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Exploring the Relationship Between Neighborhood Disadvantage and ICU Delirium Characteristics

IMPORTANCE: Delirium is a neuropsychiatric syndrome characterized by fluctuating disturbances in attention and awareness, associated with worse clinical outcomes and higher mortality. Previous research studies have noted an association between geographic disadvantage and delirium, but it is unknown if this association extends to critically ill adults.

OBJECTIVES: This study aimed to explore the relationship between geographic disadvantage and ICU delirium characteristics.

DESIGN, SETTING, AND PARTICIPANTS: We performed a secondary analysis of data collected from an National Institutes of Health-funded clinical trial, the Pharmacologic Management of Delirium study. Adults 18 years old or older admitted to the ICU who experienced delirium based on the Confusion Assessment Method for the ICU (CAM-ICU) were included.

INTERVENTIONS: None.

MEASUREMENTS AND MAIN RESULTS: The study population included 326 participants: 54.5% were female and 48% Black, with a mean age of 60.3 years, mean Acute Physiology and Chronic Health Evaluation II score of 20, and in-hospital mortality rate of 12.3%. The area deprivation index (ADI), a composite measure of geographic disadvantage derived from census data that yields a national percentile score ranging from 1 to 100 (with higher scores representing greater disadvantage), was obtained for each participant's address. Main outcome variables included delirium duration, which was assessed by the number of delirium- and coma-free days (DCFDs), and delirium severity, which was assessed by mean CAM-ICU-7 scores. Analysis of covariance models were used to examine differences in DCFDs and mean CAM-ICU-7 scores between ADI quintiles while controlling for demographic and clinical variables. Other clinical outcomes of interest included discharge home rates and in-hospital mortality. The sample was heavily skewed toward higher national ADI percentile scores (indicating greater disadvantage); only 11.7% of patients had an ADI score lower than 50. Our regression analyses did not reveal any associations between ADI quintile and DCFDs or mean CAM-ICU-7 scores, or between ADI quintile and discharge home rates or in-hospital mortality. However, the Black race was associated with longer delirium duration and greater delirium severity in the first week of ICU hospitalization.

CONCLUSIONS: Our study did not find an association between geographic disadvantage and delirium duration or severity in the ICU. However, an association with race was observed, highlighting the need for further research into how socioeconomic determinants of health relate to delirium.

KEYWORDS: delirium; intensive care unit; neighborhood disadvantage; older adults

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KEY POINTS

Question: Is there an association between geographic disadvantage and ICU delirium severity and duration in critically ill adults?

Findings: This secondary analysis of data collected from a randomized clinical trial of 326 ICU patients found no associations between geographic disadvantage as measured by area deprivation index and ICU delirium characteristics, even after adjusting for demographic and clinical characteristics, comorbidity burden, and illness severity. Unexpectedly, another social determinant of health, Black race, was associated with more severe and longer duration of ICU delirium.

Meaning: Geographic disadvantage was not associated with ICU delirium characteristics, but race was, suggesting the need for further research that elucidates the role of various social risk factors on ICU delirium outcomes.

Delirium is a clinical syndrome characterized by a patient's fluctuating inattention, confusion, and disorientation, and usually develops during acute medical illness or after surgery (1). Delirium affects an estimated 29–64% of hospitalized older adults 65 years old or greater (2). Delirium is especially prevalent in the ICU setting, affecting up to 80% of critically ill patients (3–7). Delirium costs up to \$152 billion annually in national healthcare expenditures (8–10), and is a well-known risk factor for mortality and poor clinical outcomes after discharge (3, 4, 11–22).

A growing area of research is focused on the role of social determinants of health (SDOH), particularly geographic or neighborhood disadvantage, in delirium and post-ICU outcomes. Well-validated measures of geographic disadvantage such as the area deprivation index (ADI) are now being used to study the impact of geographic disadvantage on various health outcomes (23).

Recent studies have begun to describe the role of geographic disadvantage in delirium-related outcomes during and after critical illness. In one study of older surgical patients, residing in the most disadvantaged neighborhoods was associated with a higher risk of incident delirium when compared with the least disadvantaged neighborhoods (24). Another study of older

inpatient adults 70 years old or older noted that greater neighborhood disadvantage was associated with increased odds of delirium being present at admission as well as development of delirium in the hospital (25).

Potential mechanisms for the connection between geographic disadvantage and delirium include increased baseline inflammation resulting from chronic stress (26), which may predispose to delirium during acute illness (27, 28), higher comorbidity burden (29, 30) due to lack of healthcare access (31) and exposure to local and/or occupational pollutants (32, 33), and lower educational attainment and impaired mental health (i.e., depression, anxiety, post-traumatic stress disorder) that may reduce cognitive reserve (34–36). Identifying SDOH that may affect delirium outcomes can help with risk stratification and prognostication and, more importantly, can yield insights into potential mechanisms that may underlie how nonmedical risk factors might impact clinical outcomes, suggesting potential targets for intervention outside of the clinical setting.

