Genre et fonction rénale: n'y a-t-il vraiment aucune différence?

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DFG

- DFG mesuré
- Créatinine et équations
- Cystatine C et équations

Le DFG mesuré est-il différent chez l'homme et la femme?

KDIGO 2024 CLINICAL PRACTICE GUIDELINE FOR THE EVALUATION AND MANAGEMENT OF CHRONIC KIDNEY DISEASE

KDIGO: Prognosis of CKD by GFR and albuminuria categories

GFR categories (ml/min/1.73 m²) Description and range			Persistent albuminuria categories Description and range: A1 Normal to mildly increased <30 mg/g <3 mg/mmol	A2 Moderately increased 30–300 mg/g 3–30 mg/mmol	A3 Severely increased >300 mg/g >30 mg/mmol
G1	Normal or high	≥90			
G2	Mildly decreased	60–89			
G3a	Mildly to moderately decreased	45–59			
G3b	Moderately to severely decreased	30–44			
G4	Severely decreased	15–29			
G5	Kidney failure	<15			

Green: low risk (if no other markers of kidney disease, no CKD); Yellow: moderately increased risk; Orange: high risk; Red: very high risk. GFR, glomerular filtration rate.

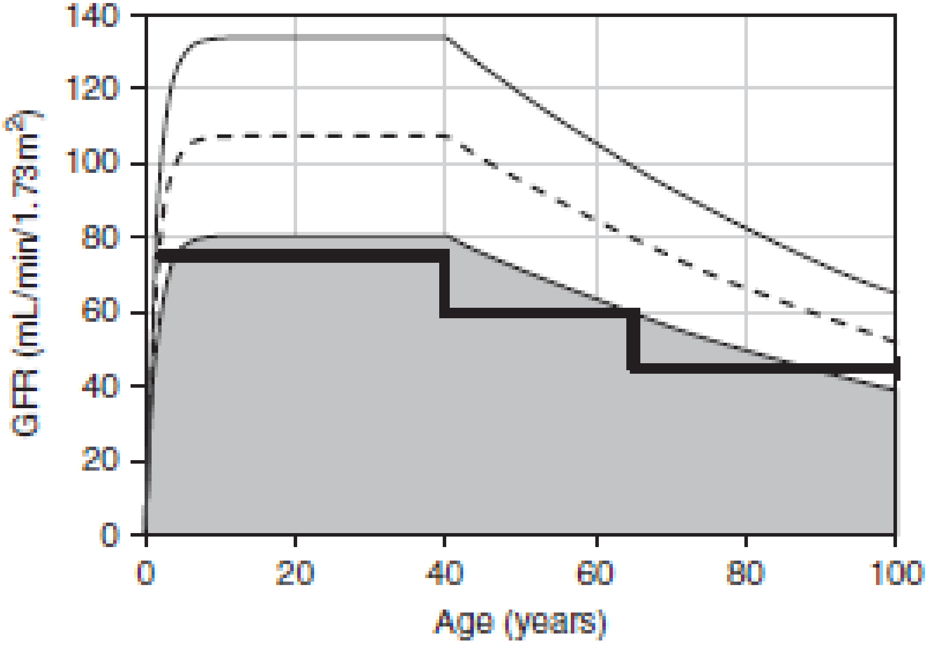


Figure 3. Age-specific thresholds in relation to age-specific GFR percentiles. GFR cut-off values and percentiles according to age (here percentiles of eGFR are calculated using the FAS equation). The bold line represents an age-adapted threshold for CKD: 75 ml/min per 1.73 m^2 for age below 40 years, 60 ml/min per 1.73 m^2 for age between 40 and 65 years, and 45 ml/min per 1.73 m^2 for age above 65 years. The dashed line represents the median (50th percentile) and the thin solid lines represent the 97.5th and 2.5th percentiles. The shaded zone is considered as below the normal reference intervals for GFR (<2.5th percentile).

Delanaye P, J Am Soc Nephrol, 2019

Le DFG mesuré est-il différent chez l'homme et la femme?

- DFG mesuré
- Sujets sains
- Donneurs de rein

CHAPTER 5: PREDONATION KIDNEY FUNCTION

KDIGO Clinical Practice Guideline on the Evaluation and Care of Living Kidney Donors

Selection

5.6: GFR of 90 mL/min per 1.73 m^2 or greater should be considered an acceptable level of kidney function for donation.

5.7: The decision to approve donor candidates with GFR 60 to 89 mL/min per 1.73 m^2 should be individualized based on demographic and health profile in relation to the transplant program's acceptable risk threshold.

5.8: Donor candidates with GFR less than 60 mL/min per 1.73 m^2 should not donate.

5.2. Évaluation rénale et du risque d'insuffisance rénale chronique terminale post-don

Christophe Mariat, François Gaillard, Marie-Alice Macher, Juliette Guegen, Marie Courbebaisse, Emmanuel Letavernier, Dany Anglicheau

5.2.1. Évaluation du débit de filtration glomérulaire avant don

Tableau 5.3 : Percentiles de DFG mesuré normal (ml/min/1,73 m²) dans une population de donneurs vivants en France et en Suisse

Âge (années)	Percentiles				
	5e	10e	50e	90e	95e
18	82	88	106	125	130
20	82	88	106	125	130
25	82	88	106	125	130
30	82	88	106	125	130
35	82	88	106	125	130
40	82	88	106	125	130
45	78	83	102	120	126
50	74	79	97	116	121
55	69	74	93	112	117
60	65	70	89	107	112
65	60	66	84	103	108
70	56	61	80	98	104
75	52	57	75	94	99
80	47	52	71	90	95
85	43	48	67	85	90
90	38	44	62	81	86
95	34	39	58	76	82

Les valeurs au-delà de 70 ans sont validées dans une population externe de 329 individus âgés en bonne santé.

Delanaye P, Clin Chem Lab Med, 2022

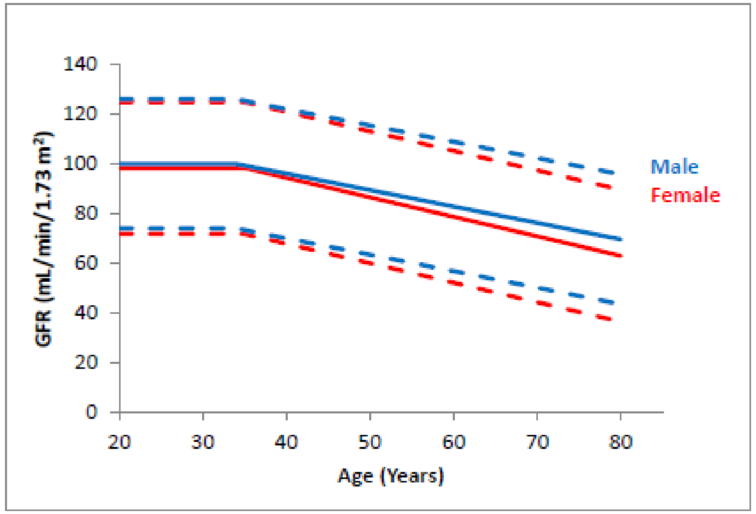
Pas de differences hommes femmes… à première vue…

5.5 ASSESSMENT OF RENAL FUNCTION

Table 5.5.1 Age and Gender-Specific GFR based on almost 3000 Healthy Potential UK living kidney donors

Age (years)	Measured GFR (mL/min/1.73m²) Male	Female
20-29	100 (74-126)	98 (72-125)
30-34	100 (74-126)	98 (72-125)
35	99 (73-126)	98 (72-125)
40	96 (70-122)	94 (68-121)
45	93 (67-119)	91 (64-117)
50	90 (63-116)	87 (60-113)
55	86 (60-112)	83 (56-109)
60	83 (57-109)	79 (52-105)
65	80 (54-106)	75 (48-101)
70	76 (50-102)	71 (44-97)
75	73 (47-99)	67 (40-94)
80	70 (44-96)	63 (36-90)

Figure 5.5.1 Mean and Lower Normal Values (-2SD) for GFR Determined in Almost 3000 Healthy UK Potential Living Kidney Donors (6)*



* The mean fall in GFR each decade after 40years is 6.6 mL/min/1.73m² for men and 7.7 mL/min/1.73m² in women

Guidelines for Living Donor Kidney Transplantation

Fourth Edition

March 2018

BTS/RA Living Donor Kidney Transplantation Guidelines 2018

United Kingdom Guidelines

Fenton A, BMC Nephrol, 2018

Clinical Practice: Original Paper

nephron Clinical Practice

Nephron
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Glomerular Filtration Rate in Healthy Living Potential Kidney Donors: A Meta-Analysis Supporting the Construction of the Full Age Spectrum Equation

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Table 3. Meta-analysis results for comparing mean GFR between men and women

Age group, years	#Studies	#M	#F	I^2 (%; p value)	Standardized effect size (95% CI)	p value	Effect size (95% CI), ml/min/1.73 m²
20–30	11/12	497	371	33.1 (0.134)	–0.03 (–0.16 to 0.11)	0.714	–0.4 (–2.3 to 1.6)
30–40	11/12	656	659	49.4 (0.032)	0.00 (–0.11 to 0.11)	0.969	0.0 (–1.5 to 1.6)
40–50	10/12	703	892	22.3 (0.238)	–0.01 (–0.11 to 0.09)	0.831	–0.1 (–1.6 to 1.3)
50–60	10/12	514	750	50.0 (0.035)	0.23 (0.12 to 0.35)	0.0001	3.4 (1.7 to 5.1)
60–70	7/12	157	206	22.6 (0.257)	0.25 (0.04 to 0.47)	0.020	3.7 (0.6 to 6.9)
>70	3/12	38	39	0.0 (1.000)	0.00 (–0.48 to 0.48)	1.000	0.0 (–6.7 to 6.7)
Total		2,565	2,917				

#Studies = The number of studies or articles involved in the hypothesis of equality (out of 12 selected articles). I^2 (p value) = measure of homogeneity among studies, with p indicating Cochran's Q significance. Standardized effect size = difference in mean mGFR between males (#M) and females (#F) divided by the pooled SD. 95% CI for the effect size. p = p value for testing the hypothesis of equality of mean mGFR between sexes. Effect size = GFR-difference corresponding to the standardized effect size expressed in ml/min/1.73 m².

12 études
n =5,482
46.8% hommes

CLINICAL EPIDEMIOLOGY www.jasn.org

GFR in Healthy Aging: an Individual Participant Data Meta-Analysis of Iohexol Clearance in European Population-Based Cohorts

Bjørn O. Eriksen,[1,2] Runolfur Palsson,[3,4] Natalie Ebert,[5] Toralf Melsom,[1,2] Markus van der Giet,[6] Vilmundur Gudnason,[4,7] Olafur S. Indridasson,[3] Lesley A. Inker,[8] Trond G. Jenssen,[1,9] Andrew S. Levey,[8] Marit D. Solbu,[1,2] Hocine Tighiouart,[10,11] and Elke Schaeffner[5]

Due to the number of contributing authors, the affiliations are listed at the end of this article.

Table 1. Characteristics of the population-based cohorts

Characteristic	RENIS-T6[a]	RENIS-FU[a]	BIS	AGES-Kidney
Number of participants, n (%)	1622 (100.0)	1324 (100.0)	547 (100.0)	716 (100.0)
Age, yr (SD)	58.1 (3.8)	63.6 (4.0)	78.4 (6.2)	80.3 (4.1)
Male sex, n (%)	797 (49.1)	657 (49.6)	311 (56.9)	317 (44.3)
Body weight, kg (SD)	79.7 (14.4)	79.4 (14.3)	77.3 (14.0)	77.1 (14.1)
Height, cm (SD)	170.6 (8.7)	170.6 (8.7)	166.2 (8.5)	167.7 (9.4)
Body mass index, kg/m^2 (SD)	27.3 (4.0)	27.2 (4.1)	27.9 (4.3)	27.4 (4.3)
Body surface area, m^2 (SD)	1.9 (0.2)	1.9 (0.2)	1.9 (0.2)	1.9 (0.2)
Cardiovascular disease, n (%)				
Myocardial infarction	1 (0.1)	18 (1.4)	83 (15.2)	89 (12.4)
Myocardial revascularization	5 (0.3)	26 (2.0)	93 (17.0)	113 (15.8)
Angina pectoris	2 (0.1)	12 (0.9)	56 (10.2)	60 (8.4)
Stroke	3 (0.2)	24 (1.8)	42 (7.7)	53 (7.4)
Diabetes, n (%)	19 (1.2)	42 (3.2)	136 (24.9)	81 (11.3)
Cancer, n (%)	76 (4.7)	120 (9.1)	123 (22.5)	134 (18.7)
Hypertension, n (%)[b]	692 (42.7)	693 (52.3)	503 (92.0)	623 (87.0)
Systolic BP, mm Hg (SD)	129.7 (17.6)	130.7 (17.0)	144.9 (21.5)	142.3 (20.3)
Diastolic BP, mm Hg (SD)	83.4 (9.8)	81.9 (9.3)	82.3 (13.0)	69.6 (10.7)
Antihypertensive medication, n (%)	298 (18.4)	420 (31.7)	425 (77.7)	524 (73.2)
Digoxin or digitoxin, n (%)	1 (0.1)	6 (0.5)	18 (3.3)	24 (3.4)
Lipid-lowering medication, n (%)	106 (6.5)	232 (17.5)	202 (36.9)	287 (40.1)
Antidiabetic medication, n (%)	0 (0.0)	11 (0.8)	99 (18.1)	44 (6.1)
Smoking, n (%)				
Never	503 (31.0)	432 (32.6)	263 (48.1)	295 (41.2)
Current	344 (21.2)	177 (13.4)	32 (5.9)	42 (5.9)
Previous	775 (47.8)	715 (54.0)	252 (46.1)	379 (52.9)
Absolute GFR, ml/min (SD)	104.0 (20.1)	98.5 (19.8)	64.8 (19.2)	66.7 (19.4)
Body surface area–indexed GFR, ml/min per 1.73 m^2 (SD)	94.0 (14.4)	89.1 (14.5)	60.5 (16.3)	61.9 (16.6)
CKD-EPI estimate of GFR based on creatinine, ml/min per 1.73 m^3 (SD)	94.9 (9.5)	88.2 (10.5)	68.8 (17.1)	65.5 (17.1)
Urinary ACR ≥30.0 mg/g, n (%)	24 (1.5)	26 (2.0)	126 (23.0)	110 (15.4)
Urinary ACR ≥300.0 mg/g, n (%)	1 (0.1)	2 (0.2)	19 (3.5)	15 (2.1)

Data are shown as mean (SD) or n (%). CKD-EPI, CKD Epidemiology Collaboration.
[a]RENIS-T6 and RENIS-FU are the baseline and follow-up examinations of the RENIS cohort.
[b]Office systolic BP ≥140 mm Hg, office diastolic BP ≥90 mm Hg, or the use of antihypertensive medications.

