

Supplementary Online Content

Ganguli I, Lupo C, Mainor AJ, et al. Prevalence and cost of care cascades after low-value preoperative electrocardiogram for cataract surgery in fee-for-service Medicare beneficiaries. *JAMA Intern Med*. Published online June 3, 2019. doi:10.1001/jamainternmed.2019.1739

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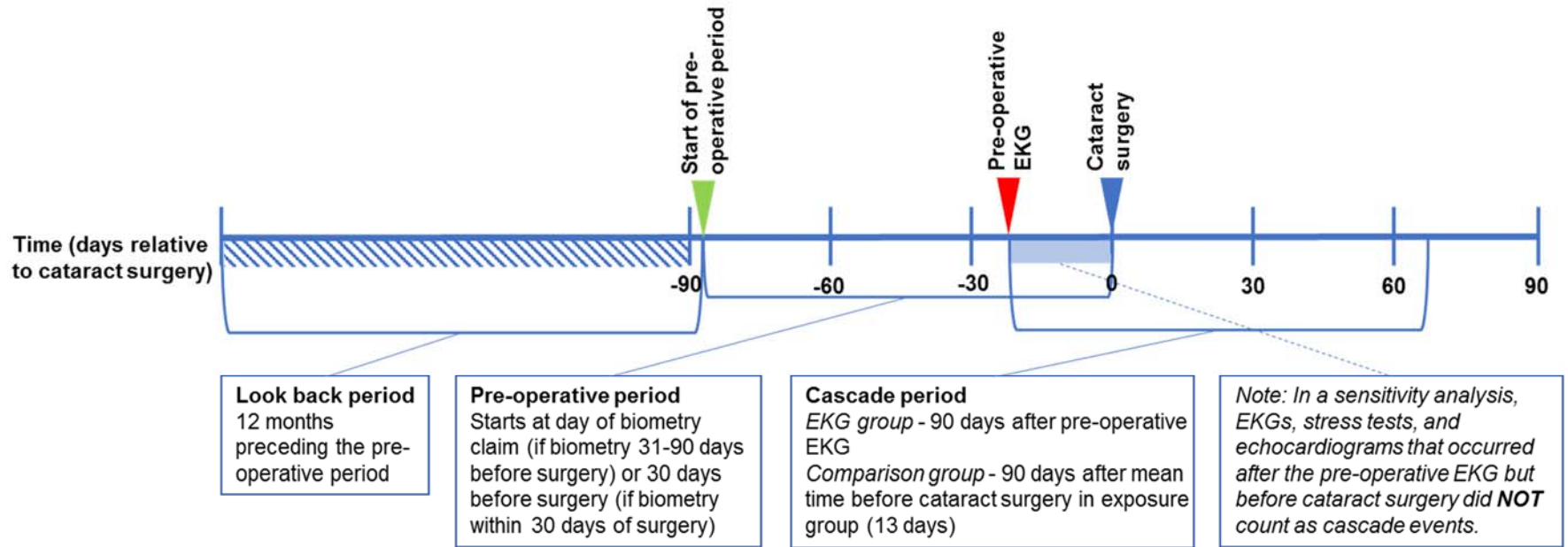
This supplementary material has been provided by the authors to give readers additional information about their work.

