Increasing Body Mass Index and Obesity in the Incident ESRD Population

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An increase in obesity prevalence among patients who initiate dialysis may influence the growth of the total ESRD population as a result of improved survival and decreased likelihood for transplantation. Temporal trends in mean body mass index (BMI) and obesity prevalence were examined among incident patients with ESRD by year of dialysis initiation between 1995 and 2002, and these trends were compared with those in the US population during this same period. Among incident dialysis patients, BMI was calculated with the height and estimated dry weight collected from the Centers for Medicare and Medicaid Services End-Stage Renal Disease Medical Evidence Form. In the US population, self-reported height and weight were used. Prevalence of total obesity and obesity stage ≥2 were defined as a BMI ≥30 and ≥35 kg/m^2, respectively. Among incident patients with ESRD, mean BMI increased from 25.7 to 27.5 kg/m^2, and total obesity and obesity stage ≥2 increased by 33 and 63%, respectively, among incident patients with ESRD (P < 0.0001 for obesity trends). BMI slope was approximately two-fold higher in the incident ESRD population compared with the US population for all age groups. However, temporal increases in obesity prevalence were similar between the two populations. As a result of the survival advantage associated with obesity and decreased likelihood for transplantation, these trends most likely will influence the total number of patients who receive dialysis in the next decade.

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Obesity has reached epidemic proportions in the United States and continues to be a growing problem worldwide. In the past 20 yr, the prevalence of obesity among adults aged 20 to 74 yr has doubled from 15 to 30% (1), whereas the number of morbidly obese adults in the United States has quadrupled from 1 in 200 adults to in 1 in 50 (2). Congruent with the obesity epidemic is a growing number of adults with end-stage renal disease ESRD, a population that is expected to double in number during the next decade (3). Obesity increases the risk for diabetes and hypertension, the two primary causes of ESRD in the United States (4), and may itself be an independent risk factor for kidney disease as a result of glomerular hyperfiltration and activation of the renin-angiotensin system (5–7). In addition, obesity is associated with improved survival in patients with ESRD (8–10) and decreased likelihood for kidney transplantation; therefore, an increase in obesity prevalence among incident dialysis patients most likely will influence the growth of the total ESRD population.

This article, which documents the increased prevalence of obesity in US patients initiating dialysis as it relates to a potential beneficial effect of obesity on dialysis patient survival, links to the article by Hjelmesaeth et al. *in the current issue of* CJASN *(pages 575–582), which suggests the possibility of an opposite, negative effect of some features of metabolic syndrome on transplant patient survival due to increased risk of cardiovascular disease.*

We examined mean body mass index (BMI) and obesity prevalence among incident patients with ESRD by year of dialysis initiation to test the hypothesis that BMI and obesity prevalence is increasing in this population. We examined both total obesity (BMI ≥ 30 kg/m^2) and obesity stage ≥2 (BMI ≥ 35 kg/m^2) because many medical centers preclude kidney transplantation in adults with this stage of obesity (11). Temporal trends in obesity prevalence in the ESRD population then were compared with trends in the total US population.

Materials and Methods

This study was approved by the Institutional Review Board at Loyola University Medical Center. Information on BMI in the ESRD population was obtained from the United States Renal Data System (USRDS), a national data system that collects, analyzes, and distributes information about ESRD in the United States and is funded by the National Institute of Diabetes and Digestive and Kidney Diseases in conjunction with the Centers for Medicare and Medicaid Services. This study was limited to adult patients who had ESRD and were 20 yr and older, initiated permanent dialysis during the years 1995 to 2002, and had complete information on height and dry weight. Height and weight were not uniformly collected before 1995, and 2002 is the most recent year that information on the US ESRD population is currently available.

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The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as an official policy or interpretation of the US government.

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Data for incident patients in 2002 were available for those who initiated dialysis from January through July. A total of 662,639 incident patients were reported to the USRDS database during 1995 to 2002, and BMI was available in 94% (n = 621,224). We excluded patients who had ESRD with a BMI <13 or >65 kg/m^2, because of potential reporting error (n = 6032). Information on 615,192 incident patients who had ESRD and initiated dialysis from 1995 to 2002 was available for the analysis.

