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Original Research

Clinician-Perceived Barriers and Facilitators for Initiation and Management of Noninvasive Ventilation Among Patients With Chronic Hypercapnia From COPD: A Qualitative Study

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Abstract

Background: Long-term noninvasive ventilation (NIV) improves survival and readmission risk for patients with chronic hypercapnia from chronic obstructive pulmonary disease (COPD). However, outpatient NIV prescription remains low.

Methods: We conducted a qualitative study using semistructured interviews with pulmonary physicians. We identified a convenience sample of community-affiliated outpatient pulmonologists who were recruited via email. Deductive and inductive thematic content analysis were used to identify how physicians screen and manage patients with COPD at risk for chronic hypercapnia and what barriers hinder their ability to care for this population.

Results: Among 15 physicians interviewed, 13 were general pulmonologists. Two were sleep certified. They spent 52.5+21.3% of clinical time on average in outpatient care. While physicians identified forced expiratory volume in 1 second and serum bicarbonate as parameters that would prompt a hypercapnia evaluation, there was no consistent threshold identified. Physicians initiated NIV themselves but varied in initial device selection and settings. Arterial blood gas testing was infrequently used to monitor improvement and opinions differed on why and how initial NIV settings needed to be changed. Barriers to management included patient factors (e.g., NIV disinterest), physician discomfort (e.g., NIV troubleshooting), poor access to testing, lack of clinical support, and insurance and durable medical equipment company logistics.

Conclusions: Pulmonary physicians face multiple barriers in caring for this population, leading to variation in screening and management practices for chronic hypercapnia in COPD. Areas for improvement include standardized screening guidance, better clinical support and testing access, improved clinical education, and a streamlined approach to insurance approval.

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Abbreviations:

ABG=arterial blood gas; **ATS**=American Thoracic Society; **BIPAP**=bilevel positive airway pressure; **CO_2**=carbon dioxide; **COPD**=chronic obstructive pulmonary disease; **DME**=durable medical equipment; **ED**=emergency department; **EPAP**=expiratory positive airway pressure; **FEV_1**=forced expiratory volume in 1 second; **GOLD**=Global initiative for chronic Obstructive Lung Disease; **HCO_3**=serum bicarbonate; **IPAP**=inspiratory positive airway pressure; **NIV**=noninvasive ventilation; **OSA**=obstructive sleep apnea; **$PaCO_2$**=partial pressure of arterial carbon dioxide; **PFTs**=pulmonary function tests; **PSG**=polysomnogram; **RT**=respiratory therapist; **SD**=standard deviation; **TCO_2**=transcutaneous carbon dioxide

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Introduction

Chronic hypercapnia, which affects 25%–30% of patients with chronic obstructive pulmonary disease (COPD), is associated with worse long-term survival in this population.[1-4] Elevated partial pressure of arterial carbon dioxide ($PaCO_2$) levels, independent of pH, adversely affect the respiratory system by impairing innate immunity and reducing pulmonary edema resorption.[5-8] Higher baseline body carbon dioxide (CO_2) stores are associated with a more rapid rise in $PaCO_2$ when minute ventilation acutely decreases.[9] Moreover, higher chronic $PaCO_2$—regardless of etiology, including COPD, obesity hypoventilation syndrome, neuromuscular disease, and thoracic cage abnormalities, is associated with an increased risk of all-cause mortality over 2 years.[10]

Long-term noninvasive ventilation (NIV) improves survival and decreases risk of readmission for patients with chronic hypercapnia from COPD when normalization or reduction of $PaCO_2$ levels is targeted.[11,12] The American Thoracic Society (ATS) recommends initiating NIV for patients with chronic stable hypercapnic COPD (forced expiratory volume in 1 second [FEV_1] to forced vital capacity [FVC]<0.70; resting $PaCO_2$>45mmHg; not during an exacerbation) with the goal of $PaCO_2$ normalization, without the use of polysomnogram (PSG), and advises against initiation during hospitalization for acute-on-chronic hypercapnic respiratory failure. Instead, NIV should be started 2–4 weeks after discharge if chronic hypercapnia persists.[13] However, despite studies and professional societies recommending long-term NIV use, outpatient prescriptions of NIV for this patient population remains low.[4,10] This may be contributed by lack of guidance from professional organizations, including ATS, on which patients with COPD would benefit from screening for chronic hypercapnia. The 2026 Global initiative for chronic Obstructive Lung Disease (GOLD) report recommended that an arterial blood gas (ABG) be obtained in the presence of peripheral oxygen saturations <92% to confirm hypoxemia; however, the guidelines do not suggest which risk factors (lab values, symptoms, etc.) indicate the need for an ABG for suspected chronic hypercapnia.[14]

Although prior studies have identified barriers to COPD care, including patient-level factors, physician knowledge, patient-physician relationships, and access to care,[15] barriers to managing chronic hypercapnia among patients with COPD have not been specifically studied. To understand the gap between guidelines and clinical practice in the management of chronic hypercapnia in patients with COPD, we interviewed pulmonary physicians about their outpatient screening practices, and initiation and management of NIV for patients with chronic hypercapnia from COPD.

