

# Chapter 8: Cardiovascular Disease in Patients with ESRD

- Cardiovascular disease (CVD) is common in adult end-stage renal disease (ESRD) patients, with coronary artery disease (CAD) and heart failure (HF) being the most common conditions (Table 8.1).
- Even relatively young ESRD patients—those aged 22-44 and 45-64 years—are likely to suffer from cardiovascular disease (Figures 8.2.a and 8.2.b).
- The presence of cardiovascular diseases is associated with both worse short and long-term survival in adult ESRD patients (Figure 8.3).
- Only about two-thirds of dialysis or transplant patients with acute myocardial infarction (AMI) received beta-blocker medication. Similarly, among ESRD patients with HF, fewer than half received angiotensin converting enzyme inhibitors (ACEIs) and angiotensin receptor blockers (ARBs). Although many ESRD patients with atrial fibrillation (AF) are at elevated risk of stroke, only about one-third of dialysis patients with AF were treated with warfarin (Table 8.4).

## Introduction

Patients with end-stage renal disease (ESRD) are among the highest risk populations for cardiovascular diseases (CVDs)—a major cause of death in ESRD patients. The relationship between kidney disease and CVD is complex and bidirectional, and close attention to CVD is vital to the care of these patients. The presence of ESRD often complicates disease management of CVD, as it can influence both medical and procedural options, thereby adversely affecting a patient’s prognosis.

The high prevalence of acute myocardial infarction (AMI), coronary artery disease (CAD), heart failure (HF), and sudden death/cardiac arrhythmias should draw more attention of kidney disease researchers and clinicians. Improving outcomes in this complex patient population remains challenging, and the presence of ESRD should not detract health care practitioners from delivering the high quality cardiovascular care that they deserve.

This chapter provides an overview of CVDs among adult ESRD patients, using administrative claims data from Medicare. We focus on reporting the prevalence and outcomes of diagnosed major cardiovascular conditions, stratifying by type of renal replacement

therapy (RRT) being received—hemodialysis (HD), peritoneal dialysis (PD), or kidney transplantation. For individual conditions, we compare the survival of ESRD patients with and without cardiovascular diseases. Given the role of Medicare as the primary health care payer for ESRD patients, our analyses are based primarily on data from the national Medicare population.

## Methods

The findings presented in this chapter were drawn from data sources from the Centers for Medicare & Medicaid Services (CMS). Details of these are described in the [Data Sources section](#) of the [ESRD Analytical Methods](#) chapter.

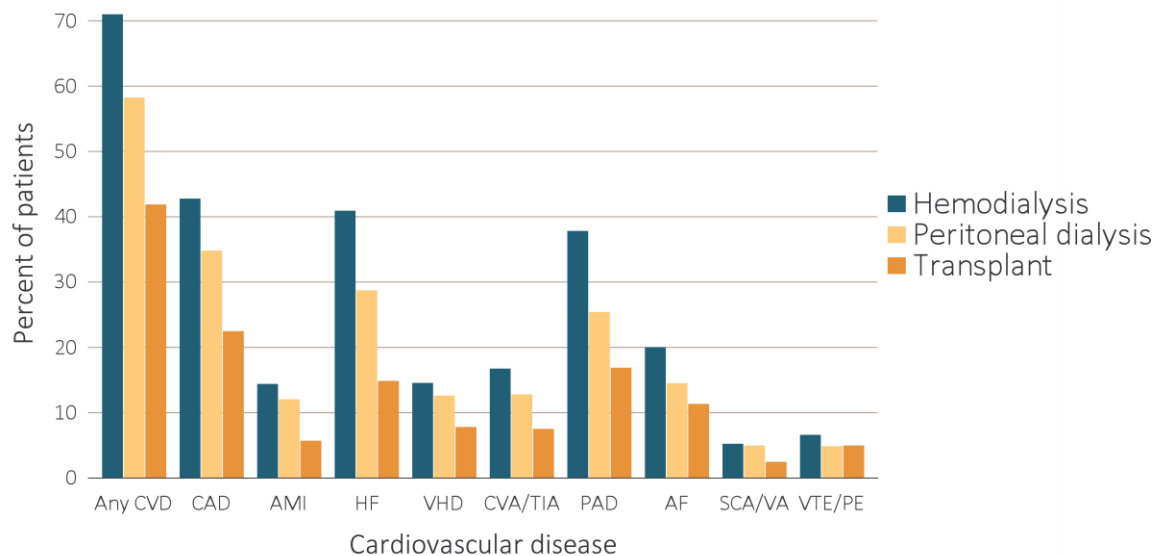
See the section addressing [Chapter 8](#) in the ESRD Analytical Methods chapter for an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter. Downloadable Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available on the [USRDS website](#).

## Cardiovascular Disease Prevalence in ESRD Patients

As expected from findings in previous Annual Data Reports, in 2016 ESRD patients had a high burden of CVD across a wide range of conditions (Figure 8.1). Mechanisms by which ESRD increases CVD risk include metastatic calcification, alterations in sodium and fluid balance, and exacerbation of inflammatory processes including atherosclerosis. Stable CAD and HF were the two most common CVDs present in adult ESRD patients. However, acute myocardial infarction

(AMI), valvular heart disease (VHD), cerebrovascular accident/transient ischemic attack (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) were also common. Aortic stenosis, in particular, may progress more aggressively in ESRD patients than in those without kidney disease (Kim et al., 2016). In general, the prevalence of these cardiovascular diseases was highest among ESRD patients who received HD (70.6%), followed by PD (57.8%), and those with kidney transplants (41.4%).

vol 2 Figure 8.1 Prevalence of cardiovascular diseases in adult ESRD patients, by treatment modality, 2016

