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Hidden in Plain Sight — Reconsidering the Use of Race Correction in Clinical Algorithms

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Physicians still lack consensus on the meaning of race. When the *Journal* took up the topic in 2003 with a debate about the role of race in medicine, one side argued that racial and ethnic categories reflected underlying population genetics and could be clinically useful.[1] Others held that any small benefit was outweighed by potential harms that arose from the long, rotten history of racism in medicine.[2] Weighing the two sides, the accompanying Perspective article concluded that though the concept of race was "fraught with sensitivities and fueled by past abuses and the potential for future abuses," race-based medicine still had potential: "it seems unwise to abandon the practice of recording race when we have barely begun to understand the architecture of the human genome."[3]

The next year, a randomized trial showed that a combination of hydralazine and isosorbide dinitrate reduced mortality due to heart failure among patients who identified themselves as black. The Food and Drug Administration granted a race-specific indication for that product, BiDil, in 2005.[4] Even though BiDil's ultimate commercial failure cast doubt on race-based medicine, it did not lay the approach to rest. Prominent geneticists have repeatedly called on physicians to take race seriously,[5,6] while distinguished social scientists vehemently contest these calls.[7,8]

Our understanding of race and human genetics has advanced considerably since 2003, yet these insights have not led to clear guidelines on the use of race in medicine. The result is ongoing conflict between the latest insights from population genetics and the clinical implementation of race. For example, despite mounting evidence that race is not a reliable proxy for genetic difference, the belief that it is has become embedded, sometimes insidiously, within medical practice. One subtle insertion of race into medicine involves diagnostic algorithms and practice guidelines that adjust or "correct" their outputs on the basis of a patient's race or ethnicity. Physicians use these algorithms to individualize risk assessment and guide clinical decisions. By embedding race into the basic data and decisions of health care, these algorithms propagate race-based medicine. Many of these race-adjusted algorithms guide decisions in ways that may direct more attention or resources to white patients than to members of racial and ethnic minorities.

To illustrate the potential dangers of such practices, we have compiled a partial list of race-adjusted algorithms (Table 1). We explore several of them in detail here. Given their potential to perpetuate or even amplify race-based health inequities, they merit thorough scrutiny.

CARDIOLOGY

The American Heart Association (AHA) Get with the Guidelines–Heart Failure Risk Score predicts the risk of death in patients admitted to the hospital.[9] It assigns three additional points to any patient identified as "nonblack," thereby categorizing all black patients as being at lower risk. The AHA does not provide a rationale for this adjustment. Clinicians are advised to use this risk score to guide decisions about referral to cardiology and allocation of health care resources. Since "black" is equated with lower risk, following the guidelines could direct care away from black patients. A 2019 study found that race may influence decisions in heart-failure management, with measurable consequences: black and Latinx patients who presented to a Boston emergency department with heart failure were less likely than white patients to be admitted to the cardiology service.[24]

Cardiac surgeons also consider race. The Society of Thoracic Surgeons produces elaborate calculators to estimate the risk of death and other complications during surgery.[10] The calculators include race and ethnicity because of observed differences in surgical outcomes among racial and ethnic groups; the authors acknowledge that the mechanism underlying these differences is not known. An isolated coronary artery bypass in a low-risk white patient carries an estimated risk of death of 0.492%. Changing the race to "black/African American" increases the risk by nearly 20%, to 0.586%. Changing to any other race or ethnicity does not increase the estimated risk of death as compared with a white patient, but it does change the risk of renal failure, stroke, or prolonged ventilation. When used preoperatively to assess risk, these calculations could steer minority patients, deemed to be at higher risk, away from surgery.

