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Race, Sex, and Age Disparities in Outpatient Dermatology Encounter Work Relative Value Units and Net Payments

By

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Abstract

Race, Sex, and Age Disparities in Outpatient Dermatology Encounter Work Relative Value Units and Net Payments

By Lauren Anne Vigil Orenstein, M.D.

This abstract and much of this thesis' text were originally published in *JAMA Dermatology.*

Clinical productivity measures may influence financial incentives to cater to specific patient populations and perpetuate inequitable healthcare. To evaluate the relationship between work relative value units (wRVUs) generated by outpatient dermatology encounters and patient race, age, and sex, this retrospective cross-sectional study evaluated administrative billing data from The Emory Clinic in Atlanta, GA. The primary dataset included 66,463 general outpatient dermatology encounters among 30,036 unique patients that occurred between September 1, 2016 and March 31, 2020. Study patients had mean age of 55.9 (SD: 18.5) years, were predominantly female (59.6%) and white (70.1%). In the general dermatology practice, the mean wRVUs per encounter was 1.40 (SD: 0.71). In adjusted analysis, non-white race, female sex, and younger age were associated with fewer wRVUs per outpatient dermatology encounter. Compared to general dermatology visits with white patients, visits with Black patients generated 0.267 (95% CI: 0.254-0.280) fewer wRVUs/encounter, visits with Asian patients generated 0.221 (95% CI: 0.195-0.247) fewer wRVUs/encounter, and visits with patients of other race generated 0.191 (95% CI: 0.142-0.239) fewer wRVUs/encounter. Female sex was also associated with 0.111 (95% CI: 0.101-0.122) fewer wRVUs per encounter, and RVUs/encounter increased by 0.006 (95% CI: 0.006-0.006) with each 1-year increase in age. In the general dermatology practice excluding Mohs surgeons, destruction of premalignant lesions and biopsies were strong mediators for the observed race, age, and sex differences. In a dataset including encounters with Mohs surgeons, the race, age, and sex differences in wRVUs/encounter were greater than in the general dermatology dataset, and Mohs for basal cell and squamous cell carcinomas was a strong mediator for the observed race, age, and sex differences. This study demonstrated that dermatology encounters among persons of color, women, and younger patients generate fewer wRVUs than those with older white males. Physician compensation based on wRVUs may encourage provision of services that exacerbate differential access to care and dermatologic healthcare disparities.

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INTRODUCTION

Healthcare equity is an important goal in American healthcare. The sources of healthcare disparities in the United States are complex and occur at many different levels including payors, health systems, and healthcare providers. In its 2003 report "Unequal Treatment: Confronting Racial and Ethnic Disparities in Healthcare," the Institute of Medicine examined racial and ethnic disparities in health, evaluated their causes, and provided recommendations for reducing healthcare disparities (2). One of these recommendations (Recommendation 5-7) was to "Structure payment systems to ensure an adequate supply of services to minority patients and limit provider incentives that may promote disparities (2)."

Within the field of dermatology, persons of color suffer from lower access to outpatient care (3) and providers with less training in diagnosing and treating dermatologic diseases in skin of color (4). Black and Latinx patients are less likely to receive outpatient care for their skin problems (3), and in the largest clinical registry of dermatology patients in the US they comprise only 3.2% and 2.7% of patients, respectively (5). Race has also been shown to influence treatment choices. In psoriasis, patients of Black race are less likely to receive biologic medications, the class of treatments with the highest efficacy in psoriasis (6). In acne, persons of color are more likely than fair skinned patients to be left with skin darkening due to post-inflammatory hyperpigmentation after resolution of acne. Despite this additional morbidity from acne, racial and ethnic minorities are less likely to receive systemic acne therapies, which are often more efficacious than topical acne treatments alone (7).

Many factors may contribute to disparities in dermatologic care in the United States, including insurance type, financial incentives, and low racial diversity among practicing dermatologists (8). However, no studies to date have evaluated financial incentives at the provider and practice level that may influence access to dermatologic care. In this retrospective cross-sectional study, we analyzed administration and billing data from 66,463 patient encounters that occurred from September 1,2016 - March 31,2020 at The Emory Dermatology Clinic (1). These data were used to assess the association between patient race and clinical “productivity” measured in work Relative Value Units.

BACKGROUND

The American healthcare system is one of the most expensive yet least equitable in the developed world, contributing to increased healthcare costs, decreased quality of life, and poor outcomes among economically disadvantaged groups and persons of color (9). Financial incentives have the potential to influence healthcare providers' behaviors and choices, serving as a powerful mechanism to either reinforce or combat structural racism (10). For example, lower payment rates through specific insurers may reduce the supply of health providers who accept that insurance, reduce the amount of time spent by providers during medical encounters for individuals with that insurance type, or even drive decisions about the communities in which medical practices are built. Such factors reduce access to care among low-income individuals and have a disproportionate effect on persons of color. To elucidate the relationship between financial incentives and provider behavior, one must first understand the current payment system.

The modern American medical payment system began with the Omnibus Budget Reconciliation Act of 1989, which established the national Medicare Fee Schedule. This national fee schedule differed from the previous local and regionally determined Medicare fees and established a new methodology based on academic survey research (11). This fee schedule was intended to incorporate two major principles: 1) the relative costs of providing services (the Resource-Based Relative Value Scale) and 2) physician time and effort for each service (weighted using Relative Value Units). Subsequently, the American Medical Association Specialty Society Relative Value Scale Update Committee (RUC) offered to advise the Center for Medicare and Medicaid Services (CMS) on the relative weights used to calculate physician payments, measured in

Relative Value Units (RVUs). Each service is identified using a Current Procedural Terminology (CPT) code.

Today, the RUC continues to make recommendations to CMS on RVUs used to calculate Medicare payments, and these recommendations are generally accepted by CMS (12). The impact of RUC and CMS on determining provider incentives extends well beyond Medicare alone. The RVU weights influence private insurer fee schedules and are used by many hospital systems as indicators of clinical "productivity" to compare the revenue generated by individual physicians. Today, fee-for-service practices, the US Department of Veterans Affairs health care system, and many academic institutions use RVUs as benchmarks when establishing provider compensation. Thus, RUC indirectly influences financial incentives to provide specific medical services across the health sector.

Higher relative values for CPT codes that are associated with differential utilization by race and sex could inadvertently incentivize, or at least reinforce, structural inequities. Prior work has highlighted the role that RUC has played in assigning higher relative values to procedures over cognitive work and the resulting elevated salary of providers in procedural medical specialties compared with non-procedural medical specialties (13). Further, patient characteristics may influence the determination of work values. For instance, mean total RVUs for female-only urologic services were substantially lower than male-only urology services (139.5 vs. 207.1) (14). It remains unknown whether patient race, sex, and age are associated with RVUs or net payments in outpatient dermatology visits.

Dermatology has one of the highest hourly wages of any medical speciality (15). Profit in dermatology is largely driven by a high volume of outpatient procedures such as cryotherapy for premalignant actinic keratoses (AKs) and skin biopsies for detection of skin cancers (16). AKs are present in approximately 12% of the US population and carry a very low risk of progression to squamous cell skin cancer (SCC) (<0.1% per year) (17). No gold standard for treatment of AKs exist. Fee-for-service models incentivize treatment with cryotherapy, in which liquid nitrogen is sprayed on the lesion for 3-5 seconds and generates 0.61 RVUs, as compared to 0.70 RVUs for a 10-19 minute established patient visit (18).

Keratinocyte skin cancers, encompassing basal cell carcinomas (BCCs) and SCCs, are the most common type of malignancy in the United States. BCCs and SCCs are most common in males with fair skin, and their incidence increases with age.(19) Keratinocyte skin cancers account for approximately 4% of all cancer healthcare expenditures, leading to billions of dollars in spending (20). BCCs may be locally invasive but do not increase all-cause mortality (21). SCCs have a disease-specific mortality of approximately 2.1% over 50 months of follow-up (22). Although AKs, BCCs, and SCCs have very low overall mortality, they are exceedingly common among individuals with fair skin and account for a large proportion of healthcare spending in the United States.

