Supplementary material

Zhang D, Fu L, Jiang S, et al. Relative superiority of the Lund–Malmö Revised equation for glomerular filtration rate estimation in patients with end-stage renal disease not on dialysis among 23 equations. Pol Arch Intern Med. 2022; 132: 16321. doi:10.20452/pamw.16321

Table S1. Equations for the estimation of glomerular filtration rates

Name	Glomerular filtration rate estimation equation
N=101	
$\text{CKD-EPI}_{\text{Scr}}$ [9]	For males with $Scr \leq 80$: $GFR = 141\frac{Scr}{0.9} - 0.411 \cdot 0.993^{age}$
	For males with $Scr > 80$: $GFR = 141\frac{Scr}{0.9} - 1.209 \cdot 0.993^{age}$
	For females with $Scr \leq 62$: $GFR = 141\frac{Scr}{0.7} - 0.329 \cdot 0.993^{age}$
	For females with $Scr > 62$: $GFR = 141\frac{Scr}{0.7} - 1.209 \cdot 0.993^{age}$
MDRDII [10]	For males: $GFR = 186Scr^{-1.154}age^{-0.203}$
	For females: $GFR = 186Scr^{-1.154}age^{-0.203} \cdot 0.742$
FAS_{Scr} [11]	For $2 \leq age \leq 40$: $GFR = \frac{107.3}{\frac{Scr}{Q}}$
	For $age > 40$: $GFR = 0.998^{age-40}\frac{107.3}{\frac{Scr}{Q}}$
EKFC [12]	For $2 \leq age \leq 40$ and $\frac{Scr}{Q} < 1$: $GFR = 107.3\left(\frac{scr}{Q}\right)^{-0.322}$
	For $2 \leq age \leq 40$ and $\frac{Scr}{Q} \geq 1$: $GFR = 107.3\left(\frac{scr}{Q}\right)^{-1.132}$
	For $age > 40$ and $\frac{Scr}{Q} < 1$: $GFR = 107.3\left(\frac{scr}{Q}\right)^{-0.322} 0.99^{age-40}$

	For $age > 40$ and $\frac{Scr}{Q} \geq 1$: $GFR = 107.3 \left(\frac{scr}{Q}\right)^{-1.132} 0.99^{age-40}$
LMR [13]	$GFR = e^{X-0.0158age+0.438\ln(age)}$
	For females with $Scr < 150$: $X = 2.5 + 0.0121\,(150 - Scr)$
	For females with $Scr \geq 150$: $X = 2.5 + 0.926\ln\left(\frac{Scr}{150}\right)$
	For males with $Scr < 180$: $X = 2.56 + 0.00968\,(180 - Scr)$
	For males with $Scr \geq 180$: $X = 2.5 + 0.926\ln\left(\frac{Scr}{150}\right)$
Mayo [14]	For males: $GFR = e^{1.911+\frac{5.249}{Scr}-\frac{2.114}{Scr^2}-0.00686\cdot age}$
	For females: $GFR = e^{1.911+\frac{5.249}{Scr}-\frac{2.114}{Scr^2}-0.00686\cdot age-0.205}$
	If $Scr < 0.8$: $Scr = 0.8$
XiangYa [15]	For males: $GFR = 2374.78Scr^{-0.54753}age^{-0.25011}$
	For females: $GFR = 2374.78Scr^{-0.54753}age^{-0.25011} \cdot 0.8526126$
XiangYa-s [16]	For males: $GFR = 627.2781Scr^{-0.38089}age^{-0.18724}$
	For females: $GFR = 627.2781Scr^{-0.38089}age^{-0.18724} \cdot 0.9286438$
Vilar [17]	$GFR = 160.3\frac{1}{\beta 2M} - 4.2$
Shafi$_{\beta 2M}$ [18]	For males: $GFR = 2852 \cdot \beta 2M - 2.417 \cdot 1.592$
	For females: $GFR = 2852 \cdot \beta 2M - 2.417$
N=81	
CKD-EPI$_{SCysC}$ [19]	For males: $GFR = 135min\left(\frac{Scr}{\kappa},1\right)^{a} max\left(\frac{Scr}{\kappa},1\right)^{-0.601} \cdot$ $min\left(\frac{CysC}{0.8},1\right)^{-0.375} max\left(\frac{CysC}{0.8},1\right)^{-0.711} 0.995age$
	For females: $GFR = 135min\left(\frac{Scr}{\kappa},1\right)^{a} max\left(\frac{Scr}{\kappa},1\right)^{-0.601} \cdot$ $min\left(\frac{CysC}{0.8},1\right)^{-0.375} max\left(\frac{CysC}{0.8},1\right)^{-0.711} 0.995age \cdot 0.969$

