Patterns of care in the management of high-risk COPD in the US (2011–2019): an observational study for the CONQUEST quality improvement program

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Summary

Background In this study, we compare management of patients with high-risk chronic obstructive pulmonary disease (COPD) in the United States to national and international guidelines and quality standards, including the COllaboratioN on QUality improvement initiative for achieving Excellence in STandards of COPD care (CONQUEST).

Methods Patients were identified from the DARTNet Practice Performance Registry and categorized into three high-risk cohorts in each year from 2011 to 2019: newly diagnosed (≤12 months after diagnosis), already diagnosed, and patients with potential undiagnosed COPD. Patients were considered high-risk if they had a history of exacerbations or likely exacerbations (respiratory consult with prescribed medication). Descriptive statistics for 2019 are reported, along with annual trends.

Findings In 2019, 10% (n = 16,610/167,197) of patients met high-risk criteria. Evidence of spirometry for diagnosis was low; in 2019, 81% (n = 1228/1523) of patients newly diagnosed at high-risk had no record of spirometry/peak expiratory flow in the 12 months pre- or post-diagnosis and 43% (n = 651/1523) had no record of COPD symptom review. Among those newly and already diagnosed at high-risk, 52% (n = 4830/9350) had no evidence of COPD medication.

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Interpretation Findings suggest inconsistent adherence to evidence-based guidelines, and opportunities to improve identification, documentation of services, assessment, therapeutic intervention, and follow-up of patients with COPD.

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Keywords: COPD; Exacerbations; Diagnosis; Spirometry; Treatment; Coordination of care

Research in context

Evidence before this study

Despite the promotion of national and global initiatives over the last twenty years and being the fourth leading cause of death prior to the COVID 19 pandemic, chronic obstructive pulmonary disease (COPD) remains an under-diagnosed and inadequately treated disease in the US and across the globe. Evidence of this is found in previous studies reporting rates of those undiagnosed or mis-diagnosed, and the variable adherence to evidence-based management strategies such as the Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Lung Disease (GOLD). A PubMed search was completed using the following keyword search: 1) COPD or Chronic Obstructive Pulmonary Disease (all fields) AND 2) Clinical Trials or Meta-Analysis (all fields) OR 3) articles in the top 20 medical or respiratory journals (available on request) or The Cochrane Database of Systematic Reviews. Additional evidence reported here is sourced from the US Center for Disease Control, reports published by the US National Institute of Health, the Healthcare Effectiveness Data and Information Set (HEDIS).

Added value of this study

This descriptive, observational study, which is focused on the management of patients at higher risk of exacerbations, i.e., those who have had ≥2 moderate or ≥1 severe (requiring hospitalization) exacerbations in the previous 12 months, includes analysis of de-identified, structured Electronic Medical Record (EMR) data from a large population of patients across US clinical organizations. Findings add significant value to both the academic community researching COPD and critically to the healthcare professionals treating patients. Results report observed trends in how patients that are at higher risk of exacerbations, both those who are diagnosed with COPD, and those undiagnosed but who are symptomatic, are identified, assessed, and managed in the US. These results are presented in relation to national and global guidelines for COPD management, and Quality Standards as outlined in The COllaboratioN on QUality improvement initiative for achieving Excellence in STandards of COPD care (CONQUEST). Collectively, results point towards the importance of promoting adherence to evidence-based guidelines, and recognition of a population of patients diagnosed and undiagnosed with COPD who are at a higher risk of exacerbations and adverse events.

Implications of all the available evidence

The implications of our findings and all available evidence include raising awareness among healthcare providers of the opportunities to improve the identification and care of their patients with COPD in accordance with expert guidelines. This includes increasing the use of spirometry as a diagnostic tool, increasing cardiac risk assessment, and assessment of risks associated with oral corticosteroids, proper review and consideration in pharmacological and non-pharmacological interventions, and regular follow-up. Should these practices be widely adopted the result would be improved identification and management of patients with COPD, and for patients, improved quality of life. This study also highlights opportunities to improve recording in EMR and includes a call to action for EMR software companies to develop tools that allow providers to easily adopt and employ coding strategies, and a call for providers to use these strategies consistently. The implication being that providers will have access to more complete medical records which are critical for patient care, and support care transitions when patients move across provider settings.

Introduction

Despite the promotion of national initiatives over the last 20 years, the prevalence of chronic obstructive pulmonary disease (COPD) in the United States (US) remains high.[1,2] These initiatives have included the National Institute of Health's (NIH) "COPD Learn More Breathe Better" campaign launched in 2007,[3] the "Public Health Strategic Framework for COPD Prevention" published by the Centers for Disease Control and Prevention (CDC) in 2011,[4] and, most recently, the "COPD National Action Plan" developed by NIH and CDC in 2018.[5] As of 2021, the CDC estimates that COPD affects more than 16.6 million Americans.[6] Although death related to many chronic conditions in the US has been decreasing, the

death rate for COPD has doubled since 1969[7] and, prior to the COVID-19 pandemic, was the fourth leading cause of death in the US.[8] More than 150,000 Americans die of COPD each year, which represents one death every 4 minutes.[9] In addition to being a leading cause of death in the US, COPD is also a leading cause of disability.[10] The projected 20-year (2019–2038) direct and indirect absenteeism costs associated with COPD in the USA are estimated at $800.9 billion and $101.3 billion, respectively.[11] COPD is also associated with a high symptomatic burden and rarely presents in isolation[12]; recent analysis of US data found that over half of patients report at least one exacerbation a year and 87% live with three or more co-morbidities—hypertension, diabetes mellitus, depression, and osteoarthritis being among the most common.[12]