By contrast, many inflammatory skin diseases such as hidradenitis suppurativa (23), scleroderma (24), and atopic dermatitis (25) disproportionately affect persons of color and may severely alter quality of life. Encounters for complex inflammatory skin diseases such as hidradenitis suppurativa rarely involve procedures and can be quite time

consuming in order to address issues such as shared decision making for high risk therapeutics, pain management, associated mental health disorders, and medical comorbidities (26). In the 2020 reimbursement model, encounters for patients such as this typically required at least 25 minutes of face to face care and 15 minutes for documentation and coordination of care but were only valued at 1.5 RVUs (CPT: 99214). In 2020, freezing a single actinic keratosis was valued at >0.6 RVUs per minute of work, whereas a medically complex visit as described above was valued at approximately 0.0375 RVUs per minute (18). Thus, current reimbursement models in dermatology provide financial incentives to have a procedurally-oriented practice.

In the United States, persons of color are much less likely to access outpatient care for their dermatologic problems (3,5). We hypothesized that current payment models and RVU assignments may structurally disincentivize dermatologists from providing services that are geared towards persons of color and that treatment of AKs and detection of BCCs and SCCs were a major driver of disparities in valuation of encounters by patient race. To test these hypotheses, we performed a cross-sectional analysis of administrative and billing data from The Emory Dermatology Clinic to assess the association between patient race and clinical "productivity" measured in work Relative Value Units (wRVUs). We also evaluated the influence of patient sex and age on wRVUS generated per outpatient dermatology encounter.

METHODS

The primary aim of this retrospective cross-sectional study was to determine the association between patient race, sex, and age (exposures) and clinical "productivity," measured as wRVUs generated per outpatient dermatology visit (Figure 1). In the case that differences in wRVUs per encounter differed by patient race, sex, or age, we also sought to determine procedures and diagnoses that mediated these differences.

Study Design, Inclusion Criteria, and Exclusion Criteria

This retrospective cross-sectional study evaluated electronic health record demographic and billing data from all adult outpatient dermatology encounters at The Emory Clinic that occurred between September 1, 2016 to March 31, 2020. The Emory Clinic is an academic dermatology practice in Atlanta, Georgia that serves patients across the Southeastern US. Exclusion criteria included: inpatient visits, nursing or post-operative encounters, phototherapy visits, cosmetic procedures, age <18, encounters with multiple providers, a zero or negative wRVU total, and encounters missing patient age, race, or sex. This evaluation focused on financial incentives for general dermatologists without an affiliated Mohs practice, and so encounters with Mohs surgeons were excluded from the primary dataset, but these encounters were added back for a sensitivity analysis.

Measurements

The primary outcome for this analysis was wRVUs generated per encounter. Exposures included patient race, age in years, and sex. Analyses were also adjusted for the confounder of insurance type.

Race was extracted from the electronic health record and categorized as Caucasian/white, African American/Black, Asian, or Other. The category Other Race included individuals of Native American, Native Hawaiian or Other Pacific Islander or multiple race. Insurance type was captured through billing data and categorized as Medicaid, Medicare, commercial, self-pay, or other. Because some individuals had more than one insurance type, each insurance category was included as a dichotomous variable. Encounters that were missing data about patient race, sex, or age were excluded from the primary analysis.

Encounter diagnoses were described according to International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10) codes and procedures were defined using CPT codes. Because we hypothesized that disparities would result from treatment of premalignant lesions and diagnosis of keratinocyte carcinomas, we pre-specified mediation analyses for premalignant destruction, skin biopsies, neoplasms of uncertain behavior, and skin cancers (see Table XX).

Sample-size and power considerations

We estimated the sample size needed for this study focusing on the difference in mean wRVUs per visit for Black patients compared to white patients using a two-sample t test for the mean difference. Assuming that the mean wRVUs per visit for white patients is 1.50 and a standard deviation of 0.70, then with 80% power at $\alpha = 0.05$, we would need at least 771 visits for Black patients and 771 visits for white patients to detect that the mean wRVU difference per encounter was ≥ 0.10.

Analytic Plan

The underlying research question pertained to financial incentives for how dermatologists allocate time for care of different patient groups. Provider schedules are typically based on a fixed number of appointment slots per day, and so the primary analyses were performed at the encounter level (fixed effects) rather than at the patient level.

Descriptive statistics were calculated, including means and standard deviations for continuous variables and frequencies and percentages for categorical variables. Encounter characteristics were stratified by race, and P-values for continuous variables were calculated by 1-way analysis of variance. P-values for categorical variables were calculated by chi-squared test of independence or Fisher exact test. The distribution of the primary outcome variable of wRVUs per encounter was evaluated and Akaike information criterion (AIC) informed our decision to model this outcome using the normal distribution.

Crude associations between encounter wRVUs and patient race, patient sex, patient age, and insurance type were assessed using bivariable normal linear regressions. Because many individuals used more than one insurance plan, insurance type was not easily collapsed into a single variable and instead five dichotomous variables were used to assess for the presence or absence of each insurance type: commercial insurance, Medicare, Medicaid, self-pay, and other. Formulas for models used to determine crude associations between the covariates and wRVUs per encounter are given in Table 2.

Multivariable normal linear regression was used to determine the adjusted associations between wRVUs and exposures including age, sex, race, and insurance types. The formula for this regression is given below, and the directed acyclic graphs

are given in **Figure 1**. E-values were calculated to determine the strength that an unknown confounder would need to have to eliminate the observed associations of wRVUs with race and sex (27–29).

Regression model:

$$wRVUs = \beta_0 + \beta_1\,(Black\ race) + \beta_2\,(Asian\ race) + \beta_3\,(Other\ race) + \beta_4\,(Female\ sex) + \beta_5\,(Age) + \beta_6\,(Commercial\ Insurance) + \beta_7\,(Medicare) + \beta_8\,(Medicaid) + \beta_9\,(Self\ pay) + \beta_{10}(Other\ insurance\ type)$$

Where:

Black race: Coded as 1 if patient reported Black race, 0 if not Black race
Asian race: Coded as 1 if patient reported Asian race, 0 if not Asian race
Other race: Coded as 1 if patient reported of Native American, Native Hawaiian or Other Pacific Islander or multiple race; Otherwise 0.
Female sex: Coded 1 if female, 0 if male
Age: Age in years at the time of the encounter
Commercial Insurance: 1 present, 0 absent
Medicare: 1 present, 0 absent
Medicaid: 1 present, 0 absent
Self-pay: 1 if no insurance type present, 0 if insurance present
Other insurance type: 1 present, 0 absent

Mediation analysis by the difference method (30) was applied to determine the contribution of skin biopsies and premalignant destructions to the observed age, race, and sex disparities in wRVUs (see Figure 2). This approach relies isolating the Direct Effect of an exposure on the outcome from the indirect or mediated effect. The Direct Effect is the relationship between the exposure and the outcome that persists even after considering the mediator. The Indirect Effect is the association between the exposure and outcome that is due to the mediator. The Total Effect of each exposure (race, sex, and age) on the outcome of wRVUs per encounter is given by a regression of the outcome (wRVUs) on the exposures (race, sex, or age) and covariates (insurance types).

[Equation 1] for Total Effect: $wRVUs = \beta_0 + \beta_1\,(Black\ race) + \beta_2\,(Asian\ race) + \beta_3\,(Other\ race) + \beta_4\,(Female\ sex) + \beta_5\,(Age\ in\ years) +$

$$\beta_6\,(Commercial\ Insurance)\ +\beta_7\,(Medicare)\ +\beta_8\,(Medicaid)\ +\\ \beta_9\,(Self\ pay)\ +\beta_{10}(Other\ insurance\ type)$$

In Equation 1, the total effect of a patient having Black race compared to white race on wRVUs per encounter is given by the coefficient β_1. The model used to determine the Direct Effect of each exposure on the outcome of wRVUs is given by adding the mediator (premalignant destruction or biopsy) to the model:

[Equation 2] for Direct Effect: $$wRVUs = \theta_0 + \theta_1\,(Black\ race) +\\ \theta_2\,(Asian\ race) + \theta_3\,(Other\ race)\ +\theta_4\,(Female\ sex)\ +\theta_5\,(Age\ in\ years) +\\ \theta_6\,(Commercial\ Insurance)\ +\theta_7\,(Medicare)\ +\theta_8\,(Medicaid)\ +\\ \theta_9\,(Self\ pay)\ +\theta_{10}(Other\ insurance\ type) +\\ \theta_{11}(Premalignant\ Destruction\ or\ Biopsy)$$

In Equation 2, the direct effect of a patient having Black race compared to white race on wRVUs per encounter is given by the coefficient θ_1. If the absolute value of the exposure coefficient β_1 goes down substantially compared to θ_1, then this suggests mediation. That is, the mediator explains some of the effect of the exposure on the outcome. The difference in these coefficients is interpreted as the mediated or indirect effect:

[Equation 3] $$Mediated\ Effect\ = Total\ Effect - Direct\ Effect$$

Following the example above the fraction of the relationship between Black race and wRVUs that was mediated by premalignant destruction or biopsy is given by:

[**Equation 4]** $$Mediated\ Effect = \beta_1 - \theta_1$$

[Equation 5] $$Proportion\ of Mediated = \frac{Mediated\ Effect}{Total\ Effect} = \frac{\beta 1 - \theta 1}{\beta 1}$$

Bootstrapping for 200 cycles with replacement was performed to estimate 95% confidence intervals for the mediation analyses.