However, the relationship between geographic disadvantage and delirium duration and delirium severity has not been examined among critically ill patients, who might exhibit a different risk profile for delirium than postoperative patients admitted to the surgical floor. While not subject to the stresses of surgery, ICU patients have higher illness severity and tend to have greater comorbidity burden than surgical patients (with multimorbidity estimates ranging from 36% to 77.3% in the ICU population and 11.2–43.9% in the surgical population) (37–41). ICU patients may also require ventilatory support, often necessitating the use of sedation, a known risk factor for delirium (7, 42, 43). Therefore, we designed this study with the primary goal of examining the relationship between geographic disadvantage and delirium duration and severity in ICU patients. We hypothesize that ICU patients who reside in more disadvantaged neighborhoods will exhibit longer delirium duration and greater delirium severity than those residing in less disadvantaged neighborhoods.

METHODS

The randomized clinical trial (Pharmacologic Management of Delirium [PMD]) on which this secondary analysis was based was originally approved by the Institutional Review Board (IRB) of Indiana University on February 12, 2009 (protocol number

1010002428; renewed November 17, 2025) and registered at ClinicalTrials.gov (NCT00842608). Approval for enrollment in the study required informed consent by the participant's legally authorized representative, and all procedures were followed in accordance with the ethical standards of the IRB of Indiana University and with the Helsinki Declaration of 1975.

Study Setting and Design

This was a secondary analysis of data collected from a randomized controlled trial, the PMD study (44). The PMD trial enrolled ICU patients with delirium from three Indianapolis hospitals between 2009 and 2015 testing an intervention (decreasing anticholinergics and benzodiazepines, prescribing low-dose haloperidol) to mitigate delirium duration and severity. Patients were recruited from medical and surgical ICUs and step-down/progressive care units. The PMD trial did not find a difference between the intervention and usual care groups in the primary outcomes of delirium duration or severity.

Inclusion criteria for the PMD trial were: 1) adult patients 18 years old or older, 2) admitted to the ICU for greater than or equal to 24 hours, 3) tested positive for delirium using the Confusion Assessment Method for the ICU (CAM-ICU), and 4) English-speaking. Exclusion criteria for the PMD trial were: 1) history of severe mental illness, 2) axis 1 psychiatric disorder, 3) severe cognitive impairment preventing study assessments, 4) alcohol-related delirium, 5) aphasic stroke or traumatic brain injury, 6) history of allergic reaction or contraindication to haloperidol, 7) withdrawal of life support, 8) pregnant or breastfeeding, 9) legally blind or deaf, 10) admission for suicide attempt, 11) corrected QT interval greater than 500 ms, or 12) previously enrolled in the PMD study or enrolled in another study. Additional exclusion criteria for this analysis included: 1) patients whose addresses were unable to be obtained from either the PMD study records or the electronic medical record (EMR) and 2) patients from outside the state of Indiana.

Exposure Variables

The ADI, a composite socioeconomic index measure of area deprivation that uses 17 weighted indicators of socioeconomic status derived from U.S. Census Bureau, comprised the primary exposure variable

(45). **Supplementary Table S1** (<https://links.lww.com/CCX/B595>) shows the census variables that are used in calculating the ADI. The ADI for a census block group tract is first calculated as a raw score, which is then converted into a state decile score and a national percentile score, with higher scores suggesting greater area deprivation (23). For example, an ADI national percentile score of 50 or higher represents the top (i.e., more socioeconomically disadvantaged) half of all neighborhoods in the United States. The ADI scores for a particular address can be obtained via an online mapping tool known as the Neighborhood Atlas (<https://www.neighborhoodatlas.medicine.wisc.edu/>), which is regularly maintained and updated by the University of Wisconsin School of Medicine and Public Health based on the latest American Community Survey results (23).

Data Source

Patients' addresses were obtained either from the PMD study's enrollment records or from the EMRs. The addresses were then entered into the Neighborhood Atlas mapping tool to yield an ADI national percentile score. If the study consent form listed an address, it was considered the definitive address for patients at the time of enrollment. If there was no address on the consent form, but an address was listed in the EMR, we used that address. In cases of misalignment between the addresses on the consent form vs. the EMR, the logical assumption was that the patient had moved during the time period between their study enrollment and their most recent visit within the hospital system. In those cases, we used the consent form address to most accurately reflect the patient's living situation at the time of enrollment. Although there is the possibility that the EMR addresses for patients without a listed address in the consent form may not have been their address at the time of study enrollment, in reviewing the few cases where a patient had changed addresses, the ADIs between the new and old addresses remained very similar. None of the patients had switched addresses from a deprived neighborhood to one that was substantially less deprived, or vice versa.

Primary Outcomes

Delirium duration, computed as the number of delirium- and coma-free days (DCFDs), and delirium

severity were the main outcomes of our analysis. DCFD refers to the duration of normal cognitive status and is defined as the number of days the patient was alive, free of delirium, and not in a coma. The presence of coma was assessed using the Richmond Agitation-Sedation Scale (RASS) (46) and was defined as a RASS score of -4 to -5 with lack of response to verbal or physical stimuli. Delirium severity was assessed using the CAM-ICU-7 (47), a 7-point scale derived from the RASS and CAM-ICU (48), with score ranges from 0 to 7 (with 0–2 categorized as no delirium, 3–5 as mild to moderate delirium, and 6–7 as severe delirium). The RASS and CAM-ICU-7 were administered bid by trained research assistants, starting from 24 hours after ICU admission and up to 28 days after, or until hospital discharge or death.

Other Outcomes

Other clinical outcomes examined in our analyses included in-hospital mortality and discharge home rates.