BMI was calculated with the height and estimated dry weight collected from the Centers for Medicare and Medicaid Services End-Stage Renal Disease Medical Evidence Form (CMS 2728). This form is completed by the dialysis health care team within 30 d of initiation of permanent dialysis. Information on age, race/ethnicity, primary cause of renal failure, and presence of diabetes also was obtained from the CMS 2728 form. Beginning in April 1995, questions on ethnicity (Hispanic yes/no) were added to the CMS 2728 form. Race/ethnicity was categorized as non-Hispanic white, non-Hispanic black, Hispanic, Asian, Native American, and other. Presence of diabetes was defined as current use of insulin or diabetes as the primary or contributing disease for kidney failure on the CMS 2728 form.

To compare trends in BMI and obesity prevalence in the incident ESRD population with the total US population, we used data from the Behavioral Risk Factor Surveillance System of the Centers for Disease Control and Prevention (Atlanta, GA). This survey is conducted annually and uses a multistage cluster design based on random-digit dialing to select a representative sample of each state's noninstitutionalized civilian residents. Data from each state then are pooled to produce nationally representative estimates (12). BMI was calculated using the self-reported height and weight measurements collected by the Behavioral Risk Factor Surveillance System. We included adults who were 20 yr and older (n = 1,260,176) and excluded those with BMI <13 and >65 kg/m^2 (n = 335), leaving a total of 1,259,841.

Statistical Analyses

Trends in mean BMI and prevalence of obesity stage I (BMI 30 to 34.9 kg/m^2) and stage ≥2 (BMI ≥ 35 kg/m^2) were examined among incident patients with ESRD by year of dialysis initiation. Trends in obesity prevalence among incident patients with ESRD by year of dialysis initiation then were reexamined after stratification by presence of diabetes. Several subgroups were examined after stratification by diabetes: Gender, race/ethnicity, and age groups (20 to 44 yr, 45 to 64 yr, 65 to 74 yr, and ≥75 yr).

A χ^2 test for trend was used to determine significant linear trends in obesity prevalence among incident patients with ESRD during the period 1995 to 2002. The incident ESRD and US populations then were stratified by age groups: 20 to 44, 45 to 64, 65 to 74, and ≥75. Trends in mean BMI slope were compared between the total ESRD and US populations and in each age strata by placing an interaction term in a regression model that predicted BMI: $\alpha + \beta_1\text{year} + \beta_2\text{data} + \beta_3\text{year} \times \text{data}$. *Data* refers to the study population (ESRD or US), and year = 0, 1, 2,. . . 7 corresponding to years 1995 to 2002. A significant interaction between year and data indicated a significant difference in BMI slopes between the two populations. Projections of total obesity and obesity stage ≥2 among patients who would have ESRD and initiate dialysis in 2007 were performed with forecasting methods (SAS Proc Forecast, version 9.1; SAS, Inc., Cary, NC) using the stepwise autoregressive method. We forecasted obesity prevalence in 2007 rather than 2010 because of the limited time period available for autoregression. The historic data were the prevalence of total obesity and obesity stage ≥2 from 1995 to 2002, and forecasting methods were applied to the total and diabetic ESRD population.

Results

The characteristics of the adult incident patients with ESRD by year of dialysis initiation are shown in Table 1. During the 8-yr period, mean age increased from 61 to 63 yr and the percentage of patients with diabetes increased from 44 to 51%. Mean BMI increased from 25.7 kg/m^2 among incident patients in 1995 to 27.5 kg/m^2 among incident patients in 2002.

Figure 1 shows the age-adjusted mean BMI among incident patients with ESRD by year of dialysis initiation and among the total adult US population for the respective years. From 1995 to 2002, mean BMI increased from 25.9 to 27.9 kg/m^2 in the incident ESRD population and from 25.7 to 26.7 kg/m^2 in the total US population. BMI slope during the 8-yr period was significantly higher in the incident ESRD population compared with the total US population (8 *versus* 4%; $P < 0.0001$).