	where $\kappa = 0.9$ (for males) and $\kappa = 0.7$ (for females); $\alpha = -0.207$ (for males) and $\alpha = -0.248$ (for females)
FAS_{SCysC} [20]	For $2 \le age \le 40$: $GFR = \frac{107.3}{\frac{SCysC}{QSCysC}}$
	For $age > 40$: $GFR = 0.988^{age-40} \frac{107.3}{\frac{SCysC}{QSCysC}}$
CAPA [21]	$GFR = 130SCysC^{-1.069}age^{-0.117} - 7$
Hoek [22]	$GFR = -0.70 + 22\frac{1}{CysC}$
Yang [23]	$GFR = \frac{1}{4}(6.736 - 0.566 \times CysC)^2 + \frac{1}{4}(6.736 - 0.566 \times CysC)^{-2} - \frac{1}{2}$
$CKD\text{-}EPI_{Scr\text{-}ScysC}$ [19]	For non-black patients: $GFR = a\left(\frac{Scr}{b}\right)^c \left(\frac{SCysC}{0.8}\right)^d \cdot 0.995age$
	For black patients: $GFR = a\left(\frac{Scr}{b}\right)^c \left(\frac{SCysC}{0.8}\right)^d \cdot 0.995age \cdot 1.08$
	For females: $a = 130$, $b = 0.7$, $c = -0.248$, and $\frac{Scr \le 0.7}{-0.601}$ or $Scr > 0.7$
	For males: $a = 135$, $b = 0.9$, $c = -0.207$, and $\frac{Scr \le 0.9}{-0.601}$ or $Scr > 0.9$
	where $d = -0.375$ for $SCysC \le 0.8$ and $d = -0.711$ for $SCysC > 0.8$
$FAS_{Scr\text{-}SCysC}$ [20]	$GFR = \frac{107.3}{0.5\frac{Scr}{Q_{Scr}}} + 0.5\frac{CysC}{Q_{CysC}} 0.988^{age-40}$, when $age > 40$
	$GFR = \frac{107.3}{0.5\frac{Scr}{QScr}} + 0.5\frac{CysC}{QCysC}$, when $age \le 40$
	where $Q_{Scr} = 0.90$ for males and $Q_{Scr} = 0.70$ for females, $Q_{CysC} = 0.82$ for $age < 70$ and $Q_{CysC} = 0.95$ for $age \ge 70$
N=70	

