

Supplementary materials

Table S1 Asthma medications

Category	Prescriptions
Antiasthmatic combinations	Dyphylline-guaifenesin, guaifenesin-theophylline, or potassium iodide-theophylline
Antibody inhibitor	Omalizumab
Inhaled steroid combinations	Budesonide-formoterol or fluticasone-salmeterol
Inhaled corticosteroids	Beclomethasone, budesonide, ciclesonide, flunisolide, fluticasone CFC free, mometasone, or triamcinolone
Leukotriene modifiers	Montelukast, zafirlukast, or zileuton
Long-acting inhaled beta-2 agonists	Arformoterol, formoterol, or salmeterol
Mast cell stabilizers	Cromolyn or nedocromil
Methylxanthines	Aminophylline, dyphylline, oxtriphylline, or theophylline
Short-acting inhaled beta-2 agonists	Albuterol, levalbuterol, metaproterenol, or pirbuterol

Abbreviation: CFC, chlorofluorocarbon.

Table S2 ICD-9-CM diagnosis and CPT codes for glucocorticoid-related side effects

ICD-9-CM code	Description
Osteoporosis	
733.0x	Osteoporosis
Fractures	
Nonvertebral	
Hip	
733.14	Pathologic fracture of neck of femur
820.xx	Fracture of the neck of femur
27220–27248 (CPT codes)	Hip joint fracture
Forearm	
733.12	Pathologic fracture of radius and ulna
813.xx	Fracture of radius and ulna, open and closed
25500–25620 (CPT codes)	Forearm fracture
All other sites	
Arm	
733.11	Pathologic fracture of humerus
812.xx	Humerus, open and closed
818.x	Ill-defined fracture of upper limb
819.x	Multiple fracture involving upper limbs, and upper limb with rib(s) and sternum
24500–24587 (CPT codes)	Humerus fracture

24620–24635, Elbow fracture
 24650–
 24685 (CPT
 codes)

Lower leg

733.15 Pathologic fracture of other unspecified part of femur
 733.16 Pathologic fracture of tibia and fibula
 733.93 Stress fracture of tibia or fibula
 823.xx Tibia and fibula, open and closed fractures.
 827.x Other, multiple, and ill-defined fracture of lower limb,
 open and closed
 828.x Multiple fractures involving both lower limbs, lower with
 upper limb, and lower limbs with rib and sternum, open
 and closed
 27750–27792 Tibia, fibula fractures
 (CPT codes)

Pelvis

808.x Pelvis fracture
 27193–27218 Pelvis fracture
 (CPT codes)

Ribs

807.0x Rib fracture, closed
 807.1x Rib fracture, open
 21800–21810 Rib fracture, open and closed treatment, with and
 (CPT codes) without internal fixation

Ankle

824.x Ankle, open and closed

27808–27832 Ankle joint fracture
(CPT codes)

Foot

733.94 Stress fracture of the metatarsal
825.xx ≥1 tarsal and metatarsal bones
826.x ≥1 phalanges of the foot

28400–28531 Foot and toe fracture
(CPT codes)

Vertebral

733.13 Pathologic fracture of vertebrae
805.xx Vertebral column without mention of spinal cord injury
806.xx Vertebral column with spinal cord injury
22305–22328 Vertebral fracture
(CPT codes)

Hip replacement

27125 (CPT code) Hemiarthroplasty, hip, partial
27130 (CPT code) Arthroplasty, acetabular and proximal femoral prosthetic replacement
27236 (CPT code) Open treatment of femoral fracture, proximal end, neck; internal fixation or prosthetic replacement

Aseptic necrosis of bone

733.4x Aseptic necrosis of bone

Cataract

366.xx Cataracts

E932.0	Adrenal cortical steroids; drugs, medicinal and biological substances causing adverse effects in therapeutic use
66982 (CPT code)	Extracapsular cataract removal with insertion of intraocular lens
66983 (CPT code)	Intracapsular cataract extraction with insertion of intraocular lens
66984 (CPT code)	Extracapsular cataract removal with insertion of intraocular lens
Ulcer disease	
531.0x	Gastric ulcer, acute with hemorrhage, with and without obstruction
531.1x	Gastric ulcer, acute with perforation, with and without obstruction
531.2x	Gastric ulcer, acute with hemorrhage and perforation, with and without obstruction
531.4x	Gastric ulcer, chronic or unspecified with hemorrhage, with and without obstruction
531.5x	Gastric ulcer, chronic or unspecified with perforation, with and without obstruction
531.6x	Gastric ulcer, chronic or unspecified with hemorrhage and perforation, with and without obstruction
532.0x	Duodenal ulcer, acute with hemorrhage, with and without obstruction
532.1x	Duodenal ulcer, acute with perforation, with and without obstruction
532.2x	Duodenal ulcer, acute with hemorrhage and perforation, with and without obstruction

