Neighborhood Disadvantage, Patterns of Unhealthy Alcohol Use, and Differential Associations by Gender, Race/Ethnicity, and Rurality: A Study of Veterans Health Administration Patients

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ABSTRACT. Objective: Stressful conditions within disadvantaged neighborhoods may shape unhealthy alcohol use and related harms. Yet, associations between neighborhood disadvantage and more severe unhealthy alcohol use are underexplored, particularly for subpopulations. Among national Veterans Health Administration (VA) patients (2013–2017), we assessed associations between neighborhood disadvantage and multiple alcohol-related outcomes and examined moderation by sociodemographic factors. **Method:** Electronic health record data were extracted for VA patients with a routine Alcohol Use Disorders Identification Test–Consumption (AUDIT-C) screen. Patient addresses were linked by census block group to the Area Deprivation Index (ADI), dichotomized at the 85th percentile, and examined in quintiles for sensitivity analyses. Using modified Poisson generalized estimating equations models, we estimated associations between neighborhood disadvantage and five outcomes: unhealthy alcohol use (AUDIT-C ≥ 5), any past-year heavy episodic drinking (HED), severe unhealthy alcohol use (AUDIT-C ≥ 8), alcohol use disorder (AUD) diagnosis, and alcohol-specific conditions diagnoses. Moderation by gender, race/ethnicity, and rurality was tested using multiplicative interaction. **Results:** Among 6,381,033 patients, residence in a highly disadvantaged neighborhood (ADI ≥ 85th percentile) was associated with a higher likelihood of unhealthy alcohol use (prevalence ratio [PR] = 1.06, 95% CI [1.05, 1.07]), severe unhealthy alcohol use (PR = 1.14, 95% CI [1.12, 1.15]), HED (PR = 1.04, 95% CI [1.03, 1.05]), AUD (PR = 1.14, 95% CI [1.13, 1.15]), and alcohol-specific conditions (PR = 1.21, 95% CI [1.18, 1.24]). Associations were larger for Black and American Indian/Alaska Native patients compared with White patients and for urban compared with rural patients. There was mixed evidence of moderation by gender. **Conclusions:** Neighborhood disadvantage may play a role in unhealthy alcohol use in VA patients, particularly those of marginalized racialized groups and those residing in urban areas. (*J. Stud. Alcohol Drugs, 83,* 867–878, 2022)

UNHEALTHY ALCOHOL USE is a serious and increasing public health concern (Spillane et al., 2020). It is the third leading preventable cause of death in the United States (Mokdad et al., 2018) and is responsible for 1 in 10 deaths among working-age adults (Stahre et al., 2014). The spectrum of unhealthy alcohol use ranges from drinking above national recommended limits and heavy episodic drinking (HED) to meeting diagnostic criteria for alcohol use disorder (AUD; Grant et al., 2017). These patterns are associated with a range of acute consequences such as injuries, chronic conditions (Room et al., 2005), poorer mental health (Jané-Llopis & Matytsina, 2006), worse social and economic outcomes (Kendler et al., 2017), and harm to others (Karriker-Jaffe et al., 2018). Of note, the prevalence of reported unhealthy alcohol use (Dawson et al., 2015; Grant et al., 2017) and mortality from alcohol-specific conditions has increased across nearly all sociodemographic groups—contributing to startling overall increases in midlife mortality (Case & Deaton, 2017; Spillane et al., 2020; Woolf et al.,

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2018). Given these patterns, additional research is needed to investigate varied factors—including stressful socioeconomic conditions—that may influence unhealthy alcohol use.

The proportion of persons residing in neighborhoods with concentrated neighborhood disadvantage in the United States increased during the 2007–2009 Great Recession and has remained at those levels (Kneebone & Holmes, 2016). This has implications for well-being, in that disadvantaged neighborhoods may expose residents to disproportionate stressors within built and social environments (e.g., more limited access to essential services, violence) above and beyond individual experiences of poverty (Diez Roux & Mair, 2010). Chronic stress and psychological distress (Petteway et al., 2019), social norms (Cohen et al., 2000), and alcohol availability (Bryden et al., 2012) are interrelated mechanisms that may link neighborhood disadvantage and patterns of unhealthy alcohol use. Neighborhood disadvantage is associated with biological markers indicative of chronic stress (Ribeiro et al., 2018) and has been linked to increased psychological distress (Boardman et al., 2001). Concentrated disadvantage could erode the ability of communities to realize common values, creating more violent and psychologically distressing environments (Joshi et al., 2017) that could shape unhealthy alcohol use (Cambron et al., 2017). Beyond stress and psychological distress–related mechanisms, neighborhood disadvantage is associated with more permissive social norms around drinking (Ahern et al., 2008) and higher alcohol retail density (Berke et al., 2010), which could work synergistically (Ahern et al., 2015).

A growing number of studies have examined the role of neighborhood context in patterns of unhealthy alcohol use and alcohol-related outcomes with mixed findings (Jackson et al., 2014; Karriker-Jaffe, 2011; Mair et al., 2019). This is likely attributable to varying definitions of neighborhoods (Duncan & Kawachi, 2018), differing neighborhood disadvantage measures, alcohol-related outcomes studied (e.g., frequency vs. quantity vs. problems; Karriker-Jaffe, 2011; Kendler et al., 2014), and the timing of the life course in which neighborhood conditions are assessed (Barr, 2018). Studies that examine moderation by individual sociodemographic characteristics may help explain heterogeneous findings and inform targeted interventions (Karriker-Jaffe et al., 2012).

