APPENDIX 1 (AS SUPPLIED BY THE AUTHOR): OUTCOMES OF PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD) DIAGNOSED WITH OR WITHOUT PULMONARY FUNCTION TESTING — SUPPLEMENTARY MATERIALS

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Supplemental Methods

To ensure the rigor of our results, a number of sensitivity analyses were conducted. First, the analysis was repeated using propensity score matching instead of propensity score adjustment.[1] Second, as a check that variables such as smoking, not available in the health administrative data, did not confound the results, a sensitivity analysis was performed using propensity score calibration.[2] In a representative sub-cohort of 1,229 people who also participated in the Canadian Community Health Survey (CCHS), which provided additional information on smoking status and exposure, body mass index, and self-reported health, a "gold standard" propensity score was calculated for each individual using both variables from the health administrative data and CCHS. This "gold standard" score was compared to their previous propensity score, using ordinary least squares regression, to obtain the relationship between the two scores. The resulting equation was then used to transform the propensity scores of all the individuals in the study (not just those with additional data) into "gold standard" scores. The primary analysis was then repeated, adjusting for the calibrated propensity scores. Third, the primary analysis was repeated in those aged 67 years and older in order to adjust for previous medication use (COPD or other), and exclude those previously prescribed a long-acting inhaled medication (an indication they may have had a unrecorded previous diagnosis of COPD). Fourth, we compared medication prescriptions one year before and after the 'pulmonary function test date' among those aged 67 years and older who had a pulmonary function test (cases) and those who did not (controls), in the matched cohort. For the cases, the 'pulmonary function test date' was the date on which they received their pulmonary function test. However, as the controls, by definition, were those who did not receive a pulmonary function test, we had to assign them a 'pulmonary function test date' equivalent. To do this we calculated the number of days prior to the study index date that each case received pulmonary function testing. We then counted back the same number of days from that case's matched control's index date, and considered this the 'pulmonary function test date' equivalent for that control. Fifth, we determined whether it was plausible that an unmeasured confounder or misclassification error could be responsible for the observed results. We varied the hazard ratio of a theoretical, unmeasured confounder and the imbalance of this confounder between the study cohorts to see at what point the observed hazard ratio was rendered null.[3] The same approach was used to estimate the effects of misclassification due to the case definition.

Supplemental Results

Impact of a potential unmeasured confounder and potential misclassification
A potential unmeasured confounder, uncorrelated with any of the covariates, with only a moderate impact on the risk of COPD hospitalization or death from any cause that was moderately more common in the non-tested group might negate the significant association observed in our primary analysis. Likewise, misclassification might explain our primary findings. However, only in the extreme and unlikely scenarios where an unmeasured confounder had a 90% difference between the groups or increased the risk of COPD hospitalization or death from any cause by 50% and had no correlation with any of the other variables adjusted for would the results in those ambulatory in the peridiagnostic period be negated. An equally extreme and clinically unlikely scenario would also have to exist to allow for misclassification to account for the results observed.

Supplemental Discussion

We posit that pulmonary function testing improves patient outcomes by offering important clinical information. We hypothesize that in most patients with suspected COPD, pulmonary function testing confirms the diagnosis and reveals the severity of disease, leading to the appropriate use of COPD medications and other interventions to improve COPD specific and all cause health outcomes. Our observation that inhaled long-acting bronchodilators, which represent first-line therapy in COPD but are contraindicated in asthma without the addition of inhaled steroids, were prescribed more often when peridiagnostic pulmonary function tests were done supports the above hypothesis. We also hypothesize that in a minority of patients with suspected COPD, pulmonary function testing rules out COPD, which helps avoid the use of unnecessary COPD medications (with their side effects), and triggers a search for and subsequent diagnosis and treatment of patients' true disease. This leads to an improvement in all cause health outcomes.