Although the national burden is high, the prevalence of COPD varies considerably by state, from 3.2% in Hawaii to 11.9% in West Virginia.[13] However, this is likely an under-estimate as key opportunities to diagnose and optimally treat COPD are often missed. Research shows that many Americans are unaware they may have the condition[14]; large population-based studies estimate that 65–80% of adults with evidence of persistent airflow obstruction remain undiagnosed.[1] Moreover, an investigation of symptomatic individuals found that 71% of those meeting diagnostic COPD criteria (i.e., with forced expiratory volume in 1 s (FEV_1)/forced vital capacity (FVC) < 70% and FEV_1 < 80%, and symptomatic) were undiagnosed.[1]

Variation in adherence to national and global evidenced-based guidelines may contribute to this under-diagnosis of COPD.[15] Reports show underutilization of spirometry, as well as low referral rates to specialists in pulmonology and respiratory rehabilitation.[15] Although smoking is the primary risk factor for COPD, with the overall age-adjusted COPD prevalence among current smokers of approximately 15% (ranging from 7.8% in Hawaii to 25.9% in West Virginia), approximately 50% of current smokers have no evidence of receiving smoking cessation support.[16] Consequences of missed diagnosis and the under-recognition of patients at higher risk of adverse outcomes are steep. For example, underdiagnosis of COPD leads to higher future risk of exacerbations, accelerated lung function decline, greater risk of cardiovascular events, higher mortality rates, and higher healthcare costs in late-diagnosed patients with a symptomatic history.[17–21]

The COllaboratioN on QUality improvement initiative for achieving Excellence in STandards of COPD care (CONQUEST) is a new, multi-national program that aims to improve quality of COPD care for patients at higher risk of exacerbations and other adverse events. To achieve this, the CONQUEST quality improvement program (QIP) is built on the implementation of four quality standards (QS)[22] developed by internationally recognized experts, through extensive literature review and iterative rounds of review until consensus was achieved. These QS (Supplementary Figure S1) include: 1) prompt identification of target population, 2) assessment of disease and quantification of future risk, 3) non-pharmacological and pharmacological intervention, and 4) regular patient follow up.[22] The aim of the present study was to assess and describe trends in US clinical practice in relation to the CONQUEST QS,[22] along with international and national standards such as those provided in the Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease (GOLD),[15,23] US organizations such as the COPD Foundation,[24] the American College of Physicians, the American College of Chest Physicians, and the American Thoracic Society[25] in order to identify and understand gaps in care and opportunities for improvement. Specifically, in this observational study, we describe how US management of patients with higher risk (i.e., patients who have frequent COPD exacerbations, or probable COPD exacerbation events) compares to CONQUEST QS by using the most recent pre-COVID information from 2019. As the CONQUEST QIP is being implemented in both the US and the UK, it was important to assess patterns of care in both countries given the differences in healthcare delivery. As such, this analysis was carried out in parallel with a UK analysis.[26]

Methods

Study design

Similar to previous retrospective cohort analyses assessing COPD care,[27,28] this opportunity analysis is a cross-sectional descriptive study of patients meeting criteria for high-risk diagnosed COPD and patients with potential undiagnosed high-risk COPD (see Supplementary Table S1 for definitions) in each year from 2011 to 2019. De-identified routinely collected clinical data were assessed within the relevant timeframe for each outcome: the 12 months before and/or after January 1 of each study year, or COPD diagnosis date (Supplementary Table S2). As the data were de-identified prior to the creation of the dataset, they were compliant with the deidentification conditions set forth in Sections 164.514 (a)–(b) 1ii of the Health Insurance Portability and Accountability Act of 1996 Privacy Rule, and the study did not require Institutional Review Board approval.

Data source

The de-identified dataset for this opportunity analysis was obtained from structured electronic medical records (EMR) using DARTNet Institute's Practice Performance Registry.[29] DARTNet is a non-profit organization that supports collaboration among health care professionals and hosts health information data for quality improvement and research.[30,31] DARTNet's Practice

Performance Registry, which is endorsed by the American Academy of Family Physicians as a Quality Improvement Registry, currently includes data from approximately 6000 clinical organizations. For this study, DARTNet provided de-identified medical records on approximately 1 million patients pulled from over 1000 clinical organizations including integrated health systems, primary care and specialty practices, urgent care and emergency departments, and solo practitioners from across the country. Federally qualified health centers and academic sites account for less than 15% of the practices overall.[29]

Inclusion and exclusion criteria

Eligible patients from the Practice Performance Registry included those who had at least two years of EMR data in the 12 months before or after January 1 of each study year and were aged ≥40 as of January 1 each year. Eligible patients either 1) had a diagnosis of COPD, or 2) did not have a diagnosis of COPD, but whose medical records indicated they had experienced probable COPD exacerbation events (i.e., potential COPD), and had a history of smoking.[22] Probable exacerbations were defined as those requiring a prescription of steroids and/or antibiotics within three days of a lower respiratory consultation or a hospital attendance. From this population, patients at high-risk were identified as those who had experienced ≥2 moderate or ≥1 severe (requiring hospitalization) exacerbations, or probable exacerbations (for patients with suspected but undiagnosed COPD) in the previous 24 months, with one of these occurring in the last 12 months (Supplementary Table S1). Patients were excluded if their EMR indicated active asthma (i.e., those with an EMR diagnostic code for asthma and evidence of an asthma consultation in the 2 years prior to January 1 each year), other significant lung disease (i.e., bronchiectasis, cystic fibrosis, interstitial lung disease, tuberculosis) and/or active cancer (with the exception of non-invasive skin cancer) (Supplementary Table S1).