532.4x	Duodenal ulcer, chronic or unspecified with hemorrhage, with and without obstruction
532.5x	Duodenal ulcer, chronic or unspecified with perforation, with and without obstruction
532.6x	Duodenal ulcer, chronic or unspecified with hemorrhage and perforation, with and without obstruction
533.0x	Peptic ulcer, acute with hemorrhage, with and without obstruction
533.1x	Peptic ulcer, acute with perforation, with and without obstruction
533.2x	Peptic ulcer, acute with hemorrhage and perforation, with and without obstruction
533.4x	Peptic ulcer, chronic or unspecified with hemorrhage, with and without obstruction
533.5x	Peptic ulcer, chronic or unspecified with perforation, with and without obstruction
533.6x	Peptic ulcer, chronic or unspecified with hemorrhage and perforation, with and without obstruction
534.0x	Gastrojejunal ulcer, acute with hemorrhage, with and without obstruction
534.1x	Gastrojejunal ulcer, acute with perforation, with and without obstruction
534.2x	Gastrojejunal ulcer, acute with hemorrhage and perforation, with and without obstruction
534.4x	Gastrojejunal ulcer, chronic or unspecified with hemorrhage, with and without obstruction
534.5x	Gastrojejunal ulcer, chronic or unspecified with perforation, with and without obstruction

534.6x	Gastrojejunal ulcer, chronic or unspecified with hemorrhage and perforation, with and without obstruction
Pneumonia	
480.x	Viral pneumonia
481	Pneumococcal pneumonia (<i>Streptococcus pneumoniae</i> pneumonia)
482.xx	Other bacterial pneumonia
483.x	Pneumonia due to other specified organism
484.x	Pneumonia in infectious disease classified elsewhere
485	Bronchopneumonia, organism unspecified
486	Pneumonia, organism unspecified
487.0	Influenza with pneumonia
Opportunistic infections	
112.4, 112.5, 112.81, 112.83, 112.84, 112.85	Severe candidiasis: candidiasis of lung, disseminated candidiasis, candidal endocarditis, candidal meningitis, candidal esophagitis, candidal enteritis
114.x	Coccidioidomycosis
117.5, 321.0	Cryptococcosis, cryptococcal meningitis
007.4	Cryptosporidiosis chronic intestinal (need 2 claims >1 month apart)
078.5, 484.1	Cytomegaloviral disease, pneumonia in cytomegalic inclusion disease
054.3, 054.5, 054.71, 054.72, 054.74	Severe herpes simplex: herpetic meningoencephalitis, herpetic septicemia, visceral herpes simplex, herpes simplex meningitis, herpes simplex myelitis

053.0, 053.10, 053.14, 053.2x, 053.79, 053.8	Disseminated herpes zoster: herpes zoster with meningitis, herpes zoster with unspecified nervous system complication, herpes zoster myelitis, herpes zoster with ophthalmic complications, herpes zoster with other specified complications (excluding otitis externa), herpes zoster with unspecified complication
115.xx	Histoplasmosis
007.2, 136.8	Microsporidia or <i>Isospora</i> : coccidiosis (infection by <i>Isospora belli</i> and <i>Isospora hominis</i> ; isosporiasis), other specified infectious and parasitic diseases (<i>Candida</i> infestation)
516.8	Lymphoid interstitial pneumonia/hyperplasia complex
031.2	Disseminated <i>Mycobacterium avium</i>
010.xx–018.xx	Tuberculosis, pulmonary or extrapulmonary
031.0, 031.1, 031.8, 031.9	All other mycobacteria infections: pulmonary, cutaneous, other specified, unspecified
136.3	<i>Pneumocystis carinii/jiroveci</i>
046.3	Progressive multifocal encephalopathy
003.xx	Recurrent salmonellosis (need 2 claims >2 months apart)
130.0	Toxoplasmosis of the brain
484.6, 117.3, 117.7	Aspergillosis and zygomycosis (mucormycosis): pneumonia in aspergillosis, zygomycosis
088.0	Bartonellosis
114.x	Coccidioidomycosis
176.x	Kaposi's sarcoma
Obesity	
278.0x	Overweight and obesity