eAppendix 1. Relevant Choosing Wisely recommendations

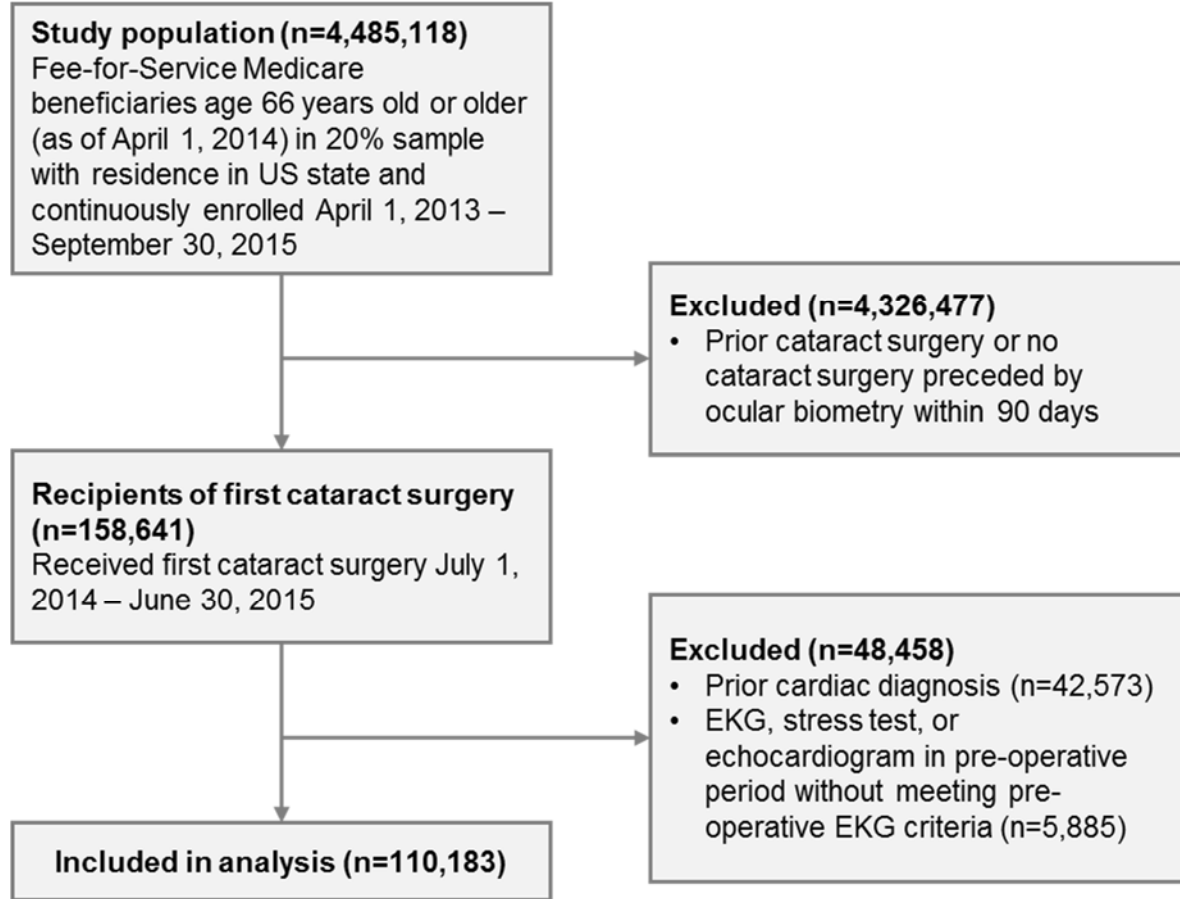
A. American Academy of Ophthalmology: Don't perform preoperative medical tests for eye surgery unless there are specific medical indications. For many, preoperative tests are not necessary because eye surgeries are not lengthy and don't pose serious risks. An EKG should be ordered if patients have heart disease. A blood glucose test should be ordered if patients have diabetes. A potassium test should be ordered if patients are on diuretics. In general, patients scheduled for surgery do not need medical tests unless the history or physical examination indicate the need for a test, e.g., the existence of conditions noted above. Institutional policies should consider these issues.¹

B. American Society for Clinical Pathology: Avoid routine preoperative testing for low risk surgeries without a clinical indication. Most preoperative tests (typically a complete blood count, Prothrombin Time and Partial Prothomboplastin Time, basic metabolic panel and urinalysis) performed on elective surgical patients are normal. Findings influence management in under 3% of patients tested. In almost all cases, no adverse outcomes are observed when clinically stable patients undergo elective surgery, irrespective of whether an abnormal test is identified. Preoperative testing is appropriate in symptomatic patients and those with risks factors for which diagnostic testing can provide clarification of patient surgical risk.²

eFigure 1. Study timeline



eFigure 2. Study Cohort Flow Diagram



Definition of cataract surgery - Code for “cataract surgery” (Current Procedural Terminology (CPT) codes: 66982-4) with ophthalmology or ambulatory surgical center specialty code ((Centers for Medicare & Medicaid Services (CMS) specialty codes 18, 48; accounted for 93% of all cataract surgeries) and absence of “prior cataract surgery” code (International Classification of Disease (ICD-9) codes: V43.1, V45.61, 379.31). Definition based on previous literature³ as well as empirical analysis and clinical review with an ophthalmology billing specialist and ophthalmologist.

