RESEARCH ARTICLE

Association of Neighborhood Socioeconomic Status With Withdrawal of Life-Sustaining Therapies After Intracerebral Hemorrhage

Kara R. Melmed, MD, Ariane Lewis, MD, Lindsey Kuohn, MD, Joanna Marmo, BSN, RN, SCRN, Nirmala Rossan-Raghunath, MSN, SCRN, Jose Torres, MD, Rajanandini Muralidharan, MD, Aaron S. Lord, MD, MSc, Koto Ishida, MD, and Jennifer A. Frontera, MD

Correspondence
Dr. Melmed
kara.melmed@nyulangone.org

Neurology® 2024;102:e208039. doi:10.1212/WNL.0000000000208039

Abstract

Background and Objectives

Mortality after intracerebral hemorrhage (ICH) is common. Neighborhood socioeconomic status (nSES) is an important social determinant of health (SDoH) that can affect clinical outcome. We hypothesize that SDoH, including nSES, contribute to differences in withdrawal of life-sustaining therapies (WLSTs) and mortality in patients with ICH.

Methods

We performed a retrospective study of patients with ICH at 3 tertiary care hospitals between January 2017 and December 2022 identified through the Get with the Guidelines Database. We collected data on age, clinical severity, race/ethnicity, median household income, insurance, marital status, religion, mortality before discharge, and WLST from the electronic medical record. We assessed for associations between SDoH and WLST, mortality, and poor discharge mRS using Mann-Whitney *U* tests and χ^2 tests. We performed multivariable analysis using backward stepwise logistic regression.

Results

We identified 868 patients (median age 67 [interquartile range (IQR) 55–78] years; 43% female) with ICH. Of them, 16% were Black non-Hispanic, 17% were Asian, and 15% were of Hispanic ethnicity; 50% were on Medicare and 22% on Medicaid, and the median (IQR) household income was $81,857 ($58,669–$122,078). Mortality occurred in 17% of patients, and of them, 84% of patients had WLST. Patients from zip codes with higher median household incomes had higher incidence of WLST and mortality ($p < 0.01$). Black non-Hispanic race was associated with lower WLST and discharge mortality ($p \leq 0.01$ for both). In multivariable analysis adjusting for age and clinical severity scores, patients who lived in zip codes with high-income levels were more likely to have WLST (adjusted odds ratio [aOR] 1.88; 95% CI 1.29–2.74) and mortality before discharge (aOR 1.5; 95% CI 1.06–2.13).

Discussion

SDoH, including nSES, are associated with WLST after ICH. This has important implications for the care and management of patients with ICH.

Introduction

Mortality after intracerebral hemorrhage (ICH) is common, occurring in 30%–40% of patients.[1,2] Withdrawal of life-sustaining therapy (WLST) is independently associated with mortality after ICH.[2] Social determinants of health (SDoH), such as area of residence,[3,4] affect health outcomes in general and, particularly, outcomes in cardiovascular and neurovascular disease.[5-10] For example, neighborhood socioeconomic status (nSES) is associated with

From the Departments of Neurology and Neurosurgery (K.R.M., A.L.), and Neurology (L.K., J.T., R.M., A.S.L., K.I., J.A.F.), NYU Langone Health and NYU Grossman School of Medicine; and Department of Neurology (J.M., N.R.-R.), NYU Langone Health, New York.

Go to Neurology.org/N for full disclosures. Funding information and disclosures deemed relevant by the authors, if any, are provided at the end of the article.

Glossary

aOR = adjusted OR; **EMR** = electronic medical record; **GWTG** = Get with the Guidelines; **ICH** = intracerebral hemorrhage; **IQR** = interquartile range; **LOS** = length of stay; **LTACH** = long-term acute care hospital; **mRS** = modified Rankin Scale; **NIHSS** = NIH Stroke Scale; **nSES** = neighborhood socioeconomic status; **OR** = odds ratio; **SAR** = subacute rehabilitation; **SDoH** = social determinants of health; **SNF** = skilled nursing facility; **WLST** = withdrawal of life-sustaining therapy.

mortality in patients hospitalized for neurologic disease.[11,12] Unfortunately, outcome disparities based on SDoH seem to be worsening.[13] We sought to determine how WLST after ICH is affected by SDoH and how this contributes to mortality before discharge.

