Chapter 4: Cardiovascular Disease in Patients with CKD

- The prevalence of cardiovascular disease (CVD) was 64.5% among patients aged 66 and older who had chronic kidney disease (CKD), compared to 32.4% among those who did not have CKD (Table 4.1).
- The presence of CKD is associated with worsened short- and long-term prognosis for many common cardiovascular diseases. The adjusted two-year survival of patients with acute myocardial infarction (AMI) and without a diagnosis of CKD was 82%, compared with 75% for CKD Stage 1-2 patients and 59% for Stage 4-5 patients (Figure 4.2).
- The presence of cardiovascular disease is also associated with worsened short- and long-term prognosis for patients with CKD. Over a two-year period, Medicare patients with both heart failure and CKD had an adjusted survival probability of 77.8%, compared to 90.2% for those with CKD alone (Figure 4.5).
- Atrial fibrillation (AF) was common among Medicare patients with CKD (23.8%). The prevalence of AF was higher among males, older persons, and patients with hypertension (HTN), advanced stages of CKD, and heart failure (HF). Nearly half of CKD patients with heart failure had a diagnosis of AF (Table 4.5).
- Angiotensin converting enzyme inhibitors (ACEs) and angiotensin receptor blockers (ARBs) are mainstays of heart failure therapy and were prescribed to 59.9% of CKD patients with HF, compared to 61.2% of non-CKD patients with HF. Although direct oral anticoagulants have been less studied among patients with CKD, these drugs were prescribed to 30.9% of patients with AF and CKD, as compared with 33.2% of patients with AF and no CKD (Table 4.4).

Introduction

Cardiovascular disease (CVD) remains the leading cause of death in the United States and most other developed countries (Centers for Disease Control and Prevention, 2015). It accounts for approximately 39% of deaths among those on dialysis (see Volume 2, Chapter 5: *Mortality*). Among patients with chronic kidney disease (CKD), death from CVD is far more common than progression to end-stage renal disease (ESRD; Gargiulo et al., 2015).

CKD has been identified as an independent risk factor for CVD, and experts have argued that it should be recognized as a coronary disease risk equivalent (Briasoulis and Bakris, 2013; Sarnak et al., 2003), similar to diabetes mellitus (DM). The complex relationship between CVD and kidney disease is thought to be due to shared traditional risk factors, such as DM, hypertension (HTN), physical inactivity, left ventricular hypertrophy, smoking, family history, and dyslipidemia.

Non-traditional risk factors may also exert an additional influence in the presence of CKD—some examples include endothelial dysfunction, vascular medial hyperplasia, sclerosis and calcification, volume overload, abnormalities in mineral metabolism, anemia, malnutrition, inflammation, oxidative stress, and autonomic imbalance. In cardiorenal syndrome, dysfunction in the heart or kidney may directly induce dysfunction in the other organ. In particular, this continues to pose both a diagnostic and therapeutic challenge for managing fluid status when treating those with heart failure (HF) (Husain-Syed et al., 2015). Thus, characterizing the epidemiology of cardiovascular comorbidities is a critical step toward improving morbidity and mortality in the CKD population.

In this chapter, we review recent trends in the prevalence and outcomes of cardiovascular disease in CKD patients and compare these to outcomes of CVD in patients without CKD, focusing on the high-risk, elderly Medicare population.

Methods

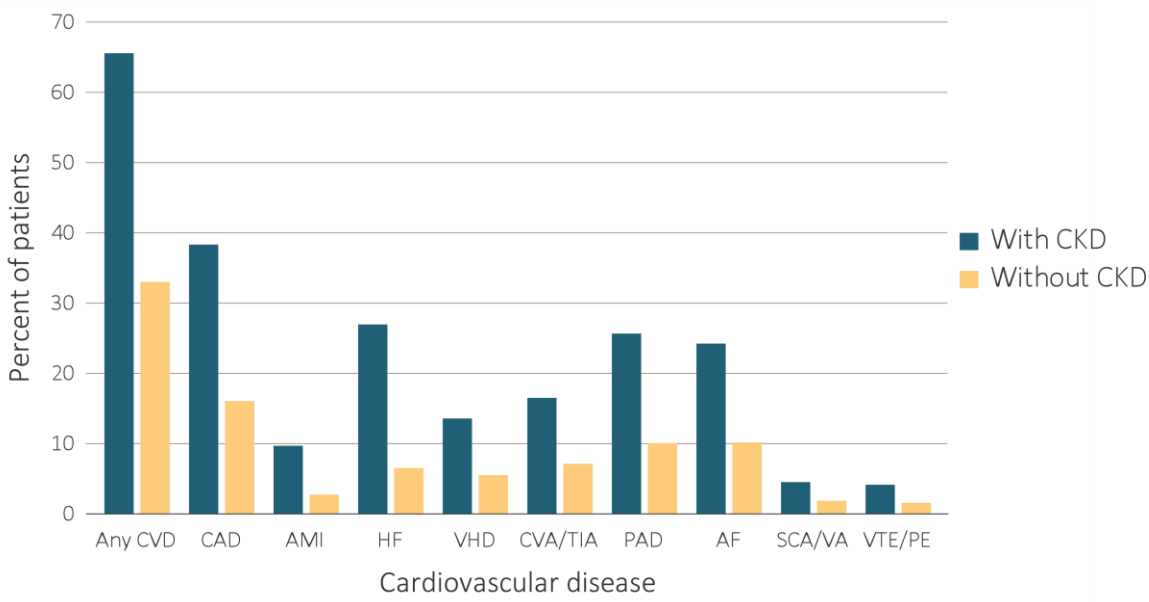
The findings presented in this chapter were drawn from data from the Medicare 5% sample's fee-for-service patients aged 66 and older. Those in the cohort were alive, without end-stage renal disease, and residing in the U.S. on 12/31/2016, with fee-for-service coverage for the entire calendar year of 2016. CKD and CVD diagnoses were obtained via billing claims from the Medicare 5% sample. The overall study cohort for 2016 included 1,262,072 patients, of whom 175,840 had CKD. Details of this data are described in the *Data Sources* section of the *CKD Analytical Methods* chapter.

For an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter, see the section on *Chapter 4* within the *CKD Analytical Methods* chapter. Downloadable Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available from the *USRDS website*.

Cardiovascular Disease Prevalence and Outcomes in CKD

As shown in Figure 4.1, elderly CKD patients had a greater burden of cardiovascular disease than did their counterparts without a diagnosis of CKD. A wide range of conditions were more common in CKD patients aged 66 and older than in those without CKD, including stable coronary artery disease (CAD), acute myocardial infarction (AMI), heart failure (HF), valvular heart disease (VHD), stroke (cerebrovascular accident/transient ischemic attack, or CVA/TIA), peripheral arterial disease (PAD), atrial fibrillation (AF), sudden cardiac arrest and ventricular arrhythmias (SCA/VA), and venous thromboembolism and pulmonary embolism (VTE/PE). Indeed, the overall prevalence of these cardiovascular conditions was double among those with CKD compared to those without (65.1% versus 32.6%). Part of this differential results from the older age of CKD patients (see Volume 1, Chapter 2: *Identification and Care of Patients with CKD)*.

vol 1 Figure 4.1 Prevalence of common cardiovascular diseases in patients with or without CKD, 2016



Data Source: Special analyses, Medicare 5% sample. Abbreviations: AF, atrial fibrillation; AMI, acute myocardial infarction; CAD, coronary artery disease; CKD, chronic kidney disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; CVD, cardiovascular disease; HF, heart failure; PAD, peripheral arterial disease; SCA/VA, sudden cardiac arrest and ventricular arrhythmias; VHD, valvular heart disease; VTE/PE, venous thromboembolism and pulmonary embolism.