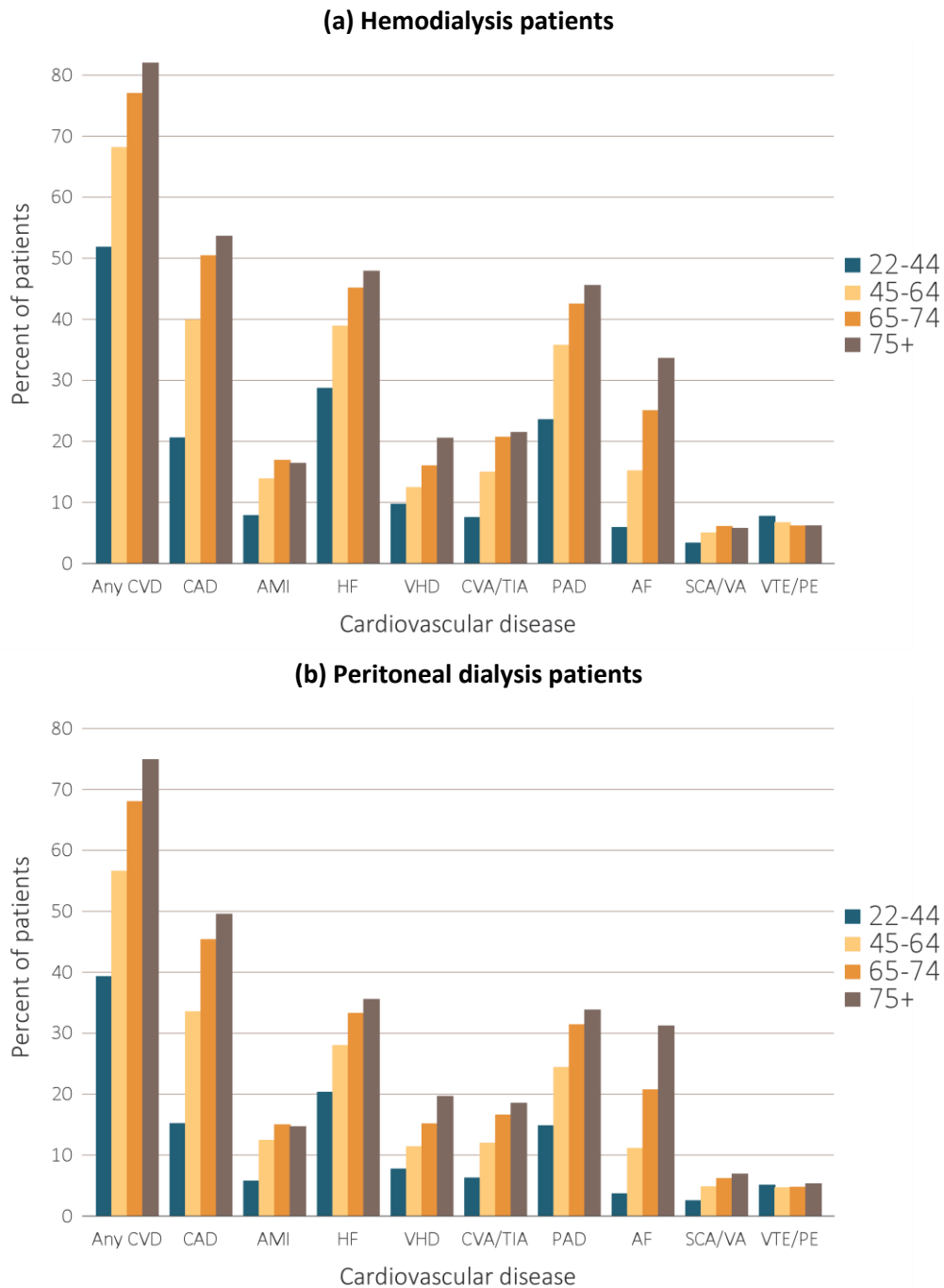


Data Source: Special analyses, USRDS ESRD Database. Point prevalent hemodialysis, peritoneal dialysis, and transplant patients aged 22 and older, who are continuously enrolled in Medicare Parts A and B, and with Medicare as primary payer from January 1, 2016 to December 31, 2016, and ESRD service date is at least 90 days prior to January 1, 2016. Abbreviations: AF, atrial fibrillation; AMI, acute myocardial infarction; CAD, coronary artery disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; CVD, cardiovascular disease; ESRD, end-stage renal 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.

Peritoneal dialysis patients had a lower burden of certain cardiovascular conditions, including CAD, HF, and PAD, as compared to their HD counterparts. Older ESRD patients tended to have a higher prevalence of cardiovascular conditions than did younger patients, whether they were receiving HD or PD (Figures 8.2.a and 8.2.b). It is notable that the prevalence of these conditions was high even among HD patients 22-44 years of age (51.4%), although a

much higher prevalence was observed among those 45 years or older (67.8% to 81.6%). The same pattern was true for PD patients. CAD was the most common condition, with a prevalence exceeding 50% in HD patients aged 65 years and older, followed by CHF, PAD, AFIB, CVA/TIA, and VHD. The presence of VTE/PE did not vary as much by age for either HD or PD patients.

vol 2 Figure 8.2 Prevalence of cardiovascular diseases in adult ESRD patients, by age, 2016



Data Source: Special analyses, USRDS ESRD Database. Point prevalent hemodialysis and peritoneal dialysis patients aged 22 and older, who are continuously enrolled in Medicare Parts A and B, and with Medicare as primary payer from January 1, 2016 to December 31, 2016, and ESRD service date is at least 90 days prior to January 1, 2016. Abbreviations: AF, atrial fibrillation; AMI, acute myocardial infarction; CAD, coronary artery disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; CVD, cardiovascular disease; ESRD, end-stage renal disease; HD, hemodialysis; HF, heart failure; PAD, peripheral arterial disease; PD, peritoneal dialysis; SCA/VA, sudden cardiac arrest and ventricular arrhythmias; VHD, valvular heart disease; VTE/PE, venous thromboembolism and pulmonary embolism.

In Table 8.1, we present the relationships between age, race, and sex, and prevalent CVDs in adult ESRD patients. As noted earlier, older age was associated with higher prevalence of cardiovascular conditions. However, the relationships with race and sex were less definitive. The prevalence of major procedures for treating CVD in ESRD patients is also reported in Table

8.1, including percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), placement of implantable cardioverter defibrillators (ICD) and cardiac resynchronization therapy with defibrillator (CRT-D) devices, and carotid artery stenting (CAS) and carotid endarterectomy (CEA). The prevalence of CAS/CEA was low in ESRD patients relative to other major procedures.

vol 2 Table 8.1 Prevalence of (a) cardiovascular comorbidities & (b) cardiovascular procedures in adult ESRD patients, by treatment modality, age, race, & sex, 2016

(a) Cardiovascular comorbidities														
	# Patients	Percentage of patients (%)												
		Overall	22-44	45-64	65-74	75+	White	Black	AI/AN	Asian	NH/PI	Other	Male	Female
<b>Any CVD</b>														
Hemodialysis	218,720	70.6	51.4	67.8	76.6	81.6	66.9	61.3	72.7	68.3	67.1	52.0	68.9	72.7
Peritoneal dialysis	22,023	57.7	38.7	56.2	67.6	74.5	49.8	51.3	60.0	54.5	51.1	35.0	60.7	54.3
Transplant	75,313	41.4	17.9	37.2	55.2	65.7	33.8	40.1	42.6	39.7	37.0	28.0	43.6	38.2
<b>Coronary artery disease (CAD)</b>														
Hemodialysis	218,720	42.3	20.2	39.5	50.0	53.2	41.8	34.3	46.2	37.5	39.0	29.5	42.6	42.0
Peritoneal dialysis	22,023	34.4	14.8	33.1	45.0	49.1	29.5	25.8	37.4	28.6	31.9	15.0	39.2	28.7
Transplant	75,313	22.1	5.6	19.2	31.7	38.0	19.5	21.8	23.3	19.0	19.4	12.0	24.9	17.9
<b>Acute myocardial infarction (AMI)</b>														
Hemodialysis	218,720	14.0	7.5	13.5	16.5	16.0	13.3	11.5	15.3	12.3	12.0	7.0	14.0	14.0
Peritoneal dialysis	22,023	11.6	5.4	12.0	14.6	14.3	8.4	8.8	12.8	9.5	12.8	10.0	13.3	9.7
Transplant	75,313	5.3	1.6	4.8	7.3	8.4	3.3	4.9	5.8	4.3	3.0	4.0	5.9	4.3
<b>Heart failure (HF)</b>														
Hemodialysis	218,720	40.4	28.3	38.5	44.7	47.5	35.8	32.8	40.8	40.8	38.6	27.3	38.5	43.1
Peritoneal dialysis	22,023	28.3	19.9	27.6	32.7	35.2	23.4	22.5	28.3	29.5	23.4	20.0	29.3	26.9
Transplant	75,313	14.4	6.0	12.4	19.5	24.9	11.4	12.7	14.1	16.2	10.9	12.7	14.8	13.9
<b>Valvular heart disease (VHD)</b>														
Hemodialysis	218,720	14.1	9.3	12.1	15.6	20.1	13.6	9.6	15.4	12.7	12.0	10.1	13.0	15.6
Peritoneal dialysis	22,023	12.2	7.3	11.0	14.7	19.3	10.0	9.2	13.0	10.9	8.5	10.0	12.0	12.4
Transplant	75,313	7.4	2.2	5.4	10.9	16.0	6.2	4.6	7.9	6.3	7.8	6.7	7.1	7.8
<b>Cerebrovascular accident/transient ischemic attack (CVA/TIA)</b>														
Hemodialysis	218,720	16.3	7.1	14.6	20.3	21.1	15.1	11.4	16.5	16.4	12.6	8.8	14.9	18.2
Peritoneal dialysis	22,023	12.4	5.9	11.6	16.2	18.1	9.4	6.3	13.3	11.1	10.6	15.0	12.2	12.5
Transplant	75,313	7.1	1.9	5.6	10.6	13.4	6.0	6.5	7.3	6.8	6.3	7.3	7.0	7.2
<b>Peripheral artery disease (PAD)</b>														
Hemodialysis	218,720	37.4	23.2	35.3	42.1	45.2	30.5	31.9	39.0	36.0	34.9	25.6	37.0	37.9
Peritoneal dialysis	22,023	25.0	14.4	24.0	31.0	33.4	17.2	23.8	27.0	21.9	14.9	25.0	26.9	22.8
Transplant	75,313	16.5	6.2	14.9	22.1	26.5	11.6	17.6	16.9	16.0	16.0	10.0	18.1	14.1
<b>Atrial fibrillation (AF)</b>														
Hemodialysis	218,720	19.6	5.5	14.8	24.6	33.2	19.3	11.3	23.2	15.1	16.3	7.9	20.2	18.9
Peritoneal dialysis	22,023	14.1	3.3	10.7	20.3	30.8	12.5	7.1	16.4	9.2	8.5	15.0	16.8	10.9
Transplant	75,313	10.9	1.6	7.3	17.2	27.1	8.0	7.4	12.3	7.8	7.2	4.7	12.2	9.0
<b>Cardiac arrest and ventricular arrhythmias (SCA/VA)</b>														
Hemodialysis	218,720	4.8	2.9	4.6	5.7	5.4	3.6	2.6	4.8	5.0	3.5	2.2	5.2	4.3
Peritoneal dialysis	22,023	4.6	2.1	4.4	5.8	6.5	3.4	2.9	4.6	4.7	2.1	5.0	5.4	3.6
Transplant	75,313	2.0	0.6	1.6	3.1	3.8	1.5	1.5	2.1	2.0	2.7	2.0	2.3	1.6
<b>Venous thromboembolism and pulmonary embolism (VTE/PE)</b>														
Hemodialysis	218,720	6.2	7.3	6.3	5.8	5.8	4.0	3.3	5.4	7.5	6.3	4.4	5.5	7.1
Peritoneal dialysis	22,023	4.4	4.7	4.3	4.3	4.9	1.7	3.8	4.2	5.7	4.3	5.0	4.0	5.0
Transplant	75,313	4.6	3.3	4.1	5.6	6.0	1.7	3.2	4.4	5.7	2.9	4.0	4.6	4.4