NEPHROLOGY

Since it is cumbersome to measure kidney function directly, researchers have developed equations that determine the estimated glomerular filtration rate (eGFR) from an accessible measure, the serum creatinine level. These algorithms result in higher reported eGFR values (which suggest better kidney function) for anyone identified as black.[11,25] The algorithm developers justified these outcomes with evidence of higher average serum creatinine concentrations among black people than among white people. Explanations that have been given for this finding include the notion that black people release more creatinine into their blood at baseline, in part because they are reportedly more muscular.[11,25] Analyses have cast doubt on this claim,[26] but the "race-corrected" eGFR remains the standard. Proponents of the equations have acknowledged that race adjustment "is problematic because race is a social rather than a biological construct" but warn that ending race adjustment of eGFR might lead to overdiagnosis and overtreatment of black patients.[27] Conversely, race adjustments that yield higher estimates of kidney function in black patients might delay their referral for specialist care or transplantation and lead to worse outcomes, while black people already have higher rates of end-stage kidney disease and death due to kidney failure than the overall population.[25] As long as uncertainty persists about the cause of racial differences in serum creatinine levels, we should favor practices that may alleviate health inequities over those that may exacerbate them.

Similar adjustment practices affect kidney transplantation. The Kidney Donor Risk Index (KDRI), implemented by the national Kidney Allocation System in 2014, uses donor characteristics, including race, to predict the risk that a kidney graft will fail.[12] The race adjustment is based on an empirical finding that black donors' kidneys perform worse than nonblack donors' kidneys, regardless of the recipient's race.[28] The developers of the KDRI do not provide possible explanations for this difference.[12] If the potential donor is identified as black, the KDRI returns a higher risk of graft failure, marking the candidate as a less suitable donor. Meanwhile, black patients in the United States still have longer wait times for kidney transplants than nonblack patients.[29] Since black patients are more likely to receive kidneys from black donors, anything that reduces the likelihood of donation from black people could contribute to the wait-time disparity.[29] Use of the KDRI may do just that. Mindful of this limitation of the KDRI, some observers have proposed replacing "the vagaries associated with inclusion of a variable termed 'race'" with a more specific, ancestry-associated risk factor, such as *APOL1* genotype.[28]

OBSTETRICS

The Vaginal Birth after Cesarean (VBAC) algorithm predicts the risk posed by a trial of labor for someone who has previously undergone cesarean section. It predicts a lower likelihood of success for anyone identified as African American or Hispanic.[13] The study used to produce the algorithm found that other variables, such as marital status and insurance type, also correlated with VBAC success.[14] Those variables, however, were not incorporated into the algorithm. The health benefits of successful vaginal deliveries are well known, including lower rates of surgical complications, faster recovery time, and fewer complications during subsequent pregnancies. Nonwhite U.S. women continue to have higher rates of cesarean section than white U.S. women. Use of a calculator that lowers the estimate of VBAC success for people of color could exacerbate these disparities. This dynamic is particularly