We acknowledge that a well-designed randomized clinical trial would most definitively establish the true merit of pulmonary function testing. However, such a trial is not likely to occur because testing has other benefits, such as predicting prognosis, leaving little equipoise to ethically allow for a control group that does not receive testing. In addition, because such a trial would need to capture patients with COPD at the time of diagnosis and follow them for years, the resources needed to conduct such a trial would be prohibitive. Unfortunately, without evidence of a benefit, there are still physicians who continue to not order pulmonary function

testing to diagnose COPD making our observational study, with its acknowledged and quantifiable limitations, a critical addition to the scientific literature.

Supplemental Tables

eTable 1. Baseline characteristics of individuals with physician diagnosed COPD who did and did not receive pulmonary function testing in the peridiagnostic period diagnosed with COPD in the ambulatory care or hospital setting (before propensity score matching)

Characteristic	Ambulatory Care setting				Hospital Setting			
	Pulmonary Function Testing In Peridiagnostic Period %		Standardized Difference, %	P Value[a]	Pulmonary Function Testing In Peridiagnostic Period, %		Standardized Difference, %	P Value[a]
	Yes	No			Yes	No		
Patients, *n*	20,023	17,700			8,363	22,812		
Demographic Characteristics								
Mean age, *years (SD)*	65.67 ± 11.36	67.54 ± 13.72	0.15	<.001	69.72 ± 11.43	72.38 ± 12.59	0.22	<.001
Women, *%*	47.7	49.8	0.04	<.001	46.7	49.0	0.05	<.001
Income Quintile, *%*			.	<.001			.	0.017
Quintile 1 (lowest)	21.8	25.0	0.08		24.6	26.2	0.04	
Quintile 2	21.4	22.5	0.03		21.7	22.1	0.01	
Quintile 3	19.9	19.3	0.01		19.5	19.2	0.01	
Quintile 4	19.0	17.3	0.04		18.0	17.5	0.01	
Quintile 5 (highest)	17.9	15.8	0.06		16.2	15.1	0.03	
Rural (versus urban) residence, %	12.6	16.4	0.11	<.001	14.2	19.1	0.13	<.001
Region of Province			.	<.001			.	<.001
Region 1	7.0	7.7	0.03		7.4	7.8	0.01	
Region 2	6.9	9.4	0.09		6.3	8.4	0.08	
Region 3	4.8	4.2	0.03		5.7	5.1	0.02	
Region 4	14.6	11.9	0.08		17.0	12.0	0.14	
Region 5	3.9	3.7	0.01		3.7	3.0	0.04	
Region 6	6.9	5.5	0.06		6.8	5.7	0.05	
Region 7	9.2	8.6	0.02		6.9	6.6	0.01	
Region 8	10.6	8.3	0.08		8.4	7.1	0.05	
Region 9	12.5	11.5	0.03		10.7	12.9	0.07	
Region 10	4.6	5.7	0.05		4.5	5.1	0.03	
Region 11	9.0	9.3	0.01		8.3	9.6	0.05	
Region 12	3.4	4.0	0.03		4.1	4.9	0.04	
Region 13	5.0	8.5	0.14		7.3	8.8	0.06	
Region 14	1.6	1.6	0.01		3.1	3.1	0.00	
Immigrant, %	7.6	7.7	0.00	0.76	6.5	5.5	0.04	0.001
Index year, %								
2005	3.7	6.2	0.12	<.001	7.0	12.2	0.18	<.001
2006	15.9	17.1	0.03		19.1	22.3	0.08	
2007	21.4	20.7	0.02		22.7	20.9	0.04	
2008	22.1	21.4	0.02		22.3	21.6	0.02	
2009	21.7	22.1	0.01		22.9	20.8	0.05	
2010	12.5	9.9	0.08		4.8	1.8	0.17	
2011	2.8	2.6	0.01		1.2	0.4	0.10	
Living in Long Term Care, %	0.5	6.3	0.32	<.001	1.9	9.1	0.32	<.001
COPD Related Characteristics, %								
Spirometry prior to peridiagnostic period								
Up to 1 year before	13.1	5.1	0.28	<.001	14.2	5.3	0.30	<.001
More than 1 to 2 years before	5.6	3.6	0.10		5.6	4.0	0.08	
More than 2 to 5 years before	10.1	7.1	0.11		10.6	8.5	0.07	
More than 5 years before or never	71.1	84.2	0.32		69.6	82.3	0.30	
Pulmonologist visit in previous year[b]	29.1	3.1	0.76	<.001	21.4	2.8	0.59	<.001