Covariates

Demographic information on age, sex, race, and years of education was collected from the EMR. The Acute Physiology and Chronic Health Evaluation (APACHE) II (49) assessed illness severity and was calculated using EMR data from the first 24 hours of ICU admission. The Charlson Comorbidity Index (CCI) (50) assessed pre-hospital comorbidity burden and was also calculated using the EMR. PMD intervention status (intervention group vs. usual care) refers to whether the patient had been randomized to the intervention group or control group (labeled as “usual care” in the tables) in the parent study.

Statistical Analyses

DCFDs and length of stay (LOS) were compared using the nonparametric Wilcoxon rank-sum test. Two time points were used for DCFDs and for delirium severity: day 8 (which was 7 d after study enrollment) and hospital discharge. Patients who died before day 8 or discharge had their subsequent delirium-/coma-free days counted as 0. Patients who were discharged before day 8 had the remaining days counted as delirium-/coma-free. To adjust for LOS when comparing DCFDs at discharge, we used a Poisson regression

model that included an offset equal to the log of LOS post-randomization.

We compared patient demographics (age, sex, and race) and proportions of comorbid medical conditions among groups defined by ADI quintiles. Analysis of covariance models were used with each delirium outcome (mean CAM-ICU-7 score and number of DCFDs) as the dependent variable, ADI quintiles as the independent variable while adjusting for patients' demographic variables, comorbidity burden, and APACHE II score at ICU admission. Logistic regression models were used to examine the association between ADI quintile groups and binary outcomes of discharged home and in-hospital mortality. We chose to divide our sample into quintiles to: 1) detect potential nonlinear trend between ADI and delirium outcomes; 2) minimize the influence of potential ADI outliers; and 3) maximize statistical power to detect a relationship between ADI and delirium outcomes.

RESULTS

Demographics

A total of 326 patients were included in the overall analysis (Table 1). The mean age of the study cohort was 60.3 years with a SD of 15.5 years. In our cohort, 54.5% were female, and 48% were Black, with a mean education of 11.5 years (SD, 2.3 yr). The median CCI was 3 (interquartile range [IQR], 1–5), and the median APACHE II score was 20 (IQR, 14–26). Acute respiratory failure or sepsis were the most frequent ICU admission diagnoses (52.2%). The overall cohort was divided into quintiles based on ADI national percentiles. There was a significant difference among quintile groups in the proportion of patients randomized to the study intervention (the PMD study) vs. usual care ($p = 0.023$). No significant differences were noted between ADI quintiles in other demographic or clinical characteristics, as shown in Table 1. In sum, the study sample represented an older population with moderate pre-existing comorbidity burden and high illness severity upon ICU admission.

ADI and Delirium Duration and Severity

Table 2 and Figure 1 show the primary and secondary outcomes of interest based on ADI quintiles. The median number of DCFDs by day 8 was 4 (IQR, 1–7) and

TABLE 1.
Baseline Demographic and Clinical Characteristics of Study Population by Area Deprivation Index Quintile

Characteristic	Overall (n = 326)	≤ 65 (n = 67)	66–83 (n = 62)	84–92 (n = 68)	93–96 (n = 65)	97–100 (n = 64)	p
Age, mean (sd)	60.3 (15.5)	60.0 (14.7)	59.6 (15.9)	59.9 (13.9)	62.7 (17.1)	59.1 (16.0)	0.710
Female, n (%)	178 (54.6)	38 (56.7)	36 (58.1)	34 (50.0)	37 (56.9)	33 (51.6)	0.847
Years of education, mean (sd)	11.5 (2.3)	11.0 (2.6)	11.8 (2.5)	11.9 (1.7)	11.5 (2.5)	11.4 (1.9)	0.200
Race, n (%)							0.573
White	165 (51.2)	37 (56.1)	35 (56.5)	36 (53.7)	29 (45.3)	28 (44.4)	
Black	155 (48.1)	29 (43.9)	26 (41.9)	31 (46.3)	35 (54.7)	34 (54.0)	
Hispanic	2 (0.6)	0 (0.0)	1 (1.6)	0 (0.0)	0 (0.0)	1 (1.6)	
Diagnosis, n (%)							0.936
Acute respiratory failure/sepsis	170 (52.2)	35 (52.2)	33 (53.2)	37 (54.4)	30 (46.2)	35 (54.7)	
Neurologic	44 (13.5)	10 (14.9)	7 (11.3)	11 (16.2)	8 (12.3)	8 (12.5)	
Other	112 (34.4)	22 (32.8)	22 (35.5)	20 (29.4)	27 (41.5)	21 (32.8)	
Charlson Comorbidity Index ^a , median (25–75%)	3 (1–5)	3 (1–5)	2.5 (1–5)	3 (1–5)	3 (1–4)	3 (1–5)	0.973
Acute Physiology and Chronic Health Evaluation II ^b , median (25–75%)	20 (14–26)	19 (13–26)	21 (15–27)	20 (15–25.5)	21 (15–25)	20 (13–25)	0.823
Usual care ^c , n (%)	162 (49.7)	30 (44.8)	28 (45.2)	43 (63.2)	37 (56.9)	24 (37.5)	0.023

^aCharlson Comorbidity Index scoring scale: comorbidity severity is 1–2 = mild, 3–4 = moderate, and ≥ 5 = severe.

^bAcute Physiology and Chronic Health Evaluation II scoring scale: score ranges from 0 to 71, with higher scores representing greater illness severity.