Table 1. Examples of Race Correction in Clinical Medicine.*

Tool and Clinical Utility	Input Variables	Use of Race	Equity Concern
Cardiology			
The American Heart Association's Get with the Guidelines–Heart Failure[9] (https://www.mdcalc.com/gwtg-heart-failure-risk-score) *Predicts in-hospital mortality in patients with acute heart failure. Clinicians are advised to use this risk stratification to guide decisions regarding initiating medical therapy.*	Systolic blood pressure Blood urea nitrogen Sodium Age Heart rate History of COPD Race: black or nonblack	Adds 3 points to the risk score if the patient is identified as nonblack. This addition increases the estimated probability of death (higher scores predict higher mortality).	The original study envisioned using this score to "increase the use of recommended medical therapy in high-risk patients and reduce resource utilization in those at low risk."[9] The race correction regards black patients as lower risk and may raise the threshold for using clinical resources for black patients.
Cardiac surgery			
The Society of Thoracic Surgeons Short Term Risk Calculator[10] (http://riskcalc.sts.org/stswebriskcalc/calculate) *Calculates a patient's risks of complications and death with the most common cardiac surgeries. Considers >60 variables, some of which are listed here.*	Operation type Age and sex Race: black/African American, Asian, American Indian/Alaskan Native, Native Hawaiian/Pacific Islander, or "Hispanic, Latino or Spanish ethnicity"; white race is the default setting. BMI	The risk score for operative mortality and major complications increases (in some cases, by 20%) if a patient is identified as black. Identification as another nonwhite race or ethnicity does not increase the risk score for death, but it does change the risk score for major complications such as renal failure, stroke, and prolonged ventilation.	When used preoperatively to assess a patient's risk, these calculations could steer minority patients, deemed higher risk, away from these procedures.
Nephrology			
Estimated glomerular filtration rate (eGFR) MDRD and CKD-EPI equations[11] (https://ukidney.com/nephrology-resources/egfr-calculator) *Estimates glomerular filtration rate on the basis of a measurement of serum creatinine.*	Serum creatinine Age and sex Race: black vs. white or other	The MDRD equation reports a higher eGFR (by a factor of 1.210) if the patient is identified as black. This adjustment is similar in magnitude to the correction for sex (0.742 if female). The CKD-EPI equation (which included a larger number of black patients in the study population), proposes a more modest race correction (by a factor of 1.159) if the patient is identified as black. This correction is larger than the correction for sex (1.018 if female).	Both equations report higher eGFR values (given the same creatinine measurement) for patients identified as black, suggesting better kidney function. These higher eGFR values may delay referral to specialist care or listing for kidney transplantation.
Organ Procurement and Transplantation Network: Kidney Donor Risk Index (KDRI)[12] (https://optn.transplant.hrsa.gov/resources/allocation-calculators/kdpi-calculator/) *Estimates predicted risk of donor kidney graft failure, which is used to predict viability of potential kidney donor.†*	Age Hypertension, diabetes Serum creatinine level Cause of death (e.g., cerebrovascular accident) Donation after cardiac death Hepatitis C Height and weight HLA matching Cold ischemia En bloc transplantation Double kidney transplantation Race: African American	Increases the predicted risk of kidney graft failure if the potential donor is identified as African American (coefficient, 0.179), a risk adjustment intermediate between those for hypertension (0.126) and diabetes (0.130) and that for elevated creatinine (0.209–0.220).	Use of this tool may reduce the pool of African-American kidney donors in the United States. Since African-American patients are more likely to receive kidneys from African-American donors, by reducing the pool of available kidneys, the KDRI could exacerbate this racial inequity in access to kidneys for transplantation.

Obstetrics			
Vaginal Birth after Cesarean (VBAC) Risk Calculator[13,14] (https://mfmunetwork.bsc.gwu.edu/PublicBSC/MFMU/VGBirthCalc/vagbirth.html) *Estimates the probability of successful vaginal birth after prior cesarean section. Clinicians can use this estimate to counsel people who have to decide whether to attempt a trial of labor rather than undergo a repeat cesarean section.*	Age BMI Prior vaginal delivery Prior VBAC Recurring indication for cesarean section African-American race Hispanic ethnicity	The African-American and Hispanic correction factors subtract from the estimated success rate for any person identified as black or Hispanic. The decrement for black (0.671) or Hispanic (0.680) is almost as large as the benefit from prior vaginal delivery (0.888) or prior VBAC (1.003).	The VBAC score predicts a lower chance of success if the person is identified as black or Hispanic. These lower estimates may dissuade clinicians from offering trials of labor to people of color.
Urology			
STONE Score[15,16] *Predicts the risk of a ureteral stone in patients who present with flank pain*	Sex Acute onset of pain Race: black or nonblack Nausea or vomiting Hematuria	Produces a score on a 13-point scale, with a higher score indicating a higher risk of a ureteral stone; 3 points are added for nonblack race. This adjustment is the same magnitude as for hematuria.	By systematically reporting lower risk for black patients than for all nonblack patients, this calculator may steer clinicians away from aggressive evaluations of black patients.
Urinary tract infection (UTI) calculator[17] (https://uticalc.pitt.edu/) *Estimates the risk of UTI in children 2–23 mo of age to guide decisions about when to pursue urine testing for definitive diagnosis*	Age <12 months Maximum temperature >39°C Race: Describes self as black (fully or partially) Female or uncircumcised male Other fever source	Assigns a lower likelihood of UTI if the child is black (i.e., reports a roughly 2.5-times increased risk in patients who do not describe themselves as black).	By systematically reporting lower risk for black children than for all nonblack children, this calculator may deter clinicians from pursuing definitive diagnostic testing for black children presenting with symptoms of UTI.
Oncology			
Rectal Cancer Survival Calculator[18] (http://www3.mdanderson.org/app/medcalc/index.cfm?pagename=rectumcancer) *Estimates conditional survival 1–5 yr after diagnosis with rectal cancer*	Age and sex Race: white, black, other Grade Stage Surgical history	White patients are assigned a regression coefficient of 1, with higher coefficients (depending on stage) assigned to black patients (1.18–1.72).	The calculator predicts that black patients will have shorter cancer-specific survival from rectal cancer than white patients. Clinicians might be more or less likely to offer interventions to patients with lower predicted survival rates.
National Cancer Institute Breast Cancer Risk Assessment Tool (https://bcrisktool.cancer.gov/calculator.html) *Estimates 5-yr and lifetime risk of developing breast cancer, for women without prior history of breast cancer, DCIS, or LCIS.*	Current age, age at menarche, and age at first live birth First-degree relatives with breast cancer Prior benign biopsies, atypical biopsies Race/ethnicity: white, African American, Hispanic/Latina, Asian American, American Indian/Alaska Native, unknown	The calculator returns lower risk estimates for women who are African American, Hispanic/Latina, or Asian American (e.g., Chinese).	Though the model is intended to help conceptualize risk and guide screening decisions, it may inappropriately discourage more aggressive screening among some groups of nonwhite women.

