

Children's Mercy Kansas City

## SHARE @ Children's Mercy

---

### Presentations

---

5-2021

## **Obesity does not increase risk for kidney replacement therapy (KRT), but weight reduction improves kidney function in children with chronic kidney disease (CKD)**

Amy Kogon

J Roem

Mark Mitsnefes

Babette Zeme

Bradley A. Warady

*See next page for additional authors*

Follow this and additional works at: <https://scholarlyexchange.childrensmercy.org/presentations>



Part of the [Nephrology Commons](#), and the [Pediatrics Commons](#)

---

---

**Creators**

Amy Kogon, J Roem, Mark Mitsnefes, Babette Zeme, Bradley A. Warady, Susan Furth, and Nancy Rodig

---

# BMI reduction improves kidney function in children with non-glomerular CKD who are obese

Amy Kogon MD MPH

Jennifer Roem, Michael Schneider, Mark Mitsnefes, Babette Zemel,  
Bradley Warady, Susan Furth, Nancy Rodig

# Conflict of Interest

- None

# Background

- Obesity in pediatric chronic kidney disease (CKD) is an increasingly prevalent problem
- Children with CKD who are obese exhibit worse markers of cardiovascular disease, more depressive symptoms and reduced quality of life
- Those who are obese at the time of renal transplant experience higher rates of graft failure and mortality

# Obesity and CKD

- In general population being overweight or obese is associated with elevated risk for the development of future CKD
- In adults with pre-existing CKD, obesity does not associate with progression of disease and the best clinical outcomes are seen in those who are mildly obese or overweight
- The effect of obesity on progression of CKD in children has not previously been evaluated

# Chronic Kidney Disease in Children Study (CKiD)

- A multicenter, observational, prospective cohort study of children, adolescents and young adults with CKD
- Primary goals of the study are to determine the risk factors for decline in kidney function and to define how a decline in kidney function affects
  - Risk factors for cardiovascular disease
  - Neurocognitive function and behavior
  - Growth failure

# Objectives

- Using CKiD data we sought to determine if obesity associates with disease progression
- We defined disease progression as
  - Time from the baseline CKiD visit to the initiation of kidney replacement therapy (KRT)
  - Annualized percentage change in eGFR between each pair of consecutive visits throughout follow-up



# Primary exposure: BMI Category

- Categorized as normal, overweight, or obese based on CDC standard growth charts or adult BMI cut-offs
- For children >17-20 years, the BMI associated with overweight and obese can exceed the adult threshold, so we used the adult definition when applicable in order to avoid changes in BMI category without a change in actual BMI
- Participants who were underweight, BMI <5<sup>th</sup> percentile or BMI <17.5, at baseline or during follow-up were excluded

# Statistical Analyses

- Parametric failure time models were used to estimate relative times to KRT which quantified how times to KRT were extended or shortened in those who were overweight or obese compared to having a normal baseline BMI.
- At each pair of sequential study visits, the annualized change in eGFR were modeled against concurrent change in BMI category using linear regression with GEEs to account for repeated visit pairs contributed by the same participant
  - quantified both (1) the annualized eGFR change for those not changing BMI categories and (2) the effect of a one-unit change in BMI category on the annualized eGFR change
- All analyses were stratified by glomerular and non-glomerular etiology of disease

# Baseline Characteristics

	Non-Glomerular CKD, n=600			Glomerular CKD, n=246		
Characteristics	Normal (n=422, 70%)	Overweight (n=86, 14%)	Obese (n=92, 15%)	Normal (n=132, 54%)	Overweight (n=50, 20%)	Obese (n=64, 26%)
CKD duration, years	8.2 [4.5, 12.9]	10.3 [5.0, 12.7]	9.0 [5.3, 11.4]	4.2 [1.9, 8.6]	1.9 [0.9, 6.0]	2.9 [1.1, 4.7]
Age, years	8.9 [4.8, 13.3]	11.0 [5.5, 13.7]	9.3 [6.5, 12.9]	14.2 [10.0, 15.8]	14.4 [11.0, 15.9]	14.3 [11.8, 16.0]
Male Sex	67% (282)	66% (57)	71% (65)	54% (71)	46% (23)	55% (35)
Race						
White	71% (299)	71% (61)	67% (62)	59% (78)	46% (23)	41% (26)
Black	18% (75)	19% (16)	24% (22)	25% (33)	38% (19)	39% (25)
Other	11% (47)	10% (9)	9% (8)	16% (21)	16% (8)	20% (13)
Maternal education						
High school	35% (144)	34% (29)	43% (39)	41% (53)	45% (21)	57% (35)
Some College	30% (125)	28% (24)	24% (22)	22% (28)	21% (10)	25% (15)
College Graduate	35% (145)	38% (32)	32% (29)	38% (49)	34% (16)	18% (11)

# Baseline Characteristics

	Non-Glomerular CKD, n=600			Glomerular CKD, n=246		
Characteristics	Normal (n=422, 70%)	Overweight (n=86, 14%)	Obese (n=92, 15%)	Normal (n=132, 54%)	Overweight (n=50, 20%)	Obese (n=64, 26%)
CKD duration, years	<b>8.2</b> <b>[4.5, 12.9]</b>	<b>10.3</b> <b>[5.0, 12.7]</b>	<b>9.0</b> <b>[5.3, 11.4]</b>	<b>4.2</b> <b>[1.9, 8.6]</b>	<b>1.9</b> <b>[0.9, 6.0]</b>	<b>2.9</b> <b>[1.1, 4.7]</b>
Age, years	8.9 [4.8, 13.3]	11.0 [5.5, 13.7]	9.3 [6.5, 12.9]	14.2 [10.0, 15.8]	14.4 [11.0, 15.9]	14.3 [11.8, 16.0]
Male Sex	67% (282)	66% (57)	71% (65)	54% (71)	46% (23)	55% (35)
Race						
White	71% (299)	54% (47)	51% (47)	54% (71)	45% (21)	41% (26)
Black	18%	28%	24%	22%	21%	39%
Other	11%	18%	24%	24%	34%	20%
Maternal education						
High school	35% (144)	54% (47)	51% (47)	22% (28)	45% (21)	57% (35)
Some College	30% (125)	28% (24)	24% (22)	22% (28)	21% (10)	25% (15)
College Graduate	35% (145)	38% (32)	32% (29)	38% (49)	34% (16)	18% (11)