^cUsual care vs. intervention refers to whether the patient was randomly assigned to the usual care group or the intervention group in the original parent study.

by day 30 was 25 (IQR, 19–29; Fig. 1A). The overall mean CAM-ICU-7 score by day 8 was 3.8 (sd, 2.3) and by discharge was 3.1 (sd, 2.1; Fig. 1B). No differences were observed in DCFDs by day 8 ($p = 0.607$) and day 30 ($p = 0.462$) or mean CAM-ICU-7 scores by day 8 ($p = 0.492$) or by day 30 ($p = 0.857$) based on ADI quintiles (Table 2 and Fig. 1).

Supplementary Table S2 (<https://links.lww.com/CCX/B595>) shows the results of our Spearman correlations examining the relationship between national ADI percentile score and delirium outcomes. No significant correlations were observed between ADI scores and either DCFDs or mean CAM-ICU-7 scores by day 8 or hospital discharge.

Table 3 shows the results of our regression analysis. There were no significant associations between ADI percentile groups and DCFDs or delirium severity by day 8 or discharge. However, several covariates in the model demonstrated an association with

delirium characteristics. Black race was associated with fewer DCFDs by day 8 ($\beta = -0.86$; SE, 0.38; $p = 0.023$) while higher CCI scores were associated with fewer DCFDs by discharge ($\beta = -0.48$; SE, 0.22; $p = 0.031$). Black race was also associated with higher delirium severity (higher mean CAM-ICU-7 scores) by day 8 ($\beta = 0.70$; SE, 0.29; $p = 0.018$), and age was associated with higher delirium severity by discharge ($\beta = 0.02$; SE, 0.01; $p = 0.011$). The regression models excluded 60 participants, mainly due to missing data regarding years of education. Additionally, we conducted a fixed effects model to account for clustering, given the different hospital sites, and the results were largely unchanged (**Supplementary Table S3A**, <https://links.lww.com/CCX/B595>). We performed the same regression analyses without controlling for years of education, as the ADI score also accounts for educational level within a neighborhood, and found that the age was no longer associated with greater

TABLE 2.
Outcomes of Interest of Study Population for Overall Cohort and by Area Deprivation Index Quintile

Characteristic	Overall (n = 326)	≤ 65 (n = 67)	66–83 (n = 62)	84–92 (n = 68)	93–96 (n = 65)	97–100 (n = 64)	p
DCFDs ^a by day 8, median (25–75%)	4 (1–7)	4 (2–8)	3.5 (1–7)	4 (0–7)	5 (2–6)	5 (2–7)	0.607
DCFDs by day 30, median (25–75%)	25 (19–29)	26 (20–30)	24 (17–29)	24 (17–29)	26 (22–28)	26 (22–29)	0.462
CAM-ICU-7 ^b score by day 8, mean (sd)	3.8 (2.3)	3.7 (2.3)	4.2 (2.4)	3.8 (2.5)	3.7 (2.1)	3.6 (2.2)	0.492
CAM-ICU-7 score by discharge, mean (sd)	3.1 (2.1)	3.2 (2.2)	3.4 (2.2)	3.2 (2.3)	3.0 (2.0)	2.9 (2.0)	0.857
Hospital length of stay, median (25–75%)	19 (13–31)	18 (11–25)	23 (16–33)	21 (14–34)	17 (12–35)	19 (13–33)	0.039
ICU length of stay, median (25–75%)	16 (10–26)	15 (10–21)	18 (12–29)	19 (12–31)	15 (9–25)	14 (10–23)	0.067
In-hospital mortality, n (%)	40 (12.3)	10 (14.9)	10 (16.1)	10 (14.7)	4 (6.2)	6 (9.4)	0.351
Discharge home, n (%)	116 (35.9)	24 (35.8)	26 (41.9)	15 (22.7)	27 (41.5)	24 (38.1)	0.137

CAM-ICU-7 = Confusion Assessment Method for the ICU-7, DCFDs = delirium- and coma-free days.

^aDCFDs (the duration of normal cognitive status, as defined as the number of days the patient was alive, free of delirium, and not in a coma).

^bCAM-ICU-7 scoring scale: 0–2 = no delirium, 3–5 = mild to moderate delirium, and 6–7 = severe delirium.

delirium severity (as evidenced by higher mean CAM-ICU-7 scores) through discharge ($\beta = 0.02$; SE, 0.01; $p = 0.053$) while Black race was now associated ($\beta = 0.57$; SE, 0.024; $p = 0.019$), as shown in **Supplementary Table S3B** (<https://links.lww.com/CCX/B595>).

ADI, Length of Stay, In-Hospital Mortality, and Discharge Home Rates

As shown in Table 2, the median hospital LOS was 19 days (IQR, 13–31 d), and the median ICU LOS was 16 days (IQR, 10–26 d). The overall in-hospital mortality rate was 12.3%, and 36% of ICU patients were discharged home. There was a significant difference among quintile groups for median hospital LOS ($p = 0.039$). No differences were observed between ADI quintiles for ICU LOS ($p = 0.067$), in-hospital mortality ($p = 0.351$), or discharged home status ($p = 0.137$; Table 2).