The Emory University institutional review board approved this study. This study followed guidelines from the Strengthening of the Reporting of Observational Studies in

Epidemiology Statement. All analyses were performed using SAS version 9.4 (SAS Institute Inc.), Python (version 3.6.8), and R (version 3.6.3).

RESULTS

General dermatology practice (excluding encounters with Mohs surgeons)

In the general outpatient dermatology practice, there were 66,463 encounters among 30,036 unique patients (**Figure 3**). Patients had mean age of 55.6 (SD: 18.5) years and were predominantly white (46,575; 70.1%) and female (39,598; 59.6%) **(Table 3)**. Age, insurance type, skin cancer diagnosis, and procedures varied significantly by race.

The mean wRVUs per encounter was 1.40 (SD: 0.71) for this general dermatology practice. In adjusted analysis, increasing age, male sex, and white race were independently associated with higher wRVUs (**Table 4)**. Dermatology encounters with Black patients were associated with 0.27 (95% CI 0.25-0.28) fewer wRVUs per encounter; those with Asian patients were associated with 0.22 (95% CI 0.20-0.25) fewer wRVUs; those with patients of other race were associated with 0.19 fewer (95% CI 0.14-0.24) wRVUs. Encounters with female patients were associated with 0.11 (95% CI: 0.10-0.12) fewer wRVUs per encounter compared to males. For every 1-year increase in age, encounters generated 0.006 more wRVUs (95% CI 0.006-0.006). E-values were calculated to determine the strength that an unmeasured confounder would need to have to eliminate the observed race and sex differences in wRVUs, ranging from 1.57-2.26 (see **Table 5)**.

Race, sex, and age differences were also observed in adjusted models with the outcome of net payments. The mean net payment was $133.39 (SD $112.74). Encounters with Black patients paid $28.25 less (95% CI: $26.26-$30.24) compared to white

patients and encounters with women paid $9.76 less (95% CI: $8.07-$11.45) compared to men (**Table 6).**

In mediation analysis of the general dermatology practice, destruction of premalignant lesions and biopsies accounted of 82.3% (95% CI:72.7-93.1) of sex differences in wRVUs, 65.6% (95% CI: 60.5-71.4) of age differences, and over half of racial differences (56.2% [95% CI: 53.1-59.3] for Black race, 53.2% [95% CI: 45.6-63.8] for Asian race, and 53.6% [95% CI: 40.4-77.4] for other race) (**Table 7)**.

Sensitivity analyses using multiple imputation for the 8,036 non-Mohs encounters that were missing race were performed and did not alter the primary study findings or conclusions of mediation analyses (**Tables 8 and 9**). Sensitivity analysis using a generalized estimate equation model was also performed to evaluate for wRVU clustering at the patient level and did not alter study findings (**Table 10**).

Combined dermatology practice (including encounters with Mohs surgeons)

In the combined outpatient dermatology practice including Mohs surgeons and general dermatologists, there were 72,012 encounters among 30,427 unique patients (**Table 11**). The mean wRVUs per encounter was 1.89 (SD: 2.63). In adjusted analysis, increasing age, male sex, and white race were independently associated with higher wRVUs. The magnitudes of the age, sex, and race differences in wRVUs per encounter were greater than in the dataset that excluded the Mohs practice (**Table 12)**.

In mediation analysis for the combined practice dataset, Mohs surgery for basal cell carcinomas and squamous cell carcinomas accounted for 47.9% (95% CI: 42.0-54.6) of sex differences, 49.2% (95% CI: 44.9-53.7) of age differences, and similar

proportions of racial differences (46.0% [95% CI: 42.6-49.4] for Black race, 41.9% [95% CI: 35.5-49.2] for Asian race, and 34.6% [95% CI: 13.8-51.5] for other race).

DISCUSSION

This single institution study demonstrated that outpatient dermatology visits for patients who were younger, female, and persons of color generated significantly fewer wRVUs than those for older white men. In the general dermatology practice excluding encounters with Mohs surgeons, these wRVU differences were traced to destruction of premalignant lesions and biopsies. The magnitude of differences in wRVUs generated by patient race, sex, and age was even greater in the combined practice including general dermatologists and Mohs surgeons. After including the embedded Mohs practice, Mohs surgery for BCCs and SCCs strongly mediated the race, sex, and age potential disparities. The observed wRVU differences highlight the relative under-valuation of care for inflammatory skin diseases that strongly influence quality of life and disproportionately affect underserved populations. (23–25)

RVUs were initially developed for a specific purpose within Medicare, and only later were adopted by private insurers. Now, fee-for-service practices, the Veterans Administration health system, and many academic institutions use RVUs internally as benchmarks to assess individual clinician "productivity" and determine compensation. Such financial incentives are likely to influence physician behavior and may even affect healthcare access and outcomes (10). For example, when one academic pediatric practice transitioned to RVU-based compensation, 90% of faculty increased their clinical "productivity"(31).

Assigning relatively higher value to skin biopsies and premalignant destructions compared to medical dermatology visits has the potential to drive provider behaviors that insidiously reinforce disparities in access to dermatologic care. Physicians

may gravitate towards providing biopsies and destruction of actinic keratoses, which generate relatively high wRVUs compared to the time required to perform these procedures. Otherwise, dermatologists will need to see many more patients to appear similarly "productive." Such a valuation system creates financial incentives to cater to patients most likely to develop non-melanoma skin cancers (NMSCs) – that is older, white males. These incentives may influence the communities in which dermatologists choose to practice, the skill set that dermatologists choose to advertise, and even the decision to pursue procedural fellowships.

Prior literature suggests that access to dermatologic care is highest in settings where the potential for profit is highest. For example, dermatology practices are most numerous in wealthy urban communities (32). The Mohs Micrographic Surgery fellowship, is another example. This fellowship trains graduates to perform specialized surgery for non-melanoma skin cancers and is highly desirable among graduating dermatology residents. In 2019, 82 Mohs fellowship positions were offered, 81 (99%) were filled, and 81/144 (56%) applicants matched. Pediatric dermatology, on the other hand, pays a much lower salary due to fewer procedures. In 2019, 30 pediatric dermatology fellowship positions were offered, 12 (40%) were filled, and all applicants (100%) matched. Ultimately, the financial incentives to provide procedural services for non-melanoma skin cancers dermatologic conditions that primarily affect older white men may drive overutilization of procedures and reduced access to care for persons of color, perpetuating structural racism (33).

Limitations

From the perspective of a general dermatologist with a set number of daily appointments, this study demonstrates a financial incentive to care for populations that are at highest risk for developing NMSCs. This financial incentive may influence dermatologists' selection of practice location and reduce access to care for individuals at lower risk of developing skin cancers. Determining whether these RVU differences is justified is beyond the scope of this study and ultimately must be decided by the specialty. Justifying these structural incentives to care for patients at highest risk of NMSCs seems to rely on one of two arguments 1) that treating NMSCs has higher intrinsic value or 2) that screening for NMSCs requires more effort and expertise than managing inflammatory skin diseases. Additional analyses to evaluate differences in the number of wRVUs generated *per unit time* by patient race, sex, and age would provide evidence for the differential effort required to provide dermatologic care for these patient populations. Outside of wRVU assignments, there are certainly additional components of structural racism that influence disparities in access to dermatologic care. Additional work is needed to elucidate these additional contributors and examine interventions to improve racial equity in dermatology.

Additionally, these findings may not be representative of other practices. However, RVUs are assigned on a national level, likely leading to similar disparities in other settings. Further, wRVUs are not a direct measure of financial compensation, which varies by payer. Nonetheless, wRVUs were selected as the primary outcome over direct collections because: 1) collections may be confounded by non-patient related factors such as local collection practices and negotiated rates with the health system,

which may not generalize as well to other centers and 2) revising wRVU valuations could be an actionable strategy to mitigate structural disparities. Our study is also limited by its observational design, which cannot account for unmeasured confounders. The database also lacked patient ethnicity.

