

## Supplementary Online Content

Romano MJ, Segal JB, Pollack CE. The association between continuity of care and the overuse of medical procedures [published online May 18, 2015]. *JAMA Intern Med*. doi:10.1001/jamainternmed.2015.1340.

eFigure 1. Derivation of analysis sample

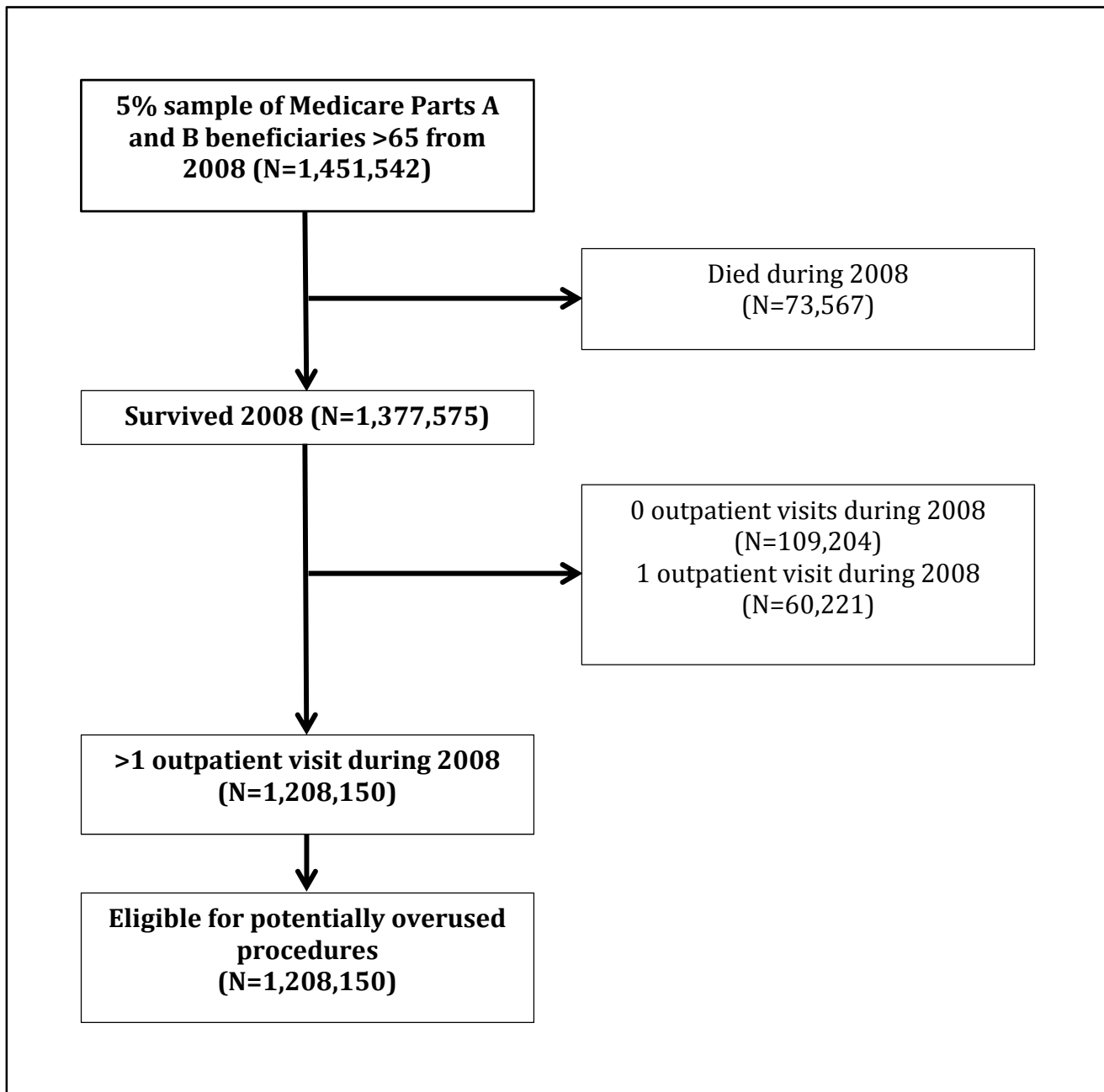
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This supplementary material has been provided by the authors to give readers additional information about their work.