The prevalence of these conditions generally increases with age and presence of CKD (Table 4.1). The relationships with race, ethnicity, and sex are less straightforward.

vol 1 Table 4.1 Prevalence of (a) cardiovascular comorbidities & (b) annual incidence of cardiovascular procedures, by CKD status, age, race, & sex, 2016

	(a) Cardiovascular comorbidities									
	# Patients	% Patients								
		Overall	66-69	70-74	75-84	85+	White	Blk/Af Am	Other	Male	Female
Any CVD											
Without CKD	1,086,232	32.4	19.8	27.3	39.2	52.1	33.4	28.7	23.8	36.3	29.5
Any CKD	175,840	64.5	50.0	56.9	66.9	76.5	65.3	62.1	57.3	68.1	61.0
Coronary artery disease (CAD)											
Without CKD	1,086,232	15.6	10.0	13.9	19.4	22.1	16.2	12.3	11.9	21.2	11.5
Any CKD	175,840	37.9	29.3	34.4	40.2	42.8	38.8	33.2	33.3	45.0	31.1
Acute myocardial infarction (AMI)											
Without CKD	1,086,232	2.3	1.6	2.1	2.7	3.4	2.4	1.9	1.6	3.1	1.7
Any CKD	175,840	9.3	8.1	8.5	9.5	10.4	9.5	8.2	7.6	11.0	7.6
Heart failure (HF)											
Without CKD	1,086,232	6.1	3.1	4.3	7.2	13.3	6.2	7.1	4.2	6.5	5.9
Any CKD	175,840	25.9	18.3	20.1	25.7	36.1	25.9	28.4	21.5	25.9	25.9
Valvular heart disease (VHD)											
Without CKD	1,086,232	5.1	2.6	3.9	6.6	9.3	5.4	3.4	3.5	5.0	5.2
Any CKD	175,840	12.8	7.5	9.3	13.6	18.1	13.4	10.1	10.2	12.8	12.9
Cerebrovascular accident/transient ischemic attack (CVA/TIA)											
Without CKD	1,086,232	6.7	3.7	5.5	8.6	11.0	6.8	7.2	4.9	6.9	6.6
Any CKD	175,840	16.1	11.4	13.8	17.5	18.9	15.9	18.6	14.7	16.4	15.8
Peripheral artery disease (PAD)											
Without CKD	1,086,232	9.7	4.8	7.1	11.6	20.1	9.8	10.6	7.1	10.0	9.4
Any CKD	175,840	25.2	17.4	20.9	26.0	32.8	25.3	26.3	22.2	26.6	24.0
Atrial fibrillation (AF)											
Without CKD	1,086,232	9.8	4.4	7.0	12.5	19.8	10.5	4.8	5.3	11.2	8.7
Any CKD	175,840	23.8	13.5	17.3	25.3	33.7	25.5	15.0	15.6	26.1	21.6
Cardiac arrest and ventricular arrhythmias (SCA/VA)											
Without CKD	1,086,232	1.4	1.0	1.4	1.8	1.8	1.5	1.1	0.9	2.0	1.0
Any CKD	175,840	4.1	3.4	3.9	4.4	4.3	4.1	4.5	3.0	5.5	2.8
Venous thromboembolism and pulmonary embolism (VTE/PE)											
Without CKD	1,086,232	1.2	0.8	1.0	1.3	1.8	1.2	1.3	0.6	1.2	1.1
Any CKD	175,840	3.7	3.3	3.4	3.8	4.2	3.7	5.1	2.2	3.7	3.8

Table 4.1 continued on next page.

vol 1 Table 4.1 Prevalence of (a) cardiovascular comorbidities & (b) annual incidence of cardiovascular procedures, by CKD status, age, race, & sex, 2016 (continued)

	(b) Cardiovascular procedures									
	# Patients	% Patients								
		Overall	66-69	70-74	75-84	85+	White	Blk/Af Am	Other	Male	Female
Revascularization – percutaneous coronary interventions (PCI)											
Without CKD	169,959	2.1	3.0	2.5	1.9	1.3	2.1	1.5	2.2	2.2	2.0
Any CKD	66,659	3.1	4.1	3.5	3.4	2.0	3.1	2.9	3.3	3.2	2.9
Revascularization – coronary artery bypass graft (CABG)											
Without CKD	169,959	1.1	1.8	1.5	1.0	0.2	1.1	0.6	1.3	1.3	0.7
Any CKD	66,659	1.5	2.7	2.4	1.6	0.3	1.6	1.0	1.0	2.0	0.9
Implantable cardioverter defibrillators & cardiac resynchronization therapy with defibrillator (ICD/CRT-D)											
Without CKD	66,426	0.6	0.6	0.8	0.6	0.3	0.6	0.4	0.6	0.8	0.4
Any CKD	45,552	1.0	1.5	1.4	1.1	0.6	1.0	1.4	1.0	1.4	0.7
Carotid artery stenting and carotid artery endarterectomy (CAS/CEA)											
Without CKD	268,808	0.5	0.6	0.7	0.6	0.2	0.6	0.3	0.4	0.6	0.4
Any CKD	93,656	0.7	0.8	0.8	0.8	0.4	0.7	0.4	0.6	0.8	0.6

Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on 12/31/2016 with fee-for-service coverage for the entire calendar year. Abbreviations: AF, atrial fibrillation; AMI, acute myocardial infarction; Blk/Af Am, Black African American; CABG, coronary artery bypass grafting; CAD, coronary artery disease; CAS/CEA, carotid artery stenting and carotid endarterectomy; CKD, chronic kidney disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; CVD, cardiovascular disease; HF, heart failure; ICD/CRT-D, implantable cardioverter defibrillators/cardiac resynchronization therapy with defibrillator devices; PAD, peripheral arterial disease; PCI, percutaneous coronary interventions; SCA/VA, sudden cardiac arrest and ventricular arrhythmias; VHD, valvular heart disease; VTE/PE, venous thromboembolism and pulmonary embolism. (a) The denominators for overall prevalence of all cardiovascular comorbidities were Medicare enrollees aged 66+ by CKD status. (b) The denominators for overall prevalence of PCI and CABG were Medicare enrollees aged 66+ with CAD by CKD status. The denominators for overall prevalence of ICD/CRT-D were Medicare enrollees aged 66+ with HF by CKD status. The denominators for overall prevalence of CAS/CEA were Medicare enrollees aged 66+ with CAD, CVA/TIA, or PAD by CKD status.

The presence of CKD also worsens the short- and long-term prognosis for many common cardiovascular diseases and for patients who undergo cardiovascular procedures. From a pathophysiologic standpoint, mechanisms by which CKD may predispose patients to cardiovascular events include alterations in sodium and fluid balance, vascular calcification, and inflammatory changes leading to atherosclerotic plaque destabilization (Briasoulis and Bakris, 2013). Figures 4.2.a through 4.2.i and Table 4.2 illustrate survival among patients with CVD. Figures 4.3.a through 4.3.d and Table 4.3 illustrate survival among patients undergoing cardiovascular procedures. Results were stratified by the presence of CKD and its severity, and adjusted for age and sex. In general, CKD patients had a lower probability of survival for all of the conditions reported, with late stages of CKD being associated with the worst outcomes. For example, the adjusted two-year survival of AMI patients without a diagnosis of CKD was 81.7%, compared to 74.5% for CKD Stage 1-2 patients, and 58.6% for CKD Stage 4-5 patients (see Table A for CKD stage definitions). This pattern also held for patients who underwent common major procedures for the treatment of CVD. The adjusted two-year survival of patients undergoing PCI without a diagnosis of CKD was 83.2%, compared to 76.3% for CKD Stage 1-2 patients and 64.3% for CKD Stage 4-5 patients.

Table A. ICD-9-CM and ICD-10-CM codes for Chronic Kidney Disease (CKD) stages

ICD-9-CM code[a]	ICD-10-CM code	Stage
585.1	N18.1	CKD, Stage 1
585.2	N18.2	CKD, Stage 2 (mild)
585.3	N18.3	CKD, Stage 3 (moderate)
585.4	N18.4	CKD, Stage 4 (severe)
585.5	N18.5	CKD, Stage 5 (excludes 585.6: Stage 5, requiring chronic dialysis[b])
CKD Stage-unspecified	CKD Stage-unspecified	For these analyses, identified by multiple codes including 585.9, 250.4x, 403.9x & others for ICD-9-CM and A18.xx, E08.xx, E11.xx and others for ICD-10-CM.