Adachi [24]	$GFR = 17.0 - 6.1log10^4U\left(\frac{CysC}{Cr}\right)$
N=58	
Shafi$_{\beta TP}$ [18]	For males: $GFR = 95\beta TP - 2.16 \cdot 1.652$
	For females: $GFR = 95\beta TP - 2.16$
Shafi$_{\beta TP\text{-}\beta 2M}$ [18]	For males: $GFR = 673\beta TP - 1.406\beta 2M - 1.096 \cdot 1.670$
	For females: $GFR = 673\beta TP - 1.406\beta 2M - 1.096$
Wong [25]	$GFR = \frac{13.471}{\beta TP} + \frac{52.379}{\beta 2M} + \frac{782.909}{Scr} + 0.519(sex\ factor) - 3.939$, where the sex factor for male patients equals 1 and, for female patients, it equals 0
CKD-EPI_3M [26]	For males: $GFR = 120min\left(\frac{Scys}{0.8},1\right)^{-0.876} max\left(\frac{Scys}{0.8},1\right)^{-0.697} \cdot \beta 2M^{-0.205}min\left(\frac{S\beta TP}{0.6},1\right)^{0.038} max\left(\frac{S\beta TP}{0.6},1\right)^{-0.243} 0.999age$
	For females: $GFR = 120min\left(\frac{Scys}{0.8},1\right)^{-0.876} max\left(\frac{Scys}{0.8},1\right)^{-0.697} \cdot \beta 2M^{-0.205}min\left(\frac{S\beta TP}{0.6},1\right)^{0.038} max\left(\frac{S\beta TP}{0.6},1\right)^{-0.243} 0.922age$
CKD-EPI_4M [26]	For males: $GFR = 131min\left(\frac{Scr}{\kappa},1\right)^{a} max\left(\frac{Scr}{\kappa},1\right)^{-0.471} min\left(\frac{Scys}{0.8},1\right)^{-0.519} \cdot max\left(\frac{Scys}{0.8},1\right)^{-0.423} S\beta 2M^{-0.103}min\left(\frac{S\beta TP}{0.6},1\right)^{-0.004} \cdot max\left(\frac{S\beta TP}{0.6},1\right)^{-0.177} 0.996age$, where $\kappa = 0.9$ and $\alpha = -0.295$
	For females: $GFR = 131min\left(\frac{Scr}{\kappa},1\right)^{a} max\left(\frac{Scr}{\kappa},1\right)^{-0.471} min\left(\frac{Scys}{0.8},1\right)^{-0.519} \cdot max\left(\frac{Scys}{0.8},1\right)^{-0.423} S\beta 2M^{-0.103}min\left(\frac{S\beta TP}{0.6},1\right)^{-0.004} \cdot max\left(\frac{S\beta TP}{0.6},1\right)^{-0.177} 0.937age$, where $\kappa = 0.7$ and $\alpha = -0.243$

Abbreviations: CAPA, Caucasian and Asian Pediatric and Adult; CKD-EPI, Chronic Kidney Disease Epidemiology Collaboration; LMR, Lund–Malmö Revised; EKFC, European Kidney Function Consortium; FAS, Full Age Spectrum; MDRD, Modification of Diet in Renal Disease; Qcrea, Q value for serum creatinine; Qcys, Q value for serum cystatin C; Scr, serum creatinine; β2M, β2-microglobulin; βTP, β-trace protein; Ucr, urinary creatinine; UCysc, urinary cystatin C

Table S2. Bias, precision, accuracy and consistency of each estimated glomerular filtration rate equation

	Bias	Precision	Accuracy	Consistency
Projects	Median	IQR	P_{30}	width of 95%LOA
$CKD\text{-}EPI_{Scr}$	-2.30	4.15	51.50%	12.70
MDRDII	-1.80 [a]	4.05	54.50%	12.80
FAS_{Scr}	0.50 [a]	4.75	59.40%	13.80
EKFC	-1.50[a]	4.65	58.40%	13.10
LMR	-0.60[a]	4.30	65.30%	12.50
Mayo	-1.30[a]	4.55	64.30%	11.50
XiangYa	14.40[a]	5.45	0.00%	16.10
XiangYa-s	14.90[a]	3.60	0.00%	12.60
Vilar	-2.50	6.40	28.70%	31.20
$Shafi_{\beta 2M}$	-2.80	8.50	21.80%	115.30
$CKD\text{-}EPI_{SCysC}$	1.50[a]	5.00	58.00%	13.70

FAS_{SCysC}	7.10[a]	6.00	22.20%	15.70
CAPA	0.50[a]	5.10	55.60%	15.00
Hoek	-6.10[a]	4.80	12.30%	12.10
Yang	-6.70[a]	4.95	9.90%	12.10
$CKD\text{-}EPI_{Scr\text{-}SCysC}$	-1.50[a]	4.40	64.20%	11.80
$FAS_{Scr\text{-}SCysC}$	3.30[a]	4.30	49.40%	14.50
Adachi	2.20[a]	6.13	52.90%	15.30
$Shafi_{\beta TP}$	-4.45	19.40	8.60%	82.40
$Shafi_{\beta TP\text{-}\beta 2M}$	-3.45	10.78	20.70%	63.30
Wong	-4.65[a]	5.00	25.90%	16.30
CKD-EPI_3M	2.55[a]	5.25	44.80%	15.10
CKD-EPI_4M	-0.25[a]	5.05	60.30%	12.60

