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Race-Based Adjustment in eGFR Algorithms: An Integrative Literature Review

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RACE-BASED ADJUSTMENT IN EGFR ALGORITHMS: AN INTEGRATIVE LITERATURE REVIEW

by

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ABSTRACT

Background: There is a 3-fold risk of developing end stage kidney disease in Non-Hispanic African Americans compared to Non-Hispanic White Americans (Centers for Disease Control and Prevention, 2017). Estimated glomerular filtration rate (eGFR), one of the fundamental algorithms for coordinating treatment for kidney disease which factors in age, race, gender, and levels of creatinine, may pose an issue in this vulnerable population. Currently African Americans receive a correction factor between 1.21 and 1.16 to their eGFR to adjusting the value higher, potentially impacting appropriate kidney disease classification, and delaying beneficial interventions (National Kidney Foundation, 2020).

Methods: A systematic literature search of four databases was completed. Eligibility criteria included 1) published in a peer reviewed journal, 2) English language, 3) the use of race correction in calculating eGFR, and 4) a quantitative study design. A total of 47 articles were screened with 17 selected for final review. The Johns-Hopkins Nursing Evidence - Based Practice evidence guide was then used to rate the strength and quality of the evidence.

Results: Early evidence of the unreliability of race based eGFR equations emerged in 2008, and the body of evidence continues to grow. Recent studies have found eGFR calculated with no race corrections correlate best with directly measured iothalmate GFR in black patients (Zelnick et al., 2021), and that a potential 1,066,026 Black Americans may be reclassified to a more severe stage of CKD (Bragg-Gresham et al., 2021). Use of the race correction in GFR equations has been poorly supported in studies conducted in Africa and Brazil. For those with HIV, an accurate eGFR is doubly important yet all eGFR equations have marked variability. Some medical

facilities have successfully updated to calculating eGFR without the racial coefficient (Shi et al., 2021).

Conclusion: Nurses should be aware of the implications of using race correction in eGFR equations, educate their patients on its use, and advocate for those near threshold targets to ensure equitable and timely access to appropriate kidney disease interventions.

DEDICATION

To my grandma, who fought for justice in the 1960's protesting segregation and continued to fight for what's right for the past 80 years. Thank you for instilling the same values in all your grandchildren.

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INTRODUCTION

The Black Lives Matter movement has inspired social and criminal justice reform nationwide against lingering discriminatory practices in America. It is long overdue that these reformations extend to healthcare, as researchers and healthcare workers have a duty to face and fix systemic racial inequalities in medicine. There are numerous examples of racial health disparities in the United States. The Coronavirus pandemic has made this glaringly evident, with people of color experiencing disproportionately higher rates of infection, morbidity, and mortality (Kullar et al., 2020). In the U.S., a country with one of the highest maternal mortality rates, non-Hispanic black women have a 3.2 times higher pregnancy-related mortality rate as compared to White women (Ahn et al., 2020; Petersen et al., 2019). Healthcare professionals have a moral responsibility to acknowledge and address these disparities in order to minimize them and promote equitable, quality outcomes for all patients.

In addition to these health disparities, the Center for Disease Control (CDC) (2017) reports that African Americans are 3 times more likely than Caucasians to develop end-stage kidney disease (ESKD), formerly called end-stage renal disease. The cause for this inequality is multifaceted and includes both biologic and social elements (Norton et al., 2016). Genetic screening has identified variations at the apolipoprotein L1 gene (*APOL1*) as a possible genetic component. The mechanism of action between the *APOL1* variant and kidney damage remains unclear. Some researchers report that this genetic variance may account for 70% of the racial disparity, while Umeukeje & Young (2019) feel that this statistic is premature. The presence of two *APOL1* high-risk variants alone does not cause kidney disease; it is likely that other genetic and environmental factors modify the expression of this gene to eventually cause kidney damage (Friedman & Pollak, 2011). Interestingly, the frequency of *APOL1* alleles is essentially

nonexistent in Ethiopia, thus Americans of Ethiopian descent are not expected to be at high risk for kidney disease, despite being categorized as African American (Friedman & Pollak, 2011). Other contributors to this disparity include social conditions such as culture and poverty, institutional context such as healthcare and legal systems, and individual risk factors such as tobacco and alcohol use (Umeukeje & Young, 2019). African Americans are also more likely to have hypertension and diabetes, two major biologic risk factors for developing kidney disease (CDC, 2017). Underlying social conditions play a big role in this disparity as African Americans are a disadvantaged group and face contributing issues such as decreased access to healthcare, psychosocial and socioeconomic disadvantages, and racial biases (Norton et al., 2016).

When analyzing racial disparities in kidney disease, it is important to look at the use of race-based algorithms in diagnosis and treatment (see Appendix A). Estimated glomerular filtration rate (eGFR) is a laboratory test commonly used to measure kidney function based on creatinine. Practitioners use this value for diagnosing kidney disease, staging the severity, and determining treatment options. A higher eGFR value indicates better kidney function. An eGFR considered 'normal' for an average healthy person is a value of 90 or higher. A value between 60 and 90 for longer than three months may indicate kidney damage, and a value below 60 for longer than 3 months indicates chronic kidney disease (CKD) (National Kidney Foundation [NKF], 2020). CKD may progress to ESKD, which will require dialysis or transplantation for treatment (CDC, 2020).

Since the mid 1920's creatinine has been used to quantify kidney function, however, obtaining direct measurements of creatine clearance remains burdensome. Creatinine equations and assays have been developed to estimate GFR. The Cockcroft-Gault equation was developed in the 1970's to estimate kidney function without a lengthy 24-hour urine collection and

introduced variables for weight and sex. Women received a correction factor of 15% that laid the groundwork for later race correction factors (Braun et al., 2021). A correction factor is a mathematical adjustment to a calculation to account for deviations in the sample or correct systematic error (Farrance & Frenkel, 2012). The Cockcroft-Gault formula is no longer recommended for clinical use as it gives inaccurate results, and overestimates kidney function by 10-20% (NKF, 2021). In the late 1990's the Modification of Diet in Renal Disease (MDRD) equation replaced the Cockcroft-Gault (Braun et al., 2021). The four variables the MDRD equationconsiders are age, sex, race, and diabetes (Florkowski et al., 2011). The developers of the equation found black race to be an independent predictor of kidney function, and suggested the difference was due to racial differences in muscle mass (Levey et al., 1999). However, only outdated research from 10-20 years prior on racial differences in muscle mass were cited in this study, and no mention of other factors such as socioeconomic class were considered. Additionally, the authors used a wide array of measurements of muscle mass and did not offer a definition of black or white (Braun et al., 2021). The MDRD equation ultimately derived a race correction of 1.21 for Black patients (Levey et al., 1999). Because the MDRD sampled only those with kidney disease, the equation has been found to be inaccurate at better levels of kidney function and near the CKD threshold of 60 1mL/min/1.73 m^2 (Stevens et al., 2011), still, more than 65% of North American laboratories continue to use this equation (Miller & Vassalotti 2020). In 2009 the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) was developed to account for the shortcomings of the MDRD and is recommended for clinical use today (NKF, 2021). The CKD-EPI equation reduced the race correction for Blacks from 1.21 to 1.16 and incorporates variables for age and gender (Florkowski et al., 2011). Race, in both the MDRD and CKD-EPI algorithm is divided into only two categories: African American or Non-

African American (NKF, 2020). Today, the justification for this correction factor remains as "higher average muscle mass and creatinine generation rate in African Americans" (NKF, 2020, p.6). Not only does this justification of increased muscle mass have roots in racism, this correlation has also been poorly supported in the literature (Braun et al., 2021).

