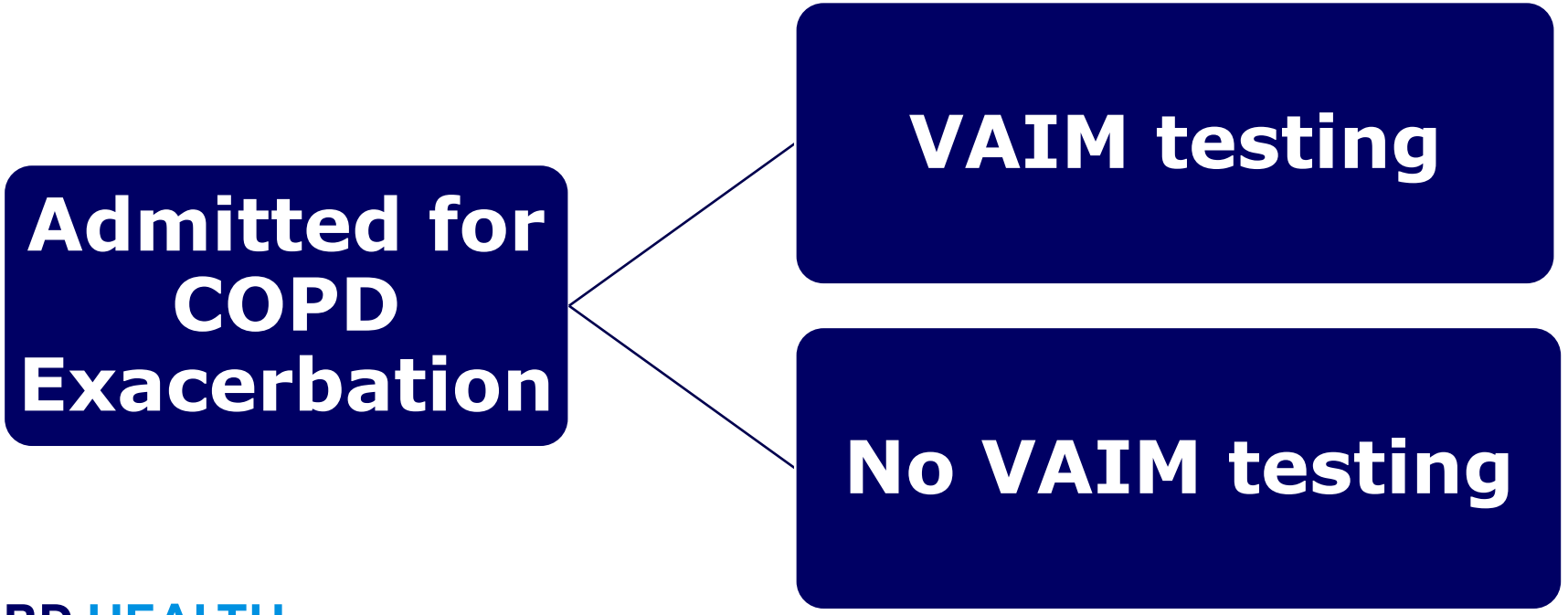
Objectives

- Evaluate the impact that pharmacist administered VAIM has on appropriate inhaler therapy
- Assess the frequency of COPD hospital readmissions with and without VAIM testing
- Identify barriers preventing patients from being on the optimal inhaler regimen

Study Design

Retrospective Cohort – Aug 2020 to Aug 2024



Study Population

Inclusion Criteria

- Patients admitted to HFH Detroit pulmonary floor (F2)
- ≥18 years of age
- Diagnosis of COPD
- Transition of Care (TOC) COPD scoring tool (diagnosis of COPD exacerbation and receiving IV steroids or PO steroids of prednisone ≥40 mg) from August 1, 2020 to August 1, 2024
- Have a prescription for an inhaler filled within the past 6 months

Exclusion Criteria

- Patients who have had a tracheostomy
- Patients who have had a lung transplant
- Other transplant patients with prolonged steroid use equivalent to oral prednisone ≥40 mg
- Diagnosis of interstitial lung disease, pulmonary arterial hypertension, sarcoidosis, or lung cancer
- Patients admitted for bronchoscopic lung volume reduction (BLVR)
- Patients who are COVID-19 positive
- Patients who are contact/droplet plus
- Patients who are pregnant, prisoners, or with a medical diagnosis of diminished mental capacity