Table 8.1 continued on next page.

vol 2 Table 8.1 Prevalence of (a) cardiovascular comorbidities & (b) cardiovascular procedures in adult ESRD patients, by treatment modality, age, race, & sex, 2016 (continued)

(b) Cardiovascular procedures														
	# Patients	Percentage of patients (%)												
		Overall	22-44	45-64	65-74	75+	White	Blk/Af Am	AI/AN	Asian	NH/PI	Other	Male	Female
<b>Revascularization – percutaneous coronary interventions (PCI)</b>														
Hemodialysis	92,625	4.9	4.4	5.6	5.0	3.6	4.8	5.6	5.1	4.5	6.1	7.5	5.0	4.8
Peritoneal dialysis	7,570	6.1	6.1	6.9	5.7	5.2	4.5	0.0	6.6	5.1	13.3	0.0	6.5	5.6
Transplant	16,615	3.3	4.2	3.5	3.1	2.9	3.2	2.3	3.5	2.4	2.0	11.1	3.4	3.1
<b>Revascularization – coronary artery bypass graft (CABG)</b>														
Hemodialysis	92,625	1.7	1.7	2.4	1.7	0.7	1.6	1.7	1.9	1.4	1.7	0.0	2.1	1.3
Peritoneal dialysis	7,570	3.4	2.8	3.9	4.1	1.4	2.8	8.1	3.6	2.7	6.7	0.0	3.9	2.5
Transplant	16,615	1.0	0.4	1.1	1.1	0.6	1.3	1.2	1.1	0.5	1.0	0.0	1.1	0.8
<b>Implantable cardioverter defibrillators &amp; cardiac resynchronization therapy with defibrillator devices (ICD/CRT-D)</b>														
Hemodialysis	88,377	0.9	0.9	1.0	1.0	0.7	0.6	1.0	1.0	0.9	1.1	1.6	1.2	0.6
Peritoneal dialysis	6,181	1.1	0.6	1.2	1.3	0.8	1.4	1.9	1.2	0.8	9.1	0.0	1.4	0.7
Transplant	10,851	0.8	0.1	0.7	0.9	1.0	1.0	0.0	0.8	0.6	0.0	5.3	1.0	0.4
<b>Carotid artery stenting and carotid artery endarterectomy (CAS/CEA)</b>														
Hemodialysis	130,581	0.4	0.1	0.3	0.5	0.4	0.2	0.4	0.5	0.2	0.0	0.0	0.4	0.4
Peritoneal dialysis	10,445	0.6	0.1	0.4	0.9	0.6	0.0	2.0	0.6	0.4	0.0	0.0	0.6	0.5
Transplant	24,331	0.4	0.1	0.2	0.5	0.6	0.3	0.8	0.5	0.2	0.0	3.3	0.5	0.3

Data Source: Special analyses, USRDS ESRD Database. Point prevalent hemodialysis, peritoneal dialysis, and transplant patients aged 22 and older, who are continuously enrolled in Medicare Parts A and B, and with Medicare as primary payer from January 1, 2016 to December 31, 2016, and ESRD service date is at least 90 days prior to January 1, 2016. (a) The denominators for all cardiovascular comorbidities are patients described above by modality. (b) The denominators for PCI and CABG are patients with CAD by modality. The denominator for ICD/CRT-D is patients with HF by modality. The denominator for CAS/CEA is patients with CAD, CVA/TIA, or PAD by modality. \*Values for cells with 10 or fewer patients are suppressed. Abbreviations: AF, atrial fibrillation; AI/AN, American Indian or Alaska Native; 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 artery endarterectomy; CVA/TIA, cerebrovascular accident/transient ischemic attack; CVD, cardiovascular disease; ESRD, end-stage renal disease; HF, heart failure; ICD/CRT-D, implantable cardioverter defibrillators/cardiac resynchronization therapy with defibrillator devices; NH/PI, Native Hawaiian or Pacific Islander; 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.

The presence of CVDs is known to increase short- and long-term mortality for ESRD patients. For example, in a classic study from the USRDS by Herzog et al. in 1998, one-year mortality after AMI approached 60% in patients on long-term dialysis. Figures 8.3.a through 8.3.i and Table 8.2 illustrate adjusted two-year survival in adult ESRD patients with and without individual CVDs. Figures 8.4.a through 8.4.d and Table 8.3 illustrate adjusted two-year survival in adult ESRD patients with and without completed cardiovascular procedures.

In general, ESRD patients have lower survival when CVD conditions are present. A pattern of lower survival was observed in those who underwent PCI, ICD/CRT-D placement (Figures 8.4.a and 8.4.c), and CAS/CEA (Figure 8.4.d), but survival appeared similar between patients who had CABG procedures, (Figure 8.4.b) and those who did not.

We compared the probability of survival of ESRD patients who underwent PCI and CABG with those who did not have these procedures, among patients with CAD (Figures 8.4.a and 8.4.b). ESRD patients with HF who underwent ICD/CRT-D placement were compared with those who did not have this procedure (Figure 8.4.c). We also compared ESRD patients with CAD, CVA/TIA, or PAD who underwent CAS/CEA with those who did not have these procedures (Figure 8.4.d). Patients who underwent PCI, ICD-CRT-D placement, and CAS/CEA had higher mortality rates than patients who did not undergo these procedures, while those who underwent CABG had a lower mortality rate than non-CABG patients. However, these descriptive results in the adult ESRD population are observational and require careful interpretation. Comparative effectiveness research with appropriate statistical methods would be necessary to evaluate whether these procedures improve or worsen patient prognoses.

**vol 2 Figure 8.3 Probability of survival of adult ESRD patients with or without a cardiovascular disease, adjusted for age and sex, 2015-2016**

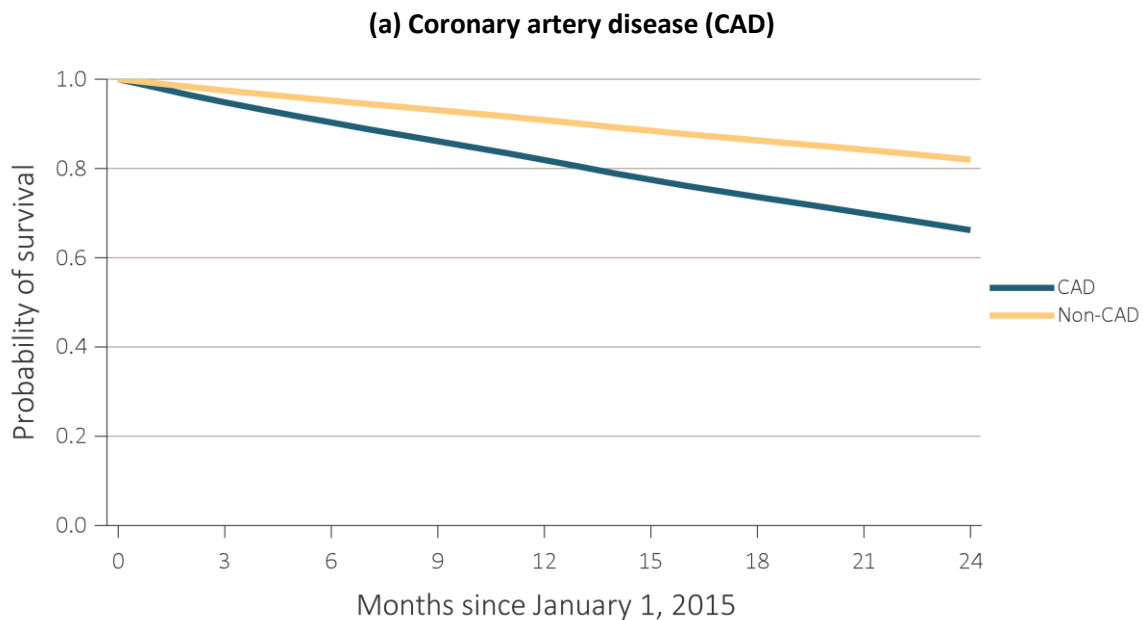


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vol 2 Figure 8.3 Probability of survival of adult ESRD patients with or without a cardiovascular disease, adjusted for age and sex, 2015-2016 (continued)