Hypertension

362.11	Hypertensive retinopathy
401.x	Essential hypertension
402.xx	Hypertensive heart disease
403.xx	Hypertensive chronic kidney disease
404.xx	Hypertensive heart and chronic kidney disease
405.xx	Secondary hypertension

Diabetes/abnormal glucose

249.xx	Secondary diabetes mellitus
250.xx	Diabetes mellitus
357.2	Polyneuropathy in diabetes
362.0x	Diabetic retinopathy
366.41	Diabetic cataract
790.2x	Abnormal glucose
996.57	Mechanical complication due to insulin pump
V45.85	Insulin pump status
V53.91	Fitting and adjustment of insulin pump
V58.67	Long-term (current) use of insulin

Lipid disorders

272.0	Pure hypercholesterolemia
272.1	Pure hyperglyceridemia
272.2	Mixed hyperlipidemia
272.3	Hyperchylomicronemia
272.4	Other and unspecified hyperlipidemia
272.8	Other disorders of lipid metabolism
272.9	Unspecified disorder of lipid metabolism

Glaucoma

365.1x–365.9

Glaucoma

Abbreviations: CPT, Current Procedural Terminology; ICD-9-CM, *International Classification of Diseases, Ninth Revision, Clinical Modification*.

Table S3 High OCS use: regression model results for overall annualized number of office visits

Parameter	Estimate (SE)	P value ^a
With vs without possible side effect	3.5 (0.7)	<0.001
Age (years)		
18–34 vs ≥65	1.3 (1.2)	0.295
35–44 vs ≥65	2.9 (0.9)	0.002
45–54 vs ≥65	1.6 (0.8)	0.044
55–64 vs ≥65	1.7 (0.7)	0.021
Female vs male	3.5 (0.5)	<0.001
Region		
Midwest vs West	–2.5 (0.8)	0.002
Northeast vs West	0.1 (1.0)	0.882
South vs West	–0.8 (0.7)	0.305
Charlson Comorbidity Index score	1.5 (0.1)	<0.001
COPD vs no COPD	0.6 (0.5)	0.284

Note: ^at test.

Abbreviations: COPD, chronic obstructive pulmonary disease; OCS, oral corticosteroid; SE, standard error.

Table S4 High OCS use: negative binomial model results for overall annualized emergency department visits

Parameter	Estimate (SE)	P value ^a
With vs without possible side effect	1.10 (0.18)	0.549
Age (years)		
18–34 vs ≥65	2.96 (0.83)	<0.001
35–44 vs ≥65	3.05 (0.67)	<0.001
45–54 vs ≥65	2.60 (0.48)	<0.001
55–64 vs ≥65	2.13 (0.38)	<0.001
Female vs male	1.43 (0.18)	0.004
Region		
Midwest vs West	1.32 (0.25)	0.133
Northeast vs West	1.15 (0.25)	0.504
South vs West	1.25 (0.21)	0.181
Charlson Comorbidity Index score	1.07 (0.02)	0.001
COPD vs no COPD	0.78 (0.10)	0.040

Note: ^aWald χ^2 test.

Abbreviations: COPD, chronic obstructive pulmonary disease; OCS, oral corticosteroid; SE, standard error.

Table S5 High OCS use: negative binomial model results for overall annualized inpatient hospitalizations

Parameter	Estimate (SE)	P value ^a
With vs without possible side effect	1.98 (0.21)	<0.001
Age (years)		
18–34 vs ≥65	2.66 (0.30)	<0.001
35–44 vs ≥65	1.75 (0.16)	<0.001
45–54 vs ≥65	1.49 (0.11)	<0.001
55–64 vs ≥65	1.33 (0.09)	<0.001
Female vs male	1.14 (0.06)	0.012
Region		
Midwest vs West	1.30 (0.10)	0.001
Northeast vs West	1.07 (0.10)	0.453
South vs West	1.03 (0.08)	0.738
Charlson Comorbidity Index score	1.17 (0.01)	<0.001
COPD vs no COPD	2.46 (0.14)	<0.001

Note: ^aWald χ^2 test.

Abbreviations: COPD, chronic obstructive pulmonary disease; OCS, oral corticosteroid; SE, standard error.

Table S6 High OCS use: regression model results for overall annualized number of asthma-related office visits

Parameter	Estimate (SE)	P value ^a
With vs without possible side effect	0.3 (0.2)	0.205
Age (years)		
18–34 vs ≥65	0.6 (0.4)	0.133
35–44 vs ≥65	1.5 (0.3)	<0.001
45–54 vs ≥65	1.1 (0.3)	<0.001
55–64 vs ≥65	0.8 (0.2)	<0.001
Female vs male	0.0 (0.2)	0.973
Region		
Midwest vs West	–0.6 (0.3)	0.022
Northeast vs West	0.1 (0.3)	0.827
South vs West	–0.1 (0.2)	0.714
Charlson Comorbidity Index score	–0.2 (0.0)	<0.001
COPD vs no COPD	0.3 (0.2)	0.096

Note: ^a*t* test.