[a] For analyses in this chapter, CKD stage estimates require at least one occurrence of a stage-specific code, and the last available CKD stage in a given year is used. [b] In USRDS analyses, patients with ICD-9-CM code 585.6 or ICD-10-CM code N18.6 & with no ESRD 2728 form or other indication of end-stage renal disease (ESRD) are considered to have code 585.5 or N18.5.

vol 1 Figure 4.2 Probability of survival of patients with a prevalent cardiovascular disease, by CKD status, adjusted for age and sex, 2015-2016

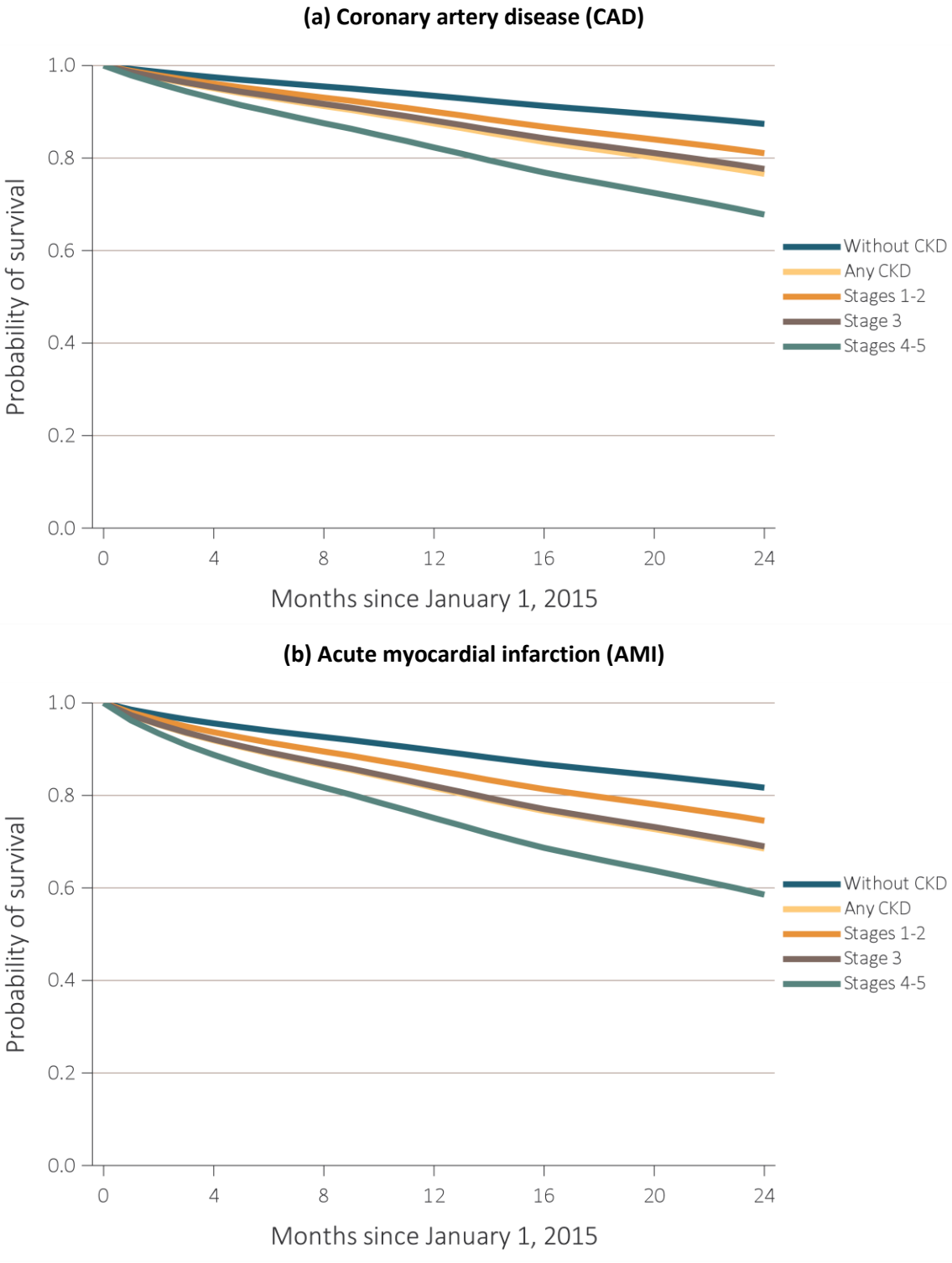


Figure 4.2 continued on next page.

vol 1 Figure 4.2 Probability of survival of patients with a prevalent cardiovascular disease, by CKD status, adjusted for age and sex, 2015-2016 (continued)

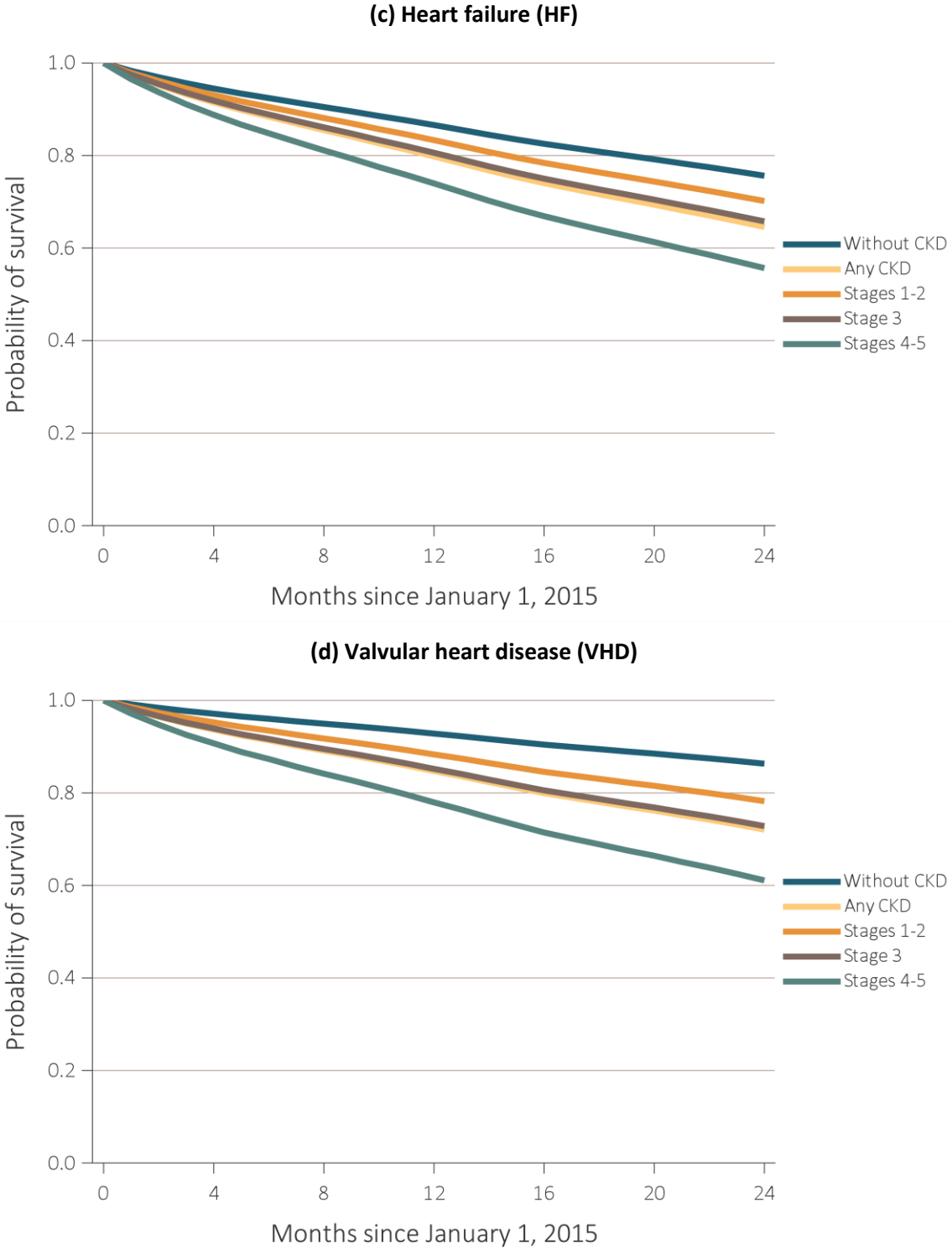
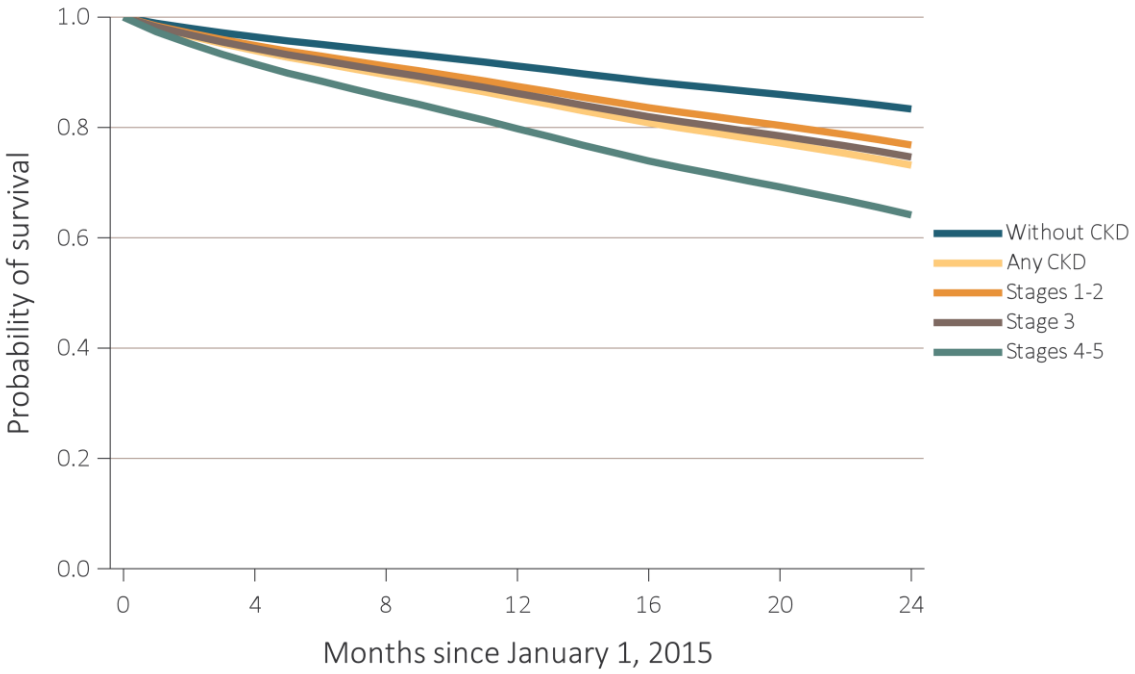