Definition of ocular biometry - CPT codes: 76516, 76519, 92136

Definition of prior cataract surgery - Claim for “prior cataract surgery” (ICD-9 codes: V43.1, V45.61, 379.31) or claim for any “cataract surgery” (CPT codes: 66982-4, 66830, 66840, 66850, 66852, 66920, 66930, 66940, 66983-6 with ophthalmology or ambulatory surgical center specialty code) in 12 months preceding index cataract surgery.

Definition of prior cardiac diagnosis - Any diagnosis code in Appendix Table 1 that appeared in one inpatient claim or in two outpatient claims within the 12 months before the start of the preoperative period.

eTable 1. Cardiac diagnoses

Diagnosis	ICD-9 Codes*
Coronary artery disease	410, 410.0-1, 410.00-2, 410.10-2, 410.20-2, 410.30-2, 410.40-2, 410.50-2, 410.60-2, 410.70-2, 410.80-2, 410.90-2, 411.0-1, 411.81, 411.89, 412, 413.0-1, 413.9, 414.00-7, 414.10-2, 414.19, 414.2-4, 414.8-9
Heart failure	398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.0-1, 428.9, 428.20-3, 428.30-3, 428.40-3
Valvular disease	394.0-2, 394.9, 395.0-2, 395.9, 396.0-3, 396.8-9, 397.0-1, 397.9, 421.2, 424.0-3
Arrhythmia	426.0, 426.2-7, 426.10-13, 426.50-4, 426.81-2, 426.89, 426.9, 427.0-2, 427.9, 427.31-2, 427.41-2, 427.60-1, 427.69, 427.81, 427.89

*Based on diagnoses in Medicare Chronic Conditions Data Warehouse

Pre-operative electrocardiogram (EKG) definition

Definition of pre-operative EKG - EKG (CPT codes: 93000, 93005, 93010, 93040-2, G0403-5) with pre-operative (ICD-9 codes: V7281-4, V7263) or cataract-related diagnosis code (ICD-9 codes: 366.00, 366.04, 366.10, 366.13, 366.15-7, 366.19, 366.30, 366.34, 366.8, 366.9) and no excluding diagnoses (eTable 2).

eTable 2. Excluding diagnoses for pre-operative EKG

Diagnosis	ICD-9 Codes
Chest pain	786.50-2, 786.59
Dyspnea	786.00-7, 786.09
Bradycardia	427.89
Congestive heart failure	428.0
Hypotension	458.9
Lower extremity edema	782.3
Tachycardia	785.0
Palpitations	785.1
Dizziness	780.4
Syncope	780.2
Cardiac ischemia	410-410.92, 427.5
Cardiac pacemaker	V45.01

eAppendix 2. EKG and comparison group definition

Definition of EKG group – Beneficiaries in cohort who received a pre-operative EKG using above definition

Definition of comparison group – Beneficiaries in cohort who did not receive any EKG, stress test, or echocardiogram during the pre-operative period.

Previous studies have defined pre-operative EKG, echocardiogram, and stress tests as any EKG, echocardiogram, or stress test occurring in the 30 days prior to cataract surgery, or between ocular biometry and cataract surgery.³⁻⁶ Because our study focused on cascades of care (including EKGs) following pre-operative EKG, we could not rely on the timing of EKGs to define them as pre-operative. Therefore, we used diagnosis codes of inclusion and exclusion to define pre-operative EKGs. Because these diagnosis codes are specific but not sensitive markers of the clinician's intent, and because prior estimates of pre-operative EKG testing rates have been higher (suggesting many of these ambiguous tests were still intended as pre-operative), we excluded beneficiaries with ambiguous cardiac testing (i.e. those who did not have a pre-operative EKG (using our conservative definition) yet had an EKG, stress test, or echocardiogram in the pre-operative period) in order to create a reasonable comparison group (see Appendix Figure 1).