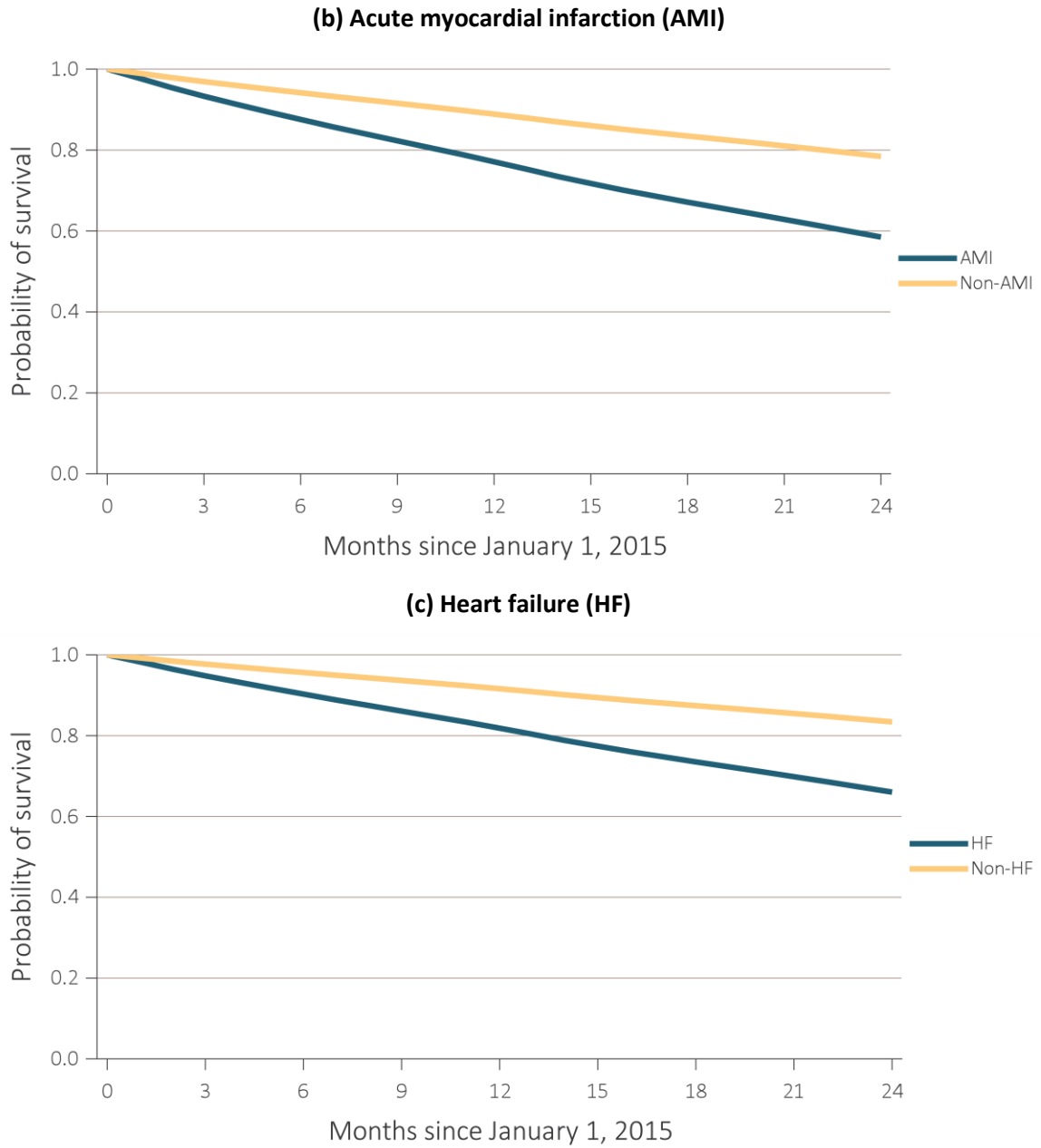


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vol 2 Figure 8.3 Probability of survival of adult ESRD patients with or without a cardiovascular disease, adjusted for age and sex, 2015-2016 (continued)

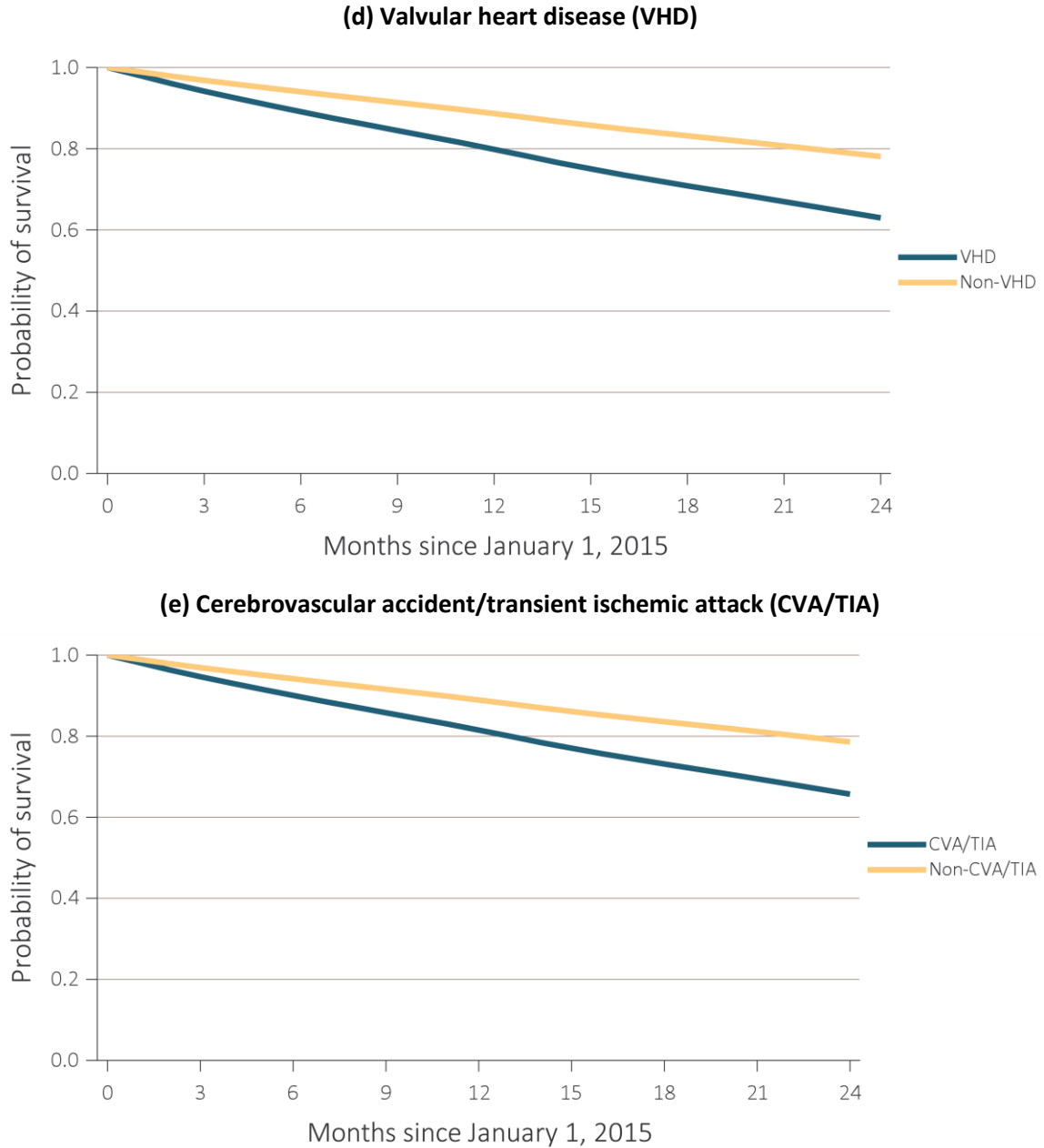


Figure 8.3 continued on next page.



vol 2 Figure 8.3 Probability of survival of adult ESRD patients with or without a cardiovascular disease, adjusted for age and sex, 2015-2016 (continued)

