

Supplemental Appendix

Table of Contents

Supplemental Table 1. List of ICD Codes for Medical Comorbidities of Patient Cohort	2
Supplemental Table 2: List of CPT, HCPCS, and ICD Codes for CAD Testing Procedures	3
Supplemental Table 3. Predictors of CAD Testing–Sensitivity Analyses by Inclusion Criteria	4
Supplemental Table 4. Predictors of CAD Testing–Sensitivity Analyses by Scenario	5
Supplemental Figure 1. Breakdown of CAD Testing and Interventions by Modality	6
Supplemental Figure 2. National Variation in CAD Testing for Incident Heart Failure Patients	7
Supplemental Figure 3. Variation in the Frequency of CAD Testing across Primary Care Physicians	8

Supplemental Table 1. List of ICD Codes for Medical Comorbidities of Patient Cohort

Variable	ICD-9						ICD-10						
Atrial fibrillation	4273-						I48-						
Alcohol use disorder	291-	303-	305-	3575	4255	5353-	E244	E8600	F10-	G312	G621	G721	
	5710	5711	5712	5713	76071	7903	I426	K292-	K70-	K852-	K860	O354XX-	
	9808	9809	V113				O9931-	R780	T510X-	Y90-	Z7141		
Cancer	14-	15-	16-	17-	18-	19-	C0-	C1-	C2-	C3-	C4-	C5-	
	200-	201-	202-	203-	204-	205-	C6-	C7-	C8-	C9-	D0-	D45	
	206-	207-	208-	2090-	2091-	2092-	D4622	D469	D46C	D46Z	D471	D473	
	2093-	2097-	230-	231-	232-	233-	D474	D47Z1	D6182	D7581			
	234-	2384	2385	2386	2387-	2592							
Cardiogenic shock	78550	78551					R570	R579					
Chronic kidney disease	28521	403-	404-	45821	582-	5853	E082-	E092-	E102-	E112-	E132-	I12-	
	5854	5855	5859	586			I13-	I953	N03-	N11-	N183-	N184	
							N185	N189	N19	O102-	O103-		
Chronic liver disease	07022	07023	07032	07033	07044	07054	B18-	K70-	K710	K711-	K713	K714	
	571-	5722	5723	5724	5728	5735	K715-	K716	K717	K718	K719	K72-	
	5738	5739	5714-	V427			K73-	K74-	K753	K754	K758-	K759	
							K76-	K77	Z944				
COPD or asthma	491-	492	4930-	4931-	4932-	496	J41-	J42-	J43-	J44-	J45-		
	4938-	4939-											
Coronary artery disease ^a	412	4140-	4142	4143	4148	4149	I251-	I252	I255	I256	I2570-	I2571-	
	4292	7932					I2572-	I2573-	I2575-	I2576-	I2579-	I258	
							I259	R931					
Dementia	2900	2901-	2902-	2903	2904-	2941-	F015-	F028-	F039-	G30-	G310-	G311	
	2942-	3310	3311-	3312	33182		G3183						
Depression	2962-	2963-	29682	2969-	3004	30112	F32-	F33-	F34-	F38-	F39	F412	
	30113	3090	3091	30928	311		F4321	F4323	F530				
Diabetes	250-						E08-	E09-	E10-	E11-	E13-	O24-	
Endocarditis	03642	07422	0932-	09884	11281	11504	A1884	A3282	A3951	A5203	A5483	B3321	
	11514	11594	3911	3979	421-	4249-	B376	I011	I091	I33-	I38	I39	
							M3211						
Heart failure	39891	402-1	404-1	404-3	428-		I0981	I110	I130	I132	I50-		
Hyperlipidemia	272-						E78-						
Hypertension	401-	402-	403-	404-	405-		I10	I11-	I12-	I13-	I15-	I16-	
	6420-	6421-	6422-	6427-	6429-		O10-	O11-	O16-				
Myocarditis	03282	03643	07423	09382	1303	3912	A381	A3952	B2682	B3322	B5881	D8685	
	3980	422-	4290				I012	I090	I40-	I41	I514	J1082	
							J1182						
Non-coronary atherosclerosis	4350	4351	4352	4353	4370	440-	E085-	E095-	E105-	E115-	E135-	I672	
	441-	442-	44389	4439	444-	445-	I70-	I711	I712	I713	I714	I715	
	4471	5571	5579				I716	I718	I719	I72-	I7389	I739	
							I74-	I75-	I771	I79-	K551	K558	
							K559	T8231-	V434	Z9582-	Z9862		
Obesity	278-	6491-	6492-	V853-	V854-		E65	E66-	E67-	E68	O9921-		
							Z683-	Z684-					
Prior history of CVA/TIA	433-	434-	4353	4358	4359	436	G450	G451	G452	G458	G459	G46-	
	4371	4378	4379	438-	V1254	V4588	I63-	I65-	I66-	I6781	I6782	I6784-	
							I6789	I693-	I698-	I699-	Z8673	Z9282	
Psychotic disorder	2908	2909	29381	29382	295-	296-4	F060	F2-	F302	F312	F315	F3164	
	297-	298-	7801				F323	F333	F53	F531	R440	R441	

