Supplemental Material

Supplementary text on the United States Renal Data System (USRDS) database:
The USRDS contains data on virtually all individuals in the United States with end stage renal disease (ESRD). Since 1995, all ESRD patients must be reported regardless of Medicare eligibility. Despite the requirement that all persons initiating ESRD care in the United States be included in the USRDS, undocumented immigrants may be incompletely included in the database. ESRD status is determined by the treating physician, who must submit a Medical Evidence Form, also known as the Centers for Medicare and Medicaid (CMS) form 2728 within 45 days of each person's date of ESRD. The CMS-2728 form captures demographic variables and the date of first ESRD care. This form is signed by the treating physician but is often filled out by staff with varying clinical experience. Patients who recover kidney function after acute kidney injury will not be included in the USRDS because the kidney injury was reversible. Patients with ESRD who die before their first dialysis treatment may be missed by the USRDS database. However, persons who die within the first 45 days of initiating ESRD must still have a CMS-2728 form submitted. The Medical Evidence Form was updated in April 1995 and the current version of the CMS-2728 form began use in June 2005. These updates included capture of an increasing number of co-morbid conditions and more information on insurance status at ESKD initiation (1-4).

There were 20 comorbidities captured on the USRDS medical evidence form as of April 1, 1995: congestive heart failure, ischemic heart disease/coronary artery disease, myocardial infarction, cardiac arrest, cardiac dysrhythmia, pericarditis, cerebrovascular disease/cerebrovascular accident/transient ischemic attack, peripheral vascular disease, history of hypertension, diabetes, diabetes currently on insulin, chronic obstructive pulmonary disease, current tobacco use, malignancy, alcohol dependence, drug dependence, HIV, AIDS, inability to ambulate, inability to transfer. Beginning June 1, 2005, the medical evidence form was updated to capture the following 23 comorbidities: congestive heart failure, atherosclerotic heart disease, other cardiac disease, cerebrovascular disease/cerebrovascular accident/transient ischemic attack, peripheral vascular disease, history of hypertension, amputation, diabetes currently on insulin, diabetes currently on oral medications, diabetes without medications, diabetic retinopathy, chronic obstructive pulmonary disease, current tobacco use, malignancy, toxic nephropathy, alcohol dependence, drug dependence, inability to ambulate, inability to transfer, needs assistance with daily activities, institutionalized, non-renal congenital abnormality, or none.

Detailed Methods:
Calculating calendar year-specific crude excess ESRD-related mortality rates for each age interval: We calculated the crude absolute mortality rate in each calendar year, for each age interval, by creating a 2-way grid including the 5 current age categories (0-14, 15-24, 25-44, 45-64, and ≥65 years) and the 19 calendar years (1995, 1996, 1997… 2013). This is the same type of indirect standardization approach that would be taken to create standardized mortality rates or standardized mortality ratios (5). See Figure S1 for an example. We determined the number of person-years each subject contributed to each calendar year, *during each specific age category*. We then summed all the person-years contributed to each calendar year, within each age category. Similarly, the numbers of deaths that occurred within each cell of the grid (i.e. in each age category and each calendar year) were determined. Observed absolute "age- and calendar year-specific" mortality rates were calculated for each cell.

In order to determine the expected mortality rate for each cell, we first had to separate the person-time within each 'calendar year- age category' cell into smaller sex, race, and finer age categories (corresponding to the age categories used for general population mortality rates: <1 y, 1-4 y, 5-9 y, 10-14 y, 15-19 y, 20-24 y, 25-29 y, 30-34 y, 35-39 y, 40-44 y, 45-49 y, 50-54 y, 55-59 y, 60-64 y, 65-69 y, 70-74 y, 75-79 y, 80-84 y, and ≥85 years). For example, the cell shown in Fig. S1 for those observed between 15 and 24 years of age in 2013 (shaded green) was split by sex (male versus female), race (white, black, other), and into 5-year age intervals (15-19 y, 20-24 y). The detailed age, sex, and race categories into which the 15-24 y cell for 2013 were split are shown in Figure S2. The number of person-years of observation in each subgroup based on sex, race, 5-year age interval, and calendar year was determined. We then used the general population age-, sex-, race-, and calendar year-specific mortality rates to determine the expected number of deaths for each of these smaller cells (general population mortality rate times person-years of observation=expected number of deaths). This allowed us to then determine the expected number of deaths in each of the larger 'calendar year- age category' cells. The expected number of deaths in each 'calendar year- age category' cell was subtracted from the observed number of deaths in the same 'calendar year- age category' cell to determine the excess number of deaths; the excess number of deaths was divided by the person-years of observation within that 'calendar year- age category' cell to determine the excess ESRD-related mortality rate.

Primary analyses did not distinguish observation time during treatment with dialysis from that during treatment with transplant, but subsequent analyses evaluated observation time during treatment with dialysis separately from time during treatment with transplant, as illustrated in Figure S1.

General information on relative survival models:
The ***relative survival*** approach is commonly used in cancer epidemiology to understand the impact of new therapies on outcomes over longer time periods (6). Relative survival models are Cox models that allows estimation of the risk of death among individuals with the disease of interest over and above the risk in the general population (excess ESRD-related mortality rate=mortality rate in ESRD minus mortality rate in the general population), and determine the excess risk among individuals with the disease in a recent time period relative to the excess risk in a comparable population in a more remote time period. The relative survival method returns 'relative excess risks'–analogous to hazard ratios or relative risks–which are interpreted as the excess risk of mortality due to ESRD in one calendar year, relative to the excess risk of mortality due to ESRD in the previous calendar year.

In order to calculate the excess risk of mortality among ESRD patients using this relative survival approach, it was necessary to obtain the expected mortality rates for the general population. These were obtained from publicly available United States National Vital Statistics data (7-11). For each calendar year from 1995 to 2013, we obtained sex- and race-specific mortality rates for the general U.S. population in the following age intervals: <1 y, 1-4 y, 5-9 y, 10-14 y, 15-19 y, 20-24 y, 25-29 y, 30-34 y, 35-39 y, 40-44 y, 45-49 y, 50-54 y, 55-59 y, 60-64 y, 65-69 y, 70-74 y, 75-79 y, 80-84 y, and ≥85 years.

Relative survival is the survival analog of excess mortality. The hazard function of the observed mortality can be written as:

$$\lambda(t; \boldsymbol{z}) = \lambda^*(t; \boldsymbol{z}) + \nu(t; \boldsymbol{z})$$

where λ*(t; z) is the expected hazard and v(t; z) is the excess hazard (related to ESRD); and the survival function of the observed survival can be written as

$$S(t; \boldsymbol{z})=S^*(t; z)\times r(t; \boldsymbol{z}).$$

The proportion hazard model can thus be expressed as

$$\lambda(\boldsymbol{x}) = \lambda^*(\boldsymbol{x}) + \exp(\boldsymbol{x}\beta).$$

Modeling changes in the excess risk of ESRD-related mortality over time:
We used time-dependent relative survival models (6) with time-varying covariates to estimate the change in the excess risk of ESRD-related mortality associated with advancing calendar year. Time zero was the date of 1st ESRD care (1st dialysis or 1st transplant, whichever came first). This approach allowed us to compare the mortality risks for individuals of the same age, with the same time since initiating ESRD care, (and similar other characteristics) in more recent calendar years with risks in more remote calendar years. In these models, the hazard function at any given time since 1st ESRD care is modeled as the sum of the *expected hazard* and the excess hazard due to the disease. The expected hazards are estimated from data external to the cohort (age-, sex-, race-, and calendar year-specific mortality rates for the general population, United States National Vital Statistics (7-11). The exponentiated parameter estimates from the models represent 'relative excess risks', defined as the excess hazard ratio of ESRD-related death.

To create these models, each subject's observation time was split into multiple observation intervals. The SAS macro 'Lexis', written by Bendix Carstensen (http://www.biostat.ku.dk/~bxc/Lexis), was used to split the individual patient data (Appendix A). Figure S3 provides an example Lexis diagram. The first set of models did not distinguish between time treated with dialysis and time treated with transplant, so the length of the observation intervals was defined only by calendar year (maximum length of 1 year). In the second set of models, the length of the observation intervals was defined by calendar year and RRT modality (i.e. if a patient changed RRT modality within the calendar year, then two intervals were created: one for each RRT modality in that calendar year). Time-varying variables were assigned a value for each observation interval. The current calendar year and the patient's current age within each observation interval, as well as the patient's sex and race, and the length of the interval, were then used to determine the patient's expected probability of death in that interval using the national population life tables. For example, the probability of death for a Black woman who was observed for 1 year in 2003 at 56 years of age was based on the mortality rate for Black women 55-59 years old in 2003 in the United States general population.