Associations between neighborhood disadvantage and unhealthy alcohol use are complex and likely depend on the characteristics of both places and individuals (Karriker-Jaffe et al., 2012). In particular, rurality, gender, and race/ethnicity may play salient moderating roles in the relationship between neighborhood disadvantage and unhealthy alcohol use. As observed for other behavioral health outcomes (Rudolph et al., 2014), neighborhood disadvantage and unhealthy alcohol use may have a more pronounced relationship in more urban areas because of distinct characteristics of social and built environments in disadvantaged urban neighborhoods (e.g., safety and policing concerns). In studies examining moderation by gender identity (or those using sex as a proxy for gender identity), associations between neighborhood disadvantage and unhealthy alcohol use among men have tended to be larger, potentially because of gendered social norms around drinking (Karriker-Jaffe et al., 2012); however, women may be more adversely affected by the stress of neighborhood disadvantage (Barrington et al., 2014). Neighborhood disadvantage may also be more strongly associated with unhealthy alcohol use for marginalized racialized groups (Chauhan et al., 2016; Jones-Webb et al., 1997; Karriker-Jaffe et al., 2012), potentially because of the compounding of disadvantages faced by people with multiple marginalized identities.

Electronic health record (EHR) data increasingly facilitate social epidemiologic (Schinasi et al., 2018) and health care disparities research (Glass & Williams, 2018). These data may be particularly valuable for studies of populations with stigmatized health conditions, such as AUD (Glass et al., 2014; Keyes et al., 2010), where broad-scale research recruitment may be particularly challenging (Casey et al., 2016). The Veterans Health Administration (VA) serves more than 9 million patients at 138 medical centers and more than 900 clinics and is the largest integrated health care system in the United States. VA patients tend to be from more disadvantaged groups (Nelson et al., 2007), and AUD prevalence among VA outpatients is higher than the prevalence among veterans in the general population (Hoggatt et al., 2021). The VA is a leader in implementing universal, population-based alcohol screening annually with a three-item instrument, the Alcohol Use Disorders Identification Test–Consumption (AUDIT-C), which enables measurement of several patterns of unhealthy alcohol use (Bradley et al., 2007). We used VA EHR data to examine associations between neighborhood disadvantage, measured with a composite index at the census block group level, and multiple patterns of unhealthy alcohol use, which have not previously been examined in a single study. Because the role of neighborhood disadvantage on unhealthy alcohol use may vary across populations, and given the sample size afforded by the EHR data, we also assessed whether associations identified differed by gender, race/ethnicity, and rurality.

Method

Data sources

Data for the present study included VA EHR data linked to the Area Deprivation Index (ADI), a composite measure of neighborhood socioeconomic status (SES). VA EHR data were extracted from the VA's Corporate Data Warehouse (CDW)—a national VA data repository that contains sociodemographic, clinical, enrollment, pharmacy, and utilization data, including geocoded patient residential addresses—for a parent study that included all patients 18 years and older who had an outpatient appointment October 1, 2009, to July 31, 2017, and one or more documented routine alcohol screens (AUDIT-Cs). Patient residential addresses from enrollment data in the CDW are geocoded annually for operations, budgeting, and research use by the VA Planning Systems Support Group using ArcGIS for Server software and the most extensive commercially available address location database.

Study population

Patients from the parent study were included in the present study if they had a last documented alcohol screen (AUDIT-C) between 2013 and 2017 because geocoded data are more accurate in those years, given transitions in geocoding technology and vendors and less stringent address matching standards in prior years (U.S. Department of Veterans Affairs, 2016). Patients also had to have a reliably geocoded residential address and live in a census block group with sufficient population size or count of housing units to be matched to a valid ADI. Of the 6,525,332 patients with a last documented alcohol screen between 2013 and 2017, 134,464 (2%) were excluded because they did not have a reliably geocoded residential address, and 9,835 (0.2%) were excluded because they did not live in a census block with a sufficient population to generate a valid ADI. The final analytic sample for the present study included 6,381,033 patients with geocoded data linked to a census block group who had a last AUDIT-C screen between 2013 and 2017. The present study was approved by the VA Puget Sound Institutional Review Board and the University of Washington and University of Pittsburgh Institutional Review Boards.

Independent variable: Neighborhood disadvantage Area Deprivation Index

Neighborhood disadvantage has long been used to indicate the lived experience of social hardship, capturing interrelated community-level conditions of poverty, inadequate housing, and poor employment quality (Gordon, 2003). The ADI is a composite measure of neighborhood SES based on the widely used Singh Deprivation Index methodology, in which census indicators theoretically related to SES and health disparities were selected, and factor analysis and principal components analysis were used to construct a composite index (Singh, 2003). The ADI was developed and made publicly available by researchers at the University of Wisconsin (Kind & Buckingham, 2018) and is based on 17 domains of SES (Supplemental Figure 1) derived from the U.S. Census Bureau's American Community Survey (ACS) 5-year estimates at the census block group level. (Supplemental material appears as an online-only addendum to the article on the journal's website.) Census block groups are the smallest available geographic unit of analysis, typically ranging from 600 to 3,000 individuals, and likely capture individual-level exposure to neighborhood disadvantage more adequately than larger census units (Duncan & Kawachi, 2018). Patients were linked by their census block group Federal Information Processing Series code to an ADI percentile based on a national ranking and the year of their AUDIT-C screen (2013–2014 linked to ADI based on 2009–2013 ACS estimates; 2015–2017 linked to ADI based on 2011–2015 ACS estimates). Given that preliminary descriptive analyses (Figure 1) and previous national analyses found a nonlinear relationship between ADI and health outcomes (Durfey et al., 2019; Hu et al., 2018; Kind et al., 2014)—with a marked increase among individuals residing in the top 15th percentile of neighborhood disadvantage nationally—a binary measure of ADI was used to compare patients living in less disadvantaged versus highly disadvantaged (≥85th percentile) neighborhoods and test for moderation. For sensitivity analyses, we also categorized ADI percentiles into quintiles.