[a]$P<0.05$, (After performing multiple comparisons by the Benjamini-Hochberg method) compared with $CKD\text{-}EPI_{Scr}$. CAPA, Caucasian and Asian Pediatric and Adult; CKD-EPI, Chronic Kidney Disease Epidemiology Collaboration; LMR, Lund–Malmö Revised; EKFC, European Kidney Function Consortium; FAS, Full Age Spectrum; MDRD, Modification of Diet in Renal Disease. LOA: limits of agreement

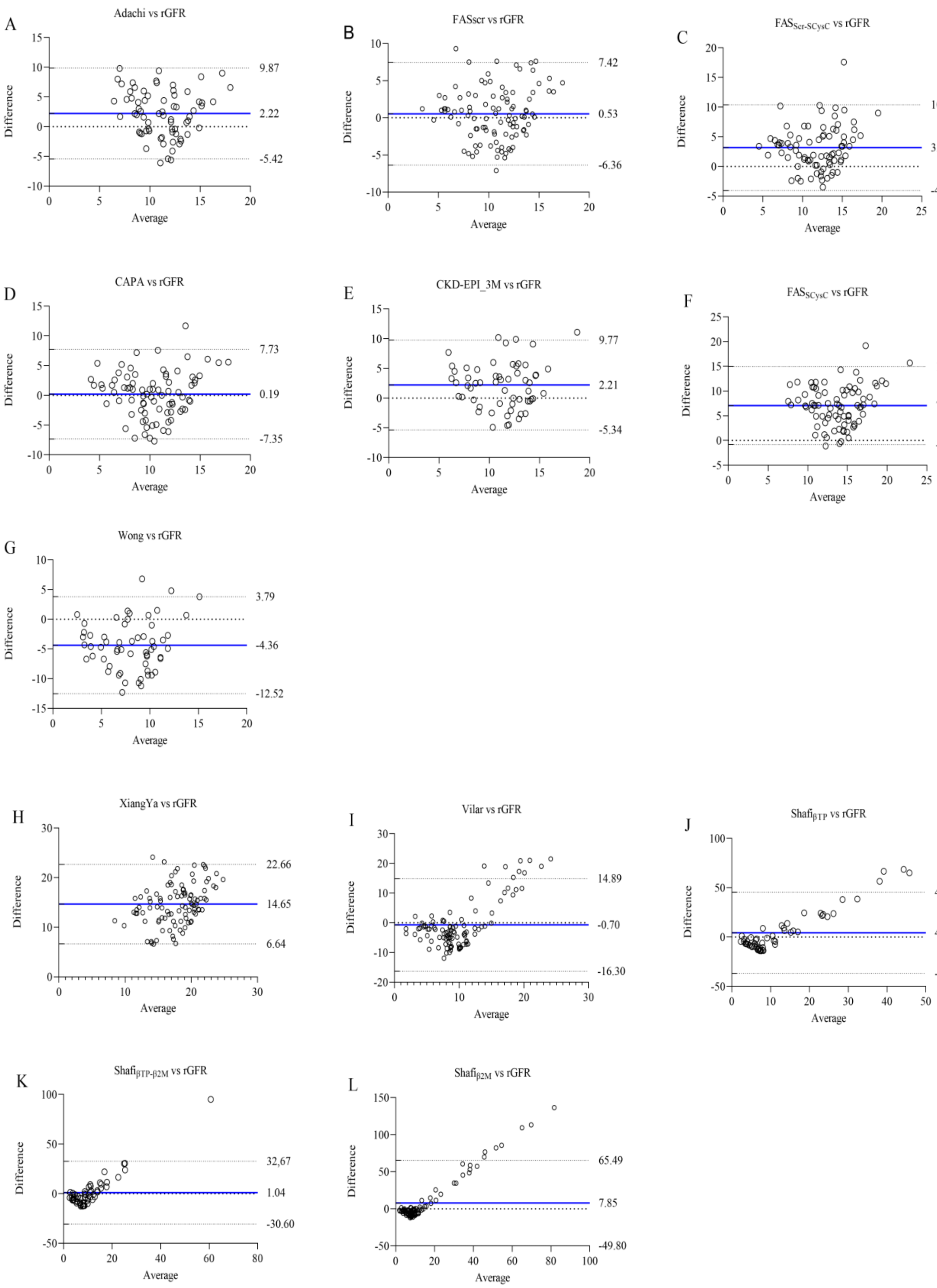

Figure S1. Bland–Altman plots of 12 equations. (A) Adachi; (B) FAS_{Scr}; (C) $FAS_{Scr\text{-}SCysC}$; (D) CAPA; (E) CKD-EPI_3M; (F) FAS_{SCysC}; (G) Wong; (H) XiangYa;