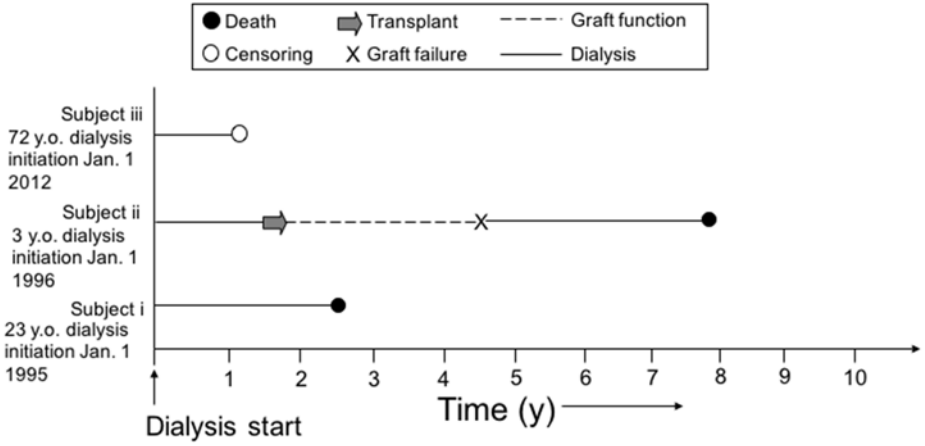
We assumed a constant baseline hazard in each 1-year (or smaller) interval, and used generalized linear models with a Poisson likelihood (6, 12) as described by Dickman (6). The SAS procedure GENMOD (with a Poisson error structure) was used to estimate the Cox survival model for the excess mortality (see example code in Appendix B).

To determine whether the change over time in ESRD-related mortality risk differed for people of different ages, we included an interaction between current age category (time-varying) and calendar year (time-varying). Initial models were unadjusted; subsequent models were adjusted for the following potential confounders: sex, race, socioeconomic status quartile (using median household income by zipcode within the 2000 United States Census data), insurance status at ESRD initiation, and primary disease or number of comorbidities at ESRD initiation.

Additional models were also adjusted for renal replacement therapy (RRT) modality (dialysis versus transplant) by including a time-varying RRT modality variable and the following interaction terms: RRT modality X calendar year, RRT modality X age, and RRT modality X age X calendar year. Missing covariate values were imputed using multiple imputation methods and the joint distributions of the other variables in the models, as well as the data from subjects with non-missing data (13-15).

.**Figure S1: Example 2-way grid**

Current age category	Calendar year												
	1995			1996			1997			→	2013		
	Person-years	Deaths	Observed Mortality rate (per 1000 py)	Person-years	Deaths	Observed Mortality rate (per 1000 py)	Person-years	Deaths	Observed Mortality rate (per 1000 py)		Person-years	Deaths	Observed Mortality rate (per 1000 py)
0 – 14				1_{ii}			1_{ii}						
15 – 24	1_i			1_i							X	Y	Y*1000/X
25 – 44							0.5_i	1_i					
45 – 64													
≥65													



Subject i from the figure to the right contributes 1 person-year to the [1995 X 15-24 y age category] "cell", 1 person-y to the [1996 X 15-24 y age category] "cell", and 0.5 person-y to the [1997 X 25-44 y age category] "cell"; he dies in the [1997 X 25-44 y age category] "cell" while treated with dialysis. **Subject ii** contributes 1 person-y to the [1996 X 0 – 14 y age category] "cell", and 0.5 person-y to the [1997 X 0 – 14 y age category] "cell" while treated with dialysis, plus 0.5 person-y to the [1997 X 0 – 14 y age category] "cell" while treated with transplant (so, 1 person-y in 1997, when considering all ESRD experience together, without distinguishing dialysis from transplant); she then contributes 1 year to each calendar year while treated with transplantation until 2000 (not shown in grid), when the graft fails and she returns to dialysis treatment, so contributes 0.5 person-y to the [2000 X 0-14 y age category] "cell" while treated with transplantation, and then continues contributing observation on dialysis each calendar year, until death in 2003 at 10 y old. **Subject iii** contributes 1 person-year to the [2012 X ≥65 y age category] "cell" (not shown in grid) and 0.25 person-y to the [2013 X ≥65 y age category] before ending observation. The person-y contributed by each subject to each cell are summed, as are the deaths in each cell. "Age- and calendar year-specific" mortality rates are calculated as total deaths divided by total

person-y (see X / Y in the [2013 X 15 – 24 y age category] cell, shaded green). Date of dialysis start, age and calendar year are aligned exactly (i.e. date of birth and date of dialysis start assumed to be Jan. 1) in this example for illustrative purposes only; the analysis captures differences in date of birth, date of dialysis start, and calendar year.

The person-time in each 'calendar year- age category' cell in Figure S1 was split into smaller sex, race, and 5-year age categories. For example, the cell for those observed between 15 and 24 years of age in 2013 (shaded in green) was split by sex (male vs. female), race (white, black, other), and into 5-year age intervals (15-19 y, 20-24 y) (see Figure S2, below).

FigureS2: Sub-divisions of the observation time shown in the green-shaded cell of Figure S1

	Female									Male								
	White			Black			Other			White			Black			Other		
Age	P-years	Deaths	Expected deaths	P-years	Deaths	Expected deaths	P-years	Deaths	Expected deaths	P-years	Deaths	Expected deaths	P-years	Deaths	Expected deaths	P-years	Deaths	Expected deaths
15-19 y	a	i	A	b	ii	B	c	iii	C	d	iv	D	e	v	E	f	vi	F
20-24 y	g	α	G	h	β	H	j	χ	J	k	δ	K	l	ε	L	m	ϕ	M

Expected deaths were calculated as: A= a * (mortality rate for 15-19 y.o. White girls in 2013)

B= b * (mortality rate for 15-19 y.o. Black girls in 2013)

Etc.

Total p-years= a+b+c+d+e+f+g+h+j+k+l+m = X (in Figure S1. above)