Methods

We performed a retrospective cross-sectional study of patients with ICH at 3 urban tertiary care hospitals in Brooklyn, Manhattan, and Long Island between January 2017 and December 2022 identified through the Get with the Guidelines (GWTG) database. We identified independent variables from data prospectively collected for the GWTG database and through automated electronic medical record (EMR) data retrieval. This study was approved by the NYU Institutional Review Board, protocol s19-01144. Written consent was not obtained from patients in this study because the protocol was exempt because of its retrospective nature.

Social Determinants of Health

SDoH were chosen based on currently available variables in our EMR. Information regarding race/ethnicity, zip code, occupation, marital status, religion, and insurance was obtained from the EMR. Race and ethnicity were either self-reported on admission or determined by hospital staff when self-reporting was not possible. Marital status, religion, and occupation, when available, were self-reported. A dummy variable of companion was created for marital status, defined as patients who reported they are married, have a significant other, or a partner.

Zip codes were linked to median household income from the 2021 US Census American Community Survey 2021 5-year estimate, which was the most current, comparable census data available at the time of analysis and are reported in 2021 inflation-adjusted dollars.[14,15] Incomes were divided in 4 quartiles, ≤$58,669, $58,670–$81,857, $81,858–$121,688, and >$121,688. We also assessed the percentage of high-income households within a zip code, defined as households with incomes in the top 10% of all US households (≥$200,000).[15] We further stratified nSES as a binary variable of the median household income by zip code less/greater than the national median household income of $70,784 in 2021.[14] The median household income in New York State was $75,157 in 2021.[14]

Insurance was recorded as Medicare, Medicaid, dual, private, or no insurance/self-pay. Dual-eligible beneficiaries, a group with unique health disparities,[16] was coded as its own group.

Outcomes

Our primary outcomes were WLST and discharge mortality. Charts were manually reviewed for WLST, which was defined by either documentation of discussion and agreement by patient surrogate to stop all life-sustaining therapy, palliative extubation, and/or admission to hospice. Neurology-trained neurointensivists conducted goals-of-care conversations for all intubated patients, or as clinically relevant, at each hospital site. Mortality included in-hospital deaths and patients discharged to hospice.

Our secondary outcomes were functional outcome on discharge and discharge disposition. We defined functional outcome on discharge by discharge modified Rankin Scale (mRS) score as documented in the discharge summary by a board-certified neurologist, dichotomizing poor discharge mRS as mRS 4–6. Discharge disposition included "home, with or without services," "acute inpatient rehabilitation," "subacute rehabilitation (SAR) or skilled nursing facility (SNF)," "long-term acute care hospital (LTACH)," or "transfer to another acute care hospital." Patients who "left against medical advice" were counted as a home disposition. We also looked at discharge as a dichotomized variable defined as good (discharge to home, acute rehabilitation or transfer to another acute care hospital) or poor (discharge to SAR, SNF, LTACH, hospice, or with mortality).