Study Design and Methods

We conducted semistructured interviews with pulmonary physicians across the United States to explore barriers to screening and treatment of patients with chronic hypercapnia from COPD. We sought to interview pulmonary physicians who practiced in outpatient clinics and managed patients with COPD. The study was approved by the University of Michigan Institutional Review Board (HUM00243170) and followed the Consolidated Criteria for Reporting Qualitative Studies (Supplemental Appendix 1 in the online supplement).

Sample

Physicians were eligible if they completed pulmonary fellowship training and were actively practicing in the United States, involved in outpatient management of patients, and not affiliated with a large academic medical center, as to exclude physicians at centers where patients with chronic hypercapnia are commonly referred to ventilator clinics. A convenience sample of physicians was recruited using snowball sampling. Recruitment proceeded through an initial query of our pulmonary colleagues for potential participants, whom they previously trained or worked with. Physicians were subsequently recruited through email. Participants provided email contacts for additional potential participants. Recruitment and interviews were conducted from January 2024 to February 2025.

Semistructured Interviews

The interview guide was developed based on prior literature and study team expertise and focused on barriers and facilitators in screening, prescription, and management of NIV devices for hypercapnic patients. It was piloted with 2 pulmonary and critical care fellows to ensure completeness before being implemented (Supplemental Appendix 2 in the

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online supplement). PJChecinski conducted all interviews via Zoom. Interviews were audio-recorded, transcribed, and de-identified. PJChecinski reviewed all transcripts for accuracy. No incentive was provided to participants.

We obtained physician (e.g., years practicing postfellowship training and at current practice) and practice characteristics (e.g., presence and type of support staff) through demographic survey questions asked prior to initiation of the interview (Supplemental Appendix 3 in the online supplement). Demographic data was not obtained from nonparticipants due to nonresponse to email invitation for participation. Continuous variables were presented as means and standard deviations and categorical variables as counts and percentages.

Analysis

We used content analysis to analyze interviews using deductive codes derived from the interview guide and inductive codes that were identified as transcripts were analyzed.[16] Two investigators (PJChecinski and KMB) with multidisciplinary backgrounds (pulmonary and critical care medicine and sociology) jointly coded each interview using MAXQDA24 (Berlin, Germany).[17] MAXQDA24 was only used for line-by-line coding. PJChecinski and KMB met regularly to review each coded transcript, identify new codes, and clarify definitions. Disagreements in coding were resolved by discussion between PJChecinski, KMB, and EMV. Data collection and analysis were iterative with discussions to assess if thematic saturation was achieved, which we defined as no additional inductive themes being identified. Once thematic saturation was achieved, no additional participants were recruited. The codebook was developed after the third interview, and no new codes were added after the 13th interview. Prior interviews were re-coded to reflect the final codebook. Trustworthiness was enhanced through investigator triangulation, independent coding by multiple researchers, iterative team discussions to achieve consensus, and maintenance of an audit trail documenting analytic decisions.

Results

We interviewed 15 clinicians of which 86.7% (N=13) identified as general pulmonologists and two were sleep certified (Table 1). Physicians were in practice for an average of 9.6 years (standard deviation: 8.5) following pulmonary fellowship training and reported spending about half of their clinical time in outpatient care.

We inductively examined variation in how physicians screen, initiate, and manage NIV ventilation for patients with chronic hypercapnia from COPD. We then deductively identified 4 key barriers that influenced screening, initiation, and maintenance of NIV prescriptions for patients with chronic hypercapnia from COPD: patient factors, physician knowledge, clinical resources, and insurance logistics. Lastly, we asked physicians who were interviewed about potential solutions.

Screening Patients With COPD for Chronic Hypercapnia

Physicians used different data sources to identify patients with COPD who are high risk for hypercapnia (Table 2). Some physicians screened patients with prior hospitalizations or COPD exacerbations. Patient-reported symptoms influenced decision to screen, but there was no consensus on which specific symptoms necessitated screening. One physician recalled, "If people… give me more symptoms associated with dynamic hyperinflation where they're just really dyspneic. They can only walk like 10 feet and then they're out of breath and... give me more of an air trapping vibe...I tend to, maybe, think more about screening for hypercarbia" (Participant 9).