3 études
n =4,209
mesures 2885
sujets
49,4% hommes

Eriksen BO, J Am Soc Nephrol, 2020

Healthy n=935

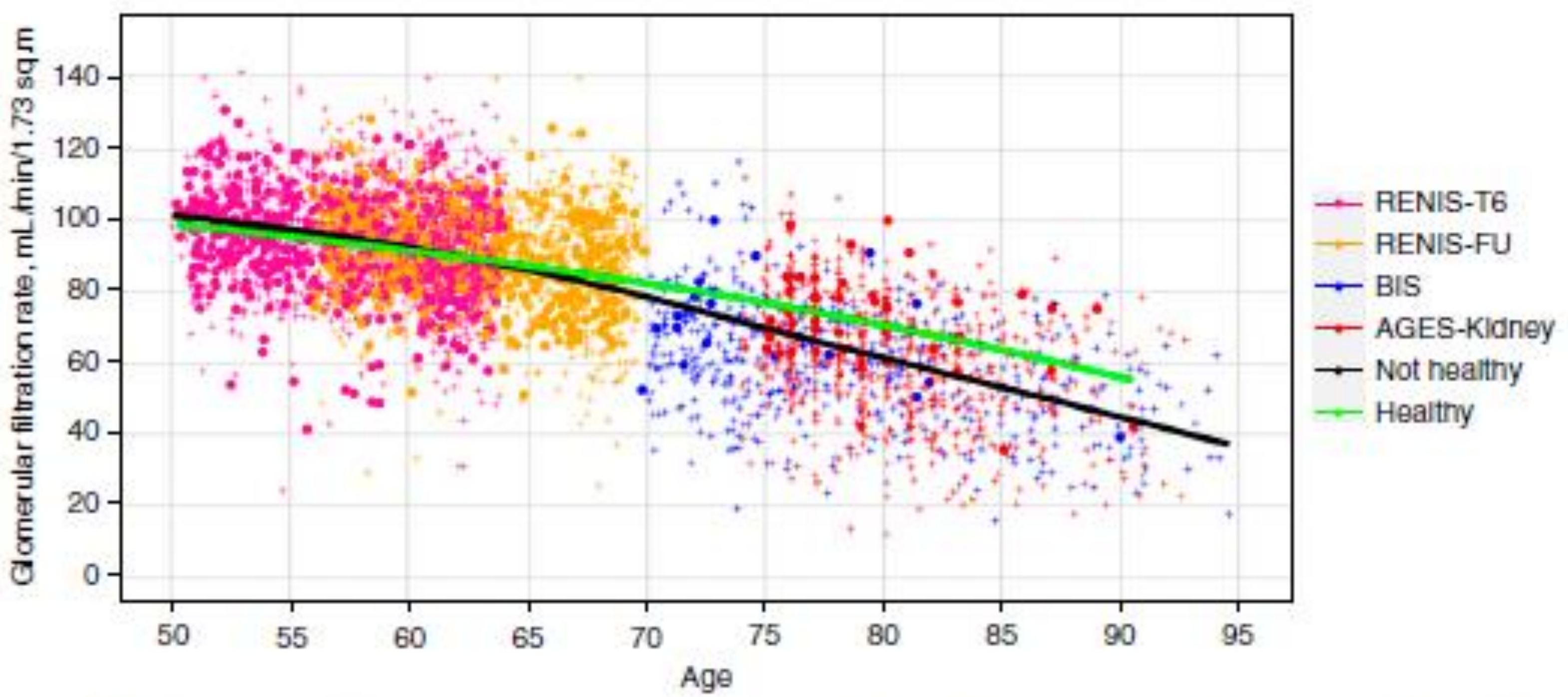

Figure 2. Unadjusted GFR according to cohort and health status. Body surface area–indexed GFR measured as plasma iohexol clearance and plotted against age in the RENIS, BIS, and AGES-Kidney cohorts (*n*=4209). The marker colors indicate cohort membership. Filled circles indicate measurements in persons who were healthy and crosses in persons who were unhealthy. Measurements for both the baseline (RENIS-T6) and the follow-up examinations (RENIS-FU) of the same persons in the RENIS cohort are shown. The red and green curves represent unadjusted locally estimated scatterplot smoothing fits to measurements in people who were unhealthy and healthy, respectively.

Table 4. Predicted percentiles of GFR (ml/min per 1.73 m^2) for healthy women and men according to age group

Age Group (yr)	Women				Men			
	Number of GFR Measurements	Median	2.5th Percentile	97.5th Percentile	Number of GFR Measurements	Median	2.5th Percentile	97.5th Percentile
50–54	226	93.4	73.7	113.1	217	93.0	73.1	113.0
55–59	405	88.8	69.2	108.3	423	89.4	69.6	109.3
60–64	566	84.2	64.7	103.6	521	85.8	66.1	105.5
65–69	296	79.6	60.3	98.9	293	82.2	62.7	101.8
70–74	129	75.0	55.8	94.1	102	78.6	59.2	98.0
75–79	253	70.4	51.4	89.4	225	75.0	55.7	94.3
80–84	164	65.8	46.9	84.7	188	71.4	52.2	90.6
85–89	68	61.2	42.4	79.9	79	67.8	48.8	86.8
≥90	20	56.6	38.0	75.2	34	64.2	45.3	83.1

Estimates corresponding to Figure 3

Healthy : ♂ -0.72 (95% CI, -0.96 to -0.48) *versus*
♀ -0.92 (95% CI, -1.14 to -0.70) ml/min per 1.73m²/year

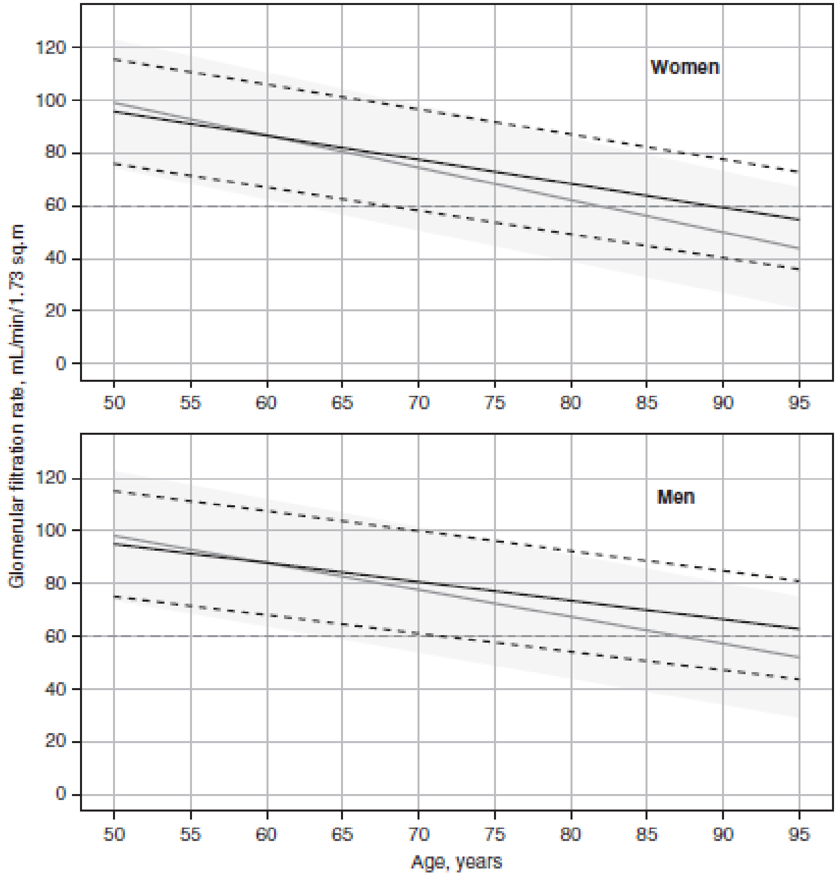

Figure 3. GFR according to sex and health status. Predicted median (bold black line) and 2.5th and 97.5th percentiles (dashed black lines) as a function of age for healthy women (upper panel) and men (lower panel). The predicted median (gray line) and 95% interpercentile intervals (dark gray band) are shown for persons classified as unhealthy for comparison. The gray dashed line indicates the 60 ml/min per 1.73 m^2 level.

CLINICAL EPIDEMIOLOGY www.jasn.org

JASN 33: 1891–1902, 2022

Sex Differences in Age-Related Loss of Kidney Function

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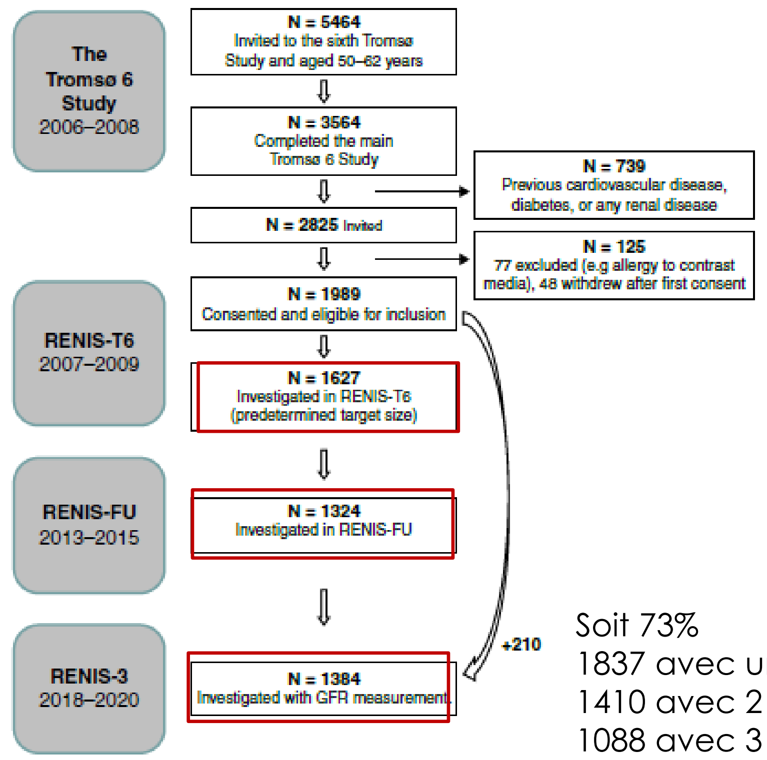

Figure 1. **Flow diagram of the study subjects in RENIS.** Inclusion of subjects in the Renal Iohexol Clearance Survey (RENIS). Participants were recruited from the sixth wave of the Tromsø Study.

Soit 73%
1837 avec une mesure
1410 avec 2 mesures
1088 avec 3 mesures

N=1,837
58 ±3,8 ans
53% femmes
Sains: 26, 27 et 22%

Très peu de personnes sont “stables” en DFG en vieillissant

Table 3. Associations between sex, health status, and GFR change rates in linear mixed models

Characteristics	Model 1: Change in GFR, ml/min per 1.73 m^2 per Year (95% Confidence Interval)	Model 1: P Value	Model 2: Change in GFR, ml/min per 1.73 m^2 per Year (95% Confidence Interval)	Model 2: P Value
Women	−0.96 (−0.88 to −1.04)	<0.001	−1.04 (−1.12 to −0.95)	<0.001
Men	−1.20 (−1.12 to −1.28)	<0.001[a]	−1.26 (−1.18 to −1.35)	<0.001
Healthy[b]			0.28 (0.15 to 0.40)	<0.001
Difference between men and women	−0.24 (−0.12 to −0.35)	<0.001	−0.23 (−0.11 to −0.34)	<0.001

Both models were adjusted for age at baseline, with separate terms for women and men.
[a] $P<6\times10^{-5}$ for effect modification by sex.
[b] Healthy, defined at each visit as no CVD, cancer, diabetes, hypertension, smoking, lipid-lowering medication or digoxin, and a BMI of <30 kg/m^2 and urinary ACR of <3.4 mg/mmol (30 mg/g).

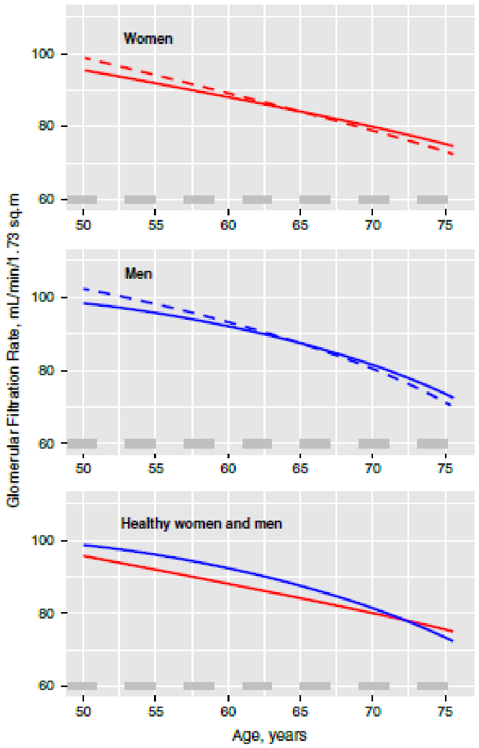

Figure 3. Mean GFR decline with age for women and men by health status ("healthy" in solid and "not healthy" in dashed). The lower panel depicts the mean GFR decline with age for healthy women versus healthy men. Calculated using a GAMM (model 3, Supplemental Table 2).

Healthy
♂ n=179
♀ n=242

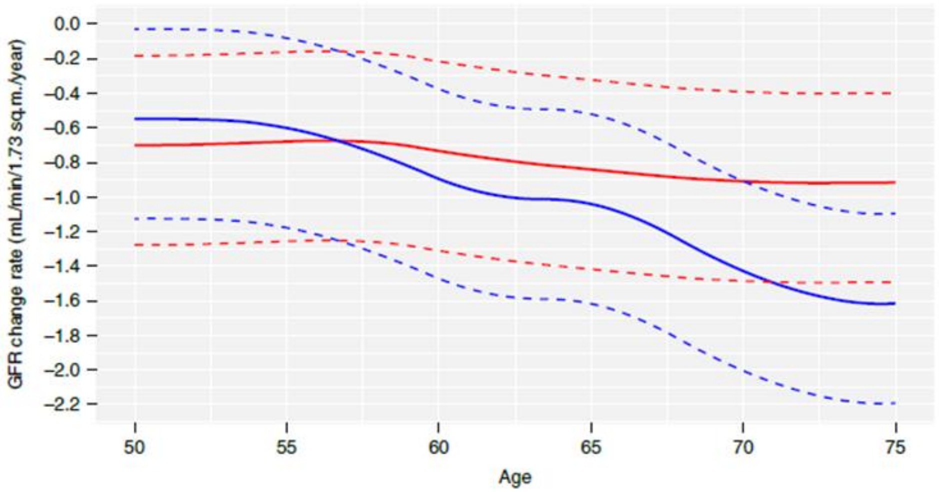

Figure 4. Sex-specific GFR change rates for healthy women and men as a function of age with 95% reference intervals. The solid lines represent the GFR change rates for women (red) and men (blue). The dashed lines represent the 95% reference intervals estimated from the best linear unbiased predictions of the random slopes of the GAMM in Supplemental Table 2.

Table 4. Age-specific annual GFR change rates for healthy women and men

Age Group, yr	Women			Men		
	Mean	Percentiles 2.5th	Percentiles 97.5th	Mean	Percentiles 2.5th	Percentiles 97.5th
50–54	−0.70	−1.25	−0.21	−0.55	−1.11	−0.06
55–59	−0.70	−1.25	−0.20	−0.73	−1.28	−0.23
60–-64	−0.79	−1.34	−0.30	−0.98	−1.53	−0.48
65–69	−0.87	−1.42	−0.38	−1.22	−1.77	−0.73
70–75	−0.92	−1.47	−0.42	−1.53	−2.08	−1.03

The values are means (ml/min per 1.73 m^2 per year) for each 5-year interval. The 95% reference intervals were estimated from the best linear unbiased predictions of the random slopes of the generalized additive model in Supplemental Table 2.

