Implementation of the 2021 CKD-EPI GFR equations
Version date: October 15, 2021

Please check back here for updated information and text as we develop more tools

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Background

Glomerular filtration rate (GFR) is most commonly estimated from serum creatinine using estimating equations. In 2021, the NKF-ASN Task Force on Reassessing the Inclusion of Race in Diagnosing Kidney Diseases concluded that race should not be included in GFR estimating equations, and recommended use of the 2021 CKD-EPI creatinine equation that includes factors for age and sex but not race group for immediate implementation by clinical laboratories. They also recommended more frequent measurement of cystatin C to confirm estimated GFR from creatinine when the clinical need requires, because combining creatinine and cystatin C gives a more accurate eGFR. The Task Force recommended the 2021 CKD-EPI creatinine-cystatin C equation as that does not include a term for race group.

Equations to be programmed into your laboratory information system

2021 CKD-EPI Creatinine equation

Expressed as a single equation

\[ eGFR = 142 \times \min\left(\frac{Scr}{\kappa}, 1\right)^{\alpha} \times \max\left(\frac{Scr}{\kappa}, 1\right)^{-1.209} \times 0.9938^{\text{Age}} \times 1.012 \] [if female]

Abbreviations/Units

- eGFR (estimated glomerular filtration rate) = mL/min/1.73 m²
- Scr (standardized serum creatinine) = mg/dL
- κ = 0.7 (females) or 0.9 (males)
- α = -0.241 (females) or -0.302 (males)
- min = indicates the minimum of Scr/κ or 1
- max = indicates the maximum of Scr/κ or 1
- Age = years

OR

CKD-EPI Equation for Estimating GFR on the Natural Scale Expressed for Specified Sex, Standardized Serum Creatinine and Standardized Serum Cystatin C (From New Eng J Med 2021)

<table>
<thead>
<tr>
<th>Sex</th>
<th>Serum Creatinine (mg/dL)</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>≤0.7</td>
<td>GFR= 142 x (Scr/0.7)^{-0.241} x 0.9938^{Age} x 1.012</td>
</tr>
<tr>
<td>Female</td>
<td>&gt;0.7</td>
<td>GFR= 142 x (Scr/0.7)^{-1.209} x 0.9938^{Age} x 1.012</td>
</tr>
<tr>
<td>Male</td>
<td>≤0.9</td>
<td>GFR= 142 x (Scr/0.9)^{-0.302} x 0.9938^{Age}</td>
</tr>
<tr>
<td>Male</td>
<td>&gt;0.9</td>
<td>GFR= 142 x (Scr/0.9)^{-1.209} x 0.9938^{Age}</td>
</tr>
</tbody>
</table>
2021 CKD-EPI Creatinine-cystatin C equation

Expressed as a single equation
\[
eGFR = 135 \times \min(\text{Scr}/\kappa,1)^{\alpha} \times \max(\text{Scr}/\kappa,1)^{-0.544} \times \min(\text{Scys}/0.8,1)^{-0.323} \times \max(\text{Scys}/0.8,1)^{-0.778} \times 0.9961^{\text{Age}} \times 0.963 \text{ [if female]}
\]

Abbreviations/Units
- eGFR (estimated glomerular filtration rate) = mL/min/1.73 m²
- SCr (standardized serum creatinine) = mg/dL
- Scys (standardized serum cystatin C) = mg/L
- \(\kappa\) = 0.7 (females) or 0.9 (males)
- \(\alpha\) = -0.219 (females) or -0.144 (males)
- \(\min\) = indicates the minimum of \(\text{Scr}/\kappa\) or 1
- \(\max\) = indicates the maximum of \(\text{Scr}/\kappa\) or 1
- age = years

OR

### CKD-EPI Equation for Estimating GFR on the Natural Scale Expressed for Specified Sex, Standardized Serum Creatinine and Standard Serum Cystatin C (From New Eng J Med 2021)

<table>
<thead>
<tr>
<th>Sex</th>
<th>Serum Creatinine (mg/dL)</th>
<th>Serum Cystatin C (mg/L)</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>≤0.7</td>
<td>≤0.8</td>
<td>(GFR= 135 \times (\text{Scr}/0.7)^{-0.219} \times (\text{Scys}/0.8)^{-0.323} \times 0.9961^{\text{Age}} \times 0.963)</td>
</tr>
<tr>
<td>Female</td>
<td>≤0.7</td>
<td>&gt;0.8</td>
<td>(GFR= 135 \times (\text{Scr}/0.7)^{-0.219} \times (\text{Scys}/0.8)^{-0.778} \times 0.9961^{\text{Age}} \times 0.963)</td>
</tr>
<tr>
<td>Female</td>
<td>&gt;0.7</td>
<td>≤0.8</td>
<td>(GFR= 135 \times (\text{Scr}/0.7)^{-0.544} \times (\text{Scys}/0.8)^{-0.323} \times 0.9961^{\text{Age}} \times 0.963)</td>
</tr>
<tr>
<td>Female</td>
<td>&gt;0.7</td>
<td>&gt;0.8</td>
<td>(GFR= 135 \times (\text{Scr}/0.7)^{-0.544} \times (\text{Scys}/0.8)^{-0.778} \times 0.9961^{\text{Age}} \times 0.963)</td>
</tr>
<tr>
<td>Male</td>
<td>≤0.9</td>
<td>≤0.8</td>
<td>(GFR= 135 \times (\text{Scr}/0.9)^{-0.144} \times (\text{Scys}/0.8)^{-0.323} \times 0.9961^{\text{Age}})</td>
</tr>
<tr>
<td>Male</td>
<td>≤0.9</td>
<td>&gt;0.8</td>
<td>(GFR= 135 \times (\text{Scr}/0.9)^{-0.144} \times (\text{Scys}/0.8)^{-0.778} \times 0.9961^{\text{Age}})</td>
</tr>
<tr>
<td>Male</td>
<td>&gt;0.9</td>
<td>≤0.8</td>
<td>(GFR= 135 \times (\text{Scr}/0.9)^{-0.544} \times (\text{Scys}/0.8)^{-0.323} \times 0.9961^{\text{Age}})</td>
</tr>
<tr>
<td>Male</td>
<td>&gt;0.9</td>
<td>&gt;0.8</td>
<td>(GFR= 135 \times (\text{Scr}/0.9)^{-0.544} \times (\text{Scys}/0.8)^{-0.778} \times 0.9961^{\text{Age}})</td>
</tr>
</tbody>
</table>