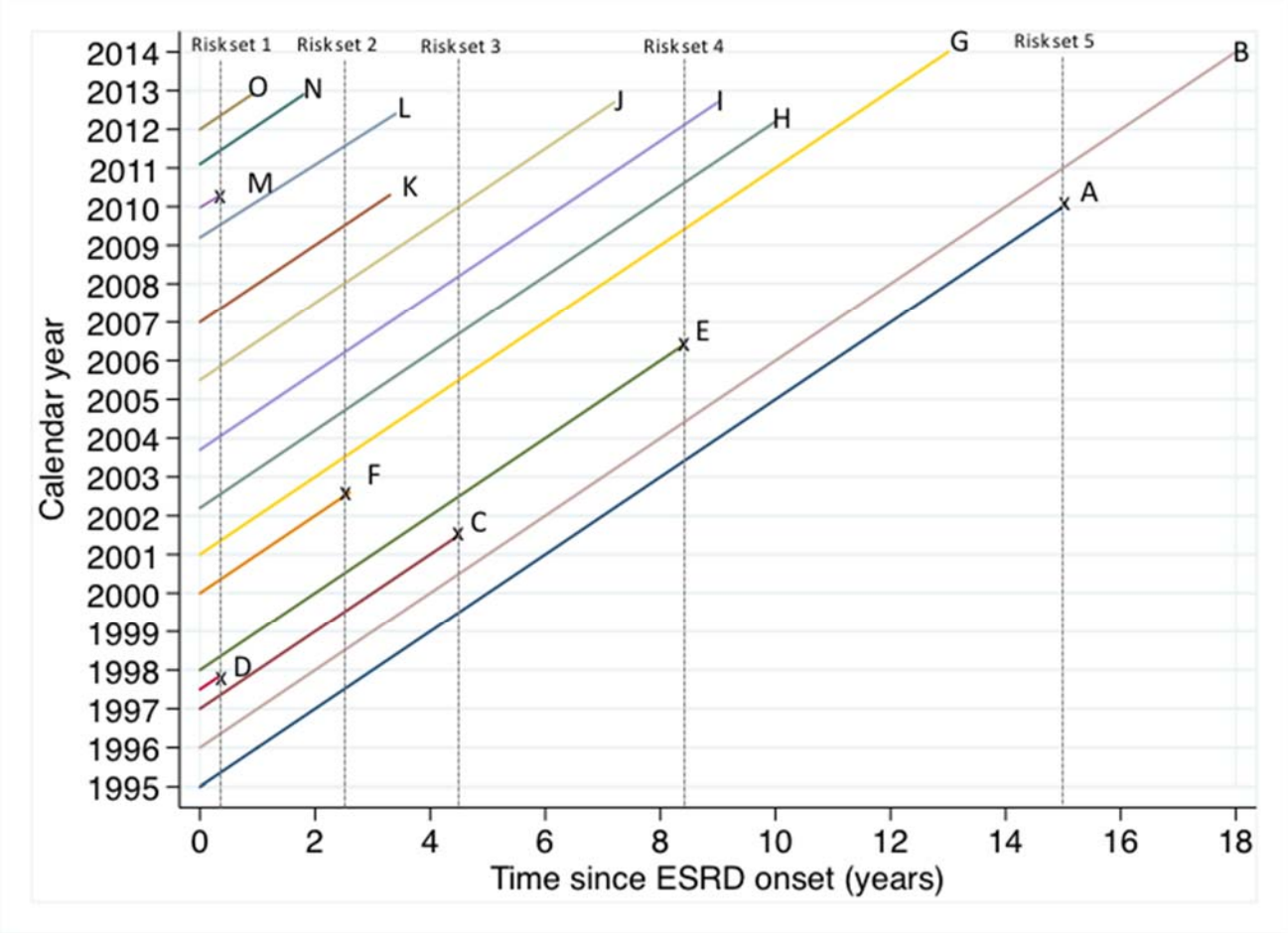
Total deaths= i+ii+iii+iv+v+vi+α+β+χ+δ+ε+ϕ = Y (in Figure S1. above)

Total expected deaths= A+B+C+D+E+F+G+H+J+K+L+M

Excess number of deaths= Y- (total expected deaths)

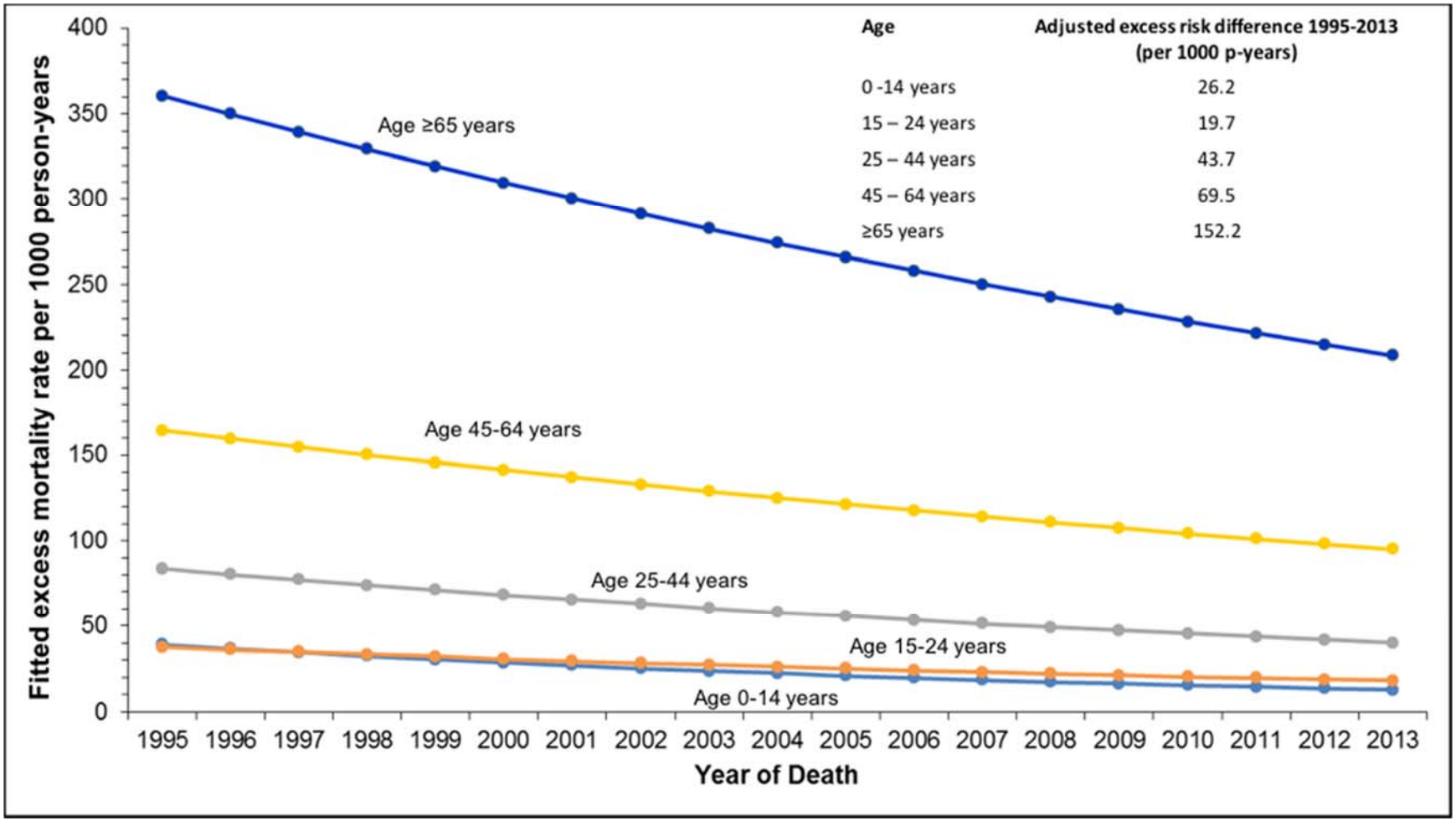
Excess ESRD-related mortality rate= Excess number of deaths/ X

Figure S3: Example Lexis diagram



Hypothetical patients A to O are shown. Each patient in the example begins ESRD care in a different calendar year. The diagram illustrates that as time since ESRD onset advances, calendar year also advances. Deaths are represented by a black X. The 'risk sets' in the Cox models are generated at each death (event), aligned on time since ESRD onset.

Figure S4: Fitted excess mortality rates by calendar year and age



Fitted excess mortality rates for all ESRD observation were calculated for each age category, in each calendar year, from the relative excess risks estimated using the adjusted relative survival models and the crude excess mortality rates for 2005 (when the proportions of incident and prevalent patients in each calendar year had reached steady state). Adjusted excess risk differences were calculated by subtracting the fitted excess mortality rate in 2013 from that in 1995.

Table S1. Composition of the observed experience by calendar period, among persons 0 to 14 years of age initiating ESRD care from 1995 to 2013 in the United States

Calendar year	1995-1999	2000-2004	2005-2009	2010-2013
Person-years of observation				
During treatment with dialysis	2925	5656	6080	5009
During treatment with transplant	3125	8960	12572	11139
Age at first ESRD service (years)	9 (4-13)	10 (4-13)	10 (3-13)	8 (2-13)
Missing age	0%	0%	0%	0%
Sex (Male)	57%	58%	60%	61%
Missing sex	0%	0%	0%	0%
Race				
White	70%	71%	72%	72%
Black	19%	18%	17%	17%
Other	11%	10%	10%	11%
Missing race	0%	0%	0%	0%
Primary kidney disease				
Diabetes	<1%	<1%	<1%	<1%
Hypertension	2%	1%	1%	1%
Glomerulonephritis[a]	27%	26%	22%	20%
Congenital anomalies of the kidneys and urinary tract	35%	36%	39%	42%
Other	31%	31%	33%	31%
Missing primary kidney disease	4%	5%	5%	6%
Socioeconomic quartile				
Lowest	20%	19%	18%	17%
Mid-low	16%	16%	16%	17%
Mid-high	22%	22%	23%	24%
Highest	32%	33%	34%	34%
Missing socioeconomic quartile	10%	10%	9%	8%
Primary Insurance Coverage				
Medicare/Medicaid	51%	50%	52%	56%
Employer/Other	39%	41%	40%	38%
No coverage	6%	6%	4%	2%
Missing insurance coverage	4%	4%	4%	4%
Comorbidities[b]				
None	91%	93%	92%	91%
1	6%	5%	5%	6%
2-3	2%	2%	2%	3%
≥4	0%	0%	<1%	<1%

Because the unit of analysis was person-time, rather than person, the characteristics presented are weighted by a factor derived from the number of person-years of observation and number of events, and presented as weighted median (interquartile range) or percent (%) (i.e percent of person-years contributed by males). ESRD, end-stage renal disease.