Rôle de l'indexation?

Nephrol Dial Transplant (2005) 20: 2024–2028
doi:10.1093/ndt/gfh983
Advance Access publication 19 July 2005

Indexing glomerular filtration rate for body surface area in obese patients is misleading: concept and example

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Nephrol Dial Transplant (2009) 24: 3593–3596
doi: 10.1093/ndt/gfp431
Advance Access publication 3 September 2009

Errors induced by indexing glomerular filtration rate for body surface area: *reductio ad absurdum*

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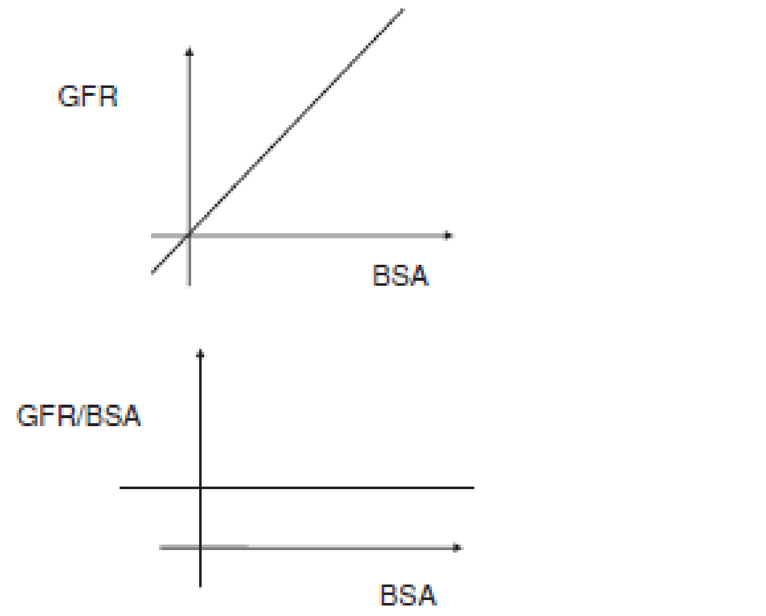

Fig. 1. Illustration of mathematical prerequisites for the use of BSA indexing.

Ratio?

CLINICAL EPIDEMIOLOGY www.jasn.org

J Am Soc Nephrol 22: 1517–1525, 2011

GFR Normalized to Total Body Water Allows Comparisons across Genders and Body Sizes

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Table 1. Study population characteristics compared to all eligible subjects

	Women		Men	
	Included (*n* = 826)	Eligible (*n* = 1542)[a]	Included (*n* = 801)	Eligible (*n* = 1283)[a]
Median age (IQR), years	57.5 (53.0 to 61.0)	57.0 (53.0 to 60.0)	57.0 (53.0 to 60.0)	57.0 (53.0 to 60.0)
Median height (IQR), cm	164.4 (160.8 to 168.6)	164.4 (160.3 to 168.5)	177.2 (172.9 to 181.1)	177.5 (173.0 to 181.7)
Median weight (IQR), kg	70.0 (63.1 to 77.7)	69.0 (62.4 to 77.4)	85.0 (77.4 to 94.0)	84.8 (77.2 to 93.2)
Median body-mass index (IQR), kg/m^2	25.7 (23.3 to 28.9)	25.6 (23.2 to 28.5)	27.1 (25.0 to 29.6)[c]	26.9 (24.9 to 29.3)
Median body-surface area (IQR), m^2	1.77 (1.68 to 1.86)[c]	1.76 (1.67 to 1.86)	2.02 (1.92 to 2.13)	2.03 (1.92 to 2.13)
Median estimated GFR (IQR), ml/min per 1.73 m^2 [b]	89.4 (79.8 to 100.4)[c]	88.0 (78.2 to 98.8)	91.9 (82.7 to 101.5)	91.7 (82.8 to 101.4)
Median unadjusted measured GFR (IQR), ml/min	90.5 (81.0 to 100.2)		112.2 (100.6 to 123.9)	
Median measured GFR (IQR), ml/min per 1.73 m^2	87.9 (79.3 to 96.6)		95.9 (86.4 to 104.8)	

The values represent the baseline measurements taken in the main part of the sixth population survey in Tromsø. IQR, interquartile range.
[a]Medians and interquartile ranges weighted according to the age stratification of RENIS-T6.
[b]GFR estimated with the recalibrated four-variable Modification of Diet in Renal Disease study equation.
[c]$P < 0.05$ for difference between included and eligible in age-adjusted quantile regression.

Table 7. Method for adjustment of GFR to 40 liters of total body water (GFR40)

1. Estimate total body water in liters from Watson's equation[a]
   men: $2.447 + (0.3362 \times \text{weight}) + (0.1074 \times \text{height}) - (0.09516 \times \text{age})$
   women: $-2.097 + (0.2466 \times \text{weight}) + (0.1069 \times \text{height})$
2. Convert the unadjusted GFR to the corresponding GFR in ml/min for the standard individual with 40 liters of total body water (GFR40)[b]
   $13.05 \times \text{unadjusted GFR} \times \text{total body water}^{-0.4963}$

[a]Height is entered in centimeters, weight is in kilograms, and age is in years.
[b]Total body water is entered in L.

Table 6. Comparison of unadjusted and adjusted glomerular filtration rates according to body-mass index and gender

	Mean (standard deviation)	
	Women	Men
Unadjusted glomerular filtration rate, ml/min		
≤25 kg/m² body-mass index	86.5 (13.9)[c]	105.0 (15.1)[c]
25 to 30 kg/m² body-mass index	91.3 (14.1)	111.5 (16.6)
>30 kg/m² body-mass index	96.4 (17.6)	122.1 (18.0)
Total body water, L		
≤25 kg/m² body-mass index	31.0 (2.1)[c]	40.7 (3.0)[c]
25 to 30 kg/m² body-mass index	33.6 (2.0)	44.7 (3.1)
>30 kg/m² body-mass index	37.5 (3.0)	50.0 (3.7)
Body-surface area, m²		
≤25 kg/m² body-mass index	1.69 (0.11)[c]	1.90 (0.12)[c]
25 to 30 kg/m² body-mass index	1.80 (0.10)	2.03 (0.12)
>30 kg/m² body-mass index	1.95 (0.13)	2.18 (0.13)
GFR adjusted to population mean body-surface area† by the ratio method, ml/min		
≤25 kg/m² body-mass index	98.2 (15.3)[c]	105.7 (14.9)
25 to 30 kg/m² body-mass index	97.2 (14.8)	105.2 (15.0)
>30 kg/m² body-mass index	94.5 (17.0)	107.2 (15.5)
GFR adjusted to population mean body-surface area by the regression method of Turner and Reilly, ml/min[a]		
≤25 kg/m² body-mass index	99.8 (15.7)[c]	105.8 (15.1)
25 to 30 kg/m² body-mass index	98.0 (15.0)	104.4 (15.0)
>30 kg/m² body-mass index	94.3 (17.1)	105.5 (15.4)
GFR adjusted to population mean total body water by the ratio method, ml/min[b]		
≤25 kg/m² body-mass index	109.8 (17.1)[c]	101.4 (14.4)[c]
25 to 30 kg/m² body-mass index	106.9 (16.3)	97.9 (14.0)
>30 kg/m² body-mass index	101.1 (18.5)	95.9 (14.0)
GFR adjusted to population mean total body water by the regression method of Turner and Reilly, ml/min[b]		
≤25 kg/m² body-mass index	102.1 (15.8)	102.4 (14.2)
25 to 30 kg/m² body-mass index	101.8 (15.3)	101.8 (14.4)
>30 kg/m² body-mass index	99.6 (17.9)	103.1 (14.6)

[a]Study population mean body-surface area was 1.9 m².
[b]Study population mean total body water was 39.2 L.
[c]$P < 0.05$ for differences across body-mass index categories within each gender.

Différence de DFG mesuré?

Différence de DFG mesuré?

- Peut-être, oui: une petite (entre 3 et 5 mL/min/1.73m²) (après 40-50 ans)
- Pentes semblent différentes (mais dans quelle sens?)
- Pourquoi = ?
- Biais de survie? Environnement hormonal?
- Rôle de l'indexation par la BSA qui est imparfaite (?)
- Est-ce important du pont de vue clinique? (âge *versus* genre)
- Je confesse…

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Single-Nephron Glomerular Filtration Rate in Healthy Adults

Aleksandar Denic, M.D., Ph.D., Jerry Mathew, M.D.,
Lilach O. Lerman, M.D., Ph.D., John C. Lieske, M.D., Joseph J. Larson, B.S.,
Mariam P. Alexander, M.D., Emilio Poggio, M.D., Richard J. Glassock, M.D.,
and Andrew D. Rule, M.D.

N Engl J Med 2017;376:2349-57.

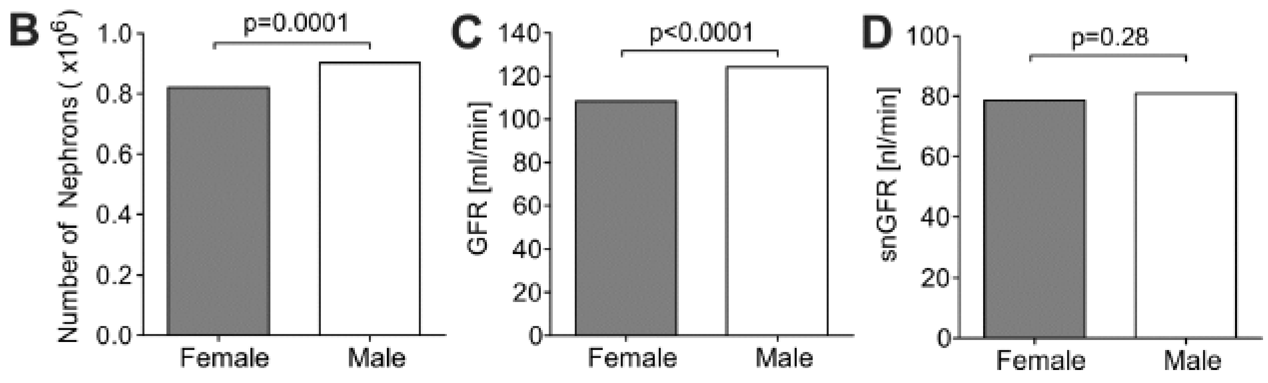


Figure S1. The mean single nephron glomerular filtration rate was relatively stable across the spectrum of age and sex.

DFG estimé: créatinine

- La Valeur normale de créatinine est différente chez les hommes et chez les femmes
- Masse musculaire

ARTICLE | Annals of Internal Medicine

A New Equation to Estimate Glomerular Filtration Rate

Andrew S. Levey, MD; Lesley A. Stevens, MD, MS; Christopher H. Schmid, PhD; Yaping (Lucy) Zhang, MS; Alejandro F. Castro III, MPH; Harold I. Feldman, MD, MSCE; John W. Kusek, PhD; Paul Eggers, PhD; Frederick Van Lente, PhD; Tom Greene, PhD; and Josef Coresh, MD, PhD, MHS, for the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration)*

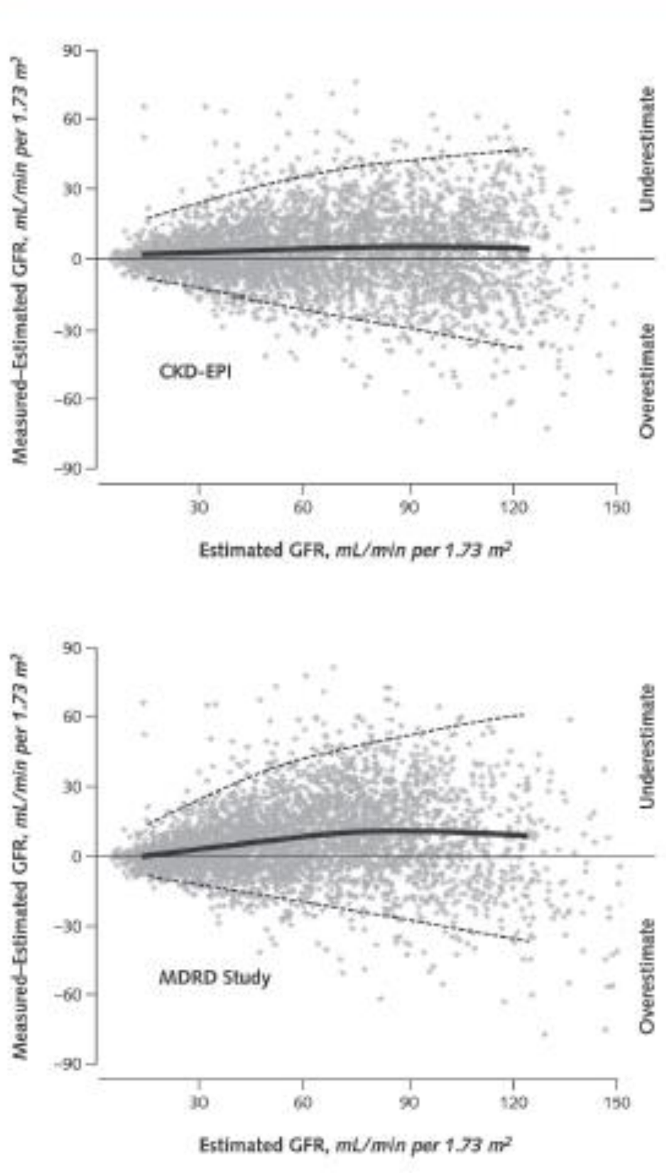
Ann Intern Med. 2009;150:604-612.

Table 2. The CKD-EPI Equation for Estimating GFR on the Natural Scale*

Race and Sex	Serum Creatinine Level, *µmol/L (mg/dL)*	Equation
Black		
Female	≤62 (≤0.7)	$GFR = 166 \times (Scr/0.7)^{-0.329} \times (0.993)^{Age}$
	>62 (>0.7)	$GFR = 166 \times (Scr/0.7)^{-1.209} \times (0.993)^{Age}$
Male	≤80 (≤0.9)	$GFR = 163 \times (Scr/0.9)^{-0.411} \times (0.993)^{Age}$
	>80 (>0.9)	$GFR = 163 \times (Scr/0.9)^{-1.209} \times (0.993)^{Age}$
White or other		
Female	≤62 (≤0.7)	$GFR = 144 \times (Scr/0.7)^{-0.329} \times (0.993)^{Age}$
	>62 (>0.7)	$GFR = 144 \times (Scr/0.7)^{-1.209} \times (0.993)^{Age}$
Male	≤80 (≤0.9)	$GFR = 141 \times (Scr/0.9)^{-0.411} \times (0.993)^{Age}$
	>80 (>0.9)	$GFR = 141 \times (Scr/0.9)^{-1.209} \times (0.993)^{Age}$

- CKD-EPI
- « Development dataset » n=5504
- « Internal validation » n=2750
- « External validation » n=3896
- Créatinine calibrée
- DFG mesuré

Figure. Performance of the CKD-EPI and MDRD Study equations in estimating measured GFR in the external validation data set.