Physicians screened patients with an elevated serum bicarbonate (HCO3-) and/or severe airflow obstruction on their pulmonary function tests. Additionally, physicians looked for prior ABG results to guide the need for screening. Notably, there was no consensus on level of HCO3- or FEV_1 percentage predicted that indicated the need to screen.

Noninvasive Ventilation Initiation for Chronic Hypercapnia in COPD

Pulmonary physicians prescribed NIV themselves when chronic hypercapnia was identified, but there was no consensus on type of device initiated, initial mode and settings chosen, and how initial settings were determined (Table 3). One physician shared, "if [the PSG] showed concerning features, and either sleep apnea or chronic hypercapnia, first do a titration or treatment polysomnogram to help us figure out what settings" (Participant 3). However, other physicians expressed having either a preferred range, a clinic order set with NIV settings, or they relied on settings from a patient's hospitalization.

Physicians commonly initiated NIV at hospital discharge with some sharing preference for inpatient initiation. A physician shared that due to this patient population's hyperinflation, they felt that "it's best done in the hospital... where you have [respiratory therapists (RTs)] who can fit the mask, and you can, like, make sure that they're doing well and get a blood gas in the morning" (Participant 4).

Noninvasive Ventilation Management for Chronic Hypercapnia in COPD

Once NIV was initiated, most physicians scheduled patients to follow-up within at least 3 months (Table 4). At these visits,

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Table 1. Characteristics of Pulmonary Physicians

	Participants (N=15)
General Pulmonologist, N (%)	13 (86.7%)
Sleep-Certified Pulmonologist, N (%)	2 (13.3%)
Time in Practice Post-Fellowship, years (SD)	9.6+8.5
Time at Current Outpatient Practice, years (SD)	8.1+8.1
Outpatient Clinical Time, percentage of effort (SD)	52.5+21.3
Clinical Support at Outpatient Practice, N (%)	
Medical Assistant	15 (100%)
Nurse	13 (86.7%)
Respiratory Therapist	12 (80%)
Advanced Practice Provider	6 (40%)
Group Outpatient Practice, N (%)	15 (100%)

Continuous variables are presented as means+SDs.
Categorical variables are presented as counts (percentages).

SD=standard deviation

Table 2. Screening Patients With COPD for Chronic Hypercapnia

Theme	Example Quote
a. History-Related/ Informal Screening	"If they've been hospitalized for hypercapnic respiratory failure, then I think that's a positive screen right there." (Participant 10) "If there was talk of, like, lethargy or tiredness, like, during the day, then I would be more inclined to get it." (Participant 14)
b. Testing-Related/ Formal Screening	"It's more of a fitting amongst... a group of criteria... It's somewhere along the combination of the low FEV1, the air trapping, the elevated bicarb, the hospital admissions." (Participant 2) "I would look if there's any old blood gases just in the system… and… try to figure out what was the circumstances regarding that blood gas… If, like, their serum bicarb is, like, consistently elevated without, like, a clear metabolic derangement, I would, sort of, use that as a proxy of maybe there's some underlying, like, hypercapnia going on. And I guess, probably just lastly, like, severity of COPD." (Participant 6)
c. Screening Threshold	"I will look back through their chemistries and check their serum bicarb… If it's in the high twenties or obviously… in the thirties or higher, then when I see them, as part of the, like, baseline PFT's… I'll order a ABG with it." (Participant 9) "So, if you're starting to fall… forties, you know, percent predicted, less than that, then there's a concern in there. I mean, can you see it with patients who have higher FEV_1's? Certainly, you can, but they usually have some other comorbidities... So, I'm looking probably less than 50% of predicted, would probably start to think about that." (Participant 10)

FEV_1=forced expiratory volume in 1 second; COPD=chronic obstructive pulmonary disease; PFTs=pulmonary function tests; ABG=arterial blood gas