Figure 4.2 continued on next page.

vol 1 Figure 4.2 Probability of survival of patients with a prevalent cardiovascular disease, by CKD status, adjusted for age and sex, 2015-2016 (continued)

(e) Cerebrovascular accident/transient ischemic attack (CVA/TIA)



(f) Peripheral arterial disease (PAD)

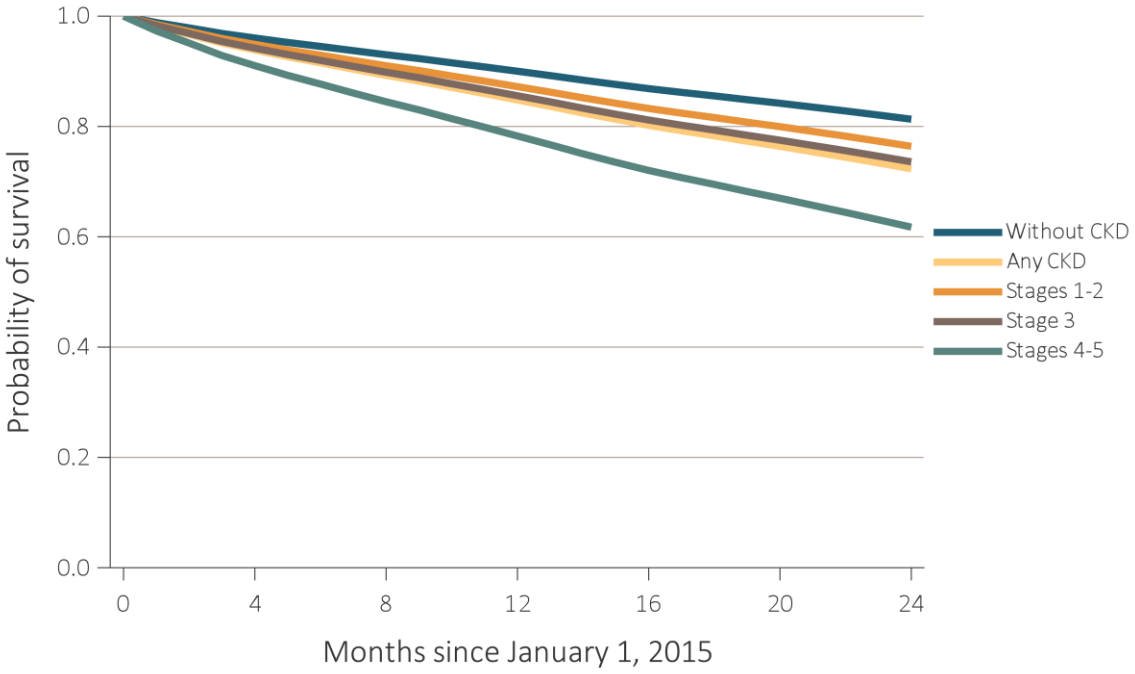
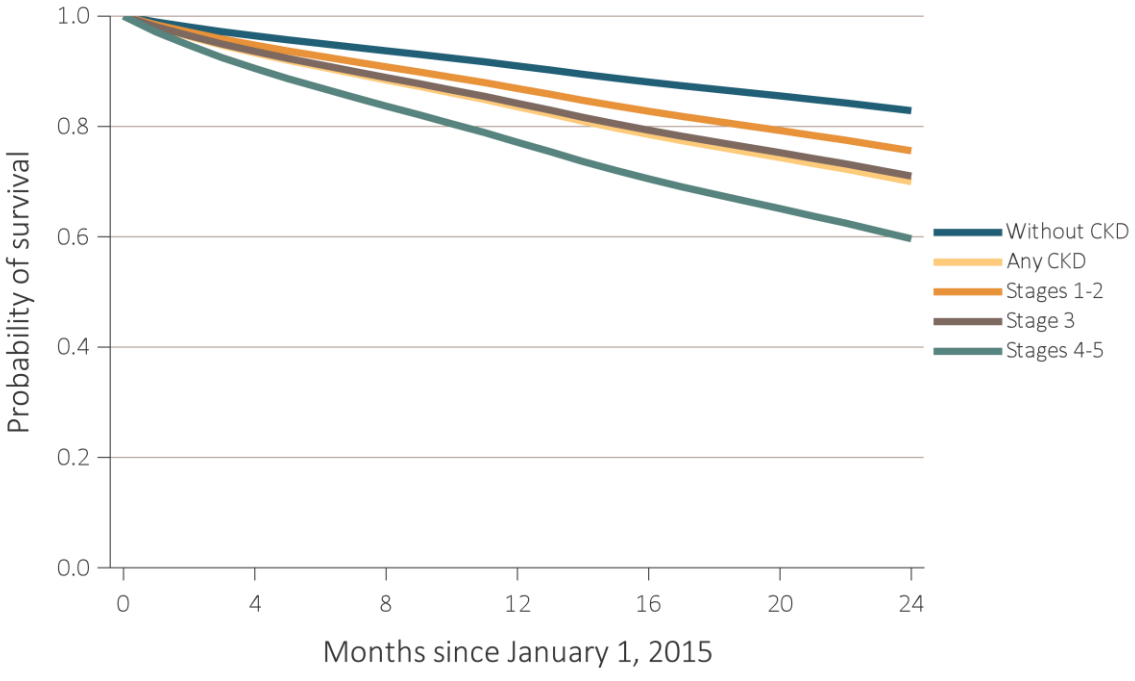


Figure 4.2 continued on next page.

vol 1 Figure 4.2 Probability of survival of patients with a prevalent cardiovascular disease, by CKD status, adjusted for age and sex, 2015-2016 (continued)

(g) Atrial fibrillation (AF)



(h) Sudden cardiac arrest and ventricular arrhythmias (SCA/VA)