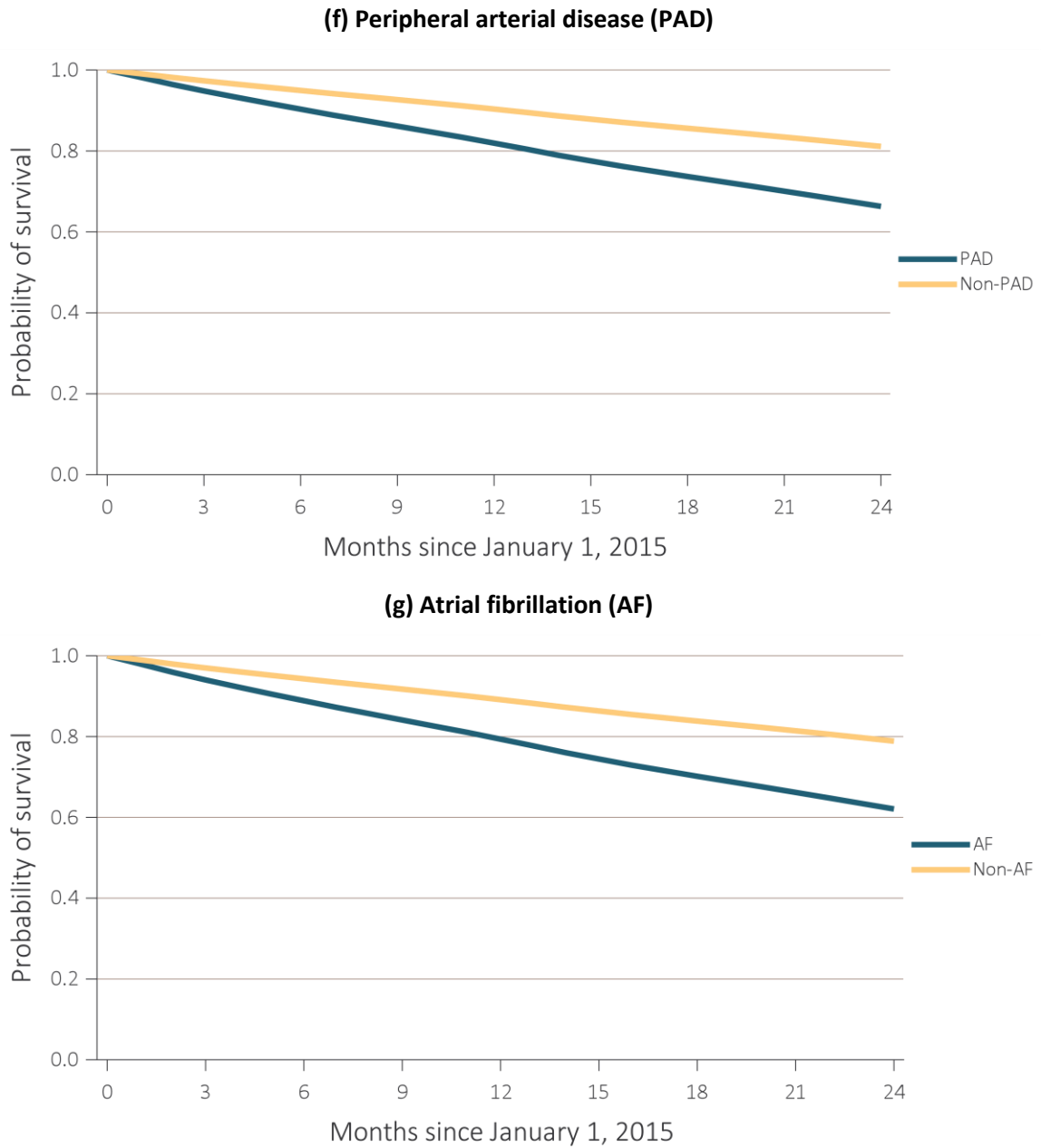
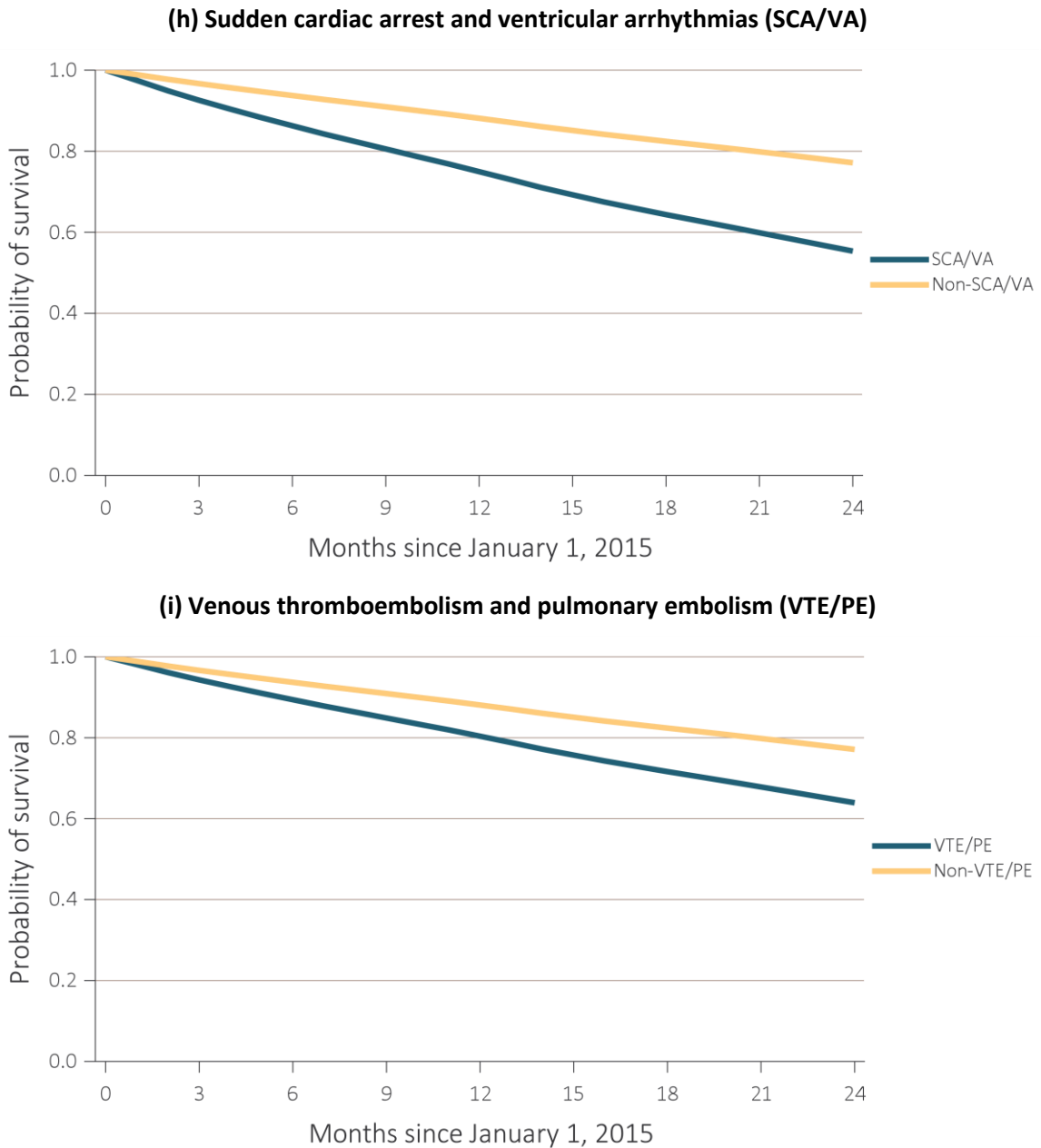


Figure 8.3 continued on next page.

vol 2 Figure 8.3 Probability of survival of adult ESRD patients with or without a cardiovascular disease, adjusted for age and sex, 2015-2016 (continued)



Data Source: Special analyses, USRDS ESRD Database. Point prevalent hemodialysis, peritoneal dialysis, and transplant patients aged 22 and older, who are continuously enrolled in Medicare Parts A and B, and with Medicare as primary payer from January 1, 2014 to December 31, 2014, and whose first ESRD service date is at least 90 days prior to January 1, 2014, and survived past 2014. Abbreviations: AF, atrial fibrillation; AMI, acute myocardial infarction; CAD, coronary artery disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; ESRD, end-stage renal 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.

vol 2 Table 8.2 Two-year survival of adult ESRD patients with or without a cardiovascular disease, adjusted for age and sex, 2015-2016

Cardiovascular disease	Presence of cardiovascular disease	
	Survival when present (%)	Survival when not present (%)
CAD	66.2	82.0
AMI	58.5	78.4
HF	66.0	83.4
VHD	63.0	78.1
CVA/TIA	65.7	78.6
PAD	66.3	81.1
AF	62.1	78.9
SCA/VA	55.3	77.2
VTE/PE	63.9	77.1