This study used hypothesis driven methods to identify CPT codes explaining the differences in wRVUs by race, sex, and age. Future studies could use data driven methods such as regularization and variable selection techniques (34) to empirically identify the minimum set of procedural and diagnostic codes that explain the observed wRVU differences by race, sex, and age.

Finally, CMS has implemented major changes to the coding system which began in January 2021. The new system places relatively higher value on medical decision making, which we anticipate will mitigate some of the observed race, sex, and age differences in wRVUs and net payments. Additional work is needed to determine the true impact of the new coding system.

Conclusion

The Institute of Medicine's landmark report on disparities in healthcare access specifically noted the need to "limit provider incentives that may promote disparities."(2) In an academic outpatient dermatology clinic, visits for older white males generated significantly more wRVUs compared to visits for patients who were younger, had skin of color, or were female. Further research is needed to determine the role that such differences may have in perpetuating disparate access to dermatologic care, to elucidate the role of the RUC and RVUs in dermatologic healthcare disparities, and confirm whether these findings are replicated across institutions.

REFERENCES

1. Orenstein LA V, Nelson MM, Wolner Z, et al. Differences in Outpatient Dermatology Encounter Work Relative Value Units and Net Payments by Patient Race, Sex, and Age. *JAMA Dermatology*. 2021;30322:1–7.
2. Smedley BD, Stith AY, Nelson AR. Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care. 2003 1–764 p.
3. Tripathi R, Knusel KD, Ezaldein HH, et al. Association of demographic and socioeconomic characteristics with differences in use of outpatient dermatology services in the United States. *JAMA Dermatology*. 2018;154(11):1286–1291.
4. Ebede T, Papier A. Disparities in dermatology educational resources. *J. Am. Acad. Dermatol.* 2006;55(4):687–690.
5. VanBeek M, Swerlick RA, Mathes B, et al. 2020 Annual Report of DataDerm™: The Database of The American Academy of Dermatology (AAD). *J. Am. Acad. Dermatol.* 2020;
6. Takeshita J, Gelfand JM, Li P, et al. Psoriasis in the U.S. Medicare population: prevalence, treatment, and factors associated with biologic use HHS Public Access. *J Invest Dermatol*. 2015;135(12):2955–2963.
7. Barbieri JS, Shin DB, Wang S, et al. Association of Race/Ethnicity and Sex with Differences in Health Care Use and Treatment for Acne. *JAMA Dermatology*. 2020;156(3):312–319.
8. Xierali IM, Nivet MA, Pandya AG. US Dermatology Department Faculty Diversity Trends by Sex and Underrepresented-in-Medicine Status, 1970 to 2018. *JAMA Dermatology*. 2020;156(3):280–287.

9. Blendon RJ, Schoen C, DesRoches CM, et al. Inequities in health care: A five-country survey. *Health Aff.* 2002;21(3):182–191.

10. Armour BS, Pitts MM, Maclean R, et al. The effect of explicit financial incentives on physician behavior. *Arch. Intern. Med.* 2001;161:1261–1266.

11. Schroeder SA, Sandy LG. Specialty Distribution of U.S. Physicians -- The Invisible Driver of Health Care Costs. *N. Engl. J. Med.* 1993;328(13):961–963.

12. Laugesen MJ, Wada R, Chen EM. In setting doctors' Medicare fees, CMS almost always accepts the relative value update panel's advice on work values. *Health Aff. (Millwood).* 2012;31(5):965–72.

13. Langer AL, Laugesen M. Billing Codes Determine Lower Physician Income for Primary Care and Non-Procedural Specialties. *Forum Health Econ. Policy*. 2019;22(2).

14. Cherouny P, Nadolski C. Underreimbursement of obstetric and gynecologic invasive services by the resource-based relative value scale. *Obstet. Gynecol.* 1996;87(3):328–31.

15. Eltorai AEM, Eltorai AS, Fuentes C, et al. Financial Implications of Physician Specialty Choice. *R. I. Med. J. (2013)*. 2018;101(8):50–55.

16. Adamson AS, Dusetzina SB. Characteristics of medicare payments to dermatologists in 2013. *JAMA Dermatology*. 2017;153(1):95–97.

17. Siegel JA, Korgavkar K, Weinstock MA. Current perspective on actinic keratosis: a review. *Br. J. Dermatol.* 2017;177(2):350–358.

18. Centers for Medicare & Medicaid Services. Search the Physician Fee Schedule. (https://www.cms.gov/medicare/physician-fee-

schedule/search?Y=0&T=4&HT=0&CT=3&H1=99212&M=5). (Accessed February 27, 2021)

19. Rogers HW, Weinstock MA, Feldman SR, et al. Incidence estimate of nonmelanoma skin cancer (keratinocyte carcinomas) in the us population, 2012. *JAMA Dermatology*. 2015;151(10):1081–1086.

20. Machlin S, Carper K, Kashihara D. Health Care Expenditures for Non-Melanoma Skin Cancer among Adults, 2005-2008 (Average Annual). 2011;(Health Care Expenditures for Non-Melanoma Skin Cancer among Adults, 2005-2008 (Average Annual)). (Accessed February 27, 2021)

21. Wehner MR, Cidre Serrano W, Nosrati A, et al. All-cause mortality in patients with basal and squamous cell carcinoma: A systematic review and meta-analysis. *J. Am. Acad. Dermatol.* 2018;78(4):663-672.e3.

22. Schmults CD, Karia PS, Carter JB, et al. Factors predictive of recurrence and death from cutaneous squamous cell carcinoma: A 10-year, single-institution cohort study. *JAMA Dermatology*. 2013;149(5):541–547.

23. Garg A, Kirby JS, Lavian J, et al. Sex- and Age-Adjusted Population Analysis of Prevalence Estimates for Hidradenitis Suppurativa in the United States. *JAMA Dermatology*. 2017;153(8):760.

24. Moore DF, Kramer E, Eltaraboulsi R, et al. Increased Morbidity and Mortality of Scleroderma in African Americans Compared to Non–African Americans. *Arthritis Care Res.* 2019;71(9):1154–1163.

25. Mei-Yen Yong A, Tay YK. Atopic Dermatitis: Racial and Ethnic Differences. *Dermatol. Clin.* 2017;35(3):395–402.

26. Jedrzejczak MJ, Ingram JR, Lowes MA, et al. Expert Knowledge, Attitudes, and Practices in Management of Hidradenitis Suppurativa Pain. *JAMA Dermatology*. 2021;

27. Chinn S. A simple method for converting an odds ratio to effect size for use in meta-analysis. *Stat. Med.* 2000;19(22):3127–31.

28. VanderWeele TJ, Ding P. Sensitivity Analysis in Observational Research: Introducing the E-Value. *Ann. Intern. Med.* 2017;167(4):268–274.

29. VanderWeele TJ. On a Square-Root Transformation of the Odds Ratio for a Common Outcome. *Epidemiology*. 2017;28(6):e58–e60.

30. VanderWeele TJ. Mediation Analysis: A Practitioner's Guide. *Annu. Rev. Public Health*. 2016;37:17–32.

31. Andreae MC, Freed GL. Using a productivity-based physician compensation program at an academic health center: A case study. *Acad. Med.* 2002;77(9):894–899.

32. Feng H, Berk-Krauss J, Feng PW, et al. Comparison of dermatologist density between urban and rural counties in the United States. *JAMA Dermatology*. 2018;154(11):1265–1271.

33. Wang LL, Adelekun A, Taylor SC, et al. Fee-for-service and structural forces may drive racial disparities in US dermatology. *Br. J. Dermatol.* 2020;183(4):750–751.

34. Zou H, Hastie T. Regularization and variable selection via the elastic net. *J. R. Stat. Soc. Ser. B (Statistical Methodol.* 2005;67(2):301–320.

Table 1: Codes used to identify procedures and diagnoses for mediation analyses.