Temporal trends in obesity prevalence among incident patients with ESRD by year of dialysis initiation are shown in Figure 2. The highest increase in prevalence was noted for obesity stage ≥2, which increased by 63% ($P < 0.0001$ for trend). Obesity stage 1 increased by 32%, whereas total obesity increased by 45% ($P < 0.0001$ for both trends). In 2002, almost one third of all incident patients with ESRD were obese. Mean unadjusted BMI in the US population and in the incident ESRD population by year of dialysis initiation after stratification by age groups is shown in Table 2. The rate of change in BMI during the 8-yr period was approximately two-fold higher in the incident ESRD population compared with the US popula-

Table 1. Characteristics of the ESRD population by year of initiation of dialysis[a]

Year	Sample Size	Mean Age (yr)	% Male	% Diabetes	Mean BMI
1995	54,159	61.0	52	44	25.7
1996	74,085	61.6	53	45	25.7
1997	78,655	62.1	53	46	25.9
1998	83,071	62.3	53	47	26.1
1999	87,154	62.7	53	47	26.5
2000	89,845	62.9	53	49	27.1
2001	92,064	63.0	54	50	27.3
2002	56,159	63.2	54	51	27.5

[a]BMI, body mass index.

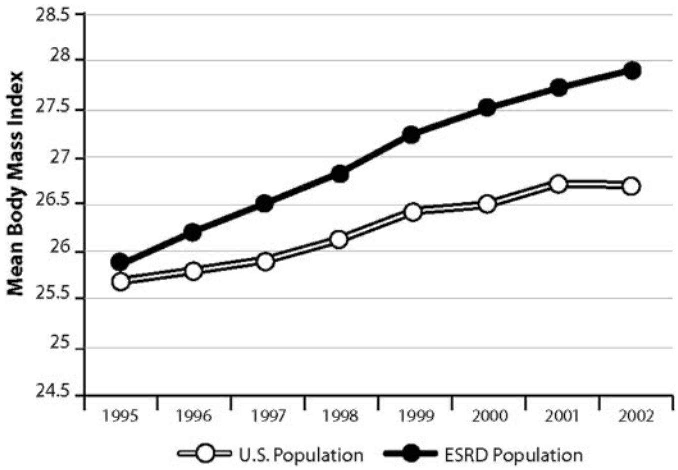

Figure 1. Temporal trends in mean body mass index (kg/m^2) among the incident adult ESRD patient population by year of first permanent dialysis initiation and in the total adult US population (Behavioral Risk Factor Surveillance System) for the corresponding year. Data are age adjusted for the 2000 US census.

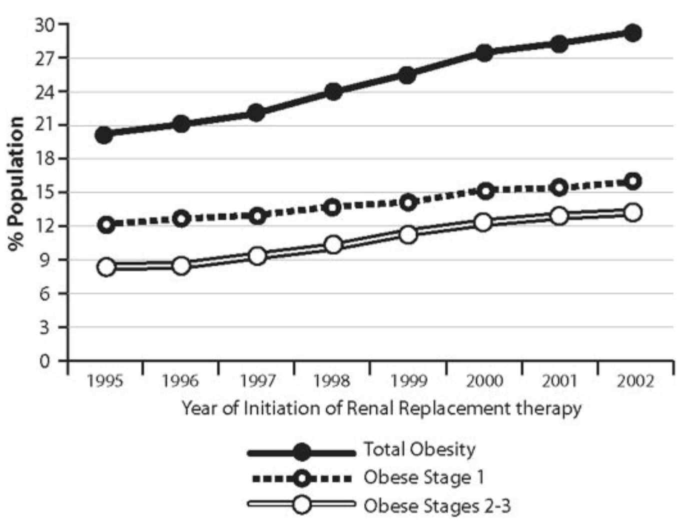

Figure 2. Temporal trends in prevalence of obesity among the incident ESRD patient population by year of initiation of dialysis.

tion for all age groups, including age 75 and older ($P < 0.0001$ for all comparisons). Increases in obesity stage 1 and stage ≥2 were similar for all age groups except for ages 65 to 74 yr. In this age group, prevalence of obesity stage ≥2 increased by 97% in the incident ESRD population and by 69% in the US population, whereas rates of change in obesity stage 1 were similar between the two populations.