[a]Includes focal segmental glomerulosclerosis.

[b]Comorbidities counted included: congestive heart failure, ischemic heart disease/coronary artery disease, myocardial infarction, cardiac arrest, cardiac dysrhythmia, pericarditis, atherosclerotic heart disease, other cardiac disease, cerebrovascular disease/cerebrovascular accident/transient ischemic attack, peripheral vascular disease, diabetes, chronic obstructive pulmonary disease, current tobacco use, malignancy, alcohol dependence, drug dependence, inability to ambulate, inability to transfer. If no comorbidities were reported there were assumed to be none.

Table S2. Composition of the observed experience by calendar period, among persons 15 to 24 years of age initiating ESRD care from 1995 to 2013 in the United States

Calendar year	1995-1999	2000-2004	2005-2009	2010-2013
Person-years of observation				
During treatment with dialysis	10976	21108	26753	23449
During treatment with transplant	5216	16861	25158	23796
Age at first ESRD service (years)	21 (19-23)	21 (19-23)	21 (19-23)	21 (19-23)
Missing age	0%	0%	0%	0%
Sex (Male)	56%	56%	56%	56%
Missing sex	0%	0%	0%	0%
Race				
White	56%	61%	64%	66%
Black	35%	30%	26%	24%
Other	9%	10%	10%	10%
Missing race	0%	0%	0%	0%
Primary kidney disease				
Diabetes	5%	3%	2%	1%
Hypertension	12%	9%	8%	7%
Glomerulonephritis[a]	49%	46%	42%	38%
Congenital anomalies of the kidneys and urinary tract	11%	15%	18%	21%
Others	22%	24%	26%	27%
Missing primary kidney disease	2%	3%	4%	5%
Socioeconomic quartile				
Lowest	24%	22%	21%	21%
Mid-low	19%	19%	18%	18%
Mid-high	23%	23%	23%	23%
Highest	27%	29%	30%	30%
Missing socioeconomic quartile	7%	8%	8%	8%
Primary Insurance Coverage				
Medicare/Medicaid	39%	38%	40%	43%
Employer/Other	38%	43%	43%	40%
No coverage	18%	17%	13%	10%
Missing insurance coverage	5%	3%	5%	6%
Comorbidities[b]				
None	85%	88%	90%	90%
1	12%	10%	8%	8%
2-3	3%	2%	2%	2%
≥4	0%	0%	0%	0%

Because the unit of analysis was person-time, rather than person, the characteristics presented are weighted by a factor derived from the number of person-years of observation and number of events, and presented as weighted median (interquartile range) or percent (%) (i.e percent of person-years contributed by males). ESRD, end-stage renal disease.

[a]Includes focal segmental glomerulosclerosis.

[b]Comorbidities counted included: congestive heart failure, ischemic heart disease/coronary artery disease, myocardial infarction, cardiac arrest, cardiac dysrhythmia, pericarditis, atherosclerotic heart disease, other cardiac disease, cerebrovascular disease/cerebrovascular accident/transient ischemic attack, peripheral vascular disease, diabetes, chronic obstructive pulmonary disease, current tobacco use, malignancy, alcohol dependence, drug dependence, inability to ambulate, inability to transfer. If no comorbidities were reported there were assumed to be none.

Table S3. Composition of the observed experience by calendar period, among persons 25 to 44 years of age initiating ESRD care from 1995 to 2013 in the United States

Calendar year	1995-1999	2000-2004	2005-2009	2010-2013
Person-years of observation				
During treatment with dialysis	93753	194147	251722	240787
During treatment with transplant	25009	92338	141698	131487
Age at first ESRD service (years)	38 (33-42)	38 (33-42)	38 (33-42)	38 (33-42)
Missing age	0%	0%	0%	0%
Sex (Male)	59%	58%	58%	59%
Missing sex	0%	0%	0%	0%
Race				
White	53%	54%	54%	55%
Black	40%	39%	38%	37%
Other	7%	8%	8%	9%
Missing race	0%	0%	0%	0%
Primary kidney disease				
Diabetes	30%	27%	24%	23%
Hypertension	21%	22%	22%	22%
Glomerulonephritis[a]	28%	30%	31%	31%
Congenital anomalies of the kidneys and urinary tract	2%	3%	3%	4%
Others	18%	18%	18%	19%
Missing primary kidney disease	1%	1%	1%	2%
Socioeconomic quartile				
Lowest	26%	24%	24%	24%
Mid-low	19%	19%	19%	19%
Mid-high	23%	23%	24%	24%
Highest	27%	28%	28%	28%
Missing socioeconomic quartile	5%	5%	5%	5%
Primary Insurance Coverage				
Medicare/Medicaid	38%	35%	34%	34%
Employer/Other	38%	43%	43%	41%
No coverage	17%	20%	20%	20%
Missing primary insurance	7%	3%	3%	4%
Comorbidities[b]				
None	54%	59%	61%	62%
1	31%	29%	27%	26%
2-3	13%	11%	11%	10%
≥4	2%	1%	1%	1%

Because the unit of analysis was person-time, rather than person, the characteristics presented are weighted by a factor derived from the number of person-years of observation and number of events, and presented as weighted median (interquartile range) or percent (%) (i.e percent of person-years contributed by males). ESRD, end-stage renal disease.

[a]Includes focal segmental glomerulosclerosis.

[b]Comorbidities counted included: congestive heart failure, ischemic heart disease/coronary artery disease, myocardial infarction, cardiac arrest, cardiac dysrhythmia, pericarditis, atherosclerotic heart disease, other cardiac disease, cerebrovascular disease/cerebrovascular accident/transient ischemic attack, peripheral vascular disease, diabetes, chronic obstructive pulmonary disease, current tobacco use, malignancy, alcohol dependence, drug dependence, inability to ambulate, inability to transfer. If no comorbidities were reported there were assumed to be none.

Table S4. Composition of the observed experience by calendar period, among persons 45 to 64 years of age initiating ESRD care from 1995 to 2013 in the United States

Calendar year	1995-1999	2000-2004	2005-2009	2010-2013
Person-years of observation				
During treatment with dialysis	230971	536032	758637	774380
During treatment with transplant	25531	131767	262916	290401
Age at first ESRD service (years)	57 (51-61)	56 (52-61)	57 (52-61)	57 (52-61)
Missing age	0%	0%	0%	0%
Sex (Male)	54%	56%	58%	59%
Missing sex	0%	0%	0%	0%
Race				
White	55%	56%	58%	59%
Black	36%	36%	35%	34%
Other	8%	8%	7%	7%
Missing race	0%	0%	0%	0%
Primary kidney disease				
Diabetes	51%	48%	44%	42%
Hypertension	20%	21%	22%	23%
Glomerulonephritis[a]	13%	14%	14%	14%
Congenital anomalies of the kidneys and urinary tract	1%	1%	1%	1%
Others	15%	16%	18%	19%
Missing primary kidney disease	0%	1%	1%	1%
Socioeconomic quartile				
Lowest	28%	26%	24%	24%
Mid-low	20%	20%	19%	19%
Mid-high	22%	23%	23%	24%
Highest	25%	27%	28%	29%
Missing socioeconomic quartile	4%	4%	5%	5%
Primary Insurance Coverage				
Medicare/Medicaid	42%	39%	38%	38%
Employer/Other	40%	45%	47%	45%
No coverage	10%	13%	13%	14%
Missing primary insurance	8%	3%	2%	3%
Comorbidities[b]				
None	30%	34%	37%	38%
1	35%	34%	33%	33%
2-3	28%	26%	25%	24%
≥4	7%	6%	6%	5%

Because the unit of analysis was person-time, rather than person, the characteristics presented are weighted by a factor derived from the number of person-years of observation and number of events, and presented as weighted median (interquartile range) or percent (%) (i.e percent of person-years contributed by males). ESRD, end-stage renal disease.