*Where possible, surgery type was determine by CPT code alone. However, some surgical excision

Diagnosis or Procedure	**ICD-10 or CPT Code(s)**
Procedures	
Premalignant destruction	17000, 17003, 17004
Skin biopsy	11100, 11101, 11102, 11103, 11104, 11105, 11106, 11107, 69100, 67810, 69100, 11755, 40490, 56605, 56606, 54100, 57105
Excision of malignant skin neoplasm*	11601, 11602, 11603, 11604, 11606, 11620, 11621, 11622, 11623, 11624, 11626, 11640, 11641, 11642, 11643, 11644, 11646
Excision of benign skin neoplasm*	11600, 11601, 11602, 11603, 11604, 11606, 11620, 11621, 11622, 11623, 11624, 11626, 11640, 11641, 11642, 11643, 11644, 11646
Mohs micrographic surgery	17311, 17312, 17313, 17314, 17315
Diagnoses	
Neoplasm of uncertain behavior of the skin	D48.5
Actinic keratosis	L57.0
Basal cell carcinoma	C44.01, C44.11x, C44.21x, C44.31x, C44.41, C44.51x, C44.61x, C44.71x, C44.81, C44.91
Melanoma	C43, C43.x
Squamous cell carcinoma	C44.02, C44.12xx, C44.22x, C44.32x, C44.42, C44.52x, C44.62x, C44.72x, C44.82, C44.92
Squamous cell carcinoma in situ	D04.xx, D09.8, D07.1
Other skin cancer	C4A, C4A.x, C44.0, C44.00, C44.09, C44.10x,C44.13x, C44.19x, C44.20x, C44.29x, C44.30x, C44.39x, C44.40, C44.49, C44.50x, C44.59x, C44.60x, C44.69x, C44.70x, C44.79x, C44.80, C44.89, C44.90, C44.99, C50.011, C51.8, C60.9, C76.42

CPT codes do not specify whether performed for malignancy. In those cases, we classified the excision as malignant if the encounter also had ICD diagnosis code for cutaneous malignancy (BCC, SCC, CIS, melanoma, or other malignant neoplasm of skin) and as benign excision if no cutaneous malignancy codes were present in the encounter.

Table 2: Models used to determine crude association between covariates and outcome of wRVUs per encounter

Exposure	***Reference group***	***Model***
Race	White race	wRVUs = $\beta_{0+}\beta_1$(Black)+ β_2(Asian) + β_3(Other)
Age	--	wRVUs = $\beta_{0+}\beta_1$(Age)
Sex	Male sex	wRVUs = $\beta_{0+}\beta_1$(Sex)
Commercial insurance	No commercial insurance	wRVUs = $\beta_{0+}\beta_1$(Commercial Insurance)
Medicare	No Medicare	wRVUs = $\beta_{0+}\beta_1$(Medicare)
Medicaid	No Medicaid	wRVUs = $\beta_{0+}\beta_1$(Medicaid)
Self-pay	No Self-pay	wRVUs = $\beta_{0+}\beta_1$(Self-pay)
Other	Other insurance absent	wRVUs = $\beta_{0+}\beta_1$(Other Insurance)

Table 3: Patient and Visit Characteristics for Outpatient Encounters in a General Dermatology Practice, Excluding Mohs Surgeons[a]

	Total	**White**	**Black**	**Asian**	**Other**	P-value[b]
All encounters, n (%)	66,463 (100.0)	46,575 (70.1)	16,273 (24.5)	2,831 (4.3)	784 (1.2)	--
Male patient encounters, n (%)	26,865 (40.4)	20,732 (44.5)	4,631 (28.5)	1,196 (42.3)	306 (39.0)	<0.0001
Age in years, mean (SD)	55.9 (18.5)	58.0 (18.4)	52.5 (17.6)	44.4 (18.2)	44.1 (16.9)	<0.0001
RVUs per encounter, mean (SD)	1.40 (0.71)	1.50 (0.74)	1.18 (0.55)	1.19 (0.60)	1.22 (0.53)	<0.0001
Net Payments per encounter, mean (SD)	$133.39 (112.74)	$145.57 (119.81)	$103.02 (86.53)	$111.46 (92.78)	$119.24 (92.11)	<0.0001
Insurance, n (%)[c]						
Commercial	51,490 (77.5)	37,595 (80.7)	10,745 (66.0)	2,479 (87.6)	671 (85.6)	<0.0001
Medicare	22,942 (34.5)	16,702 (35.9)	5751 (35.3)	391 (13.8)	98 (12.5)	<0.0001
Medicaid	1,494 (2.3)	528 (1.1)	887 (5.5)	44 (1.6)	35 (1.2)	<0.0001
Self-pay	697 (1.1)	442 (1.0)	196 (1.2)	40 (1.4)	19 (2.4)	<0.0001
Other	1,210 (1.8)	826 (1.8)	328 (2.0)	46 (1.6)	10 (1.3)	0.1140
Encounter diagnoses, n (%)						
AK	10,169 (15.3)	10,102 (21.7)	29 (0.2)	8 (0.3)	30 (3.8)	<0.0001
Neoplasm of uncertain behavior	10,638 (16.0)	9,460 (20.3)	907 (5.6)	207 (7.3)	64 (8.2)	<0.0001
BCC	413 (0.6)	403 (0.9)	8 (0.1)	1 (0.0)	1 (0.1)	<0.0001
SCC	243 (0.4)	230 (0.5)	12 (0.1)	1 (0.0)	0 (0.0)	<0.0001
SCCis	111 (0.2)	101 (0.2)	9 (0.1)	1 (0.0)	0 (0.0)	<0.0001
Melanoma	210 (0.3)	194 (0.4)	10 (0.1)	6 (0.2)	0 (0.0)	<0.0001
Other malignant neoplasm	51 (0.1)	33 (0.1)	18 (0.1)	0 (0.0)	0 (0.0)	0.1434
Any skin cancer[d]	902 (1.4)	845 (1.8)	48 (0.3)	8 (0.3)	1 (0.1)	<0.0001

Procedures rendered, n (%)						
Premalignant destruction	8,092 (12.2)	8,044 (17.3)	23 (0.1)	7 (0.3)	18 (2.3)	<0.0001
Biopsy	10,935 (16.5)	9,335 (20.0)	1,267 (7.8)	260 (9.2)	73 (9.3)	<0.0001
Malignant destruction	243 (0.4)	238 (0.5)	4 (0.0)	1 (0.0)	0 (0.0)	<0.0001
Malignant excision	228 (0.3)	223 (0.5)	4 (0.0)	0 (0.0)	1 (0.1)	<0.0001
Benign excision	279 (0.4)	189 (0.4)	82 (0.5)	8 (0.3)	0 (0.0)	0.06

AK, actinic keratosis; BCC, basal cell carcinoma; SCC, squamous cell carcinoma; SCCis, squamous cell carcinoma in situ

[a] All characteristics in this table are analyzed at the encounter level, not at the level of unique patients.

[b] P-values for continuous variables given by one-way ANOVA. P-values for categorical variables given by chi-square test of independence or Fisher's exact test.

[c] Totals for insurance type exceed the total number of encounters in the cohort because more than 1 insurance type was billed in some encounters.

[d] Including BCC, SCC, melanoma, and other malignant neoplasms of the skin

Table 4: Factors associated with wRVUs Generated by Outpatient Dermatology Encounters in a General Dermatology Practice, Excluding Mohs Surgeons (2016-2020)

	wRVUs/encounter mean (SD)	**Crude β[a] (95% CI)**	**Adjusted β[a] (95% CI)**
Overall	1.40 (0.71)	--	--
Age (per year)	--	0.008 (0.008-0.008)	0.006 (0.006, 0.006)
Sex			
Male	1.51 (0.79)	Ref	Ref
Female	1.33 (0.64)	-0.173 (-0.162, -0.184)	-0.111 (-0.101, -0.122)
Race			
White	1.50 (0.74)	Ref	Ref
Black	1.18 (0.55)	-0.322 (-0.310, -0.335)	-0.267 (-0.254, -0.280)
Asian	1.19 (0.60)	-0.314 (-0.287, -0.340)	-0.221 (-0.195, -0.247)
Other	1.22 (0.53)	-0.284 (-0.235, -0.333)	-0.191 (-0.142, -0.239)
Insurance type[b]			
Commercial	1.40 (0.69)	-0.038 (-0.025, -0.051)	0.076 (0.058, 0.093)
Medicare	1.53 (0.78)	0.197 (0.186, 0.208)	0.064 (0.046, 0.082)
Medicaid	1.37 (0.76)	-0.031 (-0.068, 0.005)	0.172 (0.135, 0.209)
Self-pay	1.44 (1.20)	0.039 (-0.014, 0.092)	0.166 (0.114, 0.219)
Other	1.33 (0.62)	-0.071 (-0.031, -0.112)	0.016 (-0.024, 0.057)

[a]β estimates give the change in RVUs billed per encounter by patient characteristic.
[b]Individual patients may have multiple insurances. We therefore analyzed each insurance type as its own dichotomous variable (i.e. present or absent). For example, in the crude analysis, encounters associated with commercial insurance had 0.038 (95% CI: 0.025-0.051) fewer wRVUs than encounters without commercial insurance.