Data Source: Special analyses, USRDS ESRD Database. Point prevalent hemodialysis, peritoneal dialysis, and transplant patients aged 22 and older, who are continuously enrolled in Medicare Parts A and B, and with Medicare as primary payer from January 1, 2014 to December 31, 2014, and whose first ESRD service date is at least 90 days prior to January 1, 2014, and survived past 2014. Abbreviations: AF, atrial fibrillation; AMI, acute myocardial infarction; CAD, coronary artery disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; ESRD, end-stage renal 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.

vol 2 Figure 8.4 Probability of survival of adult ESRD patients with or without a completed cardiovascular procedure, adjusted for age and sex, 2015-2016

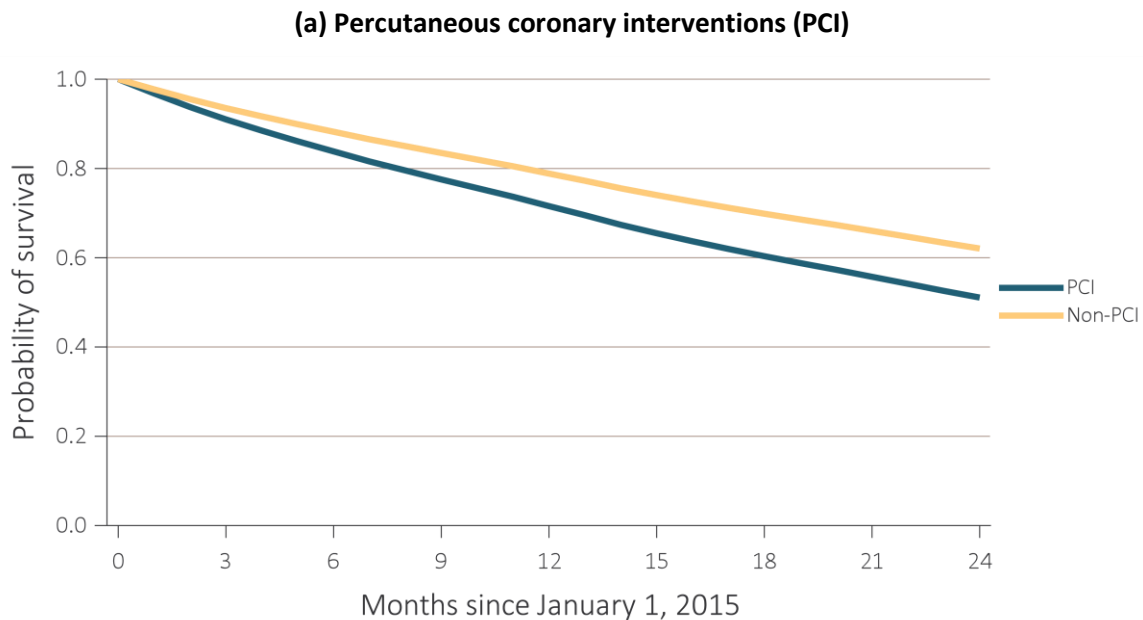
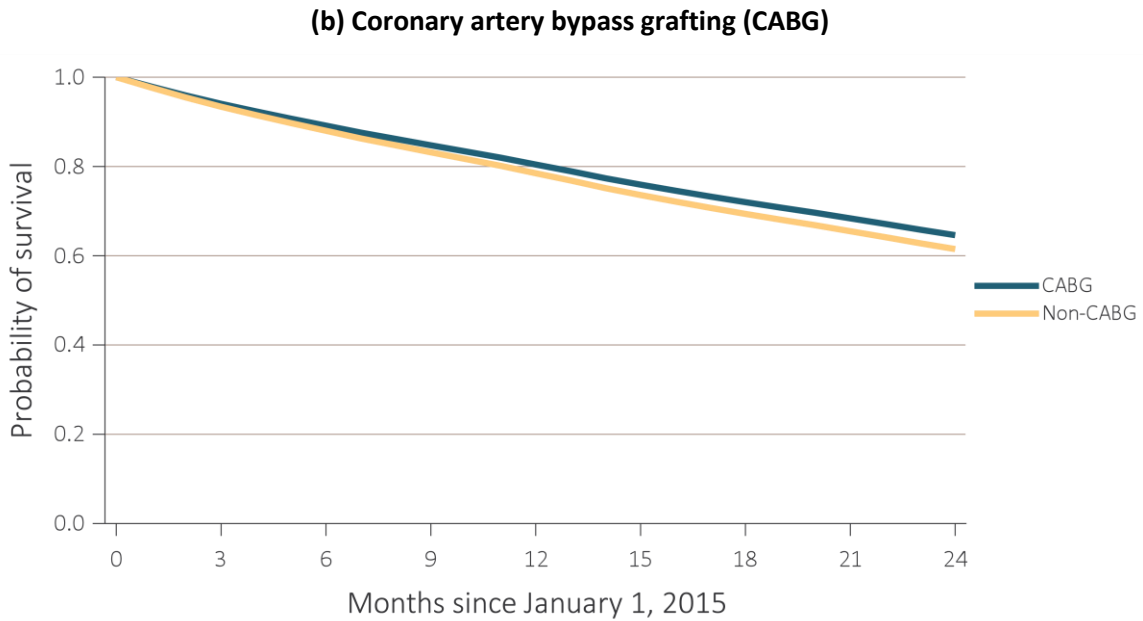


Figure 8.4 continued on next page.

vol 2 Figure 8.4 Probability of survival of adult ESRD patients with or without a completed cardiovascular procedure, adjusted for age and sex, 2015-2016 (continued)



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

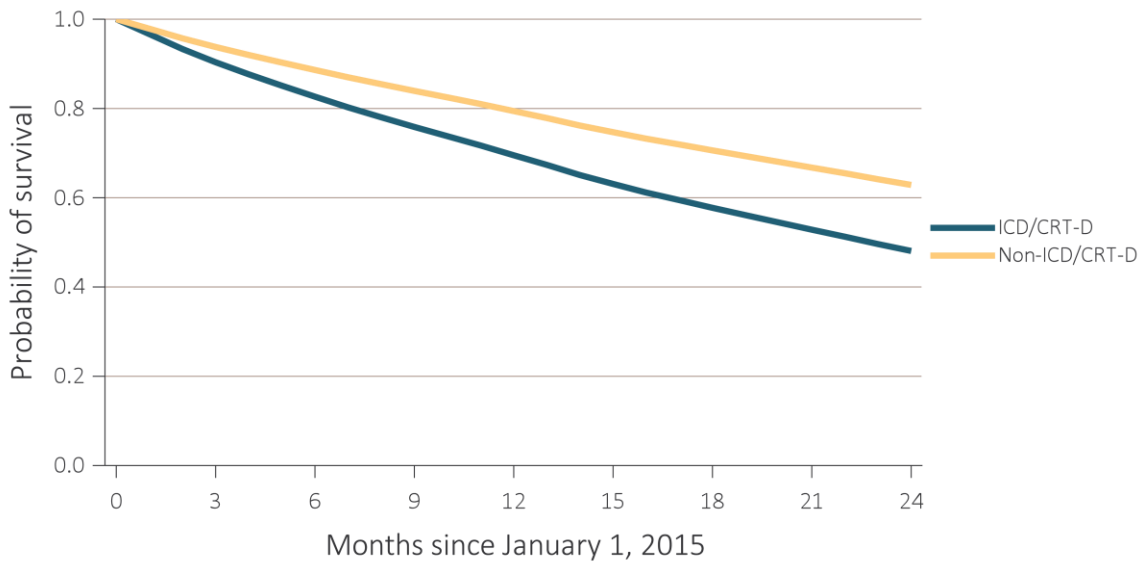
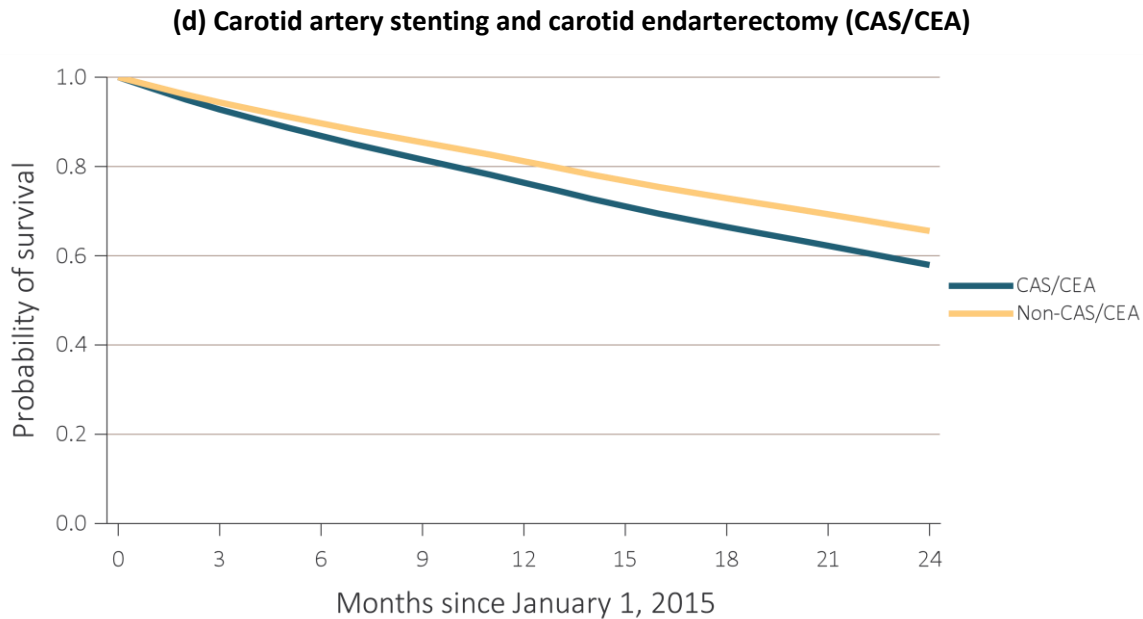