The ramifications of incorrectly increasing eGFR in a population that disproportionately suffers from kidney disease are severe, potentially delaying earlier, disease appropriate therapies and pre-emptive transplantation. On the other hand, waiving the correction factor, if correct, has the potential to over treat patients, or give them medications at a level that is too high for their kidneys to filter (Hornum & Feldt-Rasmussen, 2017). The use of race has been called into question for other medical algorithms as well (Vyas et al., 2020). Sociologists argue that race is a social, and not a biological construct (Williams & Sternthal, 2010). African Americans are not a homogenous group; they have complex ancestry and diverse genetics (Norton et al., 2016). Grouping such solely as "African American" may be insufficient to describe a population (Friedman & Pollak, 2011). Some hospitals, such as Beth Israel Deaconess Medical Center, Mass General Brigham and the University of Washington, have abandoned the use of race correction factor in eGFR in light of research highlighting the problematic nature of this algorithm (Gaffney, 2020). Additional research is needed to investigate the validity of current practices and evaluate the quality of research behind the recommendations for and against the use of race in calculating eGFR.

PROBLEM

Racial health disparities persist around the world. A serious commitment amongst researchers and medical professionals to minimize these disparities and ensure equitable outcomes is warranted. One example of a racial health disparity is the 3-fold risk of developing end stage kidney disease in Non-Hispanic African Americans compared to Non-Hispanic White Americans (Centers for Disease Control and Prevention, 2017). Estimated glomerular filtration rate (eGFR), one of the fundamental algorithms for coordinating treatment for kidney disease which factors in age, race, gender, and levels of creatinine, may pose an issue in this vulnerable population. African Americans receive a correction factor between 1.21 and 1.16 to their eGFR based on creatinine levels, adjusting the value higher in a population that disproportionately suffers from end – stage kidney disease (ESKD) (NKF, 2020). The ongoing debate over the use of race in calculating eGFR warrants further examination to inform professional nursing practice, especially nephrology nursing practice, a specialty with no currently published literature addressing this issue. Ignoring this issue has the potential to delay appropriate treatment and transplantation in African American patients (Vyas et al., 2020).

PURPOSE

The purpose of this project is to systematically appraise the quality of research that argues for or against the use of the eGFR correction factor and integrate findings into a cohesive literature review. Despite growing conversations in the medical community, there is currently no published literature on this debate within the discipline of nursing. As the most trusted profession (Saad, 2020), nurses have a duty to be aware of health disparities and advocate for their patients. This literature review will educate nurses on the implications of incorporating race into estimating kidney function and how it may exacerbate racial kidney disease disparities. Additionally, this review may potentially spark conversations about other areas of nursing practice that are outdated or inadvertently perpetuate inequitable care.

METHODS

The literature review was conducted over 4 databases including PUBMED, CINAHL, JSTOR, and Cochrane Library. The following search terms were used to identify relevant articles:

- eGFR or 'estimated GFR' or 'glomerular filtration rate'
- AND African American or black American or black
- AND 'race coefficient' or 'race multiplier' or 'race correction'

After duplicates were removed from the results, each article was screened for eligibility by reviewing the abstract. Eligibility criteria include (1) published in a peer reviewed journal (2) English language (3) included use of the African American race correction in calculating eGFR and (4) quantitative research methods. Articles that met inclusion criteria received a full text review and appraisal. The articles selected for final review were appraised for the strength (Level I-V) and quality of evidence (A, B, C) using the Johns-Hopkins Nursing Evidence-Based Practice evidence level and quality guide (see Appendix B) (Dang & Dearholt, 2017). Seventeen articles were appraised and summarized in Appendix B

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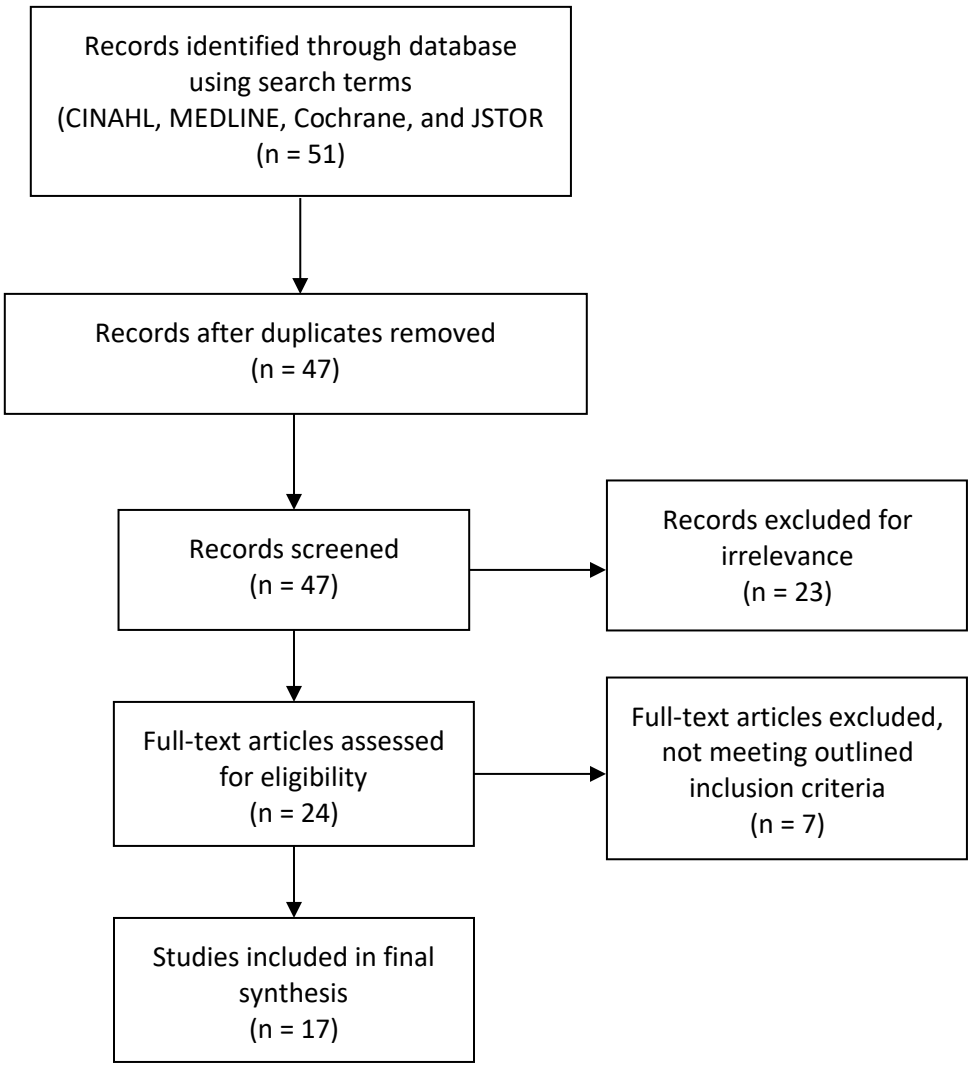
Figure 1: Selection Method of Literature



RESULTS

Of the 24 relevant articles, 17 met criteria for final synthesis. Selected studies all employed quantitative methods using a variety of designs, including validation studies, cross-sectional studies of existing de-identified data, retrospective studies, and prospective cohort studies. All were graded as evidence Level III per the Johns Hopkins Evidence-Based Nursing Model. Quality ratings ranged from A-C. The largest sample size was 786,718 and the smallest was 64. Countries involved in studies included USA, Brazil. Nigeria, Kenya, and Thailand. The earliest study was published in 2008 and the most recent was published in 2021.