[a]Includes focal segmental glomerulosclerosis.

[b]Comorbidities counted included: congestive heart failure, ischemic heart disease/coronary artery disease, myocardial infarction, cardiac arrest, cardiac dysrhythmia, pericarditis, atherosclerotic heart disease, other cardiac disease, cerebrovascular disease/cerebrovascular accident/transient ischemic attack, peripheral vascular disease, diabetes, chronic obstructive pulmonary disease, current tobacco use, malignancy, alcohol dependence, drug dependence, inability to ambulate, inability to transfer. If no comorbidities were reported there were assumed to be none.

Table S5. Composition of the observed experience by calendar period, among persons ≥65 years of age initiating ESRD care from 1995 to 2013 in the United States

Calendar year	1995-1999	2000-2004	2005-2009	2010-2013
Person-years of observation				
During treatment with dialysis	267767	583702	746976	729612
During treatment with transplant	3991	30841	86663	124991
Age at first ESRD service (years)	74 (70-79)	75 (70-80)	76 (70-81)	75 (70-81)
Missing age	0%	0%	0%	0%
Sex (Male)	51%	51%	53%	54%
Missing sex	0%	0%	0%	0%
Race				
White	68%	67%	67%	67%
Black	25%	26%	26%	26%
Other	6%	7%	7%	7%
Missing race	0%	0%	0%	0%
Primary kidney disease				
Diabetes	43%	45%	46%	45%
Hypertension	32%	31%	30%	29%
Glomerulonephritis[a]	10%	9%	8%	8%
Congenital anomalies of the kidneys and urinary tract	<1%	<1%	<1%	<1%
Others	14%	14%	16%	17%
Missing primary kidney disease	<1%	<1%	<1%	1%
Socioeconomic quartile				
Lowest	23%	22%	21%	21%
Mid-low	19%	19%	19%	19%
Mid-high	24%	24%	24%	24%
Highest	31%	32%	33%	33%
Missing socioeconomic quartile	3%	3%	4%	4%
Primary Insurance Coverage				
Medicare/Medicaid	76%	80%	77%	70%
Employer/Other	12%	14%	16%	19%
No coverage	2%	3%	4%	4%
Missing primary insurance	10%	3%	4%	7%
Comorbidities[b]				
None	24%	24%	25%	26%
1	30%	31%	31%	31%
2-3	34%	35%	34%	33%
≥4	11%	10%	11%	10%

Because the unit of analysis was person-time, rather than person, the characteristics presented are weighted by a factor derived from the number of person-years of observation and number of events, and presented as weighted median (interquartile range) or percent (%) (i.e percent of person-years contributed by males). ESRD, end-stage renal disease.

[a]Includes focal segmental glomerulosclerosis.

[b]Comorbidities counted included: congestive heart failure, ischemic heart disease/coronary artery disease, myocardial infarction, cardiac arrest, cardiac dysrhythmia, pericarditis, atherosclerotic heart disease, other cardiac disease, cerebrovascular disease/cerebrovascular accident/transient ischemic attack, peripheral vascular disease, diabetes, chronic obstructive pulmonary disease, current tobacco use, malignancy, alcohol dependence, drug dependence, inability to ambulate, inability to transfer. If no comorbidities were reported there were assumed to be none.

Table S6 Observed deaths, expected deaths, and crude excess mortality rates among persons initiating ESRD care from 1995 to 2013 in the United States, by age group and calendar year at death

Age		1995	1996	1997	1998	1999➔
0-14	Observed deaths	28	43	56	48	73
	Person-years	306	855	1274	1619	1996
	Absolute mortality rate per 1000 PY	91.5 (72.5,110.6)	50.3 (40.5,60.1)	43.9 (36.3,51.6)	29.6 (24.0,35.3)	36.6 (30.9,42.2)
	Expected deaths	0.3	0.7	0.7	0.8	0.9
	Expected mortality rate per 1000 PY	1.1	0.8	0.6	0.5	0.4
	Excess mortality rate per 1000 PY	90.4 (71.5,109.3)	49.5 (39.8,59.2)	43.4 (35.8,51.0)	29.1 (23.5,34.7)	36.1 (30.5,41.8)
15-24	Observed deaths	42	93	106	120	148
	Person-years	809	2231	3423	4377	5351
	Absolute mortality rate per 1000 PY	51.9 (43.0,60.9)	41.7 (36.2,47.2)	31.0 (27.0,34.9)	27.4 (24.1,30.7)	27.7 (24.6,30.7)
	Expected deaths	1.0	2.6	3.7	4.4	5.2
	Expected mortality rate per 1000 PY	1.2	1.2	1.1	1.0	1.0
	Excess mortality rate per 1000 PY	50.7 (41.9,59.6)	40.5 (35.1,45.9)	29.9 (26.0,33.8)	26.4 (23.2,29.7)	26.7 (23.7,29.7)
25-44	Observed deaths	764	1708	2169	2636	3125
	Person-years	5667	15751	24572	32670	40103
	Absolute mortality rate per 1000 PY	134.8 (129.7,139.9)	108.4 (105.3,111.6)	88.3 (85.9,90.6)	80.7 (78.7,82.7)	77.9 (76.1,79.7)
	Expected deaths	16.9	41.9	57.4	72.6	87.5
	Expected mortality rate per 1000 PY	3.0	2.7	2.3	2.2	2.2
	Excess mortality rate per 1000 PY	131.8 (126.8,136.9)	105.8 (102.7,108.9)	85.9 (83.6,88.3)	78.5 (76.5,80.4)	75.7 (74.0,77.5)
45-64	Observed deaths	2283	5785	8612	11261	14078
	Person-years	11973	33375	52576	70681	87897
	Absolute mortality rate per 1000 PY	190.7 (186.7,194.7)	173.3 (170.7,175.9)	163.8 (161.7,165.9)	159.3. (157.5,161.1)	160.2 (158.5,161.8)
	Expected deaths	121.2	327.3	497.6	650.3	800.8
	Expected mortality rate per 1000 PY	10.1	9.8	9.5	9.2	9.1
	Excess mortality rate per 1000 PY	180.6 (176.6,184.5)	163.5 (161.0,166.1)	154.3 (152.3,156.4)	150.1 (148.4,151.9)	151.1 (149.5,152.6)
≥65	Observed deaths	6276	14221	20588	26503	31617
	Person-years	13837	36986	57263	74658	89014
	Absolute mortality rate per 1000 PY	453.6 (449.1,458.0)	384.5 (381.6,387.4)	359.5 (357.1,361.9)	355.0 (352.9,357.1)	355.2 (353.3,357.1)
	Expected deaths	569.8	1515.7	2326.0	3045.9	3664.5
	Expected mortality rate per 1000 PY	41.2	41.0	40.6	40.8	41.2
	Excess mortality rate per 1000 PY	412.4 (408.0,416.8)	343.5 (340.6,346.4)	318.9 (316.6,321.2)	314.2 (312.1,316.2)	314.0 (312.1,315.9)