Table 1. (Continued.)

Tool and Clinical Utility	Input Variables	Use of Race	Equity Concern
Breast Cancer Surveillance Consortium Risk Calculator[19] (https://tools.bcsc-scc.org/BC5yearRisk/calculator.htm) *Estimates 5- and 10-yr risk of developing breast cancer in women with no previous diagnosis of breast cancer, DCIS, prior breast augmentation, or prior mastectomy*	Age Race/ethnicity: white, black, Asian, Native American, other/multiple races, unknown BIRADS breast density score First-degree relative with breast cancer Pathology results from prior biopsies	The coefficients rank the race/ethnicity categories in the following descending order of risk: white, American Indian, black, Hispanic, Asian.	Returns lower risk estimates for all nonwhite race/ethnicity categories, potentially reducing the likelihood of close surveillance in these patients.
Endocrinology			
Osteoporosis Risk SCORE (Simple Calculated Osteoporosis Risk Estimation)[20] (https://www.mdapp.co/osteoporosis-risk-score-calculator-316/) *Determines whether a woman is at low, moderate, or high risk for low bone density in order to guide decisions about screening with DXA scan*	Rheumatoid arthritis History of fracture Age Estrogen use Weight Race: black or not black	Assigns 5 additional points (maximum score of 50, indicating highest risk) if the patient is identified as nonblack	By systematically lowering the estimated risk of osteoporosis in black patients, SCORE may discourage clinicians from pursuing further evaluation (e.g., DXA scan) in black patients, potentially delaying diagnosis and intervention.
Fracture Risk Assessment Tool (FRAX)[21] (https://www.sheffield.ac.uk/FRAX/tool.aspx) *Estimates 10-yr risk of a hip fracture or other major osteoporotic fracture on the basis of patient demographics and risk-factor profile. Calculators are country-specific.*‡	Age and sex Weight and height Previous fracture Parent who had a hip fracture Current smoking Glucocorticoid use Rheumatoid arthritis Secondary osteoporosis Alcohol use, ≥3 drinks per day Femoral neck bone mineral density	The U.S. calculator returns a lower fracture risk if a female patient is identified as black (by a factor of 0.43), Asian (0.50), or Hispanic (0.53). Estimates are not provided for Native American patients or for multiracial patients.	The calculator reports 10-yr risk of major osteoporotic fracture for black women as less than half that for white women with identical risk factors. For Asian and Hispanic women, risk is estimated at about half that for white women. This lower risk reported for nonwhite women may delay intervention with osteoporosis therapy.
Pulmonology			
Pulmonary-function tests[22] *Uses spirometry to measure lung volume and the rate of flow through airways in order to diagnose and monitor pulmonary disease*	Age and sex Height Race/ethnicity	In the U.S., spirometers use correction factors for persons labeled as black (10–15%) or Asian (4–6%).	Inaccurate estimates of lung function may result in the misclassification of disease severity and impairment for racial/ethnic minorities (e.g., in asthma and COPD).[23]

* BIRADS denotes Breast Imaging Reporting and Data System, BMI body-mass index (the weight in kilograms divided by the square of the height in meters), CKD-EPI Chronic Kidney Disease Epidemiology Collaboration, COPD chronic obstructive pulmonary disease, DCIS ductal carcinoma in situ, DXA dual-energy x-ray absorptiometry, LCIS lobular carcinoma in situ, and MDRD Modification of Diet in Renal Disease study.