Patients meeting the above high-risk criteria as of January 1 in each year were identified and categorized into three cohorts:

- The newly diagnosed COPD cohort: patients whose first COPD diagnostic code observed in the available data was recorded in the 12 months preceding January 1 of each year (i.e., incident COPD cases).
- The already diagnosed cohort (i.e., prevalent COPD cases): patients who had a COPD diagnostic code in available EMR at any point in their history more than 12 months prior to January 1 of each year.
- The potential undiagnosed COPD cohort: patients with no COPD diagnosis code ever, or evidence of receiving a diagnostic assessment of COPD in the previous year in their available EMR prior to January 1 of each year, and who were current or former smokers with either 10 years smoking duration or 10 pack-years.

As an annual cross-sectional study, each year a segment of the potential undiagnosed COPD cohort moved into the newly diagnosed cohort the next year if they had a new recorded COPD diagnosis, and a segment of the newly diagnosed cohort moved into the already diagnosed cohort in the years following (Supplementary Figure S2).

Objectives by quality standard

The objectives of this opportunity analysis included a comprehensive assessment of US clinical practices in the management of COPD relative to global and national standards and the CONQUEST QS.[22] Specifically, structured data from EMR records of patients at high-risk were examined to assess the outcomes and opportunities. See Supplementary Table S1 for definitions and Supplementary Table S2 which details outcomes assessed for each cohort and the timeframe for analysis of each outcome reported.

Data management and statistical analyses

De-identified, structured EMR data from the DARTNet Practice Performance Registry were extracted into a study dataset and code vocabularies including SNOMED, ICD10, ICD9, CPT4, HCPCS, LOINC, and RxNorm were used to identify patient cohorts and relevant events. Data were standardized using the Observational Medical Outcomes Partnership (OMOP) common data model (v6), which allows for the analysis of data from disparate sources by transforming the data into a standard format and representation. To preserve confidentiality, all individuals were assigned a unique registry ID using a one-way hashing algorithm prior to being stored in the database.

Data were examined for quality with data cleaning processes applied that included identifying out-of-range or anomalous data and standardizing units of measurement. Potential for bias was reduced using a predefined statistical analysis plan; RStudio version 1.4.171 (Boston, MA) was used in all statistical analyses.

Study outcomes were assessed descriptively and cross sectionally for each study year. The descriptive statistics included frequency, percentages, mean and standard deviation are used in reporting patient demographics and clinical characteristics between 2011 and 2019 for the newly diagnosed, already diagnosed, and patients with potential undiagnosed COPD. Outcomes assessing current practices in COPD management are summarized and presented for 2019. Annual trends in management are summarized for each year from 2011 to 2019.

Role of funding source

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Results

Characteristics of patients meeting high-risk criteria as recorded in electronic medical records

In 2019, 167,197 patients were identified, and 16,610 (9.9%, n = 16,610/167,197) met high-risk criteria. The number of eligible patients meeting high-risk criteria by year are presented in Supplementary Table S3, and baseline characteristics and comorbidities among patients meeting high-risk criteria are provided by cohort from 2011 to 2019 in Table 1 (see Supplementary Table S4 for additional characteristics). In each cohort, women (as recorded in patient EMR) predominated and accounted for approximately 60% of eligible patients. The mean age was similar by cohort ranging from 63.9 to 67.1 years. In the already diagnosed cohort, an average of 78% (n = 42,553/54,580) of patients were identified as White, compared to 77.1% (n = 12,346/16,012) in the newly diagnosed cohort, and 71.2% (n = 28,642/40,202) in the potential undiagnosed COPD cohort. The proportion of patients identified as Black in their EMR was 9.3% (n = 5083/54,580), 9.7% (n = 1552/16,012) and 23% (n = 9117/40,202) in the already diagnosed, newly diagnosed, and potential undiagnosed COPD cohorts, respectively. On average, between 2011 and 2019, 29.4% (n = 16,069/54,580) of patients in the already diagnosed cohort and 32.1% (n = 5141/16,012) in the newly diagnosed cohort were current smokers.

Hypertension was the most prevalent comorbidity from 2011 to 2019, averaging approximately 60% in each of the three cohorts (Table 1). After hypertension, obesity was the most prevalent for the newly (42.2%, n = 6760/16,012) and potential undiagnosed COPD (54.3%, n = 21,822/40,202) cohorts. The percentage of patients with a record of depression/anxiety was highest in the already diagnosed cohort at 47.1% (n = 25,713/54,580). Among patients already diagnosed with COPD, an average of 9.7% (n = 5289/54,580) experienced a major cardiac event (new diagnosis for heart failure, revascularization, myocardial infarction, stroke), the average for patients newly diagnosed was 9.6%

	Already diagnosed	Newly diagnosed	Undiagnosed
Cohort totals[a], n	54,580	16,012	40,202
Age by index date, mean (SD)	68.7 (10.6)	67.1 (11.1)	63.6 (11.9)
Female, n (% of cohort)	31,821 (58.3)	9406 (58.7)	24,437 (60.8)
Race and Ethnicity, n (% of cohort)			
White	42,553 (78.0)	12,346 (77.1)	28,642 (71.2)
Black	5083 (9.3)	1552 (9.7)	9117 (22.7)
Other Races/Not recorded	5992 (11)	1798 (11.2)	1982 (5)
Hispanic	952 (1.7)	316 (2)	461 (1.1)
Smoking, n (% of cohort)			
Current Smoker	16,069 (29.4)	5141 (32.1)	6668 (16.6)
Ex-Smoker	19,257 (35.3)	4734 (29.6)	27,316 (67.9)
Clinically diagnosed comorbidities (ever), n (% of cohort)			
Diabetes type 2	16,499 (30.2)	4699 (29.3)	11,523 (28.7)
Osteoporosis	7404 (13.6)	1602 (10)	2893 (7.2)
Hypertension	34,571 (63.3)	9266 (57.9)	25,491 (63.4)
Chronic kidney disease	8194 (15)	2146 (13.4)	4665 (11.6)
Depression/Anxiety	25,713 (47.1)	885 (22.2)	30,142 (28.5)
Congestive Heart Disease	19,968 (36.6)	4799 (30)	9943 (24.7)
Obstructive Sleep Apnea	9942 (18.2)	2260 (14.1)	10,097 (25.1)
Gastroesophageal reflux disease (GERD)	22,293 (40.8)	5336 (33.3)	13,333 (33.2)
Anemia	12,163 (22.3)	3020 (18.9)	6858 (17.1)
Major cardiac events, n (% of cohort)	5289 (9.7)	1542 (9.6)	3140 (7.8)
BMI recorded within 5 years of index date, n (% of cohort)			
Underweight (<18.5)	1963 (3.6)	444 (2.8)	309 (0.8)
Normal weight (18.5–24)	12,907 (23.6)	3409 (21.3)	6171 (15.3)
Overweight (25–29)	14,657 (26.9)	4160 (26)	11,159 (27.8)
Obese (30.0+)	22,493 (41.2)	6760 (42.2)	21,822 (54.3)
Missing BMI	3113 (5.7)	1222 (2.4)	1069 (2.0)