Outcomes

We used the AUDIT-C screening information on alcohol consumption and diagnostic data on AUDs and alcohol-attributable conditions to assess multiple patterns of unhealthy alcohol use as outcomes because patterns of unhealthy alcohol use vary in prevalence across the population and differ in their associations with acute and chronic risk factors (Rehm et al., 2017). The AUDIT-C is a short, three-item validated screen for unhealthy alcohol use. Its items assess the quantity and frequency of average consumption and the frequency of HED in the past year. Each item is scored from 0 to 4 points and summed (total score ranges from 0 to 12), with scores of 8 or higher indicating a high likelihood of AUD (Rubinsky et al., 2010). Study outcomes included (a) unhealthy alcohol use (AUDIT-C ≥ 5), in line with VA's performance measure requiring follow-up counseling in this group (Lapham et al., 2012); (b) severe unhealthy alcohol use (AUDIT-C ≥ 8); (c) any HED (responding greater than "never" to AUDIT-C Question #3, "How often did you have 6 or more drinks on one occasion?"); (d) AUD measured based on ICD-9-CM and ICD-10-CM codes for alcohol abuse and dependence, excluding in remission, documented up to a year before the AUDIT-C screen; and (e) alcohol-specific conditions based on ICD-9-CM and ICD-10-CM codes documented up to a year before the AUDIT-C screen. Alcohol-specific conditions included conditions wholly attributable to alcohol use (Centers for Disease Control and Prevention [CDC], 2013), such as alcoholic liver disease, alcoholic myopathy, and alcohol-induced chronic pancreatitis.

Covariates

We adjusted for sets of predefined covariates hypothesized as confounders or precision variables. The year of

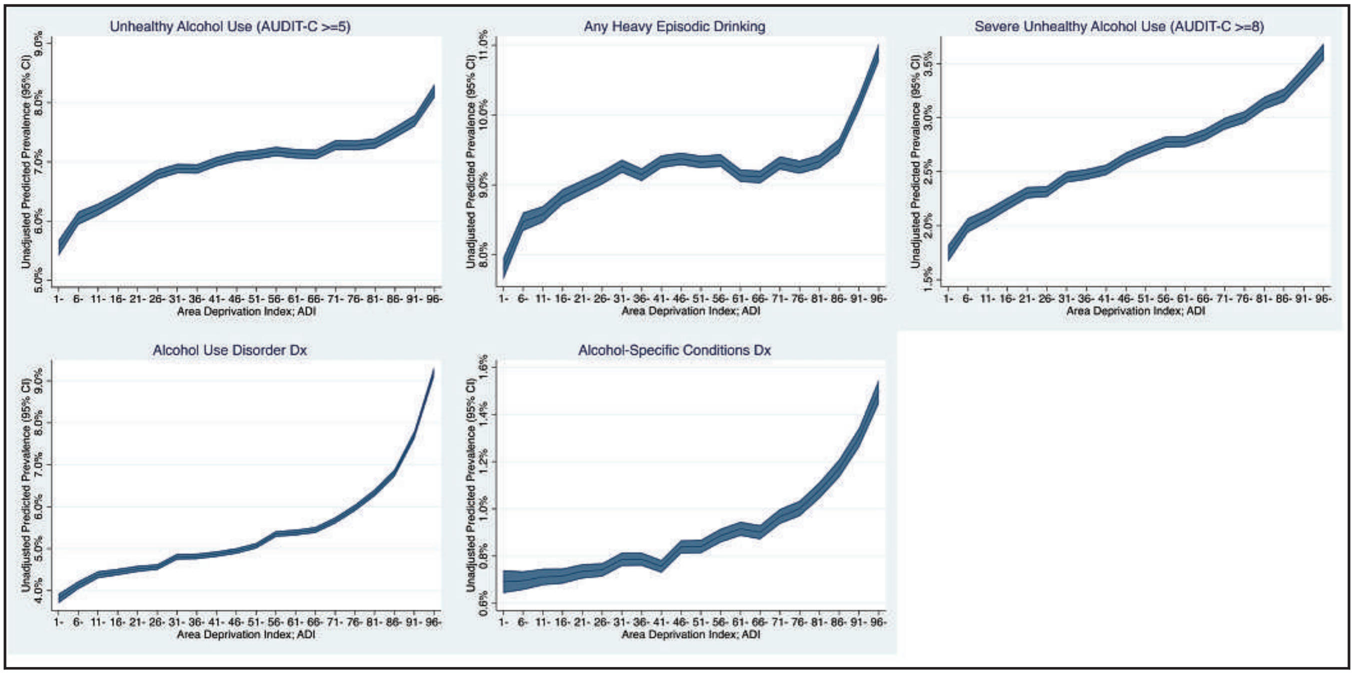

FIGURE 1. Unadjusted predicted prevalence and 95% confidence interval (CI) of outcomes across increments of Area Deprivation Index. AUDIT-C = Alcohol Use Disorders Identification Test-Consumption; Dx = diagnosis.

the AUDIT-C screen was included to adjust for any changes in VA's screening for unhealthy alcohol use over time. Sociodemographic measures were extracted for patients at the time of the AUDIT-C screen. They included age in groups, race/ethnicity, marital status, gender, rurality, and two proxy indicators of individual SES recorded in the EHR. Race/ethnicity—a proxy for experiences of discrimination and marginalization associated with selection into disadvantaged neighborhoods—was self-reported (Sohn et al., 2006) and categorized as non-Hispanic Black, non-Hispanic White, Hispanic, non-Hispanic Asian/Pacific Islander (API), non-Hispanic American Indian/Alaska Native (AI/AN), non-Hispanic multiple races, and non-Hispanic other/unknown. *Marital status* was defined using five categories (*divorced/separated, married, never married/single, widowed, unknown/missing*). Sex (a proxy for gender) is documented in the EHR as male or female.

