Online Supplement Materials

Original Research
Reducing Health Care Resource Utilization in COPD: A Retrospective Matched Control Analysis of a Digital Quality Improvement Program

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Healthcare resource utilization definitions:

The different healthcare resources presented in this study are defined as follow:

- Office visit: primary care physicians provide first contact comprehensive care and continuing care for those with an undiagnosed sign, symptom or health concern.
- Urgent care visit: to treat an urgent but not life-threatening medical issue, that could not wait for a primary care visit appointment.
- Emergency department visit: when people suffer from severe symptoms and need emergency care.
- Hospitalization: the medical issue is severe and need 24/24h care and/or surveillance, or surgery is required.

COPD-related Code based on Mapel 2021 and Mapel 2011

ICD10	ICD9	DESCRIPTION
j18	blank	Pneumonia, unspecified organism
j20	blank	Acute bronchitis
j21	blank	Acute bronchiolitis
j22	5198	Unspecified acute lower respiratory infection
j40	490	Bronchitis, not specified as acute or chronic
j41	blank	Simple and mucopurulent chronic bronchitis
j42	4919	Unspecified chronic bronchitis
j43	blank	Emphysema
j440	49122	Chronic obstructive pulmonary disease with acute lower respiratory infection
j440	49321	Chronic obstructive pulmonary disease with acute lower respiratory infection
j441	49121	Chronic obstructive pulmonary disease with (acute) exacerbation
j441	49322	Chronic obstructive pulmonary disease with (acute) exacerbation
j449	49120	Chronic obstructive pulmonary disease, unspecified
j449	49320	Chronic obstructive pulmonary disease, unspecified

j449	496	Chronic obstructive pulmonary disease, unspecified
j45901	49392	Unspecified asthma with (acute) exacerbation
j80	51882	Acute respiratory distress syndrome
j960	blank	Acute respiratory failure
j962	blank	Acute and chronic respiratory failure
j969	blank	Respiratory failure, unspecified
r05	7862	Cough
r060	blank	Dyspnea
r062	78607	Wheezing
r063	78604	Periodic breathing
r068	blank	Other abnormalities of breathing
r071	78652	Chest pain on breathing
r072	78651	Precordial pain
r078	blank	Other chest pain
r079	78650	Chest pain, unspecified
r090	blank	Asphyxia and hypoxemia
j22	5198	Unspecified acute lower respiratory infection
j41	blank	Simple and mucopurulent chronic bronchitis
j42	4919	Unspecified chronic bronchitis
j43	blank	Emphysema
j440	49122	Chronic obstructive pulmonary disease with acute lower respiratory infection
j440	49321	Chronic obstructive pulmonary disease with acute lower respiratory infection
j441	49121	Chronic obstructive pulmonary disease with (acute) exacerbation

j441	49322	Chronic obstructive pulmonary disease with (acute) exacerbation
j449	49120	Chronic obstructive pulmonary disease, unspecified
j449	49320	Chronic obstructive pulmonary disease, unspecified
j449	496	Chronic obstructive pulmonary disease, unspecified
j80	51882	Acute respiratory distress syndrome
j960	blank	Acute respiratory failure
j962	blank	Acute and chronic respiratory failure
j969	blank	Respiratory failure, unspecified
r0603	blank	Acute respiratory distress
a150	1190	Tuberculosis of lung
a154	1210	Tuberculosis of intrathoracic lymph nodes
a155	1130	Tuberculosis of larynx, trachea and bronchus
a155	1220	Tuberculosis of larynx, trachea and bronchus
a155	1230	Tuberculosis of larynx, trachea and bronchus
a156	1200	Tuberculous pleurisy
a157	1090	Primary respiratory tuberculosis
a158	1280	Other respiratory tuberculosis
a159	1280	Respiratory tuberculosis unspecified
b440	1173	Invasive pulmonary aspergillosis
b440	4846	Invasive pulmonary aspergillosis
b441	1173	Other pulmonary aspergillosis
b442	1173	Tonsillar aspergillosis
b447	1173	Disseminated aspergillosis
b4481	5186	Allergic bronchopulmonary aspergillosis