Table 5: E-values for comparison of mean differences in wRVUs

Comparison	**E-value**
Female vs. male	1.57
Black vs white race	2.26
Asian vs white race	2.03
Other race vs white race	1.94

Table 6: Factors associated with Net Payments Received for Outpatient Dermatology Encounters in a General Dermatology Practice, Excluding Mohs Surgeons

	Net Payments/encounter mean (SD)	Crude β[a] (95% CI)	Adjusted β[a] (95% CI)
Overall	$133.39 (112.74)	--	--
Age (per year)	--	0.225 (0.179, 0.271)	1.02 (0.96, 1.08)
Sex			
Male	$141.95 (121.99)	Ref	Ref
Female	$127.58 (105.62)	-14.36 (-12.62, -16.10)	-9.76 (-8.07, -11.45)
Race			
White	$145.57 (119.81)	Ref	Ref
Black	$103.02 (86.53)	-42.55 (-40.56, -44.53)	-28.25 (-26.26, -30.24)
Asian	$111.46 (92.78)	-34.11 (-29.89, -38.33)	-30.98 (-26.87, -35.10)
Other	$119.25 (92.11)	-26.33 (-18.48, -34.17)	-21.33 (-13.73, -28.94)
Insurance type[b]			
Commercial	$147.51 (118.70)	62.66 (60.67, 64.67)	46.82 (44.07, 49.57)
Medicare	$112.57 (80.16)	-31.79 (-30.01, -33.58)	-37.12 (-34.30, -39.94)
Medicaid	$77.24 (67.38)	-57.44 (-51.68, -63.21)	-4.71 (-10.61, 1.18)
Self-pay	$45.68 (103.20)	-88.63 (-80.25, -97.02)	-64.31 (-56.05, -72.58)
Other	$124.19 (96.22)	-9.37 (-2.96, -15.78)	10.50 (4.14, 16.86)

[a]β estimates give the change in net payments per encounter by patient characteristic.
[b]Individual patients may have multiple insurances. We therefore analyzed each insurance type as its own dichotomous variable (i.e. present or absent). For example, in adjusted analysis, encounters associated with commercial insurance reimbursed $46.82 (95% CI: 44.07 - 49.57) more per encounter than encounters without commercial insurance.

Table 7: Proportion of wRVU Differences Explained by Procedures in a General Dermatology Practice, Excluding Mohs Surgeons[a]

	Age	Female sex	Black race	Asian race	Other race
Destruction of premalignant lesion	0.429 (0.385, 0.472)	0.602 (0.523, 0.693)	0.312 (0.292, 0.335)	0.303 (0.249, 0.368)	0.272 (0.198, 0.405)
Biopsy	0.263 (0.233, 0.297)	0.257 (0.204, 0.31)	0.277 (0.257, 0.299)	0.255 (0.201, 0.326)	0.294 (0.197, 0.426)
Destruction premalignant lesion or biopsy	0.656 (0.605, 0.714)	0.823 (0.727, 0.931)	0.562 (0.531, 0.593)	0.532 (0.456, 0.638)	0.536 (0.404, 0.774)
Malignant destruction	0.011 (0.007, 0.017)	0.017 (0.009, 0.029)	0.01 (0.007, 0.014)	0.01 (0.005, 0.017)	0.012 (0.008, 0.02)
Malignant neoplasm excision	0.062 (0.039, 0.087)	0.047 (0.01, 0.085)	0.048 (0.037, 0.061)	0.05 (0.038, 0.067)	0.04 (-0.036, 0.086)
Benign neoplasm excision	-0.014 (-0.036, 0.008)	0.032 (0.001, 0.062)	-0.007 (-0.024, 0.007)	0.015 (-0.021, 0.041)	0.058 (0.038, 0.088)

[a]Male sex and white race were used as reference groups.

Table 8: Factors associated with wRVUs Generated by Outpatient Dermatology Encounters, Excluding Mohs Surgeons: Sensitivity Analysis using Multiple Imputation to Include non-Mohs Participants with Missing Race[a]

	wRVUs/encounter mean (SD)	Crude β, (95% CI)	Adjusted β, (95% CI)
Overall		--	--
Age (per year)	--	0.008 (0.008, 0.008)	0.007 (0.006, 0.007)
Sex			
Male	1.49 (0.78)	Ref	Ref
Female	1.33 (0.64)	-0.158 (-0.147, -0.168)	-0.102 (-0.092, -0.112)
Race			
White/Caucasian	1.48 (0.73)	Ref	Ref
Black/African American	1.18 (0.55)	-0.298 (-0.285, -0.310)	-0.254 (-0.242, -0.267)
Asian	1.19 (0.60)	-0.289 (-0.263, -0.315)	-0.204 (-0.178, -0.229)
Other	1.22 (0.53)	-0.258 (-0.209, 0.306)	-0.173 (-0.125, -0.221)
Insurance type			
Commercial	1.39 (0.68)	-0.051 (-0.038, -0.063)	0.074 (0.057, 0.091)
Medicare	1.53 (0.77)	0.206 (0.195, 0.216)	0.060 (0.043, 0.077)
Medicaid	1.37 (0.74)	-0.023 (-0.057, 0.011)	0.173 (0.138, 0.208)
Self-pay	1.41 (1.15)	0.013 (-0.033, 0.058)	0.130 (0.084, 0.175)
Other	1.33 (0.61)	-0.064 (-0.025, -0.102)	0.021 (-0.017, 0.060)

[a] Sensitivity analysis included 8,036 non-Mohs patients with missing race, for a total sample size of 74,499 encounters. Race was imputed using age, sex, insurance status, and home zip code.

Table 9: Sensitivity Analysis for wRVU Differences Explained by Procedures, using Multiple Imputation to Include 8,036 non-Mohs Encounters Missing Race[a]

	Age	Female sex	Black race	Asian race	Other race
Destruction of premalignant lesion	0.403 (0.368, 0.441)	0.622 (0.54, 0.724)	0.312 (0.289, 0.332)	0.307 (0.262, 0.374)	0.261 (0.187, 0.352)
Biopsy	0.269 (0.234, 0.306)	0.272 (0.224, 0.325)	0.272 (0.255, 0.296)	0.251 (0.191, 0.307)	0.288 (0.174, 0.395)
Destruction premalignant lesion or biopsy	0.634 (0.588, 0.699)	0.851 (0.745, 0.97)	0.553 (0.519, 0.59)	0.528 (0.449, 0.619)	0.516 (0.382, 0.65)
Malignant destruction	0.011 (0.006, 0.016)	0.018 (0.007, 0.032)	0.01 (0.007, 0.015)	0.01 (0.004, 0.017)	0.013 (0.008, 0.02)
Malignant neoplasm excision	0.056 (0.034, 0.082)	0.054 (0.016, 0.102)	0.049 (0.039, 0.063)	0.052 (0.04, 0.065)	0.038 (-0.032, 0.084)
Destruction of malignant neoplasm	-0.011 (-0.031, 0.004)	0.023 (-0.004, 0.054)	-0.01 (-0.028, 0.006)	0.015 (-0.025, 0.05)	0.061 (0.041, 0.092)

[a]Male sex and white race were used as reference groups.

Table 10: Factors associated with wRVUs Generated by General Outpatient Dermatology Encounters, Excluding Mohs Surgeons: Sensitivity Analysis using a Generalized Estimating Equation Model to account for RVU Clustering at the Patient Level

	Crude β, Patient clustering analysis[a] (95% CI)	**Adjusted β, Patient clustering analysis[a] (95% CI)**
Age (per year)	0.006 (0.005,0.006)	0.004 (0.004, 0.005)
Sex		
Male	Ref	Ref
Female	-0.122 (-0.110, -0.134)	-0.068 (-0.058, -0.077)
Race		
White/Caucasian	Ref	Ref
Black/African American	-0.242 (-0.230, -0.254)	-0.199 (-0.189, -0.209)
Asian	-0.235 (-0.209, -0.260)	-0.162 (-0.139, -0.186)
Other	-0.210 (-0.167, -0.253)	-0.137 (-0.102, -0.171)
Insurance type		
Commercial	-0.027 (-0.013, -0.040)	0.075 (0.060, 0.091)
Medicare	0.138 (0.126, 0.149)	0.045 (0.029, 0.061)
Medicaid	-0.022 (-0.062, 0.017)	0.127 (0.093, 0.161)
Self-pay	0.027 (-0.071, 0.126)	0.146 (0.054, 0.239)
Other	-0.052 (-0.023, -0.081)	0.033 (0.003. 0.062)
[a] Sensitivity analysis included 66,463 encounters among 30,036 unique patients with a mean cluster size of 2.2.		