DISCUSSION

While the argument against race based GFR has recently gained more traction (Gaffney, 2020), studies published as early as 2008 raised concerns about eGFR limitations and variability. In an early study conducted in the Department of Defense medical system, eGFR was calculated using the MDRD equation to explore the association between race and compliance with selected CKD quality outcome targets and determine if equitable care was achieved in a system without financial barriers. However, in this medical system a race correction factor was not automatically incorporated, and providers were reminded by a message box to manually multiply the result by a factor of 1.18. Provider adherence to this step was not assessed. While this study found that Black and White patients with CKD stage 3 and 4 met most compliance targets similarly, there was a potential confounding variable if providers were not uniformly applying the race correction to Black patients. This study demonstrated that equitable access to healthcare may overcome CKD disparities; it also presents an example of confounding research results when eGFR corrections are not applied in a standardized manner. Additionally, the authors bring up concerns about limitations of the MDRD acknowledging the complexity of race as a construct that frequently exceeds the boundaries of the dichotomous race category (Black; yes/no) used in the MDRD equation (Gao et al., 2008). Kramer et al. (2008) found that three eGFR equations - the MDRD, Cystatin-C with no gender or race correction, and Cystatin-C *with* gender and race correction all had significant variability when estimating CKD prevalence across racial and ethnic groups, especially in women, and suggested more research into the accuracy of eGFR equations was needed. Two years later Peralta et al. (2010) found that the MDRD and CKD-EPI equations with race corrections "may lead to a systematic misclassification of CKD in young blacks" (p. 3938), as Black men with a GFR above the CKD threshold still had a 2.5-fold higher

prevalence of CKD risk factors when compared to Whites, and thus were likely being misclassified as CKD free.

Evidence against eGFR race correction factors continued to emerge. An analysis of 1342 patients with CKD found no significant difference in the creatinine clearance to GFR ratio among different races or ethnicities (Lin et al., 2013). In an analysis of the CKD-EPI equation with and without race correction, CKD-EPI with the race correction overestimated iGFR by 3.1mL/min/1.73 m2 (95% CI, 2.2-3.9 mL/min/1.73 m2; P < .001), while omitting the race correction underestimated iGFR by a smaller magnitude. Additionally, for Black participants, the equation with the strongest correlation with iGFR was the CKD-EPI equation *without* race correction (r=0.75) (Zelnick et al., 2021). After investigating a proposed four level CKD-EPI equation (Black, Asian, Native American and Hispanic, and White) to replace the standard two-level variable (Black, White and other) race correction, Stevens et al. (2011) did not recommend the four-level equation, as it was more accurate in some, but not all populations. They found that the two-level CKD-EPI equation performed well for Blacks in the USA and Europe with a GFR < 90mL/min per 1.73m^2, but poorly in the South African cohort, where eGFR performance was best with no race correction at all. These findings were converse to the study by Omuse et al. (2017) who studied subjectively healthy Black Africans. In their comparison of several equations for estimating GFR, including full age spectrum, Cockroft-Gault, and CDK-EPI and MDRD with and without the race corrections, CDK-EPI *with* the race correction ultimately performed the best as it accurately classified 93.6% of its healthy participants in a GFR as stage 1 CKD. However, Omuse et al. (2017) had no direct GFR measurement for comparison nor were urine samples for hematuria or proteinuria collected.

Discourse and disagreement on the accuracy of eGFR equations has been found to be global problem amongst multiple ethnicities. In Brazil, two validation studies (Veronese et al., 2014; Zanocco et al., 2012) failed to show an improvement in accuracy with the use of race correction in the CKD-EPI equation, thus Barreto et al. (2016) did not use race correction in their estimation of prevalence and disparity in CKD in Brazil. Haas Pizarro et al. (2020) found that when recalculating eGFR using the CKD-EPI equation *with* race correction in patients with CKD and a genomic ancestry $\geq$ 50% African, 13 out of 23 patients were falsely reclassified to a normal renal function. In Asian countries, Japanese and Chinese race corrections for eGFR have also been derived for use in the MDRD equation. Praditpornsilpa et al. (2011) found the MDRD and CKD-EPI to have levels of disagreement at 9.6 mL/min per $1.73m^2$ and 8.0 mL/min per $1.73m^2$, respectively, and recommended validation of the MDRD equation in each specific ethnic population.

Accurate measurement of GFR in patients with Human Immunodeficiency Virus (HIV) is essential, as this group is vulnerable to CKD and ESKD due to medication dosages of antiretroviral therapy (ART)being dependent on kidney function. A study of 99 HIV-infected and ART naïve Kenyan adults found that the CKD-EPI performed the best compared to directly measured iGFR (R^2=23) and showed modest improvements in bias and accuracy with removal of race correction (85% of estimates within 30% of measured GFR) (Wyatt et al., 2013). To investigate this population in America, Anker et al. (2016) sampled 21,905 treatment naïve HIV-infected Black veterans through the Department of Veterans Affairs HIV Clinical Case Registry. They found that those reclassified to an eGFR <60 mL/min per $1.73m^2$ after calculating eGFR without race correction had a higher incidence of CKD risk factors, when compared to Whites.

This finding is likely indicative of a misclassification under the MDRD formula, similar to the findings of Peralta et al. (2010) in healthy Black Americans.

The ramifications of abandoning the race correction are immense. Bragg-Gresham et al. (2021) estimate that removing the race correction would reclassify an estimated 1,066,027 Black adults in the United States, to CKD stage 3 or more severe. A study using data from two large medical centers found that 33.4% of their sample of 2225 would hypothetically be reclassified to a more severe CKD stage if the race correction was removed. Importantly, this study also found that none of the patients reclassified to meet the kidney transplant threshold without the race correction were referred, evaluated, or waitlisted for transplant (Ahmed et al., 2021). This coincides with a study by Zelnick et al. (2020), who found a use of eGFR *with* race correction factors was associated with a 35% (95% CI, 29%-41%) higher risk of achieving an eGFR less than 20 mL/min/1.73 m2 and a potential transplant delay of 1.9 years in their sample of 1658 Black patients. Lastly, drug dosages are impacted by estimates of renal function. Two pharmacists found that CKD-EPI without race correction was less biased and more precise than CKD-EPI with race correction (median difference 4.3 [IQR = 9.8] mL/min vs 15.1 [IQR= 19.7] mL/min; $P < 0.0001$). CKD-EPI without race correction also had a higher level of agreement with dosing by creatinine clearance (CrCl; $\kappa = 0.779$) and was the authors ultimate recommendation when guiding drug dosing by creatinine clearance (Miller & Knorr, 2021).

Successful steps have been taken to remove race correction from GFR calculations in the U.S. The University of Washington Medicine System moved from MDRD to CKD-EPI with no race correction on May 29th, 2020 (Hong, 2020; Shi et al., 2021). Before the switch, it was the providers choice whether to include a race correction. Shi et al. (2021) studied the impact of the change at the University of Washington Medical Center and found that the change in use from

the MDRD to CKD-EPI with no race correction resulted in 3.5% of all patients reclassified to a worse kidney function (N=241,760). They also found fewer patients overall with an eGFR <60 mL/min per 1.73m^2, demonstrating that the switch did not cause an overwhelming increase in nephrology referrals.

LIMITATIONS

The principal limitation in this review was the use of variable methods to validate eGFR equations. While some studies compared to direct measure of GFR such as iothalamate clearance (iGFR) (Zelnick et al., 2021; Wyatt et al., 2013), others created their own model (Anker et al., 2016; Peralta et al., 2010), used other measurements such as urine microalbumin (Barreto et al., 2016; Lin et al., 2013), GFR mean (Stevens et al., 2011) or had no direct measure for comparison (Abefe et al., 2009; Bragg-Gresham et al., 2021; Haas Pizarro et al., 2020; Kramer et al., 2008; Omuse et al., 2017) The second limitation was the complexity of statistical analyses performed in each of the studies. As a novice researcher, the depth of the review was based on the author's understanding of the literature.