Table 3. Noninvasive Ventilation Initiation for Chronic Hypercapnia in COPD

Theme	Example Quote
a. Device Initiation	"I would say in my group, this more commonly gets done on the way out of the hospital… If there's some complexity, comorbid sleep apnea, sometimes those people will go through the sleep providers. If it's purely for COPD, that's something that most of us are, at least that I… feel pretty comfortable doing myself." (Participant 2) "If they ended up having like OSA and they had a titration with BIPAP with a transcutaneous CO_2… I would use those settings, but if they didn't, if they were a smaller person, I would probably start with an EPAP of 5 and if they were on the larger side, I'd probably start an EPAP of 8 and then I would set usually a delta of like 10 to 12." (Participant 4)
b. Physician Preferences	"I personally generally do like to start with more simpler devices, unless I think… they actually do require a ventilator. I do like to start with BIPAP… but what I try to do is, if they've… been in the hospital for a COPD exacerbation, and more likely than not had to use a BIPAP during that hospital stay, I generally… start with the inpatient settings for my initial prescription." (Participant 3) "At least for us, I bet you 80, maybe 90% of our starts are on the back end of a hospitalization as opposed to de novo starts in the office where people start to think about it, and then set it up. And the more I think it through, it's because there are far fewer impediments for the hospital." (Participant 12)

COPD=chronic obstructive pulmonary disease; OSA=obstructive sleep apnea; BIPAP=bilevel positive airway pressure; EPAP=expiratory positive airway pressure

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Table 4. Noninvasive Ventilation Management for Chronic Hypercapnia in COPD

Theme	Example Quote
a. Timeline/ Scheduling	"This is an individual who I'm wanting to see no less frequent than every 3 months at least for the next few visits, to really be sure that things are going okay." (Participant 15) "I'll just see 'em back in like 3 months and see how they're doing with the device and just check in… I just follow up like I would regularly for any of my COPD patients, and usually they're pretty symptomatic, so those are people I'm seeing like every 3 or 4 months, anyways." (Participant 9)
b. Formal Quantification of Improvement	"Just usage, honestly, is the biggest one… I might look at, like, leak and things like that. But again, like, the little things, the RTs do a good job of, like, fixing so I'm just looking at, are they using it every day and for at least 4 hours." (Participant 9) "I don't always get labs right away, because that just takes time to, you know, to change and that's not always the end all be all, either. There's other things that are impacting their bicarbonate levels and things like that." (Participant 10)
c. Informal Quantification of Improvement	"I think it's nice to see if they're not in the hospital, which a lot of these people, they're the ones that are kind of frequently coming back to the ED or the hospital, so if they can stay out, that's also a sign that they're improving." (Participant 1) "And subjectively, a lot of times when people get on it, they feel like they sleep a little better. They feel better in the morning, and so, you know, a little bit like some sleep apnea type subjective improvement symptoms. But honestly, mostly just trying to keep out of the hospital." (Participant 2)
d. Making NIV Changes	"If the CO_2 bicarb numbers aren't moving, then... do you want to target... higher minute ventilation, tidal volume, set a higher backup rate, just things to get them to ventilate better. Theoretically, it registers with me... how that would work... but I think that's where I just start getting a little bit like, I don't know if I'm doing it right and I just... hand them off" (Participant 7) "If I were to do something like a 10 over 5 setting right out of the gate, if they're… if I've got, you know, evidence that they're wearing it for a solid 8 hours or so at night, and they're not having any difficulty, and they think it's helping. I would probably submit an order to the home medical equipment company, let's drive that IPAP up and then maybe do that at least for… one follow-up cycle, as long as that, you know, that… You hear about it pretty quick if they don't like it." (Participant 15)

COPD=chronic obstructive pulmonary disease; RT=respiratory therapist; ED=emergency department; NIV=noninvasive ventilation; IPAP=inspiratory positive airway pressure

improvement was largely quantified based off symptoms and need for recurrent hospitalization. It was uncommon to repeat an ABG after NIV initiation. One physician said, "I don't typically get another blood gas routinely, just to...prove that it's gone down" (Participant 6). Instead, physicians reviewed data downloads to assess usage and mask leak.

There was no consensus on why and how changes were made to initial NIV settings. Some physicians made changes based off data downloads, others repeated sleep titration studies, and others referred to a clinician with more expertise in NIV management. One physician explained, "if it looks like we're still maybe not where we need to be, sometimes I'll make some minor adjustments to the machine… If we've tweaked it a few times, and we're really struggling, then at that point, we need to get back in the lab and have a night to just completely titrate the patient" (Participant 10).