[a]See Supplementary Table S4 for further baseline characteristics.

Table 1: **Baseline characteristics of patients meeting high-risk criteria as observed in electronic medical records.**

(n = 1542/16,012), and 7.8% (n = 3140/40,202) among patients with potential undiagnosed COPD (Table 1).

Proportion of eligible patients classified as high-risk COPD

In 2019, 12.8% (n = 1523/11,906) of newly diagnosed, and 10.7% (n = 7827/73,111) of already diagnosed patients with COPD met the high-risk criteria (Supplementary Table S3). The prevalence of patients at high-risk in these cohorts remained fairly stable over time with a slight increase noted from 2015 to 2019.

Analysis of high-risk patients according to CONQUEST QS in 2019 and over the period 2011–2019 by cohort

High-risk newly diagnosed cohort

Although EMR records of COPD symptom review (i.e., cough, dyspnea, sputum, wheeze) and spirometry did increase slightly from 2011 to 2019, in 2019, 42.7% (n = 651/1523) of newly diagnosed patients at high-risk had no record of having their COPD symptoms reviewed in the 12 months prior to or after their diagnosis date, and 80.6% (n = 1228/1523) had no record of spirometry or peak expiratory flow (PEF) assessment (Fig. 1). The low recordings of spirometry were consistent irrespective of exacerbation history; in 2019, among patients with 4 or more exacerbations, 17.5% (n = 37/212) of patients had spirometry evaluation coded in the year before or after their diagnosis (Supplementary Figure S3). Additionally, 97.8% (n = 1489/1523) of patients in this cohort in 2019 had no recorded evidence of having a cardiac risk assessment; the highest proportion between 2011 and 2019 was 2.9% (92/3195) in 2017 (Fig. 1). Cardiac risk assessment was measured using a comprehensive and specific EMR code list including ICD-9, ICD-10, SNOMED, CPT4 and LOINC codes (Supplementary Table S1). Higher percentages (61.7%, n = 940/1523) were observed for other cardiac related assessments. Among those with cardiac related assessment, 90.1% (n = 847/940) had cholesterol recorded, 38.9% (n = 366/940) with EKG, 9.9% (n = 93/940) with echocardiogram, and 4.1% (n = 39/940) with brain natriuretic peptide (BNP).

In 2019, 59.3% (n = 302/509) of current smokers in this cohort had no EMR evidence of receiving prescribed or recommended formal smoking cessation support (EMR query included pharmacological and/or non-pharmacological codes), with a downward trend noted from 2011 to 2019. Among patients who received a second acute course of oral corticosteroids (OCS) within 12 months before or after January 1 2019, 96.9% (n = 282/291) had no evidence of assessment of comorbidities potentially related to OCS use, specifically assessments for osteoporosis and/or diabetes (Supplementary Table S1) in the 12 months following the second OCS course (Fig. 1). Indeed, the recording of formal OCS risk assessment remained consistently under 5% from 2014 to 2019 (Fig. 1).

High-risk newly and already diagnosed treatment status

In 2019, 51.7% (n = 4830/9350) of patients newly and already diagnosed meeting high-risk criteria had no record of an inhaled COPD medication prescription. Triple therapy (fixed and loose) was prescribed for 10% (n = 938/9350) of patients, with 12.8% (n = 1195/9350) prescribed a reliever only, and 2.9% (n = 272/9350) inhaled corticosteroid (ICS) only (Supplementary Figure S4).

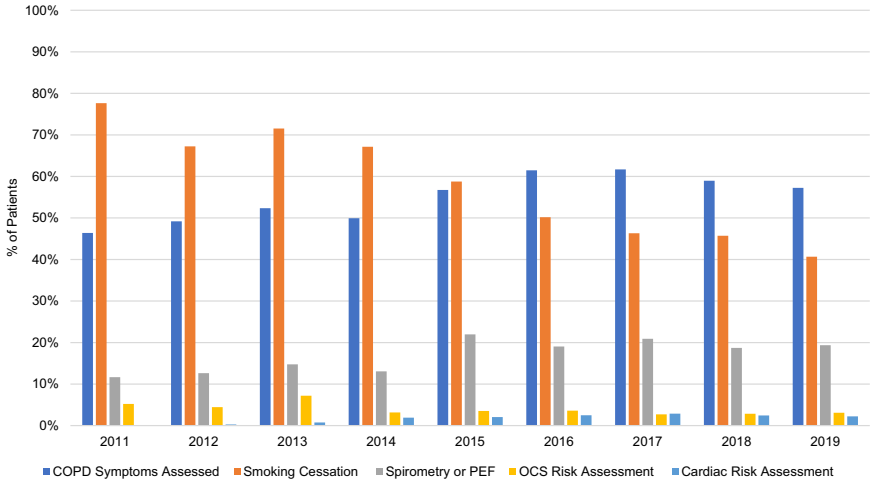

Fig. 1: Patients newly diagnosed with COPD meeting high-risk criteria: Key Trends. **Abbreviations:** COPD: chronic obstructive pulmonary disease; OCS: oral corticosteroid; PEF: peak expiratory flow. **Definitions:** See Supplementary Tables S1 and S2 for definitions and analysis timeframes of all outcome variables.