† The current calculator uses Ethnicity/Race, with the following options: American Indian or Alaska Native, Asian, Black or African American, Hispanic/Latino, Native Hawaiian or Other Pacific Islander, White, and Multiracial.

‡ Three countries' calculators are further subcategorized by race, ethnicity, or location: China (Mainland China, Hong Kong), Singapore (Chinese, Malay, Indian), and the United States (Caucasian, black, Hispanic, Asian).

troubling because black people already have higher rates of maternal mortality.[30]

UROLOGY

The STONE score predicts the likelihood of kidney stones in patients who present to the emergency department with flank pain. The "origin/race" factor adds 3 points (of a possible 13) for a patient identified as "nonblack."[15] By assigning a lower score to black patients, the STONE algorithm may steer clinicians away from thorough evaluation for kidney stones in black patients. The developers of the algorithm did not suggest why black patients would be less likely to have a kidney stone. An effort to externally validate the STONE score determined that the origin/race variable was not actually predictive of the risk of kidney stones.[16] In a parallel development, a new model for predicting urinary tract infection (UTI) in children similarly assigns lower risk to children identified as "fully or partially black."[17] This tool echoes UTI testing guidelines released by the American Academy of Pediatrics in 2011 that were recently criticized for categorizing black children as low risk.[31]

ASSESSMENT

Similar examples can be found throughout medicine. Some algorithm developers offer no explanation of why racial or ethnic differences might exist. Others offer rationales, but when these are traced to their origins, they lead to outdated, suspect racial science or to biased data.[22,30,31] In the cases discussed here, researchers followed a defensible empirical logic. They examined data sets of clinical outcomes and patient characteristics and then performed regression analyses to identify which patient factors correlated significantly with the relevant outcomes. Since minority patients routinely have different health outcomes from white patients, race and ethnicity often correlated with the outcome of interest. Researchers then decided that it was appropriate — even essential — to adjust for race in their model.

These decisions are the crux of the problem. When compiling descriptive statistics, it may be appropriate to record data by race and ethnicity and to study their associations. But if race does appear to correlate with clinical outcomes, does that justify its inclusion in diagnostic or predictive tools? The answer should depend on how race is understood to affect the outcome.[30] Arriving at such an understanding is not a simple matter: relationships between race and health reflect enmeshed social and biologic pathways.[32] Epidemiologists continue to debate how to responsibly make causal inferences based on race.[33] Given this complexity, it is insufficient to translate a data signal into a race adjustment without determining what race might represent in the particular context. Most race corrections implicitly, if not explicitly, operate on the assumption that genetic difference tracks reliably with race. If the empirical differences seen between racial groups were actually due to genetic differences, then race adjustment might be justified: different coefficients for different bodies.

Such situations, however, are exceedingly unlikely. Studies of the genetic structure of human populations continue to find more variation within racial groups than between them.[34,35] Moreover, the racial differences found in large data sets most likely often reflect effects of racism — that is, the experience of being black in America rather than being black itself — such as toxic stress and its physiological consequences.[32] In such cases, race adjustment would do nothing to address the cause of the disparity. Instead, if adjustments deter clinicians from offering clinical services to certain patients, they risk baking inequity into the system.

This risk was demonstrated in 2019 when researchers revealed algorithmic bias in medical artificial intelligence.[36] A widely used clinical tool took past health care costs into consideration in predicting clinical risk. Since the health care system has spent more money, on average, on white patients than on black patients, the tool returned higher risk scores for white patients than for black patients. These scores may well have led to more referrals for white patients to specialty services, perpetuating both spending discrepancies and race bias in health care.