Abbreviations: COPD, chronic obstructive pulmonary disease; OCS, oral corticosteroid; SE, standard error.

Table S7 High OCS use: negative binomial model results for asthma-related annualized emergency department visits

Parameter	Estimate (SE)	P value ^a
With vs without possible side effect	1.38 (0.65)	0.451
Age (years)		
18–34 vs ≥65	52.77 (47.67)	<0.001
35–44 vs ≥65	8.12 (5.80)	<0.001
45–54 vs ≥65	4.02 (2.47)	0.007
55–64 vs ≥65	1.08 (0.70)	0.882
Female vs male	1.02 (0.35)	0.943
Region		
Midwest vs West	13.10 (13.83)	<0.001
Northeast vs West	2.62 (3.50)	0.264
South vs West	5.90 (6.16)	0.018
Charlson Comorbidity Index score	1.11 (0.07)	0.104
COPD vs no COPD	3.64 (1.37)	<0.001

Note: ^aWald χ^2 test.

Abbreviations: COPD, chronic obstructive pulmonary disease; OCS, oral corticosteroid; SE, standard error.

Table S8 High OCS use: negative binomial model results for asthma-related annualized inpatient hospitalizations

Parameter	Estimate (SE)	P value ^a
With vs without possible side effect	2.26 (0.50)	<0.001
Age (years)		
18–34 vs ≥65	7.47 (1.95)	<0.001
35–44 vs ≥65	4.25 (0.95)	<0.001
45–54 vs ≥65	3.24 (0.63)	<0.001
55–64 vs ≥65	1.96 (0.38)	<0.001
Female vs male	1.47 (0.19)	0.002
Region		
Midwest vs West	1.51 (0.30)	0.031
Northeast vs West	1.51 (0.33)	0.057
South vs West	1.06 (0.20)	0.760
Charlson Comorbidity Index score	1.01 (0.02)	0.615
COPD vs no COPD	5.27 (0.72)	<0.001

Note: ^aWald χ^2 test.

Abbreviations: COPD, chronic obstructive pulmonary disease; OCS, oral corticosteroid; SE, standard error.

Table S9 High OCS use: regression model results for overall annualized^a costs

Parameter	Estimate (SE)	P value^b
With vs without possible side effect	\$3,285 (\$1,264)	0.009
Age (years)		
18–34 vs ≥65	\$11,830 (\$2102)	<0.001
35–44 vs ≥65	\$9769 (\$1659)	<0.001
45–54 vs ≥65	\$10,471 (\$1375)	<0.001
55–64 vs ≥65	\$9615 (\$1308)	<0.001
Female vs male	\$1020 (\$935)	0.275
Region		
Midwest vs West	–\$1780 (\$1412)	0.208
Northeast vs West	–\$3076 (\$1676)	0.067
South vs West	–\$1878 (\$1292)	0.146
Charlson Comorbidity Index score	\$4720 (\$176)	<0.001
COPD vs no COPD	\$4107 (\$954)	<0.001

Notes: ^aAnnualized costs using total costs from years 1 and 2. ^b*t* test.

Abbreviations: COPD, chronic obstructive pulmonary disease; OCS, oral corticosteroid; SE, standard error.

Table S10 High OCS use: regression model results for total annualized^a asthma-related costs

Parameter	Estimate (SE)	P value ^b
With vs without possible side effect	\$261 (\$298)	0.382
Age (years)		
18–34 vs ≥65	\$146 (\$496)	0.769
35–44 vs ≥65	\$480 (\$391)	0.220
45–54 vs ≥65	\$302 (\$324)	0.352
55–64 vs ≥65	\$530 (\$308)	0.086
Female vs male	–\$367 (\$220)	0.096
Region		
Midwest vs West	–\$191 (\$333)	0.567
Northeast vs West	\$20 (\$395)	0.960
South vs West	–\$210 (\$305)	0.491
Charlson Comorbidity Index score	–\$234 (\$42)	<0.001
COPD vs no COPD	\$1,175 (\$225)	<0.001

Notes: ^aAnnualized costs using total costs from years 1 and 2. ^b*t* test.

Abbreviations: COPD, chronic obstructive pulmonary disease; OCS, oral corticosteroid; SE, standard error.