b4489	1173	Other forms of aspergillosis
b59	1363	Pneumocystosis
c33	1620	Malignant neoplasm of trachea
c3400	1622	Malignant neoplasm of unspecified main bronchus
c3411	1623	Malignant neoplasm of upper lobe, right bronchus or lung
c3432	1625	Malignant neoplasm of lower lobe, left bronchus or lung
c3480	1628	Malignant neoplasm of overlapping sites of unspecified bronchus and lung
c3481	1628	Malignant neoplasm of overlapping sites of right bronchus and lung
c3490	1629	Malignant neoplasm of unspecified part of unspecified bronchus or lung
c384	1639	Malignant neoplasm of pleura
c782	1972	Secondary malignant neoplasm of pleura
c3402	1622	Malignant neoplasm of left main bronchus
c3492	1629	Malignant neoplasm of unspecified part of left bronchus or lung
e8411	27701	Meconium ileus in cystic fibrosis
e8419	27703	Cystic fibrosis with other intestinal manifestations
e848	27709	Cystic fibrosis with other manifestations
e849	27700	Cystic fibrosis, unspecified
i2601	4150	Septic pulmonary embolism with acute cor pulmonale
i2601	41512	Septic pulmonary embolism with acute cor pulmonale
i2690	41512	Septic pulmonary embolism without acute cor pulmonale
i270	4160	Primary pulmonary hypertension
i2723	blank	Pulmonary hypertension due to lung diseases and hypoxia
i2724	blank	Chronic thromboembolic pulmonary hypertension
i2729	blank	Other secondary pulmonary hypertension

i2782	4162	Chronic pulmonary embolism
a221	221	Pulmonary anthrax
a221	221	Pulmonary anthrax
a221	4845	Pulmonary anthrax
a3791	339	Whooping cough, unspecified species with pneumonia
a3791	4843	Whooping cough, unspecified species with pneumonia
b250	785	Cytomegaloviral pneumonitis
b250	4841	Cytomegaloviral pneumonitis
j1108	4870	Influenza due to unidentified influenza virus with specified pneumonia
j1281	4803	Pneumonia due to SARS-associated coronavirus
j13	481	Pneumonia due to Streptococcus pneumoniae
j14	4822	Pneumonia due to Hemophilus influenzae
j154	48231	Pneumonia due to other streptococci
j154	48239	Pneumonia due to other streptococci
j155	48282	Pneumonia due to Escherichia coli
j158	48281	Pneumonia due to other specified bacteria
j158	48289	Pneumonia due to other specified bacteria
j160	4831	Chlamydial pneumonia
j188	486	Other pneumonia, unspecified organism
j189	486	Pneumonia, unspecified organism
j439	4920	Emphysema, unspecified
j439	4928	Emphysema, unspecified
j441	49121	Chronic obstructive pulmonary disease with (acute) exacerbation
j441	49322	Chronic obstructive pulmonary disease with (acute) exacerbation

j471	4941	Bronchiectasis with (acute) exacerbation
j479	4940	Bronchiectasis, uncomplicated
j8409	5168	Other alveolar and parieto-alveolar conditions
j842	51635	Lymphoid interstitial pneumonia
j679	4959	Hypersensitivity pneumonitis due to unspecified organic dust
j82	5183	Pulmonary eosinophilia, not elsewhere classified
j9600	51851	Acute respiratory failure, unspecified whether with hypoxia or hypercapnia
j9600	51881	Acute respiratory failure, unspecified whether with hypoxia or hypercapnia
r230	7825	Cyanosis
b449	1173	Aspergillosis, unspecified
c3401	1622	Malignant neoplasm of right main bronchus
c3410	1623	Malignant neoplasm of upper lobe, unspecified bronchus or lung
c3412	1623	Malignant neoplasm of upper lobe, left bronchus or lung
c342	1624	Malignant neoplasm of middle lobe, bronchus or lung
c3431	1625	Malignant neoplasm of lower lobe, right bronchus or lung
c3482	1628	Malignant neoplasm of overlapping sites of left bronchus and lung
c3491	1629	Malignant neoplasm of unspecified part of right bronchus or lung
d751	2890	Secondary polycythemia
i2602	4150	Saddle embolus of pulmonary artery with acute cor pulmonale
i2602	41513	Saddle embolus of pulmonary artery with acute cor pulmonale
i2609	4150	Other pulmonary embolism with acute cor pulmonale
i2609	41519	Other pulmonary embolism with acute cor pulmonale
i2692	41513	Saddle embolus of pulmonary artery without acute cor pulmonale