(I) Vilar; (J) Shafi$_{\beta TP}$; (K) Shafi$_{\beta TP-\beta 2M}$; (L) Shafi$_{\beta 2M}$. Solid lines represent the mean difference between two methods, and dotted lines denote the 95% limits of agreement. CAPA, Caucasian and Asian Pediatric and Adult; CKD-EPI, Chronic Kidney Disease Epidemiology Collaboration; FAS, Full Age Spectrum; rGFR, glomerular filtration rate measured by the revised Gates method;

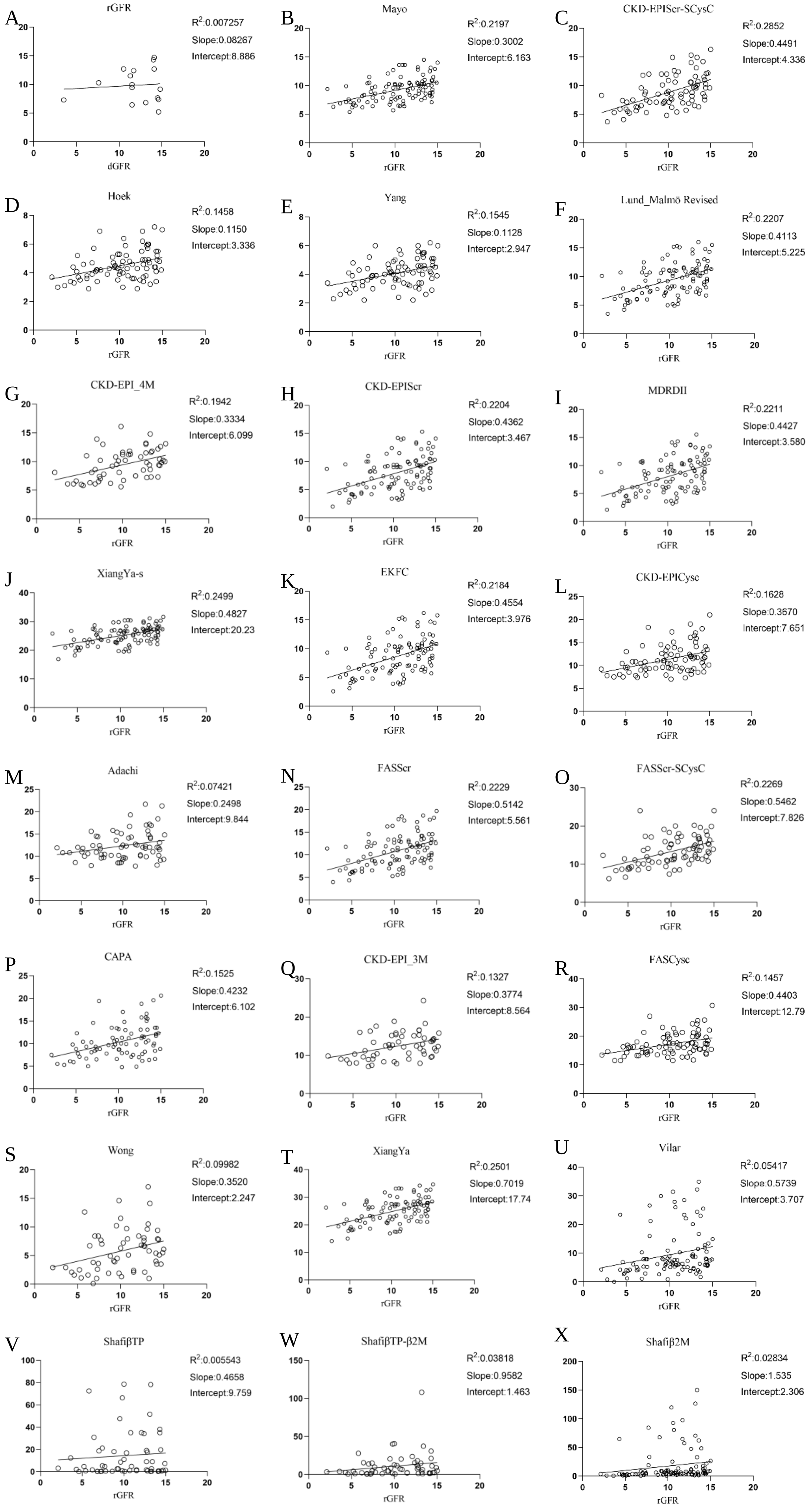
A rGFR
R2:0.007257
Slope:0.08267
Intercept:8.886
dGFR
B Mayo
R2:0.2197
Slope:0.3002
Intercept:6.163
rGFR
C CKD-EPIScr-SCysC
R2:0.2852
Slope:0.4491
Intercept:4.336
rGFR
D Hoek
R2:0.1458
Slope:0.1150
Intercept:3.336
rGFR
E Yang
R2:0.1545
Slope:0.1128
Intercept:2.947
rGFR
F Lund_Malmö Revised
R2:0.2207
Slope:0.4113
Intercept:5.225
rGFR
G CKD-EPI_4M
R2:0.1942
Slope:0.3334
Intercept:6.099
rGFR
H CKD-EPIScr
R2:0.2204
Slope:0.4362
Intercept:3.467
rGFR
I MDRDII
R2:0.2211
Slope:0.4427
Intercept:3.580
rGFR
J XiangYa-s
R2:0.2499
Slope:0.4827
Intercept:20.23
rGFR
K EKFC
R2:0.2184
Slope:0.4554
Intercept:3.976
rGFR
L CKD-EPICysc
R2:0.1628
Slope:0.3670
Intercept:7.651
rGFR
M Adachi
R2:0.07421
Slope:0.2498
Intercept:9.844
rGFR
N FASScr
R2:0.2229
Slope:0.5142
Intercept:5.561
rGFR
O FASScr-SCysC
R2:0.2269
Slope:0.5462
Intercept:7.826
rGFR
P CAPA
R2:0.1525
Slope:0.4232
Intercept:6.102
rGFR
Q CKD-EPI_3M
R2:0.1327
Slope:0.3774
Intercept:8.564
rGFR
R FASCysc
R2:0.1457
Slope:0.4403
Intercept:12.79
rGFR
S Wong
R2:0.09982
Slope:0.3520
Intercept:2.247
rGFR
T XiangYa
R2:0.2501
Slope:0.7019
Intercept:17.74
rGFR
U Vilar
R2:0.05417
Slope:0.5739
Intercept:3.707
rGFR
V ShafiβTP
R2:0.005543
Slope:0.4658
Intercept:9.759
rGFR
W ShafiβTP-β2M
R2:0.03818
Slope:0.9582
Intercept:1.463
rGFR
X Shafiβ2M
R2:0.02834
Slope:1.535
Intercept:2.306
rGFR