**eFigure 1.** Derivation of analysis sample

Measure	Formula	Concept Represented
Bice-Boxerman Continuity of Care Index (COC)	$\frac{(\sum_{i=1}^p n_i^2) - n}{n(n-1)}$	Degree of coordination required between different providers during an episode
Usual Provider of Care (UPC)	$\max\left(\frac{n_i}{n}\right)$	Concentration of care with a primary provider
Sequential Continuity Index (SECON)	$\frac{\sum_{j=1}^{n-1} c_j}{n-1}$	Number of handoffs of information required between providers

**eFigure 2.** Formulae for calculating continuity metrics<sup>1</sup>

**Legend:**  $p$  = total number of providers;  $n$  = total number of visits during episode;  $n_i$  = number of visits to provider  $i$ ;  $c_j$  = indicator of sequential visits to same providers, equal to 1 if visits  $j$  and  $j+1$  are to the same provider, 0 otherwise.

<sup>1</sup> Pollack CE, Hussey PS, Rudin RS, Fox DS, Lai J, Schneider EC. Measuring Care Continuity: A Comparison of Claims-based Methods. *Med Care*. 2013. [Epub ahead of print].

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**eTable 1.** Definitions of potentially overused procedures

<b>Procedure</b>	<b>Numerator Indications</b>	<b>Denominator Indications</b>
<b>Diagnostic Tests</b>		
Fiberoptic laryngoscopy for patients with a diagnosis of sinusitis	Laryngoscopy with ICD-9 code indicating sinusitis on the same claim	Individuals with a diagnosis of sinusitis (acute or chronic)
Nasal endoscopy for sinusitis diagnosis	Nasal endoscopy with ICD-9 code indicating sinusitis on the same claim	Individual with a diagnosis of sinusitis (acute or chronic)
EEG monitoring in individuals presenting with syncope	EEG on the same claim as diagnosis of syncope or at any time during the hospitalization with a code for syncope	Individuals with an outpatient visit with diagnosis of syncope or hospitalization for syncope
MRI in individuals with traumatic brain injury	MRI on the same claim as diagnosis of mild traumatic brain injury if outpatient or during hospitalization if inpatient within first 2 days	Individuals with traumatic brain injury
Stress echocardiography for detection of coronary artery disease/risk assessment in symptomatic or ischemic equivalent acute chest pain (i.e. Acute Coronary Syndrome)	Individuals with stress echocardiography associated with an emergency room visit or hospitalization	Individuals with a code for emergency visit or hospitalization with any of the symptomatic or ischemic equivalent acute chest pain primary or secondary diagnoses
Sinus CT or indiscriminate antibiotics for uncomplicated acute rhinosinusitis	Any occurrence of sinus CT in the 3 months preceding the diagnosis of acute sinusitis	Individuals with acute sinusitis without a diagnosis of acute or chronic sinusitis in the prior 3 months
Unproven diagnostic tests, such as immunoglobulin G (IgG) testing or an indiscriminate battery of Immunoglobulin E (IgE) tests, in the evaluation of allergy	Use of unproven tests on the same claim as a code for diagnoses in the denominator column	Individuals with allergic rhinitis, asthma, or other allergies
Tumor marker studies in asymptomatic women with previously treated breast cancer	CEA, CA 15-3 (CA 27.29) testing	Individuals with previously treated breast cancer
Abdomen CT with and without contrast material	The number of abdomen CT studies with and without contrast ("combined studies")	Individuals with abdomen CT studies performed (with contrast, without contrast, or both with and without contrast) excluding neoplastic or genitourinary diagnoses
MRI lumbar spine for low back pain	MRI of the lumbar spine studies with a diagnosis of low back pain (from the denominator) without the patient having claims-based evidence of prior antecedent conservative therapy	Individuals with MRI of the lumbar spine with a diagnosis of low back pain on the imaging claim and no intra-spinal abscess
PET, CT, and radionuclide bone scans in individuals with low-risk prostate cancer	PE, CT, or radionuclide bone scan after diagnosis of prostate cancer	Men with low-risk prostate cancer excluding intermediate/high risk of recurrence
Preoperative chest radiography in the absence of a clinical suspicion for	Chest radiography in a 30-day window before the anesthesia code.	Individuals who had anesthesia with exclusion of intra-thoracic concerns