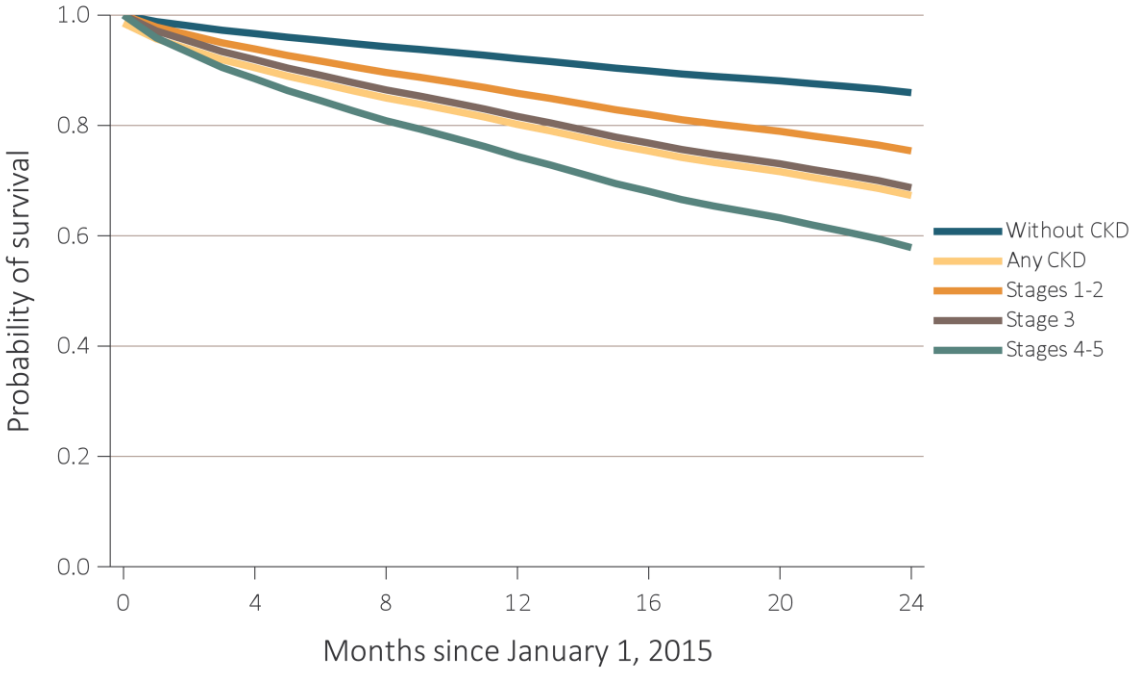
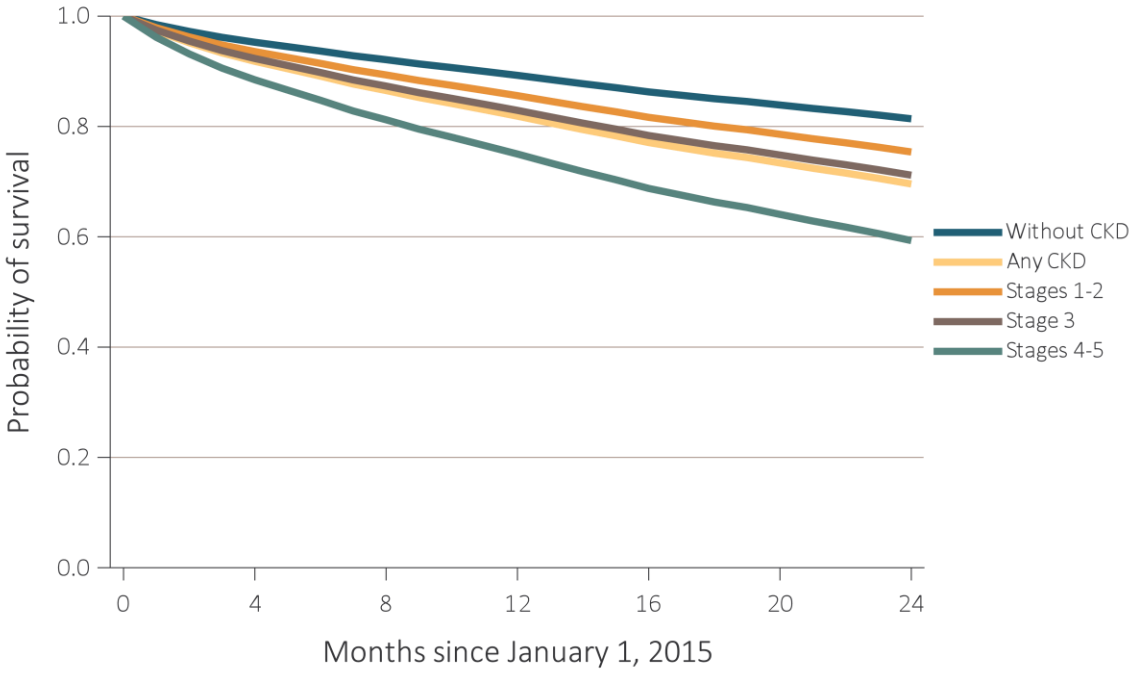


Figure 4.2 continued on next page.

vol 1 Figure 4.2 Probability of survival of patients with a prevalent cardiovascular disease, by CKD status, adjusted for age and sex, 2015-2016 (continued)

(i) Venous thromboembolism and pulmonary embolism (VTE/PE)



Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on 12/31/2014, with fee-for-service coverage for the entire calendar year. Abbreviation: CKD, chronic kidney disease.

vol 1 Table 4.2 Two-year survival of patients with a prevalent cardiovascular disease, by CKD status, adjusted for age and sex, 2015-2016

	CKD status				
Cardiovascular disease	No CKD (%)	CKD (%)	Stages 1 to 2 (%)	Stage 3 (%)	Stages 4 to 5 (%)
CAD	87.4	76.6	81.1	77.6	67.4
AMI	81.7	68.5	74.5	69.0	58.6
HF	75.6	64.6	70.2	65.8	55.7
VHD	86.3	72.1	78.2	72.8	61.1
CVA/TIA	83.3	73.2	76.8	74.6	64.1
PAD	81.3	72.3	76.4	73.6	61.7
AF	82.9	70.0	75.6	71.0	59.6
SCA/VA	86.0	68.8	75.4	68.7	57.9
VTE/PE	81.4	69.6	75.4	71.2	59.3

Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on 12/31/2014, with fee-for-service coverage for the entire calendar year. Abbreviations: AF, atrial fibrillation; AMI, acute myocardial infarction; CAD, coronary artery disease; CKD, chronic kidney disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; HF, heart failure; PAD, peripheral arterial disease; SCA/VA, sudden cardiac arrest and ventricular arrhythmias; VHD, valvular heart disease; VTE/PE, venous thromboembolism and pulmonary embolism.

vol 1 Figure 4.3 Probability of survival of patients with a cardiovascular procedure, by CKD status, adjusted for age and sex, 2014-2016