Table 4 shows the results of our logistic regression model for odds of discharge home alive or in-hospital mortality. ADI percentile scores above 50 were not significantly associated with odds of discharge home or

in-hospital mortality. Greater age (odds ratio [OR], 0.95; 95% CI, 0.93–0.97; $p < 0.001$) and severity of illness by APACHE II scores (OR, 0.95; 95% CI, 0.92–0.99; $p = 0.013$) were associated with lower odds of discharge home, while greater comorbidity burden as assessed by CCI scores was associated with increased odds of in-hospital mortality (OR, 1.25; 95% CI, 1.10–1.42; $p = 0.001$). Performing a fixed effects model to account for hospital site, and subsequently excluding education did not change the results (**Supplementary Table S4, A and B**, <https://links.lww.com/CCX/B595>).

DISCUSSION

Our results did not support our hypothesis of an association between geographic disadvantage and delirium characteristics in the ICU. However, we did find associations between other demographic and clinical variables and delirium characteristics. Black race and comorbidity burden were associated with longer delirium duration, and Black race and age were associated with greater delirium severity. We also found that higher age and illness severity were each associated with lower odds of discharge

home and that greater comorbidity burden was associated with higher odds of in-hospital mortality. Geographic disadvantage was not associated with other clinical outcomes of interest, except for hospital LOS, in which the middle ADI quintiles had longer hospital LOS than those in the lowest or highest ADI quintiles. We were unable to account for this finding; it may be due to chance, given our

small sample size. A prospective research study with a larger sample would be needed to ascertain whether this is a true phenomenon and to identify the underlying contributory factors.

While geographic disadvantage and its role in health outcomes has become a burgeoning topic of research, there has been very limited research on geographic disadvantage and delirium. The mechanisms

underlying a potential link between geographic disadvantage and delirium characteristics are likely complex and multifaceted. Geographic disadvantage may reflect chronic environmental and socioeconomic stressors that impact brain health and cognitive reserve in a way that confers vulnerability to delirium during medical illness. Chronic stress is thought to affect the hypothalamic-pituitary-adrenal axis by causing a dysregulated “flight-or-fight” response (51), leading to persistently elevated cortisol levels, which have been associated with impairments in cognitive functioning (52). Mental health may also mediate the link between stress and cognition. For example, lower socioeconomic status is associated with an increased risk of clinical depression (53, 54), potentially resulting in subclinical impairments in cognitive health that could predispose patients to delirium during acute medical illness. Finally, geographic disadvantage may also reflect the availability (or lack thereof) of community resources, such as lack of nutritious food options (55–57) or limited access to healthcare providers (31, 58–60), or a specific harm posed by living in a particular area, such as exposure to pollutants (61, 62). Patients from deprived