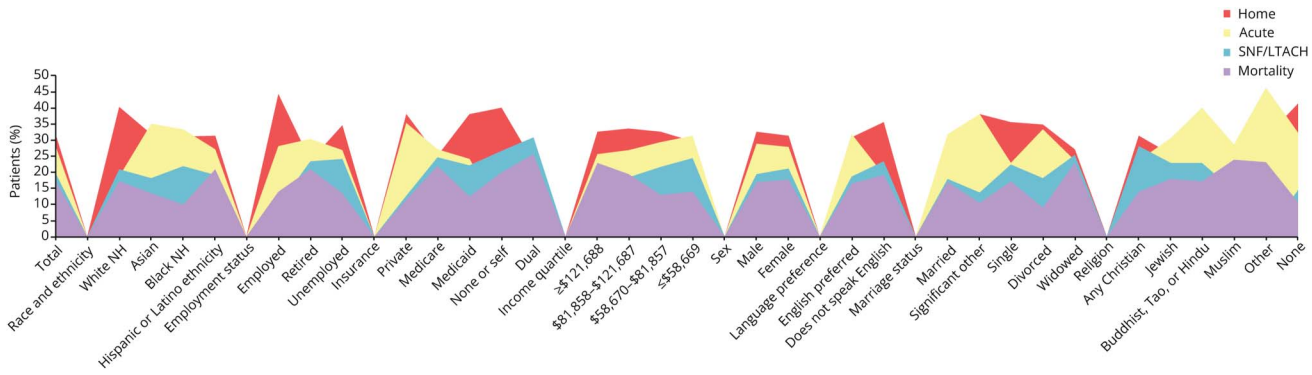
Other Covariates

Comorbidities including medical history of hypertension, diabetes, and coronary artery disease were extracted from the medical record. The NIH Stroke Scale (NIHSS)[17] and ICH Score[18] were used as markers of clinical severity on admission. Hospital length of stay (LOS) and days on a ventilator were used as markers of illness severity.

Statistical Analysis

We summarized the characteristics of the study population using frequencies and percentages for categorical variables and medians with interquartile ranges (IQRs) for continuous variables. Missing variables were dealt with using population median imputation.[19] Mann-Whitney U tests and χ^2 tests were used to analyze continuous and noncontinuous variables, using dummy variables for each category of SDoH. We assessed for interaction effects using analysis of variance. We then built multivariable models to identify covariates associated with each outcome, initially using all covariates with $p > 0.1$ in univariable analysis and including SDoH categories as a single group and then covariates were backwards eliminated. Once the strongest model was identified, we ran multivariable

Figure 1 Discharge Disposition and Mortality



LTACH = long-term acute care hospital; NH = non-Hispanic; SNF = skilled nursing facility.

analysis for each SDoH category and individual variable (eTables 1 and 2, links.lww.com/WNL/D344) for both mortality and WLST prediction. We performed receiver operating characteristic curves for median household income within a zip code to predict WLST.

Finally, we ran an additional univariable and multivariable analyses using the most conservative model that included all factors associated with WLST (age, ICH score, ventilator days, hospital LOS) in patients who lived in zip codes in which median household income was below the national median. The significance threshold was set at a 2-sided p-value of 0.05, and 95% CI were reported for all odds ratios (ORs). All analysis was performed on SPSS v28.

Results

From 11,732 patients enrolled in GWTG across 3 campuses over 6 years of interest, we identified 868 patients (median age 67 [IQR 55–78] years; 43% female) with ICH. Most patients went home after admission for ICH (32%), 28% went to acute rehabilitation, and 20% went to a SNF (Figure 1). The median mRS at discharge was 4 (2–5) (Figure 2). Mortality occurred in 150 (17%) patients, and of them, 84% were due to WLST. Medical history of hypertension, diabetes, and coronary artery disease did not result in a difference of WLST nor mortality, although each were individually associated with poor mRS (p < 0.01 for all).

Factors Associated With WLST, Mortality, and Clinical Outcome

Age

Older age was associated with WLST (median age of 77 years [64–86] vs 66 years [53–77], p < 0.001) (Table 1). Discharge mortality was also associated with older age (p < 0.001; eTable 1, links.lww.com/WNL/D344). In addition, patients with poor mRS were significantly older (69 [59–80] years vs 61 [48.5–73.5] years, p < 0.001, Table 2).

Sex and Race/Ethnicity

Of the patients in this cohort, 16% were Black non-Hispanic, 17% were Asian, and 15% were of Hispanic ethnicity. WLST was significantly less likely among Black non-Hispanic patients WLST (7% vs 18%, p < 0.01). Mortality was lower in Black non-Hispanic patients (9%) compared with survival (18%) (p = 0.04). Female sex was not associated with any of the outcomes on univariable analysis, but female patients were less likely to undergo WLST after adjusting for age, LOS, ventilator days, and ICH score (adjusted OR [aOR] 0.44; 95% CI 0.2–0.97). Hispanic patients were less likely to be discharged to acute rehabilitation (11% vs 18%, p = 0.006) but more likely to go home (20% vs 14%, p = 0.04; Figure 1).