Table 11: Patient and Visit Characteristics for Outpatient Dermatology Encounters in a Combined Practice, Including Mohs Surgeons[a]

	Total	**White**	**Black**	**Asian**	**Other**	P-value[b]
All encounters, n (%)	72,012	51,407 (71.4)	16,867 (23.4)	2,917 (4.1)	821 (1.1)	--
Male patient encounters, n (%)	30,047 (41.7)	23,618 (45.9)	4,870 (28.9)	1,233 (42.3)	326 (39.7)	<0.0001
Age in years, mean (SD)	56.6 (18.5)	58.9 (18.3)	52.5 (17.6)	44.6 (18.3)	44.7 (17.2)	<0.0001
RVUs per encounter, mean (SD)	1.89 (2.63)	2.13 (3.00)	1.27 (1.06)	1.28 (1.19)	1.41 (1.63)	<0.0001
Net Payments/encounter, mean (SD)	$182.11 (294.85)	$208.69 (331.52)	$113.79 (154.49)	$119.80 (128.88)	$142.43 (197.64)	<0.0001
Insurance, n (%)[c]						
Commercial	55,616 (77.2)	41,224 (80.2)	11,139 (66.0)	2,550 (27.4)	703 (85.6)	<0.0001
Medicare	25,755 (35.8)	19,274 (37.5)	5,966 (35.4)	409 (14.0)	106 (12.9)	<0.0001
Medicaid	1,673 (2.3)	658 (1.3)	931 (5.5)	47 (1.6)	37 (4.5)	<0.0001
Self-pay	738 (1.0)	467 (0.9)	210 (1.3)	41 (1.4)	20 (2.4)	<0.0001
Other	1,319 (1.8)	911 (1.8)	349 (2.1)	49 (1.7)	10 (1.2)	0.0385
Encounter diagnoses, n (%)						
AK	10,731 (14.9)	10,658 (20.7)	30 (0.2)	9 (0.3)	34 (4.1)	<0.0001
Neoplasm of uncertain behavior	11,605 (16.1)	10,228 (19.9)	1,076 (6.4)	225 (7.7)	76 (9.3)	<0.0001
BCC	2,276 (3.2)	2,233 (4.3)	28 (0.2)	7 (0.2)	8 (1.0)	<0.0001
SCC	1,475 (2.1)	1,427 (2.8)	37 (0.2)	4 (0.1)	7 (0.9)	<0.0001
SCCis	424 (0.6)	403 (0.8)	16 (0.1)	4 (0.1)	1 (0.1)	<0.0001
Melanoma	336 (0.5)	317 (0.6)	11 (0.1)	7 (0.2)	1 (0.1)	<0.0001
Other malignant neoplasm	105 (0.2)	72 (0.1)	31 (0.2)	2 (0.1)	0 (0.0)	0.2424

Any skin cancer[d]	4,050 (5.6)	3,908 (7.6)	107 (0.6)	20 (0.7)	15 (1.8)	<0.0001
Procedures rendered, n (%)						
Premalignant destruction	8,366 (11.6)	8,317 (16.2)	23 (0.1)	7 (0.2)	19 (2.3)	<0.0001
Biopsy	11,513 (16.0)	9,832 (19.1)	1,332 (7.9)	266 (9.1)	83 (10.1)	<0.0001
Malignant destruction	506 (0.70)	497 (1.0)	6 (0.0)	2 (0.1)	1 (0.1)	<0.0001
Malignant excision	1,031 (1.4)	1,012 (2.0)	12 (0.1)	2 (0.1)	5 (0.6)	<0.0001
Benign excision	1,292 (1.8)	873 (1.7)	369 (2.2)	44 (1.5)	6 (0.7)	<0.0001
Mohs surgery	2,365 (3.3)	2,296 (4.5)	48 (0.3)	12 (0.4)	9 (1.1)	<0.0001

AK, actinic keratosis; BCC, basal cell carcinoma; SCC, squamous cell carcinoma; SCCis, squamous cell carcinoma in situ

[a] All characteristics in this table are analyzed at the encounter level, not at the level of unique patients.

[b] P-values for continuous variables given by one-way ANOVA. P-values for categorical variables given by chi-square test of independence or Fisher's exact test.

[c] Totals for insurance type exceed the total number of encounters in the cohort because more than 1 insurance type was billed in some encounters.

[d] Including BCC, SCC, melanoma, and other malignant neoplasms of the skin

Table 12: Factors associated with wRVUs Generated by Outpatient Dermatology Encounters in a Combined Practice, Including Mohs Surgeons

	wRVUs/ encounter mean (SD)	**Crude β[a] (95% CI)**	**Adjusted β[a] (95% CI)**
Overall	1.89 (2.63)	--	--
Age (per year)	--	0.027 (0.026, 0.028)	0.019 (0.017, 0.020)
Sex			
Male	2.25 (3.29)	Ref	Ref
Female	1.63 (1.99)	-0.626 (-0.587, -0.664)	-0.432 (-0.394, -0.471)
Race			
White	2.13 (3.00)	Ref	Ref
Black	1.27 (1.06)	-0.860 (-0.815, -0.905)	-0.652 (-0.605, -0.698)
Asian	1.28 (1.19)	-0.852 (-0.754, -0.949)	-0.511 (-0.414, -0.607)
Other	1.41 (1.63)	-0.728 (-0.549, -0.908)	-0.394 (-0.217, -0.571)
Insurance type[b]			
Commercial	1.85 (2.50)	-0.194 (-0.148, -0.240)	0.320 (0.258, 0.382)
Medicare	2.37 (3.52)	0.751 (0.711, 0.791)	0.367 (0.304, 0.431)
Medicaid	2.10 (3.16)	0.219 (0.091, 0.346)	0.812 (0.679, 0.944)
Self-pay	1.72 (2.45)	-0.175 (-0.366, 0.015)	0.334 (0.144, 0.525),
Other	1.75 (2.20)	-0.144 (-0.001, -0.288)	0.216 (0.072, 0.361)

[a] β estimates give the change in RVUs billed per encounter by patient characteristic.
[b] Individual patients may have multiple insurances. We therefore analyzed each insurance type as its own dichotomous variable (i.e. present or absent). For example, in adjusted analysis, encounters associated with commercial insurance had 0.320 (95% CI: 0.258-0.382) more wRVUs than encounters without commercial insurance.

Figure 1: Directed acyclic graphs (DAGs) for the relationships between the exposures of patient race, sex, and age and the outcome of wRVUs generated per outpatient dermatology encounter.

Figure 1a: Relationship between patient race and wRVUs generated per encounter

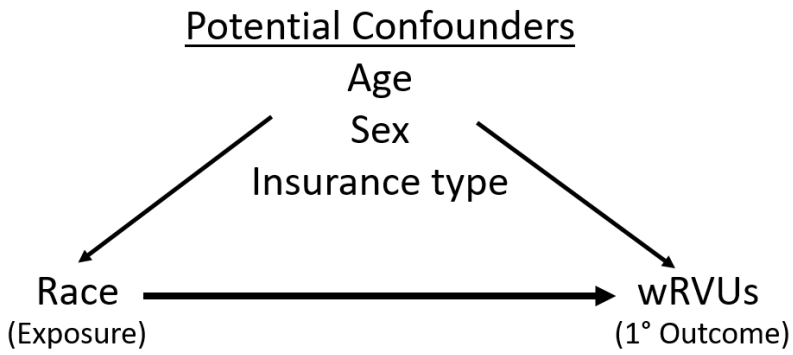


Figure 1b: Relationship between patient sex and wRVUs generated per encounter

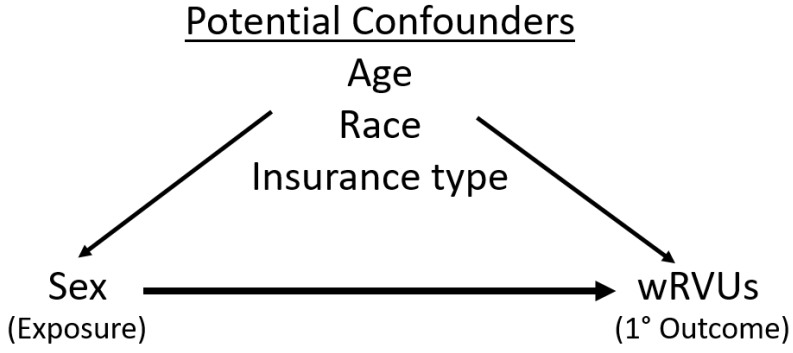


Figure 1c: Relationship between patient age and wRVUs generated per encounter

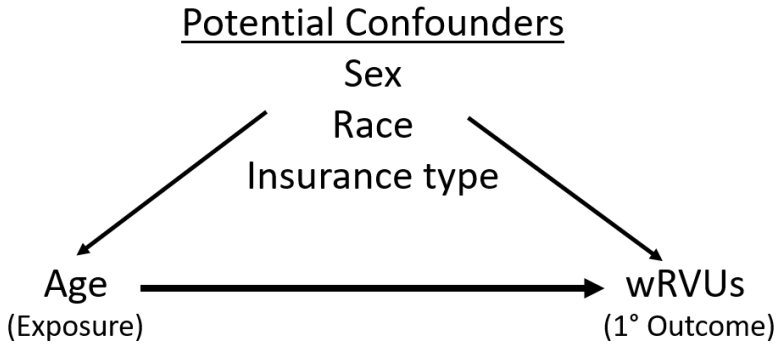


Figure 2: Directed acyclic graph for relationship between mediators, exposures, and outcome.