							R442	R443						
Sleep apnea	3272-	78051	78053	78057			G473-							
Systolic dysfunction	428-	4284-					I502-	I504-	I5082	I5084				
Tobacco use disorder	3051	6490-	98984	V1582			F172-	O9933-	T652-	Z716	Z720	Z87891		
Valvular disorders	<i>Dx</i> 394-	395-	396-	397-	3989-	4240	I05-	I06-	I07-	I08-	I091	I098-		
	4241	4242	4243	7460-	7461	7462	I099	I34-	I35-	I36-	I37-	Q22-		
	7463	7464	7465	7466	7467	99602	Q23-	T820-	T8222-	T826-	Z952	Z953		
	99671	V422	V433				Z954							
	<i>Proc</i> 350-	351-	352-	3596	3597	3599	025F-	025G-	025H-	025J-	027F-	027G-		
							027H-	027J-	02BF-	02BG-	02BH-	02BJ-		
							02NF-	02NG-	02NH-	02NJ-	02QF-	02QG-		
							02QH-	02QJ-	02RF-	02RG-	02RH-	02RJ-		
							02TH-	02UF-	02UG-	02UH-	02UJ-	02VG-		
							02WF-	02WG-	02WH-	02WJ-	X2RF-			
Ventricular arrhythmia	4271	4274-					I462	I469	I470	I472	I490-	I493		

^a Does not include unstable angina pectoris or acute coronary syndrome codes
 Symbols: - Wildcard digit or character

Supplemental Table 2. List of CPT, HCPCS, and ICD Codes for CAD Testing Procedures

Variable	CPT / HCPCS						ICD-9 / 10							
Stress ECG	93015	93016	93017	93018			8941	8942	8943	8944				
Stress Echocardiography	93350	93351	93352											
Stress Testing							4A-2XM4							
Nuclear	78451	78452	78453	78454	7846-	7847-	9205	C21-	C22-	C23-				
	7848-	7849-												
Cardiac MRI	7555-	7556-					8892	B23-						
Coronary CTA	75571	75574					B22-							
Coronary Angiography	93454	93455	93456	93457	93458	93459	8850	8853	8854	8855	8856	8857		
	93460	93461	93508*	93539*	93540*	93545*	8859	B21-	4A033-C					
	93556*	93567	93571	93572										
PCI ^a	9292-	9293-	92943	92944	92973	9298-*	0066	1755	3606	3607	3609	027-3-		
	92995*	92996*	C1874*	C1875*	G0290*	G0291*	027-4-	02C03-	02C13-	02C23-	02C33-	02C04-		
	C9600	C9601	C9602	C9603	C9604	C9605	02C14-	02C24-	02C34-	02H03-	02H13-	02H23-		
	C9607	C9708					02H33-	02H04-	02H14-	02H24-	02H34-			

Abbreviations: ECG, electrocardiogram; MRI, magnetic resonance imaging; CTA, computed tomography angiography; PCI, percutaneous coronary intervention; ^a Includes atherectomy, thrombectomy, and stenting but not adjunctive therapies (e.g., brachytherapy, chemical thrombolysis). Does not include left heart catheterization codes given not specific for PCI
 Symbols: * Deleted code; - Wildcard digit or character