A second problem arises from the ways in which racial and ethnic categories are operationalized. Clinicians and medical researchers typically use the categories recommended by the Office of Management and Budget: five races and two ethnicities. But these categories are unreliable proxies for genetic differences and fail to capture the complexity of patients' racial and

ethnic backgrounds.[34,35] Race correction therefore forces clinicians into absurdly reductionistic exercises. For example, should a physician use a double correction in the VBAC calculator for a pregnant person from the Dominican Republic who identifies as black and Hispanic? Should eGFR be race-adjusted for a patient with a white mother and a black father? Guidelines are silent on such issues — an indication of their inadequacy.

Researchers are aware of this dangerous terrain. The Society of Thoracic Surgeons acknowledged concerns raised by clinicians and policymakers "that inclusion of SES factors in risk models may 'adjust away' disparities in quality of care." Nonetheless, it proceeded to consider "all preoperative factors that are independently and significantly associated with outcomes": "Race has an empiric association with outcomes and has the potential to confound the interpretation of a hospital's outcomes, although we do not know the underlying mechanism (e.g., genetic factors, differential effectiveness of certain medications, rates of certain associated diseases such as diabetes and hypertension, and potentially [socioeconomic status] for some outcomes such as readmission)."[10] This decision reflects a default assumption in medicine: it is acceptable to use race adjustment even without understanding what race represents in a given context.

To be clear, we do not believe that physicians should ignore race. Doing so would blind us to the ways in which race and racism structure our society.[37-39] However, when clinicians insert race into their tools, they risk interpreting racial disparities as immutable facts rather than as injustices that require intervention. Researchers and clinicians must distinguish between the use of race in descriptive statistics, where it plays a vital role in epidemiologic analyses, and in prescriptive clinical guidelines, where it can exacerbate inequities.

This problem is not unique to medicine. The criminal justice system, for instance, uses recidivism-prediction tools to guide decisions about bond amounts and prison sentences. One tool, COMPAS (Correctional Offender Management Profiling for Alternative Sanctions), while not using race per se, uses many factors that correlate with race and returns higher risk scores for black defendants.[40] The tool's creators explained that their design simply reflected empirical data.[41] But if the underlying data reflect racist social structures, then their use in predictive tools cements racism into practice and policy. When these tools influence high-stakes decisions, whether in the clinic or the courtroom, they propagate inequity into our future.

In 2003, Kaplan and Bennet asked researchers to exercise caution when they invoked race in medical research: whenever researchers publish a finding based on race or ethnicity, they should follow seven guidelines, including justifying their use of race and ethnicity, describing how subjects were assigned to each category, and carefully considering other factors — especially socioeconomic status — that might affect the results.[42] We propose an adaptation of these guidelines to evaluate race correction in clinical settings. When developing or applying clinical algorithms, physicians should ask three questions: Is the need for race correction based on robust evidence and statistical analyses (e.g., with consideration of internal and external validity, potential confounders, and bias)? Is there a plausible causal mechanism for the racial difference that justifies the race correction? And would implementing this race correction relieve or exacerbate health inequities?

If doctors and clinical educators rigorously analyze algorithms that include race correction, they can judge, with fresh eyes, whether the use of race or ethnicity is appropriate. In many cases, this appraisal will require further research into the complex interactions among ancestry, race, racism, socioeconomic status, and environment. Much of the burden of this work falls on the researchers who propose race adjustment and on the institutions (e.g., professional societies, clinical laboratories) that endorse and implement clinical algorithms. But clinicians can be thoughtful and deliberate users. They can discern whether the correction is likely to relieve or exacerbate inequities. If the latter, then clinicians should examine whether the correction is warranted. Some tools, including eGFR and the VBAC calculator, have already been challenged; clinicians have advocated successfully for their institutions to remove the adjustment for race.[43,44] Other algorithms may succumb to similar scrutiny.[45] A full reckoning will require medical specialties to critically appraise their tools and revise them when indicated.

Our understanding of race has advanced considerably in the past two decades. The clinical

tools we use daily should reflect these new insights to remain scientifically rigorous. Equally important is the project of making medicine a more antiracist field.[46] This involves revisiting how clinicians conceptualize race to begin with. One step in this process is reconsidering race correction in order to ensure that our clinical practices do not perpetuate the very inequities we aim to repair.