Age		➔2000	2001	2002	2003	2004➔
0-14	Observed deaths	64	77	62	77	74
	Person-years	2334	2689	2976	3204	3413
	Absolute mortality rate per 1000 PY	27.4 (22.8,32.0)	28.6 (24.2,33.0)	20.8 (17.2,24.4)	24.0 (20.3,27.7)	21.7 (18.2,25.1)
	Expected deaths	1.1	1.1	1.1	1.1	1.3
	Expected mortality rate per 1000 PY	0.5	0.4	0.4	0.4	0.4
	Excess mortality rate per 1000 PY	27.0 (22.4,31.5)	28.2 (23.9,32.6)	20.5 (16.9,24.0)	23.7 (20.0,27.4)	21.3 (17.9,24.7)
15-24	Observed deaths	165	194	192	240	246
	Person-years	6227	6911	7617	8294	8920
	Absolute mortality rate per 1000 PY	26.5 (23.7,29.3)	28.1 (25.4,30.8)	25.2 (22.8,27.7)	28.9 (26.4,31.5)	27.6 (25.2,30.0)
	Expected deaths	6.1	6.7	7.3	7.9	8.2
	Expected mortality rate per 1000 PY	1.0	1.0	1.0	1.0	0.9
	Excess mortality rate per 1000 PY	25.5 (22.8,28.3)	27.1 (24.4,29.8)	24.2 (21.8,26.7)	28.0 (25.5,30.5)	26.7 (24.3,29.0)
25-44	Observed deaths	3320	3545	3894	4006	3980
	Person-years	46932	52584	57849	62289	66830
	Absolute mortality rate per 1000 PY	70.7 (69.1,72.3)	67.4 (65.9,68.9)	67.3 (65.9,68.7)	64.3 (63.0,65.6)	59.6 (58.3,60.8)
	Expected deaths	101.1	114.2	124.9	132.8	136.3
	Expected mortality rate per 1000 PY	2.2	2.2	2.2	2.1	2.0
	Excess mortality rate per 1000 PY	68.6 (67.0,70.2)	65.2 (63.8,66.7)	65.2 (63.8,66.5)	62.2 (60.9,63.5)	57.5 (56.3,58.7)
45-64	Observed deaths	15806	17844	19234	20942	22079
	Person-years	104126	119298	133972	148098	162305
	Absolute mortality rate per 1000 PY	151.8 (150.3,153.3)	149.6 (148.2,150.9)	143.6 (142.3,144.8)	141.4 (140.2,142.6)	136.0 (134.9,137.2
	Expected deaths	933.6	1048.0	1165.3	1280.9	1360.2
	Expected mortality rate per 1000 PY	9.0	8.8	8.7	8.6	8.4
	Excess mortality rate per 1000 PY	142.8 (141.4,144.3)	140.8 (139.5,142.1)	134.9 (133.6,136.1)	132.8 (131.6,133.9)	127.7 (126.6,128.8)
≥65	Observed deaths	34855	38272	40743	42510	43861
	Person-years	102171	113447	123850	133372	141703
	Absolute mortality rate per 1000 PY	341.1 (339.3,342.9)	337.4 (335.6,339.1)	329.0 (327.3,330.6)	318.7 (317.2,320.3)	309.5 (308.0,311.0)
	Expected deaths	4157.9	4528.1	4901.1	5182.5	5294.3
	Expected mortality rate per 1000 PY	40.7	39.9	39.6	38.9	37.4
	Excess mortality rate per 1000 PY	300.4 (298.7,302.2)	297.4 (295.8,299.1)	289.4 (287.8,291.0)	279.9 (278.4,281.4)	272.2 (270.2,273.6)

Age		➔2005	2006	2007	2008	2009➔
0-14	Observed deaths	76	75	59	64	70
	Person-years	3555	3632	3740	3830	3895
	Absolute mortality rate per 1000 PY	21.4 (18.0,24.7)	20.7 (17.4,23.9)	15.8 (12.9,18.6)	16.7 (13.8,19.6)	18.0 (15.0,20.9)
	Expected deaths	1.2	1.2	1.2	1.2	1.3
	Expected mortality rate per 1000 PY	0.3	0.3	0.3	0.3	0.3
	Excess mortality rate per 1000 PY	21.0 (17.7,24.4)	20.3 (17.1,23.6)	15.5 (12.7,18.2)	16.4 (13.5,19.2)	17.6 (14.7,20.6)
15-24	Observed deaths	247	262	228	238	219
	Person-years	9474	9972	10424	10866	11175
	Absolute mortality rate per 1000 PY	26.1 (23.8,28.3)	26.3 (24.1,28.5)	21.9 (19.9,23.8)	21.9 (20.0,23.8)	19.6 (17.8,21.4)
	Expected deaths	8.9	9.5	9.6	9.5	9.1
	Expected mortality rate per 1000 PY	0.9	0.9	0.9	0.9	0.8
	Excess mortality rate per 1000 PY	25.1 (22.9,27.3)	25.3 (23.2,27.5)	21.0 (19.0,22.9)	21.0 (19.1,22.9)	18.8 (17.0,20.5)
25-44	Observed deaths	4096	4161	4149	4055	4128
	Person-years	70856	75106	78974	82712	85771
	Absolute mortality rate per 1000 PY	57.8 (56.6,59.0)	55.4 (54.3,56.5)	52.5 (51.5,53.6)	49.0 (48.0,50.1)	48.1 (47.1,49.1)
	Expected deaths	144.8	152.3	154.5	154.9	158.3
	Expected mortality rate per 1000 PY	2.0	2.0	2.0	1.9	1.8
	Excess mortality rate per 1000 PY	55.8 (54.6,56.9)	53.4 (52.3,54.5)	50.6 (49.5,51.6)	47.2 (46.1,48.2)	46.3 (45.3,47.3)
45-64	Observed deaths	22799	24129	24245	24810	25684
	Person-years	175675	190041	204349	218831	232658
	Absolute mortality rate per 1000 PY	129.8 (128.7,130.8)	127.0 (125.9,128.0)	118.6 (117.7,119.6)	113.4 (112.5,114.3)	110.4 (109.5,111.3)
	Expected deaths	1472.0	1561.2	1649.5	1751.4	1844.1
	Expected mortality rate per 1000 PY	8.4	8.2	8.1	8.0	7.9
	Excess mortality rate per 1000 PY	121.4 (120.4,122.4)	118.8 (117.8,119.7)	110.6 (109.6,111.5)	105.4 (104.5,106.3)	102.5 (101.6,103.3)
≥65	Observed deaths	45140	45680	45835	46426	46878
	Person-years	149001	157499	166089	175762	185288
	Absolute mortality rate per 1000 PY	303.0 (301.5,304.4)	290.0 (288.6,291.4)	276.0 (274.6,277.3)	264.1 (262.9,265.4)	253.0 (251.8,254.2)
	Expected deaths	5515.4	5626.5	5764.7	6038.4	6108.9
	Expected mortality rate per 1000 PY	37.0	35.7	34.7	34.4	33.0
	Excess mortality rate per 1000 PY	265.9 (264.5,267.3)	254.3 (253.0,255.7)	241.3 (240.0,242.5)	229.8 (228.6,231.0)	220.0 (218.9,221.2)

Age		➔2010	2011	2012	2013
0-14	Observed deaths	79	54	53	54
	Person-years	3938	4010	4097	4104
	Absolute mortality rate per 1000 PY	20.1 (17.0,23.1)	13.5 (10.9,16.0)	12.9 (10.5,15.4)	13.2 (10.7,15.6)
	Expected deaths	1.2	1.3	1.3	1.2
	Expected mortality rate per 1000 PY	0.3	0.3	0.3	0.3
	Excess mortality rate per 1000 PY	19.8 (16.7,22.8)	13.2 (10.7,15.6)	12.6 (10.2,15.0)	12.9 (10.4,15.3)
15-24	Observed deaths	223	210	189	174
	Person-years	11481	11778	11990	11996
	Absolute mortality rate per 1000 PY	19.4 (17.6,21.2)	17.8 (16.1,19.5)	15.8 (14.2,17.3)	14.5 (13.0,16.0)
	Expected deaths	9.1	9.3	9.2	9.0
	Expected mortality rate per 1000 PY	0.8	0.8	0.8	0.7
	Excess mortality rate per 1000 PY	18.6 (16.9,20.4)	17.0 (15.4,18.7)	15.0 (13.5,16.5)	13.8 (12.3,15.2)
25-44	Observed deaths	3913	3814	3714	3598
	Person-years	88909	91532	94755	97078
	Absolute mortality rate per 1000 PY	44.0 (43.1,45.0)	41.7 (40.8,42.6)	39.2 (38.3,40.1)	37.1 (36.2,37.9)
	Expected deaths	155.4	160.4	165.0	169.9
	Expected mortality rate per 1000 PY	1.7	1.8	1.7	1.7
	Excess mortality rate per 1000 PY	42.3 (41.3,43.2)	39.9 (39.0,40.8)	37.5 (36.6,38.3)	35.3 (34.5,36.1)
45-64	Observed deaths	26175	26621	25924	25317
	Person-years	2472967	260801	273264	283419
	Absolute mortality rate per 1000 PY	105.8 (105.0,106.7)	102.1 (101.3,102.9)	94.9 (94.1,95.6)	89.3 (88.6,90.1)
	Expected deaths	1934.6	2032.4	2133.6	2228.3
	Expected mortality rate per 1000 PY	7.8	7.8	7.8	7.9
	Excess mortality rate per 1000 PY	98.0 (97.2,98.8)	94.3 (93.5,95.1)	87.1 (86.3,87.8)	81.5 (80.8,82.2)
≥65	Observed deaths	47338	47925	46948	47038
	Person-years	195962	205785	219335	233521
	Absolute mortality rate per 1000 PY	241.6 (240.4,242.8)	232.9 (231.7,234.0)	214.0 (213.0,215.1)	201.4 (200.4,202.5)
	Expected deaths	6392.4	6588.4	6838.5	7213.9
	Expected mortality rate per 1000 PY	32.6	32.0	31.2	30.9
	Excess mortality rate per 1000 PY	208.9 (207.8,210.1)	200.9 (199.8,202.0)	182.9 (181.9,183.9)	170.5 (169.6,171.5)