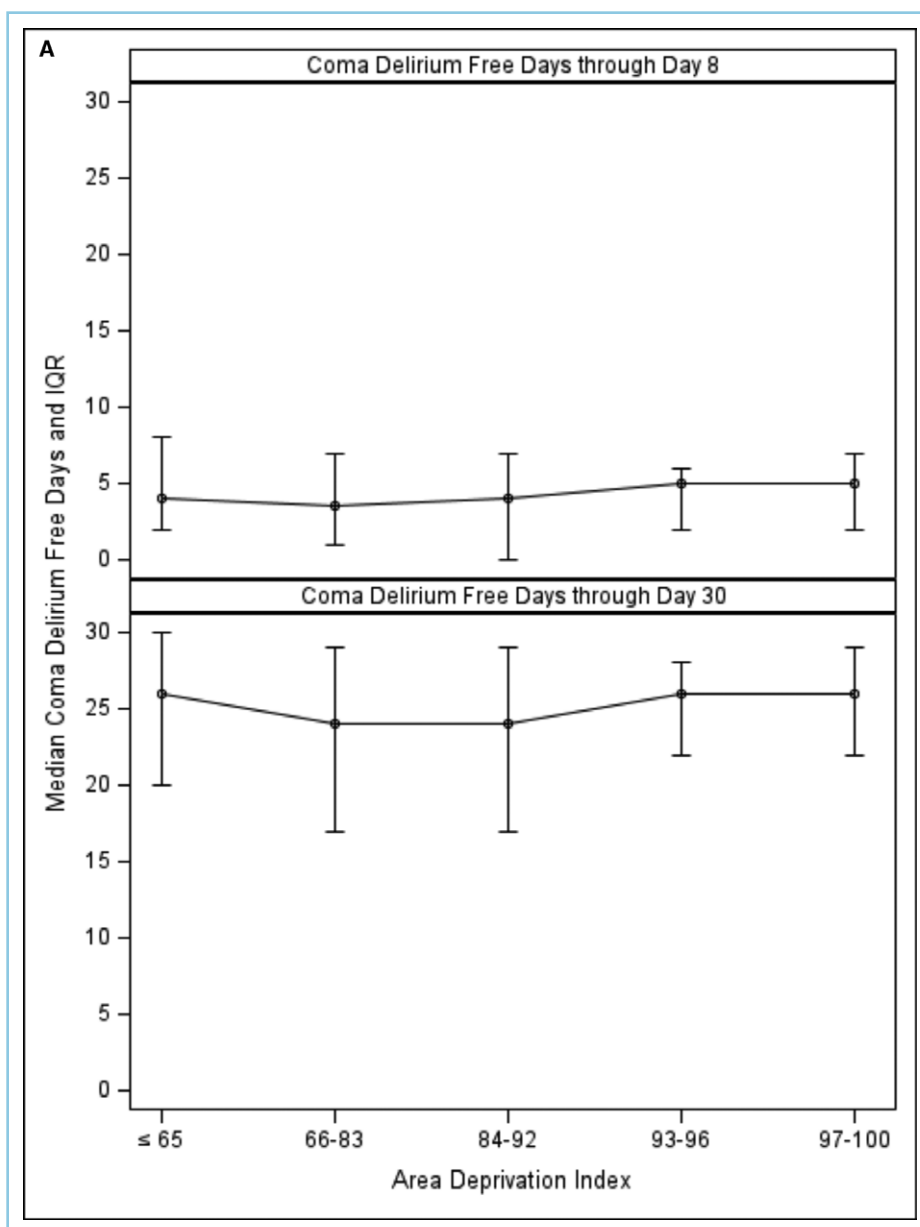


Figure 1. Delirium duration and severity by area deprivation index (ADI) quintile. **A.** Median number of days free of coma and delirium by ADI through day 8 (**top**) and through day 30 (**bottom**) for each ADI quintile group in our study population. The ADI national percentile score ranges from 1 to 100, with higher numbers representing greater disadvantage. The bars represent the interquartile ranges (IQRs) for each value. There were no significant differences between groups in the median number of days free of coma and delirium. (Continued)

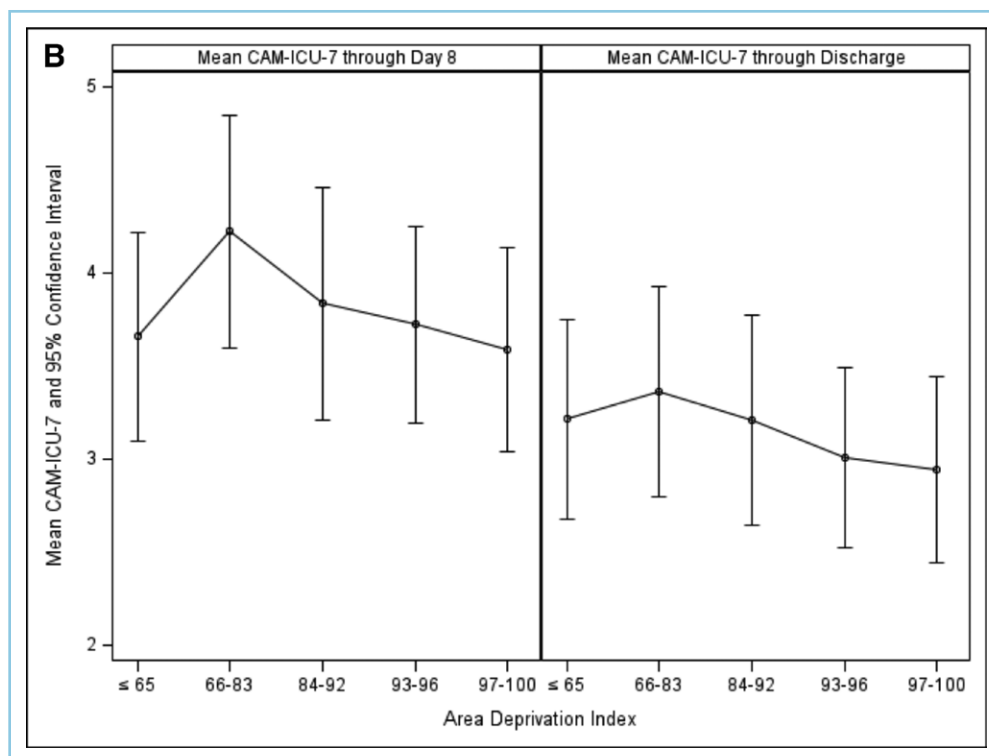


Figure. (Continued). **B**, Mean Confusion Assessment Method for the ICU (CAM-ICU)-7 scores by ADI quintile through day 8 (**left**) and through day 30 (**right**) for each ADI quintile group in our study population. The *bars* represent the 95% CIs for each value. There were no significant differences in the mean CAM-ICU-7 scores between groups.

neighborhoods are more likely to be on public insurance (63), and therefore face more barriers accessing primary and specialty care, including lower provider acceptance rates and longer wait times for appointments (64, 65), and the potential for insurance-based discrimination (66). These factors may lead to poorer baseline health status, higher comorbidity burden, and worse illness severity, leading to a higher risk for developing delirium.

A cohort study of older postoperative patients by Arias et al (24) found a statistically significant association between geographic disadvantage as measured by national ADI percentile and delirium incidence and severity. Their study also found that the degree of geographic disadvantage correlated with delirium severity in an exposure-response relationship. Our study failed to replicate the findings of Arias et al (24), but there were key differences between our study and the Arias et al (24). The cohort in their study was predominantly White with 8% of the cohort categorized as non-White, with ADI national percentile scores in the bottom half of the range (suggesting less disadvantage), and the most disadvantaged 5% of their sample

having an ADI of greater than 44. Our study population was more diverse and had a large proportion of non-White patients (48.1% Black and 0.6% Hispanic) and was heavily skewed toward greater geographic disadvantage, with ADI scores in the top half of the range (suggesting greater disadvantage), and the most disadvantaged 5% of our sample having an ADI of 99. This may have made it difficult to detect an association between geographic disadvantage and delirium characteristics, given that most of our study participants lived in areas of moderate to severe geographic disadvantage. We also controlled for level of education and other demo-

graphic and clinical factors that could account for any association between geographic disadvantage and delirium characteristics. Finally, the cohort in the Arias et al (24) study consisted of postoperative patients who had undergone elective surgery, while our sample population consisted of critically ill patients with various etiologies for ICU admission, both medical and surgical. Key differences in delirium mechanisms and subtypes may influence how various risk factors affect delirium outcomes across the two study populations.