High-risk already diagnosed cohort

In 2019, 83.7% (n = 6552/7827) of already diagnosed patients at high-risk had no recorded evidence of spirometry or PEF (Fig. 2), and the presence of spirometry or PEF assessments remained low over the 2011–2019 timeframe (Fig. 3). Additionally, in 2019 97.9% (n = 7664/7827) had no record of a cardiac risk assessment (specific code list applied); 51.7% (n = 4048/7827) had evidence of other cardiac related assessments; among those with an assessment, 89.1% (n = 3605/4048) with cholesterol, 36.5% (n = 1478/4048) with EKG, 9.4% (n = 380/4048) with echocardiogram, and 5.1% (n = 207/4048) with BNP. Among current smokers, 63.7% (n = 1620/2544) had no record of receiving smoking cessation support, 29.1% (n = 2278/7827) had no record of receiving a COPD review (e.g., patients with record of codes denoting clinical review and COPD, or review of inhaler technique), and 96.6% (n = 1327/1373) of patients who received a second acute course of OCS within 12 months of the first course had no recorded evidence of OCS risk assessment for comorbidities potentially related to OCS use (Fig. 2).

In general, the proportion of already diagnosed patients at high risk receiving a COPD review has improved in the past few years, whereas the proportion receiving smoking cessation support has declined (Fig. 3). EMR records of spirometry, cardiac risk assessments, and assessment of comorbidities potentially related to OCS use has not improved in recent years, remaining relatively flat from 2011 to 2019 (Fig. 3). For example, for each year between 2011 and 2019, <10% of patients had evidence of OCS risk assessment and <4% had evidence of a cardiac risk assessment.

Potential undiagnosed COPD

In 2019, 33.7% (n = 2452/7260) of patients with potential undiagnosed COPD at high risk had two probable COPD exacerbation events, 12.1% (n = 875/7260) had three, and 7.5% (n = 542/7260) had four (Supplementary Figure S5). 96.4% (n = 6997/7260) of patients had no evidence of spirometry or PEF, and 94.4% (n = 319/338) who received a second course of acute OCS within 12 months of a first dose had no record of assessment of comorbidities potentially related to OCS use (Supplementary Figure S6). In 2019, 6.2% (n = 447/7260) of patients with potential undiagnosed COPD at high risk in the year prior were ultimately diagnosed with COPD. Among those diagnosed, 77% (n = 344/447) had no record of spirometry.

The proportion of patients receiving any of these assessments did not improve over time, remaining very low and flat from 2011 to 2019 (Supplementary Figure S6). In 2019, 9.2% (n = 670/7260) of patients with potential undiagnosed COPD at high risk had evidence of being prescribed ICS, ICS/LAMA, or other

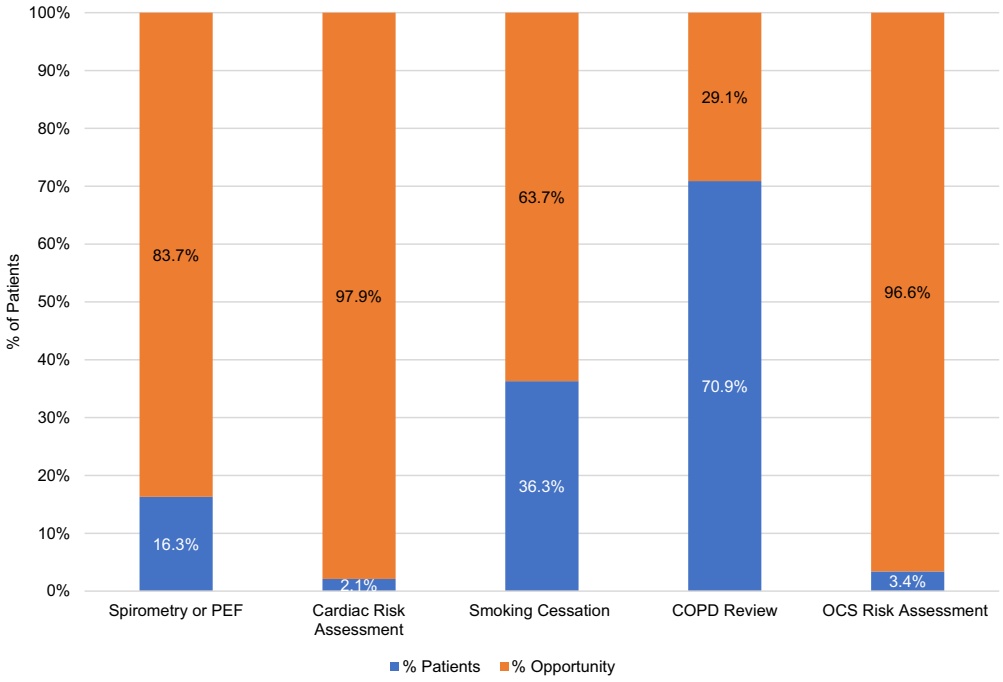

Fig. 2: Patients already diagnosed with COPD meeting high-risk criteria: 2019. **Abbreviations:** COPD: chronic obstructive pulmonary disease; OCS: oral corticosteroid; PEF: peak expiratory flow. **Definitions:** See Supplementary Tables S1 and S2 for definitions and analysis timeframes of all outcome variables.