CONCLUSION

Substantial evidence against the need for race correction of eGFR equations continues to emerge in the literature. Some facilities in the U.S. have already started to move away from race - based MDRD and CKD-EPI equations (Gaffney, 2020; Shi et al., 2021). Both early and recent research has identified inaccuracies in eGFR equations. Additionally, the race correction has been poorly validated for accuracy in other countries, including Brazil (Barreto et al., 2016; Haas Pizarro et al., 2020) and South Africa (Stevens et al., 2011). For patients with HIV, accurate classification of kidney function is key to dosing of medications necessary for their survival, yet Blacks with HIV are likely overestimated in their kidney function (Anker et al., 2016; Wyatt et al., 2013). To guide drug dosages, CKD-EPI without race correction performed the best (Miller & Knorr, 2021).

In addition to the quantitative research, sociologic arguments have emerged. Braun et al. (2021) found that in a literature review of research on GFR comparisons between Black and White persons with CKD, the majority (28 out of 38) offer no explanation for the racial difference demonstrating that muscle mass as an innate difference has become a "fact" with no need for explicit restating. Eneanya et al. (2019) explained that using race for clinical decision making "is justified only if (1) the use confers substantial benefit; (2) the benefit cannot be achieved through other feasible approaches; (3) patients who reject race categorization are accommodated fairly; and (4) the use of race is transparent" (p. 114). In response to these criteria, Levey et al. (2020) propose continuation of the use of race correction with full disclosure to patients, and mindful use of Cystatin-C as a confirmatory test.

The implications of these findings for professional nursing practice warrant education and advocacy. An understanding of culture, socioeconomic factors, and the consequences of

treating racial groups as a homogenous population is paramount to combatting disparities (Pearson, 2008). Nephrology nurses especially should be aware of the racial disparities in CKD and how current eGFR race corrections may exacerbate them. Black patients with poor kidney function and patients with HIV are especially vulnerable populations for overestimating kidney function. Nephrology nurses should take notice of patients who are near thresholds such as below 60 mL/min per $1.73m^2$ for diagnosis of CKD or near 20 mL/min per $1.73m^2$ for transplant qualification, and advocate for other confirmatory diagnostic tests. Nurses may also wish to inform patients if the correction is being used and educate them on its purpose and implications to increase transparency and meet the criteria proposed by Eneanya et al. (2019). Lastly, depending upon the eGFR equation being used, there is potential for under or overestimating drug dosages; nurses should vigilant to monitor for adverse effects from medication.

More research on this topic is warranted as the methods used to validate and compare eGFR equations varied across studies. In addition, confirmatory studies on drug dosages, using consistent measures of GFR for comparison and conducted in a variety of populations are needed. The National Kidney Foundation – American Society of Nephrology task force is actively working to determine and approach to address this issue and construct recommendations on how to proceed and to standardize care (Delgado et al., 2021).

APPENDIX A: EGFR EQUATIONS

eGFR Equations

Cockcroft-Gault:

C_{Cr}={((l 40–age) x weight)/(72xS_{Cr})}x 0.85 (if female)

4 Variable MDRD:

186 x [Plasma Creatinine (µmol/L) x 0.0011312] -1.154 x [age (years)] -0.203 x [0.742 if female] x [1.212 if black]

CKD-EPI eGFR:

Female with Creatinine < 62 µmol/L; use eGFR = 144 x (Cr/61.6)-0.329 x (0.993)Age

Female with Creatinine > 62 µmol/L; use eGFR = 144 x (Cr/61.6)-1.209 x (0.993)Age

Male with Creatinine < 80 µmol/L; use eGFR = 141 x (Cr/79.2)-0.411 x (0.993)Age

Male with Creatinine > 80 µmol/L; use eGFR = 141 x (Cr/79.2)-1.209 x (0.993)Age

where Cr is the plasma creatinine (µmol/L) and C_{Cr} is the creatinine clearance (mL/minute)

(Florkowski et al., 2011; NKF, 2021)

APPENDIX B: JOHN HOPKINS NURSING EVIDENCE-BASED RESEARCH EVIDENCE APPRAISAL

Evidence and Quality Rating adapted from Dang & Dearholt (2017)

Evidence Levels	Quality Ratings
Level I Experimental study, randomized controlled trial (RCT) Explanatory mixed method design that includes only a level I quaNtitative study Systematic review of RCTs, with or without meta- analysis **Level II** Quasi-experimental study Explanatory mixed method design that includes only a level II quaNtitative study Systematic review of a combination of RCTs and quasi-experimental studies, or quasi- experimental studies only, with or without meta-analysis **Level III** Nonexperimental study Systematic review of a combination of RCTs, quasi-experimental and nonexperimental studies, or nonexperimental studies only, with or without meta-analysis Exploratory, convergent, or multiphasic mixed methods studies Explanatory mixed method design that includes only a level III quaNtitative study QuaLitative study Meta-synthesis	**QuaNtitative Studies** **A High quality**: Consistent, generalizable results; sufficient sample size for the study design; adequate control; definitive conclusions; consistent recommendations based on comprehensive literature review that includes thorough reference to scientific evidence. **B Good quality**: Reasonably consistent results; sufficient sample size for the study design; some control, fairly definitive conclusions; reasonably consistent recommendations based on fairly comprehensive literature review that includes some reference to scientific evidence. **C Low quality or major flaws**: Little evidence with inconsistent results; insufficient sample size for the study design; conclusions cannot be drawn. **QuaLitative Studies** No commonly agreed-on principles exist for judging the quality of quaLitative studies. It is a subjective process based on the extent to which study data contributes to synthesis and how much information is known about the researchers' efforts to meet the appraisal criteria. *For meta-synthesis, there is preliminary agreement that quality assessments of individual studies should be made before synthesis to screen out poor-quality studies*[1]. **A/B High/Good quality** is used for single studies and meta-syntheses[2]. The report discusses efforts to enhance or evaluate the quality of the data and the overall inquiry in sufficient detail; and it describes the specific techniques used to enhance the quality of the inquiry. Evidence of some or all of the following is found in the report: • Transparency: Describes how information was documented to justify decisions, how data were reviewed by others, and how themes and categories were formulated. • Diligence: Reads and rereads data to check interpretations; seeks opportunity to find multiple sources to corroborate evidence. • Verification: The process of checking, confirming, and ensuring methodologic coherence. • Self-reflection and scrutiny: Being continuously aware of how a researcher's experiences, background, or prejudices might shape and bias analysis and interpretations. • Participant-driven inquiry: Participants shape the scope and breadth of questions; analysis and interpretation give voice to those who participated. • Insightful interpretation: Data and knowledge are linked in meaningful ways to relevant literature. **C Low quality** studies contribute little to the overall review of findings and have few, if any, of the features listed for high/good quality.

Evidence Levels	Quality Ratings
Level IV Opinion of respected authorities and/or nationally recognized expert committees or consensus panels based on scientific evidence Includes: • Clinical practice guidelines • Consensus panels/position statements	**A** **High quality:** Material officially sponsored by a professional, public, or private organization or a government agency; documentation of a systematic literature search strategy; consistent results with sufficient numbers of well-designed studies; criteria-based evaluation of overall scientific strength and quality of included studies and definitive conclusions; national expertise clearly evident; developed or revised within the past five years **B** **Good quality:** Material officially sponsored by a professional, public, or private organization or a government agency; reasonably thorough and appropriate systematic literature search strategy; reasonably consistent results, sufficient numbers of well-designed studies; evaluation of strengths and limitations of included studies with fairly definitive conclusions; national expertise clearly evident; developed or revised within the past five years **C** **Low quality or major flaws:** Material not sponsored by an official organization or agency; undefined, poorly defined, or limited literature search strategy; no evaluation of strengths and limitations of included studies, insufficient evidence with inconsistent results, conclusions cannot be drawn; not revised within the past five years
Level V Based on experiential and nonresearch evidence Includes: • Integrative reviews • Literature reviews • Quality improvement, program, or financial evaluation • Case reports • Opinion of nationally recognized expert(s) based on experiential evidence	**Organizational Experience (quality improvement, program or financial evaluation)** **A** **High quality**: Clear aims and objectives; consistent results across multiple settings; formal quality improvement, financial, or program evaluation methods used; definitive conclusions; consistent recommendations with thorough reference to scientific evidence **B** **Good quality**: Clear aims and objectives; consistent results in a single setting; formal quality improvement, financial, or program evaluation methods used; reasonably consistent recommendations with some reference to scientific evidence **C** **Low quality or major flaws**: Unclear or missing aims and objectives; inconsistent results; poorly defined quality improvement, financial, or program evaluation methods; recommendations cannot be made **Integrative Review, Literature Review, Expert Opinion, Case Report, Community Standard, Clinician Experience, Consumer Preference** **A** **High quality**: Expertise is clearly evident; draws definitive conclusions; provides scientific rationale; thought leader(s) in the field **B** **Good quality**: Expertise appears to be credible; draws fairly definitive conclusions; provides logical argument for opinions **C** **Low quality or major flaws**: Expertise is not discernable or is dubious; conclusions cannot be drawn