Figure 3 shows the rate of increase in obesity stage ≥2 among patients who had ESRD and initiated dialysis from 1995 to 2002 by gender, racial/ethnic groups, and age groups after stratification by presence of diabetes. Both prevalence and rate of increase in prevalence of obesity stage ≥2 were higher among all subgroups with diabetes compared with the subgroups without diabetes during the 8-yr period. For example, among incident female patients in 1995, the prevalence of obesity stage ≥2 was 13.6% in the group with diabetes compared with 8.1% in the group without diabetes. The prevalence of obesity stage ≥2 increased by 61% among incident female patients with diabetes compared with 44% among incident female patients without diabetes. Similar patterns were noted in other subgroups. Therefore, both the burden and the growth of obesity prevalence were higher in the incident patients with ESRD and diabetes compared with incident patients without diabetes. The highest prevalence of obesity stage ≥2 was among women compared with men and among non-Hispanic black patients compared with all other race/ethnicity groups. These findings were consistent in the groups with and without diabetes. In the ESRD population with diabetes, patients who were between the ages of 45 and 64 yr at dialysis initiation had the highest prevalence of obesity stage ≥2. In the group without diabetes, prevalence of obesity stage ≥2 was similar for the 20 to 44 and 45 to 65 yr age groups, which had the highest prevalence of obesity stage ≥2.

According to the forecasted estimates, prevalence of total obesity and obesity stage ≥2 may reach 36% (95% confidence interval [CI] 35 to 38%; Figure 4) and 17.5% (95% CI 16.6 to 18.4%; Figure 5), respectively, among patients who initiate dialysis in 2007. In the population with diabetes, the forecasted prevalence of total obesity and obesity stage ≥2 among incident patients in 2007 is 44.6% (95% CI 43.0 to 46.2%) and 22.7% (95% CI 21.7 to 23.6%), respectively (data not shown).

Discussion

In the adult incident ESRD population, this study found significant trends in increasing obesity prevalence during the period 1995 to 2002. Although the rate of change in BMI was approximately two-fold higher in all age subgroups in the ESRD population compared with the US population, trends in increasing obesity in the ESRD population overall mirrored trends in the US adult population. The increasing BMI among patients who initiate dialysis certainly will influence the total number of patients who receive dialysis in the next decade. In contrast to the general population (13), obesity is associated with improved survival (10,14,15) and decreased hospitalization rates (10) among patients with ESRD. Using data on >400,000 incident dialysis patients during the period 1995 to 2000, Johansen *et al.* (10) noted an approximately 20% lower mortality risk among those with a BMI >37 kg/m^2 at dialysis initiation compared with patients with a BMI between 22 and <24.9 kg/m^2 at dialysis initiation. This difference remained after adjustment for demographic and nutritional variables and comorbidities. Moreover, this survival advantage was reported for all BMI categories ≥25 kg/m^2 compared with BMI 22 to 24.9 kg/m^2 and for most racial/ethnic groups despite higher diabetes prevalence among overweight and obese patients. In addition, the association between obesity and decreased mortality remained significant when alternative estimates of adiposity were used and after adjustment for serum albumin (10). It is hypothesized that a higher level of adiposity may provide a survival advantage for patients with ESRD, a catabolic disease state (10). Because of the paradoxic association between higher

Table 2. Mean BMI and obesity prevalence in the US and incident ESRD population from 1995 to 2002