Based on the census tract, patients were assigned to one of four 2010 Rural-Urban Commuting Areas rurality classifications, capturing population density and linkage to larger urban centers. Although VA EHR data do not have reliable measures of income and education, we used two proxy indicators for individual-level SES. These include VA copay status and financial hardship. Copay status was ascertained using a four-category variable based on VA copay requirements (*VA copay required due to means, no copay required due to disability, no copay required due to means/other,* and *not assigned;* Williams et al., 2012). Financial hardship was measured using a binary variable based on diagnosis codes and stop codes in the prior 2 years indicative of housing instability, homelessness, or economic hardship (Blosnich et al., 2017). Because comorbidities including physical and mental conditions could be downstream of both unhealthy alcohol use and neighborhood disadvantage and raise potential for collider bias, we did not adjust for this.

Statistical analyses

First, we examined the data's nested structure and performed analyses to understand the distribution of ADI percentile values in relation to prevalence of outcomes. Next, we described the sociodemographic and health characteristics of the sample and outcomes, overall and across the binary and categorical measures of neighborhood disadvantage. For inferential analyses, we used modified Poisson (log-linear models with robust standard errors) generalized estimating equations (GEE) models with an exchangeable covariance structure to estimate prevalence ratios [PRs] and 95% confidence intervals [CIs]. Modified Poisson models are commonly used to estimate PRs for non-rare binary outcomes (Greenland, 2004; Zou, 2004), are more conservative than alternatives, and perform better in cases of model misspecification (Chen et al., 2018). We selected a GEE approach over a multilevel model approach to analyze correlated data because we were interested in estimating marginal population average rather than neighborhood-specific effects (i.e., conditional on random effects; Hubbard et al., 2010).

Modified Poisson models were fit using GEE with models clustered on census tract to optimize the estimation of standard errors (Bottomley et al., 2016) and were adjusted for year, state of residence, and sociodemographic characteristics. To test for multiplicative interaction suggestive of moderation (VanderWeele & Knol, 2014), an interaction term was fit between the binary measure of neighborhood disadvantage and each potential categorical moderator (gender, race/ethnicity, and rurality) in separate models. We presented stratified findings for models with evidence of moderation at alpha level .05. To illustrate the magnitude of differences in alcohol outcomes across categories of ADI, recommended marginal standardization techniques (Muller & MacLehose, 2014) were used to estimate predicted probabilities and 95% CIs. Given that *p* values may be sensitive because of the very large data set, we focused presentation of findings on association estimates and predicted probabilities. We used Stata 15.1 (StataCorp LLC, College Station, TX) for all analyses.

Results

A lower proportion of patients residing in highly disadvantaged neighborhoods (*n* = 878,759) compared with those in less disadvantaged neighborhoods (*n* = 5,502,274) were non-Hispanic White, and a lower proportion were married. A higher proportion of patients residing in highly disadvantaged neighborhoods compared with those in less disadvantaged neighborhoods lived in rural areas, and a higher proportion had no copay (Table 1). Similar patterns were found comparing categories of neighborhood disadvantage (Supplemental Table 1). The raw prevalence of all outcomes was descriptively higher among those living in highly disadvantaged versus less disadvantaged neighborhoods, and similar patterns were observed across categories of neighborhood disadvantage (Table 2). When examining the unadjusted predicted prevalence of outcomes across categories of ADI in 5-percentile increments, we found that unadjusted predicted prevalences were more pronounced for patients residing in highly disadvantaged neighborhoods (Figure 1).

In adjusted models, we observed that those living in highly disadvantaged neighborhoods had a significantly higher likelihood of unhealthy alcohol use (PR = 1.04, 95% CI [1.03, 1.05]), severe unhealthy alcohol use (PR = 1.12, 95% CI [1.11, 1.13]), HED (PR = 1.04, 95% CI [1.02, 1.04]), AUD (PR = 1.12, 95% CI [1.11, 1.13]), and alcohol-specific conditions (PR = 1.18, 95% CI [1.15, 1.20]) than did those living in less disadvantaged neighborhoods (Table 3).

In sensitivity analyses in which neighborhood disadvantage was modeled in categories, we observed consistent patterns, whereby higher PRs of outcomes were observed with increasing categories of disadvantage compared with patients in the least disadvantaged category (Table 4). Specifically, compared with patients in neighborhoods with the lowest quintile of ADI (least disadvantaged), we identified that patients in the highest quintile of ADI (most disadvantaged) had a significantly higher likelihood of unhealthy alcohol use (PR = 1.14, 95% CI [1.13, 1.16]), severe unhealthy alcohol use (PR = 1.38, 95% CI [1.35, 1.41]), HED (PR = 1.09, 95% CI [1.07, 1.10]), AUD (PR = 1.30, 95% CI [1.28, 1.32]), and alcohol-specific conditions (PR = 1.49, 95% CI [1.44, 1.54]). Adjusted predicted prevalences and corresponding 95% CIs from these models are shown in Figure 2 to illustrate the magnitude of differences across ADI.