Levey AS, Ann Intern Med, 2009, p604

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

New Creatinine- and Cystatin C–Based Equations to Estimate GFR without Race

L.A. Inker, N.D. Eneanya, J. Coresh, H. Tighiouart, D. Wang, Y. Sang, D.C. Crews, A. Doria, M.M. Estrella, M. Froissart, M.E. Grams, T. Greene, A. Grubb, V. Gudnason, O.M. Gutiérrez, R. Kalil, A.B. Karger, M. Mauer, G. Navis, R.G. Nelson, E.D. Poggio, R. Rodby, P. Rossing, A.D. Rule, E. Selvin, J.C. Seegmiller, M.G. Shlipak, V.E. Torres, W. Yang, S.H. Ballew, S.J. Couture, N.R. Powe, and A.S. Levey, for the Chronic Kidney Disease Epidemiology Collaboration*

> N Engl J Med. 2021 Nov 4;385(19):1737-1749.

Table 3. Accuracy of Current and New Approaches for GFR Estimation as Compared with Measured GFR in the Validation Data Set.

Filtration Marker and Equation*	Black Participants	Non-Black Participants	Difference between Black Participants and Non-Black Participants (95% CI)†
	Bias: Median Difference between Measured GFR and eGFR (95% CI)‡		
	milliliters per minute per 1.73 square meters		
Creatinine			
eGFRcr(ASR), current	−3.7 (−5.4 to −1.8)	−0.5 (−0.9 to 0.0)	−3.2 (−5.0 to −1.3)
eGFRcr(ASR-NB), new	7.1 (5.9 to 8.8)	−0.5 (−0.9 to 0.0)	7.6 (6.1 to 9.0)
eGFRcr(AS), new	3.6 (1.8 to 5.5)	−3.9 (−4.4 to −3.4)	7.6 (5.6 to 9.5)
Creatinine			
eGFRcr(ASR), current	85.1 (82.2 to 87.9)	89.5 (88.5 to 90.4)	−4.4 (−7.6 to −1.2)
eGFRcr(ASR-NB), new	86.4 (83.4 to 89.1)	89.5 (88.5 to 90.4)	−3.1 (−6.2 to 0)
eGFRcr(AS), new	87.2 (84.5 to 90.0)	86.5 (85.4 to 87.6)	0.7 (−2.4 to 3.8)

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

New Creatinine- and Cystatin C–Based Equations to Estimate GFR without Race

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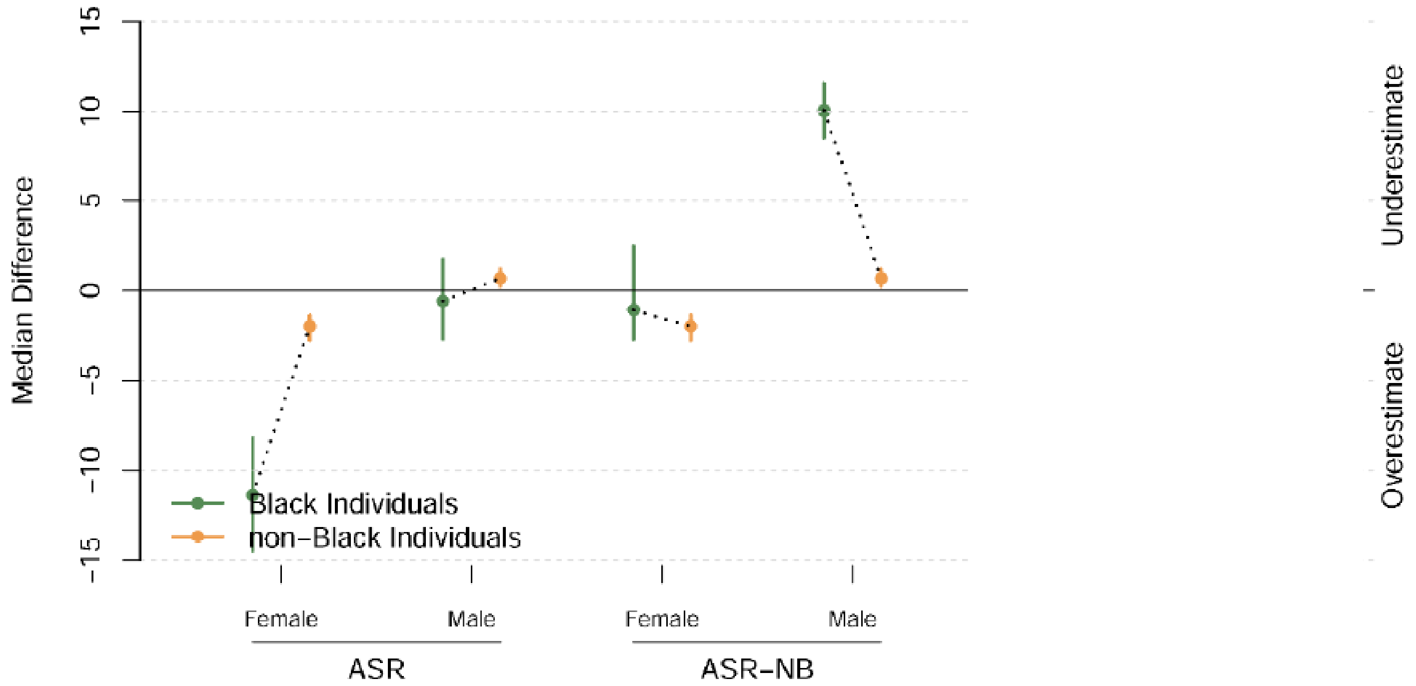
j. Performance of eGFR creatinine by sex subgroups in 2021 external validation



The NEW ENGLAND JOURNAL of MEDICINE

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New Creatinine- and Cystatin C–Based Equations to Estimate GFR without Race

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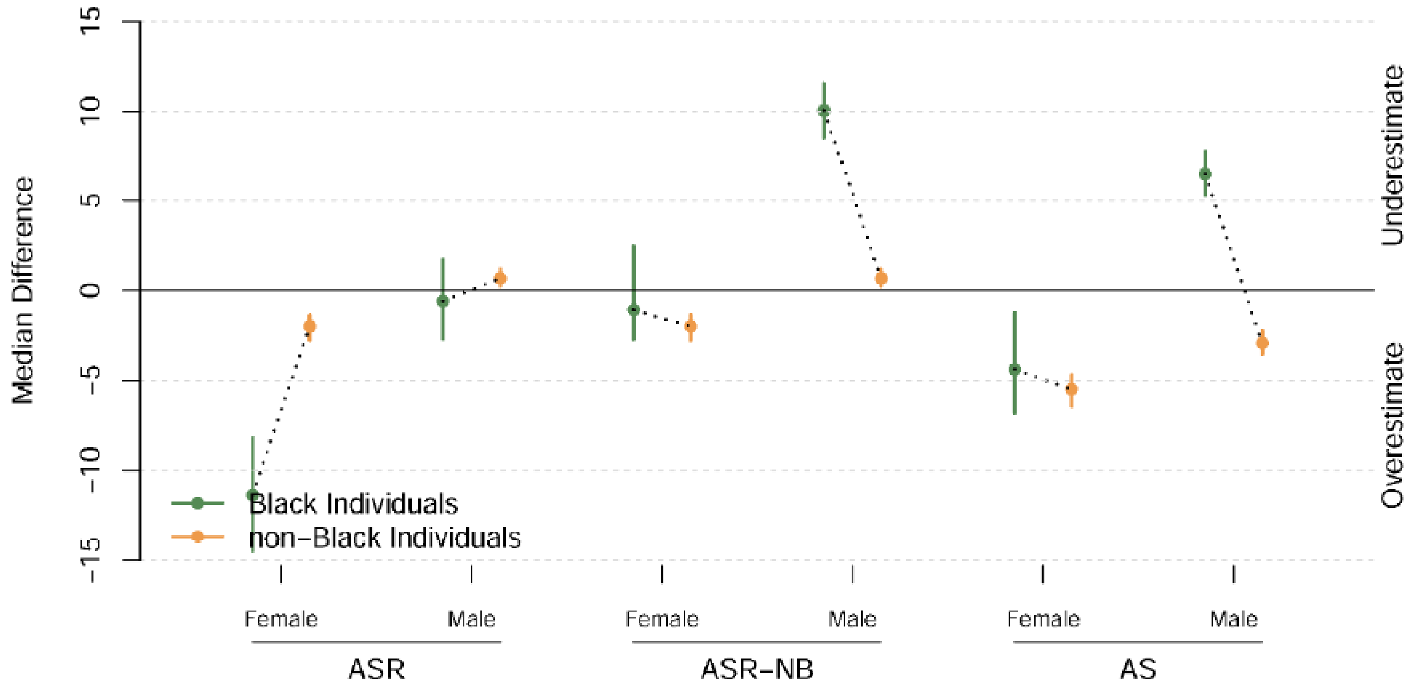

CKD-EPI: What else?

Ann Intern Med. 2021;174:183-191. doi:10.7326/M20-4366

Annals of Internal Medicine ORIGINAL RESEARCH

Development and Validation of a Modified Full Age Spectrum Creatinine-Based Equation to Estimate Glomerular Filtration Rate

A Cross-sectional Analysis of Pooled Data

Hans Pottel, PhD*; Jonas Björk, PhD*; Marie Courbebaisse, MD, PhD; Lionel Couzi, MD, PhD; Natalie Ebert, MD, MPH; Björn O. Eriksen, MD, PhD; R. Neil Dalton, PhD; Laurence Dubourg, MD, PhD; François Gaillard, MD, PhD; Cyril Garrouste, MD; Anders Grubb, MD, PhD; Lola Jacquemont, MD, PhD; Magnus Hansson, MD, PhD; Nassim Kamar, MD, PhD; Edmund J. Lamb, PhD; Christophe Legendre, MD; Karin Littmann, MD; Christophe Mariat, MD, PhD; Toralf Melsom, MD, PhD; Lionel Rostaing, MD, PhD; Andrew D. Rule, MD; Elke Schaeffner, MD, PhD, MSc; Per-Ola Sundin, MD, PhD; Stephen Turner, MD, PhD; Arend Bökenkamp, MD; Ulla Berg, MD, PhD; Kajsa Åsling-Monemi, MD, PhD; Luciano Selistre, MD, PhD; Anna Åkesson, BSc; Anders Larsson, MD, PhD; Ulf Nyman, MD, PhD†; and Pierre Delanaye, MD, PhD†

DFG mesuré et créatinine calibrée
N=11,251 (“development and internal validation dataset”)
N=8,378 (“external validation dataset”)
N=1,254 entre 2 et 18 ans
7+6 cohortes
Caucasiens

Figure 1. The new EKFC equation.

Age	SCr/Q	Equation
2–40 y	<1	$107.3 \times (SCr/Q)^{-0.322}$
	≥1	$107.3 \times (SCr/Q)^{-1.132}$
>40 y	<1	$107.3 \times (SCr/Q)^{-0.322} \times 0.990^{(Age-40)}$
	≥1	$107.3 \times (SCr/Q)^{-1.132} \times 0.990^{(Age-40)}$

Q Values

For ages 2–25 y:
Males:
$\ln(Q) = 3.200 + 0.259 \times Age - 0.543 \times \ln(Age) - 0.00763 \times Age^2 + 0.0000790 \times Age^3$
Females:
$\ln(Q) = 3.080 + 0.177 \times Age - 0.223 \times \ln(Age) - 0.00596 \times Age^2 + 0.0000686 \times Age^3$

For ages >25 y:
Males:
Q = 80 µmol/L (0.90 mg/dL)
Females:
Q = 62 µmol/L (0.70 mg/dL)

SCr and Q in µmol/L (to convert to mg/dL, divide by 88.4)

Q values (in µmol/L or mg/dL) correspond to the median SCr values for the age- and sex-specific populations. EKFC = European Kidney Function Consortium; SCr = serum creatinine.

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	≥1	$107.3 \times (SCr/Q)^{-1.132} \times 0.990^{(Age-40)}$

Q Values

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DE GRUYTER Clin Chem Lab Med 2022; 60(3): 401–407

Pierre Delanaye*, François Gaillard, Jessica van der Weijden, Geir Mjøen, Ingela Ferhman-Ekholm, Laurence Dubourg, Natalie Ebert, Elke Schaeffner, Torbjörn Åkerfeldt, Karolien Goffin, Lionel Couzi, Cyril Garrouste, Lionel Rostaing, Marie Courbebaisse, Christophe Legendre, Maryvonne Hourmant, Nassim Kamar, Etienne Cavalier, Laurent Weekers, Antoine Bouquegneau, Martin H. de Borst, Christophe Mariat, Hans Pottel and Marco van Londen

Age-adapted percentiles of measured glomerular filtration in healthy individuals: extrapolation to living kidney donors over 65 years

Avant 40 ans: DFGm = 107 mL/min/1.73m²

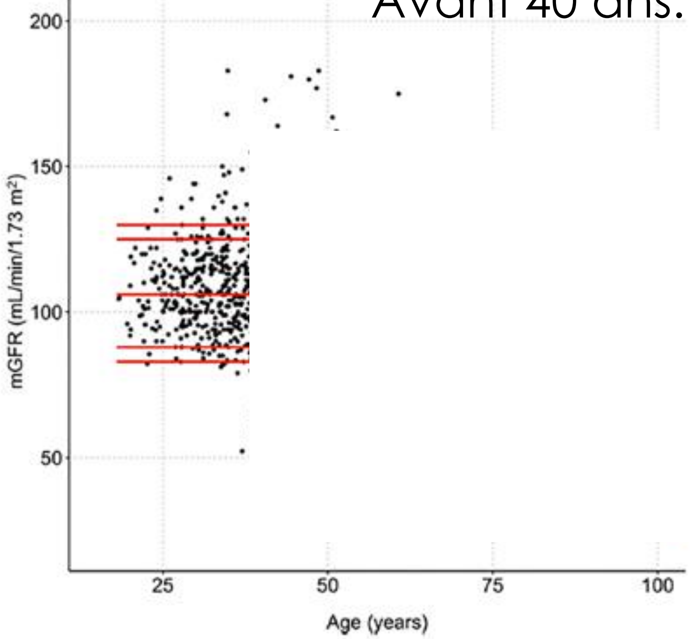

Figure 3: mGFR according to age in the development (dark dots) and external validation cohort (n=329) (gray dots). Red lines are percentiles 5, 10, 50, 90 and 95, calculated from kidney donors younger than 65 years and extrapolated for ages >65 years.