i2699	41519	Other pulmonary embolism without acute cor pulmonale
i271	4161	Kyphoscoliotic heart disease
i2722	blank	Pulmonary hypertension due to left heart disease
i2781	4169	Cor pulmonale (chronic)
i2783	blank	Eisenmenger's syndrome
i279	4169	Pulmonary heart disease, unspecified
i2720	blank	Pulmonary hypertension, unspecified
b440	1173	Invasive pulmonary aspergillosis
b440	4846	Invasive pulmonary aspergillosis
b4481	5186	Allergic bronchopulmonary aspergillosis
j1100	4870	Influenza due to unidentified influenza virus with unspecified type of pneumonia
j120	4800	Adenoviral pneumonia
j121	4801	Respiratory syncytial virus pneumonia
j122	4802	Parainfluenza virus pneumonia
j123	4808	Human metapneumovirus pneumonia
j129	4809	Viral pneumonia, unspecified
j129	4870	Viral pneumonia, unspecified
j150	4820	Pneumonia due to Klebsiella pneumoniae
j151	4821	Pneumonia due to Pseudomonas
j153	48232	Pneumonia due to streptococcus, group B
j156	48283	Pneumonia due to other aerobic
j157	4830	Pneumonia due to Mycoplasma pneumoniae
j159	4829	Unspecified bacterial pneumonia
j168	4838	Pneumonia due to other specified infectious organisms

j17	4847	Pneumonia in diseases classified elsewhere
j17	4848	Pneumonia in diseases classified elsewhere
j17	5171	Pneumonia in diseases classified elsewhere
j440	49122	Chronic obstructive pulmonary disease with (acute) lower respiratory infection
j440	49321	Chronic obstructive pulmonary disease with (acute) lower respiratory infection
j4521	49302	Mild intermittent asthma with (acute) exacerbation
j4521	49312	Mild intermittent asthma with (acute) exacerbation
j4522	49301	Mild intermittent asthma with status asthmaticus
j4522	49311	Mild intermittent asthma with status asthmaticus
j45901	49392	Unspecified asthma with (acute) exacerbation
j61	501	Pneumoconiosis due to asbestos and other mineral fibers
j690	5070	Pneumonitis due to inhalation of food and vomit
j8403	5161	Idiopathic pulmonary hemosiderosis
j84113	51632	Idiopathic non-specific interstitial pneumonitis
j84117	51637	Desquamative interstitial pneumonia
j849	5169	Interstitial pulmonary disease, unspecified
j850	5130	Gangrene and necrosis of lung
j851	5130	Abscess of lung with pneumonia
j9312	51282	Secondary spontaneous pneumothorax
j9500	51900	Unspecified tracheostomy complication
j9509	51909	Other tracheostomy complication
j95821	51851	Acute postprocedural respiratory failure