When examining moderation, we observed the presence of statistically significant multiplicative interactions between neighborhood disadvantage and race/ethnicity and rural residence for nearly all outcomes (Table 3). However, gender was a less consistent moderator, and, notably, neighborhood disadvantage had a more pronounced association with past-year AUD diagnosis for men than for women, but we observed the opposite pattern for unhealthy alcohol use. In a post hoc analysis examining moderation by age, mixed findings were also observed (Supplemental Table 2). When comparing across racial/ethnic groups, association estimates for neighborhood disadvantage were largest for Black or AI/AN patients for all outcomes except alcohol-specific conditions, and, when comparing across urban–rural categories, associations were strongest for patients living in the most urban areas.

Discussion

We identified that neighborhood disadvantage was associated with higher rates of all alcohol-related outcomes and that effect estimates were consistently larger for Black and AI/AN patients (compared with patients of other races/ethnicities) and urban patients (compared with patients living in more rural areas). This study is the first, to our knowledge, to use EHR and alcohol screening data to examine the role of neighborhood disadvantage in patterns of unhealthy alcohol use and related outcomes in an integrated national health care system. This study builds on prior studies by using a neighborhood-level index that captures multiple dimensions of disadvantage (Karriker-Jaffe, 2011) and by examining outcomes such as AUD and alcohol-specific conditions that have been infrequently studied in relation to neighborhood disadvantage (Ahern et al., 2015; Cambron et al., 2017; Rhew et al., 2018). Furthermore, EHR data facilitated examination of moderation by gender, race/ethnicity, and rurality.

Our main findings support previous studies across varying populations using twin-matched (Rhew et al., 2018) and longitudinal designs (Brenner et al., 2015; Cambron et al., 2017; Cerdá et al., 2010; Rhew et al., 2020) that have found that neighborhood disadvantage is modestly positively associated with alcohol consumption, heavy drinking, and

TABLE 1. VA patient characteristics, overall and across neighborhood disadvantage

Variable	All patients (*n* = 6,381,033)	Patients living in less disadvantaged neighborhoods, <85th percentile (*n* = 5,502,274)	Patients living in highly disadvantaged neighborhoods, ≥85th percentile (*n* = 878,759)
Age, *M* (*SD*)	62.0 (17.1)	62.0 (17.2)	61.9 (16.0)
Age groups, *n* (%)			
18–44	1,132,563 (17.7%)	999,140 (18.2%)	133,423 (15.2%)
45–64	1,896,259 (29.7%)	1,580,232 (28.7%)	316,027 (36.0%)
65–74	1,926,945 (30.2%)	1,671,065 (30.4%)	255,880 (29.1%)
≥75	1,425,266 (22.3%)	1,251,837 (22.8%)	173,429 (19.7%)
Marital status, *n* (%)			
Divorced/separated	1,591,551 (24.9%)	1,299,650 (23.6%)	291,901 (33.2%)
Married	3,505,231 (54.9%)	3,127,213 (56.8%)	378,018 (43.0%)
Never married/single	842,385 (13.2%)	698,995 (12.7%)	143,390 (16.3%)
Widowed	399,365 (6.3%)	337,897 (6.1%)	61,468 (7.0%)
Unknown/missing	42,501 (0.7%)	38,519 (0.7%)	3,982 (0.5%)
Race/ethnicity, *n* (%)			
AI/AN	42,364 (0.7%)	34,092 (0.6%)	8,272 (0.9%)
API	106,916 (1.7%)	98,573 (1.8%)	8,343 (0.9%)
Black	1,050,033 (16.5%)	786,697 (14.3%)	263,336 (30.0%)
White	4,545,996 (71.2%)	4,059,114 (73.8%)	486,882 (55.4%)
Multiple races	46,798 (0.7%)	39,866 (0.7%)	6,932 (0.8%)
Unknown/missing	198,939 (3.1%)	174,148 (3.2%)	24,791 (2.8%)
Hispanic	389,987 (6.1%)	309,784 (5.6%)	80,203 (9.1%)
Gender, *n* (%)			
Female	490,420 (7.7%)	424,327 (7.7%)	66,093 (7.5%)
Rurality, *n* (%)			
Urban core	4,178,508 (65.5%)	3,606,128 (65.5%)	572,380 (65.1%)
Suburban	820,155 (12.9%)	758,761 (13.8%)	61,394 (7.0%)
Large rural	739,265 (11.6%)	609,226 (11.1%)	130,039 (14.8%)
Small town/rural	643,105 (10.1%)	528,159 (9.6%)	114,946 (13.1%)
Copay, *n* (%)			
Copay required due to means	1,518,264 (23.8%)	1,357,131 (24.7%)	161,133 (18.3%)
No copay required due to disability	1,241,961 (19.5%)	1,085,698 (19.7%)	156,263 (17.8%)
No copay required due to means/other	2,163,677 (33.9%)	1,771,108 (32.2%)	392,569 (44.7%)
Unassigned	1,457,131 (22.8%)	1,288,337 (23.4%)	168,794 (19.2%)
Hardship, *n* (%)	468,251 (7.3%)	357,987 (6.5%)	110,264 (12.5%)
Year of last AUDIT-C screen, *n* (%)[a]			
2013	340,531 (5.3%)	291,026 (5.3%)	49,505 (5.6%)
2014	435,762 (6.8%)	372,462 (6.8%)	63,300 (7.2%)
2015	651,379 (10.2%)	557,392 (10.1%)	93,987 (10.7%)
2016	2,544,572 (39.9%)	2,193,287 (39.9%)	351,285 (40.0%)
2017	2,408,789 (37.7%)	2,088,107 (37.9%)	320,682 (36.5%)