Barriers to Noninvasive Ventilation Use for Chronic Hypercapnia in COPD

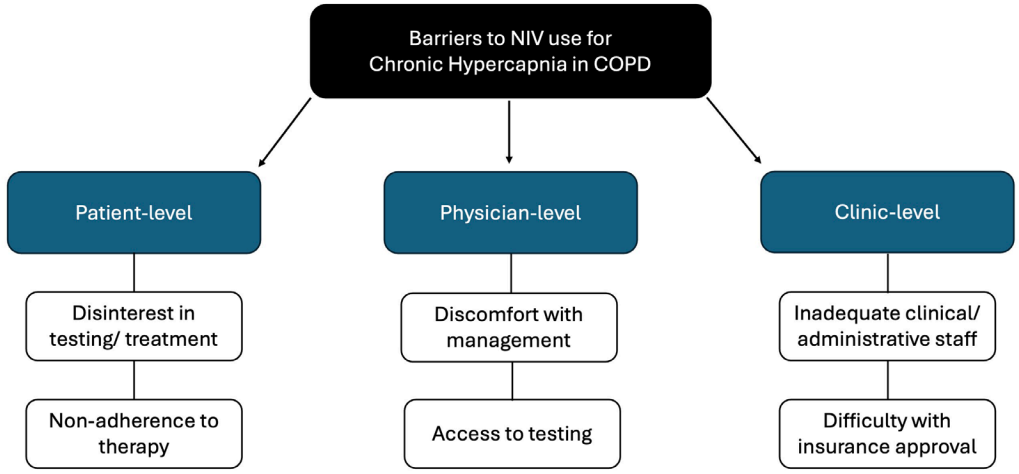
Patient-level factors posed barriers, including disinterest, nonadherence, and difficulty in tolerating NIV therapy and obtaining required testing, such as ABG (Figure 1, Table 5). One physician expressed that "these are the folks who literally they don't leave their house until they're calling... the ambulance to go to the [emergency department] and you offer them to do outpatient testing and they fight it because it's difficult for them" (Participant 3).

Physician-level barriers included discomfort with managing chronic hypercapnia and limited clinical resources (Figure 1, Table 5). Physicians described relying on others when patients struggled with NIV management, noting that "if something's off with the follow-up, the patient's struggling with the pressures…I'm pretty quick to hand that off to somebody" (Participant 7). Logistical constraints further limited care, particularly access to testing. As one participant noted, "[I] can send people down to get venous blood draws easily after their appointments versus an ABG can be done by the RTs in our clinic, but that requires a separate appointment" (Participant 2). Notably, no physicians reported access to outpatient transcutaneous CO_2 (TCO_2) monitoring, despite it being a useful noninvasive alternative for CO_2 measurement with values that strongly correlate with arterial CO_2 levels.[18]

Barriers at the clinic-level stemmed from inadequate clinical and administrative support (Figure 1, Table 5). As one physician shared, their clinic is "not a vent clinic… and there's not necessarily a dedicated RT… getting paid just to provide patient education… So, there's limited time for teaching" (Participant 6). Physicians relied on durable medical equipment (DME) companies, but some physicians had poor experiences because the companies sent technicians and not RTs who could assist in troubleshooting issues with the patient. Additionally, physicians struggled with insurance approvals for testing and preferred devices. One physician recalled, "there actually have been an increase in denials we've been getting from insurance companies about getting these devices… It's enough of a headache that it

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Figure 1. Barriers to Noninvasive Ventilation Use for Chronic Hypercapnia in COPD



NIV=noninvasive ventilation; COPD=chronic obstructive pulmonary disease

takes a pretty big signal for me to like start pursuing this in somebody that's not in the hospital" (Participant 2).

Solutions/Facilitators to Noninvasive Ventilation Use for Chronic Hypercapnia in COPD

Despite the many barriers physicians identified, they also proposed solutions. Physician-level solutions included improved access to necessary testing and assistance with identifying patients with COPD who needed screening for chronic hypercapnia (Table 6). For example, a physician felt "access to an ABG in the office, or at least a [venous blood gas] in the office" (Participant 12) would be helpful. Physicians also thought TCO_2 monitors would be beneficial as another noninvasive adjunct to measure the patient's hypercapnia in clinic. Additionally, they felt an electronic medical record alert could help facilitate care for this population, such as this physician described— "if it said like, hey, this patient had a [partial pressure of carbon dioxide] recently recorded greater than 52 or a serum bicarb of over, like, 32, consider NIV evaluation… I think that might actually get my attention. And then, if that same alert had a smart set link to it of NIV and the settings… It just kind of would streamline and remind you and reinforce how the workup goes" (Participant 7). Finally, education on data download interpretation or an algorithm for NIV troubleshooting were physician-level solutions that would facilitate care for this patient population. For example, a physician shared "the thing that I'm less comfortable with is the… troubleshooting management of it afterwards. Kind of, like we were talking about with the downloads" (Participant 1).