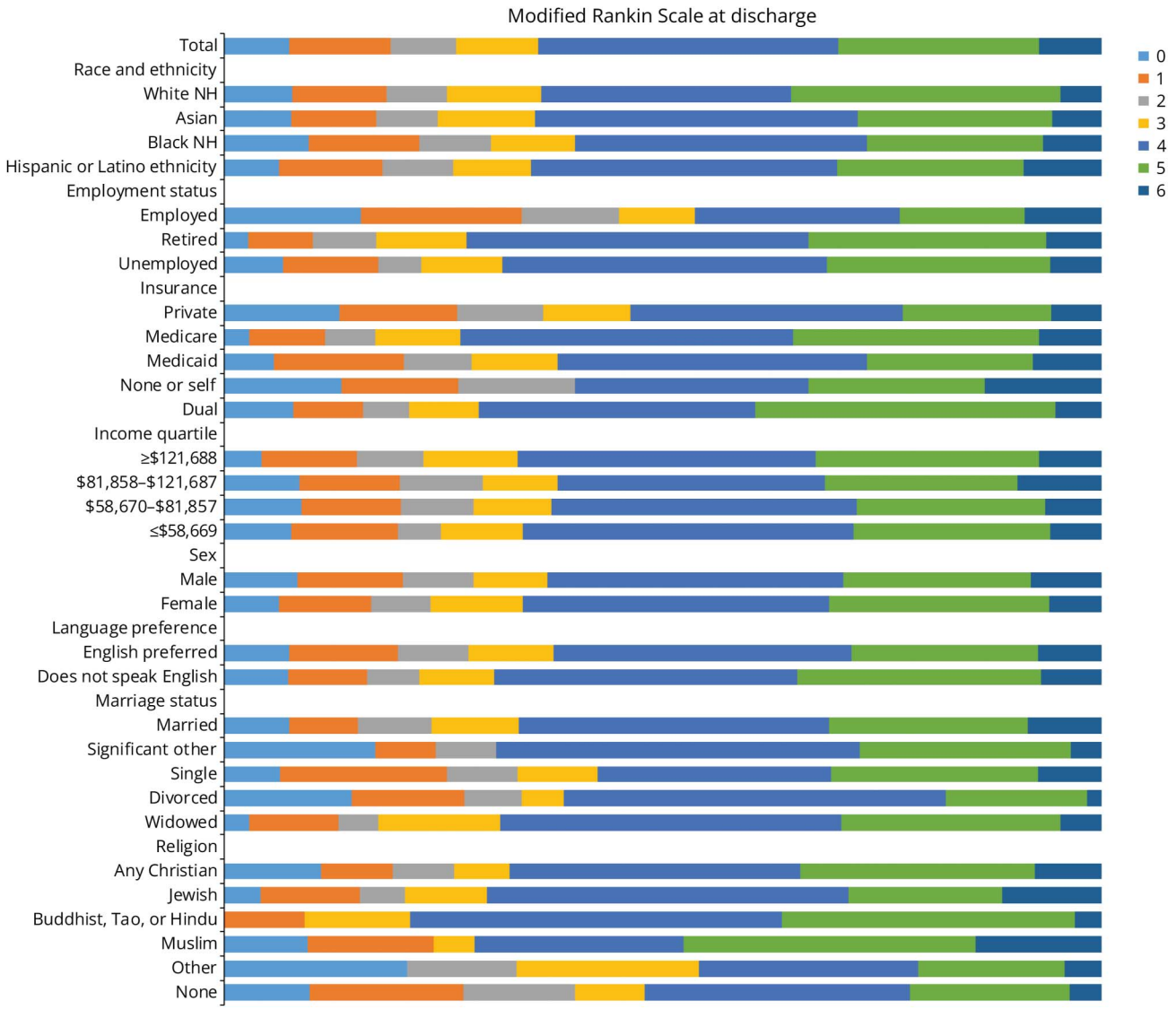
Primary Language

The primary language was English in 72% of patients (Table 1). Primary language was not associated with WLST or mortality, but patients with primary English language were more likely to have a good discharge mRS (60% vs 27% with a poor discharge mRS p < 0.001) and were more likely to be discharged to acute rehabilitation (80%) than not (68%) (p < 0.001) (Figure 1). After multivariable analysis and adjustment for ICH score and ventilator days, English language remained associated with a better discharge mRS (OR 0.29; 95% CI 0.09–0.93). Patients with primary English language were more likely to have a good dichotomized discharge disposition (381 [74%] good vs 191 [67%] bad, p = 0.03).

Religion

Most patients reported any Christian denomination (57%), and of these patients, Catholic religion was the most common (63%), although patients also self-reported as Christian (18%), Baptist (3%), Protestant (2%), Greek Orthodox (2%), Lutheran (1%), Pentecostal (1%), Episcopal (1%), Methodist (1%), Unitarian Universalist (1%), Russian Orthodox (0.8%), Jehovah's Witness (0.6%), Presbyterian (0.4%), Seventh Day Adventist (0.4%), Anglican (0.2%), Mormon (0.2%), and Nazarene (0.2%). Patients who self-reported as Christian were more likely to undergo WLST (66% vs 56%, p < 0.05).

Figure 2 Modified Rankin Scale at Discharge



NH = non-Hispanic.