Figure 2A: DAG for analysis of mediation of the race-wRVU association by premalignant destructions and skin biopsies

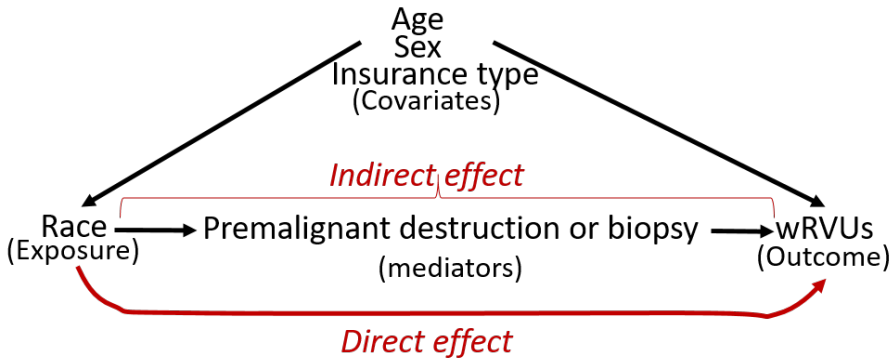


Figure 2B: DAG for analysis of mediation of the sex-wRVU association by premalignant destructions and skin biopsies

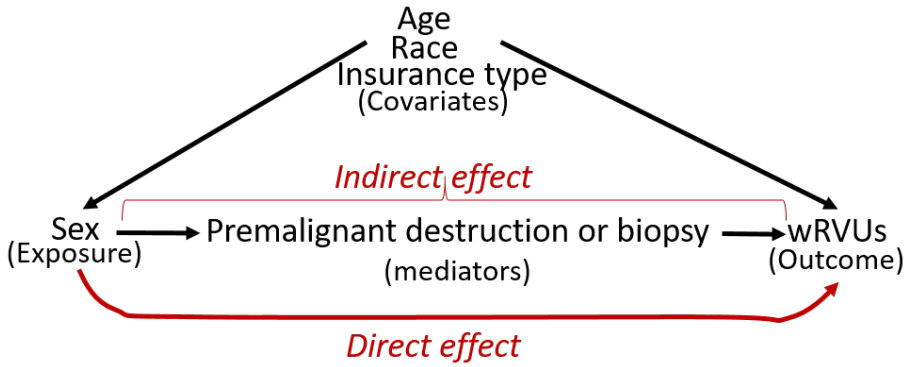


Figure 2C: DAG for analysis of mediation of the age-wRVU association by premalignant destructions and skin biopsies

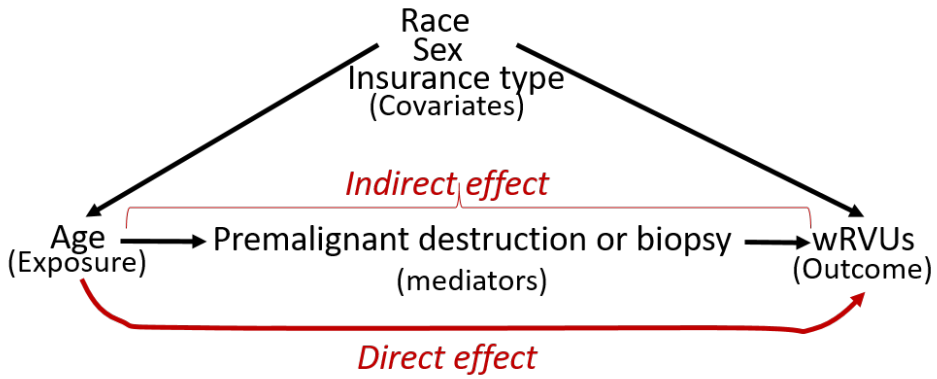
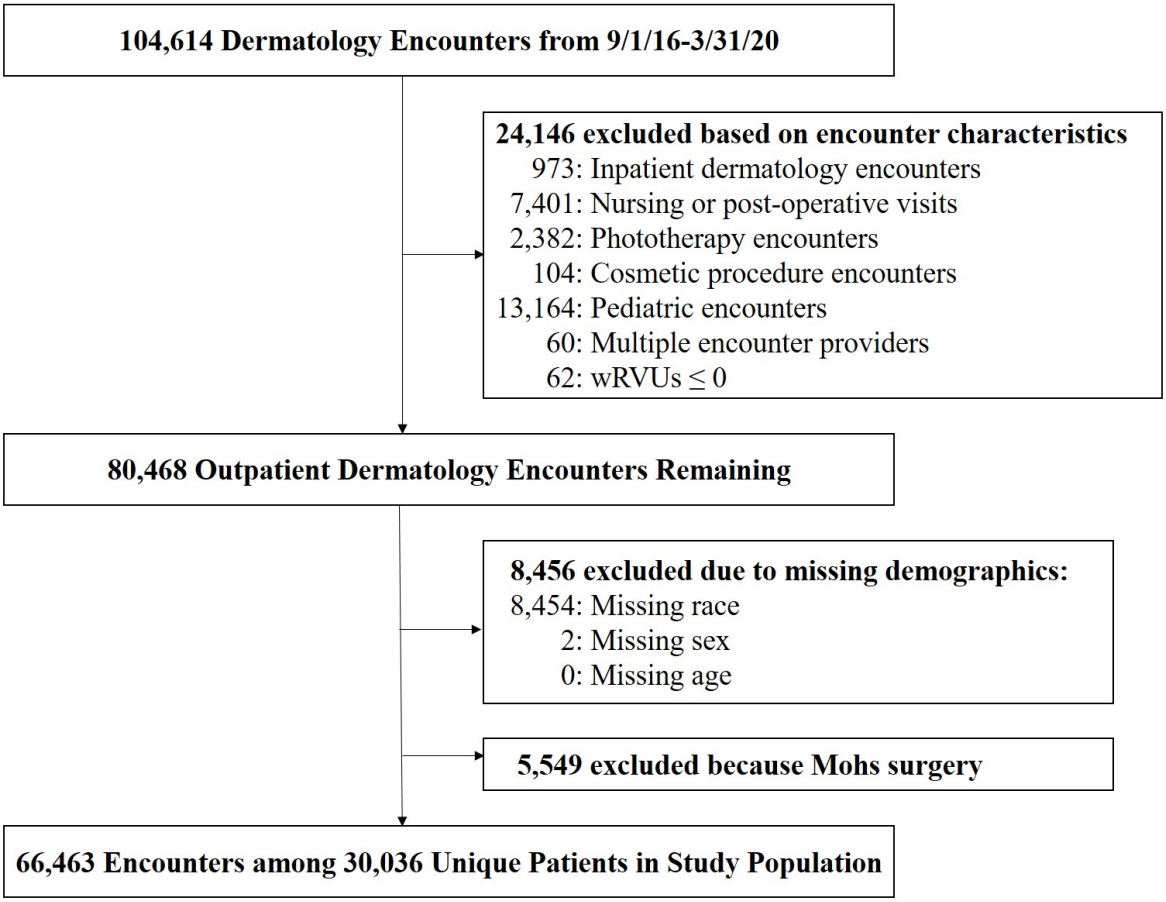


Figure 3: Encounter Eligibility Flowsheet



wRVUs: work Relative Value Units