Figure 8.4 continued on next page.

vol 2 Figure 8.4 Probability of survival of adult ESRD patients with or without a completed cardiovascular procedure, adjusted for age and sex, 2015-2016 (continued)



Data Source: Special analyses, USRDS ESRD Database. Point prevalent hemodialysis, peritoneal dialysis, and transplant patients aged 22 and older, who are continuously enrolled in Medicare Parts A and B, and with Medicare as primary payer from January 1, 2014 to December 31, 2014, and whose first ESRD service date is at least 90 days prior to January 1, 2014, and survived past 2014. Abbreviations: CABG, coronary artery bypass grafting; CAS/CEA, carotid artery stenting and carotid artery endarterectomy; ICD/CRT-D, implantable cardioverter defibrillators/cardiac resynchronization therapy with defibrillator devices; PCI, percutaneous coronary interventions.

vol 2 Table 8.3 Two-year survival of adult ESRD patients with or without a completed cardiovascular procedure, adjusted for age and sex, 2015-2016

Cardiovascular procedure	Presence of cardiovascular procedure	
	Survival when present (%)	Survival when not present (%)
PCI	51.1	62.1
CABG	64.6	61.5
ICD/CRT-D	48.1	62.9
CAS/CEA	57.9	65.6

Data Source: Special analyses, USRDS ESRD Database. Point prevalent hemodialysis, peritoneal dialysis, and transplant patients aged 22 and older, who are continuously enrolled in Medicare Parts A and B, and with Medicare as primary payer from January 1, 2014 to December 31, 2014, and whose first ESRD service date is at least 90 days prior to January 1, 2014, and survived past 2014. Abbreviations: CABG, coronary artery bypass grafting; CAS/CEA, carotid artery stenting and carotid artery endarterectomy; ESRD, end-stage renal disease; ICD/CRT-D, implantable cardioverter defibrillators/cardiac resynchronization therapy with defibrillator devices; PCI, percutaneous coronary interventions.

## Cardiovascular Disease and Pharmacological Treatments

Medical therapy for CVD in the ESRD population is fraught with challenges. These patients are usually excluded from large clinical trials for conditions such as CAD, HF, and AF, and as a result, the risks and benefits of various medications in the ESRD population are often not well understood. Drug therapy may be limited by safety issues, such as risk of hyperkalemia with Angiotensin converting enzyme inhibitor and angiotensin receptor blocker (ACEI/ARB) therapy, and intradialytic hypotension among HD patients. It is noteworthy that although administration of beta-blockers for AMI is a widely cited quality metric for cardiovascular care, only about two-thirds of dialysis or transplant patients with AMI received these drugs. Similarly, among ESRD patients with heart failure, less than half received ACEIs or ARBs.

Although many ESRD patients with AF are at elevated risk of stroke, only 32.5% of HD and 31.5% of PD patients with AF were treated with warfarin (Table 8.4). One possible explanation for these relatively low rates is that ESRD patients on warfarin have a significantly increased risk of bleeding as compared to non-dialysis patients, and the benefit of warfarin in terms of stroke prevention has been called into question (Shah et al., 2014). Direct oral anticoagulants have not been well studied for stroke prevention in AF among ESRD patients, yet were nonetheless used in 9.4% of HD and 9.4% of PD patients. Note that Medicare claims data do not capture all prescription drugs taken by beneficiaries, as drugs purchased without insurance coverage are not included (Colantonio et al., 2016). Patients purchase aspirin most commonly over the counter rather than by prescription, thus we could not reliably assess aspirin use in this cohort.

vol 2 Table 8.4 Cardiovascular pharmacological treatments by (a) comorbidities and (b) procedures in adult ESRD patients, by modality, 2016

(a) Cardiovascular comorbidities							
	# Patients	Percentage of patients (%)					
		Beta-blockers	Statins	P2Y12 inhibitors	Warfarin	Direct oral anticoagulants	ACEIs/ARBs
<b>Any CVD</b>							
Hemodialysis	154,310	60.8	48.6	20.0	13.0	3.6	35.9
Peritoneal dialysis	12,713	61.0	49.1	18.5	11.4	3.1	41.6
Transplant	31,208	59.1	53.9	13.5	13.7	6.7	33.0
<b>Coronary artery disease (CAD)</b>							
Hemodialysis	92,625	64.7	56.6	27.6	13.4	4.0	37.5
Peritoneal dialysis	7,570	63.3	56.7	26.1	11.8	3.3	42.0
Transplant	16,615	63.6	60.4	20.6	12.2	6.5	34.2
<b>Acute myocardial infarction (AMI)</b>							
Hemodialysis	30,572	69.3	61.9	36.5	15.0	4.5	41.1
Peritoneal dialysis	2,559	68.0	61.5	36.3	13.6	3.9	44.9
Transplant	3,976	68.3	63.8	30.1	15.2	8.5	35.2
<b>Heart failure (HF)</b>							
Hemodialysis	88,377	66.2	50.6	21.8	14.2	4.2	39.6
Peritoneal dialysis	6,181	66.2	50.4	20.6	13.5	3.7	44.4
Transplant	10,851	65.9	55.9	14.9	16.5	8.6	34.6
<b>Valvular heart disease (VHD)</b>							
Hemodialysis	30,906	63.9	49.7	22.1	18.0	4.8	37.9
Peritoneal dialysis	2,687	62.4	49.0	19.2	16.8	4.8	41.5
Transplant	5,561	61.0	53.5	14.1	17.7	7.9	33.3
<b>Cerebrovascular accident/transient ischemic attack (CVA/TIA)</b>							
Hemodialysis	35,710	64.2	58.3	28.1	13.8	4.4	38.8
Peritoneal dialysis	2,726	63.2	57.3	26.4	12.9	3.3	44.3
Transplant	5,347	59.2	59.8	20.9	14.3	7.2	34.4
<b>Peripheral artery disease (PAD)</b>							
Hemodialysis	81,792	60.4	51.3	24.5	13.4	3.9	35.3
Peritoneal dialysis	5,501	60.6	52.4	24.3	12.0	3.3	41.4
Transplant	12,394	59.2	55.4	18.2	12.5	5.9	33.9
<b>Atrial fibrillation (AF)</b>							
Hemodialysis	42,853	61.0	49.5	18.3	32.5	9.4	30.5
Peritoneal dialysis	3,098	60.7	50.4	16.7	31.5	9.4	35.2
Transplant	8,222	63.1	51.8	9.5	32.6	17.8	32.0
<b>Cardiac arrest and ventricular arrhythmias (SCA/VA)</b>							
Hemodialysis	10,531	67.7	52.7	25.2	19.5	5.7	38.1
Peritoneal dialysis	1,003	62.5	50.9	22.5	18.4	5.2	40.1
Transplant	1,540	65.3	54.4	16.8	19.9	9.6	33.7
<b>Venous thromboembolism and pulmonary embolism (VTE/PE)</b>							
Hemodialysis	13,522	58.8	45.0	18.2	38.7	9.7	32.8
Peritoneal dialysis	978	59.5	45.3	14.3	40.2	10.1	38.4
Transplant	3,428	56.1	47.2	9.0	42.4	17.0	30.8

Table 8.4 continued on next page.