Outcomes

Primary outcome

- Proportion of patients who are readmitted for COPD exacerbation within 30 days of discharge

Secondary outcomes

- Discharge medication cost inquiries (DMCIs)
- Appropriate therapy at discharge
- Financial barriers preventing patients from being on appropriate inhaler therapy
- Inpatient spacer usage

GOLD Guidelines: Appropriate Inhaler Therapy

Exacerbation History

≥2 moderate exacerbations or ≥1 leading to hospitalization	**E: LABA + LAMA** • **If eos ≥300, consider LABA + LAMA + ICS**	**E: LABA + LAMA** • **If eos ≥300, consider LABA + LAMA + ICS**
0 or 1 moderate exacerbations (not leading to hospitalization)	**A: Bronchodilator, either long- or short-acting: LABA, LAMA, SABA, or SAMA**	**B: LABA + LAMA**
	mMRC 0-1 CAT <10	**mMRC ≥2 CAT ≥10**

Symptoms

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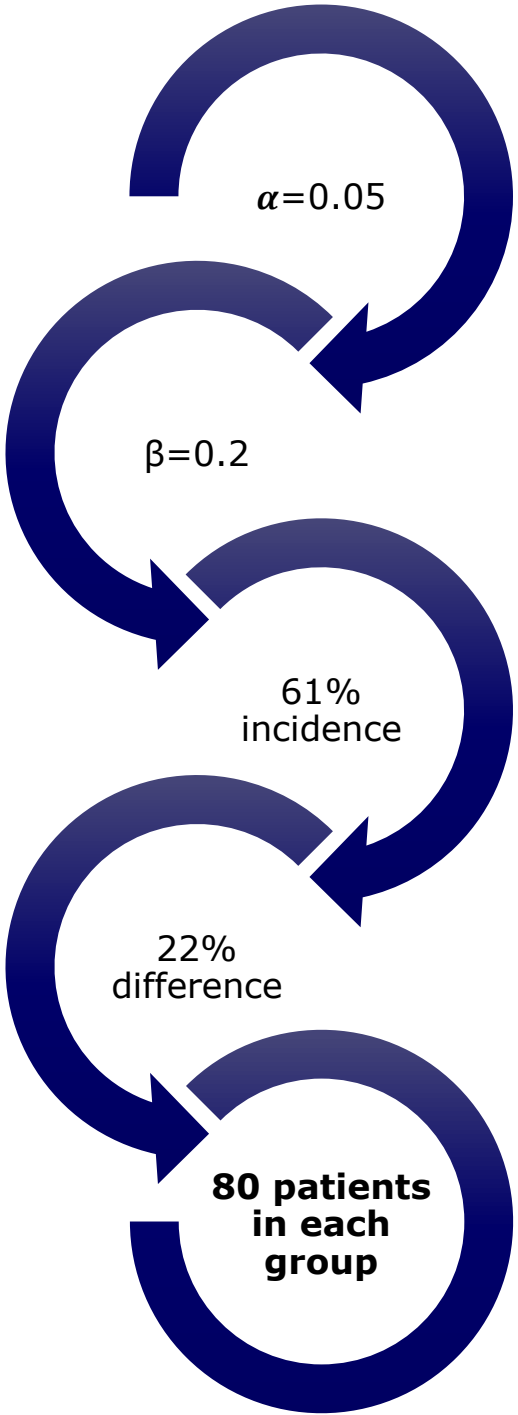
Global Initiative for Chronic Obstructive Lung Disease 2024.

Sample Size



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Blum E, et al. J Am Pharm Assoc 2019.

Results

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Baseline Patient Characteristics

	VAIM (n=29)	No VAIM (n=29)
Age (IQR)	63.5 (8)	65.5 (15)
Sex (%) Male Female	 9 (31) 20 (69)	 11 (37.9) 18 (62.1)
Race (%) White African American Hispanic/Latin	 5 (17.2) 23 (79.3) 1 (3.4)	 5 (17.2) 24 (82.8) 0 (0%)
Tobacco Use Status (%) Never Former Current	 1 (3.4) 13 (44.8) 15 (51.7)	 1 (3.4) 13 (44.8) 15 (51.7)
# of Exacerbations in the Past Year (IQR)	5 (7)	3.5 (9)