Notes: VA = Veterans Health Administration; AI/AN = American Indian/Alaska Native; API = Asian/Pacific Islander. [a]Patients include those with an Alcohol Use Disorders Identification Test–Consumption (AUDIT-C) screen between 2013 and 2017; data from last screen for each patient were selected.

alcohol-related problems among adults. We found pronounced associations between neighborhood disadvantage and unhealthy alcohol use for Black and AI/AN patients and for patients living in the most urban areas, whereas findings related to moderation by gender were mixed. The most notable differences were across race/ethnicity, corroborating the results of other studies that have identified larger effect estimates between neighborhood disadvantage and alcohol-related outcomes for marginalized racial/ethnic groups (Jones-Webb et al., 1997; Karriker-Jaffe et al., 2012; Zemore et al., 2016). Living in a disadvantaged area may subject Black or AI/AN persons to substantially more discriminatory experiences, which could elevate stress and distress in ways that could relate to patterns of alcohol use. Additional studies are needed to understand the place-based inequities in conjunction with historical trauma and social norms (Ehlers et al., 2013) in influencing patterns of alcohol use among AI/ANs.

Furthermore, findings across the urban–rural continuum suggest that conditions present in disadvantaged urban neighborhoods may be distinct in their relationship with alcohol-related outcomes, potentially because of issues specific to urban environments such as safety and policing concerns (Shmool et al., 2015), gentrification (Izenberg et

Table 2. Raw prevalence of outcomes across neighborhood disadvantage

Variable	Patients living in less disadvantaged neighborhoods, ADI <85th pctl. (*n* = 5,502,274) *n* (%)	Patients living in highly disadvantaged neighborhoods, ADI ≥85th pctl. (*n* = 878,759) *n* (%)	Patients living in the least disadvantaged quintiles of neighborhoods, Pctl. 1–20 (*N* = 763,425) *n* (%)	Pctl. 21–40 (*N* = 1,393,242) *n* (%)	Pctl. 41–60 (*N* = 1,589,448) *n* (%)	Pctl. 61–80 (*N* = 1,483,336) *n* (%)	Patients living in most disadvantaged quintile, Pctl. 81–100 (*N* = 151,582) *n* (%)
Unhealthy alcohol use (AUDIT-C ≥ 5)	381,102 (6.9%)	67,800 (7.7%)	46,793 (6.1%)	94,643 (6.8%)	112,809 (7.1%)	106,847 (7.2%)	87,810 (7.6%)
Severe unhealthy alcohol use (AUDIT-C ≥ 8)	142,688 (2.6%)	29,570 (3.4%)	15,723 (2.1%)	33,329 (2.4%)	42,218 (2.7%)	42,868 (2.9%)	38,120 (3.3%)
Any HED	502,867 (9.1%)	88,482 (10.1%)	65,121 (8.5%)	127,184 (9.1%)	148,560 (9.3%)	136,506 (9.2%)	113,978 (9.9%)
AUD diagnosis	278,620 (5.1%)	67,315 (7.7%)	32,529 (4.3%)	65,287 (4.7%)	80,365 (5.1%)	83,227 (5.6%)	84,527 (7.3%)
Alcohol-specific condition diagnosis	46,164 (0.8%)	11,346 (1.3%)	5,393 (0.7%)	10,648 (0.8%)	13,200 (0.8%)	14,021 (0.9%)	14,248 (1.2%)

Notes: ADI = Area Deprivation Index; pctl. = percentile; AUDIT-C = Alcohol Use Disorders Identification Test–Consumption; HED = heavy episodic drinking; AUD = alcohol use disorder.

Table 3. Prevalence ratios (PRs) estimates of association between high neighborhood disadvantage and alcohol outcomes among Veterans Health Administration patients, pooled and stratified by gender, race/ethnicity, and rurality

Variable	Unhealthy alcohol use, PR [95% CI]	Severe unhealthy alcohol use, PR [95% CI]	HED, PR [95% CI]	AUD diagnosis, PR [95% CI]	Alcohol-specifi condition diagnosis, PR [95% CI]
Pooled	1.06 [1.05, 1.07]	1.14 [1.12, 1.15]	1.04 [1.03, 1.05]	1.14 [1.13, 1.15]	1.21 [1.18, 1.24]
Gender					
Male	1.06 [1.04, 1.07]	–	–	1.14 [1.13, 1.15]	–
Female	1.11 [1.06, 1.16]	–	–	1.08 [1.04, 1.13]	–
Race/ethnicity					
NH White	1.02 [1.01, 1.03]	1.11 [1.09, 1.13]	1.00 [1.00, 1.01]	1.11 [1.09, 1.12]	1.18 [1.15, 1.22]
NH Black	1.14 [1.12, 1.16]	1.19 [1.16, 1.22]	1.11 [1.10, 1.13]	1.20 [1.18, 1.22]	1.27 [1.22, 1.33]
Hispanic	1.11 [1.08, 1.15]	1.18 [1.13, 1.23]	1.06 [1.03, 1.08]	1.09 [1.05, 1.12]	1.14 [1.06, 1.23]
NH API	1.09 [1.00, 1.18]	1.08 [0.94, 1.24]	1.02 [0.95, 1.09]	1.20 [1.09, 1.32]	1.63 [1.29, 2.07]
NH AI/AN	1.20 [1.12, 1.30]	1.34 [1.20, 1.50]	1.16 [1.09, 1.23]	1.25 [1.16, 1.35]	1.15 [0.94, 1.41]
NH multiple races	1.06 [0.97, 1.16]	1.14 [1.00, 1.31]	1.04 [0.96, 1.11]	1.18 [1.08, 1.28]	1.22 [0.97, 1.54]
Rurality					
Urban core	1.09 [1.07, 1.10]	1.16 [1.15, 1.18]	1.06 [1.05, 1.07]	1.16 [1.15, 1.18]	1.24 [1.21, 1.28]
Suburban	1.04 [1.01, 1.07]	1.12 [1.06, 1.17]	1.01 [0.98, 1.04]	1.09 [1.05, 1.13]	0.98 [0.90, 1.07]
Large town	1.03 [1.00, 1.05]	1.10 [1.07, 1.14]	1.02 [1.00, 1.05]	1.11 [1.08, 1.14]	1.14 [1.07, 1.22]
Small town/rural	0.98 [0.95, 1.00]	1.05 [1.01, 1.09]	0.98 [0.95, 1.00]	1.06 [1.03, 1.09]	1.17 [1.09, 1.25]