Year	US Population			Incident ESRD Population		
	BMI	% Obesity Stage 1	% Obesity Stage ≥2	BMI	% Obesity Stage 1	% Obesity Stage ≥2
Aged 20 to 44 yr						
1995	25.2	9.6	3.8	25.6	10.8	9.4
1996	25.4	9.9	4.2	26.0	11.2	10.2
1997	25.4	10.7	4.3	26.3	11.5	10.9
1998	25.7	11.0	5.1	26.7	12.1	12.2
1999	26.0	12.0	5.6	27.0	12.7	13.3
2000	26.1	12.4	5.9	27.3	13.1	142
2001	26.2	12.8	6.4	27.5	14.1	15.1
2002	26.3	13.1	6.4	27.7	15.3	15.4
% increase	4.4	36	68	8.2	42	64
Aged 45 to 64 yr						
1995	26.7	14.2	6.0	27.1	15.8	12.1
1996	26.8	14.3	6.3	27.4	16.4	12.6
1997	26.8	14.8	5.9	27.7	16.7	13.6
1998	27.1	15.5	7.3	28.0	17.4	14.7
1999	27.3	16.5	7.9	28.3	17.5	16.4
2000	27.4	16.6	8.1	28.7	18.5	17.5
2001	27.6	17.6	8.5	28.8	18.4	18.2
2002	27.6	17.2	9.0	29.1	18.7	19.2
% increase	3.3	21	50	7.3	18	59
Aged 65 to 74 yr						
1995	26.1	11.8	3.9	25.4	11.7	6.1
1996	26.0	12.3	3.9	25.6	12.6	6.5
1997	26.2	12.9	3.9	25.9	12.8	7.4
1998	26.5	13.7	5.0	26.3	14.1	8.5
1999	26.8	16.1	5.3	26.7	15.0	9.7
2000	26.8	15.4	5.6	27.2	16.5	11.0
2001	27.1	16.4	6.3	27.3	16.3	11.6
2002	27.1	16.9	6.6	27.5	17.0	12.0
% increase	3.8	43	69	8.3	45	97
Aged 75+ yr						
1995	24.9	8.4	1.9	23.6	6.8	3.0
1996	24.8	8.4	2.0	23.8	6.8	2.9
1997	24.9	9.1	2.0	24.1	7.5	3.4
1998	25.0	9.4	2.4	24.3	7.9	4.1
1999	25.4	11.0	3.2	24.6	8.7	4.1
2000	25.3	10.3	2.5	24.9	10.2	5.0
2001	25.6	11.5	3.1	25.1	10.6	5.2
2002	25.7	11.3	3.4	25.3	11.2	5.2
% increase	3.2	35	79	7.2	65	73

BMI and survival in this population, the increasing obesity prevalence among patients who initiate dialysis can lead only to increased numbers of prevalent patients with ESRD, a population that is projected to reach 600,000 by 2010 with costs exceeding $28 billion annually (3).

In 2002, 13% of all patients who initiated dialysis were classified as obese stage ≥2 (BMI ≥ 35 kg/m^2), and by 2007, this percentage may increase to 18% among incident patients with ESRD. Many medical centers currently preclude kidney transplantation at this level of obesity, but the issue remains controversial (16–18). Morbidly obese transplant recipients may have higher rates of wound infections, delayed graft function, and rejection (19–21). Decreased renal allograft survival also may be noted in morbidly obese kidney transplant recipients as a result of mismatch of renal mass for body size (20–22). Currently, 60% of all patients who have ESRD and receive a kidney transplant are either overweight or obese at the time of transplantation (23). There are currently no estimates of how many patients are refused transplantation as a result of body size alone, but our study suggests that the number may be increasing. Adequate