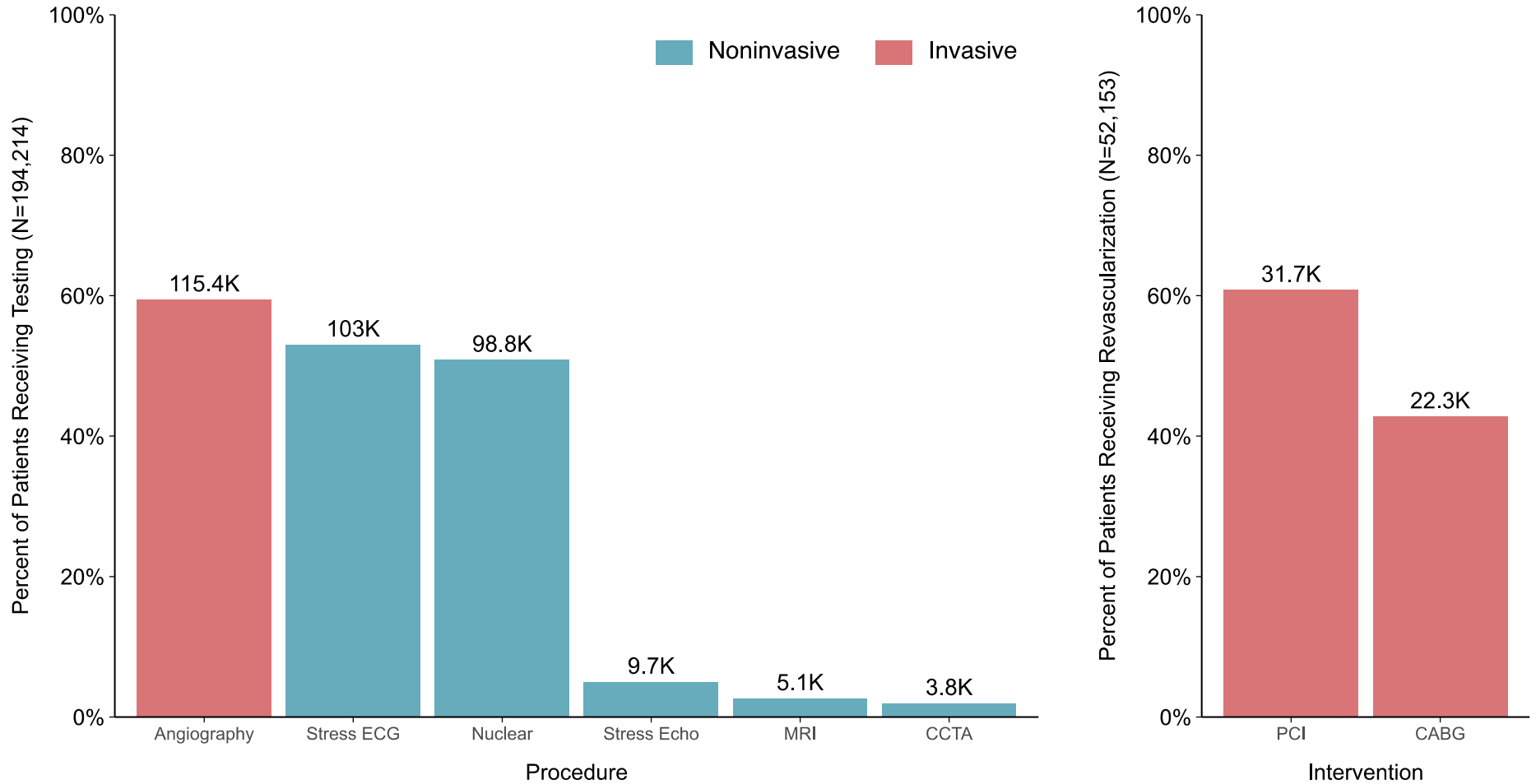
Supplemental Table 3. Predictors of CAD Testing – Sensitivity Analyses by Inclusion Criteria