Children with non-glomerular CKD have longer duration of disease

# Baseline Characteristics

	Non-Glomerular CKD, n=600			Glomerular CKD, n=246		
Characteristics	Normal (n=422, 70%)	Overweight (n=86, 14%)	Obese (n=92, 15%)	Normal (n=132, 54%)	Overweight (n=50, 20%)	Obese (n=64, 26%)
CKD duration, years	8.2 [4.5, 12.9]	10.3 [5.0, 12.7]	9.0 [5.3, 11.4]	4.2 [1.9, 8.6]	1.9 [0.9, 6.0]	2.9 [1.1, 4.7]
Age, years	<b>8.9</b> <b>[4.8, 13.3]</b>	<b>11.0</b> <b>[5.5, 13.7]</b>	<b>9.3</b> <b>[6.5, 12.9]</b>	<b>14.2</b> <b>[10.0, 15.8]</b>	<b>14.4</b> <b>[11.0, 15.9]</b>	<b>14.3</b> <b>[11.8, 16.0]</b>
Male Sex	67% (282)	66% (57)	71% (65)	54% (71)	46% (23)	55% (35)
Race						
White	71% (299)				58% (23)	41% (26)
Black	18% (75)					39% (25)
Other	11%					20% (13)
Maternal education						
High school	35% (144)					57% (35)
Some College	30% (125)				21% (10)	25% (15)
College Graduate	35% (145)	38% (32)	32% (29)	38% (49)	34% (16)	18% (11)

Children with non-glomerular CKD are younger

# Baseline Characteristics

	Non-Glomerular CKD, n=600			Glomerular CKD, n=246		
Characteristics	Normal (n=422, 70%)	Overweight (n=86, 14%)	Obese (n=92, 15%)	Normal (n=132, 54%)	Overweight (n=50, 20%)	Obese (n=64, 26%)
CKD duration, years	8.2 [4.5, 12.9]	10.3 [5.0, 12.7]	9.0 [5.3, 11.4]	4.2 [1.9, 8.6]	1.9 [0.9, 6.0]	2.9 [1.1, 4.7]
Age, years	8.9 [4.8, 13.3]	11.0 [5.5, 13.7]	9.3 [6.5, 12.9]	14.2 [10.0, 15.8]	14.4 [11.0, 15.9]	14.3 [11.8, 16.0]
Male Sex	<b>67% (282)</b>	<b>66% (57)</b>	<b>71% (65)</b>	<b>54% (71)</b>	<b>46% (23)</b>	<b>55% (35)</b>
Race						
White	71% (299)	71% (61)	71% (65)	54% (71)	46% (23)	41% (26)
Black	18% (75)	18% (16)	18% (17)	18% (23)	18% (9)	39% (25)
Other	11% (48)	11% (10)	11% (10)	11% (14)	11% (6)	20% (13)
Maternal education						
High school	35% (148)	35% (30)	35% (32)	35% (45)	35% (18)	57% (35)
Some College	30% (125)	30% (26)	30% (28)	30% (38)	30% (15)	25% (15)
College Graduate	35% (145)	35% (30)	35% (32)	35% (45)	34% (16)	18% (11)

Male predominance more pronounced in children with non-glomerular CKD

# Baseline Characteristics

	Non-Glomerular CKD, n=600			Glomerular CKD, n=246		
Characteristics	Normal (n=422, 70%)	Overweight (n=88, 15%)	Obese (n=90, 15%)	Normal (n=159, 65%)	Overweight (n=59, 24%)	Obese (n=28, 11%)
CKD duration, years	8.2 [4.5, 12.0]					2.9 [1.1, 4.7]
Age, years	8.9 [4.8, 13.3]					14.3 [11.8, 16.0]
Male Sex	67% (282)	68% (60)	67% (62)	67% (23)	65% (23)	55% (35)
Race						
White	<b>71% (299)</b>	<b>71% (61)</b>	<b>67% (62)</b>	<b>59% (78)</b>	<b>46% (23)</b>	<b>41% (26)</b>
Black	<b>18% (75)</b>	<b>19% (16)</b>	<b>24% (22)</b>	<b>25% (33)</b>	<b>38% (19)</b>	<b>39% (25)</b>
Other	<b>11% (47)</b>	<b>10% (9)</b>	<b>9% (8)</b>	<b>16% (21)</b>	<b>16% (8)</b>	<b>20% (13)</b>
Maternal education						
High school	35% (144)	34% (29)	43% (39)	41% (53)	45% (21)	57% (35)
Some College	30% (125)	28% (24)	24% (22)	22% (28)	21% (10)	25% (15)
College Graduate	35% (145)	38% (32)	32% (29)	38% (49)	34% (16)	18% (11)

Black children are more likely to be overweight or obese

# Baseline Characteristics

	Non-Glomerular CKD, n=600			Glomerular CKD, n=246		
Characteristics	Normal (n=422)	Overweight (n=86)	Obese (n=92)	Normal (n=132)	Overweight (n=50)	Obese (n=64)
CKD duration, years	8.2 [4.5, 12.9]	10.3	10.3	4.2	1.9 [1.1, 3.0]	2.9 [1.1, 4.7]
Age, years	8.9 [4.8, 13.0]	8.9	8.9	8.9	8.9	14.3 [11.8, 16.0]
Male Sex	67% (211)	67%	67%	67%	67%	55% (35)
Race						
White	71% (299)	71%	71%	71%	71%	41% (26)
Black	18% (75)	19% (16)	24% (22)	25% (33)	38% (19)	39% (25)
Other	11% (47)	10% (9)	9% (8)	16% (21)	16% (8)	20% (13)
Maternal education						
High school	<b>35% (144)</b>	<b>34% (29)</b>	<b>43% (39)</b>	<b>41% (53)</b>	<b>45% (21)</b>	<b>57% (35)</b>
Some College	<b>30% (125)</b>	<b>28% (24)</b>	<b>24% (22)</b>	<b>22% (28)</b>	<b>21% (10)</b>	<b>25% (15)</b>
College Graduate	<b>35% (145)</b>	<b>38% (32)</b>	<b>32% (29)</b>	<b>38% (49)</b>	<b>34% (16)</b>	<b>18% (11)</b>