Equations in statistical code
Formulas in R and SAS

Prior equations
Formulas for 2009 and 2012 CKD-EPI equations
eGFR reporting by clinical laboratories

Please see the NKF website for tools for laboratories:

Laboratory Implementation of the NKF-ASN Task Force Reassessing the Inclusion of Race in Diagnosing Kidney Diseases | National Kidney Foundation

Key points to consider:

1. Use the CKD-EPI 2021 equations for all people 18 years of age and older. For people less than 18 years of age, the Bedside Schwartz equation is recommended for use Pediatric GFR Calculator | National Kidney Foundation.
2. Using the CKD-EPI 2021 equation, specific values throughout the GFR range can be reported. That is, numeric values above and below 60 should be reported.
3. Age can be computed as differences in date from date of birth, which would give more precision than if used as a whole number. However, if only age in whole years is available, that is acceptable.
4. Serum creatinine should be reported to 2 decimal places
5. Methods for assay of serum creatinine and cystatin C should be traceable to higher order references; IDMS reference measurement procedures for creatinine and the ERM-DA471/IFCC certified reference material for cystatin C.

Educational material for health care providers or laboratories

ASN-NKF Task Force Report
NKF GFR Calculator

How should differences in a patient’s eGFR be interpreted during the transition from the old to the new equations?

The rationale for the development of the 2021 CKD-EPI equations was to avoid need to specify race in our multiracial and diverse population. On average, for patients who previously identified as Black, eGFR using the 2021 equations will be lower than eGFR using the 2009 creatinine or 2012 creatinine – cystatin C equation. On average, for patients who previously identified as non-Black, eGFR using the 2021 equations will be higher than eGFR using the 2009 creatinine or 2012 creatinine-cystatin C equations. The magnitude of the difference will depend on age and sex (Table). These differences may impact a diagnosis of CKD, the CKD G stages, medication use and dosing, the need for interdisciplinary care and decisions about kidney replacement therapy planning and initiation. Given the uncertainty of the eGFR estimated by the equations, small differences in eGFR may not be clinically important. If there is uncertainty about clinical decision-making using the 2021 creatinine equations, it is recommended to measure serum cystatin C and use the 2012 cystatin C equation and the 2021 creatinine-cystatin C equation. For the 2021 creatinine-cystatin C equation, the difference in eGFR compared to the 2012 creatinine-cystatin C equation is smaller than the difference between the 2021 and 2009 creatinine equations. There is no difference using the 2012 cystatin C equation.
The table below provides comparison of eGFR values using the 2009 and 2012 CKD-EPI creatinine equations for select ages and creatinine values.

<table>
<thead>
<tr>
<th>Race groups</th>
<th>Age</th>
<th>Creatinine (mg/dl)</th>
<th>50 years</th>
<th>75 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.6</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Black</td>
<td>Male</td>
<td>2009 eGFRcr</td>
<td>135</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>2021 eGFRcr</td>
<td>117</td>
<td>92</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>18</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Female</td>
<td>2009 eGFRcr</td>
<td>123</td>
<td>76</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>2021 eGFRcr</td>
<td>109</td>
<td>69</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>14</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>NonBlack</td>
<td>Male</td>
<td>2009 eGFRcr</td>
<td>117</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>2021 eGFRcr</td>
<td>118</td>
<td>92</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>-1</td>
<td>-5</td>
<td>-3</td>
</tr>
<tr>
<td>Female</td>
<td>2009 eGFRcr</td>
<td>106</td>
<td>66</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>2021 eGFRcr</td>
<td>109</td>
<td>69</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>-3</td>
<td>-3</td>
<td>-2</td>
</tr>
</tbody>
</table>

Please check back for additional materials in development

**Educational material for patients**

*NKF newsletter to patients Sept 2021*

**Approach to GFR evaluation**

Click on any of these to learn more about our approach to GFR evaluation.

*Measurement and estimation of GFR for use in clinical practice: Core Curriculum, Inker and Titan AJKD 2021*

*Measured and estimated glomerular filtration rate: current status and future directions, Levey, Coresh and Tighiouart et al Nat Rev Nephrol 2020*

*KDIGO clinical practice guidelines on the evaluation and management of CKD*

*Tufts Medical Center’s Kidney Function Evaluation Center*