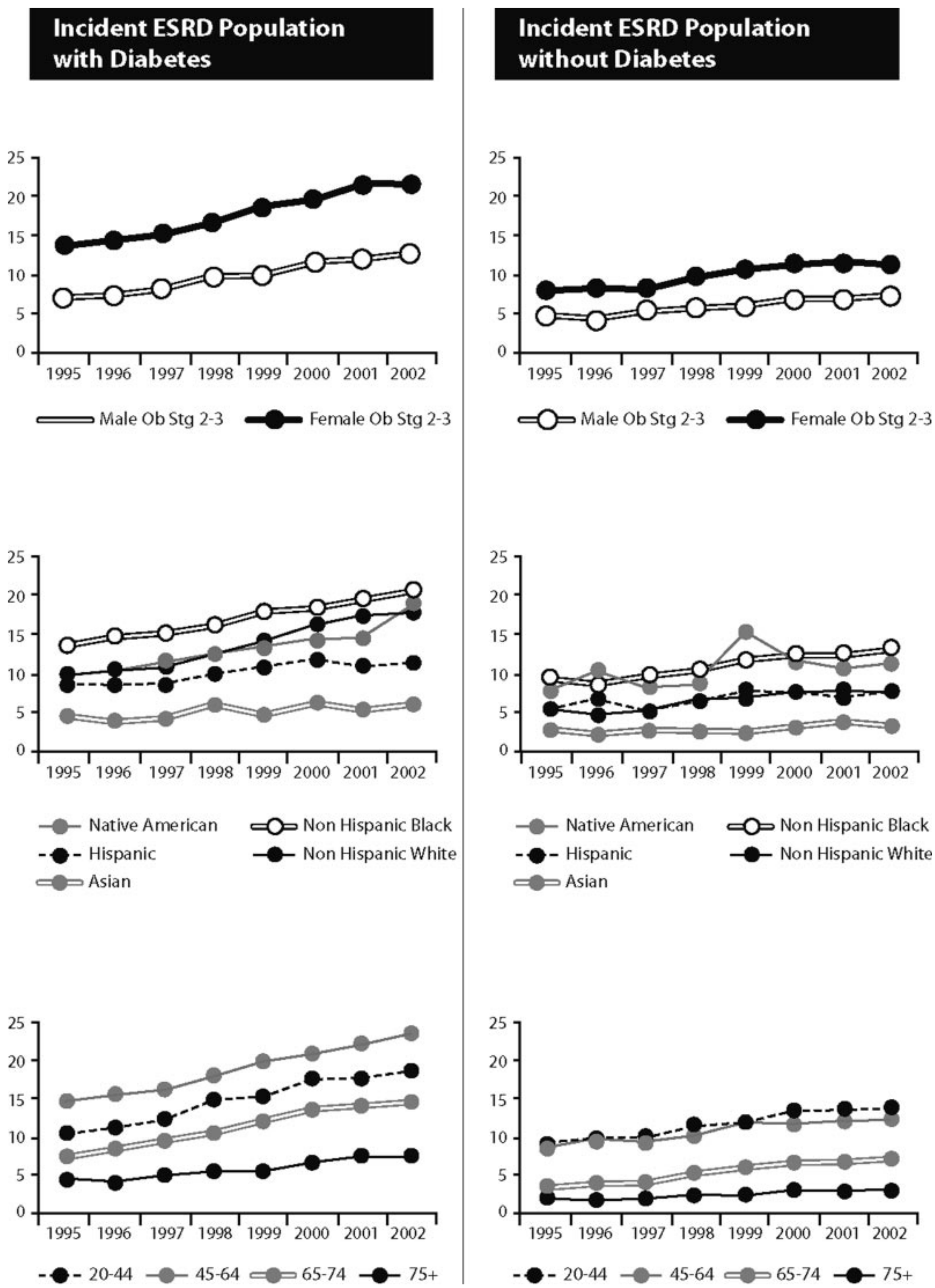

Figure 3. Temporal trends in obesity stage ≥2 among incident dialysis patients by year of dialysis initiation after stratification by diabetes and by gender, racial/ethnic group, and age group.

cadaver kidneys will never go unused because of the large number of potential recipients who are not morbidly obese. However, some obese patients may have a living donor but do not receive a transplant or are not put on the waiting list because of their body habitus. As the number of morbidly obese patients who need kidney transplantation increases, the transplant community may need to reevaluate the exclusion criteria or provide interventions for safe and effective weight loss when diet and exercise programs fail (24). The inability to transition from dialysis to transplantation as a result of obesity alone will positively influence the growth of the ESRD population.

Strengths and Limitations

BMI was calculated with the estimated dry weight, which is based on measured postdialysis weights. Estimated dry weight