Mothers of children who are obese are more likely to have lower level of educational attainment



# Baseline Characteristics

	Non-Glomerular CKD, n=600			Glomerular CKD, n=246		
Characteristics	Normal (n=422, 70%)	Overweight (n=86, 14%)	Obese (n=92, 15%)	Normal (n=132, 54%)	Overweight (n=50, 20%)	Obese (n=64, 26%)
<b>Proteinuria</b>						
<0.5	66% (279)	57% (49)	71% (65)	51% (67)	44% (22)	31% (20)
0.5 to 2.0	27% (115)	28% (24)	23% (21)	27% (35)	32% (16)	42% (27)
> 2.0	7% (28)	15% (13)	7% (6)	23% (30)	24% (12)	27% (17)
<b>eGFR</b>						
< 30	17% (73)	7% (6)	11% (10)	11% (14)	4% (2)	6% (4)
≥ 30 to 45	30% (128)	24% (21)	25% (23)	24% (31)	24% (12)	22% (14)
≥ 45 to 60	28% (119)	25% (21)	25% (23)	24% (31)	24% (12)	28% (18)
≥ 60	24% (102)	25% (21)	25% (23)	24% (31)	24% (12)	44% (28)
<b>Blood pressure</b>						
Normal	60% (253)	25% (21)	25% (23)	60% (79)	25% (12)	47% (30)
Elevated BP	12% (51)	25% (21)	25% (23)	12% (16)	25% (12)	28% (18)
Hypertension	28% (118)	25% (21)	25% (23)	28% (37)	25% (12)	25% (16)
<b>Albumin, g/dL</b>	4.4 [4.2, 4.6]	4.5 [4.3, 4.7]	4.4 [4.2, 4.6]	4.2 [3.9, 4.5]	4.0 [3.7, 4.3]	4.1 [3.4, 4.4]
<b>Height z-score</b>	-0.7[-1.4, 0.2]	-0.4[-1.3, 0.1]	-0.1[-0.8, 0.6]	-0.5 [-1.1, 0.2]	0.0 [-0.7, 0.8]	0.2 [-0.4, 1.2]

Degree of proteinuria more associated with obesity in the children with glomerular disease

# Baseline Characteristics

	Non-Glomerular CKD, n=600			Glomerular CKD, n=246		
Characteristics	Normal (n=422)	Overweight (n=86)	Obese (n=92)	Normal (n=132)	Overweight (n=50)	Obese (n=64)
<b>Proteinuria</b>						
<0.5	66% (279)	57% (49)	71% (65)	51% (67)	44% (22)	31% (20)
0.5 to 2.0	27% (115)	28% (24)	23% (21)	27% (35)	32% (16)	42% (27)
> 2.0	7% (28)	15% (13)	7% (6)	23% (30)	24% (12)	27% (17)
<b>eGFR</b>						
< 30	<b>17% (73)</b>	<b>7% (6)</b>	<b>11% (10)</b>	<b>11% (14)</b>	<b>4% (2)</b>	<b>6% (4)</b>
≥ 30 to 45	<b>30% (128)</b>	<b>24% (21)</b>	<b>27% (25)</b>	<b>20% (27)</b>	<b>24% (12)</b>	<b>22% (14)</b>
≥ 45 to 60	<b>28% (119)</b>	<b>42% (36)</b>	<b>29% (27)</b>	<b>24% (32)</b>	<b>22% (11)</b>	<b>28% (18)</b>
≥ 60	<b>24% (102)</b>	<b>27% (23)</b>	<b>33% (30)</b>	<b>45% (59)</b>	<b>50% (25)</b>	<b>44% (28)</b>
<b>Blood pressure</b>						
Normal	60% (253)	53% (46)	56% (51)	57% (75)	50% (25)	47% (30)
Elevated BP	12% (50)	16% (14)	13% (12)	12% (16)	16% (8)	28% (18)
Hypertension	28% (119)	31% (26)	31% (28)	31% (41)	34% (17)	25% (16)
<b>Albumin, g/dL</b>	4.4 [4.2, 4.6]	4.4 [4.2, 4.6]	4.4 [4.2, 4.6]	4.4 [4.2, 4.6]	4.4 [4.2, 4.6]	4.1 [3.4, 4.4]
<b>Height z-score</b>	-0.7[-1.4, 0.2]	-0.4[-1.5, 0.7]	-0.4[-1.5, 0.7]	0.0 [-0.7, 0.8]	0.0 [-0.7, 0.8]	0.2 [-0.4, 1.2]

Children with glomerular CKD and children with obesity are more likely to have eGFR>60

# Baseline Characteristics

	Non-Glomerular CKD, n=600			Glomerular CKD, n=246		
Characteristics	Normal (n=422)	Overweight (n=86)	Obese (n=92)	Normal (n=132)	Overweight (n=50)	Obese (n=64)
<b>Proteinuria</b>						
<0.5	66% (279)					31% (20)
0.5 to 2.0	27% (114)					42% (27)
> 2.0	7% (29)					27% (17)
<b>eGFR</b>						
< 30	17% (73)					6% (4)
≥ 30 to 45	30% (128)	24% (21)		24% (32)	24% (12)	22% (14)
≥ 45 to 60	28% (119)	42% (36)	29% (27)	24% (32)	22% (11)	28% (18)
≥ 60	24% (102)	27% (23)	33% (30)	45% (59)	50% (25)	44% (28)
<b>Blood pressure</b>						
Normal	<b>60% (253)</b>	<b>55% (47)</b>	<b>54% (50)</b>	<b>70% (93)</b>	<b>50% (25)</b>	<b>47% (30)</b>
Elevated BP	<b>12% (51)</b>	<b>16% (14)</b>	<b>12% (11)</b>	<b>11% (15)</b>	<b>16% (8)</b>	<b>28% (18)</b>
Hypertension	<b>28% (118)</b>	<b>29% (25)</b>	<b>34% (31)</b>	<b>19% (24)</b>	<b>34% (17)</b>	<b>25% (16)</b>
<b>Albumin, g/dL</b>	4.4 [4.2, 4.6]	4.5 [4.3, 4.7]	4.4 [4.2, 4.6]	4.2 [3.9, 4.5]	4.0 [3.7, 4.3]	4.1 [3.4, 4.4]
<b>Height z-score</b>	-0.7[-1.4, 0.2]	-0.4[-1.3, 0.1]	-0.1[-0.8, 0.6]	-0.5 [-1.1, 0.2]	0.0 [-0.7, 0.8]	0.2 [-0.4, 1.2]