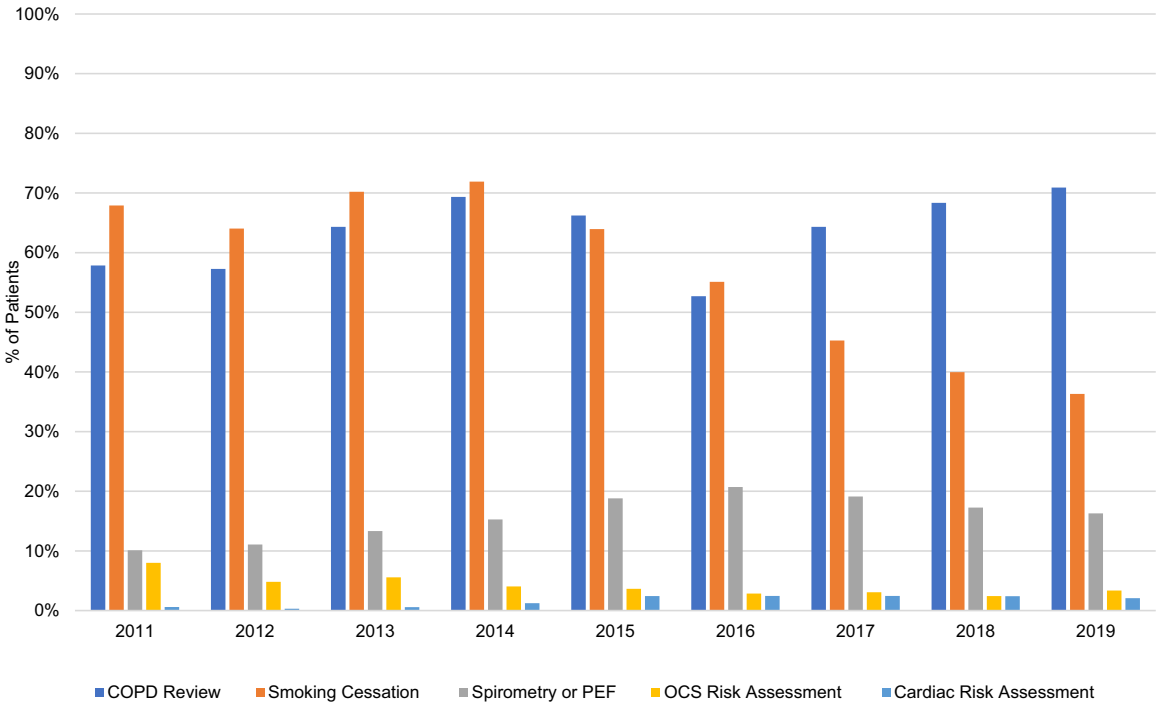

Fig. 3: Patients already diagnosed with COPD meeting high-risk criteria: Key Trends. **Abbreviations:** COPD: chronic obstructive pulmonary disease; OCS: oral corticosteroid; PEF: peak expiratory flow. **Definitions:** See Supplementary Tables S1 and S2 for definitions and analysis timeframes of all outcome variables.

maintenance medication; 6.9% (n = 502/7260) were on reliever only (Supplementary Figure S4).

Discussion

In assessing current practices against the CONQUEST QS, the presented analyses underscore opportunities for improved identification, diagnosis, disease assessment, and follow-up in the US. Critically, trends in practice were assessed among a sub-set of patients who are at higher risk of exacerbations and have documented moderate or severe exacerbations, or likely exacerbations occurring in the previous 12 months. In other words, there is a patient population with symptomatic COPD with clear opportunities to intervene and improve well-being. Although findings rely on the accuracy and completeness of recorded events in patients' EMRs, the opportunities for improvement are evident. These include (1) use of spirometry to confirm diagnosis, (2) regular COPD review to ensure appropriate pharmacological and non-pharmacological interventions, (3) cardiac risk assessment as cardiovascular disease is a common cause of death, (4) OCS risk assessment to minimize adverse events associated with OCS use, and (5) provision of smoking cessation interventions where appropriate to reduce associated risks. The opportunities identified in this US analysis are consistent with findings from the UK opportunity analysis.[26]

Future investigation into identifying and addressing the barriers patients experience in gaining access to healthcare professionals, completing assessments such as spirometry, adhering to prescribed medication, and smoking cessation is additionally needed. Analysis of demographic information in available EMR revealed that 23% (n = 9117/40,202) of patients with potential undiagnosed COPD were identified as Black compared to representing 9.3% (n = 5083/54,580) and 9.7% (n = 1552/16,012), respectively, of the already and newly diagnosed patient populations. This suggests race is a factor in diagnosing patients, which aligns with previous studies reporting the ongoing racial disparities in respiratory outcomes and the importance of considering the social and economic context when addressing patient barriers to care.[32–34]

Analysis of structured EMR data revealed the limitations in the data readily available to health care professionals and an opportunity to improve the recording of patient health information. Improving quality of care includes ensuring that patient information is well-documented and coded in EMR so that health care professionals have a comprehensive record to inform their clinical decisions. If results of spirometry or PEF, cardiac risk assessment, etc. are not readily available to

the patient's primary care provider at point-of-care, important information may be overlooked. Improving EMR software and the ability of healthcare organizations to bring together disparate data sources, and incentivizing consistent and complete documentation will improve clinical decision making and help support care transitions across provider settings. Previous work utilizing algorithms that combine diagnostic and therapy codes has shown high validity in identifying acute exacerbations of COPD.[35] Therefore, the adoption of common strategies in primary care could allow for earlier identification of COPD.