APPENDIX C: TABLE OF EVIDENCE

Summary Table of Research Literature on eGFR Race Correction

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Abefe et al. (2009)	Secondary analysis of a previous quantitative study	32 healthy Nigerians and 34 Nigerian patients with CKD; serum creatinine consistently above 177 [micro]mol/L, passing at least 500 ml of urine/24hrs. and not previously dialyzed.	To examine the usefulness of 6 eGFR formulas in an African population to measured creatinine clearance	Cockroft-Gault MDRD Jeliffe Mawer Hull Gates	All predictive formulas correlated significantly with creatinine clearance in CKD subjects and controls. Cockroft-Gault outperformed MDRD and had the least variance (6.3% vs. 16.3%) and highest accuracy (49.3% vs 9.9%) Cockroft-Gault had the highest r^2 of 0.94	Cockroft-Gault may be best for homogenous African Black populations	Level: III Quality: B
Ahmed et al., (2021)	Cross-sectional study	N = 2225 self-reported African Americans Two large academic medical centers and affiliated community primary care and specialty practices.	To examine the impact of the race multiplier for African Americans in the CKD-EPI eGFR equation on CKD classification and care delivery.	CKD-EPI with / without race correction	743 of 2225 African American patients would be reclassified to a more severe CKD stage with no race correction 64 of 2069 African American patients would be reassigned To meet transplant requirements with no race multiplier, yet 0 of these 64 were referred, evaluated, or waitlisted for kidney transplant	Informing patients on whether the race correction is being used on them Advocating for borderline patients on the transplant threshold	Level: III Quality: B

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Anker et al. (2016)	Retrospective cohort study patients	N=21,905 treatment naïve HIV-infected veterans in the VA health system Used HIV Clinical Case Registry	Investigate whether eGFR equations in clinical use might systematically over-estimate the kidney function misclassifying the CKD status of Black Americans with HIV Compared removing race coefficient from equations on comparisons between Black/White veterans. Since no gold standard measurements were available, outcomes measured were all-cause mortality since CKD is strongly associated with death of HIV	MDRD with/ without race correction CKD-EPI with/without race correction	Persons with eGFR <45 mL/min/1.73m2 had a higher risk of death compared with those with eGFR >80 mL/min/1.73m2 among both Blacks and Whites, but the association appeared to be stronger in Blacks. Blacks with eGFR 45-60 mL/min/1.73m2 also had a higher risk of death but Whites did not. Racial differences were substantially attenuated when eGFR was re-calculated without the race coefficient	eGFR without race coefficient may be more appropriate for Blacks with HIV	Level: III Quality: B

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Barreto et al. (2016)	Secondary analysis of a longitudinal, multicenter cohort study.	Public sector employees enrolled in the Brazilian Longitudinal Study of Adult Health cohort N= 14,636	Determine prevalence and disparities in CKD in Brazil Measured eGFR without the race correction factor, and urinary albumin-creatinine ratio	CKD-EPI without correction for race	High albumin - creatinine ratio (ACR) or low eGFR was higher in individuals of low socioeconomic status, black and indigenous individuals. Marked discrepancies in the increases in reduced eGFR and high ACRs with age and race. The combination of higher prevalence of CKD in black and indigenous individuals could not be explained by socioeconomic and health risk factors. Differences most likely explained by health inequalities	Racial and socio-economic CKD disparities found in other countries as well CKD-EPI without correction for race was justified in this experimental design	Level: III Quality: B

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Bragg-Gresham et al. (2021)	Cross-sectional study / secondary analysis of de-identified NHANES data from surveys between 1999-2018	N = 9682 self-reported Black adults from the National Health and Nutrition Examination Study (representative of US population)	To assess how much removing the race coefficient would affect the distribution of eGFR categories below eGFR of 60 mL/min/1.73 m2 both the US general population and the population of US veterans who use the Veterans Affairs (VA) Health System.	CKD-EPI with / without correction for race	The mean eGFR decreased from 102.8 mL/min/1.73m^2 to 88.1 mL/min/1.73m^2 using the CKD-EPI equation without the race coefficient in the US adult black population. The mean eGFR decreased from 82.9 mL/min/1.73 m^2 to 71.6 mL/min/1.73 m^2 without the race coefficient in black US veterans. Elimination of the race coefficient would result in 981,038 more Black adults in the US, and an additional 84,988 Black adults in the VA health system being classified as having CKD	Substantial increase in estimated prevalence of CKD with elimination of the race coefficient.	Level: III Quality: B

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Gao et al. (2008)	Retrospective cohort study Association between race and compliance with selected Kidney Disease Outcomes Quality Initiative CKD recommended targets in the Department of Defense medical system	N=8318 Patients with CKD stage 3 or stage 4 who receive free medical care as beneficiaries of the Department of Defense medical system	Determine if care is equitable between Blacks and Whites with CKD in the Department of Defense medical system	MDRD 5-variable formula requiring manual correction for Black race by the provider (Provider adherence not assessed) Black coefficient = 1.18	Compliance with LDL cholesterol monitoring was the only significant difference between White and Black Blacks were referred to nephrology equitably compared to Whites Provider compliance with CKD stage 3 and 4 targets was not significantly lower for Blacks that Whites with the exception of LDL. Patients categorized as “other” race were less likely to achieve targets than Whites.	Provider education on eGFR limitations Unknown provider compliance with race correction in some medical systems Improvement in CKD disparity with access to healthcare reliance primarily on serum creatinine level may be advantageous for Blacks, both in comparison to Whites and to other races, especially patients whose serum creatinine levels were relatively low compared with their true GFR.	Level: III Quality: B

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Haas Pizarro et al. (2020)	Cross-sectional, muti-center study	N=85 85 Brazilian patients with genomic ancestry >50% African Cohort all had type 1 diabetes CKD defined as eGRF , 60ml/min.	To compare, in patients with type 1 diabetes, the eGFR calculated without the use of the correction factor, with the values obtained using the correction factor in patients presenting 50% or more of African genomic ancestry.	CKD-EPI with / without race correction	CKD was present in 23 patients and 56.5% of them were redefined as having normal renal function after using the correction factor Genomic Ancestry did not match self-reported race	Genomic ancestry may be a better tool than self-reporting race when determining use of race coefficients.	Level: III Quality: C

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Kramer et al. (2008)	Population -based study; descriptive/comparative	N= 6747 Sample from Multi-Ethnic Study of Atherosclerosis cohort, but who do not have clinical cardiovascular disease, ages 45-85.	Comparison of prevalence estimates of CKD among gender and racial/ethnic groups using three different GFR prediction equations	4 variable MDRD Cystatin C with / without gender and race coefficient	Women: CKD prevalence estimates varied across equations; however, were more congruent with the use of Cystatin C-based equation without the use of coefficients. Men: CKD prevalence estimates differed significantly with the Cystatin C formula which incorporates gender and race coefficients. CKD prevalence estimates vary across racial/ethnic groups, and the degree of variability depends on the method used to estimate GFR, especially among women.	More investigation needed to determine accuracy of eGFR, especially in racially diverse populations	Level: III Quality: A