Inclusion Criteria	Base case (<i>N</i> = 558,322)	24-mo. lookback (<i>N</i> = 412,154)	CAD subset (<i>N</i> = 213,926)	Inpatient HF subset (<i>N</i> = 64,153)
Adj. Probability (95% CI), %	34.5 (33.4–35.6)	31.8 (31.7–32.0)	32.9 (32.7–33.1)	47.6 (47.2–48.0)
Variables	Adjusted OR (95% CI)			
Age Group (<i>vs.</i> <40)				
40 – 64	1.54 (1.47–1.61)	1.53 (1.44–1.62)	0.93 (0.77–1.12)	1.39 (1.22–1.58)
65 – 79	0.99 (0.94–1.03)	0.96 (0.90–1.01)	0.68 (0.56–0.82)	0.83 (0.73–0.94)
≥ 80	0.51 (0.48–0.53)	0.50 (0.47–0.53)	0.42 (0.35–0.51)	0.35 (0.30–0.40)
Female Sex	0.74 (0.73–0.75)	0.73 (0.72–0.75)	0.80 (0.79–0.82)	0.77 (0.74–0.80)
Race and ethnicity (<i>vs.</i> White)				
Asian	1.06 (1.01–1.10)	1.03 (0.99–1.09)	1.09 (1.02–1.16)	1.08 (0.95–1.22)
Black	0.90 (0.88–0.92)	0.90 (0.88–0.92)	0.94 (0.91–0.97)	0.95 (0.91–1.00)
Hispanic	0.99 (0.97–1.02)	0.98 (0.95–1.00)	1.02 (0.98–1.05)	1.05 (0.99–1.13)
Unknown	0.94 (0.92–0.96)	0.93 (0.90–0.95)	0.99 (0.95–1.02)	0.99 (0.93–1.05)
Region (<i>vs.</i> Northeast)				
Midwest	1.08 (1.06–1.11)	1.07 (1.04–1.10)	1.05 (1.01–1.08)	1.05 (0.99–1.12)
South	1.06 (1.04–1.09)	1.05 (1.02–1.07)	1.06 (1.03–1.09)	1.04 (0.99–1.11)
West	1.02 (0.84–1.22)	1.06 (0.86–1.32)	1.39 (0.95–2.03)	0.94 (0.54–1.63)
Unknown	0.85 (0.83–0.87)	0.83 (0.81–0.85)	0.98 (0.94–1.01)	0.82 (0.77–0.88)
Care Setting – ED / Inpatient	1.43 (1.42–1.45)	1.42 (1.40–1.44)	1.69 (1.66–1.73)	n/a
Systolic Dysfunction	2.49 (2.46–2.53)	2.50 (2.46–2.54)	1.67 (1.64–1.71)	2.33 (2.25–2.42)
Cardiovascular Conditions				
Atrial fibrillation/flutter	0.89 (0.87–0.90)	0.89 (0.88–0.91)	0.86 (0.84–0.87)	0.77 (0.74–0.80)
Cardiogenic shock	2.55 (2.44–2.66)	2.58 (2.46–2.71)	2.74 (2.54–2.97)	2.91 (2.53–3.35)