The EKG group did not similarly exclude beneficiaries who received a stress test or echocardiogram during the pre-operative period (2.4% of EKG group beneficiaries) as these tests may have been part of cascades. However, because cascade period EKGs, stress tests, and echocardiograms could also have been intended as pre-operative tests, we only counted them if they did not have a pre-operative diagnosis. Then in a sensitivity analysis to provide a lower bound on cascade events (i.e. under the assumption that ALL ambiguous tests were intended as pre-operative and therefore not cascades), we did not count any EKGs, stress tests, or echocardiograms as cascade events if they occurred before surgery.

Cascade event definition

eTable 3. Cascade tests

Cascade pathway	Cascade cardiac tests	CPT Codes
Ischemic heart disease	Troponin	84484
	Electrocardiogram (EKG)*	93000, 93005, 93010, 93040-2, G0403-5, G0366-8, 3120F
	Stress test*	93015-8, 93350-1, 93024, 75563
	Coronary computed tomography angiography (CTA)	75571-4
	Coronary ultrasound	92978-9
	Cardiac positron emission tomography (PET)	78459, 78466, 78468-9, 78483, 78491-2, 78499
Structural heart disease	Brain natriuretic peptide (BNP)	83880
	Echocardiogram*	93303-4, 93306-8, 93312-93318, 93320-1, 93325, 93350-2, 93355
	Cardiac magnetic resonance imaging (MRI)	75557, 75559, 75561, 75563, 75565
	Nuclear imaging	78414, 78428, 78451-4, 78472-3, 78481, 78483, 78494, 78496
Arrhythmia	Holter monitor	93224-7
	Event monitor	93228-9, 93232, 93268, 93270-2, 93278
	Implantable loop recorder	33282, 33284, E0616
	Electrophysiology testing	93623 93600, 93602-3, 93609-10, 93612-3, 93615-6, 93618-22, 93624, 93631, 93640-2, 93644, 93650-4, 93656, 93660, 93662
	Pacer evaluation	93279-99

*Event excluded if pre-operative or cataract diagnosis or if occurred prior to cataract surgery

eTable 4. Cascade procedures and treatments

Cascade pathway	Cascade cardiac procedure	CPT Codes
Ischemic heart disease	Coronary repair	33500,33501-5, 33507
	Coronary artery bypass graft surgery	33510-23, 33530, 33533-48, 33572
	Percutaneous coronary angioplasty/cardiac catheterization	92920-1, 92924-5, 92928-33, 92933-4, 92937-8, 92941, 92943-4, 92973, 92975, 92977, 92980-4, 92995-6
Structural heart disease	Valve repair/replacement	33361-33403, 33405-18, 33420-30, 33460-5, 33474-5, 33478, 92986-7, 92990, 92992, 0343T
Arrhythmia	Electrophysiology procedures	33250-66, 92960-1, 92970-1, 93655-7
	Pacemaker procedures	93260-1, 33202-44, 33249, 33262-4, 33270-3, 92953

Cascade visit definitions – Code for new patient visit (CPT codes: 99201-5) or established patient visit (CPT codes: 99211-5) billed by physician with cardiac specialty (Appendix Table 5). Visit for abnormal findings defined by ICD-9 codes 793.2, 794.30-1, 794.39, 796.4. We also examined codes for emergency department visits (99281-5), observation status visits (99218-20, 99224-6, 99234-6), hospital outpatient visits (G0463), and federally qualified health center visits (G0466-9) and found that each of these categories of codes were billed too infrequently to count.