Normal weight children more likely to have a normal blood pressure

# Baseline Characteristics

	Non-Glomerular CKD, n=600			Glomerular CKD, n=246		
Characteristics	Normal (n=422)	Overweight (n=86)	Obese (n=92)	Normal (n=132)	Overweight (n=50)	Obese (n=64)
<b>Proteinuria</b>						
<0.5	66% (279)	57% (49)	71% (65)	51% (67)	44% (22)	31% (20)
0.5 to 2.0	27% (115)	28% (24)	23% (21)	27% (35)	32% (16)	42% (27)
> 2.0	7% (28)	15% (12)	6% (6)	22% (29)	24% (12)	27% (17)
<b>eGFR</b>						
< 30	17% (71)	13% (11)	10% (9)	10% (13)	10% (5)	6% (4)
≥ 30 to 45	30% (126)	28% (24)	23% (21)	27% (35)	32% (16)	22% (14)
≥ 45 to 60	28% (118)	29% (25)	34% (31)	19% (24)	34% (17)	28% (18)
≥ 60	24% (102)	30% (26)	33% (30)	44% (57)	24% (12)	44% (28)
<b>Blood pressure</b>						
Normal	60% (253)	55% (47)	54% (50)	70% (93)	50% (25)	47% (30)
Elevated BP	12% (51)	16% (14)	12% (11)	11% (15)	16% (8)	28% (18)
Hypertension	28% (118)	29% (25)	34% (31)	19% (24)	34% (17)	25% (16)
<b>Albumin, g/dL</b>	<b>4.4 [4.2, 4.6]</b>	<b>4.5 [4.3, 4.7]</b>	<b>4.4 [4.2, 4.6]</b>	<b>4.2 [3.9, 4.5]</b>	<b>4.0 [3.7, 4.3]</b>	<b>4.1 [3.4, 4.4]</b>
<b>Height z-score</b>	-0.7[-1.4, 0.2]	-0.4[-1.3, 0.1]	-0.1[-0.8, 0.6]	-0.5 [-1.1, 0.2]	0.0 [-0.7, 0.8]	0.2 [-0.4, 1.2]

Children with glomerular CKD have lower albumin, with a lower range of albumin in the children with obesity

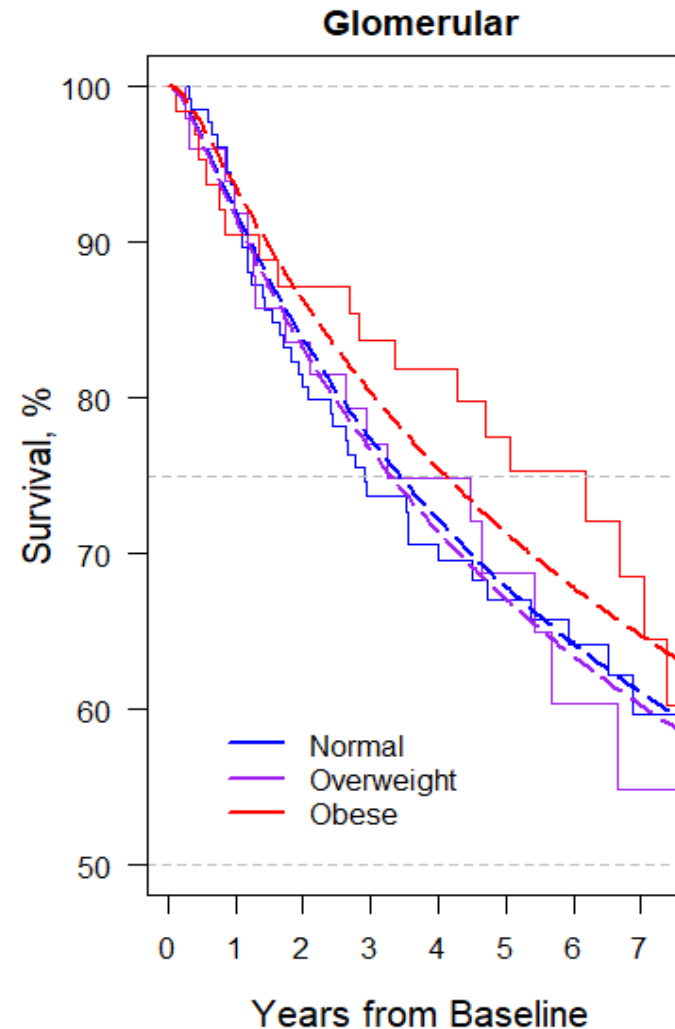
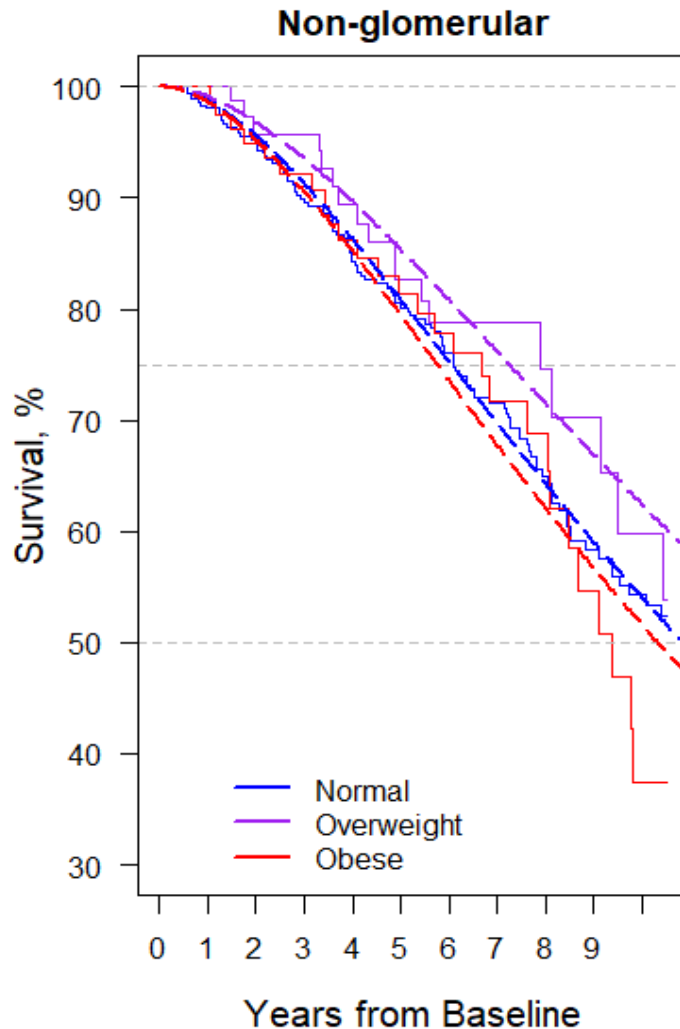
# Baseline Characteristics

