Population-based Trends in Obesity and Kidney Transplantation Among Patients With End-stage Kidney Disease

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INTRODUCTION

In 2019, the president of the United States signed an executive order entitled Advancing American Kidney Health.1 This directive outlines plans to reduce the risks of kidney failure, improve the quality of care for patients with end-stage kidney disease (ESKD), and increase access to kidney transplantation. Central to the success of these initiatives will be the management of a growing population of patients with ESKD and obesity. Not only does obesity increase the progression of kidney failure, but it also leads to lower hemodialysis fistula maturation rates, decreases access to transplantation, and negatively impacts post transplant outcomes.2–8

Despite its broad clinical and epidemiologic importance, contemporary data on the prevalence of obesity in patients with ESKD are limited. In 2002, approximately 30% of patients with ESKD had concurrent obesity (body mass index [BMI] >30 kg/m²), with rates increasing at twice that of the non-ESKD population.9 Unfortunately, a comprehensive follow-up to that literature is lacking. For the non-ESKD population, it is known that rates of obesity vary widely by state, making it unlikely that obesity has affected transplant centers across the United States equally. This may be particularly important because of how the Centers for Medicare and Medicaid Services organize efforts to improve the quality and value of care through a system of 18 regional ESKD networks. There is known geographic variation in ESKD incidence, clinical outcomes, dialysis access, and transplantation rates, but correlation to rates of obesity are unclear.10–12 This suggests that better data on...
how the obesity epidemic currently impacts patients with ESKD may have policy implication and also impact how transplant centers are addressing these new challenges in clinical care. Using population-based data from the United States Renal Data System, we assessed trends in the proportion of beneficiaries with ESKD and obesity between 2008 and 2016. To better understand the interplay between obesity and kidney

**FIGURE 1.** Flow diagram detailing cohort selection. BMI, body mass index; USRDS, United States Renal Data System.

**TABLE 1.** Demographic and clinical characteristics of end-stage kidney disease beneficiaries from 2008 to 2016

| Incident beneficiary characteristics, 2008–2016 | Underweight | Normal | Overweight | Obese |
|------------------------------------------------|-------------|--------|------------|-------|
| No. of beneficiaries                           | 71,750      | 274,683| 309,707    | 423,270|
| Age at baseline, mean (SD), y                  | 65.1 (17.0) | 65.3 (16.0)| 64.4 (14.6)| 60.7 (13.6)|
| Age categories, y                              |             |        |            |       |
| 18–29                                          | 33,66 (4.7) | 87,11 (3.2)| 62,84 (2.0)| 80,70 (1.9)|
| 30–44                                          | 56,29 (7.8) | 22,02 (8.0)| 25,22 (8.1)| 45,92 (10.8)|
| 45–54                                          | 82,34 (11.5)| 33,33 (12.1)| 42,21 (13.6)| 74,81 (17.7)|
| 55–64                                          | 13,55 (18.9)| 55,00 (20.0)| 70,28 (22.7)| 11,75 (27.8)|
| 65–79                                          | 25,12 (35.0)| 98,44 (35.8)| 11,17 (37.8)| 14,52 (34.3)|
| 80 and older                                   | 15,83 (22.1)| 57,16 (20.8)| 48,95 (15.7)| 31,64 (7.5)|
| Sex                                            |             |        |            |       |
| Female                                         | 36,29 (50.6) | 106,27 (38.7)| 115,52 (37.3)| 203,60 (48.1)|
| Male                                           | 35,45 (49.4) | 168,40 (52.3)| 194,16 (62.7)| 219,67 (51.9)|
| Race/Ethnicity                                 |             |        |            |       |
| Hispanic                                       | 7,69 (10.7) | 38,96 (14.2)| 47,43 (15.3)| 53,15 (12.6)|
| Non-Hispanic Black                             | 20,73 (28.9)| 70,28 (25.6)| 80,23 (25.9)| 123,85 (29.3)|
| Non-Hispanic White                             | 36,77 (51.2)| 144,09 (52.5)| 165,15 (53.3)| 231,37 (54.7)|
| Other                                          | 6,55 (9.1)  | 21,34 (7.9)| 16,80 (5.5)| 14,88 (3.5)|
| Comorbidities                                  |             |        |            |       |
| Diabetes                                       | 23,69 (33.0)| 124,46 (45.3)| 173,28 (56.0)| 286,51 (67.7)|
| Myocardial infarction                          | 11,43 (15.9)| 49,14 (17.9)| 58,03 (18.7)| 74,50 (17.6)|
| Peripheral vascular disease                    | 8,99 (12.5)| 33,09 (12.0)| 37,34 (12.1)| 50,51 (11.9)|
| Chronic obstructive pulmonary disease          | 8,75 (12.2)| 25,00 (9.1)| 26,29 (8.5)| 43,75 (10.2)|
| Cerebrovascular disease                        | 7,32 (10.2)| 26,92 (9.8)| 28,95 (9.3)| 34,61 (8.2)|
| Hypertension                                   | 59,17 (82.5)| 234,46 (85.4)| 269,78 (87.1)| 373,67 (88.3)|
| Congestive heart failure                       | 19,45 (27.1)| 78,23 (28.5)| 93,15 (30.1)| 142,26 (33.6)|