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Lin et al. (2013)	Cross-sectional / secondary analysis of data from the Chronic Renal Insufficiency Cohort (CRIC)	N=1342 chronic kidney disease patients with baseline measures of iGFR and 24 – hour urine collections	Determine whether higher levels of albuminuria would be associated with higher, and being non-Hispanic Black with lower, CrCl/GFR ratio.	CrCl/iGFR ratio	There was no association between race/ethnicity and CrCl/iGFR ratio. No indication of differences between Black and Whites in tubular secretion of creatinine	This study does not confirm the need for race correction factors	Level: III Quality: B
Miller & Knorr (2021)	Retrospective study	N = 210 n = 177 Black patients n = 33 White patients Hospitalized patients who were prescribed an antimicrobial that includes renal dosage recommendations in the product labeling.	To determine the impact of removing the race coefficient on drug dosing in Black patients in comparison to conventional methods.	Deindexed CKD-EPI using Body Surface Area and no race correction CKD-EPI with race correction Cockroft-Gault	18% rate of discordance when GFR was estimated with race coefficient vs. without. GFR without race had a higher level of agreement with dosing by creatine clearance. Deindexed CKD-EPI without Race had a higher level of agreement and less drug dose discordance than CKD-EPI with race coefficients, in comparison to CrCl estimates.	Deindexed CKD-EPI without race correction should be considered for guiding drug dosages	Level: III Quality: B

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Omuse et al, (2017)	Secondary analysis of data obtained in a global reference interval study.	Subjectively healthy Kenyan adults with no symptoms of kidney disease from the Committee of Reference intervals and Decision Limits study N=533	Determine the proportion of asymptomatic Black Africans with reduced eGFR using four different equations Comparison of the association between known risk factors for CKD and eGFR using these equations	4 -v MDRD with / without correction for race Cockcroft -Gault Full Age Spectrum Serum creatinine CKD-EPI with/without race and gender coefficients	The 4v–MDRD equation without correction for race classified the least number of participants (61.7%) as having an eGFR equivalent to CKD stage G1 CKD-EPI with race correction performed the best in their population, and MDRD performed the worst Only age had a statistically significant linear association with eGFR across all equations after performing multiple regression analysis	CKD-EPI with race correction may be the most accurate eGFR equation in healthy Black Africans	Level: III Quality: C

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Peralta et al. (2010)	Secondary analysis of data from the Coronary Artery Risk Development in Young Adults (CARDIA) cohort study.	N = 3501 healthy young adults (black/white); ages 18-30 living in Birmingham, AL, Chicago, IL, Minneapolis, MN, and Oakland, CA	Study the prevalence of CKD in a young, healthy, bi-racial cohort using the MDRD and the CKD-EPI equations; and evaluate the impact of the race correction coefficients on CKD classification by race.	MDRD = 1.21 CKD-EPI = 1.16 CARDIA derived race coefficient = 1.12	Using the MDRD equation, prevalence of CKD stages 4 and 5 was higher for Blacks compared with Whites, yet Whites had a higher prevalence of CKD stages 3 and above. Prevalence of CKD was similar for Blacks and Whites using CKD-EPI equation Among persons with close to the threshold of stake 3 CKD, Blacks had higher incidence of CKD risk factors	CKD classification among young Blacks is very sensitive to the race coefficients. Despite Whites having higher rates of CKD stage 3, Blacks with eGFRs just above the CKD threshold had higher rates of CKD risk factors Current equations used to define CKD may systematically miss a high-risk group of Blacks at a crucial time in the disease process where interventions may be beneficial.	Level: III Quality: B

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Praditpornsilpa et al. (2011)	eGRF equation validation study	N = 350 Thai adults with CKD	Validate the Japanese and Chinese CKD-EPI and MDRD equation in Thai populations	MDRD MDRD with Thai variable CKD-EPI Chinese equation Japanese equation Reference for GFR: ^{99m}Tc-DTPA plasma clearance	Derived an adjustment of 1.129 in MDRD equation for Thais MDRD had a disagreement with measured GFR of 9.6 mL/min/1.73 m2 CKD-EPI was 8.0 mL/ min/1.73 m2 Japanese was 1.9 mL/min/1.73 m2 Chinese was 20.9 mL/min/1.73 m2 Race/ethnic differences can significant impact results obtained using the MDRD-based eGFR equation.	Each population should validate eGFR equations before applying the equation in epidemiologic studies or clinical use.	Level: III Quality: B

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Shi et al. (2021)	Retrospective analysis of serum creatinine and eGFR values calculated by the various formulas over 20.5-month period	N=241,760 96% of samples from outpatient and emergency department visits	To evaluate the impact on our patient population upon adoption of the CKD-EPI equation and the removal of the race correction factor from the equation after previously using MDRD	4 variable MDRD CKD-EPI with/without race correction	3.5% of all patients, including 4.29% of blacks were reclassified to categorically have worse kidney function when changing from MDRD to CKD-EPI$_{\text{no race}}$ Distributions of creatinine and eGFR calculated with CKD-EPI with no race correction were not meaningfully different in Black and non-Black patients. Overall number of those with eGFR under threshold for nephrology referral decreased by 2%	Successful example of medical system switching from eGFR equations that incorporate race, to CKD-EPI with no race correction Lower referral rate to nephrology	Level: III Quality: B

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Stevens et al. (2011)	Validation study Four-level CKD-EPI racial coefficients were developed from N=8254 then tested for external validation of N=3036	External validation: Worldwide databases used n= 1022 from United States and Europe n=675 from China n=248 from Japan and n=99 from South Africa	Explore the performance of a CKD-EPI two-level race equation (Black or White / Other), and CKD-EPI four-level race equation (Black, Asian, Native American, Hispanic)	Two-level CKD-EPI: White coefficient =1 Black coefficient = 1.157 Four-level CKD-EPI: White coefficient =1 Black coefficient = 1.160 Native American and Hispanic = 1.010 Asian = 1.052	The four-level race equation that was developed for the study was more accurate than the CKD-EPI (two-level race-equation in some but not all populations. In South Africa, both the two and four level race equations performed worse, and performance was better when no coefficient was used Minimal bias in two-level race equation, except for Asians A four variable CKD-EPI is not accurate enough to be implemented in clinical practice. Racial differences in creatinine-based estimating equations likely reflect geographic and ethnic differences rather than race alone.	CKD-EPI appropriate for United States and Europe with the understanding that there is likely variation in the accuracy of GFR estimates among and within racial and ethnic groups	Level: III Quality: A

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Wyatt et al. (2013)	GFR equations compared against a direct measure of GFR by iohexol clearance. Iohexol clearance was calculated using dried blood spots on filters, an approach for areas with low resources such as Africa	N=99 HIV positive, antiretroviral therapy naïve Kenyan adults	Determine which calculation of eGFR has the lowest bias ratio and best accuracy for this population	Cockcroft-Gault 4 variable MDRD with/without race coefficient CKD-EPI with/without race coefficient iGFR for direct measurement	CKD-EPI had the highest accuracy, and bias and accuracy were improved by eliminating the Black race coefficient The MDRD also performed better without the race coefficient	HIV patients in Africa may benefit from using the CKD-EPI with no race coefficient to measure eGFR for their medications which dosages depend on kidney function	Level: III Quality: C