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intra-thoracic pathology		
Thorax CT with and without contrast material	The number of thorax CT studies with and without contrast ("combined studies")	All individuals with thorax CT studies (with contrast, without contrast, or both with and without contrast)
<b>Therapeutic Procedures</b>		
Laminectomy and/or spinal fusion	Laminectomy or spinal fusion	All individuals minus those with a clear indication of herniated disc (i.e. radicular symptoms)
Hysterectomy for benign disease	Any hysterectomy not specified for malignancy treatment	All women minus those with a malignancy diagnosis
Traction for low back pain	Traction with diagnosis of low back pain	Individuals with low back pain diagnosis
<b>Screening Tests</b>		
Screening for asymptomatic carotid artery stenosis (CAS) in the general adult population	CAS screening in outpatient setting (not emergency room)	Individuals with no symptoms of CAS
Serological tests for helicobacter (H.) pylori	Any code indicating testing for H. pylori	Whole population
<b>Monitoring Tests</b>		
Routine monitoring of digoxin in patients with congestive heart failure	Any measure of digoxin with no hospitalizations or ER visits during that year	Individuals with CHF and/or atrial fibrillation

**Legend:** Computed Tomography, CT; Electro-encephalography, EEG; Magnetic Resonance Imaging, MRI; Positron Emission Tomography, PET

**eTable 2.** Examples of Continuity of Care (COC) Indices for Patients with 13 Total Visits

No. of Visits	No. of Doctors	Visits to Dr. A	Visits to Dr. B	Visits to Dr. C	Visits to Dr. D	Visits to Dr. E	Visits to Dr. F	Visits to Dr. G	Visits to Dr. H	Visits to Dr. I	Visits to Dr. J	Visits to Dr. K	Visits to Dr. L	Visits to Dr. M	COC Index
13	1	13													1
13	2	12	1												0.85
13	2	11	2												0.72
13	3	11	1	1											0.71
13	2	10	3												0.62
13	3	10	2	1											0.59
13	4	10	1	1	1										0.58
13	2	9	4												0.54
13	3	9	3	1											0.50
13	2	8	5												0.49
13	3	9	2	2											0.49
13	4	9	2	1	1										0.47
13	2	7	6												0.46
13	5	9	1	1	1	1									0.46
13	3	8	4	1											0.44
13	3	8	3	2											0.41
13	4	8	3	1	1										0.40



13	5	5	4	2	1	1												0.22
13	4	5	3	3	2													0.22
13	7	6	2	1	1	1	1	1										0.21
13	6	5	4	1	1	1	1											0.21
13	5	5	3	3	1	1												0.21
13	4	4	4	3	2													0.21
13	8	6	1	1	1	1	1	1	1									0.19
13	5	5	3	2	2	1												0.19
13	5	4	4	3	1	1												0.19
13	4	4	3	3	3													0.19
13	6	5	3	2	1	1	1											0.18
13	5	5	2	2	2	2												0.18
13	5	4	4	2	2	1												0.18
13	7	5	3	1	1	1	1	1										0.17
13	6	5	2	2	2	1	1											0.17
13	6	4	4	2	1	1	1											0.17
13	5	4	3	3	2	1												0.17
13	7	5	2	2	1	1	1	1										0.15
13	7	4	4	1	1	1	1	1										0.15
13	6	4	3	3	1	1	1											0.15
13	5	4	3	2	2	2												0.15
13	5	3	3	3	3	1												0.15
13	8	5	2	1	1	1	1	1	1									0.14
13	6	4	3	2	2	1	1											0.14
13	5	3	3	3	2	2												0.14
13	9	5	1	1	1	1	1	1	1	1								0.13
13	7	4	3	2	1	1	1	1										0.13