DE GRUYTER Clin Chem Lab Med 2022; 60(3): 401–407

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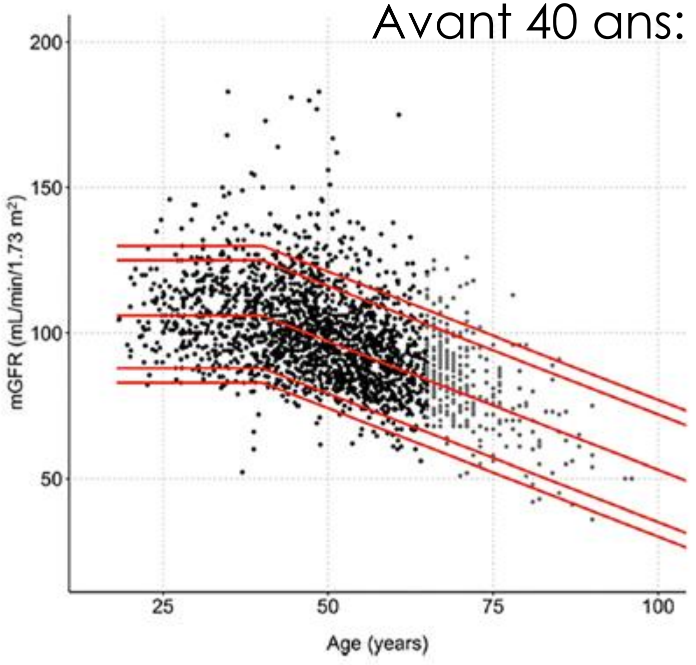

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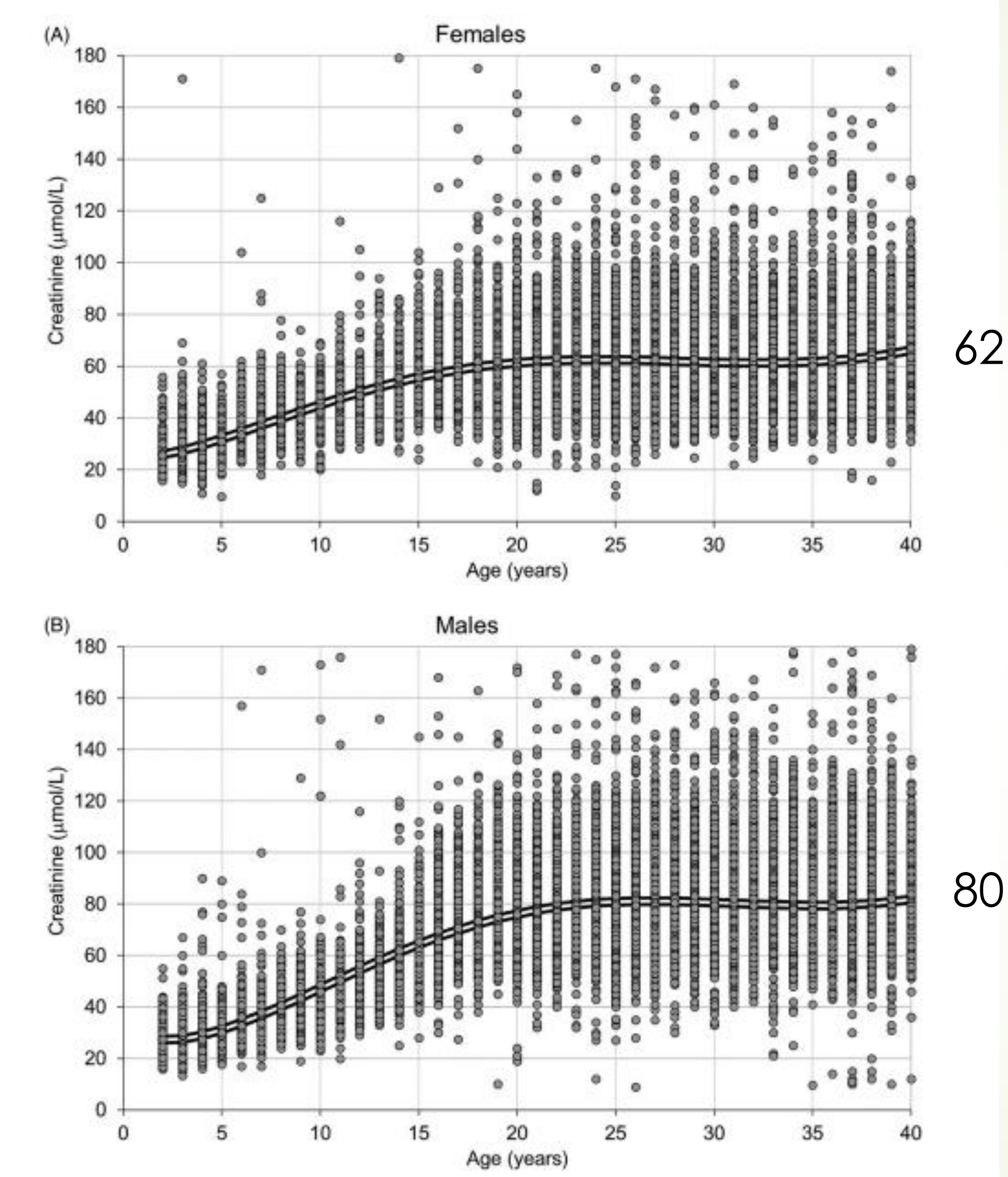

N=83,257 données de 3 laboratoires (Suède et Belgique)

62 µmol/L= 0,70 mg/dL

80 µmol/L= 0,90 mg/dL

Bjork J, Scand J Clin Lab Invest, 2020, 80, p456

Figure 1. The new EKFC equation.

Age	SCr/Q	Equation
2–40 y	<1	$107.3 \times (SCr/Q)^{-0.322}$
	≥1	$107.3 \times (SCr/Q)^{-1.132}$
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	≥1	$107.3 \times (SCr/Q)^{-1.132} \times 0.990^{(Age-40)}$

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Females:

$\ln(Q) = 3.080 + 0.177 \times Age - 0.223 \times \ln(Age) - 0.00596 \times Age^2 + 0.0000686 \times Age^3$

For ages >25 y:

Males:

Q = 80 μmol/L (0.90 mg/dL)

Females:

Q = 62 μmol/L (0.70 mg/dL)

SCr and Q in μmol/L (to convert to mg/dL, divide by 88.4)

Q values (in μmol/L or mg/dL) correspond to the median SCr values for the age- and sex-specific populations. EKFC = European Kidney Function Consortium; SCr = serum creatinine.

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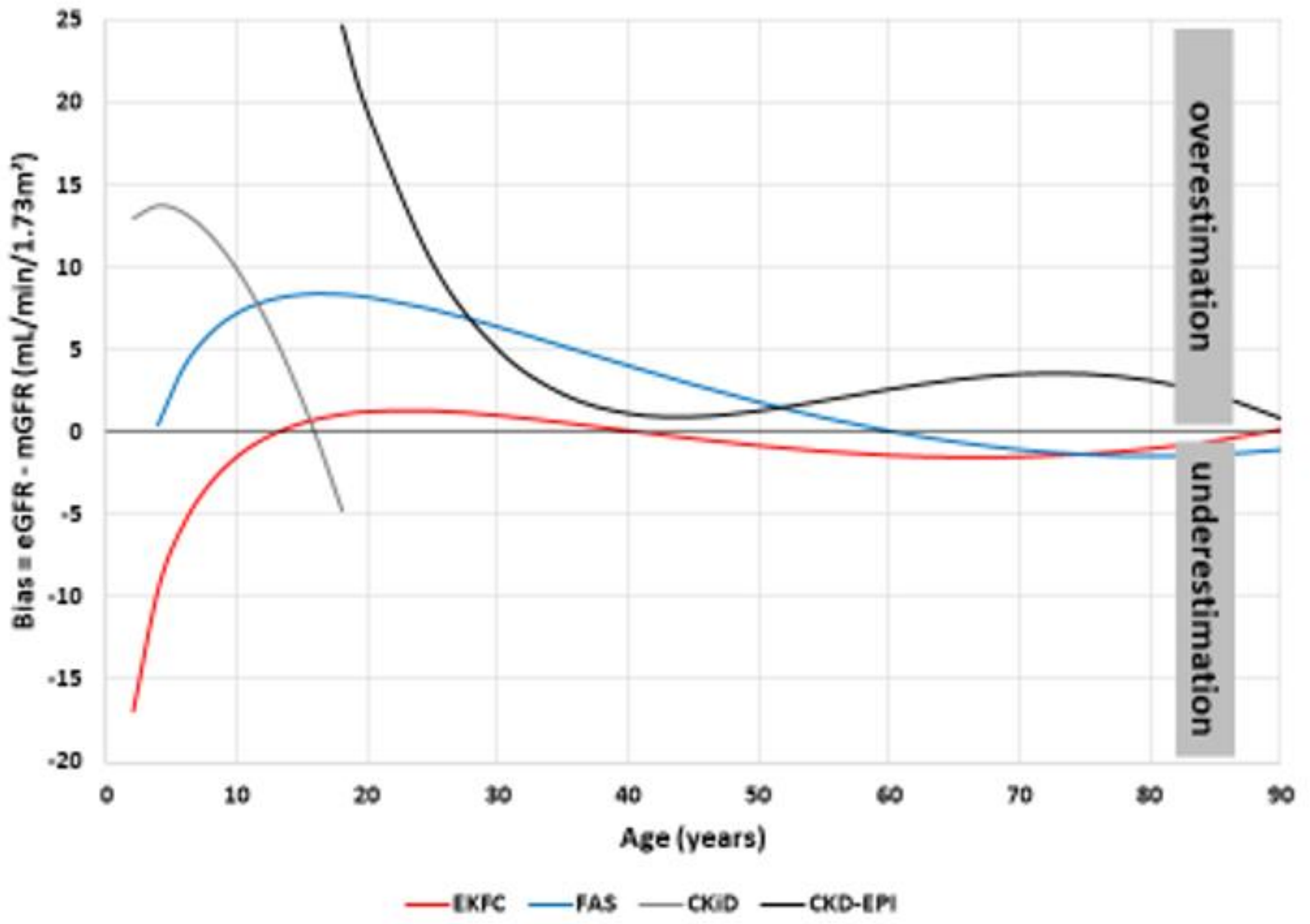

25
20
15
10
5
0
-5
-10
-15
-20
Bias = eGFR - mGFR (mL/min/1.73m²)
0
10
20
30
40
50
60
70
80
90
Age (years)
overestimation
underestimation
EKFC
FAS
CKiD
CKD-EPI

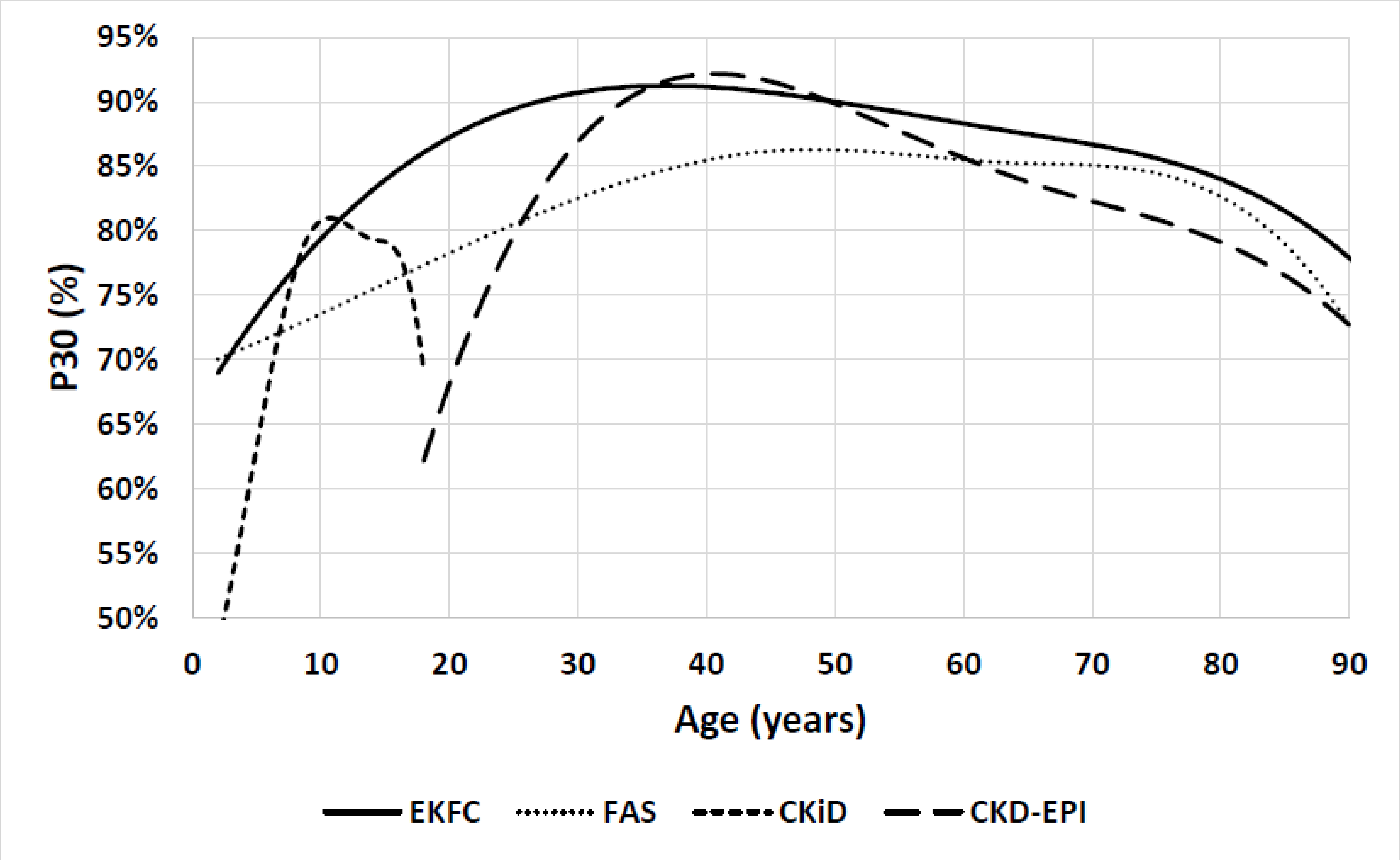

Figure S8. P30-accuracy against age for the EKFC, FAS, CKiD and CKD-EPI equation in the external validation dataset. P30 (%) was graphically presented across the age spectrum using cubic splines with two free knots and using 3rd degree polynomials.

Nephrology Dialysis Transplantation (2023) 38: 106–118
https://doi.org/10.1093/ndt/gfac241
Advance Access publication date 24 August 2022

Performance of creatinine-based equations to estimate glomerular filtration rate in White and Black populations in Europe, Brazil and Africa

Pierre Delanaye[1,2,*], Emmanuelle Vidal-Petiot[3,*], Jonas Björk[4,5], Natalie Ebert[6], Björn O. Eriksen[7], Laurence Dubourg[8], Anders Grubb[9], Magnus Hansson[10], Karin Littmann[11], Christophe Mariat[12], Toralf Melsom[7], Elke Schaeffner[6], Per-Ola Sundin[13], Arend Bökenkamp[14], Ulla B. Berg[15], Kajsa Åsling-Monemi[15], Anna Åkesson[4,5], Anders Larsson[16], Etienne Cavalier[17], R. Neil Dalton[18], Marie Courbebaisse[19], Lionel Couzi[20], Francois Gaillard[21], Cyril Garrouste[22], Lola Jacquemont[23], Nassim Kamar[24], Christophe Legendre[25], Lionel Rostaing[26], Thomas Stehlé[27,28], Jean-Philippe Haymann[29], Luciano da Silva Selistre[30], Jorge P. Strogoff-de-Matos[31], Justine B. Bukabau[32], Ernest K. Sumaili[32], Eric Yayo[33], Dagui Monnet[33], Ulf Nyman[34], Hans Pottel[35,†] and Martin Flamant[36,†]

Table 2: Median bias (mL/min/1.73 m^2) and P30 (%) for the five different creatinine-based equations according to mGFR, age, sex and BMI.