	Non-Glomerular CKD, n=600			Glomerular CKD, n=246		
Characteristics	Normal (n=422)	Overweight (n=86)	Obese (n=92)	Normal (n=132)	Overweight (n=50)	Obese (n=64)
<b>Proteinuria</b>						
<0.5	66% (279)	57% (49)	71% (65)	51% (67)	44% (22)	31% (20)
0.5 to 2.0	27% (115)	28% (24)	23% (21)	27% (35)	32% (16)	42% (27)
> 2.0	7% (28)	15% (12)	6% (6)	22% (29)	24% (12)	27% (17)
<b>eGFR</b>						
< 30	17% (72)	17% (15)	16% (15)	13% (17)	12% (6)	6% (4)
≥ 30 to 45	30% (127)	29% (25)	28% (26)	27% (35)	28% (14)	22% (14)
≥ 45 to 60	28% (118)	28% (24)	27% (25)	27% (35)	32% (16)	28% (18)
≥ 60	24% (102)	26% (22)	29% (27)	33% (43)	26% (13)	44% (28)
<b>Blood pressure</b>						
Normal	60% (253)	55% (47)	54% (50)	70% (93)	50% (25)	47% (30)
Elevated BP	12% (51)	16% (14)	12% (11)	11% (15)	16% (8)	28% (18)
Hypertension	28% (118)	29% (25)	34% (31)	19% (24)	34% (17)	25% (16)
<b>Albumin, g/dL</b>	4.4 [4.2, 4.6]	4.5 [4.3, 4.7]	4.4 [4.2, 4.6]	4.2 [3.9, 4.5]	4.0 [3.7, 4.3]	4.1 [3.4, 4.4]
<b>Height z-score</b>	<b>-0.7[-1.4, 0.2]</b>	<b>-0.4[-1.3, 0.1]</b>	<b>-0.1[-0.8, 0.6]</b>	<b>-0.5 [-1.1, 0.2]</b>	<b>0.0 [-0.7, 0.8]</b>	<b>0.2 [-0.4, 1.2]</b>

Height is more preserved in the children who are obese

# Time to KRT by baseline BMI Category

- 5.5 [2.0,7.9] years of follow up
- 27% went to KRT
  - 27% normal weight
  - 21% overweight
  - 29% obese



- 4.5 [2.3,6.6] years of follow-up
- 31% went to KRT
  - 32% normal weight
  - 34% overweight
  - 28% obese

# Relative Time (RT) to KRT by baseline BMI Category

	Non-glomerular CKD (N=600; 160 events)			Glomerular CKD (N=246; 77 events)		
Baseline BMI Category	n; number of Events	Unadjusted RT (95% CI)	Adjusted* RT (95% CI)	n; number of Events	Unadjusted RT (95% CI)	Adjusted* RT (95% CI)
Normal	422; 115	1 (reference)	1 (reference)	132; 42	1 (reference)	1 (reference)
Overweight	86; 18	1.20 (0.86, 1.66)	1.28 (0.97, 1.68)	50; 17	0.96 (0.48, 1.92)	0.97 (0.61, 1.54)
Obese	92; 27	0.95 (0.71, 1.25)	0.92 (0.73, 1.15)	64; 18	1.20 (0.60, 2.38)	1.17 (0.76, 1.80)

\*Adjusted for male sex, Black race, and baseline age, estimated GFR, proteinuria, and hypertension.

# Distribution of changes in BMI categories between two paired visits by initial BMI category in the visit pair

	Non-Glomerular CKD			Glomerular CKD		
	Normal 1646 visit pairs	Overweight 379 visit pairs	Obese 404 visit pairs	Normal 417 visit pairs	Overweight 165 visit pairs	Obese 217 visit pairs
No change	1526 (93%)	238 (63%)	349 (86%)	378 (91%)	101 (61%)	186 (86%)
Increase 1 category	109 (7%)	55 (14%)	NA	35 (8%)	24 (15%)	NA
Increase 2 categories	11 (1%)	NA	NA	4 (1%)	NA	NA
Decrease 1 category	NA	86 (23%)	48 (12%)	NA	40 (24%)	30 (14%)
Decrease 2 categories	NA	NA	7 (2%)	NA	NA	1 (<1%)



# Unadjusted and adjusted annualized percentage changes in eGFR by initial BMI category in the visit pair

	Non-Glomerular CKD		
	Normal 1646 visit pairs	Overweight 379 visit pairs	Obese 404 visit pairs
<b>Unadjusted Analyses</b>			
Mean (95% CI) Annualized eGFR change among constant BMI	<b>-2.2%</b> <b>(-3.0%, -1.5%)</b>	<b>-3.2%</b> <b>(-4.6%, -1.9%)</b>	<b>-4.8%</b> <b>(-6.4%, -3.1%)</b>
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	+0.6% (-1.6%, +2.9%)	+0.2% (-2.0%, +2.4%)	+4.0% (+0.2%, +7.8%)
<b>Adjusted Analyses<sup>a</sup></b>			
Mean (95% CI) Annualized eGFR change among constant BMI <sup>b</sup>	-1.6% (-3.0%, -0.1%)	-0.7% (-3.2%, +1.8%)	-2.6% (-6.4%, +1.1%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	+0.1% (-2.1%, +2.3%)	+0.4% (-1.8%, +2.5%)	+3.8% (+0.3%, +7.3%)

<sup>a</sup> Each of the three analyses were adjusted for male sex, Black race, and first visit within the visit pair values of age, eGFR, indicators of nephrotic range proteinuria and hypertension.