A clinic-level solution proposed was development of a protocol with the addition of clinical support, including RTs for NIV teaching and clinical staff for NIV insurance approval. One physician who already had nursing and RT support staff available expressed, "we could make it easier and better if we… came up with… a practice plan… we could have them come in and do teaching with the RT at our office… instead of having to worry or rely on the DME company who's variable" (Participant 4).

Discussion

We identified multiple barriers and targets for improving care and NIV prescription for patients with chronic hypercapnia due to COPD at the patient, physician, and clinical level. We found physicians varied in identifying patients with COPD for chronic hypercapnia screening, and limited access to testing further hindered diagnosis. Although NIV was generally initiated once patients were identified, practice often diverged from evidence with no consensus on device choice or initial settings. Insurance barriers and insufficient clinical support, particularly from RTs, increased reliance on variable-quality DME companies. Patient nonadherance and disengagement further challenged care delivery.

Relationship to Prior Studies

Prior studies demonstrated that NIV prolongs the time to hospital readmission or death in patients with COPD who remain hypercapnic 2–4 weeks after an acute hypercapnic exacerbation when $PaCO_2$ level reduction is targeted.[11,12] This mortality benefit was not seen when NIV was initiated for patients with COPD who were persistently hypercapnic during an active admission for acute hypercapnic respiratory failure.[19] Despite this evidence, many patients who would benefit from NIV are not receiving it.[4,10] Our study builds on this work and begins to highlight the barriers to implementing NIV for patients with chronic hypercapnia from COPD which encompass patient, physician, and clinic level barriers. For example, improving clinician knowledge on who to screen and when to initiate NIV treatments—both of which have evidence-guidance—by creating electronic screening tools or order sets may help to overcome this barrier.[13,20]

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Table 5. Barriers to Noninvasive Ventilation Use for Chronic Hypercapnia in COPD

Theme	Example Quote
a. Access to Testing	"I remember X clinic had the transcutaneous CO_2's for the noninvasive clinic and I've always been like, oh, why don't we have that? That'd be nice, because we have patients that are on… Trilogy's, and it'd be nice to know if the settings are appropriate." (Participant 7) "It's just not typically occurring, that an ABG happens. Now, it may be also that it's mechanistically a little hard. Our clinic is across the street from the hospital and so, to get an ABG is… is to schedule a procedure... It's done in the outpatient respiratory area in the hospital… There's a blood drawing station in my building. They don't do ABGs." (Participant 12)
b. DME Companies	"the second problem [we] run into is, it's just highly variable DME training… sometimes the patients show up and they just have an all-star, and [the DME] really get them fitted properly for a mask and I feel like there's really good teaching and really good patient education… Then other patients… [the DME] just… hand me this box and told me to have a good day and [the patients] call with questions and they don't pick up the phone." (Participant 6) "And unfortunately, you pick the home medical equipment company that's either easiest to communicate with, or, you know, recently were successful in getting a patient a device. And not necessarily the one I wanted, but a device… then fax that piece of paper to the company, and then that creates a cascade of documents that then go back and forth between basically our office's fax machine and the home medical equipment company. That process can often take couple weeks to really clarify in all that dyssynchronous communication what we need to do, document, write, order additional testing." (Participant 15)
c. Clinical Support	"I think the process is much more streamlined in that it's very easy to get an overnight oximetry at the hospital… The RTs are very capable of setting that up… And then it's… also… easier, because the case managers know the drill and they… will help us arrange BIPAP in that circumstance, whereas getting that set up… in the office is just challenging…" (Participant 12) "In my opinion, those, kind of, facilities, if you have a specifically COPD nurse navigator who does this thing for day in and out, I think that will help, or a respiratory therapist or somebody, meaning by any ancillary staff who specifically trained to work with COPD patients and then go through all this logistic issues. I think that will help." (Participant 11)
d. Patient Factors	"I think that it's often more… are they willing to get it?… because it requires them making a trip over [to] the hospital, an arterial puncture… I also… will go into… what are we gonna do about this if we find it? And there's some patients that are like, they're doing all the therapy that they're willing to do, and would never consider… nocturnal ventilation." (Participant 1) "Yeah, I think there is a lot of issues with mask compliance… Unless they actually feel better on it. Again, there are some people where I talk to them and they're like, I feel so much better when I wear this mask." (Participant 8)
e. Insurance	"Over the past couple of years, there were… clearly situations where I wanted to get people home on BIPAP, but I simply couldn't qualify them and… there was some glitch… that we were getting pushback from a DME Company, saying, oh, this person needs to have a formal sleep study in addition to… what you're trying to do, because they clearly have sleep apnea and we're not going to get paid if this person has apparent underlying sleep apnea. And so, it's in those kind of circumstances where we just… throw up our hands and we go, you know what, we are reaching a roadblock of getting BIPAP and so we know that there's a way to get a home vent set up in… a BIPAP equivalent mode." (Participant 12) "I think that insurance is another barrier, like navigating approvals and… and making sure that they're getting… like being able to get supplies and other stuff is… is again something that takes more time than… and sometimes patients have a hard time navigating those systems." (Participant 1)
f. Provider Hesitation	"I feel decently comfortable about the indications for it. I think that the thing that I'm less comfortable with is the… troubleshooting management of it afterwards..." (Participant 1) "You know, we were trained on it, but again, most of our training is very inpatient, like, focused training, which is why I think sending patients home with it was very comfortable for me, but managing it outpatient, especially if you don't… if I wasn't like… like in a dedicated clinic with that, kind of, thing, it… yeah, it does get a little bit more uncomfortable." (Participant 14)