Catholic patients had more WLST and higher mortality (45% vs 34%, p = 0.02). Patients who reported no religion or atheism were less likely to undergo WLST and had lower mortality (p < 0.05 for both). Only 1% of patients did not report a religion. After adjusting for age, ICH score, hospital LOS, and ventilator days, Jewish patients were less likely to have WLST (aOR 0.15; 95% CI 0.03–0.78).

Marital Status

Most patients reported having a companion (53%), with married patients comprising 84%. Patients without companions were widowed (13%), divorced or separated (8%), or single (27%). Widowed patients were more likely to undergo WLST (19% vs 12%, p = 0.02). In just patients living in zip codes comprising patients with incomes lower than the national median (eTable 2, links.lww.com/WNL/D344), WLST was lower in patients who were married (50% vs 30%, p = 0.03) or had any companion (54% vs 30%, p = 0.01).

Occupation

In this cohort, 44% of patients were retired, and only 26% were employed (Table 1). Employed patients were less likely to undergo WLST (18% vs 28%, p = 0.02). Patients with good discharge mRS were more likely to be employed than not (40% vs 19%, p < 0.001; Figure 2). Poor discharge disposition as a dichotomized outcome was associated with employment status; 32% of employed patients had a good discharge disposition compared with 18% with a poor discharge disposition (p < 0.001). There was no difference in occupation status in patients who went to acute rehabilitation after discharge. Although almost a third of patients was unemployed (248, 29%), there was no difference in any outcome measure for these patients.