The expected number of deaths in each calendar year was calculated based on the age-, sex-, race-, and calendar year-specific United States general population mortality rates (16-18) and the age, sex, and race distributions of ESRD person-time within each calendar year. We subtracted expected from observed deaths in each year to determine the calendar year-specific excess ESRD-related mortality rate (deaths per 1000 person-years, PY) (6). These are raw numbers of deaths and crude rates.

Table S7. Associations between Covariates and Relative Excess Risks of Mortality

	Models including primary disease		Models including comorbidity	
Variable	**All ESRD observation time**	**Adjusted for RRT modality**	**All ESRD observation time**	**Adjusted for RRT therapy modality**
Current Age				
0 to 14 years	0.16 (0.14-0.18)	0.27 (0.20-0.37)	0.19 (0.16-0.21)	0.29 (0.21-0.39)
15 to 24 years	0.14 (0.13-0.15)	0.14 (0.11-0.19)	0.16 (0.15-0.17)	0.15 (0.11-0.20)
25 to 44 years	0.31 (0.31-0.32)	0.30 (0.27-0.33)	0.36 (0.35-0.37)	0.31 (0.28-0.34)
45 to 64 years	0.54 (0.53-0.54)	0.64 (0.59-0.69)	0.57 (0.56-0.57)	0.65 (0.60-0.70)
≥65 years	Reference	Reference	Reference	Reference
Dialysis (versus Transplant)	---	5.70 (5.35-6.07)	---	5.09 (4.78-5.42)
Male sex (versus Female)	1.01 (1.01-1.02)	1.03 (1.02-1.03)	0.99 (0.98-0.99)	1.01 (1.00-1.01)
Race				
White	1.29 (1.28-1.30)	1.32 (1.31-1.34)	1.23 (1.22-1.24)	1.27 (1.26-1.28)
Black	1.10 (1.09-1.11)	1.06 (1.05-1.07)	1.10 (1.09-1.11)	1.05 (1.04-1.05)
Other	Reference	Reference	Reference	Reference
Primary kidney disease				
Diabetes	1.63 (1.62-1.64)	1.49 (1.48-1.50)	---	---
Hypertension	1.43 (1.42-1.45)	1.32 (1.31-1.33)	---	---
Glomerulonephritis	Reference	Reference	---	---
Congenital anomalies of the kidneys and urinary tract	0.91 (0.89-0.94)	1.00 (0.97-1.03)	---	---
Other	1.46 (1.45-1.47)	1.40 (1.39-1.42)	---	---
Socioeconomic quartile				
Lowest	1.11 (1.11-1.12)	1.06 (1.05-1.06)	1.11 (1.10-1.11)	1.06 (1.05-1.06)
Mid-low	1.09 (1.08-1.10)	1.05 (1.05-1.06)	1.07 (1.06-1.08)	1.04 (1.03-1.05)
Mid-high	1.05 (1.04-1.05)	1.03 (1.02-1.03)	1.03 (1.03-1.04)	1.01 (1.01-1.02)
Highest	Reference	Reference	Reference	Reference
Primary insurance coverage				
Private	0.67 (0.67-0.67)	0.75 (0.74-0.75)	0.71 (0.71-0.72)	0.79 (0.78-0.79)
Public	Reference	Reference	Reference	Reference
No coverage	0.72 (0.72-0.73)	0.69 (0.68-0.69)	0.77 (0.76-0.78)	0.73 (0.72-0.74)
Comorbidity				
≥4	---	---	2.60 (2.58-2.61)	2.33 (2.31-2.34)
2 to 3	---	---	1.87 (1.86-1.88)	1.69 (1.68-1.70)
1	---	---	1.41 (1.40-1.41)	1.31 (1.30-1.32)
0	---	---	Reference	Reference

The table shows adjusted relative excess risks (95% confidence intervals, CI) of endstage renal disease (ESRD)-relatedmortality associated with each of the covariates included in the models. RRT, renal replacement therapy. All p-values<0.0001.

Appendix A: **SAS Macro Lexis**

```
/*****************************************************************************
Author: Bendix Carstensen, 1999-2002
Update: Paul Dickman, BxC, November 2003
Bug-fix: BxC, December 2007:
         If the origin= argument had missing values erroneous output would
         be generated (too much risk time). Now remedied so that
         observations with missing values of origin are excluded.
This macro is in: http://www.biostat.ku.dk/~bxc/Lexis/Lexis.sas
Example program:  http://www.biostat.ku.dk/~bxc/Lexis/xLexis.sas
*****************************************************************************/

%macro Lexis ( data = ,       /* Data set with original data,             */
                              /*    defaults to last                    */
               out = ,        /* Where to put the result,                 */
                              /*    defaults to &data.                   */
             entry = entry,   /* Variable holding the entry date          */
              exit = exit,    /* Variable holding the exit date           */
              fail = fail,    /* Variable holding the exit status         */
                              /* If any of the entry, exit or fail        */
                              /*    variables are missing the person is   */
                              /*    discarded from the computations.      */
            breaks = ,        /* Specification of the cutpoints on        */
                              /*    the transformed scale.                */
                              /*    Syntax as for a do statement.         */
                              /*    The ONLY Mandatory argument.          */
cens = 0,      /* Code for censoring (may be a variable)   */
             scale = 1,       /* Factor to transform from the scale       */
                              /*    of entry and exit to the scale        */
                              /*    where breaks and risk are given       */
            origin = 0,       /* Origin of the transformed scale          */
              risk = risk,    /* Variable receiving the risk time         */
lrisk = lrisk,  /* Variable receiving the log(risk time)    */
              left = left,    /* Variable receiving left  endpoint of int */
             other = ,        /* Other dataset statements to be used such */
                              /*     as: %str( formatvar ddmmyy10. ; )    */
                              /*     or: %str( label risk =''P-years'' ; )  */
```

```
               disc = discrd, /* Dataset holding discarded observations   */
           /*-------------------------------------------------------------*/
           /* Variables for making life-tables and other housekeeping:    */
           /* These will only appear in the output dataset if given here  */
           /* The existence of these arguments are tested in the macro so */
           /* they cannot have names that are also logical operators such */
           /* as: or, and, eq, ne, le, lt, gt.                            */
           /*-------------------------------------------------------------*/
              right = ,       /* Variable receiving right endpoint of int */
               lint = ,       /* Variable receiving interval length       */
os_left= ,       /* Variable receiving left  endpoint of int */
os_right= ,       /* Variable receiving right endpoint of int */
os_lint= ,       /* Variable receiving interval length       */
                               /*    - the latter three on original scale  */
cint= ,       /* Variable receiving censoring indicator   */
                               /*    for the current input record          */
nint =         /* Variable receiving index of follow-up    */
                               /*       interval;                          */
             );


%if &breaks.= %then %put ERROR: breaks MUST be specified. ;
%if &data.  = %then %let data = &syslast. ;
%if &out.   = %then %do ;
                      %let out=&data. ;
                      %put
NOTE: Output dataset not specified, input dataset %upcase(&data.) will be overwritten.
;
                   %end ;


data &disc. &out. ;
  set &data. ;
  if ( nmiss ( &entry., &exit., &fail., &origin. ) gt 0 )
     then do ; output &disc. ;
gotonext ;
end ;
  * Labelling of variables ;
  label &entry.  = 'Entry into interval' ;
  label &exit.   = 'Exit from interval' ;
```

```
  label &fail.   = 'Failure indicator for interval' ;

  label &risk.   = 'Risktime in interval' ;

  label &lrisk.  = 'Natural log of risktime in interval' ;

  label &left.   = 'Left endpoint of interval (transformed scale)' ;

%if    &right.^= %then  label &right. = 'Right endpoint of interval (transformed
scale)' ; ;

%if     &lint.^= %then  label &lint. = 'Interval width (transformed scale)' ; ;

%if  &os_left.^= %then  label &os_left. = 'Left endpoint of interval (original scale)'
; ;

%if &os_right.^= %then  label &os_right. = 'Right endpoint of interval (original
scale)' ; ;

%if  &os_lint.^= %then  label &os_lint. = 'Interval width (original scale)' ; ;

%if     &cint.^= %then  label &cint. = 'Indicator for censoring during the interval' ;
;

%if     &nint.^= %then  label &nint. = 'Sequential index for follow-up interval' ; ;

&other. ;

  drop entryexitfail

originbreak

currcurl intrintl

firstcintnint;


/*

Temporary variables in this macro:


entry  holds entry date on the transformed timescale

exit   holds exit  date on the transformed timescale

fail   holds exit  status

break  current cut-point

originorigin of the time scale

curl   left  endpoint of current risk interval

curr   right endpoint of current risk interval

intlleft  endpoint of current break interval

intr   right endpoint of current break interval

first  indicator for processing of the first break interval

cint   indicator for censoring during the interval

nint   sequential index of interval


If a variable with any of these names appear in the input dataset it will

not be present in the output dataset.
```

```
*/

origin = &origin. ;
entry  = ( &entry. - origin ) / &scale. ;
exit   = ( &exit.  - origin ) / &scale. ;
fail   = &fail. ;
curl   = entry ;
first  = 1 ;

  do break = &breaks. ;
     if first then do ;
nint=-1;
curl = max ( break, entry ) ;
intl = break ;
end ;
nint + 1;
first = 0 ;
intr = break ;
curr = min ( exit, break ) ;
     if currgtcurl then do ;
/*
Endpoints of risk interval are put back on original scale.
If any of left or right are specified the corresponding endpoint
of the break-interval are output.
*/
&entry.  = curl * &scale. + origin ;
&exit.   = curr * &scale. + origin ;
&risk.   = curr - curl ;
&lrisk.  = log ( &risk. ) ;
&fail.   = fail * ( exiteqcurr ) +
&cens. * ( exitgtcurr ) ;
cint   = not( fail ) * ( exiteqcurr ) ;
        %if     &left.^= %then &left.     = intl ; ;
        %if    &right.^= %then &right.    = intr ; ;
        %if     &lint.^= %then &lint.     = intr - intl ; ;
        %if  &os_left.^= %then &os_left.  = intl * &scale. + origin ; ;
        %if &os_right.^= %then &os_right. = intr * &scale. + origin ; ;
```

```
        %if  &os_lint.^= %then &os_lint.  = ( intr - intl ) * &scale. ; ;
        %if     &cint.^= %then &cint.     = cint ; ;
        %if     &nint.^= %then &nint.     = nint ; ;
        output &out. ;
end ;
curl = max ( entry, break ) ;
intl = break ;
end ;
  next: ;
run ;

%mend Lexis ;
```