Baseline Patient Characteristics

	VAIM (n=29)	No VAIM (n=29)
FEV1 (%)		
≥80%	1 (3.4)	1 (3.4)
50% to <80%	6 (20.7)	6 (20.7)
30% to 50%	3 (10.3)	7 (24.1)
<30%	6 (20.7)	5 (17.2)
Unknown	13 (44.8)	10 (34.5)
Home O2 PTA (%)	24 (82.6)	14 (48.3)
Home O2 Flow Rate (IQR)	3 (2)	3 (1)
Comorbidities (%)		
Diabetes	6 (20.7)	10 (34.5)
Hypertension	23 (79.3)	24 (82.8)
Heart Failure	8 (27.6)	10 (34.5)
Obesity	8 (27.6)	13 (44.8)
Obstructive Sleep Apnea	6 (20.7)	6 (20.7)

Primary Endpoint: Readmission for COPD exacerbation within 30 days of discharge

	VAIM (n=29)	No VAIM (n=29)	P-value
Readmission within 30 days of discharge (%)	10 (34.5)	8 (27.6)	0.57

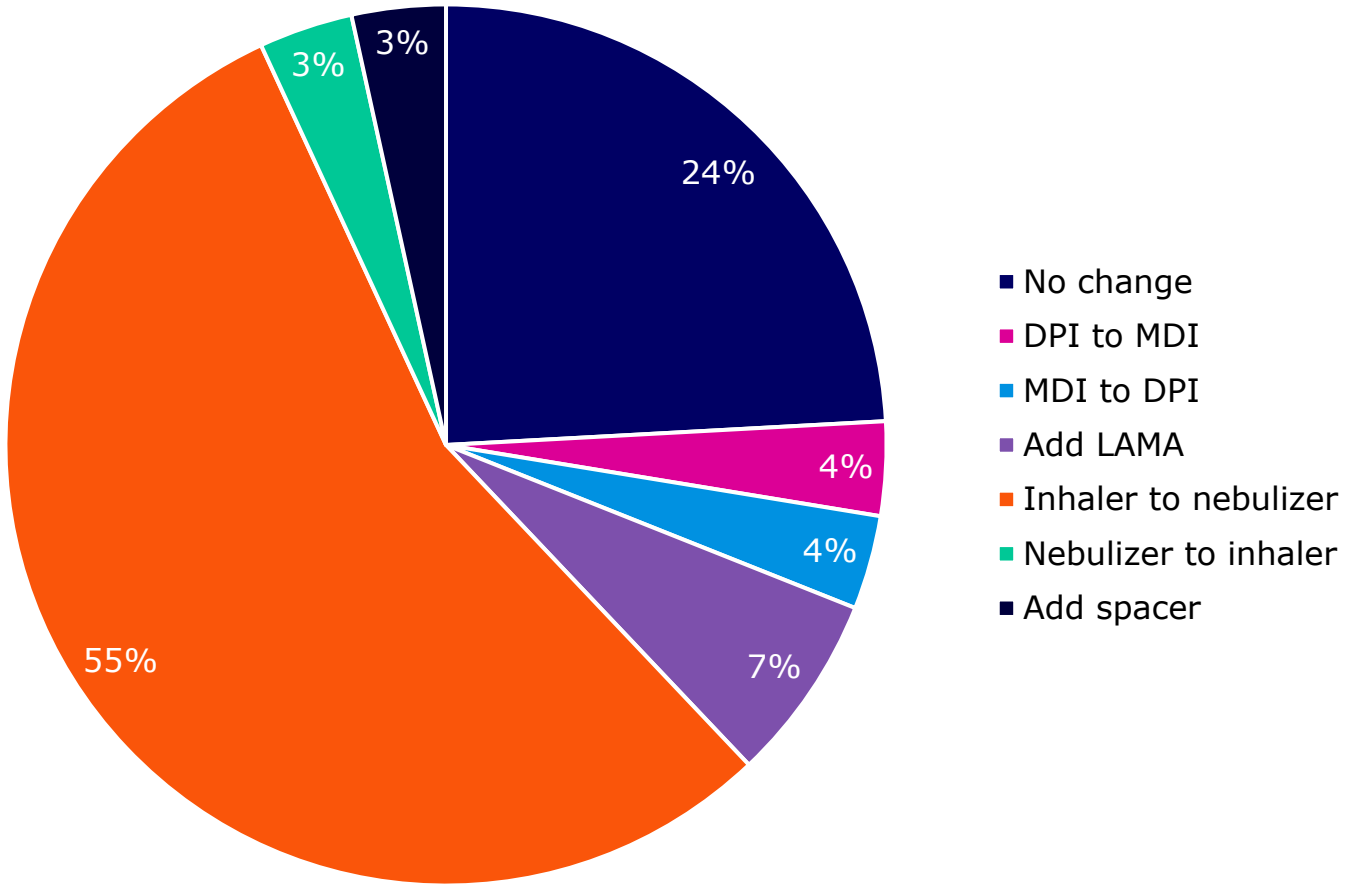
Secondary Endpoints

	VAIM (n=29)	No VAIM (n=29)	P-value