Notes: Stratified estimates shown only if Wald test p values testing interactions were statistically significant (<.05). All pooled findings were statistically significant (<.0001). Modified Poisson generalized estimating equations models adjusted for age, race/ethnicity, gender (electronic health record–defined sex), rurality, marital status, copay status, economic/housing hardship, state, year, and clustered on census tract. CI = confidence interval; HED = heavy episodic drinking; AUD = alcohol use disorder; NH = non-Hispanic; API = Asian/Pacific Islander; AI/AN = American Indian/Alaska Native.

al., 2018), and high alcohol outlet density (Trangenstein et al., 2020). Reasons are unclear for inconsistent moderation by gender for two outcomes and the nonpresence of moderation for three other outcomes; additional research is needed on neighborhood factors and experiences among women with unhealthy alcohol use served by the VA (Cucciare et al., 2016).

The associations we identified between neighborhood disadvantage and patterns of alcohol use and alcohol-specific conditions should be interpreted with attention to the alcohol harm paradox. The alcohol harm paradox (Bellis et al., 2016) is the repeat finding that alcohol use may be especially harmful to more disadvantaged communities than to more advantaged communities even at similar levels of alcohol use (Katikireddi et al., 2017; Sadler et al., 2017). Notably, similar patterns have been observed across race/ethnicity in U.S. contexts. For example, Hispanic, Black, and AI/AN persons face disproportionate negative consequences of alcohol compared with Whites, unexplained by differences in the volume of alcohol consumed (Zemore et al., 2018).

Thus, higher levels of unhealthy alcohol use observed among VA patients residing in more disadvantaged neighborhoods may be amplified, leading to disproportionately more alcohol-related harm. This is a reason why association sizes between neighborhood disadvantage and alcohol-related outcomes tended to be the largest for more severe outcomes. The alcohol harm paradox is understudied (Boyd et al., 2021) and may exist in part because of interactions

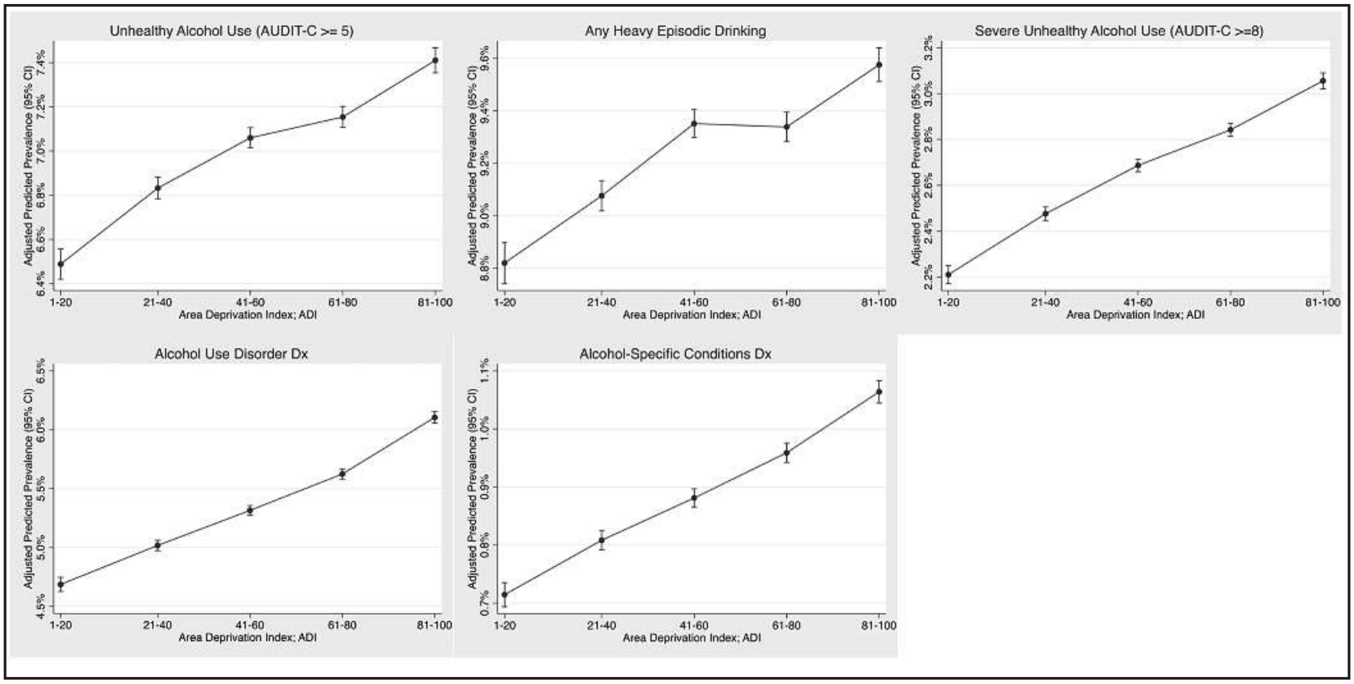

FIGURE 2. Adjusted predicted prevalence and 95% confidence interval (CI) of outcomes across quintiles of Area Deprivation Index. AUDIT-C = Alcohol Use Disorders Identification Test-Consumption; Dx = diagnosis.

between alcohol use and other exposures, quantity and type of alcohol consumed, as well as worse access to health care (Bellis et al., 2016). Future theory-focused studies could be important for clarifying the contribution of modifiable factors in alcohol-related disparities.