Internal medicine or geriatrics specialist visit	48.5	29.1	0.40	<.001	56.9	39.8	0.35	<.001
Long term oxygen therapy	2.7	1.3	0.10	<.001	3.4	1.6	0.11	<.001
General Health Characteristics								
Median primary care physician visits in previous year, *(interquartile range)*[b]	7 (4-11)	7 (4-11)	0.01	0.619	7 (4-11)	6 (3-11)	0.11	<.001
Influenza vaccination, *%*	48.7	43.2	0.11	<.001	48.2	42.6	0.11	<.001
Previous or Coexisting Medical								
Asthma	30.1	20.1	0.23	<.001	27.8	19.5	0.20	<.001
Other chronic respiratory disease	17.7	8.6	0.27	<.001	17.1	8.0	0.28	<.001
Lung cancer	5.9	2.9	0.15	<.001	16.1	4.9	0.37	<.001
Pulmonary embolism	2.1	2.3	0.01	0.235	4.3	3.4	0.05	<.001
Cor pumonale	0.1	0	0.03	0.016	0.1	0.1	0.02	0.036
Acute myocardial infarction	25.2	25.6	0.01	0.341	42.3	40.6	0.03	0.01
Other ischemic heart disease	20.5	19.5	0.02	0.024	34.9	32.4	0.05	<.001
Congestive heart failure	13.5	16.8	0.09	<.001	34.2	33.9	0.01	0.663
Dementia	4.1	12	0.29	<.001	8.6	17.8	0.28	<.001
Arrhythmias	17.1	19	0.05	<.001	31.9	30.1	0.04	0.002
Cerebrovascular disease	8.9	13.9	0.16	<.001	16.0	20.4	0.11	<.001
End stage renal disease	1.0	1.5	0.05	<.001	3.0	3.4	0.02	0.068
Diabetes	20.3	22.5	0.05	<.001	33.9	34.9	0.02	0.116
Hypertension	56.6	58.9	0.04	<.001	73.0	74.5	0.03	0.007
Non-lung cancer	17.6	17.4	0.00	0.705	25.2	23.3	0.04	<.001
Osteoporosis	2.0	3.5	0.09	<.001	2.8	4.8	0.10	<.001
Psychiatric disease								
Requiring hospitalization	0.6	1.5	0.09	<.001	1.1	1.9	0.07	<.001
Requiring ambulatory care visits	8.8	9.0	0.01		10.4	9.8	0.02	
none	90.6	89.5	0.04		88.5	88.3	0.00	
Palliative	0.6	1.3	0.07	<.001	2.6	2.7	0.00	0.837
Overall level of comorbidity[c]								
High	27.7	25.2	0.06	<.001	36.8	30.9	0.13	<.001
Medium	43.7	39.9	0.08		42.4	40.8	0.03	
Low	28.6	34.9	0.13		20.7	28.3	0.18	
Recent Acute Events, %								
Most recent hospitalization for acute bronchitis, pneumonia or influenza								
In the past 6 months	1.8	2.8	0.07	<.001	3.7	3.6	0.01	0.002
> 6 months before index date	3.8	4.2	0.02		6.5	7.7	0.05	
Never	94.3	93	0.05		89.8	88.7	0.03	
Most recent hospitalization for asthma								
In the past 6 months	0.4	0.2	0.05	<0.001	0.7	0.2	0.07	
> 6 months before index date	0.8	0.5	0.04		1.6	0.9	0.06	
Never	98.8	99.3	0.06		97.7	98.9	0.09	
Most recent hospitalization for other respiratory disease								<.001
In the past 6 months	1.5	1.5	0.00	<0.001	1.8	1.0	0.06	
>6 months before index date	2.1	1.2	0.07		2.5	1.8	0.05	
Never	96.3	97.3	0.06		95.7	97.2	0.08	