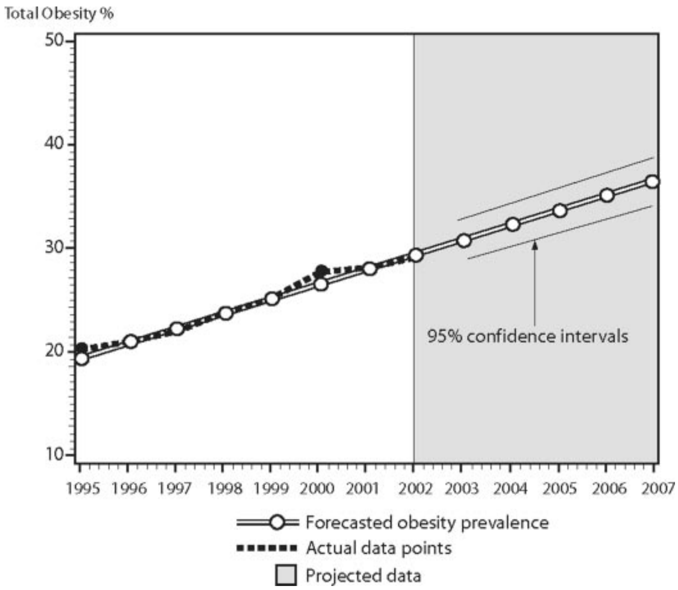

Figure 4. Forecasted prevalence of total obesity among incident dialysis patients by year of dialysis initiation. The line with circles indicates the forecasted obesity prevalence; the dashed line above and below the line with circles indicates the 95% confidence intervals for the forecasted prevalence.

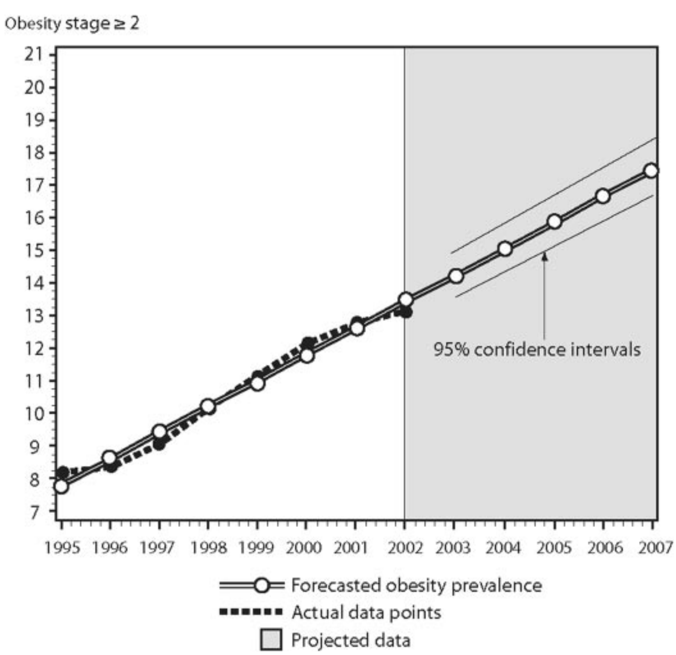

Figure 5. Forecasted prevalence of obesity stage ≥2 among incident dialysis patients by year of dialysis initiation. The line with circles indicates the forecasted obesity prevalence; the dashed line above and below the line with circles indicates the 95% confidence intervals for the forecasted prevalence.

in some patients may include both the true dry weight plus several kilograms of fluid, depending on comorbid conditions at the time of dialysis initiation. However, errors in estimation of dry weight would be unlikely to change over time and would not explain the significant temporal trends that we noted in BMI and obesity prevalence. BMI estimates in the total US population were based on self-reported height and weight, and underreporting of weight actually increases with a respondent's actual weight. Therefore, these estimates will underestimate BMI and obesity prevalence in the US population. However, this study focused on temporal trends in BMI, which would not be influenced substantially by errors in self-reported weight and height. This study was limited to the incident dialysis population. Temporal trends in BMI and obesity prevalence in the total dialysis population including both incident and prevalent patients could not be determined because height and weight are reported only to the USRDS at the time of dialysis initiation. The forecasted obesity prevalence among incident patients in 2007 is calculated using regression methods and depends on obesity slope during the period 1995 to 2002. These estimates should be considered with caution as forecasting methods provide very crude estimates and do not incorporate potential changes in future slope of obesity prevalence. Obviously, obesity prevalence cannot continue to increase linearly indefinitely. However, there currently is no indication that the strong and linear increase in obesity prevalence that is occurring among incident patients with ESRD has subsided.

Conclusion

We noted significant increases in the prevalence of obesity among incident patients with ESRD during the period 1995 to 2002. These trends will positively influence the growth of the total ESRD population in the next decade as a result of the survival advantage associated with obesity in this population. The preclusion of obese patients with ESRD from kidney transplantation needs to be readdressed as more and more patients who meet this exclusion criterion will be seeking transplantation.

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H.J.K. had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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