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1. Burchard EG, Ziv E, Coyle N, et al. The importance of race and ethnic background in biomedical research and clinical practice. N Engl J Med 2003;348:1170-5.
2. Cooper RS, Kaufman JS, Ward R. Race and genomics. N Engl J Med 2003;348:1166-70.
3. Phimister EG. Medicine and the racial divide. N Engl J Med 2003;348:1081-2.
4. Jones DS, Dorr GM, Pollock A. Symposium: race, pharmaceuticals, and medical technology. J Law Med Ethics 2008;36:439-545.
5. Leroi AM. A family tree in every gene. New York Times. March 14, 2005:A21.
6. Reich D. How genetics is changing our understanding of 'race.' New York Times. March 23, 2018:SR1.
7. Social Science Research Council. Is race "real"? June 2006 (http://raceandgenomics.ssrc.org).
8. Kahn J, Nelson A, Graves JL Jr, et al. How not to talk about race and genetics. Buzzfeed News. March 30, 2018 (https://www.buzzfeednews.com/article/bfopinion/race-genetics-david-reich).
9. Peterson PN, Rumsfeld JS, Liang L, et al. A validated risk score for in-hospital mortality in patients with heart failure from the American Heart Association Get with the Guidelines program. Circ Cardiovasc Qual Outcomes 2010;3:25-32.
10. Shahian DM, Jacobs JP, Badhwar V, et al. The Society of Thoracic Surgeons 2018 adult cardiac surgery risk models. 1. Background, design considerations, and model development. Ann Thorac Surg 2018;105:1411-8.
11. Levey AS, Stevens LA, Schmid CH, et al. A new equation to estimate glomerular filtration rate. Ann Intern Med 2009;150:604-12.
12. Rao PS, Schaubel DE, Guidinger MK, et al. A comprehensive risk quantification score for deceased donor kidneys: the kidney donor risk index. Transplantation 2009;88:231-6.
13. Grobman WA, Lai Y, Landon MB, et al. Development of a nomogram for prediction of vaginal birth after cesarean delivery. Obstet Gynecol 2007;109:806-12.
14. Landon MB, Leindecker S, Spong CY, et al. The MFMU Cesarean Registry: factors affecting the success of trial of labor after previous cesarean delivery. Am J Obstet Gynecol 2005;193:1016-23.
15. Moore CL, Bomann S, Daniels B, et al. Derivation and validation of a clinical prediction rule for uncomplicated ureteral stone — the STONE score: retrospective and prospective observational cohort studies. BMJ 2014;348:g2191.
16. Wang RC, Rodriguez RM, Moghadassi M, et al. External validation of the STONE score, a clinical prediction rule for ureteral stone: an observational multi-institutional study. Ann Emerg Med 2016;67(4):423.e2-432.e2.
17. Shaikh N, Hoberman A, Hum SW, et al. Development and validation of a calculator for estimating the probability of urinary tract infection in young febrile children. JAMA Pediatr 2018;172:550-6.
18. Bowles TL, Hu C-Y, You NY, Skibber JM, Rodriguez-Bigas MA, Chang GJ. An individualized conditional survival calculator for patients with rectal cancer. Dis Colon Rectum 2013;56:551-9.
19. Tice JA, Miglioretti DL, Li C-S, Vachon CM, Gard CC, Kerlikowske K. Breast density and benign breast disease: risk assessment to identify women at high risk of breast cancer. J Clin Oncol 2015;33:3137-43.
20. Lydick E, Cook K, Turpin J, Melton M, Stine R, Byrnes C. Development and validation of a simple questionnaire to facilitate identification of women likely to have low bone density. Am J Manag Care 1998;4:37-48.
21. Kanis JA. Assessment of osteoporosis at the primary health care level. WHO Scientific Group technical report. Sheffield, United Kingdom: World Health Organization Collaborating Centre for Metabolic Bone Diseases, University of Sheffield, 2007.
22. Braun L. Breathing race into the machine: The surprising career of the spirometer from planation to genetics. Minneapolis: University of Minnesota Press, 2014.
23. Kumar R, Seibold MA, Aldrich MC, et al. Genetic ancestry in lung-function predictions. N Engl J Med 2010;363:321-30.
24. Eberly LA, Richterman A, Beckett AG, et al. Identification of racial inequities in access to specialized inpatient heart failure care at an academic medical center. Circ Heart Fail 2019;12(11):e006214.
25. Eneanya ND, Yang W, Reese PP. Reconsidering the consequences of using race to estimate kidney function. JAMA 2019;322:113-4.
26. Hsu J, Johansen KL, Hsu C-Y, Kaysen GA, Chertow GM. Higher serum creatinine concentrations in black patients with chronic kidney disease: beyond nutritional status and body composition. Clin J Am Soc Nephrol 2008;3:992-7.
27. Levey AS, Tighiouart H, Titan SM, Inker LA. Estimation of glomerular filtration rate with vs without including patient race. JAMA Intern Med 2020;180:793-5.
28. Julian BA, Gaston RS, Brown WM, et al. Effect of replacing race with apolipoprotein L1 genotype in calculation of Kidney Donor Risk Index. Am J Transplant 2017;17:1540-8.
29. Cannon RM, Brock GN, Marvin MR, Slakey DP, Buell JF. The contribution of donor quality to differential graft survival in African American and Caucasian renal transplant recipients. Am J Transplant 2012;12:1776-83.
30. Vyas DA, Jones DS, Meadows AR, Diouf K, Nour NM, Schantz-Dunn J. Challenging the use of race in the vaginal birth after cesarean section calculator. Womens Health Issues 2019;29:201-4.
31. Kowalsky RH, Rondini AC, Platt SL. The case for removing race from the American Academy of Pediatrics clinical practice guideline for urinary tract infection in infants and young children with fever. JAMA Pediatr 2020;174:229-30.
32. Krieger N. Methods for the scientific study of discrimination and health: an ecosocial approach. Am J Public Health 2012;102:936-44.
33. VanderWeele TJ, Robinson WR. On the causal interpretation of race in regressions adjusting for confounding and mediating variables. Epidemiology 2014;25:473-84.
34. Maglo KN, Mersha TB, Martin LJ. Population genomics and the statistical values of race: an interdisciplinary perspective on the biological classification of human populations and implications for clinical genetic epidemiological research. Front Genet 2016;7:22.