**vol 2 Table 8.4 Cardiovascular pharmacological treatments by (a) comorbidities and (b) procedures in adult ESRD patients, by modality, 2016 (continued)**

<b>(b) Cardiovascular procedures</b>							
# Patients	Percentage of patients (%)						
	Beta-blockers	Statins	P2Y12 inhibitors	Warfarin	Direct Oral Anticoagulants	ACEIs/ARBs	
<b>Revascularization – percutaneous coronary interventions (PCI)</b>							
Hemodialysis	4,553	75.1	73.1	77.1	12.5	3.8	49.5
Peritoneal dialysis	466	70.4	70.0	71.5	11.4	3.9	45.7
Transplant	542	74.7	72.3	72.1	11.3	6.1	43.5
<b>Revascularization – coronary artery bypass graft (CABG)</b>							
Hemodialysis	1,612	76.4	75.9	39.9	17.6	4.1	47.3
Peritoneal dialysis	257	74.3	73.2	38.1	12.1	3.5	47.9
Transplant	162	69.1	67.3	30.2	15.4	5.6	34.0
<b>Implantable cardioverter defibrillators &amp; cardiac resynchronization therapy with defibrillator (ICD/CRT-D)</b>							
Hemodialysis	848	72.2	55.1	28.9	27.0	8.0	46.8
Peritoneal dialysis	74	66.2	56.8	32.4	14.9	6.8	41.9
Transplant	92	70.7	62.0	27.2	22.8	12.0	41.3
<b>Carotid artery stenting and carotid artery endarterectomy (CAS/CEA)</b>							
Hemodialysis	465	66.0	68.8	51.0	13.8	2.6	42.6
Peritoneal dialysis	58	65.5	60.3	37.9	12.1	0.0	41.4
Transplant	94	69.1	64.9	34.0	18.1	12.8	34.0

*Data Source: Special analyses, USRDS ESRD Database. Point prevalent hemodialysis, peritoneal dialysis, and transplant patients aged 22 and older, who are continuously enrolled in Medicare Parts A, B, and D, and with Medicare as primary payer from January 1, 2016 to December 31, 2016, and ESRD service date is at least 90 days prior to January 1, 2016. Abbreviations: ACEIs/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; CVA/TIA, cerebrovascular accident/transient ischemic attack; CVD, cardiovascular disease; ESRD, end-stage renal 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 among ESRD Patients

Heart failure (HF) is a highly prevalent CVD among ESRD patients. Common cardiac structural and functional changes that predispose ESRD patients to clinical heart failure include left ventricular hypertrophy associated with left ventricular diastolic dysfunction, left and right ventricular dilation and systolic dysfunction, and aortic and mitral valve disease. In the absence of meaningful renal function, volume status assessment and management are very challenging, given the limitations of the physical exam, lack of objective criteria by which to quantify intra- and extravascular volume, and patients' variable adherence to sodium and fluid restriction recommendations. Moreover, intradialytic hypotension, a complex and multifactorial problem that is more common among hemodialysis patients

with HF, may limit ultrafiltration volumes (Reeves and McCausland, 2018). Most patients will experience at least some improvement in HF symptoms with ultrafiltration, but many remain dyspneic even when euvolemic (Chawla et al., 2014).

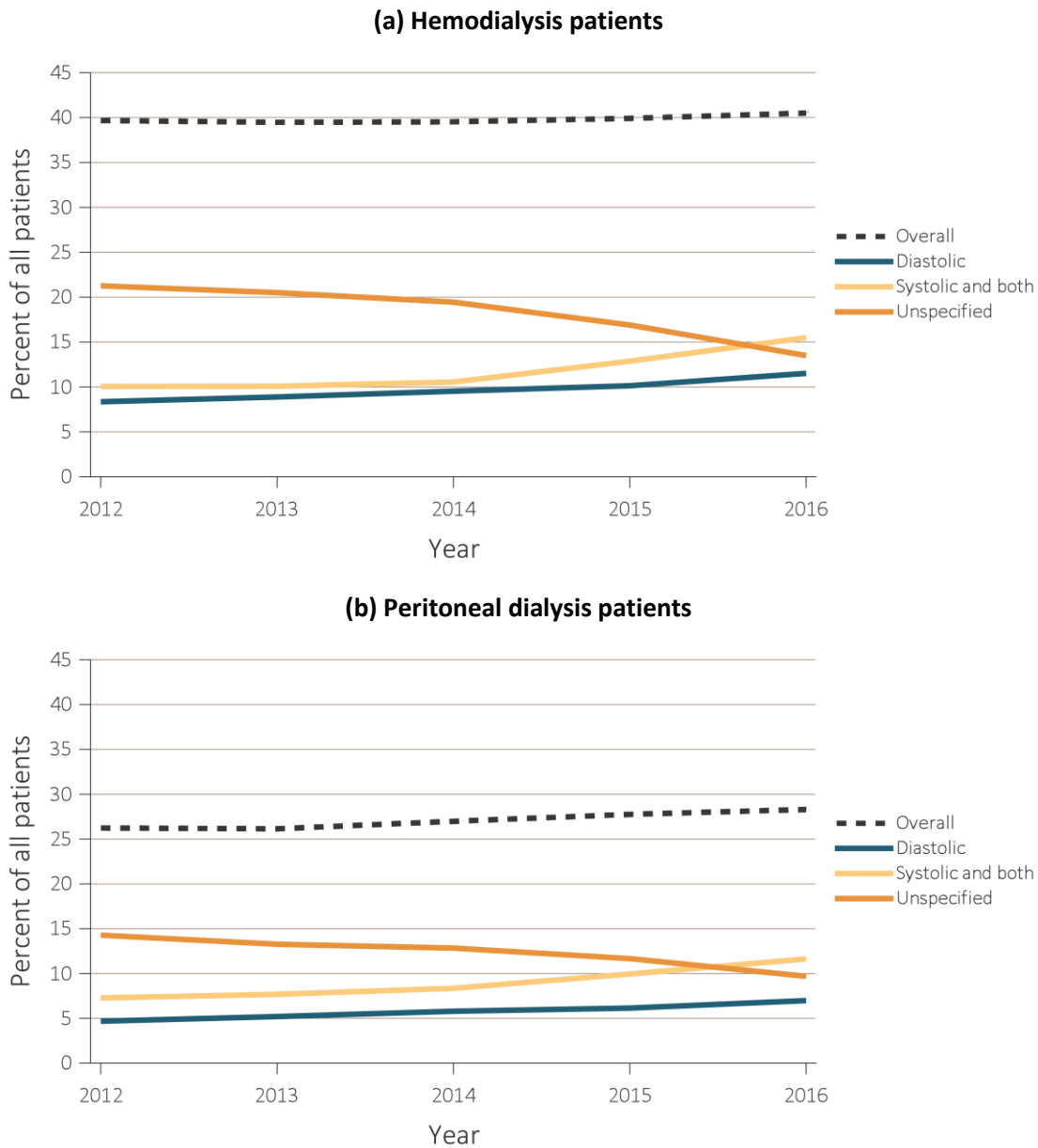
HF in ESRD patients is stratified in Figure 8.5 according to left ventricular systolic dysfunction (i.e., heart failure with reduced ejection fraction), left ventricular diastolic dysfunction (i.e., heart failure with preserved ejection fraction), and unspecified cardiac dysfunction. Note that for ease of reporting and consistency in studying clinical approaches, we include in the systolic HF grouping all patients with systolic dysfunction, regardless of the presence of concomitant diastolic dysfunction. Patients with isolated diastolic HF were analyzed separately, since treatments and prognoses are markedly different for this group.



Among adult ESRD patients, the largest percentage of patients had unspecified HF in 2012, with a trend toward more specific classification into systolic and diastolic heart failure over the ensuing years, such that systolic heart failure was more prevalent than unspecified heart failure in 2016. The relative proportion of patients with systolic HF was slightly higher than diastolic HF throughout 2012-2016 (Figure 8.5). These patterns were true for both HD and PD

patients. The percentage of patients experiencing each type of heart failure was slightly higher among HD patients compared to PD patients. We identified categories of systolic dysfunction and diastolic dysfunction through ICD-9-CM and ICD-10-CM diagnosis codes, which have limitations as sole source data. Thus, these findings should be considered cautiously in the absence of further, confirmatory clinical data.

vol 2 Figure 8.5 Heart failure in adult ESRD patients by modality, 2012-2016



Data Source: Special analyses, USRDS ESRD Database. Point prevalent hemodialysis and peritoneal dialysis patients aged 22 and older, who are continuously enrolled in Medicare Parts A and B, and with Medicare as primary payer from January 1, 2012 to December 31, 2016, and ESRD service date is at least 90 days prior to January 1, 2012. Abbreviation: ESRD, end-stage renal disease.

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