	Sample (%)	Bias CKD-EPI$_{ASR}$/CKD-EPI$_{ASR-NB}$/CKD-EPI$_{AS}$/LMREV/EKFC	P30 CKD-EPI$_{ASR}$/CKD-EPI$_{ASR-NB}$/CKD-EPI$_{AS}$/LMREV/EKFC
Sex			
Male			
White Europeans	9068 (52.4)	2.2/2.2/5.7/−4.1/−0.4	81.9/81.9/77.4/86.3/85.5
Black Europeans	596 (61.8)	−0.6/−8.1/−5.5/−11.5/−7.8	81.4/78.2/81.5/70.3/79.4
Black Africans	271 (53.3)	10.9/−2.7/1.2/−11.3/−5.1	66.8/74.2/72.3/75.3/78.2
Female			
White Europeans	8253 (47.6)	3.7/3.7/6.5/−2.3/−0.2	83.2/83.2/79.7/88.4/87.8
Black Europeans	368 (38.2)	5.9/−2.3/−0.5/−5.3/−3.7	70.9/78.5/80.2/80.4/82.3
Black Africans	237 (46.7)	15.4/1.4/4.2/−5.5/−3.6	59.9/77.6/76.8/80.6/80.6

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Cystatin C–Based Equation to Estimate GFR without the Inclusion of Race and Sex

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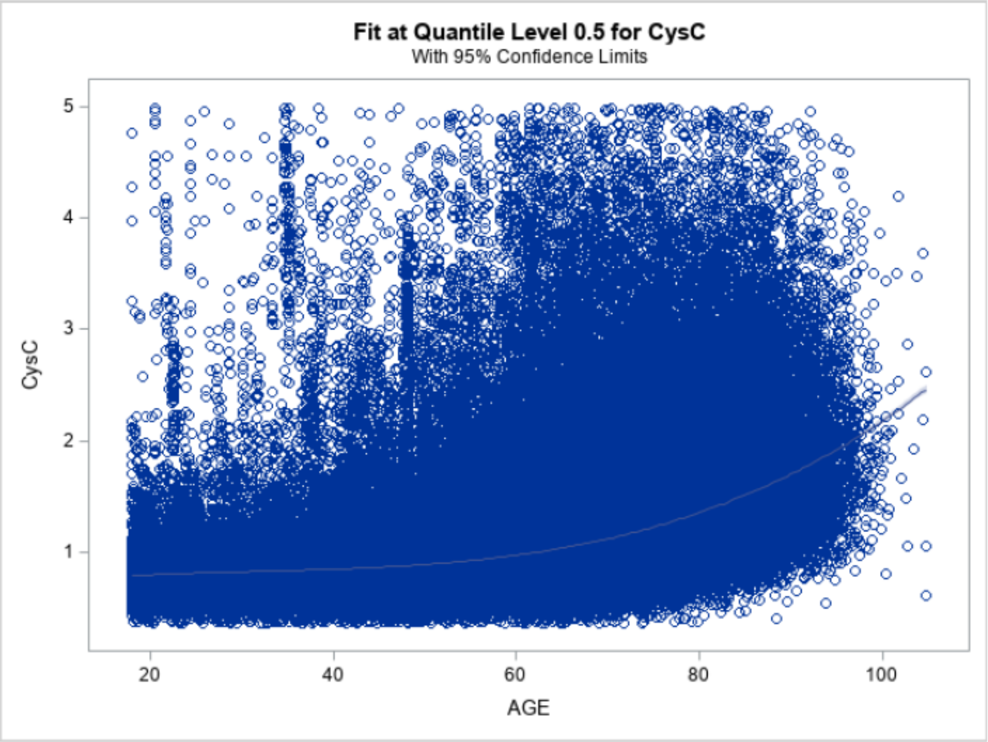
ABSTRACT

N Engl J Med 2023;388:333-43.

Etape 1: cystatine C et âge

Données de laboratoire de Suède
N=227,643
♀ 95,469
♂ 132,174

Figure S3. Cystatin C versus age and the median quantile line for the 227,643 included subjects.

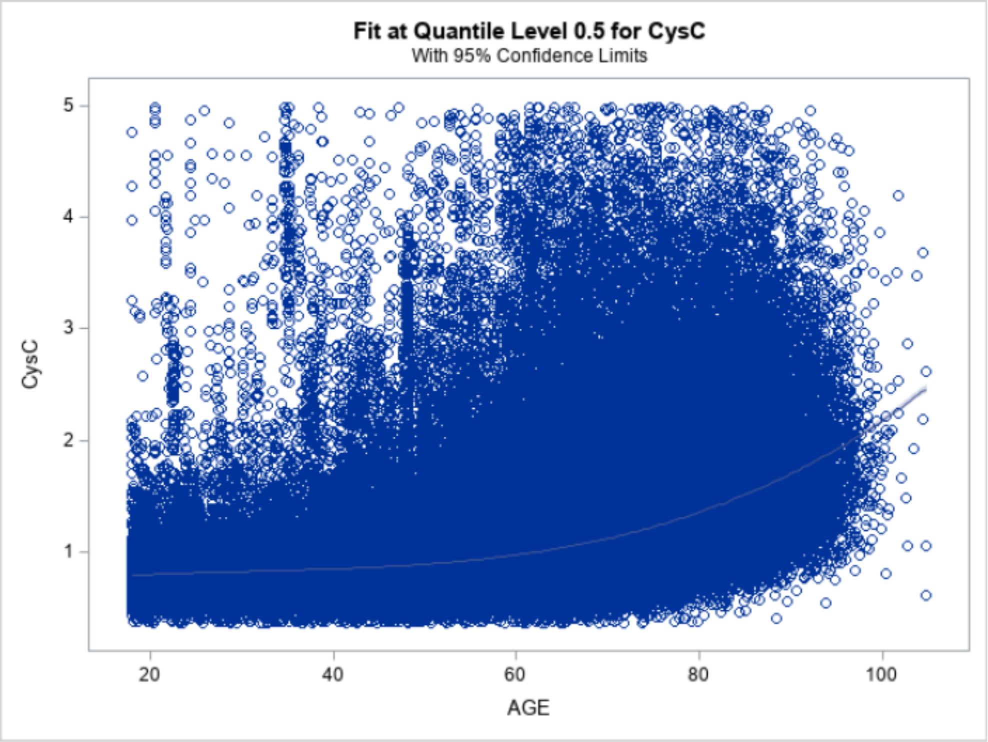


♀ Q' = 0.79 mg/L until 50 y,
Q' = 0.79 + 0.005 x (Age – 50)
♂ Q' = 0.86 mg/L until 50 y
Q' = 0.86 + 0.005 x (Age – 50)

Etape 2: cystatine C et genre

Données de laboratoire de Suède
N=227,643
♀ 95,469
♂ 132,174

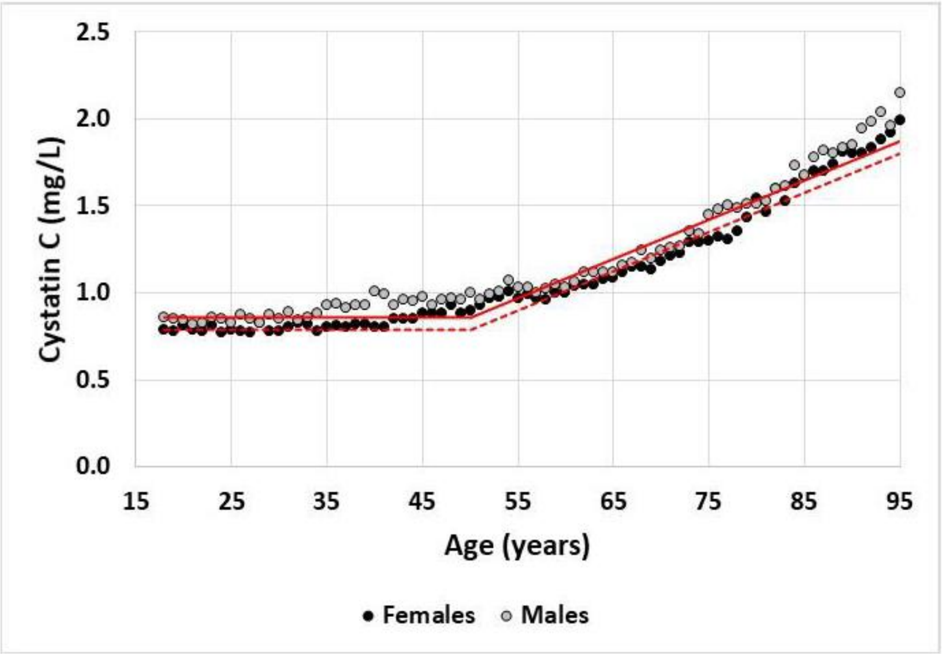
Figure S3. Cystatin C versus age and the median quantile line for the 227,643 included subjects.



♀ Q' = 0.79 mg/L until 50 y,
Q' = 0.79 + 0.005 x (Age – 50)
♂ Q' = 0.86 mg/L until 50 y
Q' = 0.86 + 0.005 x (Age – 50)

Etape 2: cystatine C et genre

Figure S4. Median plasma cystatin C in one-year intervals against age for men and women. A mathematical model to define Q'-values is proposed (red solid line): for adults Q' = 0.79 mg/L (women, dashed line) and 0.86 mg/L (men, solid line) until 50 years and a linear increasing model thereafter.



Q' = 0.83 mg/L until 50 years
Q' = 0.83 + 0.005 x (Age – 50)

Etape 3: Cystatine C et “race”

- Données du même centre français
- Méthodes pour mesurer le DFG (Cr-EDTA), la créatinine et la cystatine C identiques
- Populations noire et blanche

Table S3. Patient characteristics of the entire cohorts used for the matching analysis (mean ± SD)

Ethnicity/Sex	N	Age (years)	BMI (kg/m²)	mGFR (mL/min/1.73m²)	SCr (mg/dL)	CysC (mg/L)
White Men	1296 (57%)	53.0 ± 14.6	26.2 ± 4.9	61.8 ± 26.0	1.52 ± 0.73	1.52 ± 0.68
Black Men	436 (63%)	50.7 ± 13.1	26.3 ± 4.5	62.0 ± 22.1	1.73 ± 0.81	1.41 ± 0.61
White Women	966 (43%)	52.5 ± 15.2	25.8 ± 6.2	62.8 ± 26.8	1.16 ± 0.61	1.38 ± 0.73
Black Women	261 (37%)	51.9 ± 15.2	27.4 ± 5.8	59.1 ± 25.6	1.40 ± 0.79	1.46 ± 0.76

Etape 3: Cystatine C et “race”

Analyse matchée 1:1 pour

- genre
- IMC (±2,5 kg/m²)
- DFG mesuré (±3 mL/min/1.73m²)
- âge (± 3 y)

Table S4. Demographic and renal characteristics of the matched White and Black subjects (mean ± SD)

Sex	N	Age (years)	BMI (kg/m²)	mGFR (mL/min/1.73m²)	SCr (mg/dL)	CysC (mg/L)
White Men	377	51.1 ± 12.2	25.7 ± 3.4	63.8 ± 21.0	1.43 ± 0.62	1.41 ± 0.56
Black Men	377	50.8 ± 12.3	25.8 ± 3.5	63.6 ± 21.0	1.65 ± 0.64	1.37 ± 0.59
White Women	200	53.4 ± 11.9	26.1 ± 4.6	59.7 ± 23.2	1.16 ± 0.53	1.40 ± 0.69
Black Women	200	53.3 ± 11.9	26.2 ± 4.6	59.8 ± 23.1	1.33 ± 0.61	1.41 ± 0.64

Etape 4: Validation

$$\text{EKFC} - \text{eGFR} = 107.3/[\text{Biomarker}/Q]^{\alpha} \times [0.990^{(\text{Age}-40)} \text{ if age} > 40 \text{ years}],$$

with $\alpha = 0.322$ when biomarker/Q is less than 1 and $\alpha = 1.132$ when biomarker/Q is 1 or more.

Adultes
DFG mesuré, creatinine “IDMS traceable” et cystatine C calibrée
N=12,832

11 cohortes
White Europeans: n=7,727
White Europeans from Paris: n=2,646
White US: n=1,093
Black Europeans from Paris: n=858
Black Africans: n=508

Table 1. Performance of Single Biomarker (Serum Creatinine or Cystatin C)–Based Equations to Estimate the Glomerular Filtration Rate.*

Variable	Serum Creatinine–Based Equations		
	CKD-EPI eGFRcr(ASR)	CKD-EPI eGFRcr(AS)	EKFC eGFRcr
EKFC cohort, 7727 White patients			
Median bias (95% CI) — ml/min/1.73 m²†	3.96 (3.67 to 4.32)	7.40 (7.02 to 7.76)	0.58 (0.32 to 0.86)
IQR of estimated GFR− measured GFR— ml/min/1.73 m²‡	15.5 (−3.0 to 12.5)	16.3 (0.0 to 16.3)	14.5 (−6.5 to 8.0)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	14.8 (14.4 to 15.2)	16.3 (15.9 to 16.6)	13.1 (12.8 to 13.4)
P_{10} — % (95% CI)¶	40.3 (39.2 to 41.4)	34.7 (33.6 to 35.8)	43.3 (42.2 to 44.4)
P_{30} — % (95% CI)‖	81.6 (80.8 to 82.5)	75.7 (74.8 to 76.7)	85.8 (85.0 to 86.5)

7.40 (7.02 to 7.76)	0.58 (0.32 to 0.86)
16.3 (0.0 to 16.3)	14.5 (−6.5 to 8.0)
16.3 (15.9 to 16.6)	13.1 (12.8 to 13.4)
34.7 (33.6 to 35.8)	43.3 (42.2 to 44.4)
75.7 (74.8 to 76.7)	85.8 (85.0 to 86.5)

Table 1. Performance of Single Biomarker (Serum Creatinine or Cystatin C)–Based Equations to Estimate the Glomerular Filtration Rate.*

Variable	Cystatin C–Based Equations	
	CKD-EPI eGFRcys	EKFC eGFRcys without Sex
EKFC cohort, 7727 White patients		
Median bias (95% CI) — ml/min/1.73 m^2†	0.28 (−0.02 to 0.64)	0.00 (−0.37 to 0.27)
IQR of estimated GFR− measured GFR— ml/min/1.73 m^2‡	19.1 (−7.9 to 11.2)	14.4 (−7.9 to 6.5)
Root-mean-square error (95% CI) — ml/min/1.73 m^2¶	15.8 (15.5 to 16.1)	13.5 (12.9 to 14.1)
P_{10} — % (95% CI)¶	32.0 (31.0 to 33.0)	41.7 (40.6 to 42.8)
P_{30} — % (95% CI)‖	80.8 (79.9 to 81.7)	86.2 (85.4 to 87.0)

Cystatin C–Based Equations

CKD-EPI eGFRcys	EKFC eGFRcys without Sex
0.28 (−0.02 to 0.64)	0.00 (−0.37 to 0.27)
19.1 (−7.9 to 11.2)	14.4 (−7.9 to 6.5)
15.8 (15.5 to 16.1)	13.5 (12.9 to 14.1)
32.0 (31.0 to 33.0)	41.7 (40.6 to 42.8)
80.8 (79.9 to 81.7)	86.2 (85.4 to 87.0)

Table 1. Performance of Single Biomarker (Serum Creatinine or Cystatin C)–Based Equations to Estimate the Glomerular Filtration Rate.*