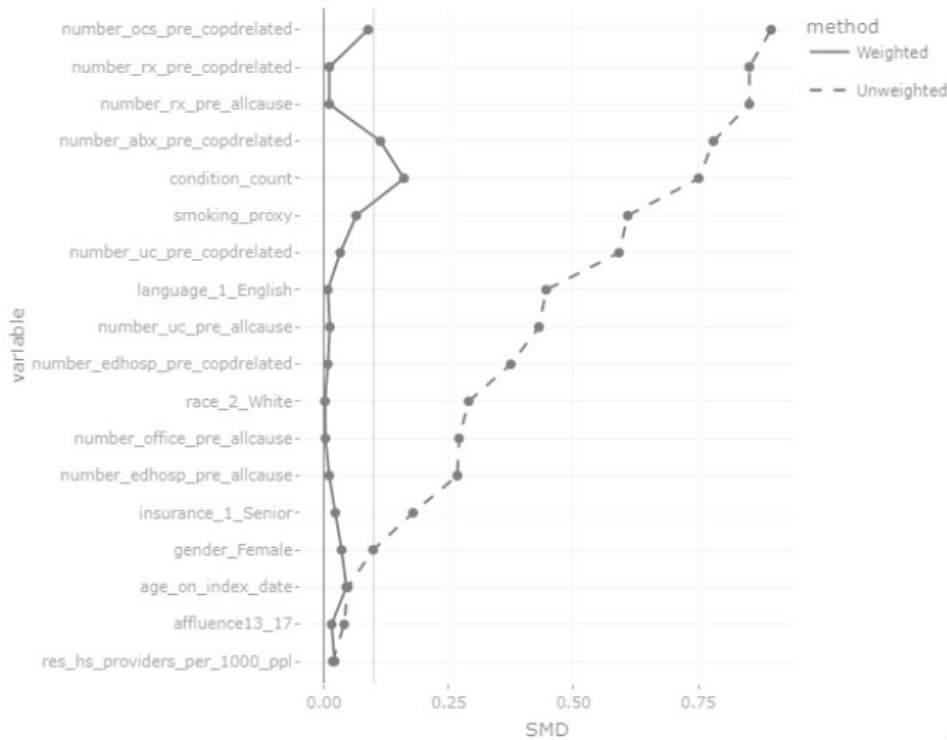|		
j9610	51883	Chronic respiratory failure, unspecified whether with hypoxia or hypercapnia
j99	5178	Respiratory disorders in diseases classified elsewhere
j15211	48241	Pneumonia due to Methicillin susceptible Staphylococcus aureus
j1529	48249	Pneumonia due to other staphylococcus
j84111	51630	Idiopathic interstitial pneumonia, not otherwise specified
j84115	51634	Respiratory bronchiolitis interstitial lung disease
j852	5130	Abscess of lung without pneumonia
j853	5131	Abscess of mediastinum
j869	5109	Pyothorax without fistula
j869	5110	Pyothorax without fistula
j9381	51283	Chronic pneumothorax
j9383	51289	Other pneumothorax
j9502	51901	Infection of tracheostomy stoma
j952	51852	Acute pulmonary insufficiency following nonthoracic surgery
j953	51852	Chronic pulmonary insufficiency following surgery
j95822	51853	Acute and chronic postprocedural respiratory failure
j9690	51881	Respiratory failure, unspecified, unspecified whether with hypoxia or hypercapnia
r0481	78631	Acute idiopathic pulmonary hemorrhage in infants
r049	78630	Hemorrhage from respiratory passages, unspecified
z430	v550	Encounter for attention to tracheostomy
z9981	v462	Dependence on supplemental oxygen
c3430	1625	Malignant neoplasm of lower lobe, unspecified bronchus or lung
i2721	blank	Secondary pulmonary arterial hypertension

j2789	4168	Other specified pulmonary heart diseases
j1289	4808	Other viral pneumonia
j1520	48240	Pneumonia due to staphylococcus, unspecified
j15212	48242	Pneumonia due to Methicillin resistant Staphylococcus aureus
j182	514	Hypostatic pneumonia, unspecified organism
j45902	49391	Unspecified asthma with status asthmaticus
j670	4950	Farmer's lung
j80	51882	Acute respiratory distress syndrome
j810	5184	Acute pulmonary edema
j811	514	Chronic pulmonary edema
j8410	515	Pulmonary fibrosis, unspecified
j930	5120	Spontaneous tension pneumothorax
j9311	51281	Primary spontaneous pneumothorax
j9620	51853	Acute and chronic respiratory failure, unspecified whether with hypoxia or hypercapnia
j9620	51884	Acute and chronic respiratory failure, unspecified whether with hypoxia or hypercapnia
j180	485	Bronchopneumonia, unspecified organism
j181	481	Lobar pneumonia, unspecified organism
j8401	5160	Alveolar proteinosis
j84112	51631	Idiopathic pulmonary fibrosis
j84114	51633	Acute interstitial pneumonitis
j84116	51636	Cryptogenic organizing pneumonia
j860	5100	Pyothorax with fistula
j860	53084	Pyothorax with fistula