35. American Association of Physical Anthropologists. AAPA statement on race & racism. March 27, 2019 (https://physanth.org/about/position-statements/aapa-statement-race-and-racism-2019/).
36. Obermeyer Z, Powers B, Vogeli C, Mullainathan S. Dissecting racial bias in an algorithm used to manage the health of populations. Science 2019;366:447-53.
37. Roberts D. Fatal invention: how science, politics, and big business re-create race in the twenty-first century. New York: New Press, 2011.
38. Yudell M, Roberts D, DeSalle R, Tishkoff S. Taking race out of human genetics. Science 2016;351:564-5.
39. Benjamin R. Race after technology: abolitionist tools for the new Jim code. Medford, MA: Polity, 2019.
40. Angwin J, Larson J, Mattu S, Kirchner L. Machine bias. ProPublica. May 23, 2016 (https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing).
41. Dieterich W, Mendoza C, Brennan T. COMPAS risk scales: demonstrating accuracy equity and predictive parity. Northpointe. July 8, 2016 (http://go.volarisgroup.com/rs/430-MBX-989/images/ProPublica_Commentary_Final_070616.pdf).
42. Kaplan JB, Bennett T. Use of race and ethnicity in biomedical publication. JAMA 2003;289:2709-16.
43. Morris JE, Grubbs V, Hahn M, Richmond S. Abolish race-based medicine in kidney disease and beyond. San Francisco Examiner. November 27, 2019 (https://www.sfexaminer.com/opinion/abolish-race-based-medicine-in-kidney-disease-and-beyond/).
44. UW Medicine to exclude race from calculation of eGFR (measure of kidney function). University of Washington, Department of Medicine, May 29, 2020 (https://medicine.uw.edu/news/uw-medicine-exclude-race-calculation-egfr-measure-kidney-function).
45. Tsai J. What role should race play in medicine? Scientific American. September 12, 2018 (https://blogs.scientificamerican.com/voices/what-role-should-race-play-in-medicine/).
46. Jones CP. Toward the science and practice of anti-racism: launching a national campaign against racism. Ethn Dis 2018;28:231-4.

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