Key points regarding QS 1: identification

Gaps in early and accurate diagnosis are particularly striking considering that analyses focus on patients at high risk. Yet, only approximately 6% (n = 447/7260) of the patients with undiagnosed potential high-risk COPD went on to receive a new diagnosis in 2019. While the US Preventive Services Task Force does not recommend screening asymptomatic patients for COPD,[36] analysis of structured EMR reveals opportunities for early diagnosis. Early and accurate diagnosis of COPD and the implementation of appropriate interventions reduces early lung function decline and is essential for effective long-term management.[23] Although spirometry is a key diagnostic tool,[23] in 2019, approximately 80% (n = 1228/1523) of the newly diagnosed cohort at high-risk had no recorded evidence of spirometry or PEF in the 12 months prior to or following their first COPD diagnosis. This proportion, which is lower than the approximately one-third of patients with spirometry reported by Healthcare Effectiveness Data and Information Set (HEDIS),[37] is persistent over time and did not vary with exacerbation history. Results show that record of spirometry among those with evidence of four or more exacerbations (17.5%, n = 37/212) was similar to those with two (21%, n = 153/729). Additionally, diagnosis without spirometry may contribute to overdiagnosis and ill-fitted treatment.[38]

Key points regarding QS 2: assessment

Appropriate COPD assessment, including assessment of COPD symptoms and cardiac risk is necessary to determine the best therapeutic interventions for patients and to quantify their future risk. However, our findings suggest that the proportion of patients at high-risk of future exacerbations and adverse events in the US with EMR evidence of relevant disease and risk assessment is low. Cardiovascular disease is one of the most common causes of death among patients diagnosed with COPD, and one of the leading causes of death in the US.[8] There is growing evidence that exacerbations are closely associated with cardiovascular events and that COPD patients have higher comorbid cardiovascular conditions,[20,39] yet recorded evidence of cardiac risk assessment was less than 10% for all cohorts. Focusing on assessment among the newly diagnosed high-risk cohort highlights opportunities for improvement. In 2019, approximately 43% (n = 651/1523) of newly diagnosed patients at high-risk had no evidence of assessment of their COPD symptoms (i.e., cough, dyspnea, sputum, wheeze) in the 12 months prior to and following their diagnosis. Further, oral corticosteroids are associated with an increased risk of osteoporosis and diabetes[40]; however, between 2011 and 2019, less than 10% of all high-risk patients who received a second acute course of OCS within 12 months of their first course have evidence of receiving such risk assessments. Adopting strategies to incorporate regular risk and disease assessment into routine primary care management of patients with COPD and patients who are current or former smokers is therefore a priority.

Key point regarding QS3: appropriate non-pharmacological and pharmacological intervention

Opportunities to improve non-pharmacological and pharmacological intervention were also revealed. The observed decline in recorded evidence of smoking cessation support is notable. Among current smokers in 2019, approximately 64% (n = 1620/2544) of the already diagnosed high-risk cohort, 60% (n = 302/509) of the newly diagnosed high-risk cohort, and 80% (n = 740/920) of the potential undiagnosed COPD cohort had no evidence of receiving support for smoking cessation. Queries included code lists capturing support in the form of medication, referral to support programs, and provider counseling. However, opportunities to receive smoking cessation support are available to patients through many avenues including receiving community counseling and, in a growing number of states, prescriptions for the United States Food and Drug Administration's approved tobacco cessation products from their local pharmacists. This support outside their primary care providers office may not be recorded in patient EMR; however the trend warrants further investigation.

Despite effective medication options being available, a surprising proportion of newly diagnosed and already diagnosed (51.7%, n = 4830/9350) patients at high risk had no evidence of receiving a prescription for an inhaled maintenance therapy 2019. According to GOLD recommendations, long-acting muscarinic antagonist (LAMA) with long-acting β2-agonist (LABA) may be chosen as an initial treatment for patients with more severe symptoms.[23] Conversely, some 16% (n = 1172/7260) of the potential undiagnosed high-risk COPD cohort are already on a maintenance or reliever medication and yet have no COPD diagnosis. More investigation is needed to better understand these incongruities; a percentage of those diagnosed but with no record of inhaled therapy could be mis-diagnosed,[1,38] underscoring the importance of disease and risk assessment to inform therapeutic interventions.

Barriers to treatment access, including limited access to affordable and adequate health insurance coverage must also be considered.

Key points regarding QS 4: appropriate follow-up

There is a significant opportunity to improve management by ensuring all patients have a review following initiation of, or changes to, therapy, particularly for newly diagnosed patients who may have never used an inhaler before or who may not know what to expect from their medication. Although conducting regular COPD clinical reviews among patients already diagnosed patients is recommended,[23] about 30% (n = 2278/7827) of already diagnosed patients at high risk in 2019 had no evidence of receiving a review in their available EMR. Regular clinical reviews with patients can aid in keeping patients' COPD controlled.[23] They are an important opportunity to review inhaler technique, adherence to prescribed COPD medications and to make any therapy changes (when appropriate), promote smoking cessation for current smokers, encourage physical activity, consider pulmonary rehabilitation, and to update the patient's COPD action plan.[23]

Strengths and limitations

The data source for this analysis contains both strengths and weaknesses. The Practice Performance Registry is a comprehensive data source; data for this opportunity analysis is pulled from over 1000 clinical organizations across the US. Additionally, comprehensive code lists were developed for search queries that included the following code vocabularies: SNOMED, ICD-10, ICD-9, CPT4, RxNorm, and LOINC. The algorithm developed to identify COPD exacerbations and probable exacerbations was specific, offering assurance that the cohorts identified are indeed at higher risk of future exacerbations. Analyses were carried out on structured EMR data and did not include free-text or prescription claims data and consequently, it is possible to have missed exacerbations and potential exacerbations. The de-identified dataset did not include geographical information, or information on size, entry, or exit of participating organizations. Therefore, although we were informed the registry grew significantly in 2015, it was not possible to determine if new data sources were drawn from representative healthcare practices across the US. As a cross-sectional and descriptive study, no formal statistical tests were conducted to determine if there were changes within each cohort overtime.