COPD=chronic obstructive pulmonary disease; ABG=arterial blood gas; DME=durable medical equipment; RT=respiratory therapist; BIPAP=bilevel positive airway pressure

Implications

Our study implies that there are multiple levels of barriers that are preventing the optimal care of patients with chronic hypercapnia from COPD. Broadly, patients require education of the importance of NIV use and assistance in troubleshooting equipment issues so that they find the devices tolerable. However, this requires physicians to be knowledgeable in how to identify patients at highest risk, be comfortable in managing and troubleshooting these devices with the patients, and have the time to do both while working with insurance companies to obtain approvals. While electronic medical record alerts and decisional support algorithms may help clinicians, additional resources will be needed to optimize use of NIV. Physicians need improved access to necessary testing and support from clinic staff. Clinical support, such as a qualified RT, is crucial in the care of this patient population both in assisting with device approval, navigating DME services, patient device education, and troubleshooting devices and patient discomfort.

We found that it was uncommon for physicians to evaluate post-treatment $PaCO_2$ levels. Patients may not be attaining mortality benefit from NIV if $PaCO_2$ levels remain elevated without appropriate changes to NIV settings. Lack of repeat testing could be secondary to difficulties in obtaining ABG's in the outpatient setting and patient disinterest in testing as shared by physicians in our study. Outpatient practices could consider surrogate measures of $PaCO_2$, such as TCO_2 monitors, as they are convenient and noninvasive. A

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Table 6. Solutions/Facilitators to Noninvasive Ventilation Use for Chronic Hypercapnia in COPD

Theme	Example Quote
a. Access to Testing	"Just like the ease of getting… gases or ease of understanding patients' CO_2 levels, I think would be one thing… having someone be poked in the artery is like... you just have to make... sure you actually want to do it. So, if there is an easier way in clinic that's… not expensive and something that accurately does it, then that would be one thing" (Participant 4) "I wish we had, like a, you know, transcutaneous CO_2." (Participant 7)
b. Clinical Support	"My suspicion's this is a universal experience, unless somebody has what I call… a BIPAP ventilator navigator ninja, who just happens to understand all the nuances… They… know how to make it happen and put the order in front of you and you sign it and it… just happens. And those people are invaluable." (Participant 15) "The respiratory therapists definitely help with obtaining devices in these such situations and they do a lot of work back and forth with the medical equipment companies… and the insurance companies." (Participant 3)
c. Education/ Patient Identification	"It's like, oh well, they're… fine… They're compensated. It's… not a problem. Their CO_2 is in the upper fifties or sixties, but they're… doing fine. It's just 1 or 2 exacerbations. They have a high serum bicarb. They're in a state of normalcy or something. So, I think there's still a little bit of just a lack of like awareness of like, no, there's probably good evidence to say these people are… quite literally more likely to die. They're more likely to use health care… this is just among pulmonologists and not to factor in… we're… one tiny fraction of the pie. You think of all the patients that the hospitalists see." (Participant 6) "The first time I even saw a BIPAP form was when I graduated. Like, I did not even really… Well, no, that's not true. I did it in fellowship, too. Not often, but I did it in, like, on pulm consults. I'd have to fill them out. No, actually, maybe I gave them to my attending? So, like, yeah, I don't even know if I really filled them out during… I've seen them, but did I fill them out? I honestly don't remember, but I think, kind of, handholding through that process until somebody feels comfortable enough to do them… do it independently, I think that would be a really good education in fellowship, for sure." (Participant 14)

COPD=chronic obstructive pulmonary disease; BIPAP=bilevel positive airway pressure

study of patients treated with NIV for chronic hypercapnic respiratory failure found that daytime $PaCO_2$ levels strongly correlated with TCO_2 values, with no difference in values exceeding 7.5mmHg.[18] All the physicians interviewed shared that TCO_2 monitors would be helpful in their clinical practice, but none had access to them.