Appropriate therapy at discharge (%)	23 (79.3)	26 (89.7)	0.277
DMCI (%)	21 (72.4)	8 (27.6)	<0.001

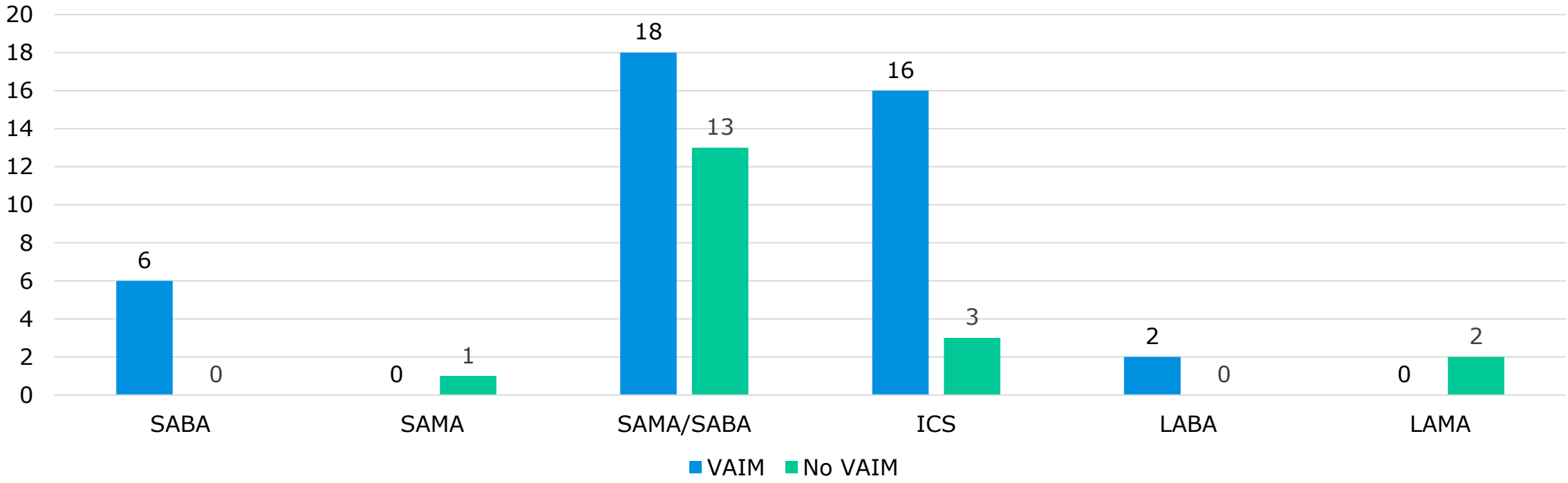
	VAIM (n=25)	No VAIM (n=28)	P-value
Financial barriers (%)	1 (3.8)	0 (0)	0.295

- Spacers not utilized inpatient for either group

VAIM Testing Results – Pharmacist Recommendations



Nebulizers on Discharge



Conclusions

- Inpatient VAIM testing did not have a significant impact on patient readmission for COPD exacerbation within 30 days of discharge
  - Low number of patients receiving VAIM testing limited ability to find a difference
- Patients who received VAIM testing were more likely to be evaluated for affordability through cost inquiry
- The most significant pharmacy intervention involved transitioning patients from inhalers to nebulizers