eTable 5. Physician specialty codes

Specialty group	Specialty	Specialty code
Primary care	General practice	01
	Family practice	08
	Internal medicine	11
	Pediatric medicine	37
	Geriatric medicine	38
	Preventive medicine	84
Cardiac specialty	Cardiology	06
	Cardiac electrophysiology	21
	Cardiac surgery	78
	Interventional cardiology	C3
Other	Includes ophthalmology, nurse practitioner, physician assistant	02, 03, 05, 09, 10, 12-3, 18, 25, 29, 30, 33-4, 36, 39, 44, 46, 50, 63, 66, 70, 79, 81, 83, 90, 93, 97-9

Specialty codes used for definition of cardiac specialist visits and for specialty of physician performing the index EKG.

eTable 6. Cascade new diagnoses

Cascade pathway	Cascade new diagnosis type	ICD-9 Codes*
Ischemic heart disease		410, 410.0-1, 410.00-2, 410.10-2, 410.20-2, 410.30-2, 410.40-2, 410.50-2, 410.60-2, 410.70-2, 410.80-2, 410.90-2, 411.0-1, 411.81, 411.89, 412, 413.0-1, 413.9, 414.00-7, 414.10-2, 414.19, 414.2-4, 414.8-9
Structural heart disease	Heart failure	398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.0-1, 428.9, 428.20-3, 428.30-3, 428.40-3
	Valvular disease	394.0-2, 394.9, 395.0-2, 395.9, 396.0-3, 396.8-9, 397.0-1, 397.9, 421.2, 424.0-3
Arrhythmia		426.0, 426.2-7, 426.10-13, 426.50-4, 426.81-2, 426.89, 426.9, 427.0-2, 427.9, 427.31-2, 427.41-2, 427.60-1, 427.69, 427.81, 427.89

*Based on diagnoses in Medicare Chronic Conditions Data Warehouse. New diagnosis defined by diagnosis code on one inpatient claim or two outpatient claims during cascade period.

eTable 7. Cascade hospitalizations

Cascade pathway	Diagnosis-related group (DRG) codes
Ischemic heart disease	410.01, 410.11, 410.21, 410.31, 410.70-2, 410.81, 410.91, 411.1, 413.1, 414.00-1, 440.29
Structural heart disease	426.0, 426.12-3, 427.0-1, 427.31-2, 427.41, 427.69, 427.81, 427.89, 427.9, 785.0
Arrhythmia	396.8, 402.91, 404.01, 420.9-1, 423.0, 423.8-9, 424.1, 425.4, 428.0, 428.21, 428.23, 428.31, 428.33, 428.40-1, 428.43, 429.83

Determined empirically based on clinical review of hospitalizations in study cohort and cardiac diagnoses in Medicare Chronic Conditions Data Warehouse (Appendix Tables 1, 6).

eTable 8. Prior Elixhauser conditions in order of prevalence

Condition	EKG group	Comparison group
Hypertension	38.08%	36.78%
Diabetes	14.98%	14.75%
Hypothyroidism	9.31%	9.04%

eTable 9. Most common potential cascade treatments, new diagnoses, and hospitalization primary diagnoses, rate per 100 beneficiaries during 90 day cascade period