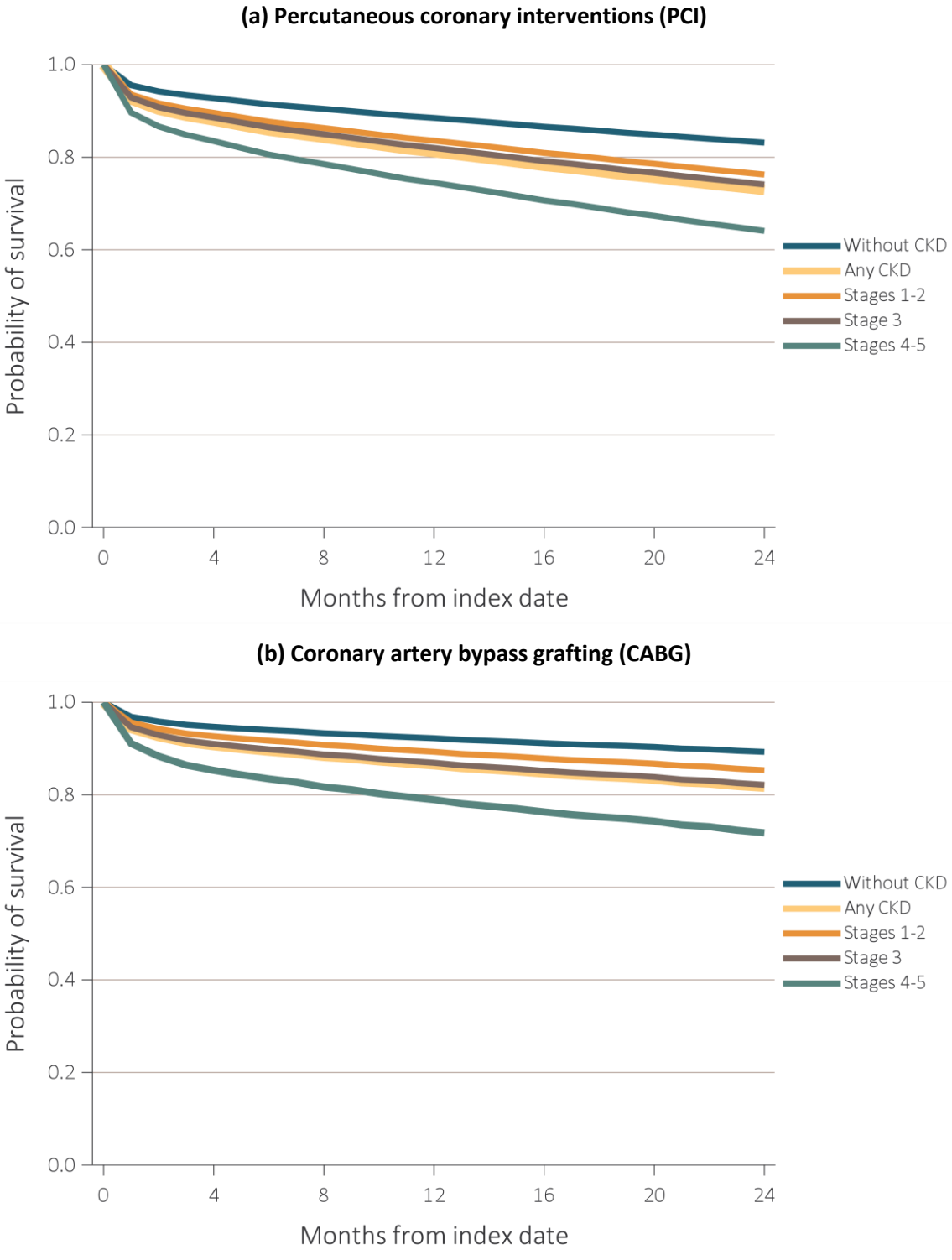
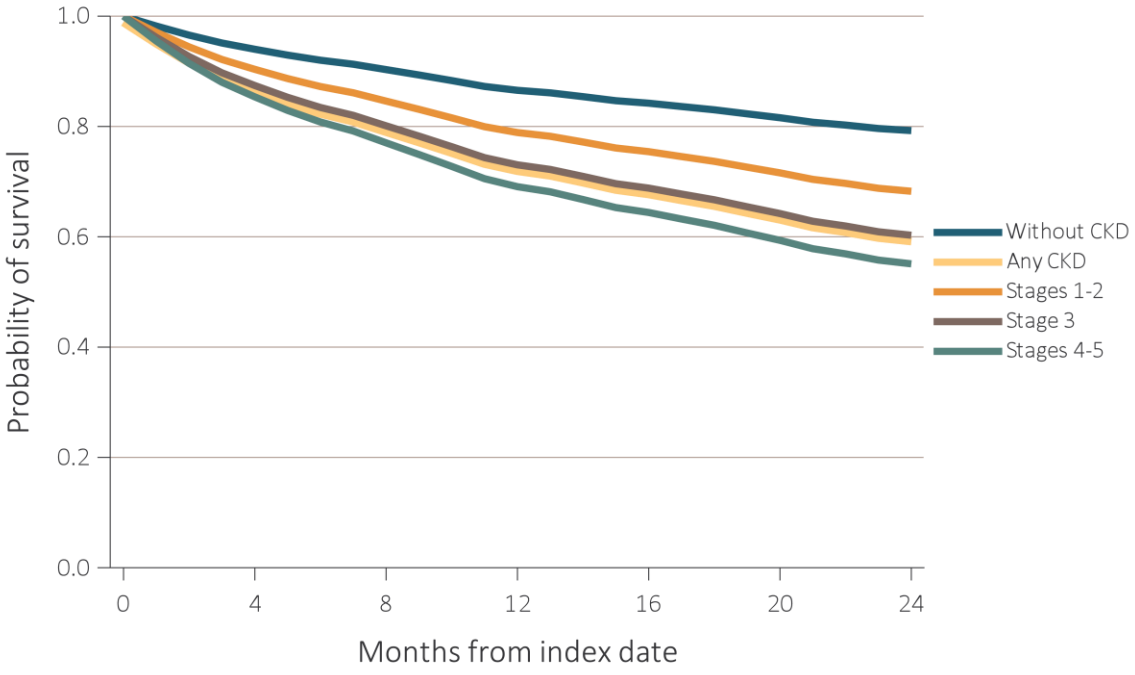


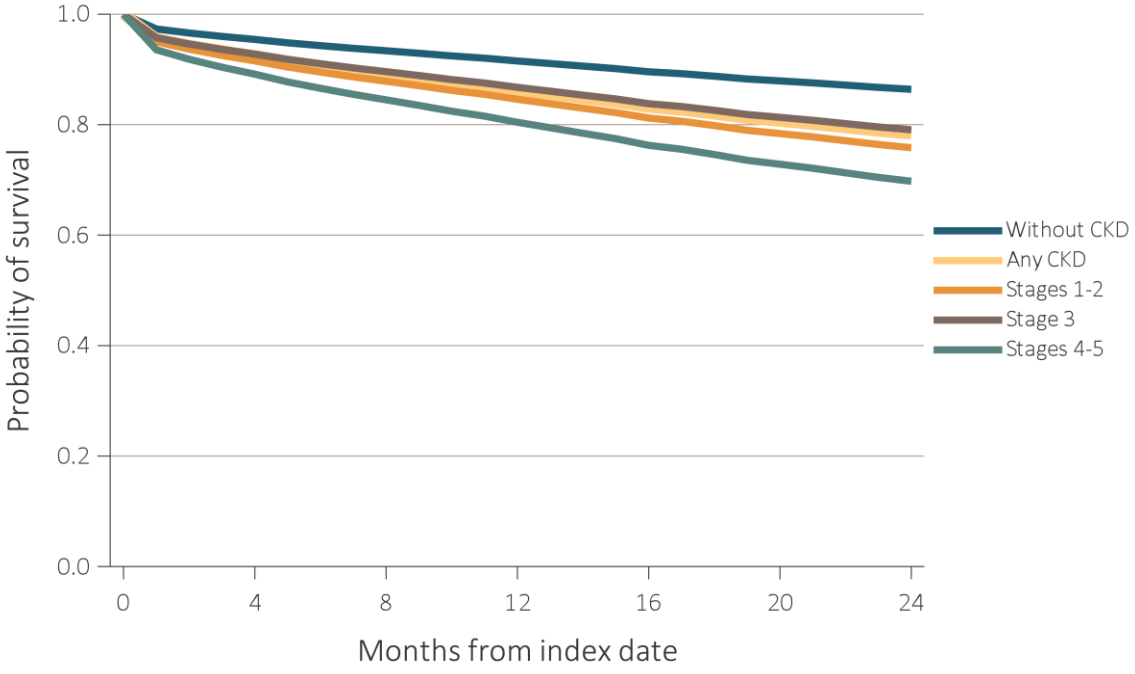
Figure 4.3 continued on next page.

vol 1 Figure 4.3 Probability of survival of patients with a cardiovascular procedure, by CKD status, adjusted for age and sex, 2014-2016 (continued)

(c) Implantable cardioverter defibrillators/cardiac resynchronization therapy with defibrillator devices (ICD/CRT-D)



(d) Carotid artery stenting and carotid endarterectomy (CAS/CEA)



Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on the index date, which was the date of the first procedure claim, with fee-for-service coverage for the entire year prior to this date. Abbreviation: CKD, chronic kidney disease.

vol 1 Table 4.3 Two-year survival of patients with a cardiovascular procedure, by CKD status, adjusted for age and sex, 2014-2016

	CKD status				
Cardiovascular procedure	No CKD (%)	CKD (%)	Stages 1 to 2 (%)	Stage 3 (%)	Stages 4 to 5 (%)
PCI	83.2	73.0	76.3	74.1	64.3
CABG	89.3	81.8	85.3	82.2	71.8
ICD/CRT-D	79.2	60.3	68.3	60.3	55.1
CAS/CEA	86.4	78.2	78.5	79.0	70.1

Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on the index date, which was the date of the first procedure claim, with fee-for-service coverage for the entire year prior to this date. Abbreviations: CABG, coronary artery bypass grafting; CAS/CEA, carotid artery stenting and carotid endarterectomy; CKD, chronic kidney disease; ICD/CRT-D, implantable cardioverter defibrillators/cardiac resynchronization therapy with defibrillator devices; PCI, percutaneous coronary interventions.