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13	6	4	2	2	2	2	1										0.13
13	6	3	3	3	2	1	1										0.13
13	8	4	3	1	1	1	1	1	1								0.12
13	7	4	2	2	2	1	1	1									0.12
13	7	3	3	3	1	1	1	1									0.12
13	6	3	3	2	2	2	1										0.12
13	8	4	2	2	1	1	1	1	1								0.10
13	7	3	3	2	2	1	1	1									0.10
13	6	3	2	2	2	2	2										0.10
13	9	4	2	1	1	1	1	1	1	1							0.09
13	8	3	3	2	1	1	1	1	1	1							0.09
13	7	3	2	2	2	2	1	1									0.09
13	10	4	1	1	1	1	1	1	1	1	1						0.08
13	9	3	3	1	1	1	1	1	1	1	1						0.08
13	8	3	2	2	2	1	1	1	1								0.08
13	7	2	2	2	2	2	2	1									0.08
13	9	3	2	2	1	1	1	1	1	1	1						0.06
13	8	2	2	2	2	2	1	1	1								0.06
13	10	3	2	1	1	1	1	1	1	1	1	1					0.05
13	9	2	2	2	2	1	1	1	1	1	1						0.05
13	11	3	1	1	1	1	1	1	1	1	1	1	1				0.04
13	10	2	2	2	1	1	1	1	1	1	1	1					0.04
13	11	2	2	1	1	1	1	1	1	1	1	1	1				0.03
13	12	2	1	1	1	1	1	1	1	1	1	1	1	1			0.01
13	13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.00

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**eTable 3:** Comparison of continuity metrics COC, UPC, and SECON for associations with overuse