This study has several limitations. First, VA patients are not representative of the broader U.S. population (Wong et al., 2016). Unmeasured confounding may be present because of limited individual-level data on SES (e.g., no data on individual-level income) as well as alcohol policy conditions and health care quality differences unaccounted for by state fixed effects. Despite the VA's extensive efforts to identify and treat unhealthy alcohol use, underdiagnosis of AUD, under-identification of unhealthy alcohol use because of variation in screening techniques, and inability to ascertain chronic versus acute unhealthy alcohol use may be limitations of using EHR data. For example, past-year AUD prevalence based on standardized assessment is approximately 14% in the general population (Grant et al., 2015) and 10% in the VA patient population (Hoggatt et al., 2021), yet was substantially lower in the present study based on documented diagnosis. Temporal order cannot be established given a cross-sectional design. Therefore, patterns of unhealthy alcohol use could precede or even induce selection into more disadvantaged neighborhoods (Oakes, 2004).

Finally, the ADI measure of neighborhood disadvantage used does not allow for the isolation of mechanisms, and our use of this administratively defined measure of neighborhood at the census block group level could result in bias related to the modifiable areal unit problem, where boundary definitions could bias observed associations (Wong, 2004). Alternative strategies, such as latent class approaches (Rhew et al., 2017) and approaches to defining neighborhoods that account for the racialized historical factors (e.g., redlining)

TABLE 4. Prevalence ratio (PR) estimates of association, quintiles of neighborhood disadvantage, and alcohol outcomes among Veterans Health Administration patients, pooled estimates

Neighborhood disadvantage quintiles,	Alcohol use PR [95% CI]	Severe alcohol use PR [95% CI]	Unhealthy HED PR [95% CI]	Unhealthy AUD PR [95% CI]	Alcohol-specific condition PR [95% CI]
Least disadvantaged ADI pctl. 1–20	reference	reference	reference	reference	reference
ADI pctl. 21–40	1.05 [1.04, 1.07]	1.12 [1.10, 1.14]	1.03 [1.02, 1.04]	1.07 [1.05, 1.09]	1.13 [1.09, 1.17]
ADI pctl. 41–60	1.09 [1.07, 1.10]	1.22 [1.19, 1.24]	1.06 [1.05, 1.07]	1.13 [1.11, 1.15]	1.19 [1.19, 1.28]
ADI pctl. 61–80	1.10 [1.09, 1.12]	1.29 [1.29, 1.31]	1.06 [1.05, 1.07]	1.20 [1.18, 1.22]	1.34 [1.30, 1.39]
ADI pctl. 81–100	1.14 [1.13, 1.16]	1.38 [1.35, 1.41]	1.09 [1.07, 1.10]	1.30 [1.28, 1.32]	1.49 [1.44, 1.54]

Notes: All comparisons were statistically significant (<.0001). Modified Poisson generalized estimating equations models adjusted for age, race/ethnicity, gender (electronic health record–defined sex), rurality, marital status, copay status, economic/housing hardship, state, year. CI = confidence interval; HED = heavy episodic drinking; AUD = alcohol use disorder; ADI = Area Deprivation Index; pctl. = percentile.

that shape them (Lee et al., 2020; Trangenstein et al., 2020), could help clarify mechanisms and interventions (Riley, 2018).

Nonetheless, this study adds to a growing literature on place-based inequities in health among VA patients (Hatef et al., 2019; Nelson et al., 2017; Wong et al., 2020) and highlights that socioeconomic gradients in alcohol-related health outcomes persist across patients served by a universal health care system with extensive efforts to address unhealthy alcohol use. Responsible for addressing its patients' medical and nonmedical needs, the VA is increasingly interested in addressing upstream social determinants of health. The VA could leverage neighborhood disadvantage data and other SES measures to document inequities and ensure equitable care. For example, the VA is examining place-based interventions to enhance social support for patients with cardiovascular diseases (Nelson et al., 2018). Similar approaches to alcohol-related care could be developed, given that increased social support may disrupt associations between neighborhood disadvantage and unhealthy alcohol use (Karriker-Jaffe et al., 2017).

Furthermore, the socioeconomic gradients in unhealthy alcohol use observed underscore that enhanced medical care that addresses individual social needs is, alone, insufficient to address social determinants of health (Castrucci & Auerbach, 2019). Targeted policy strategies, such as Federal Housing Choice Voucher programs—including those administered in partnership with the VA—could be leveraged to promote affordable housing in higher-opportunity areas (Patterson et al., 2014), and broader population-level strategies such as expansion of social safety net programs could have important influences on poverty and health among residents of disadvantaged areas (Allen et al., 2019; Berube, 2006; Wicks-Lim & Arno, 2017). Future research is needed to evaluate targeted health care and population-level approaches to addressing unhealthy alcohol use and alcohol-related racial/ethnic, gender, and geographic inequities.

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