Cardiovascular Disease and Pharmacological Treatments

For clinicians, pharmacological treatment of cardiovascular disorders in the CKD population is fraught with challenges given that many drugs are cleared by the kidneys. Patients with advanced renal dysfunction are often excluded from large clinical trials, so the risk-benefit ratios of their treatment with various medications are often unclear. Angiotensin converting enzyme inhibitors (ACEs) and angiotensin receptor blockers (ARBs) are mainstays of HF therapy and are frequently prescribed to CKD patients. In 2016, these drugs were prescribed to 59.7% of CKD patients, as compared with 53.8% of non-CKD patients who also had CVD (Table 4.4). This difference may be explained in part by the fact that ACEs and ARBs are also used for their nephroprotective effects. Despite the potential clinical benefits, these drugs must be prescribed with caution in this population due to increased risk of hyperkalemia.

Warfarin dose adjustment can be more difficult among patients with CKD, and renal failure is a risk factor for bleeding while on warfarin therapy. Although direct oral anticoagulants have not been as well studied as warfarin among patients with CKD, these drugs were used quite frequently in this group, particularly for stroke prevention in the context of AF (Table 4.4). Aspirin is commonly recommended to those with cardiovascular diseases such as CAD and PAD, regardless of the patient's renal function. As it is most often purchased over the counter, however, prescribing rates for aspirin were low (<1%) for patients with all types of CVD; therefore, aspirin is omitted from Table 4.4.

vol 1 Table 4.4 Cardiovascular pharmacological treatments by (a) comorbidities and (b) procedures, by CKD status, 2016

		(a) Cardiovascular comorbidities					
		% Patients					
	# Patients	Beta-blockers	Statins	P2Y12 inhibitors	Warfarin	Direct Oral Anticoagulants	ACEs/ ARBs
Any CVD							
Without CKD	247,266	54.6	63.0	16.2	12.8	11.8	53.8
Any CKD	80,331	65.1	68.2	20.4	15.3	13.4	59.7
Coronary artery disease (CAD)							
Without CKD	119,066	65.2	75.7	26.1	9.8	9.5	59.2
Any CKD	47,197	73.0	75.7	28.7	14.8	13.0	61.8
Acute myocardial infarction (AMI)							
Without CKD	17,202	74.8	78.4	40.4	11.5	11.5	63.6
Any CKD	11,514	79.9	78.8	39.8	16.6	14.8	63.4
Heart failure (HF)							
Without CKD	47,170	70.5	60.6	16.6	18.9	16.6	61.2
Any CKD	32,658	75.6	67.3	21.7	20.5	17.1	59.9
Valvular heart disease (VHD)							
Without CKD	38,681	57.6	61.7	13.9	15.4	13.1	55.0
Any CKD	15,804	71.3	69.0	21.5	20.2	16.9	61.0
Cerebrovascular accident/transient ischemic attack (CVA/TIA)							
Without CKD	51,550	49.1	69.3	24.7	10.5	9.9	54.4
Any CKD	20,225	64.7	73.5	30.6	14.2	13.0	60.8
Peripheral artery disease (PAD)							
Without CKD	75,554	48.3	59.5	17.8	9.4	8.3	52.3
Any CKD	31,982	63.6	68.2	24.3	14.0	12.1	59.5
Atrial fibrillation (AF)							
Without CKD	73,778	67.2	57.9	8.7	34.6	33.2	51.3
Any CKD	29,174	74.0	65.7	14.2	34.8	30.9	56.8
Cardiac arrest and ventricular arrhythmias (SCA/VA)							
Without CKD	10,866	69.9	63.9	17.4	13.2	14.4	58.4
Any CKD	5,014	79.4	70.6	25.2	22.0	19.4	64.0
Venous thromboembolism and pulmonary embolism (VTE/PE)							
Without CKD	8,895	41.7	49.4	7.8	47.8	31.8	45.3
Any CKD	4,695	59.3	57.2	12.0	45.2	32.5	54.2

Table 4.4 continued on next page.

vol 1 Table 4.4 Cardiovascular pharmacological treatments by (a) comorbidities and (b) procedures, (%) by CKD status, 2016 (continued)

		(b) Cardiovascular procedures					
		% Patients					
	# Patients	Beta-blockers	Statins	P2Y12 inhibitors	Warfarin	Direct Oral Anticoagulants	ACEs/ ARBs
Revascularization – percutaneous coronary interventions (PCI)							
Without CKD	2,390	84.8	88.2	94.5	7.7	8.6	73.9
Any CKD	1,418	88.5	87.0	92.5	13.6	12.6	70.0
Revascularization – coronary artery bypass graft (CABG)							
Without CKD	1,210	92.1	90.0	39.1	17.4	12.0	68.3
Any CKD	681	92.7	90.7	38.6	21.4	16.0	70.5
Implantable cardioverter defibrillators & cardiac resynchronization therapy with defibrillator (ICD/CRT-D)							
Without CKD	337	85.2	72.1	25.2	24.9	23.7	72.7
Any CKD	345	88.4	74.5	29.3	30.1	28.7	72.5
Carotid artery stenting and carotid artery endarterectomy (CAS/CEA)							
Without CKD	1,018	56.2	82.8	50.3	7.5	11.1	63.2
Any CKD	437	71.4	87.6	54.5	12.1	11.4	65.7

Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on 12/31/2016 with fee-for-service and Part D coverage for the entire calendar year. Abbreviations: ACEs/ARBs, Angiotensin converting enzyme inhibitors and angiotensin receptor blockers; AF, atrial fibrillation; AMI, acute myocardial infarction; CAD, coronary artery disease; CABG, coronary artery bypass grafting; CAS/CEA, carotid artery stenting and carotid endarterectomy; CKD, chronic kidney disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; CVD, cardiovascular disease; HF, heart failure; ICD/CRT-D, implantable cardioverter defibrillators/cardiac resynchronization therapy with defibrillator devices; PAD, peripheral arterial disease; PCI, percutaneous coronary interventions; SCA/VA, sudden cardiac arrest and ventricular arrhythmias; VHD, valvular heart disease; VTE/PE, venous thromboembolism and pulmonary embolism.

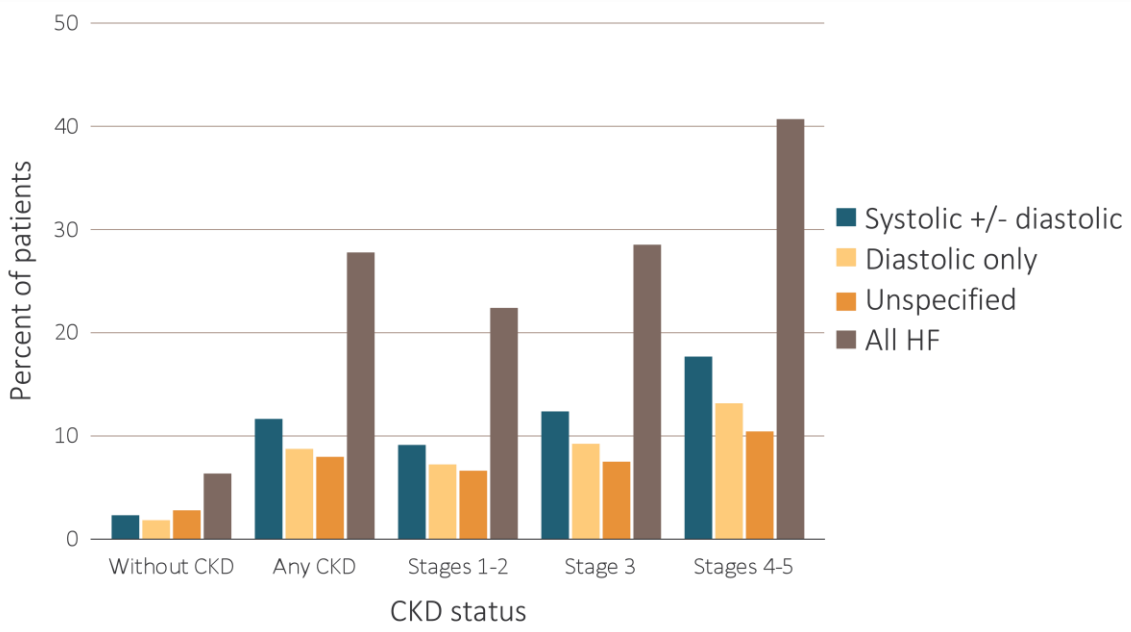
Heart Failure and CKD

Heart failure (HF) is among the more frequently diagnosed cardiovascular diseases in the CKD population. Given the critical role of the kidney in sodium and fluid handling, derangements in kidney function can have a profound impact on intracardiac filling pressures. Conversely, in the setting of heart failure when intracardiac filling pressures are elevated and/or cardiac output is reduced, venous congestion and reduced perfusion can worsen kidney function, often in a dynamic fashion. This bidirectional pathophysiologic interaction between heart and kidney, often referred to as cardiorenal syndrome (Damman and Testani, 2015), is both clinically challenging and epidemiologically important, particularly as the U.S. population ages.