Procedure	Adjusted Odds Ratio for COC (95%CI*)	Adjusted Odds Ratio for UPC (95%CI*)	Adjusted Odds Ratio for SECON (95%CI*)	Adjusted odds ratio for COC in preceding 6 months (95% CI)**	Adjusted odds ratio with Primary Care Provider as covariate (95% CI*)
<b>Diagnostic Tests</b>					
Laryngoscopy for sinusitis	0.84 (0.80; 0.88)*	0.82 (0.80; 0.85)*	0.91 (0.89; 0.94)*	0.95 (0.90; 1.00)*	0.84 (0.80; 0.88)*
Nasal endoscopy for sinusitis	0.84 (0.82; 0.87)*	0.84 (0.83; 0.85)*	0.90 (0.89; 0.91)*	0.96 (0.93; 0.98)*	0.84 (0.82; 0.86)*
Electroencephalogram in syncope	0.88 (0.86; 0.91)*	0.90 (0.89; 0.92)*	0.96 (0.94; 0.97)*	1.02 (0.99; 1.04)	0.88 (0.86; 0.90)*
Stress echocardiography for acute chest pain	0.94 (0.90; 0.99)*	0.95 (0.92; 0.98)*	0.95 (0.93; 0.98)*	1.00 (0.94; 1.05)	0.94 (0.90; 0.99)*
MRI in mild traumatic brain injury	0.94 (0.90; 0.99)*	0.95 (0.92; 0.98)*	0.97 (0.95; 1.00)	1.02 (0.97; 1.07)	0.94 (0.90; 0.99)*
Sinus CT or antibiotics for rhinosinusitis	0.96 (0.92; 1.01)	0.97 (0.95; 1.00)	0.99 (0.97; 1.02)	1.00 (0.96; 1.06)	0.96 (0.92; 1.00)
Unproven allergy tests	0.97 (0.94; 1.00)	0.94 (0.92; 0.96)*	1.01 (0.99; 1.03)	0.99 (0.95; 1.02)	0.97 (0.94; 1.00)
Tumor marker studies in asymptomatic breast cancer	0.99 (0.97; 1.00)	0.95 (0.94; 0.96)*	0.97 (0.96; 0.98)*	1.00 (0.99; 1.02)	0.98 (0.97; 1.00)
Abdomen CT with and without contrast	0.99 (0.98; 1.00)*	0.97 (0.97; 0.98)*	1.00 (0.99; 1.00)	0.99 (0.98; 1.00)	0.99 (0.98; 1.00)*
MRI lumbar spine for low back pain	1.00 (0.98; 1.01)	1.05 (1.03; 1.06)*	1.00 (0.99; 1.01)	1.00 (0.98; 1.02)	0.99 (0.98; 1.01)
Advanced imaging in low-risk prostate cancer	1.00 (0.98; 1.02)	0.96 (0.95; 0.97)*	1.05 (1.04; 1.06)*	1.05 (1.03; 1.07)*	1.00 (0.98; 1.01)
Preoperative chest radiograph	1.01 (1.00; 1.02)	1.00 (0.99; 1.00)	1.04 (1.04; 1.05)*	1.04 (1.04; 1.05)*	1.01 (1.00; 1.02)
Thorax CT with and without contrast	1.06 (1.05; 1.08)*	1.06 (1.05; 1.07)*	1.06 (1.05; 1.07)*	1.04 (1.02; 1.06)*	1.06 (1.04; 1.08)*
<b>Therapeutic Procedures</b>					
Laminectomy and/or spinal fusion	0.81 (0.78; 0.85)*	0.82 (0.80; 0.84)*	0.91 (0.89; 0.93)*	0.93 (0.89; 0.97)*	0.81 (0.78; 0.84)*
Hysterectomy for benign disease	0.86 (0.82; 0.89)*	0.86 (0.83; 0.88)*	0.91 (0.89; 0.93)*	0.95 (0.91; 1.00)	0.86 (0.82; 0.89)*
Traction for low back pain	0.87 (0.86; 0.88)*	0.85 (0.85; 0.86)*	0.92 (0.92; 0.93)*	0.95 (0.94; 0.95)*	0.87 (0.86; 0.88)*
<b>Screening Tests</b>					
Carotid artery stenosis screening	0.99 (0.98; 1.00)	0.97 (0.96; 0.97)*	1.00 (1.00; 1.01)	1.01 (1.00; 1.03)*	0.99 (0.98; 1.00)
Serological tests for H. pylori	1.05 (1.04; 1.06)*	1.05 (1.04; 1.06)*	1.05 (1.03; 1.06)*	1.04 (1.03; 1.06)*	1.05 (1.04; 1.06)*
<b>Monitoring Test</b>					
Routine monitoring of digoxin	1.03 (1.02; 1.04)*	1.02 (1.02; 1.03)*	1.00 (0.99; 1.01)	1.03 (1.01; 1.04)*	1.03 (1.02; 1.04)*
<b>Any Overused Procedure</b>	0.93 (0.93; 0.94)*	0.90 (0.90; 0.90)*	0.97 (0.97; 0.97)*	0.99 (0.99; 1.00)*	0.93 (0.93; 0.94)

\* Confidence intervals are adjusted for 19 multiple comparisons based on Holm-Bonferroni correction with overall alpha=0.05 for each overused procedure.

Confidence interval for "Any Overused Procedure" is not adjusted for multiple comparisons because it is a summative measure.

\*\* Adjusted odds ratio for overuse occurring during July to December 2008 based on continuity calculated using visits from January to June 2008

**Legend:** Bice-Boxerman Continuity of Care index, COC; Computed Tomography, CT; Magnetic Resonance Imaging, MRI; SEquential CONTinuity index, SECON; Usual Provider of Care index, UPC