Author / Year	Design	Sample / Settings	Aim / Objective	eGFR Equation(s)	Key Findings	Implications for Practice	JHEBN
Zelnick et al. (2021)	Prospective cohort study	Self-identified Black patients from Chronic Renal Insufficiency Cohort study N=1658	To compare eGFR with measured GFR and evaluate the association between eGFR calculated with vs without a coefficient for race and time to eligibility for kidney transplant.	Creatinine based CKD-EPI with/without race coefficient Cystatin-C based CKD-EPI which does not have a race coefficient iGFR for direct measurement	The CKD-EPI eGFR with the race coefficient overestimated iGFR by a mean of 3.1 mL/min/1.73 m^2 and by 5.1mL/min/1.73m^2 at lower GFR levels The mean difference between CKD-EPI eGFR without the race coefficient and iGFR was much smaller at -1.71mL/min/1.73m^2 Use of eGFR race coefficient had a 35% higher risk of achieving an eGFR less than 20 mL/min/1.73 m2 and a shorter median time to this end point of 1.9 years.	Potential need for more flexible eGFR thresholds, or use of iGFR for strict threshold Race-based eGFR may be associated with potential Kidney transplant delays	Level: III Quality: B

REFERENCES

Abefe, S. A., Abiola, A. F., Olubunmi, A. A., & Adewale, A. (2009). Utility of predicted creatinine clearance using MDRD formula compared with other predictive formulas in Nigerian patients. *Saudi Journal of Kidney Diseases and Transplantation : An Official Publication of the Saudi Center for Organ Transplantation, Saudi Arabia*, *20*(1), 86–90.

Ahmed, S., Nutt, C. T., Eneanya, N. D., Reese, P. P., Sivashanker, K., Morse, M., Sequist, T., & Mendu, M. L. (2020). Examining the potential impact of race multiplier utilization in estimated glomerular filtration rate calculation on African-American care outcomes. *Journal of General Internal Medicine*, 1–8. https://doi.org/10.1007/s11606-020-06280-5

Ahn, R., Gonzalez, G. P., Anderson, B., Vladutiu, C. J., Fowler, E. R., & Manning, L. (2020). Initiatives to reduce maternal mortality and severe maternal morbidity in the United States: A narrative review. *Annals of Internal Medicine*, *173*(11_Supplement), S3–S10. https://doi.org/10.7326/M19-3258

Anker, N., Peralta, C., Banjeree, T., Shlipak, M., Scherzer, R., & Powe, N. (2016). Racial disparities in creatinine-based kidney function estimates among HIV-infected adults. *Ethnicity & Disease*, *26*(2), 213–220. https://doi.org/10.18865/ed.26.2.213

Barreto, S. M., Ladeira, R. M., Duncan, B. B., Schmidt, M. I., Lopes, A. A., Benseñor, I. M., Chor, D., Griep, R. H., Vidigal, P. G., Ribeiro, A. L., Lotufo, P. A., & Mill, J. G. (2016). Chronic kidney disease among adult participants of the ELSA-Brasil cohort: Association with race and

socioeconomic position. *Journal of Epidemiology and Community Health*, *70*(4), 380–389. https://doi.org/10.1136/jech-2015-205834

Bragg-Gresham, J., Zhang, X., Le, D., Heung, M., Shahinian, V., Morgenstern, H., & Saran, R. (2021). Prevalence of chronic kidney disease among black individuals in the US after removal of the black race coefficient from a glomerular filtration rate estimating equation. *JAMA Network Open*, *4*(1), e2035636–e2035636. https://doi.org/10.1001/jamanetworkopen.2020.35636

Braun, L., Wentz, A., Baker, R., Richardson, E., & Tsai, J. (2021). Racialized algorithms for kidney function: Erasing social experience. *Social Science & Medicine*, *268*, 113548. https://doi.org/10.1016/j.socscimed.2020.113548

Centers for Disease Control and Prevention [CDC]. (2017). *National chronic kidney disease fact sheet, 2017*. US Department of Health and Human Services, Centers for Disease Control and Prevention. https://www.cdc.gov/diabetes/pubs/pdf/kidney_factsheet.pdf

Centers for Disease Control and Prevention {CDC]. (2020). *Chronic kidney disease basics*. https://www.cdc.gov/kidneydisease/basics.html#:~:text=If%20left%20untreated%2C%20CKD%20can,stage%20renal%20disease%20(ESRD).

Dang, D., & Dearholt, S. L. (2017). *Johns Hopkins nursing evidence-based practice: Model and guidelines* (3rd ed). Sigma Theta Tau International.

Delgado, C., Baweja, M., Burrows, N. R., Crews, D. C., Eneanya, N. D., Gadegbeku, C. A., Inker, L. A., Mendu, M. L., Miller, W. G., Moxey-Mims, M. M., Roberts, G. V., St Peter, W. L., Warfield, C., & Powe, N. R. (2021). Reassessing the inclusion of race in diagnosing kidney diseases: An interim report from the NKF-ASN task force. *American Journal of Kidney*

Diseases : The Official Journal of the National Kidney Foundation. https://doi.org/10.1053/j.ajkd.2021.03.008

Eneanya, N. D., Yang, W., & Reese, P. P. (2019). Reconsidering the consequences of using race to estimate kidney function. *Jama*, *322*(2), 113–114. https://doi.org/10.1001/jama.2019.5774

Farrance, I., & Frenkel, R. (2012). Uncertainty of measurement: a review of the rules for calculating uncertainty components through functional relationships. *The Clinical Biochemist Reviews*, *33*(2), 49.

Friedman, D. J., & Pollak, M. R. (2011). Genetics of kidney failure and the evolving story of APOL1. *The Journal of Clinical Investigation*, *121*(9), 3367–3374. https://doi.org/10.1172/JCI46263

Florkowski, C. M., & Chew-Harris, J. S. (2011). Methods of estimating GFR - Different equations including CKD-EPI. *The Clinical biochemist. Reviews*, *32*(2), 75–79.

Gaffney, T. (2020, July 17). A yearslong push to remove racist bias from kidney testing gains new ground. *STAT News*. https://www.statnews.com/2020/07/17/egfr-race-kidney-test/

Gao, S. W., Oliver, D. K., Das, N., Hurst, F. P., Lentine, K. L., Agodoa, L. Y., Sawyers, E. S., & Abbott, K. C. (2008). Assessment of racial disparities in chronic kidney disease stage 3 and 4 care in the department of defense health system. *Clinical Journal of the American Society of Nephrology : CJASN*, *3*(2), 442–449. https://doi.org/10.2215/CJN.03940907

Haas Pizarro, M., Conte Santos, D., Gomes Nunes Melo, L., Senger Vasconcelos Barros, B., Harcar Muniz, L., Porto, L. C., Silva, D. A., Bregman, R., & Brito Gomes, M. (2020). Glomerular filtration rate estimated by the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI)

equation in type 1 diabetes based on genomic ancestry. *Diabetology & Metabolic Syndrome*, *12*, 71. https://doi.org/10.1186/s13098-020-00578-4

Hong, S. (2020, July 7). 'An entire system is changing': UW Medicine stops using race-based equation to calculate kidney function. *The Daily of the University of Washington*. https://www.dailyuw.com/news/article_ff37cd76-c000-11ea-a71a-c7b116369e37.html

Hornum, M., & Feldt-Rasmussen, B. (2017). Drug dosing and estimated renal function-any step forward from effersoe? *Nephron*, *136*(4), 268–272. https://doi.org/10.1159/000456621

Kramer, H., Palmas, W., Kestenbaum, B., Cushman, M., Allison, M., Astor, B., & Shlipak, M. (2008). Chronic kidney disease prevalence estimates among racial/ethnic groups: The Multi-Ethnic Study of Atherosclerosis. *Clinical Journal of the American Society of Nephrology : CJASN*, *3*(5), 1391–1397. https://doi.org/10.2215/CJN.04160907

Kullar, R., Marcelin, J. R., Swartz, T. H., Piggott, D. A., Macias Gil, R., Mathew, T. A., & Tan, T. (2020). Racial disparity of coronavirus disease 2019 in African American Communities. The Journal of Infectious Diseases, 222(6), 890–893. https://doi.org/10.1093/infdis/jiaa372