In 2016, the prevalence of HF in CKD patients aged 66 and older was close to 26%, compared to 6% among patients without CKD (Table 4.1). Given its importance in this population, we further examined key characteristics of HF in CKD patients after stratifying HF based on presence or absence of left ventricular systolic dysfunction (i.e., "systolic" heart failure with decreased ejection fraction, "diastolic" heart failure with preserved ejection fraction, or unspecified; Figure 4.4). For ease of reporting and consistency with clinical approaches for categorizing the disease, systolic HF includes patients with left ventricular systolic dysfunction, regardless of the presence of concomitant diastolic dysfunction. Patients with isolated diastolic HF were treated separately, since long-term risk assessments and treatments vary for this group.

All types of HF were more common among those with CKD than among non-CKD patients. The relative proportion of CKD patients with systolic HF was higher than with diastolic HF, and increased with greater severity of CKD stage. The percentage of patients without CKD who had unspecified HF was slightly higher than for systolic or diastolic HF. For patients with CKD, the percentage with unspecified HF was slightly lower than with systolic HF (Figure 4.4).

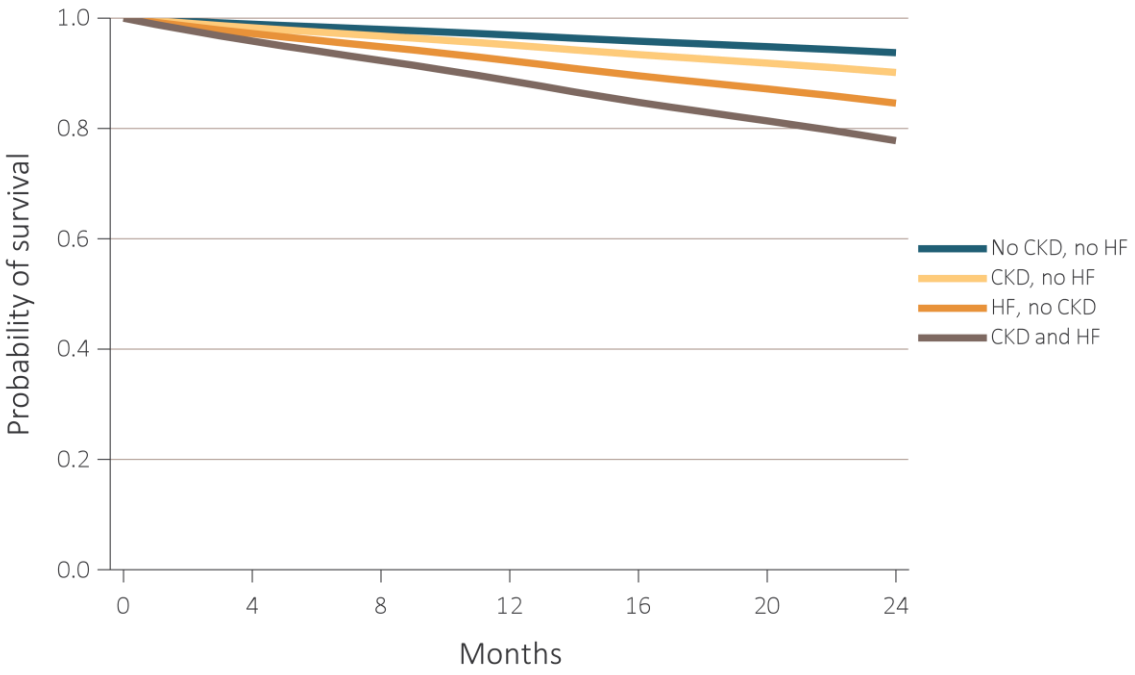
vol 1 Figure 4.4 Heart failure in patients with or without CKD, 2016



Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on 12/31/2016 with fee-for-service coverage for the entire calendar year. Abbreviation: CKD, chronic kidney disease.

The presence of HF reduced the probability of survival among patients both with and without CKD (Figure 4.5), but to a greater extent among those with CKD (p-value for interaction <0.0001). Over a two-year period, patients with both HF and CKD had an adjusted survival probability of 77.8%, as compared to 84.6% for those with HF alone, 90.2% for those with CKD alone, and 93.7% for those without HF or CKD.

vol 1 Figure 4.5 Adjusted survival of patients by CKD and heart failure status, 2015-2016



Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on 12/31/2014 with fee-for-service coverage for the entire calendar year. Survival was adjusted for age, sex, race, diabetic status, and hypertension status. Abbreviation: CKD, chronic kidney disease.

Atrial Fibrillation and CKD

Atrial fibrillation (AF) is one of the most common arrhythmias seen in the general U.S. population, and is associated with significant morbidity and mortality. Multiple comorbidities that are common among CKD patients, including hypertension, HF, diabetes mellitus, and obesity, are well-established risk factors for AF. Cardiac structural changes accompanying these disease states, including left ventricular hypertrophy, atrial dilation, and atrial fibrosis, have been implicated in the pathophysiology of AF (Lau et al., Circulation 2017). The prevalence of AF among CKD patients is high, being present in approximately one-quarter of the population.

In 2016, the prevalence of AF increased with more advanced stages of CKD, age, male sex, white race, hypertension, and heart failure (Table 4.5). In patients with CKD, the presence of HF increased the prevalence of AF to about half of all patients. Patients with AF and CKD have an increased risk of stroke and bleeding, making the use of oral anticoagulants challenging, as demonstrated by recent reports. Warfarin was prescribed to 34.6% of patients without CKD and 34.8% of patients with CKD, while direct oral anticoagulants were prescribed to 33.2% of patients without CKD and 30.9% of patients with CKD (Table 4.4).

vol 1 Table 4.5 Prevalence of atrial fibrillation by stage of CKD, age, race, sex, and diabetic, hypertension, and heart failure status, 2016

	No CKD	CKD stage				
		Stages 1-2	Stage 3	Stages 4-5	Unknown stage	All CKD stages
# Patients	1,086,232	18,750	88,322	14,833	53,935	175,840
Atrial fibrillation (Overall)	9.8	21.3	25.4	28.3	20.9	23.8
Age						
66-69	4.4	11.9	15.5	17.8	11.3	13.5
70-74	7.0	15.9	18.4	22.0	15.4	17.3
75-84	12.5	23.2	26.1	28.3	23.7	25.3
85+	19.8	32.4	34.0	35.6	32.7	33.7
Sex						
Male	11.2	24.1	28.2	30.8	22.4	26.1
Female	8.7	18.5	22.8	26.3	19.2	21.6
Race						
White	10.5	23.1	27.1	30.8	22.2	25.5
Black/African American	4.8	13.9	15.7	18.3	12.7	15.0
Other	5.3	13.9	16.9	19.1	13.3	15.6
Comorbidity						
No diabetes	9.0	21.0	25.2	28.1	20.2	23.4
Diabetes	12.9	21.7	25.6	28.5	21.6	24.3
No hypertension	4.0	9.8	14.3	15.5	8.6	11.0
Hypertension	14.3	22.5	26.2	28.9	23.3	25.2
No heart failure	7.5	13.4	15.1	15.0	13.7	14.4
Heart failure	44.6	50.0	51.8	48.2	49.4	50.6

Data Source: Special analyses, Medicare 5% sample. Patients aged 66 and older, alive, without end-stage renal disease, and residing in the United States on 12/31/2016 with fee-for-service coverage for the entire calendar year. Abbreviation: CKD, chronic kidney disease.

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