<sup>b</sup> The expected annualized eGFR change for a 15-year-old non-Black female without hypertension and with eGFR = 70 and proteinuria < 0.5 at the first visit within the visit pair and who does not change BMI category within the visit pair.

# Unadjusted and adjusted annualized percentage changes in eGFR by initial BMI category in the visit pair

	Non-Glomerular CKD		
	Normal 1646 visit pairs	Overweight 379 visit pairs	Obese 404 visit pairs
<b>Unadjusted Analyses</b>			
Mean (95% CI) Annualized eGFR change among constant BMI	-2.2% (-3.0%, -1.5%)	-3.2% (-4.6%, -1.9%)	-4.8% (-6.4%, -3.1%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	<b>+0.6%</b> (-1.6%, +2.9%)	<b>+0.2%</b> (-2.0%, +2.4%)	<b>+4.0%</b> <b>(+0.2%, +7.8%)</b>
<b>Adjusted Analyses <sup>a</sup></b>			
Mean (95% CI) Annualized eGFR change among constant BMI <sup>b</sup>	-1.6% (-3.0%, -0.1%)	-0.7% (-3.2%, +1.8%)	-2.6% (-6.4%, +1.1%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	+0.1% (-2.1%, +2.3%)	+0.4% (-1.8%, +2.5%)	+3.8% (+0.3%, +7.3%)

<sup>a</sup> Each of the three analyses were adjusted for male sex, Black race, and first visit within the visit pair values of age, eGFR, indicators of nephrotic range proteinuria and hypertension.

<sup>b</sup> The expected annualized eGFR change for a 15-year-old non-Black female without hypertension and with eGFR = 70 and proteinuria < 0.5 at the first visit within the visit pair and who does not change BMI category within the visit pair.

# Unadjusted and adjusted annualized percentage changes in eGFR by initial BMI category in the visit pair

	Non-Glomerular CKD		
	Normal 1646 visit pairs	Overweight 379 visit pairs	Obese 404 visit pairs
<b>Unadjusted Analyses</b>			
Mean (95% CI) Annualized eGFR change among constant BMI	-2.2% (-3.0%, -1.5%)	-3.2% (-4.6%, -1.9%)	-4.8% (-6.4%, -3.1%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	+0.6% (-1.6%, +2.9%)	+0.2% (-2.0%, +2.4%)	+4.0% (+0.2%, +7.8%)
<b>Adjusted Analyses<sup>a</sup></b>			
Mean (95% CI) Annualized eGFR change among constant BMI <sup>b</sup>	<b>-1.6%</b> <b>(-3.0%, -0.1%)</b>	<b>-0.7%</b> <b>(-3.2%, +1.8%)</b>	<b>-2.6%</b> <b>(-6.4%, +1.1%)</b>
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	+0.1% (-2.1%, +2.3%)	+0.4% (-1.8%, +2.5%)	+3.8% (+0.3%, +7.3%)

<sup>a</sup> Each of the three analyses were adjusted for male sex, Black race, and first visit within the visit pair values of age, eGFR, indicators of nephrotic range proteinuria and hypertension.

<sup>b</sup> The expected annualized eGFR change for a 15-year-old non-Black female without hypertension and with eGFR = 70 and proteinuria < 0.5 at the first visit within the visit pair and who does not change BMI category within the visit pair.

# Unadjusted and adjusted annualized percentage changes in eGFR by initial BMI category in the visit pair

	Non-Glomerular CKD		
	Normal 1646 visit pairs	Overweight 379 visit pairs	Obese 404 visit pairs
<b>Unadjusted Analyses</b>			
Mean (95% CI) Annualized eGFR change among constant BMI	-2.2% (-3.0%, -1.5%)	-3.2% (-4.6%, -1.9%)	-4.8% (-6.4%, -3.1%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	+0.6% (-1.6%, +2.9%)	+0.2% (-2.0%, +2.4%)	+4.0% (+0.2%, +7.8%)
<b>Adjusted Analyses<sup>a</sup></b>			
Mean (95% CI) Annualized eGFR change among constant BMI <sup>b</sup>	-1.6% (-3.0%, -0.1%)	-0.7% (-3.2%, +1.8%)	-2.6% (-6.4%, +1.1%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	<b>+0.1%</b> (-2.1%, +2.3%)	<b>+0.4%</b> (-1.8%, +2.5%)	<b>+3.8%</b> <b>(+0.3%, +7.3%)</b>

<sup>a</sup> Each of the three analyses were adjusted for male sex, Black race, and first visit within the visit pair values of age, eGFR, indicators of nephrotic range proteinuria and hypertension.

<sup>b</sup> The expected annualized eGFR change for a 15-year-old non-Black female without hypertension and with eGFR = 70 and proteinuria < 0.5 at the first visit within the visit pair and who does not change BMI category within the visit pair.

# Unadjusted and adjusted annualized percentage changes in eGFR by initial BMI category in the visit pair

	Glomerular CKD		
	Normal 417 visit pairs	Overweight 165 visit pairs	Obese 217 visit pairs
<b>Unadjusted Analyses</b>			
Mean (95% CI) Annualized eGFR change among constant BMI category	<b>-6.5%</b> <b>(-9.1%, -3.8%)</b>	<b>-4.5%</b> <b>(-7.8%, -1.2%)</b>	<b>-3.3%</b> <b>(-6.2%, -0.4%)</b>
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	-0.7% (-5.2%, +3.7%)	-3.1% (-8.8%, +2.6%)	-2.0% (-8.2%, +4.1%)
<b>Adjusted Analyses <sup>a</sup></b>			
Mean (95% CI) Annualized eGFR change among constant BMI category	-2.3% (-6.2%, +1.6%)	+1.1% (-3.5%, +5.8%)	+0.5% (-4.2%, +5.2%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	+1.5% (-2.8%, +5.7%)	-2.8% (-7.3%, +1.6%)	-2.4% (-8.4%, +3.5%)

<sup>a</sup> Each of the three analyses were adjusted for male sex, Black race, and first visit within the visit pair values of age, eGFR, indicators of proteinuria and hypertension.