Most recent hospitalization for other causes								<.001
In the past 6 months	7.7	11.5	0.13	<0.001	21.0	20.6	0.01	
> 6 months before index date	27.1	28.1	0.02		32.6	36.7	0.09	
Never	65.2	60.4	0.10		46.4	42.6	0.08	
Most recent emergency department visit for acute bronchitis, pneumonia or influenza								0.04
In the past 6 months	3.2	3.7	0.03	0.002	4.5	4.1	0.02	
>6 months before index date	8.2	7.5	0.02		8.4	7.7	0.03	
Never	88.6	88.8	0.00		87.1	88.2	0.03	
Most recent emergency department visit for asthma								<.001
In the past 6 months	1.4	1.0	0.03	<.001	1.7	0.8	0.07	
>6 months before index date	2.9	2.0	0.06		2.8	1.9	0.06	
Never	95.8	97	0.06		95.6	97.3	0.09	
Most recent emergency department visit for other respiratory disease								
In the past 6 months	0.6	0.5	0.01	<.001	0.7	0.4	0.04	<.001
>6 months before index date	0.7	0.4	0.04		0.8	0.5	0.05	
Never	98.8	99.2	0.04		98.5	99.1	0.06	
Most recent emergency department visit for other causes								0.014
In the past 6 months	19.8	22.2	0.06	<.001	30.7	30.9	0.00	
>6 months before index date	44	43.1	0.02		40.5	41.9	0.03	
Never	36.2	34.6	0.03		28.8	27.2	0.04	
Primary Care Physician Characteristics								
Mean age, *years ± SD*	52.75 ± 10.33	54.00 ± 10.23	0.12	<.001	53.14 ± 10.33	53.30 ± 10.22	0.02	0.232
Women, %	24.0	18.3	0.14	<.001	22.2	19.1	0.07	<.001
Graduated from a Canadian Medical School,	75.2	74.6	0.01	0.173	76.5	77.0	0.01	0.338
Median Continuity of Care Index, *(interquartile range)* [d]	1 (1-1)	1 (0-1)	0.03	0.014	1 (1-1)	1 (0-1)	0.01	0.679
Quality of Care Measures, %								
Glucose testing in previous 3 years	89.4	83.6	0.17	<.001	87.3	83.3	0.11	<.001
Cholesterol testing in previous 3 years	80.9	70.8	0.25	<.001	75.8	67.5	0.18	<.001