Our study also infers that many pulmonary physicians are uncomfortable with NIV management, especially after initiation, and that differences in practices may be related to varying recommendations available to physicians. UpToDate, a commonly used tool by providers, shares a differing opinion from ATS, recommending NIV initiation in a monitored setting, such as a sleep laboratory.[21] We believe variability in fellowship training on home NIV management contributes to the knowledge gaps described and is compounded by difficulty navigating insurance coverage algorithms, the rapid expansion in NIV technology and their indications, and detailed education needed to address patient nonadherence to NIV. Given this, we question whether all pulmonologists should be prescribing and managing NIV for their patients with COPD. Some experts in the field argue that dedicated training in chronic respiratory failure, combining pulmonary, critical care, and sleep medicine education, is required to effectively manage these patients and the depth of knowledge required falls out of the scope of general pulmonary and critical care training.[22] Other experts have proposed ways to improve NIV education of fellows in pulmonary and critical care programs through a blended model of online and in-person hands on NIV instruction, which showed improvement in NIV knowledge and confidence in management in a small group of fellows.[23] The appropriate approach is unknown. However, given the mortality of COPD and prevalence of hypercapnia, expertise is needed in managing these patients.

Many physicians shared that insurance was a barrier to care, specifically the difficulty of following insurance algorithms and the need for additional testing for device approval. The Centers for Medicare & Medicaid Services recently revised their reimbursement guidelines for treatment of chronic hypercapnia related to COPD, now providing separate coverage requirements for authorization of a respiratory assist device with or without a back-up rate and a home mechanical ventilator in the outpatient and inpatient setting, removing need for overnight pulse oximetry for approval, and adding 6-month requalification requirements. However, despite these recent changes, these guidelines remain complex and challenging for general pulmonologists to navigate.

Lastly, many physicians preferred initiation of home NIV in the hospital as compared to initiation in the clinic, which opposes the recommendation by ATS. Recent literature argues that delaying NIV initiation to clinic follow-up could leave this patient population susceptible to hospital readmission and opportunities for better patient NIV education could be missed.[24] Additionally, a recent study using claims data found that early NIV initiation for chronic hypercapnia in COPD was associated with a reduced risk of death and decreased Medicare expenditures over the next year.[25] A barrier experienced by some participants included difficulty starting BIPAP on discharge and needing to send patients home with more expensive ventilators. This is an additional challenge that needs to be addressed and could potentially

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be improved by the recent revisions in reimbursement guidelines made by the Centers for Medicare & Medicaid Services.

Our study has several strengths. First, we obtained perspectives from pulmonary physicians from various clinical practices across the United States, reaching thematic saturation. Second, our study is the first to explore the barriers faced by physicians in managing chronic hypercapnia in COPD and uncovers potential targets for improvement and future research. However, there are also several limitations to our study. First, participants may have shared what they ideally would have done and not what they do in clinical practice (observer-expectancy effect). Additionally, we interviewed a convenience sample of physicians and excluded physicians at academic centers so our findings may not represent all pulmonary providers' practice patterns. Also, some findings are limited to physician practice in the United States as the barriers identified are dependent on the U.S. health care system. Demographic data were not available for nonparticipants, limiting our ability to assess differences from participants. However, nonparticipants were similarly not affiliated with large academic centers, suggesting they may have represented comparable practice settings.

Conclusion

Pulmonary physicians vary in their approaches to screening and management of chronic hypercapnia in patients with COPD, and there is a discordance between practice patterns described and research evidence. Screening guidance for at-risk individuals and a NIV treatment algorithm could help general pulmonologists in caring for this patient cohort. Additional solutions include improved physician education, better outpatient clinical support, access to necessary testing, and streamlined algorithms for NIV approval.

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Data sharing statement: The codebook will be available upon reasonable request following publication of the manuscript.

Declaration of Interest

WWL reports consulting fees from Inogen and Verona. PJChoi reports advisory fees from Breas Medical, Philips Respironics, and Sentec, Inc. All other authors declare no conflicts of interest.

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