Underweight (BMI <18.5), normal (BMI 18.5 to <25.0), overweight (BMI 25.0 to <30), and obese (BMI ≥30); BMI, body mass index.
transplantation, we investigated rates of transplant among patients in different weight classifications. Finally, we evaluated how these trends correlated and varied across geographic regions of the United States.

MATERIALS AND METHODS
Data Source and Study Population
We used patient-level data from the US Renal Data System (USRDS) for the years 2008 through 2016 to identify a prevalent cohort of patients with ESKD in the United States. The USRDS is composed of several files that provide detailed demographic, clinical, and claims-based information for Medicare beneficiaries on dialysis. Beneficiaries are identified by unique identifiers that permit the linking of information across the various files included in the USRDS. We used the Medical Evidence files to obtain information on demographics, including age, race, and geographic location. These files also contain information on patient comorbidities (e.g., presence of hypertension, diabetes, and congestive heart failure).

**FIGURE 2.** A and B. Shows the proportion of Medicare beneficiaries with end-stage kidney disease within each class (underweight, normal, overweight, obese) defined by BMI. Categories were defined by underweight (BMI <18.5), normal (BMI 18.5 to <25.0), overweight (BMI 25.0 to <30), Obese (BMI ≥30) (A). Classes of obesity were defined as class 1 (30.0 to <35.0), class 2 (35.0 to <40.0), and class 3 (≥40.0) obesity (B) BMI, body mass index.
Table 2.

Trends in obesity and transplant rate for beneficiaries with end-stage kidney disease between 2008 and 2016

| Year | Underweight % (N) | Normal % (N) | Overweight % (N) | Obese % (N) |
|------|------------------|-------------|-----------------|-------------|
| 2008 | 7.3 (6515)       | 26.8 (23859)| 29.1 (25962)    | 36.8 (32733)|
| 2016 | 5.8 (29240)      | 24.4 (122070)| 29.6 (147952)  | 40.2 (201212)|
| Trend (95% CI) | -0.12 (-0.20 to -0.05) | -0.21 (-0.35 to -0.07) | 0.07 (0.04 to 0.09) | 0.28 (0.05 to 0.51) |

| Year | Transplant rate % (N) |
|------|-----------------------|
| 2008 | 4.9 (124)             |
| 2016 | 3.9 (449)             |
| Trend (95% CI) | -0.08 (-0.21 to -0.05) | -0.42 (-0.82 to -0.03) | -0.16 (-0.34 to 0.08) | 0.67 (0.11 to 1.22) |

These data reflect the incident cohort by year. Underweight (BMI < 18.5), normal (BMI 18.5 to < 25.0), overweight (BMI 25.0 to < 30.0), and obese (BMI ≥ 30.0). The trend is the slope from linear regression models representing the annual rate of change between 2008 and 2016.