EKG group (N=12,408)			Comparison group (N=97,775)		
<i>Treatments</i>					
Rank	Event	Rate per 100 beneficiaries (number of events)	Rank	Event	Rate per 100 beneficiaries (number of events)
1	PTCA	0.23 (28)	1	PTCA	0.12 (121)
1	CABG	0.23 (28)	2	CABG	0.11 (105)
2	Pacemaker placement	<0.09 (<11)	3	Pacemaker placement	0.08 (79)
3	Electrophysiology	<0.09 (<11)	4	Electrophysiology	0.06 (57)
4	Valve repair	<0.09 (<11)	5	Valve repair	<0.01 (<11)
<i>New diagnoses</i>					
1	Coronary artery disease	3.55 (440)	1	Coronary artery disease	3.20 (3,125)
2	Heart failure/ Cardiomyopathy	0.94 (117)	2	Heart failure/ Cardiomyopathy	1.48 (1,445)
3	Diseases of mitral and aortic valves	0.70 (87)	3	Diseases of mitral and aortic valves	0.52 (506)
4	Conduction disorders	0.21 (26)	4	Conduction disorders	0.11 (109)
5	Diseases of tricuspid valve	<0.09 (<11)	5	Diseases of tricuspid valve	0.06 (58)
<i>Hospitalization primary diagnoses</i>					
1	Subendocardial infarction, initial episode of care	0.11 (14)	1	Atrial fibrillation	0.05 (50)
2	Coronary atherosclerosis of native coronary	<0.09 (<11)	2	Subendocardial infarction, initial episode of care	0.05 (49)
3	Atrial fibrillation	<0.09 (<11)	3	Coronary atherosclerosis of native coronary	0.04 (39)
4	Congestive heart failure	<0.09 (<11)	4	Diastolic heart failure	0.02 (15)
5	Aortic valve disorder	<0.09 (<11)	5	Acute MI inferior wall, initial episode	0.01 (14)

PTCA = Percutaneous transluminal coronary angioplasty; CABG = Coronary artery bypass graft

eTable 10. Cascade-Attributable Event Rates and Spending Following Pre-Operative Electrocardiogram for Cataract Surgery, Including Sensitivity Analysis

Event rate per 100 beneficiaries	EKG group (N=12,408)	Comparison group (N=97,775)	Cascade-attributable event rate	Adjusted cascade-attributable event rate (95%CI) ^a
All events ^b	44.4 (5,506)	37.0 (36,173)	7.4	5.11 ^c (3.96-6.25)
All events	50.4 (6,259)	37.0 (36,173)	13.4	10.92 ^c (9.76-12.08)
All tests ^b	23.4 (2,901)	19.9 (19,488)	3.5	2.18 ^c (1.34-3.02)
All tests	29.5 (3,654)	19.9 (19,488)	9.6	7.98 ^c (7.12-8.84)
All treatments	0.6 (74)	0.4 (368)	0.22	0.33 ^c (0.19-0.46)
<i>Tests and treatments</i>				
Electrocardiogram ^b	11.5 (1,427)	10.7 (10,471)	0.79	-0.19 ^c (-0.79-0.41)
Electrocardiogram	13.7 (1,697)	10.7 (10,471)	3.0	1.81 ^c (1.20-2.42)
Stress test ^b	2.4 (297)	2.0 (1,928)	0.42	0.36 ^c (0.10-0.63)
Stress test	4.1 (503)	2.0 (1,928)	2.1	2.03 ^c (1.74-2.32)
Echocardiogram ^b	4.7 (582)	3.7 (3,625)	0.98	0.75 ^c (0.38-1.11)
Echocardiogram	6.9 (859)	3.7 (3,625)	3.2	2.90 ^c (2.51-3.28)
Myocardial perfusion test	2.1 (259)	1.1 (1,065)	1.0	0.94 ^c (0.73-1.15)
Event/Holter monitor	1.6 (204)	0.9 (916)	0.71	0.68 ^c (0.49-0.88)
Cardiac catheterization	0.2 (28)	0.1 (121)	0.10	0.15 ^c (0.07-0.23)
<i>Visits and hospitalizations</i>				
All cardiac specialist visits	9.6 (1,196)	7.2 (7,060)	2.4	1.27 ^c (0.78-1.76)
New patient cardiac specialist visit	2.7 (336)	1.2 (1,146)	1.5	1.40 ^c (1.18-1.62)
Cardiac specialist visit for abnormal finding	1.0 (122)	0.3 (262)	0.72	0.57 ^c (0.46-0.68)
Cardiac hospitalizations	0.4 (49)	0.3 (284)	0.10	0.15 ^c (0.04-0.26)
<i>Diagnoses</i>				
New cardiac diagnoses	10.4 (1,286)	9.2 (8,973)	1.2	1.21 ^c (0.62-1.79)
<i>Medicare spending per beneficiary</i>				
Allowable charges related to cascade events in 90-day period, \$ mean (SD) ^b	1,778 (14,487)	1,201 (10,999)	577	559 ^c (342-775)
Allowable charges related to cascade events in 90-day period, \$ mean (SD)	1,789 (14,489)	1,201 (10,999)	588	565 ^c (348-781)
Total Medicare allowable charges in 90-day period, \$ mean (SD)	11,666 (22,235)	9,880 (18,021)	1,786	1,707 ^c (1,358-2,055)