The expected annualized eGFR change for a 15-year-old non-Black female without hypertension and with eGFR = 70 and proteinuria < 0.5 at the first visit within the visit pair and who does not change BMI category within the visit pair.

# Unadjusted and adjusted annualized percentage changes in eGFR by initial BMI category in the visit pair

	Glomerular CKD		
	Normal 417 visit pairs	Overweight 165 visit pairs	Obese 217 visit pairs
<b>Unadjusted Analyses</b>			
Mean (95% CI) Annualized eGFR change among constant BMI category	<b>-6.5%</b> <b>(-9.1%, -3.8%)</b>	<b>-4.5%</b> <b>(-7.8%, -1.2%)</b>	<b>-3.3%</b> <b>(-6.2%, -0.4%)</b>
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	-0.7% (-5.2%, +3.7%)	-3.1% (-8.8%, +2.6%)	-2.0% (-8.2%, +4.1%)
<b>Adjusted Analyses<sup>a</sup></b>			
Mean (95% CI) Annualized eGFR change among constant BMI category	-2.3% (-6.2%, +1.6%)	+1.1% (-3.5%, +5.8%)	+0.5% (-4.2%, +5.2%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	+1.5% (-2.8%, +5.7%)	-2.8% (-7.3%, +1.6%)	-2.4% (-8.4%, +3.5%)

<sup>a</sup> Each of the three analyses were adjusted for male sex, Black race, and first visit within the visit pair values of age, eGFR, indicators of proteinuria and hypertension.

The expected annualized eGFR change for a 15-year-old non-Black female without hypertension and with eGFR = 70 and proteinuria < 0.5 at the first visit within the visit pair and who does not change BMI category within the visit pair.

# Unadjusted and adjusted annualized percentage changes in eGFR by initial BMI category in the visit pair

	Glomerular CKD		
	Normal 417 visit pairs	Overweight 165 visit pairs	Obese 217 visit pairs
<b>Unadjusted Analyses</b>			
Mean (95% CI) Annualized eGFR change among constant BMI category	-6.5% (-9.1%, -3.8%)	-4.5% (-7.8%, -1.2%)	-3.3% (-6.2%, -0.4%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	-0.7% (-5.2%, +3.7%)	-3.1% (-8.8%, +2.6%)	-2.0% (-8.2%, +4.1%)
<b>Adjusted Analyses <sup>a</sup></b>			
Mean (95% CI) Annualized eGFR change among constant BMI category	-2.3% (-6.2%, +1.6%)	+1.1% (-3.5%, +5.8%)	+0.5% (-4.2%, +5.2%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	+1.5% (-2.8%, +5.7%)	-2.8% (-7.3%, +1.6%)	-2.4% (-8.4%, +3.5%)

<sup>a</sup> Each of the three analyses were adjusted for male sex, Black race, and first visit within the visit pair values of age, eGFR, indicators of proteinuria and hypertension.

The expected annualized eGFR change for a 15-year-old non-Black female without hypertension and with eGFR = 70 and proteinuria < 0.5 at the first visit within the visit pair and who does not change BMI category within the visit pair.

# Unadjusted and adjusted annualized percentage changes in eGFR by initial BMI category in the visit pair

	Glomerular CKD		
	Normal 417 visit pairs	Overweight 165 visit pairs	Obese 217 visit pairs
<b>Unadjusted Analyses</b>			
Mean (95% CI) Annualized eGFR change among constant BMI category	-6.5% (-9.1%, -3.8%)	-4.5% (-7.8%, -1.2%)	-3.3% (-6.2%, -0.4%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	-0.7% (-5.2%, +3.7%)	-3.1% (-8.8%, +2.6%)	-2.0% (-8.2%, +4.1%)
<b>Adjusted Analyses <sup>a</sup></b>			
Mean (95% CI) Annualized eGFR change among constant BMI category	-2.3% (-6.2%, +1.6%)	+1.1% (-3.5%, +5.8%)	+0.5% (-4.2%, +5.2%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	+1.5% (-2.8%, +5.7%)	-2.8% (-7.3%, +1.6%)	-2.4% (-8.4%, +3.5%)

<sup>a</sup> Each of the three analyses were adjusted for male sex, Black race, and first visit within the visit pair values of age, eGFR, indicators of proteinuria and hypertension.

The expected annualized eGFR change for a 15-year-old non-Black female without hypertension and with eGFR = 70 and proteinuria < 0.5 at the first visit within the visit pair and who does not change BMI category within the visit pair.



# Unadjusted and adjusted annualized percentage changes in eGFR by initial BMI category in the visit pair

	Glomerular CKD		
	Normal 417 visit pairs	Overweight 165 visit pairs	Obese 217 visit pairs
<b>Unadjusted Analyses</b>			
Mean (95% CI) Annualized eGFR change among constant BMI category	-6.5% (-9.1%, -3.8%)	-4.5% (-7.8%, -1.2%)	-3.3% (-6.2%, -0.4%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	-0.7% (-5.2%, +3.7%)	-3.1% (-8.8%, +2.6%)	-2.0% (-8.2%, +4.1%)
<b>Adjusted Analyses <sup>a</sup></b>			
Mean (95% CI) Annualized eGFR change among constant BMI category	-2.3% (-6.2%, +1.6%)	+1.1% (-3.5%, +5.8%)	+0.5% (-4.2%, +5.2%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	+1.5% (-2.8%, +5.7%)	-2.8% (-7.3%, +1.6%)	-2.4% (-8.4%, +3.5%)

<sup>a</sup> Each of the three analyses were adjusted for male sex, Black race, and first visit within the visit pair values of age, eGFR, indicators of proteinuria and hypertension.