BMI, body mass index (kg/m²); CI, confidence interval.
transplant rates among those patients ranging from 22.4% to 46.8%. Figure 3A shows the proportion of beneficiaries with ESKD and obesity by state. Patients with obesity tend to cluster in the Midwestern and Southern regions of the country, whereas the coastal regions had a qualitatively lower proportion of patients with obesity. Figure 3B displays the obesity transplant rates by state. There is a weak correlation between states with increased rates of obese ESKD patients and states with an increased obesity transplant rate as indicated with \( r = 0.40 (P = 0.003) \). Finally, we analyzed the difference in BMI between beneficiaries who received a kidney transplant from a deceased donor and beneficiaries who received a transplant from a living donor. Those receiving transplants from a deceased donor had a mean BMI of 28.8, (SD 6.4) and those receiving transplants from living donor had a mean of 28.4 (SD 6.2), which was not a clinically significant difference.

FIGURE 3. A, Map of the United States detailing the proportion of Medicare beneficiaries with obesity and end-stage renal disease by state from 2008 to 2016. Proportions were stratified into quartiles. B, Map of the United States detailing the rate of transplants performed on Medicare beneficiaries with obesity and end-stage kidney disease by state. Rates were stratified into quartiles.
This population-based study suggests that beneficiaries with obesity now represent the largest demographic of Medicare beneficiaries with ESKD in the United States. This demographic has also experienced the largest growth over the decade studied between 2008 and 2016. We observed significant geographic variation in rates of obesity among patient with ESKD, concentrating in the Midwestern and Southern states. Furthermore, states with higher rates of obese ESKD beneficiaries poorly correlated with higher rates of transplant in patients with obesity. These data highlight the importance of incorporating obesity treatment strategies into initiatives or policies aiming to improve care for patients with ESKD.

Policies designed to increase rates of kidney transplantation have not historically included provisions to address implications of the obesity epidemic. For instance, the Advancing American Kidney Health initiative encourages cost and quality interventions with a particular focus on increasing rates of kidney transplant; however, for the growing proportion of ESKD patients with obesity, increasing BMI is associated with lower rates of access to kidney transplant and worse outcomes. The lack of strong geographic correlation between ESKD beneficiary obesity rates and obese beneficiary transplant rates demonstrates that transplant centers handle these patients differently, offering an opportunity to study and align best practice to improve kidney transplant candidacy. One potential target is to improve access to and utilization of bariatric surgery, the most effective and durable treatment for obesity. Despite known benefits, it remains underutilized in the ESKD population. In addition to facilitating durable access to transplant, the most effective and durable treatment for obesity, increasing BMI is associated with lower rates of access to kidney transplant and worse outcomes. The lack of strong geographic correlation between ESKD beneficiary obesity rates and obese beneficiary transplant rates demonstrates that transplant centers handle these patients differently, offering an opportunity to study and align best practice to improve kidney transplant candidacy.

Medical comorbidities such as diabetes, hypertension, and cardiovascular disease are more common in patients with obesity, which contributes to higher rates of morbidity and cardiovascular mortality in the ESKD population. Obesity at the time of dialysis initiation adversely impacts both management through lower fistula maturation rates and cure through decreased access to transplant compared with patients with a normal BMI. Conversely, once on dialysis, patients with obesity have been found to have a lower risk of all-cause mortality—an effect often referred to as the obesity paradox. Although the paradox has been demonstrated numerous times, the association may obscure the potential benefits of healthy weight loss—including improved candidacy for kidney transplant. These competing risks highlight the importance of understanding trends in obesity among patients with ESKD, especially as prevalence increases over time.

This study should be interpreted with the context of certain limitations. Although focusing on Medicare beneficiaries with ESKD may limit generalizability, Medicare covers the majority of ESKD patients across the United States. Claims-based registries often lack clinical granularity; however, the USRDS addresses this by collecting data specific to ESKD care. For the purposes of this study, the USRDS collects data from dialysis centers that are required to document beneficiaries’ heights and weights at the time of dialysis initiation and at subsequent episodes. This enables accurate assignment of BMI data across a large population of beneficiaries. Missing data can limit the effectiveness of claims-based studies; however, for the variables collected, missingness was <1%.

Beneficiaries with obesity are now the largest and fastest-growing demographic among patients with ESKD in the United States. There is significant geographic variation in the prevalence of beneficiaries with obesity, with weak correlation to rates of kidney transplantation. These findings suggest that any policies and practices aiming to improve outcomes for patients with kidney disease would be enhanced by a greater focus on obesity management and prevention.

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