Another notable difference is that our sample was comprised of patients who had already developed delirium, so we could not explore whether there might be a relationship between geographic disadvantage and delirium incidence. An important consideration is that while baseline characteristics, both clinical and demographic, may contribute to the risk of delirium incidence, it is less clear whether those same pre-hospital risk factors also affect delirium duration and severity. Research on risk factors related specifically to delirium duration, severity, and persistence to discharge is limited, as compared with research examining risk factors for delirium incidence. Inouye et al (67) found that

TABLE 3.

Regression Results for Mean Confusion Assessment Method for the ICU Severity and Delirium- and Coma-Free Days ($n = 266$)^a

Characteristic	Delirium- and Coma-Free Days				Mean Confusion Assessment Method for the ICU Score-7			
	Through Day 8		Through Discharge		Through Day 8		Through Discharge	
	B (SE)	p	B (SE)	p	B (SE)	p	B (SE)	p
Age	-0.003 (0.01)	0.843	-0.03 (0.04)	0.515	0.01 (0.01)	0.598	0.02 (0.01)	0.011
Female	-0.05 (0.38)	0.898	-0.07 (1.19)	0.953	-0.09 (0.30)	0.754	0.06 (0.27)	0.826
Education	-0.04 (0.08)	0.632	-0.04 (0.26)	0.888	0.05 (0.07)	0.477	0.04 (0.06)	0.450
Black	-0.86 (0.38)	0.023	-1.55 (1.17)	0.186	0.70 (0.29)	0.018	0.47 (0.26)	0.077
Charlson Comorbidity Index scoring scale	-0.09 (0.07)	0.197	-0.48 (0.22)	0.031	0.07 (0.06)	0.210	0.09 (0.05)	0.059
Acute Physiology and Chronic Health Evaluation II scoring scale	-0.02 (0.02)	0.495	-0.03 (0.08)	0.643	-0.01 (0.02)	0.779	0.01 (0.02)	0.752
Usual care ^b	-0.21 (0.38)	0.584	-0.22 (1.19)	0.857	0.001 (0.30)	0.998	0.11 (0.27)	0.689
Area deprivation index								
66–83	-0.75 (0.58)	0.198	-1.69 (1.79)	0.347	0.52 (0.45)	0.253	0.02 (0.40)	0.968
84–92	-0.11 (0.59)	0.849	-0.72 (1.83)	0.694	-0.10 (0.46)	0.826	-0.27 (0.41)	0.517
93–96	0.19 (0.58)	0.747	1.74 (1.80)	0.336	-0.31 (0.45)	0.495	-0.56 (0.40)	0.165
97–100	-0.15 (0.56)	0.792	0.97 (1.75)	0.579	-0.10 (0.44)	0.821	-0.23 (0.39)	0.550
≤ 65 (reference)								

^aThe smaller sample size is due to missing data observations (education, $n = 50$; Acute Physiology and Chronic Health Evaluation II, $n = 8$; and race, $n = 2$).

^bUsual care vs. intervention refers to whether the patient was randomly assigned to the usual care group or the intervention group in the original parent study.

the only hospital-related risk factor that predicted delirium persisting to discharge was the use of restraints, with the other risk factors being dementia, visual impairment, functional impairment, and high comorbidity. It is likely the case that some pre-hospital risk factors for delirium incidence also increase the risk of more severe and prolonged delirium, but that once delirium has occurred, management strategies may play a larger contributory role in determining duration and severity.

While not the main focus of our study, the associations between race and ICU delirium characteristics in our study results add to a body of evidence on racial identity as an SDOH risk factor for delirium. A previous study by our research group did not find a relationship between race and ICU delirium incidence or prevalence (68), while another found Black race was

associated with greater delirium severity and less improvement of delirium during the ICU stay (69). Other studies have noted an increased risk of delirium in Black patients compared with White patients (25, 70, 71). Although we cannot ascertain whether Black racial identity might be a risk factor for delirium incidence or prevalence, as our study focused only on delirium severity and duration, our results suggest that Black racial identity may be a risk factor for greater delirium severity and longer duration of delirium. There may be several possibilities for these findings. Differences in baseline risk factors for Black patients may increase the likelihood of more severe or prolonged delirium, such as greater comorbidity burden resulting from chronic exposure to socioeconomic disadvantage that lead to accelerated aging and decline in health, termed the “weathering” hypothesis (72). Although we did control

TABLE 4.
Logistic Regression Results for Discharge Home and In-Hospital Mortality (n = 266)