Diabetes	0.97 (0.96–0.99)	0.99 (0.97–1.00)	1.06 (1.03–1.08)	1.02 (0.98–1.06)
Endocarditis	1.17 (1.12–1.22)	1.18 (1.12–1.24)	1.11 (1.04–1.19)	1.25 (1.11–1.41)
Hyperlipidemia	1.80 (1.78–1.83)	1.81 (1.78–1.84)	1.92 (1.86–1.99)	1.59 (1.53–1.65)
Hypertension	1.08 (1.06–1.11)	1.09 (1.07–1.12)	1.19 (1.13–1.25)	0.93 (0.87–0.99)
Myocarditis	2.79 (2.49–3.12)	2.77 (2.42–3.17)	1.52 (1.24–1.85)	1.91 (1.46–2.54)
Noncoronary atherosclerosis	1.13 (1.12–1.15)	1.12 (1.10–1.14)	1.10 (1.08–1.13)	1.11 (1.07–1.16)
Obesity	1.07 (1.05–1.09)	1.06 (1.04–1.08)	1.08 (1.05–1.11)	0.97 (0.93–1.02)
Prior history of CVA/TIA	1.13 (1.11–1.15)	1.14 (1.12–1.16)	1.13 (1.10–1.15)	1.09 (1.04–1.14)
Valvular disorder	1.79 (1.76–1.81)	1.76 (1.74–1.79)	1.46 (1.43–1.49)	1.39 (1.34–1.44)
Ventricular arrhythmia	1.92 (1.88–1.96)	1.91 (1.86–1.96)	1.42 (1.38–1.46)	1.76 (1.66–1.86)
Other Conditions				
Alcohol use disorder	0.82 (0.80–0.85)	0.81 (0.78–0.84)	0.86 (0.81–0.90)	1.06 (0.98–1.14)
Cancer	0.89 (0.88–0.91)	0.90 (0.88–0.91)	0.90 (0.88–0.92)	0.92 (0.88–0.96)
Chronic kidney disease	0.76 (0.75–0.77)	0.76 (0.75–0.77)	0.86 (0.84–0.88)	0.75 (0.72–0.78)
Chronic liver disease	0.89 (0.87–0.91)	0.89 (0.87–0.92)	0.93 (0.90–0.97)	1.03 (0.97–1.10)
COPD or asthma	0.82 (0.81–0.83)	0.82 (0.81–0.84)	0.89 (0.87–0.90)	0.85 (0.82–0.88)
Dementia	0.38 (0.37–0.39)	0.38 (0.37–0.39)	0.46 (0.44–0.48)	0.42 (0.39–0.45)
Depression	0.86 (0.85–0.87)	0.86 (0.84–0.87)	0.91 (0.89–0.93)	0.93 (0.89–0.98)
Psychotic disorder	0.59 (0.57–0.61)	0.58 (0.56–0.61)	0.66 (0.63–0.70)	0.62 (0.56–0.68)
Sleep apnea	1.01 (0.99–1.03)	1.02 (0.99–1.04)	1.10 (1.07–1.13)	0.89 (0.84–0.93)
Tobacco use disorder	1.32 (1.30–1.34)	1.30 (1.28–1.33)	1.15 (1.13–1.18)	1.20 (1.15–1.25)