Levey, A. S., Titan, S. M., Powe, N. R., Coresh, J., & Inker, L. A. (2020). Kidney disease, race, and GFR estimation. *Clinical Journal of the American Society of Nephrology : CJASN*, *15*(8), 1203–1212. https://doi.org/10.2215/CJN.1279101

Levey, A. S., Bosch, J. P., Lewis, J. B., Greene, T., Rogers, N., & Roth, D. (1999). A more accurate method to estimate glomerular filtration rate from serum creatinine: a new prediction equation. *Annals of internal medicine*, *130*(6), 461-470. https://doi.org/10.7326/0003-4819-130-6-199903160-00002

Lin, Y., Bansal, N., Vittinghoff, E., Go, A. S., & Hsu, C. (2013). Determinants of the creatinine clearance to glomerular filtration rate ratio in patients with chronic kidney disease: A cross-sectional study. *BMC Nephrology*, *14*(1), 268–268. https://doi.org/10.1186/1471-2369-14-268

Miller, G. & Vassalotti, J. A. (2020). Kidney biomarkers: the kidney profile order, urine albumin-creatinine ratio (uACR), and estimated glomerular filtration rate (eGFR), *College of American Pathologists*. https://documents.cap.org/documents/2020-a-kidney-biomarkers.pdf

Miller, J., & Knorr, J. P. (2021). Impact of removing the race coefficient in renal function estimate equations on drug dosage recommendations. *The Annals of Pharmacotherapy* https://doi.org/10.1177/10600280211010228

National Kidney Foundation. (2020). *Frequently asked questions about GFR estimates*. https://www.kidney.org/sites/default/files/12-10-4004_FAQ-ABE.pdf

National Kidney Foundation. (2021). *Cockcroft-Gault formula*. https://www.kidney.org/professionals/kdoqi/gfr_calculatorcoc

Norton, J. M., Moxey-Mims, M. M., Eggers, P. W., Narva, A. S., Star, R. A., Kimmel, P. L., & Rodgers, G. P. (2016). Social determinants of racial disparities in CKD. *Journal of the American Society of Nephrology*, *27*(9), 2576–2595. https://doi.org/10.1681/ASN.2016010027

Omuse, G., Maina, D., Mwangi, J., Wambua, C., Kanyua, A., Kagotho, E., Amayo, A., Ojwang, P., & Erasmus, R. (2017). Comparison of equations for estimating glomerular filtration rate in screening for chronic kidney disease in asymptomatic black Africans: A cross sectional study. *BMC Nephrology*, *18*, 1–8. https://doi.org/10.1186/s12882-017-0788-y

Pearson, M. Z. (2008). Racial Disparities in Chronic Kidney Disease: Current Data and Nursing Roles. *Nephrology Nursing Journal*, *35*(5), 485–489.

Peralta, C. A., Lin, F., Shlipak, M. G., Siscovick, D., Lewis, C., Jacobs, D. R., Jr, & Bibbins-Domingo, K. (2010). Race differences in prevalence of chronic kidney disease among young adults using creatinine-based glomerular filtration rate-estimating equations. *Nephrology, Dialysis, Transplantation : Official Publication of the European Dialysis and Transplant Association - European Renal Association*, *25*(12), 3934–3939. https://doi.org/10.1093/ndt/gfq299

Petersen, E. E., Davis, N. L., Goodman, D., Cox, S., Syverson, C., Seed, K., Shapiro-Mendoza, C., Callaghan, W. M., & Barfield, W. (2019). Racial/ethnic disparities in pregnancy-related deaths—United States, 2007–2016. *Morbidity and Mortality Weekly Report*, *68*(35), 762. https://doi.org/10.15585/mmwr.mm6835a3

Praditpornsilpa, K., Townamchai, N., Chaiwatanarat, T., Tiranathanagul, K., Katawatin, P., Susantitaphong, P., Trakarnvanich, T., Kanjanabuch, T., Avihingsanon, Y., Tungsanga, K., & Eiam-Ong, S. (2011). The need for robust validation for MDRD-based glomerular filtration rate estimation in various CKD populations. *Nephrology, Dialysis, Transplantation : Official Publication of the European Dialysis and Transplant Association - European Renal Association*, *26*(9), 2780–2785. https://doi.org/10.1093/ndt/gfq815

Saad, L. (2020, December 22). U.S. Ethics ratings rise for medical workers and teachers. *Gallup*. https://news.gallup.com/poll/328136/ethics-ratings-rise-medical-workers-teachers.aspx

Shi, J., Lindo, E. G., Baird, G. S., Young, B., Ryan, M., Jefferson, J. A., Mehrotra, R., Mathias, P. C., & Hoofnagle, A. N. (2021). Calculating estimated glomerular filtration rate without the race correction factor: Observations at a large academic medical system. *Clinica Chimica Acta; International Journal of Clinical Chemistry*, *520*, 16–22. https://doi.org/10.1016/j.cca.2021.05.022

Stevens, L. A., Claybon, M. A., Schmid, C. H., Chen, J., Horio, M., Imai, E., Nelson, R. G., Van Deventer, M., Wang, H.-Y., Zuo, L., Yaping, Z., & Levey, A. S. (2011). Evaluation of the Chronic Kidney Disease Epidemiology Collaboration equation for estimating the glomerular filtration rate in multiple ethnicities. *Kidney International*, *79*(5), 555–562. https://doi.org/10.1038/ki.2010.462

Umeukeje, E. M., & Young, B. A. (2019). Genetics and ESKD disparities in African Americans. *American Journal of Kidney Diseases*, *74*(6), 811–821. https://doi.org/10.1053/j.ajkd.2019.06.006.

Veronese, F. V., Gomes, E. C., Chanan, J., Carraro, M. A., Camargo, E. G., Soares, A. A., Thomé, F. S., & Silveiro, S. P. (2014). Performance of CKD-EPI equation to estimate glomerular filtration rate as compared to MDRD equation in South Brazilian individuals in each stage of renal function. *Clinical Chemistry and Laboratory Medicine (CCLM)*, *52*(12), 1747–1754. https://doi.org/10.1515/cclm-2014-0052

Vyas, D. A., Eisenstein, L. G., & Jones, D. S. (2020). *Hidden in plain sight—Reconsidering the use of race correction in clinical algorithms*. https://doi.org/doi:10.1001/jama.2019.5774

Williams, D. R., & Sternthal, M. (2010). Understanding racial-ethnic disparities in health: Sociological contributions. *Journal of Health and Social Behavior*, *51*(1_suppl), S15–S27. https://doi.org/10.1177/0022146510383838

Wyatt, C. M., Schwartz, G. J., Owino Ong'or, W., Abuya, J., Abraham, A. G., Mboku, C., M'mene, L. B., Koima, W. J., Hotta, M., Maier, P., Klotman, P. E., & Wools-Kaloustian, K. (2013). Estimating kidney function in HIV-infected adults in Kenya: Comparison to a direct measure of glomerular filtration rate by iohexol clearance. *PloS One*, *8*(8), e69601. https://doi.org/10.1371/journal.pone.0069601

Zanocco, J. A., Nishida, S. K., Passos, M. T., Pereira, A. R., Silva, M. S., Pereira, A. B., & Kirsztajn, G. M. (2012). Race adjustment for estimating glomerular filtration rate is not always necessary. *Nephron Extra*, *2*(1), 293–302.

Zelnick, L. R., Leca, N., Young, B., & Bansal, N. (2021). Association of the estimated glomerular filtration rate with vs without a coefficient for race with time to eligibility for kidney transplant. *JAMA Network Open*, *4*(1), e2034004. https://doi.org/10.1001/jamanetworkopen.2020.34004