Utilize VAIM testing in patients who have a history of frequent exacerbations

In patients who fail VAIM, switch inhaler regimen to nebulizers

Limitations

Underpowered

- Post-COVID staffing shortages

Selection bias

- Patients who will benefit most from VAIM selected

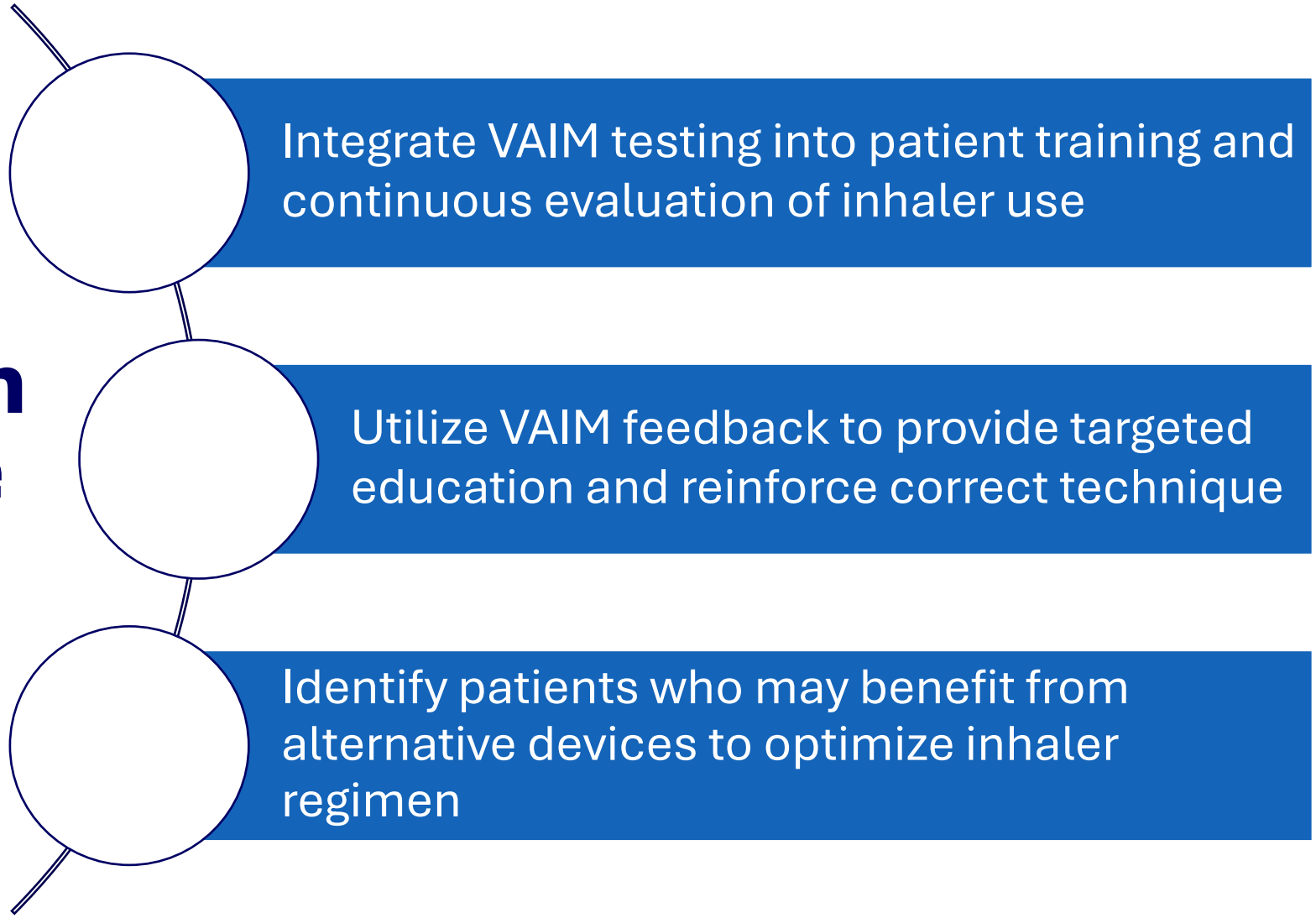
Observer bias

- Different pharmacists performing VAIM testing and documenting notes

Socioeconomic barriers

Nonadherence to inhaler or nebulizer

Application to Practice



Take-Home Points

Poor inhaler technique remains common

Education improves inhaler technique, but sustained improvement requires ongoing assessment

VAIM provides objective data to guide patient-specific care

Routine use of VAIM can:

- Improve inhaler effectiveness
- Reduce preventable COPD exacerbations and readmissions
- Support better long-term disease control and quality of life

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