Supplemental Table 4. Predictors of CAD Testing – Sensitivity Analyses by Scenario

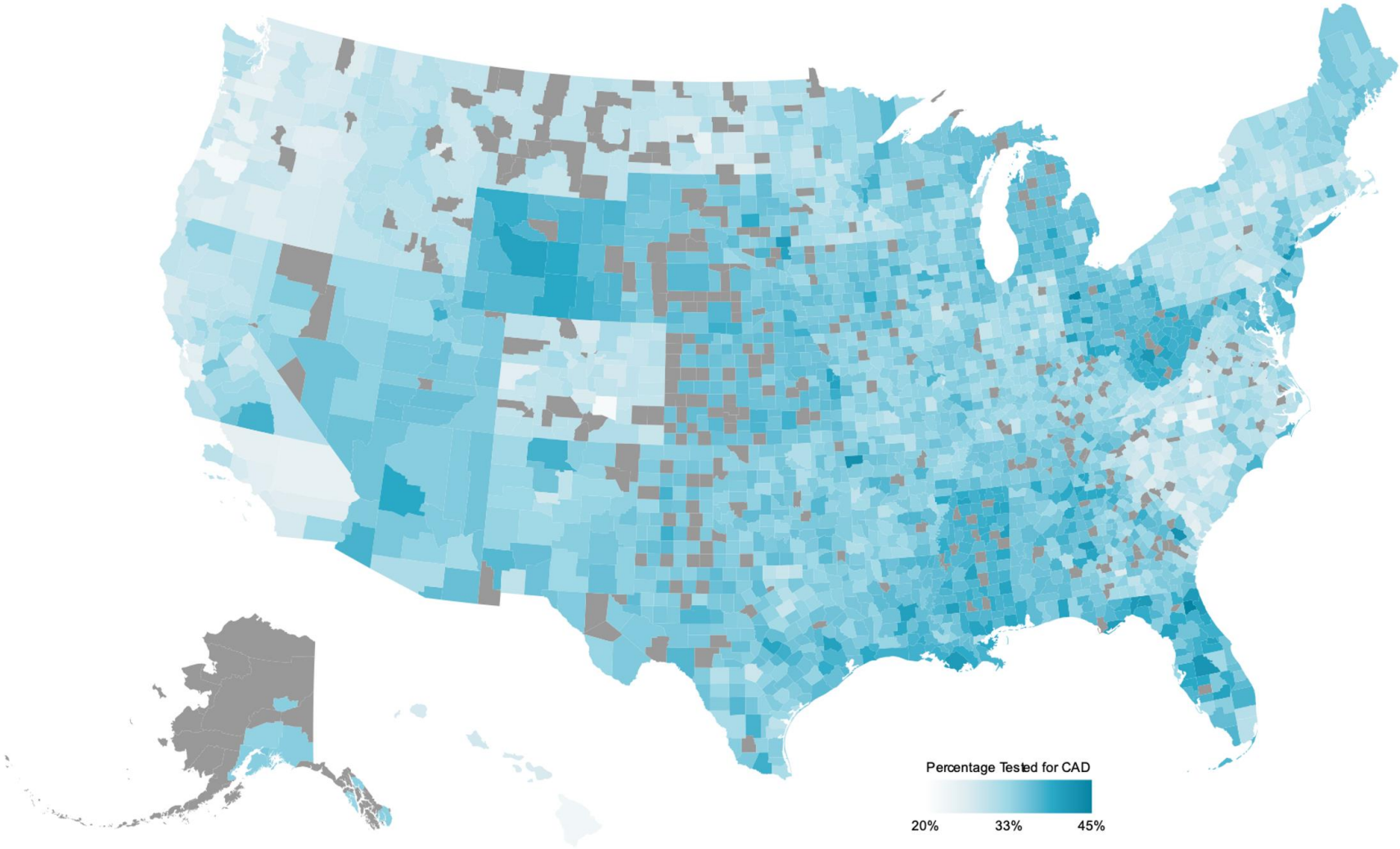
Scenario	Restricted (N = 473,753)	Base case (N = 558,322)	Expanded (N = 515,605)
Outcome Window	From index to 90 days post-index	From 90 days pre- to 90 days post-index	From 90 days pre- to 180 days post-index
Adj. Probability (95% CI), %	24.6 (24.4–24.7)	34.5 (33.4–35.6)	35.7 (35.6–35.9)
Variables Adjusted OR (95% CI)			
Age Group (vs. <40)			
40 – 64	1.61 (1.53–1.69)	1.54 (1.47–1.61)	1.57 (1.49–1.64)
65 – 79	1.02 (0.97–1.07)	0.99 (0.94–1.03)	1.02 (0.97–1.07)
≥ 80	0.51 (0.49–0.54)	0.51 (0.48–0.53)	0.52 (0.49–0.54)
Female Sex	0.75 (0.74–0.77)	0.74 (0.73–0.75)	0.74 (0.73–0.75)
Race and ethnicity (vs. White)			
Asian	1.08 (1.03–1.13)	1.06 (1.01–1.10)	1.06 (1.02–1.11)
Black	0.92 (0.90–0.94)	0.90 (0.88–0.92)	0.92 (0.90–0.93)
Hispanic	1.01 (0.99–1.04)	0.99 (0.97–1.02)	1.00 (0.98–1.02)
Unknown	0.94 (0.92–0.96)	0.94 (0.92–0.96)	0.93 (0.91–0.95)
Region (vs. Northeast)			
Midwest	1.05 (1.03–1.08)	1.08 (1.06–1.11)	1.08 (1.05–1.10)
South	1.04 (1.02–1.07)	1.06 (1.04–1.09)	1.06 (1.04–1.08)
West	0.96 (0.78–1.19)	1.02 (0.84–1.22)	1.01 (0.84–1.22)
Unknown	0.83 (0.81–0.85)	0.85 (0.83–0.87)	0.85 (0.83–0.87)
HF Dx in ED/Inpatient Claims	1.82 (1.79–1.85)	1.43 (1.42–1.45)	1.40 (1.39–1.42)
Systolic Dysfunction	2.90 (2.86–2.95)	2.49 (2.46–2.53)	2.42 (2.39–2.46)
Cardiovascular Conditions			
Atrial fibrillation/flutter	0.84 (0.83–0.85)	0.89 (0.87–0.90)	0.90 (0.89–0.91)