j90	5111	Pleural effusion, not elsewhere classified
j90	51189	Pleural effusion, not elsewhere classified
j9503	51902	Malfunction of tracheostomy stoma
j9503	51909	Malfunction of tracheostomy stoma
j9811	5180	Atelectasis
j8489	515	Other specified interstitial pulmonary diseases
j951	51852	Acute pulmonary insufficiency following thoracic surgery
m3481	5172	Systemic sclerosis with lung involvement
m3481	7101	Systemic sclerosis with lung involvement
r042	78630	Hemoptysis
r0489	78639	Hemorrhage from other sites in respiratory passages
r0601	78602	Orthopnea
r092	7991	Respiratory arrest
z902	v4576	Acquired absence of lung [part of]
z930	v440	Tracheostomy status
z9911	v4611	Dependence on respirator [ventilator] status
z9912	v4612	Encounter for respirator [ventilator] dependence during power failure
e840	27702	Cystic fibrosis with pulmonary manifestations
j9382	51284	Other air leak
j9819	5180	Other pulmonary collapse

Supplement Table: Consort Flow

	Whole sample, N	Digital QI Program (n)	Control (n)
Complete Dataset	23725	308	23417
Patients who synced	23613	196	23417
Patients who had PERSON.NBR, zip code (to merge w SES data)	23538	196	23342
Patients enrolled in the Digital Quality Improvement Program between January 1, 2015 and 2019-06-30	23439	97	23342
Patient resides in the United States	23439	97	23342
Aged >= 40 years on index date	23352	97	23255
>= 30 days enrollment in Propeller platform	23348	93	23255
Prescription drug data available in DO dataset	19870	91	19779
Exclude comorbidities	19866	91	19775
Ever used rescue/controller inhaler	19859	84	19775
Continuous HCRU data 6 months pre- and post-index	14179	80	14099
No missing data for variables entered into the matching process for 6 months	14001	80	13921
Able to match on covariates	13658	79	13579

Figure Supplement: Standardized Mean Difference of covariates before and after propensity score matching

SUPPLEMENT SENSITIVITY ANALYSIS TO ACCOUNT FOR BASELINE MATCHING IMBALANCE

Supplement Table 3s
Six-month HCRU utilizations per person post-index via weighted doubly robust estimation modeling*

	Weighted + Adjusted for number of comorbidities and anti-biotics at pre-index			
	IRR	Lower CI	Upper CI	P value
All Cause				
# Office visits post-index	1.11	0.90	1.38	0.339
# Urgent care visits post-index	1.30	0.96	1.75	0.087
# ED + Hospitalizations post-index	0.58	0.33	1.05	0.072

COPD-related				
# Urgent care visits post-index	2.11	1.26	3.54	0.005
# Antibiotics post-index	1.19	0.72	1.97	0.492
# Oral corticosteroids post-index	1.48	0.91	2.38	0.111
# ED + Hospitalizations post-index	0.33	0.10	1.09	0.069

ED emergency department, HCRU healthcare resource utilization, QI Quality Improvement, SMD Standardized Mean Difference.

Incidence Rate Ratio (IRR): relative difference measure used to compare the incidence rates of events between 2 groups occurring at any given point in time:

- IRR > 1: the healthcare utilization rate is higher in the Propeller group
- IRR < 1: the healthcare utilization rate is lower in the Propeller group

*Poisson or negative binomial, depending on overdispersion issue