The expected annualized eGFR change for a 15-year-old non-Black female without hypertension and with eGFR = 70 and proteinuria < 0.5 at the first visit within the visit pair and who does not change BMI category within the visit pair.

# Summary

- No significant effect of baseline BMI category to time to KRT
- Most participants maintain their initial BMI category throughout the study
- Those with non-glomerular CKD who were obese and move into a lower BMI category over the course of a year experience a significant improvement in eGFR

# Limitations/Strengths

- Lack of robust measures of dietary intake, physical activity and lean muscle mass
- For participants with glomerular disease, BMI may overestimate obesity due to edema
- We did not evaluate for an effect of extreme obesity
- Large sample size and long-term follow-up

# Conclusions

- Obesity may represent a target of intervention to improve kidney function in children with CKD

# Acknowledgements

- Mike Schneider
- Jennifer Roem
- Nancy Rodig
- Mark Mitsnefes
- Babette Zemel
- Sue Furth
- Brad Warady
- Funding: the CKiD is funded by the National Institute of Diabetes and Digestive and Kidney Diseases with additional funding from the National Institute of Child Health and Human Development, and the National Heart, Lung, and Blood Institute (U01-DK-66143, U01-DK-66174, and U01-DK-66116)

# Unadjusted and adjusted annualized percentage changes in eGFR by initial BMI category in the visit pair

	Non-Glomerular CKD		
	Normal 1646 visit pairs	Overweight 379 visit pairs	Obese 404 visit pairs
<b>Unadjusted Analyses</b>			
Mean (95% CI) Annualized eGFR change among constant BMI	-2.2% (-3.0%, -1.5%)	-3.2% (-4.6%, -1.9%)	-4.8% (-6.4%, -3.1%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	+0.6% (-1.6%, +2.9%)	+0.2% (-2.0%, +2.4%)	<b>+4.0%</b> <b>(+0.2%, +7.8%)</b>
<b>Adjusted Analyses <sup>a</sup></b>			
Mean (95% CI) Annualized eGFR change among constant BMI <sup>b</sup>	-1.6% (-3.0%, -0.1%)	-0.7% (-3.2%, +1.8%)	-2.6% (-6.4%, +1.1%)
Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change	+0.1% (-2.1%, +2.3%)	+0.4% (-1.8%, +2.5%)	+3.8% (+0.3%, +7.3%)

<sup>a</sup> Each of the three analyses were adjusted for male sex, Black race, and first visit within the visit pair values of age, eGFR, indicators of nephrotic range proteinuria and hypertension.

<sup>b</sup> The expected annualized eGFR change for a 15-year-old non-Black female without hypertension and with eGFR = 70 and proteinuria < 0.5 at the first visit within the visit pair and who does not change BMI category within the visit pair.

# Baseline Characteristics

	Non-Glomerular CKD, n=600			Glomerular CKD, n=246		
Characteristics	Normal (n=422)	Overweight (n=86)	Obese (n=92)	Normal (n=132)	Overweight (n=50)	Obese (n=64)
CKD duration, years	8.2 [4.5, 12.9]	10.3 [5.0, 12.7]	9.0 [5.3, 11.4]	4.2 [1.9, 8.6]	1.9 [0.9, 6.0]	2.9 [1.1, 4.7]
Age, years	8.9 [4.8, 13.3]	11.0 [5.5, 13.7]	9.3 [6.5, 12.9]	14.2 [10.0, 15.8]	14.4 [11.0, 15.9]	14.3 [11.8, 16.0]
Male Sex	67% (282)	66% (57)	71% (65)	54% (71)	46% (23)	55% (35)
Race						
White	71% (299)	71% (61)	67% (62)	59% (78)	46% (23)	41% (26)
Black	18% (75)	19% (16)	24% (22)	25% (33)	38% (19)	39% (25)
Other	11% (47)	10% (9)	9% (8)	16% (21)	16% (8)	20% (13)
Maternal education						
High school	35% (144)	34% (29)	43% (39)	41% (53)	45% (21)	57% (35)
Some College	30% (125)	28% (24)	24% (22)	22% (28)	21% (10)	25% (15)
College Graduate	35% (145)	38% (32)	32% (29)	38% (49)	34% (16)	18% (11)

# Unadjusted and adjusted annualized percentage changes in eGFR by initial BMI category in the visit pair

	Non-Glomerular CKD			Glomerular CKD		
	Normal 1646 visit pairs	Overweight 379 visit pairs	Obese 402 visit pairs	Normal 417 visit pairs	Overweight 165 visit pairs	Obese 217 visit pairs
<b>Unadjusted Analyses</b>						
<b>Mean (95% CI) Annualized eGFR change among constant BMI category</b>	-2.2% (-3.0%, -1.5%)	-3.2% (-4.6%, -1.9%)	-4.8% (-6.4%, -3.1%)	-6.5% (-9.1%, -3.8%)	-4.5% (-7.8%, -1.2%)	-3.3% (-6.2%, -0.4%)
<b>Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change</b>	+0.6% (-1.6%, +2.9%)	+0.2% (-2.0%, +2.4%)	+4.0% (+0.2%, +7.8)	-0.7% (-5.2%, +3.7%)	-3.1% (-8.8%, +2.6%)	-2.0% (-8.2%, +4.1%)
<b>Adjusted Analyses <sup>a</sup></b>						
<b>Mean (95% CI) Annualized eGFR change among constant BMI category</b>	-0.4% (-1.0%, +1.8%)	-0.6% (-3.0%, +1.9%)	-0.1% (-3.1%, +2.9%)	-0.2% (-4.4%, +3.9%)	+5.6% (-2.8%, +13.9%)	+5.7% (+0.2%, +11.2%)
<b>Mean (95% CI) effect of 1-unit decrease in BMI category on annualized eGFR change</b>	+0.1% (-2.1%, +2.3%)	+0.4% (-1.8%, +2.5%)	+3.8% (+0.3%, +7.3)	+1.5% (-2.8%, +5.7%)	-2.8% (-7.3%, +1.6%)	-2.4% (-8.4%, +3.5%)

<sup>a</sup> Each of the three analyses were adjusted for male sex, Black race, and first visit within the visit pair values of age, eGFR, indicators of proteinuria and hypertension.