Cardiogenic shock	2.49 (2.38–2.61)	2.55 (2.44–2.66)	2.50 (2.39–2.62)
Diabetes	0.99 (0.97–1.00)	0.97 (0.96–0.99)	0.99 (0.98–1.01)
Endocarditis	1.13 (1.07–1.19)	1.17 (1.12–1.22)	1.16 (1.11–1.21)
Hyperlipidemia	1.65 (1.62–1.68)	1.80 (1.78–1.83)	1.74 (1.72–1.77)
Hypertension	1.04 (1.02–1.06)	1.08 (1.06–1.11)	1.07 (1.05–1.09)
Myocarditis	2.79 (2.46–3.16)	2.79 (2.49–3.12)	2.73 (2.42–3.08)
Noncoronary atherosclerosis	1.05 (1.04–1.07)	1.13 (1.12–1.15)	1.13 (1.11–1.14)
Obesity	1.04 (1.02–1.06)	1.07 (1.05–1.09)	1.06 (1.04–1.07)
Prior history of CVA/TIA	1.02 (1.01–1.04)	1.13 (1.11–1.15)	1.13 (1.11–1.14)
Valvular disorder	1.72 (1.70–1.75)	1.79 (1.76–1.81)	1.75 (1.73–1.78)
Ventricular arrhythmia	1.81 (1.77–1.86)	1.92 (1.88–1.96)	1.87 (1.82–1.91)
Other Conditions			
Alcohol use disorder	0.86 (0.83–0.89)	0.82 (0.80–0.85)	0.83 (0.80–0.85)
Cancer	0.84 (0.82–0.85)	0.89 (0.88–0.91)	0.93 (0.91–0.94)
Chronic kidney disease	0.76 (0.75–0.77)	0.76 (0.75–0.77)	0.77 (0.76–0.79)
Chronic liver disease	0.84 (0.82–0.87)	0.89 (0.87–0.91)	0.92 (0.90–0.94)
COPD or asthma	0.81 (0.80–0.83)	0.82 (0.81–0.83)	0.84 (0.82–0.85)
Dementia	0.37 (0.36–0.38)	0.38 (0.37–0.39)	0.37 (0.36–0.39)
Depression	0.82 (0.81–0.84)	0.86 (0.85–0.87)	0.87 (0.86–0.88)
Psychotic disorder	0.57 (0.54–0.59)	0.59 (0.57–0.61)	0.61 (0.58–0.63)
Sleep apnea	0.98 (0.96–1.01)	1.01 (0.99–1.03)	1.02 (1.00–1.04)
Tobacco use disorder	1.24 (1.22–1.26)	1.32 (1.30–1.34)	1.31 (1.29–1.33)