Characteristic	Discharge Home		In-Hospital Mortality	
	OR (95% CI)	p	OR (95% CI)	p
Age	0.95 (0.93–0.97)	< 0.001	1.01 (0.98–1.04)	0.616
Female	0.93 (0.52–1.67)	0.811	1.06 (0.47–2.41)	0.880
Education	0.93 (0.82–1.05)	0.248	0.95 (0.80–1.14)	0.589
Black	0.96 (0.54–1.72)	0.902	0.90 (0.40–2.03)	0.803
Charlson Comorbidity Index scoring scale	0.90 (0.81–1.01)	0.081	1.25 (1.09–1.42)	0.001
Acute Physiology and Chronic Health Evaluation II scoring scale	0.95 (0.91–0.98)	0.004	1.03 (0.98–1.08)	0.236
Usual care ^a	1.01 (0.56–1.82)	0.972	1.09 (0.48–2.46)	0.836
Area deprivation index				
66–83	2.12 (0.88–5.14)	0.095	1.15 (0.37–3.57)	0.808
84–92	0.72 (0.28–1.86)	0.497	1.44 (0.48–4.35)	0.515
93–96	2.37 (0.98–5.72)	0.056	0.22 (0.04–1.14)	0.071
97–100	1.32 (0.56–3.14)	0.529	0.50 (0.14–1.81)	0.289
≤ 65 (reference)				

OR = odds ratio.

^aUsual care vs. intervention refers to whether the patient was randomly assigned to the usual care group or the intervention group in the original parent study.

for comorbidity burden in our analyses using the CCI, it may not accurately capture all relevant comorbidities or reflect the full impact of preexisting disease burden on acute critical illness, especially in Black patients or patients from other minority groups, given the question of racial or ethnic diversity in the original cohort in which the CCI was developed (50). It is also possible that Black racial identity (or identification with another minority group) might lead to delayed diagnosis or underrecognition of delirium symptoms and suboptimal management by clinicians. Although there are no specific research studies that have examined this question, a number of studies suggest an increased use of physical restraints in Black patients as compared with White patients in the emergency department setting (73–75), as well as longer duration of physical restraints (76) and increased use of chemical sedation (77) in Black vs. White patients presenting with psychiatric symptoms. While our ICU staff have been trained to recognize and address delirium in all critically ill patients, the turnover of nurses, the addition of new trainees annually, and varying practice patterns among individual clinicians may result in inconsistent application of this training and subconscious bias that

may disproportionately affect Black patients. Although we did not examine whether there may be racial differences in timely and accurate delirium diagnosis or delirium management among our ICU patients, this may need to be a consideration in future research studies.

Given the complexity of the relationship among race, ethnicity, and socioeconomic factors, further research that considers various socioeconomic and contextual risk factors when examining these associations is needed. Due to a variety of factors, minority populations are concentrated in areas that are more impoverished and geographically disadvantaged, which has been associated with a variety of worse health outcomes (78). In our study population, the two most disadvantaged ADI quintiles did have a greater proportion of Black participants (54% Black) compared with the other three quintiles (approximately 42–46% Black; Table 1), although this difference was not high enough to be statistically significant. On the other hand, there is evidence to suggest that Black patients may not experience the protective benefits of living in a more advantaged neighborhood, compared with White patients. One retrospective cohort study examining 30-day readmission rates among Medicare

participants with dementia found that while geographic disadvantage was associated with greater readmission rates for White beneficiaries, this did not hold true for Black beneficiaries, who had 37% higher odds of readmission compared with White beneficiaries even after adjusting for numerous social, geographic, demographic, hospital, and stay-level factors and patient comorbidities (79). This raises the question of whether there may indeed be an association between geographic disadvantage and delirium characteristics, but that race happens to be a more “potent” SDOH risk factor, which may have been more evident in our sample population with a higher proportion of Black participants than the Arias et al (24) cohort.

Strengths of our study include the higher proportion of Black patients and a greater degree of geographic disadvantage, which allowed for the opportunity to test our hypothesis in a study population that is socioeconomically distinct from the Arias et al (24) study population. Delirium outcomes were measured through validated instruments. We collected delirium severity outcomes, which are not routinely collected in ICU studies.

Our study had some limitations. One is the relatively small sample size and skewed nature of our sample, with few participants with ADIs in the lower range (suggesting less disadvantage). We used EMR data and not patient self-identification during study enrollment for race ascertainment, which in certain cases could have led to misidentification by staff, especially for patients who were unable to provide information on hospital arrival or admission due to their clinical condition. Due to the enrollment criteria of the original study, which required the ability to speak English, our sample had a limited number of participants who identified as Latinx, Asian, American Indian, or another racial or ethnic minority group. Given that deprived neighborhoods may have a higher proportion of non-English speaking populations, this may have had implications for our results.

While our results did not find a significant association between geographic disadvantage and ICU delirium characteristics, our study adds to a growing body of research exploring links between SDOH and delirium. Further research with a sample population representing a wide range of ADIs is needed to ascertain whether an association truly exists between geographic disadvantage and delirium.

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Dr. Chi conceived of and designed the research project, collected data, and wrote the article. Dr. Perkins prepared data, performed the analysis, created figures and tables, and provided substantial revisions to the article. Dr. Corlett assisted with conception and design of the project and with data collection. Drs. Khan and Wang provided substantial revisions to the article. Dr. Gao provided oversight on statistical analysis and interpretation of data and provided substantial revisions to the article. Dr. Boustani contributed the data from the parent study for this work. Dr. Khan provided supervision and guidance during the conception of the research question and design, oversaw the data analysis and interpretation by the biostatisticians, and provided substantial revisions to the article.

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