Positive smoking history was part of the inclusion criteria for the undiagnosed potential COPD cohort, therefore those patients who had experienced COPD like-symptoms due to non-smoking reasons such as environmental toxins may have been missed. As asthma was part of the exclusion criteria, patients with asthma-COPD overlap syndrome are not represented. Limitations relevant to all US databases also apply here; patients often receive care across multiple locations and providers, and consequently EMR records cannot be assumed to be a full accounting of a patient's care. Attempts to mitigate these limitations are reflected in our eligibility criteria which excludes patients with less than two years of valid EMR data and in our thorough quality assurance checks.

This analysis includes data through 2019, to minimize the potential, yet temporary, impact the COVID-19 pandemic could have on long-term trends related to the quality of COPD medical care. The analysis was not intended to assess the impact of the COVID-19 pandemic itself, rather to show the historical trends as a baseline. Recent studies show the impact across care settings is significant[41]; retrospective analysis of 4422 COPD admissions in a large, multicenter US healthcare system revealed a seasonal-matched decline in COPD hospitalization of 53% during the COVID-19 pandemic.[42] Adoption of risk-reduction measures such as social distancing, mask wearing, and avoiding large crowds likely contributed to fewer exacerbations due to reduced transmission of seasonal respiratory viruses.[42] Exacerbation rates will be important to monitor as social engagement returns to pre-pandemic levels.

Conclusion

This analysis reveals the gaps and opportunities for improvement in the identification and management of patients with COPD in the US. Improvement in consistent and accurate coding in patient medical records, along with additional EMR software tools that allow for this, are critically needed, both for appropriate identification and management of patients with COPD and for population health studies in order to better understand broad national trends and inform public health agendas and initiatives. Further, evidence suggests that influential factors contributing to these gaps include missed and late diagnosis, inadequate disease assessment to determine a patients current and future risk, and delayed implementation of appropriate pharmacological interventions. Collectively, these trends point towards the importance of promoting adherence to evidence-based guidelines, and recognition of a population of diagnosed and undiagnosed patients with COPD who are at a higher risk of exacerbations and adverse events.

Contributors

The authors meet criteria for authorship as recommended by the International Committee of Medical Journal Editors. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis, and interpretation, or in all these areas. All authors had direct access to the data, MK and SE verified. All authors took part in drafting, revising or critically reviewing the article. All authors gave final approval of the version to be published. All authors have agreed on the journal to which the article has been submitted and agree to be accountable for all aspects of the work. All authors have given approval for the submission of this

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Data sharing statement

The dataset supporting the conclusions of this article was derived from DARTNet's Practice Performance Registry. The authors do not have permission to give public access to the study dataset; researchers may request access to the Registry data for their own purposes via dartnet.info/contact.htm.

Declaration of interests

Alan Kaplan is a member of the advisory board of, or speakers bureau for, AstraZeneca, Behring, Boehringer Ingelheim, Covis, Grifols, GlaxoSmithKline, Merck Frosst, Novo Nordisk, Novartis, Pfizer, Purdue, Sanofi, Teva, and Trudel.

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Jill Ohar has participated in advisory boards for Sunovion Pharmaceuticals Inc., AstraZeneca, Boehringer Ingelheim, GlaxoSmithKline, Novartis, Mylan, and Theravance and has received grant funding from Sunovion Pharmaceuticals Inc and Boehringer Ingelheim.

MeiLan Han reports personal fees from GlaxoSmithKline, AstraZeneca, Boehringer Ingelheim, Cipla, Chiesi, Novartis, Pulmonx, Teva, Verona, Merck, Mylan, Sanofi, DevPro, Aerogen, Polarian, Regeneron, Amgen, UpToDate, Altesa Biopharma, Medscape, NACE, MDBriefcase, Integrity and Medwiz. She has received either in kind research support or funds paid to the institution from the NIH, Novartis, Sunovion, Nuvaira, Sanofi, Astrazeneca, Boehringer Ingelheim, Gala Therapeutics, Biodesix, the COPD Foundation and the American Lung Association. She has participated in Data Safety Monitoring Boards for Novartis and Medtronic with funds paid to the institution. She has received stock options from Meissa Vaccines and Altesa Biopharma.

Nicola Hanania served as an advisor or consultant for Astra Zeneca, GSK, Sanofi, Genentech, Teva, Verona, Amgen and his institution received research grant support from Astra Zeneca, GSK, Sanofi, Genentech and Teva.

Wilson Pace is on the advisory board for Mylan; stock from Novo Nordisk, Pfizer, Novartis, Johnson & Johnson, Stryker, Amgen, Gilead, and Sanofi.

Michael Pollack, Hana Muellerova, Norbert Feigler and Hitesh Gandhi are employees of AstraZeneca and hold stock and/or stock options in the company. AstraZeneca is a co-funder of the CONQUEST initiative.

Konstantinos Kostikas has received honoraria for presentations and consultancy fees from AstraZeneca, Boehringer Ingelheim, CSL Behring, Chiesi, ELPEN, GILEAD, GSK, Menarini, Novartis, Sanofi, Specialty Therapeutics; (paid to the University of Ioannina); his department has received funding and grants from AstraZeneca, Boehringer Ingelheim, Chiesi, Innovis, ELPEN, GSK, Menarini, Novartis and NuvoAir (paid to the University of Ioannina); KK is a member of the GOLD Assembly.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2023.100546.

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