Supplemental Figure 1. Breakdown of CAD Testing and Interventions by Modality



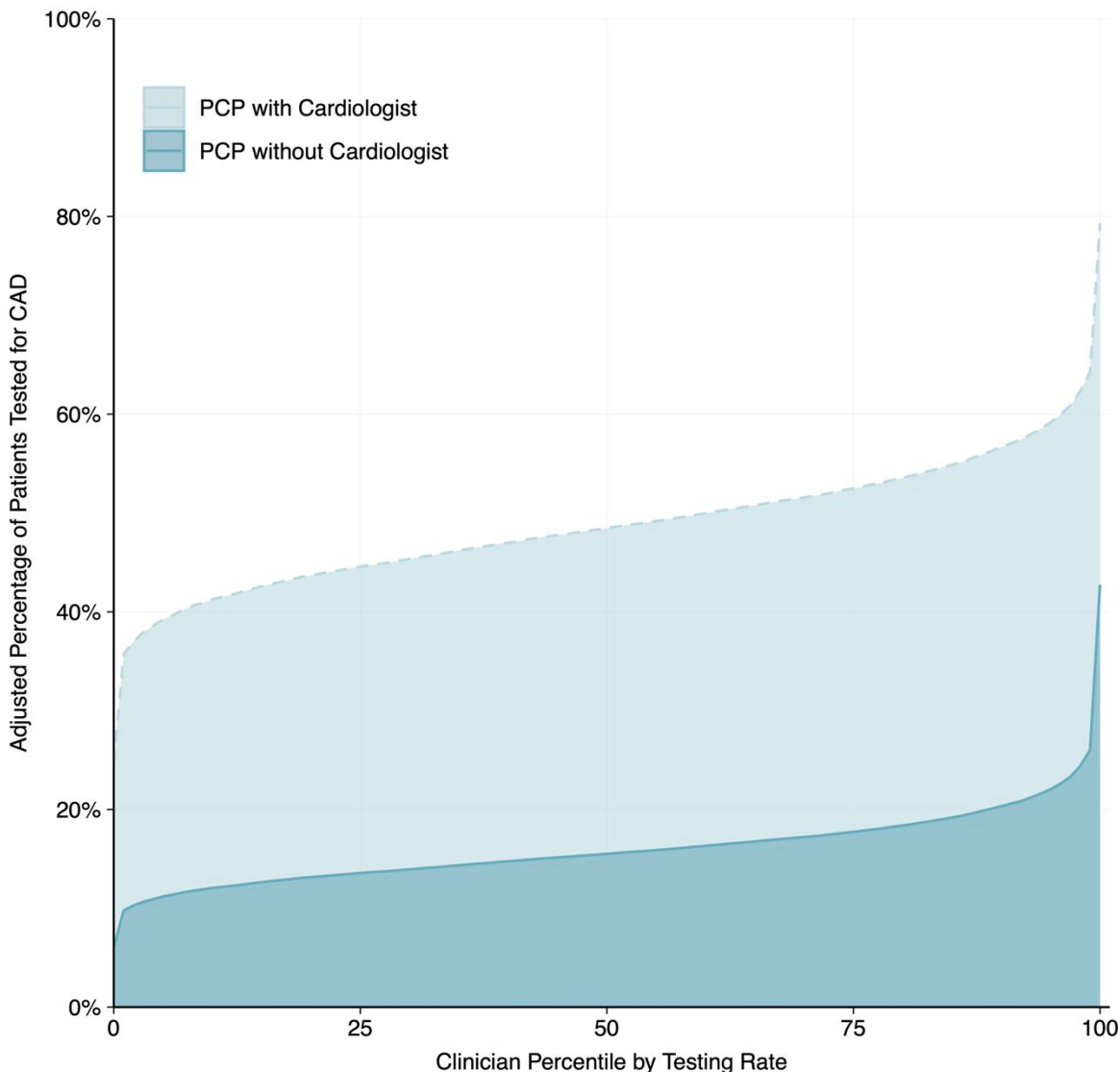
This graph displays the 194,214 patients who undergo CAD testing separated by procedure type and color-coded by interventional status. As shown, the most frequent procedures are coronary angiography, stress ECG, and nuclear imaging studies. 52,153 patients receive revascularization, with the majority undergoing percutaneous coronary intervention.

Supplemental Figure 2. National Variation in CAD Testing for Incident Heart Failure Patients



This choropleth map visualizes the adjusted percentage of patients tested for CAD across counties. Counties with insufficient data are colored dark gray. Testing probabilities range from 20.4% in San Luis Obispo County of California to 45.2% in Clay County of Florida.

Supplemental Figure 3. Variation in the Frequency of CAD Testing across Primary Care Physicians



This cumulative distribution curve shows 8,447 primary care physicians ordered by their CAD testing rates for an average-risk patient. The dotted curve represents CAD testing rates with cardiologist co-management. All patient-level covariates are conditioned at their means. The interquartile range of testing probability, as seen by the 25th and 75th clinician percentiles, is 13.6 to 17.7% for PCP alone and 44.6 to 52.5% with a co-managing cardiologist. Only PCPs with at least 10 new HF diagnoses during the study period are included in this analysis.