Figure S2. Direct scatter plots of measured glomerular filtration rate and 23 equations. (A) rGFR; (B) Mayo; (C) CKD-EPI$_{Scr-SCysC}$; (D) Hoek; (E) Yang; (F) Lund–Malmö Revised; (G) CKD-EPI_4M; (H) CKD-EPI$_{Scr}$; (I) MDRDII; (J) XiangYa-s; (K) EKFC; (L) CKD-EPI$_{SCysC}$; (M) Adachi; (N) FAS$_{Scr}$; (O) FAS$_{Scr-SCysC}$; (P) CAPA; (Q) CKD-EPI_3M; (R) FAS$_{SCysC}$; (S) Wong; (T) XiangYa; (U) Vilar; (V) Shafi$_{\beta TP}$; (W) Shafi$_{\beta TP-\beta 2M}$; (X) Shafi$_{\beta 2M}$. CKD-EPI, Chronic Kidney Disease Epidemiology Collaboration; EKFC, European Kidney Function Consortium; MDRD, Modification of Diet in Renal Disease; CAPA, Caucasian and Asian Pediatric and Adult; CKD-EPI, Chronic Kidney Disease Epidemiology Collaboration; FAS, Full Age Spectrum; dGFR, glomerular filtration rate measured by the dual plasma sampling method; rGFR, glomerular filtration rate measured by the revised Gates method;