Variable	Serum Creatinine–Based Equations			Cystatin C–Based Equations	
	CKD-EPI eGFRcr(ASR)	CKD-EPI eGFRcr(AS)	EKFC eGFRcr	CKD-EPI eGFRcys	EKFC eGFRcys without Sex
EKFC cohort, 7727 White patients					
Median bias (95% CI) — ml/min/1.73 m²†	3.96 (3.67 to 4.32)	7.40 (7.02 to 7.76)	0.58 (0.32 to 0.86)	0.28 (−0.02 to 0.64)	0.00 (−0.37 to 0.27)
IQR of estimated GFR− measured GFR— ml/min/1.73 m²‡	15.5 (−3.0 to 12.5)	16.3 (0.0 to 16.3)	14.5 (−6.5 to 8.0)	19.1 (−7.9 to 11.2)	14.4 (−7.9 to 6.5)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	14.8 (14.4 to 15.2)	16.3 (15.9 to 16.6)	13.1 (12.8 to 13.4)	15.8 (15.5 to 16.1)	13.5 (12.9 to 14.1)
P_{10} — % (95% CI)¶	40.3 (39.2 to 41.4)	34.7 (33.6 to 35.8)	43.3 (42.2 to 44.4)	32.0 (31.0 to 33.0)	41.7 (40.6 to 42.8)
P_{30} — % (95% CI)‖	81.6 (80.8 to 82.5)	75.7 (74.8 to 76.7)	85.8 (85.0 to 86.5)	80.8 (79.9 to 81.7)	86.2 (85.4 to 87.0)

Table 2. Performance of Combined Serum Creatinine– and Cystatin C–Based Equations to Estimate GFR.*

Variable	CKD-EPI eGFRcr-cys(ASR)	CKD-EPI eGFRcr-cys(AS)	EKFC eGFRcr-cys without Sex
EKFC cohort, 7727 White patients			
Median bias (95% CI) — ml/min/1.73 m²†	2.50 (2.17 to 2.76)	5.04 (4.69 to 5.36)	0.37 (0.14 to 0.66)
IQR of estimated GFR – measured GFR — ml/min/1.73 m²‡	14.8 (−3.6 to 11.2)	16.7 (−1.8 to 14.9)	12.0 (−5.9 to 6.1)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	13.1 (12.8 to 13.4)	14.7 (14.4 to 15.0)	11.3 (11.0 to 11.6)
P_{10} — % (95% CI)¶	41.5 (40.4 to 42.6)	37.2 (36.2 to 38.3)	48.9 (47.8 to 50.0)
P_{30} — % (95% CI)‖	88.3 (87.6 to 89.0)	84.2 (83.4 to 85.0)	90.4 (89.8 to 91.1)
Paris cohort, 2646 White patients			
Median bias (95% CI) — ml/min/1.73 m²†	−1.35 (−1.82 to −0.97)	0.64 (0.16 to 1.15)	−0.65 (−1.06 to −0.23)
IQR of estimated GFR – measured GFR — ml/min/1.73 m²‡	13.4 (−7.5 to 5.8)	14.1 (−5.8 to 8.3)	12.4 (−6.8 to 5.6)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	12.1 (11.6 to 12.7)	12.6 (12.0 to 13.1)	11.8 (11.2 to 12.4)
P_{10} — % (95% CI)¶	43.9 (42.0 to 45.8)	42.3 (40.4 to 44.1)	45.8 (43.9 to 47.7)
P_{30} — % (95% CI)‖	89.7 (88.5 to 90.8)	89.2 (88.0 to 90.4)	92.1 (91.1 to 93.1)
U.S. cohort, 1093 White patients			
Median bias (95% CI) — ml/min/1.73 m²†	9.23 (8.45 to 10.10)	13.9 (13.1 to 14.9)	0.97 (0.01 to 2.12)
IQR of estimated GFR – measured GFR — ml/min/1.73 m²‡	18.4 (0.5 to 18.8)	18.1 (5.1 to 23.3)	17.4 (−8.2 to 9.2)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	18.1 (17.1 to 19.1)	21.0 (20.1 to 22.0)	15.5 (14.3 to 16.7)
P_{10} — % (95% CI)¶	37.1 (34.3 to 40.0)	28.1 (25.4 to 30.8)	45.7 (42.7 to 48.6)
P_{30} — % (95% CI)‖	79.5 (77.1 to 81.9)	72.1 (69.4 to 74.8)	88.7 (86.9 to 90.6)
Paris cohort, 858 Black patients			
Median bias (95% CI) — ml/min/1.73 m²†	−0.37 (−1.06 to 0.57)	−2.08 (−2.71 to −1.32)	−0.65 (−1.23 to 0.11)
IQR of estimated GFR – measured GFR — ml/min/1.73 m²‡	15.2 (−6.4 to 8.8)	14.0 (−7.9 to 6.1)	12.4 (−6.2 to 6.2)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	13.3 (11.9 to 14.6)	12.6 (11.2 to 13.9)	11.6 (10.0 to 13.0)
P_{10} — % (95% CI)¶	38.7 (35.4 to 42.0)	38.9 (35.7 to 42.2)	48.3 (44.9 to 51.6)
P_{30} — % (95% CI)‖	87.9 (85.7 to 90.1)	89.0 (87.0 to 91.1)	92.0 (90.1 to 93.8)
African cohort, 508 Black patients			
Median bias (95% CI) — ml/min/1.73 m²†	8.55 (6.87 to 10.30)	4.08 (2.37 to 5.78)	0.42 (−1.03 to 1.51)
IQR of estimated GFR – measured GFR — ml/min/1.73 m²‡	24.7 (−4.5 to 20.1)	22.0 (−7.4 to 14.7)	17.1 (−7.2 to 10.0)
Root-mean-square error (95% CI) — ml/min/1.73 m²§	19.7 (18.2 to 21.1)	17.2 (15.8 to 18.5)	14.7 (13.3 to 16.0)
P_{10} — % (95% CI)¶	28.7 (24.8 to 32.7)	34.3 (30.1 to 38.4)	43.5 (39.2 to 47.8)
P_{30} — % (95% CI)‖	75.0 (71.2 to 78.8)	77.6 (73.9 to 81.2)	84.3 (81.1 to 87.4)

Section S9. Performance statistics according to mGFR-level, sex and age subgroups

Table S9.1a. Comparison of Bias for mGFR < 60 mL/min/1.73m²

	Men			Women		
BIAS [95%CI]	age 18-40	age 40-65	age ≥ 65	age 18-40	age 40-65	age ≥ 65
N	223	1008	1556	184	741	1197
EKFC-eGFR$_{Cr}$	4.3 [2.2; 5.1]	2.5 [1.7; 3.2]	0.8 [0.4; 1.4]	4.3 [1.8; 6.6]	2.7 [1.9; 3.5]	0.6 [0.1; 1.3]
CKD-EPI-eGFR$_{Cr}$ (AS)	6.5 [4.3; 8.1]	3.4 [2.5; 4.4]	4.8 [4.3; 5.5]	6.6 [3.8; 8.8]	4.6 [3.5; 5.4]	5.5 [5.0; 6.3]
EKFC-eGFR$_{Cys}$ (S)	5.7 [4.3; 6.7]	1.1 [0.5; 1.6]	0.9 [0.5; 1.3]	4.0 [2.4; 5.5]	0.8 [0.1; 1.3]	0.3 [-0.3; 0.8]*
EKFC-eGFR$_{Cys}$	3.6 [2.6; 5.1]	-0.4 [-1.0; 0.2]*	-0.2 [-0.7; 0.2]*	6.5 [4.6; 7.8]	2.6 [2.1; 3.3]	2.0 [1.4; 2.4]
CKD-EPI-eGFR$_{Cys}$	-0.0 [-1.4; 1.3]*	-3.5 [-4.3; -2.9]	-2.8 [-3.3; -2.3]	-0.2 [-1.9; 1.4]*	-2.7 [-3.4; -2.1]	-2.6 [-3.1; -2.0]
EKFC-eGFR$_{Cr+Cys}$(S)	5.6 [4.1; 6.5]	2.1 [1.6; 2.7]	1.2 [0.8; 1.6]	5.0 [4.0; 6.2]	1.8 [1.2; 2.3]	0.5 [-0.1; 1.0]*
EKFC-eGFR$_{Cr+Cys}$	4.6 [3.4; 5.6]	1.4 [0.9; 2.0]	0.6 [0.3; 1.1]	6.1 [5.0; 7.8]	2.8 [2.2; 3.2]	1.3 [0.8; 1.8]
CKD-EPI-eGFR$_{Cr+Cys}$(AS)	1.7 [0.4; 2.6]	-0.7 [-1.3; 0.1]*	0.7 [0.4; 1.2]	2.0 [0.3; 4.1]	0.0 [-0.8; 0.8]*	0.8 [0.3; 1.3]

Table S9.1b. Comparison of Bias for mGFR ≥ 60 mL/min/1.73m²

	Men			Women		
BIAS [95%CI]	age 18-40	age 40-65	age ≥ 65	age 18-40	age 40-65	age ≥ 65
n	782	2452	858	640	2243	948
EKFC-eGFR$_{Cr}$	2.3 [0.6; 3.5]	-3.9 [-4.6; -3.4]	-5.0 [-6.0; -4.0]	3.1 [1.1; 4.5]	-0.0 [-0.8; 0.5]*	-3.7 [-4.5; -2.7]
CKD-EPI-eGFR$_{Cr}$ (AS)	8.8 [7.0; 10.4]	2.7 [2.0; 3.4]	6.0 [4.9; 7.4]	10.9 [9.0; 12.9]	7.5 [6.8; 8.3]	8.1 [7.2; 9.3]
EKFC-eGFR$_{Cys}$ (S)	3.2 [2.1; 4.5]	-1.9 [-2.5; -1.1]	-4.5 [-5.3; -3.4]	2.9 [1.5; 4.6]	0.7 [0.1; 1.5]	-4.5 [-5.5; -3.3]
EKFC-eGFR$_{Cys}$	0.2 [-1.0; 1.8]*	-3.8 [-4.3; -3.0]	-6.0 [-6.9; -5.2]	6.8 [5.4; 8.4]	3.4 [2.7; 4.1]	-2.0 [-3.2; -1.0]
CKD-EPI-eGFR$_{Cys}$	4.8 [3.0; 6.6]	5.2 [4.0; 6.2]	-0.1 [-2.0; 0.8]*	6.6 [5.0; 8.1]	8.1 [7.3; 9.0]	0.6 [-1.0; 2.2]*
EKFC-eGFR$_{Cr+Cys}$(S)	1.9 [1.0; 3.2]	-2.6 [-3.2; -2.0]	-4.5 [-5.6; -3.6]	3.6 [2.2; 4.7]	0.3 [-0.4; 0.8]*	-4.1 [-4.9; -3.5]
EKFC-eGFR$_{Cr+Cys}$	0.5 [-0.2; 1.8]*	-3.5 [-4.2; -3.0]	-5.5 [-6.4; -4.6]	5.1 [4.1; 6.6]	1.5 [0.9; 2.2]	-3.0 [-3.7; -2.3]
CKD-EPI-eGFR$_{Cr+Cys}$(AS)	7.0 [5.6; 8.0]	6.6 [5.7; 7.4]	5.3 [4.3; 6.6]	10.1 [8.8; 11.5]	11.8 [11.0; 12.5]	7.6 [6.5; 8.8]

EKFC-eGFR$_{Cys}$ (S) = Sex-dependent EKFC-eGFR$_{Cys}$-equation; CKD-EPI-eGFR$_{Cr}$ (AS) = race-independent CKD-EPI equation; EKFC-eGFR$_{Cr+Cys}$(S) = SCr/ sex-free CysC combined EKFC equation. As a rule of thumb, one may consider an absolute bias less than 5 mL/min/1.73m² as "clinically" non-significant.

* means unbiased.

Table S9.4a. P30-accuracy (% of subjects with eGFR within 30% of mGFR) for mGFR < 60 mL/min/1.73m²

P30 [95%CI]	Men			Women		
	age 18-40	age 40-65	age ≥ 65	age 18-40	age 40-65	age ≥ 65
N	223	1008	1556	184	741	1197
EKFC-eGFR$_{Cr}$	69.5 [63.4; 75.6]	70.6 [67.8; 73.5]	77.2 [75.1; 79.3]	65.2 [58.3; 72.2]	72.2 [69.0; 75.4]	76.4 [74.0; 78.8]
CKD-EPI-eGFR$_{Cr}$ (AS)	62.8 [56.4; 69.2]	66.4 [63.4; 69.3]	63.2 [60.8; 65.6]	56.5 [49.3; 63.8]	66.7 [63.3; 70.1]	62.4 [59.7; 65.2]
EKFC-eGFR$_{Cys}$ (S)	77.1 [71.6; 82.7]	80.3 [77.8; 82.7]	78.9 [76.8; 80.9]	69.0 [62.3; 75.8]	76.1 [73.0; 79.2]	76.7 [74.3; 79.1]
EKFC-eGFR$_{Cys}$	80.7 [75.5; 85.9]	81.9 [79.6; 84.3]	80.5 [78.5; 82.4]	65.2 [58.3; 72.2]	74.9 [71.8; 78.0]	75.5 [73.1; 78.0]
CKD-EPI-eGFR$_{Cys}$	80.7 [75.5; 85.9]	78.8 [76.2; 81.3]	77.3 [75.2; 79.4]	72.8 [66.3; 79.3]	74.0 [70.8; 77.1]	71.6 [69.0; 74.2]
EKFC-eGFR$_{Cr+Cys}$(S)	78.0 [72.6; 83.5]	81.2 [78.7; 83.6]	84.4 [82.6; 86.2]	74.5 [68.1; 80.8]	80.2 [77.3; 83.0]	82.7 [80.6; 84.9]
EKFC-eGFR$_{Cr+Cys}$	79.8 [74.5; 85.1]	82.5 [80.2; 84.9]	85.3 [83.5; 87.0]	70.1 [63.4; 76.8]	79.6 [76.7; 82.5]	81.5 [79.2; 83.7]
CKD-EPI-eGFR$_{Cr+Cys}$(AS)	85.2 [80.5; 89.9]	83.3 [81.0; 85.6]	81.0 [79.1; 83.0]	75.0 [68.7; 71.3]	79.9 [77.0; 82.8]	78.1 [75.8; 80.5]

Table S9.4b. P30-accuracy (% of subjects with eGFR within 30% of mGFR) for mGFR ≥ 60 mL/min/1.73m²