Appendix B: Sample SAS code

```
title "Model with MI";

ods output parameterestimates=parmest /* parameter estimates */

modelinfo=modelinfo        /* Model information */

modelfit=modelfit          /* Model fit information */

convergencestatus=converge /* Whether the model converged */

           type3=type3estimates;      /* Type III estimates */


proc genmod data=Imp_cut order=formatted;

title2 'Regression model with a Poisson error structure fitted to individual data
[model 3 in Dickman et al. (2004)]';

title3 'Main effects model (calendar year and current age)';

fwdlink link = log(_MEAN_-d_star);

invlinkilink= exp(_XBETA_)+d_star;

class age_curfu sex race q_incomeinsur(ref=" Medicare/medicaidcov") diseasec(ref="GN")
;

model event =fuyear|age_cur sex race q_incomeinsurdiseasec  /error=poisson link=log
offset=ln_y type3;

format age_curagc.  diseasecdis. ;

by _imputation_;

ods output ParameterEstimates=gmparms21

CovB=gmcovb21;

run;


data gmparms211;

set gmparms21;

if dfgt 0 then do;

rer=exp(estimate);

low_rer=exp(estimate-1.96*stderr);

hi_rer=exp(estimate+1.96*stderr);

end;

run;


data gmparms212;set gmparms211;

if Level1='0-14' then do;

if Parameter='age_cur' then Parameter='age_cur1';

if Parameter='year*age_cur' then Parameter='year*age_cr1';end;


if Level1='15-24' then do;
```

```
if Parameter='age_cur' then Parameter='age_cur2';
if Parameter='year*age_cur' then Parameter='year*age_cr2';end;

if Level1='25-44' then do;
if Parameter='age_cur' then Parameter='age_cur3';
if Parameter='year*age_cur' then Parameter='year*age_cr3';end;

if Level1='45-64' then do;
if Parameter='age_cur' then Parameter='age_cur4';
if Parameter='year*age_cur' then Parameter='year*age_cr4';end;

if Level1='>=65' then do;
if Parameter='age_cur' then Parameter='age_cur5';
if Parameter='year*age_cur' then Parameter='year*age_cr5';end;

if Level1='Female' and Parameter='sex' then Parameter='Female';
if Level1='Male' and Parameter='sex' then Parameter='Male';

if Level1='Black' and Parameter='race' then Parameter='Black';
if Level1='Others' and Parameter='race' then Parameter='Others';
if Level1='White' and Parameter='race' then Parameter='White';

if Level1='0' and Parameter='Q_INCOME' then Parameter='Q_INCOME1';
if Level1='1' and Parameter='Q_INCOME' then Parameter='Q_INCOME2';
if Level1='2' and Parameter='Q_INCOME' then Parameter='Q_INCOME3';
if Level1='3' and Parameter='Q_INCOME' then Parameter='Q_INCOME4';

if Level1='Employ/other cov' and Parameter='INSUR' then Parameter='Emp_othcov';
if Level1='No cov' and Parameter='INSUR' then Parameter='No_cov';
if Level1='Medicare/medicaidcov' and Parameter='INSUR' then Parameter='public';

if Level1='Cakut' and Parameter='DISEASEC' then Parameter='Cakut';
if Level1='Diabete' and Parameter='DISEASEC' then Parameter='Diabete';
if Level1='GN' and Parameter='DISEASEC' then Parameter='GN';
if Level1='Hyperten' and Parameter='DISEASEC' then Parameter='Hyperten';
if Level1='Other' and Parameter='DISEASEC' then Parameter='Other';
```

```
if Level1='0' and Parameter='COMOC4' then Parameter='COMOC0';
if Level1='1' and Parameter='COMOC4' then Parameter='COMOC1';
if Level1='2' and Parameter='COMOC4' then Parameter='COMOC2';
if Level1='3' and Parameter='COMOC4' then Parameter='COMOC_ge3';
run;

ods output ParameterEstimates = est21;
proc mianalyzeparms=gmparms212;
MODELEFFECTS year age_cur1 age_cur2 age_cur3 age_cur4 age_cur5
             year*age_cr1 year*age_cr2 year*age_cr3 year*age_cr4 year*age_cr5
             Female Male
             White Black Others
             Q_INCOME1 Q_INCOME2 Q_INCOME3 Q_INCOME4
Emp_othcovNo_cov public
CakutDiabete GN Hyperten Other
                    /*COMOC0 COMOC1 COMOC2 COMOC_ge3*/
                     ;
run;

data est_21;set est21;
if Parm ^="Intercept";
OR = round(exp(estimate),0.001);
L_OR=round(EXP(LOG(OR) - (1.96 * StdErr)),0.001) ;
U_OR=round(EXP(LOG(OR) + (1.96 * StdErr)),0.001) ;

run;

title "Model with MI";
title2 "The MIANALYZE Procedure";
proc print data = est_21 noobs;
varParm Estimate StdErrLCLMeanUCLMeantValueProbt
    OR L_OR U_OR;
run;
```

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