Table 2. ^aThe multivariable model included the following covariates: age, sex, race, Medicaid enrollment, Elixhauser condition count, disability (reason for Medicare eligibility), end stage renal disease (reason for Medicare eligibility), and setting of residence. ^bSensitivity analysis in which no electrocardiogram, stress test, or echocardiogram performed during the cascade period but before cataract surgery was counted as a cascade event. ^cStatistically significant at p<0.05.

eTable 11. Characteristics Associated with Experience of Potential Cascade Among Beneficiaries Receiving Pre-Operative EKG for Cataract Surgery, Sensitivity Analysis

Characteristic		Experienced potential cascade (N=1,823)	Did not experience potential cascade (N=10,585)	Adjusted Odds Ratio, 95% CI ^b
Age in years, % (n)	66-74	47.2 (861)	56.7 (5,997)	1 [Reference]
	75-84	43.9 (800)	36.4 (3,853)	1.44 ^c (1.29-1.60)
	≥85	8.9 (162)	6.9 (735)	1.48 ^c (1.23-1.78)
Female sex		64.5 (1,176)	65.8 (6,969)	0.93 (0.84-1.03)
Race, % (n)	White	83.1 (1,514)	85.2 (9,019)	1 [Reference]
	Black	6.9 (125)	5.4 (571)	1.12 (0.91-1.38)
	Hispanic	5.7 (103)	4.4 (464)	1.19 (0.94-1.51)
	Other	4.4 (81)	5.0 (531)	0.86 (0.67-1.11)
Medicaid enrollment, % (n)		7.1 (129)	5.6 (591)	1.12 (0.91-1.39)
Setting of residence, % (n)	Metropolitan	84.7 (1,544)	83.2 (8,802)	1 [Reference]
	Micropolitan	7.7 (141)	9.4 (994)	0.90 (0.74-1.09)
	Suburban	4.3 (79)	4.2 (445)	1.12 (0.87-1.45)
	Rural	3.2 (59)	3.3 (344)	1.12 (0.83-1.49)
Elixhauser condition count, mean (SD)		1.4 (1.5)	1.0 (1.3)	1.20 ^c (1.16-1.24)
Physician ordering pre-operative EKG, % (n)	Primary care physician	68.2 (1,244)	72.5 (7,677)	1 [Reference]
	Cardiac specialist	19.3 (353)	16.3 (1,722)	1.33 ^c (1.16-1.52)
	Other	12.4 (226)	11.2 (1,186)	1.18 (1.01-1.38)
Practice region, % (n)	Northeast	35.0 (638)	32.6 (3,446)	0.92 (0.75-1.12)
	South	32.9 (599)	32.0 (3,387)	1.06 (0.88-1.26)
	West	16.5 (300)	18.0 (1,903)	1.01 (0.82-1.25)
	Midwest	15.7 (286)	17.5 (1,849)	1 [Reference]
Cardiologists per 10,000 residents in HRR, mean (SD) ^a		7.6 (2.1)	7.4 (2.0)	1.07 ^c (1.03-1.11)

Table 3. Abbreviation: HRR is hospital referral region. ^a Dartmouth Atlas, 2011. ^b Among beneficiaries who received a pre-operative EKG, we compared those who did or did not experience a potential cascade using univariate analyses and multivariable logistic regression in which the primary outcome was experience of the cascade and the predictors were all characteristics included in the table and HRR random effects. In this sensitivity analysis, we did not count any EKGs, stress tests, or echocardiograms occurring prior to cataract surgery as cascade events. ^c Statistically significant at p<0.05.

eReferences.

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