COPD, chronic obstructive pulmonary disease

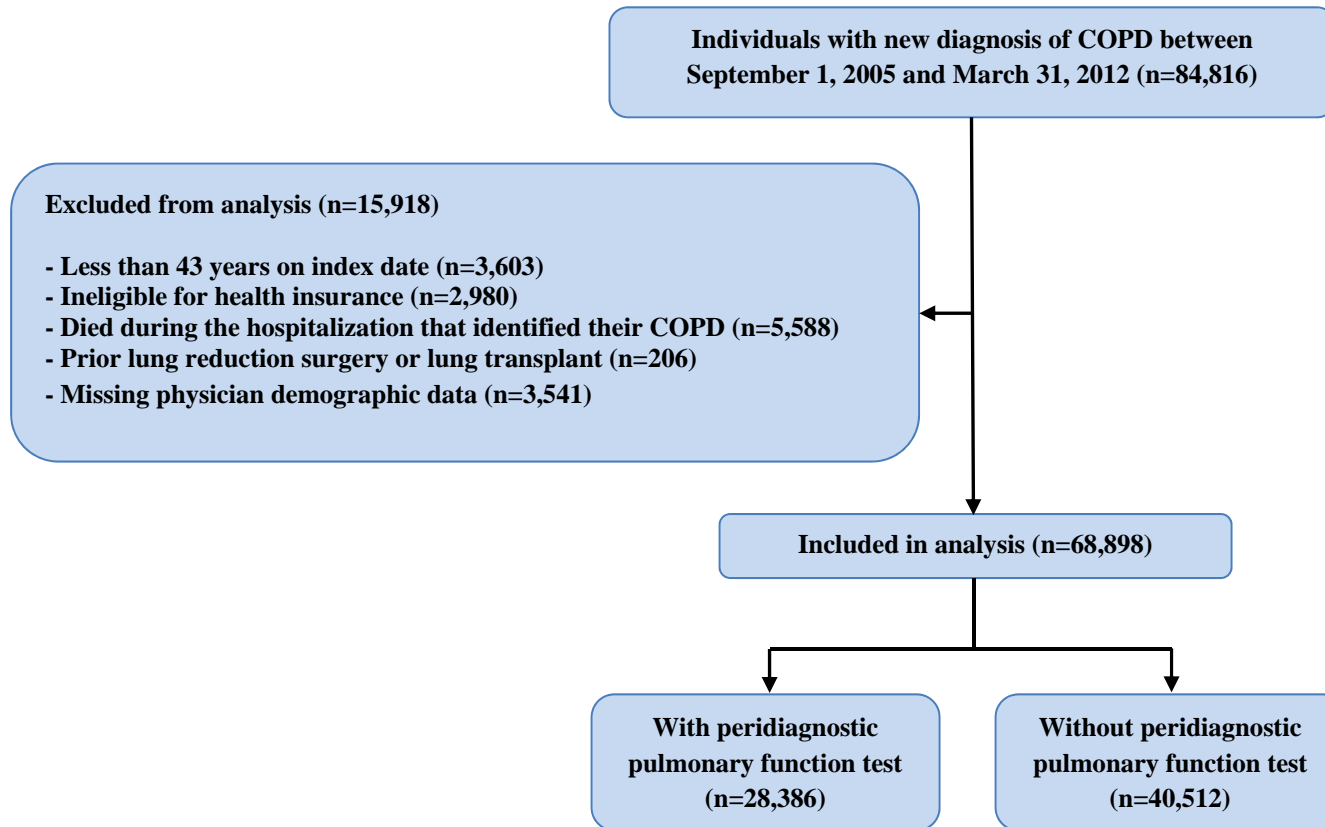[a] Testing the hypothesis of no difference between the groups with and without pulmonary function testing.

[b] In Ontario, primary care is provided by family and general physicians, and specialist COPD care is usually provided by pulmonologists, general internists, or geriatricians.

[c] As indicated by Johns Hopkins Collapsed Ambulatory Diagnostic Groups.

[d] A measure of patients' access to ambulatory care through the same care provider over time, calculated using the Bice method.[3,4]

Supplemental Figures

eFigure 1. Study flow diagram.

Individuals with new diagnosis of COPD between September 1, 2005 and March 31, 2012 (n=84,816)

Excluded from analysis (n=15,918)

- Less than 43 years on index date (n=3,603)
- Ineligible for health insurance (n=2,980)
- Died during the hospitalization that identified their COPD (n=5,588)
- Prior lung reduction surgery or lung transplant (n=206)
- Missing physician demographic data (n=3,541)

Included in analysis (n=68,898)

With peridiagnostic pulmonary function test (n=28,386)

Without peridiagnostic pulmonary function test (n=40,512)

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COPD = chronic obstructive pulmonary disease

References

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