P30 [95%CI]	Men			Women		
	age 18-40	age 40-65	age ≥ 65	age 18-40	age 40-65	age ≥ 65
N	782	2452	858	640	2243	948
EKFC-eGFR$_{Cr}$	89.5 [87.4; 91.7]	93.3 [92.3; 94.3]	94.1 [92.5; 95.6]	89.2 [86.8; 91.6]	94.6 [93.7; 95.5]	95.0 [93.7; 96.4]
CKD-EPI-eGFR$_{Cr}$ (AS)	80.6 [77.8; 83.3]	89.4 [88.1; 90.6]	86.8 [84.6; 89.1]	79.8 [76.7; 83.0]	88.5 [87.2; 89.8]	84.8 [82.5; 87.1]
EKFC-eGFR$_{Cys}$ (S)	89.0 [86.8;91.2]	92.4 [91.3; 93.4]	91.3 [89.4; 93.2]	90.6 [88.4; 92.9]	92.5 [91.4; 93.6]	90.5 [88.6; 92.4]
EKFC-eGFR$_{Cys}$	91.0 [89.0; 93.1]	91.7 [90.6; 92.8]	90.2 [88.2; 92.2]	88.0 [85.4; 90.5]	91.9 [90.8; 93.1]	92.0 [90.3; 93.7]
CKD-EPI-eGFR$_{Cys}$	84.9 [82.4; 87.4]	83.5 [92.1; 85.0]	83.8 [81.3; 86.3]	85.2 [82.4; 87.9]	82.7 [81.1; 84.2]	81.9 [79.4; 84.3]
EKFC-eGFR$_{Cr+Cys}$(S)	94.5 [92.9; 96.1]	95.4 [94.6; 96.2]	95.8 [94.5; 97.1]	94.4 [92.6; 96.2]	97.0 [96.3; 97.7]	96.6 [95.5; 97.8]
EKFC-eGFR$_{Cr+Cys}$	94.8 [93.2; 96.3]	95.7 [94.9; 96.5]	95.5 [94.1; 96.9]	93.1 [91.2; 95.1]	96.3 [95.5; 97.1]	96.9 [85.8; 98.0]
CKD-EPI-eGFR$_{Cr+Cys}$(AS)	89.6 [87.5; 91.8]	88.9 [87.7; 90.2]	87.1 [84.8; 89.3]	87.0 [84.4; 89.6]	83.3 [81.8; 84.9]	84.7 [82.4; 87.0]

Cystatine C/EKFC

- Cystatine C permet une estimation du DFG sans la variable sexe/genre
- EKFC cystatine est la même équation que EKFC créatinine, seule la valeur de Q change
- Continuum entre les adolescents et les jeunes adultes
- Les équations EKFC sont meilleures que les équations CKD-EPI correspondantes => alternative valable en Europe, Afrique et USA
- Les équations combinant la cystatine C et la créatinine sont meilleures
- Standardisation de la cystatine C
- Coût de la cystatine C
- Comment interpréter les résultats discordants?

https://ekfccalculator.pages.dev/

KDIGO 2024 CLINICAL PRACTICE GUIDELINE FOR THE EVALUATION AND MANAGEMENT OF CHRONIC KIDNEY DISEASE

1.2.4 Selection of GFR estimating equations

Recommendation 1.2.4.1: We recommend using a validated GFR estimating equation to derive GFR from serum filtration markers (eGFR) rather than relying on the serum filtration markers alone (*1D*).

Practice Point 1.2.4.1: Use the same equation within geographical regions (as defined locally [e.g., continent, country, and region] and as large as possible). Within such regions, equations may differ for adults and children.

Practice Point 1.2.4.2: Use of race in the computation of eGFR should be avoided.

Special considerations

Pediatric considerations

Practice Point 1.2.4.3: Estimate GFR in children using validated equations that have been developed or validated in comparable populations.

Table 14 | Validated GFR estimating equations

Marker	Equation name and year	Age	Variables	Development populations
Creatinine	CKD-EPI 2009[238]	≥18; modification CKD-EPI 40 for pediatric available	Developed using A, S, R but reported not using the Black race coefficient, A, S, R (NB)	8254 Black and NB individuals from 10 studies in the United States and Europe[a]
	CKiD U25 2021[239]	1–25	A, S, height	928 children with CKD in the United States and Canada
	CKD-EPI 2021[147]	≥18	A, S	8254 Black and NB individuals from 10 studies in the United States and Europe[a]
	EKFC 2021[240]	2–100	A, S, European Black and NB specific Q-value; separate Q-values for Africa vs. Europe	mGFR vs. SCr (11,251 participants in 7 studies in Europe and 1 study from the United States) Normal GFR from 5482 participants in 12 studies of kidney donor candidates (100% Caucasian) European NB Q from 83,157 laboratory samples (age 2–40 years) in 3 European hospital clinical laboratories; European Black Q-value (N = 90 living kidney donors from Paris); African Black Q-value (N = 470 healthy individuals from République Démocratique de Congo); All Q-values developed in cohorts independent for EKFC development and validation
Cystatin C	CKD-EPI 2012[148]	≥18	A, S	5352 Black and NB individuals from 13 studies in the United States and Europe
	EKFC 2023[91]	18–100	A	mGFR vs. SCys (assumed to be the same as mGFR vs. SCr) Normal GFR (same as for the SCr equation) Q from laboratory samples from 227,643 (42% female) laboratory samples from Uppsala University Hospital, Sweden

Limitations des formules = créatinine

Populations spécifiques:
Les équations ne sont pas magiques!!
Gardons notre sens clinique!!

[redacted]

Cirrhose (Skluzacek PA, Am J Kidney Dis, 2003, 42, 1169)

USI (Delanaye P, BMC Nephrology, 2014, 15, 9)

Hospitalisés (Poggio ED, Am J Kidney Dis, 2005, 46, 242)

Greffés cœur (Delanaye P, Clin Transplant, 2006, 20, 596)

Greffés rein (Masson I, Transplantation, 2013, 95, 1211)

Obèse (Bouquegneau A, NDT, 2013, 28, iv122)

Ne pas sur-interpreter un DFG estimé…

Toutes les équations restent des estimations

OK au niveau populationnel

Manque de précision au niveau individuel

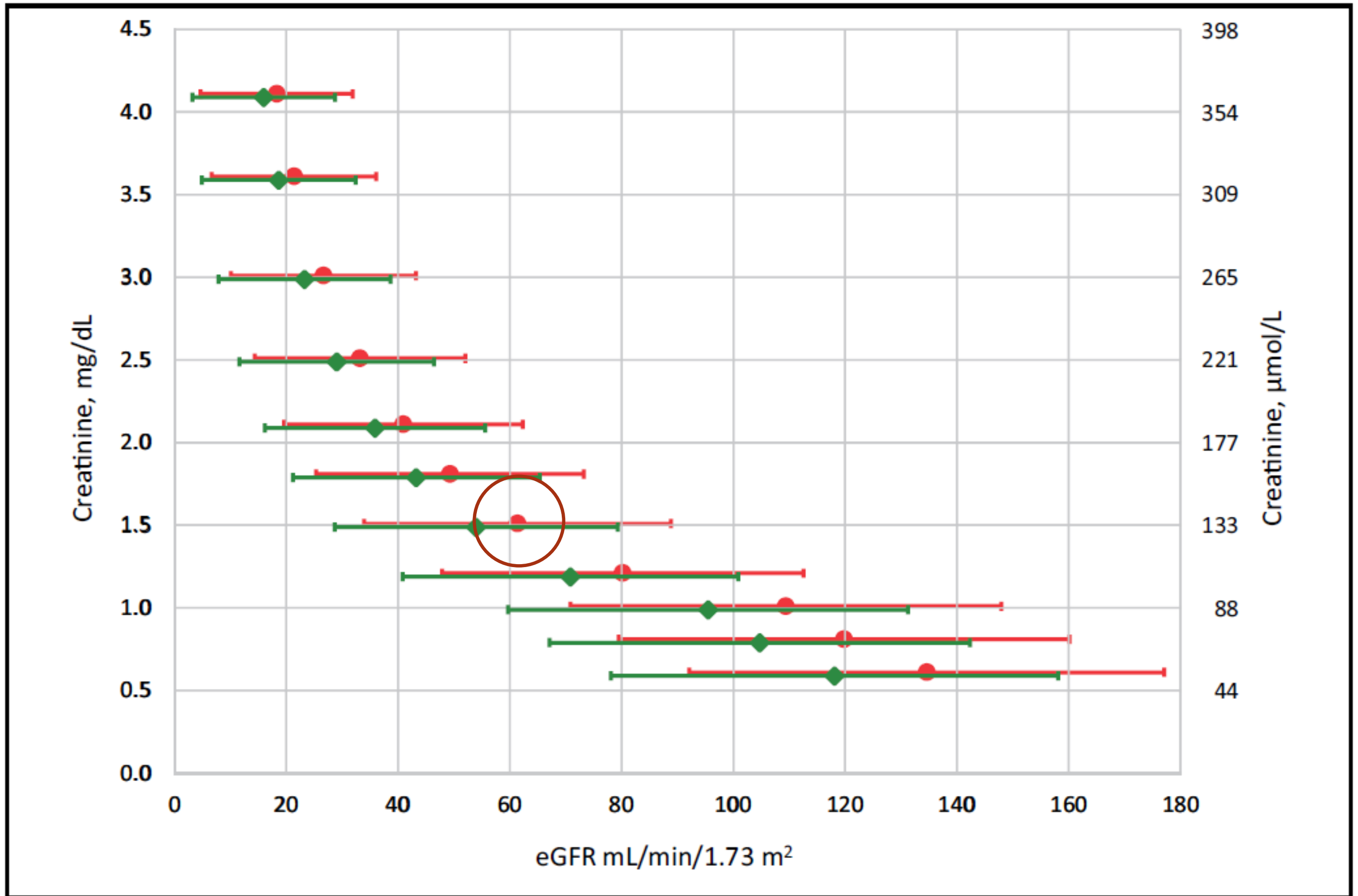


Fig. 1. Uncertainty of eGFR calculated using the CKD-EPI equations for African-Americans and non-African-Americans at various creatinine concentrations for a 50-year-old male. Circles (red, larger values) indicate African-American and diamonds (green, lower values) indicate non-African-American equations. Plot symbols are the eGFR values and error bars represent the 95% CI for each eGFR value.

DFGe = 60,25 ml/min/1.73m²

Miller WG, Clin Chem, 2021, p693 and p820

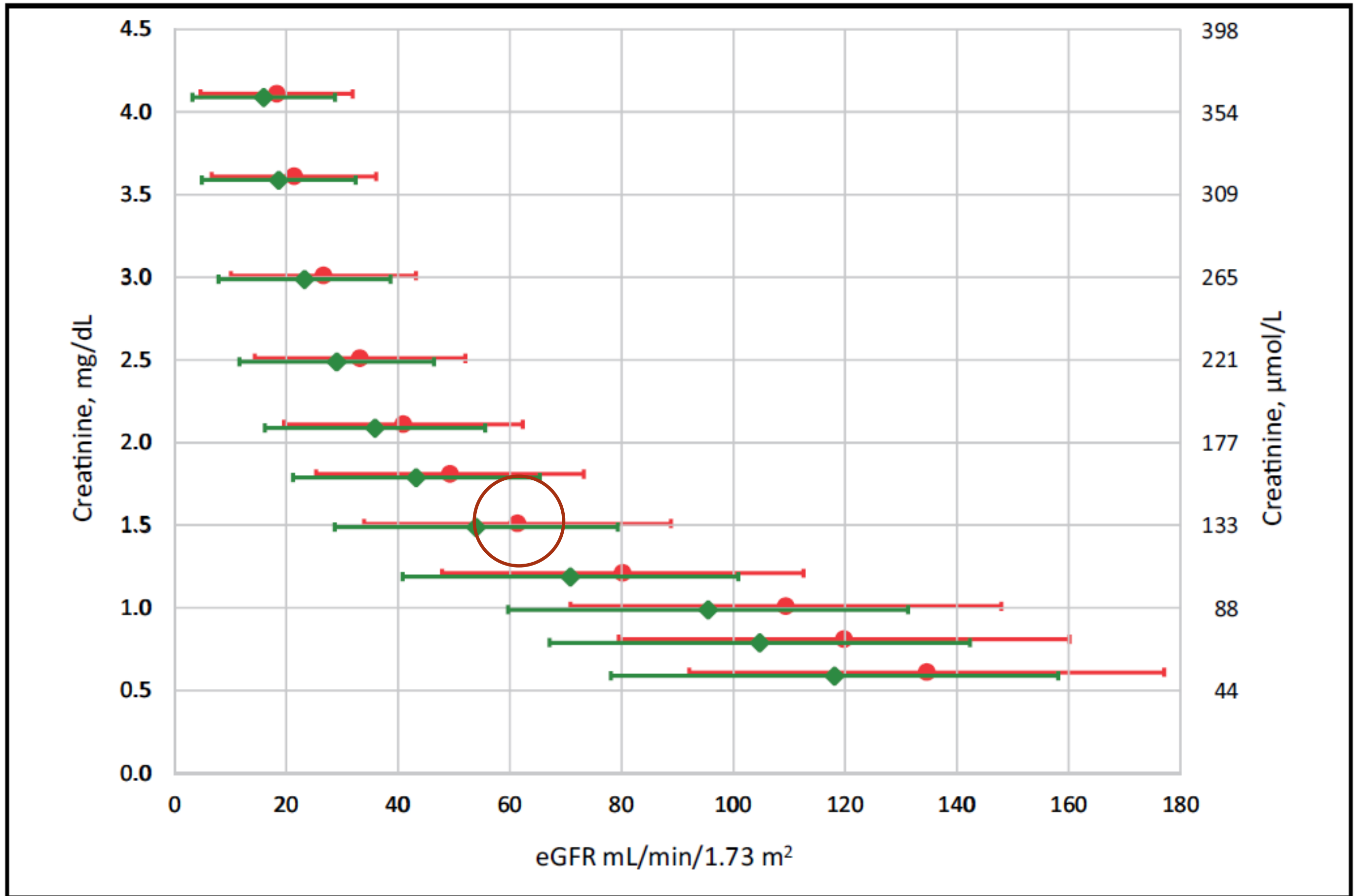


Fig. 1. Uncertainty of eGFR calculated using the CKD-EPI equations for African-Americans and non-African-Americans at various creatinine concentrations for a 50-year-old male. Circles (red, larger values) indicate African-American and diamonds (green, lower values) indicate non-African-American equations. Plot symbols are the eGFR values and error bars represent the 95% CI for each eGFR value.

DFGe = ~~60,25 ml/min/1.73m²~~

= 60 ml/min/1.73m² (CI 95%: 33-87)

Miller WG, Clin Chem, 2021, p693 and p820

REVIEWS

The applicability of eGFR equations to different populations

Pierre Delanaye and Christophe Mariat

RETOUR à une mesure du DFG

Delanaye P, Nature Rev Nephrol, 2013, 9, p513
Ebert N, Clin Kidney J, 2021, 14, p1861
Agarwal R, Nephrol Dial Transplant, 2019, 34, p2001
Shafi T, Ann Intern Med, 2022, 175, p1073

Retour au genre: Conclusions (essai)

- C'est pas si simple…
- DFGm il y a des différences, sont-elles cliniquement "relevantes"?
- Seule la précision du DFGm autorise de se poser la question
- Créatinine : oui, il y a des différences donc genre doit être intégrer dans la formule
- Cystatine C: oui, il y a des différences mais elles sont minimes et ne pas intégrer dans une formule aboutit à une perte négligeable de performance
- Parallèle intéressant avec le débat sur la « race » et le DFG aux USA avec des questions ou des implications sociétales voire philosophiques?
- Le premier regard est parfois trompeur…

Merci de votre attention

nature reviews nephrology
https://doi.org/10.1038/s41581-023-00784-z

Review article

Check for updates

Differences in the epidemiology, management and outcomes of kidney disease in men and women

Nicholas C. Chesnaye[1,2], Juan Jesus Carrero[3,4], Manfred Hecking[5,6] & Kitty J. Jager[1,2]

Abstract

Sections