Table 1 Factors Associated With WLST

	Total (N = 868)	No WLST (n = 741)	WLST (n = 127)	*p* Value
Age, y, median (IQR)	67 (55–79)	66 (53–77)	77 (64–86)	<0.001
Female	378 (44)	320 (43)	58 (46)	0.6
English primary[a]	625 (72)	540 (73)	85 (67)	0.2
Race/ethnicity[a]				0.03
Asian	148 (17)	131 (18)	17 (14)	0.2
Black, non-Hispanic	141 (16)	132 (18)	9 (7)	<0.01
White, non-Hispanic	362 (42)	304 (42)	57 (46)	0.4
Hispanic or Latino	132 (15)	113 (16)	19 (18)	0.6
Marital status[b]				0.04
Married	420 (49)	362 (50)	58 (47)	0.5
Partner	29 (3)	27 (4)	2 (2)	0.2
Any companion	449 (53)	389 (53)	60 (48)	0.3
Single	227 (27)	194 (27)	33 (27)	1.0
Widowed	110 (13)	86 (12)	24 (19)	0.02
Divorced or separated	64 (8)	58 (8)	6 (5)	0.2
Lives in a zip code in which				
Real median household income <$70,784	324 (37)	294 (40)	30 (24)	<0.01
% of households with income >$200,000, median (IQR)	13.9 (7.2–24.9)	13.7 (7.2–24.6)	15.2 (9.6–31.2)	<0.001
Median household income of zip code, $, median (IQR)	81,857 (58,669–122,078)	77,350 (58,487–117,581)	88,687 (73,489–136,431)	<0.001
Religion[c]				0.7
None	167 (20)	151 (21)	16 (13)	0.04
Any Christian denomination	481 (57)	401 (56)	80 (66)	0.046
Catholicism	304 (36)	246 (34)	58 (48)	<0.01
Other Christian denomination	177 (21)	155 (22)	22 (18)	0.4
Judaism	98 (12)	87 (12)	11 (9)	0.3
Buddhism, Taoism, or Hinduism	34 (4)	28 (4)	6 (5)	0.6
Islam	21 (3)	18 (3)	3 (2)	1.0
Other religion	26 (3)	21 (3)	5 (4)	0.5
Employment[b]				<0.01
Unemployed	248 (29)	218 (30)	30 (24)	0.2
Employed	223 (26)	201 (28)	22 (18)	0.02
Retired	380 (44)	307 (42)	73 (58)	<0.01
Insurance[d]				<0.001
Medicare	433 (51)	350 (48)	83 (69)	<0.001
Private	289 (34)	265 (37)	24 (20)	<0.001
Medicaid	193 (23)	171 (24)	22 (18)	0.2
Dual	39 (5)	29 (4)	10 (8)	0.04
None or self-insured	16 (2)	13 (2)	3 (3)	0.6

Continued

Table 1 Factors Associated With WLST *(continued)*

	Total (N = 868)	No WLST (n = 741)	WLST (n = 127)	*p* Value
Comorbidities[a]				
CAD or MI	431 (50)	361 (50)	70 (59)	0.1
Hypertension	789 (91)	672 (91)	117 (94)	0.4
Diabetes	284 (33)	243 (34)	41 (36)	0.7
Admission NIHSS, median (IQR)	7 (3–15)	7 (2–13)	12 (7–27)	<0.001
Admission ICH score, median (IQR)	1 (0–2)	1 (0–2)	3 (1–4)	<0.001
Ventilator days, median (IQR)	6 (2–15)	7 (2–18)	4 (2–11)	0.03
Hospital LOS, d, median (IQR)	6 (3–13)	6 (3–14)	4 (2–10)	<0.001

Abbreviations: CAD = coronary artery disease; ICH = intracerebral hemorrhage; IQR = interquartile range; LOS = length of stay; MI = myocardial infarction; NIHSS = NIH Stroke Scale; WLST = withdrawal of life-sustaining therapy.
Data are presented as n (%) unless otherwise indicated.
[a] n = 859.
[b] n = 852.
[c] n = 839.
[d] n = 846.

Insurance Status

Half of all patients (50%) were on Medicare and 22% on Medicaid (Table 1). Patients with private insurance were less likely to have WLST (20% vs 37%, $p < 0.001$) or a poor discharge mRS (29% vs 44%, $p < 0.001$). Similarly, patients with private insurance were more likely to be discharged alive than to die in the hospital (242 [36%] vs 33 [23%], $p < 0.01$) and less likely to have WLST (24 [20%] vs 267 [37%], $p < 0.001$). Patients with private insurance were more likely to be kept full code (21 [21%] vs 251 [37%], $p < 0.01$) and more likely to have a good discharge disposition (41% vs 23%, $p < 0.001$). Patients with dual coverage were more likely to undergo WLST (8% vs 4%, $p = 0.04$) and have a bad discharge disposition (6% vs 3%, $p = 0.03$).

Neighborhood Socioeconomic Status

The median (IQR) household income was $81,857 ($58,669–$122,078) (Table 1). WLST was more common in patients who lived in areas with higher median household income ($88,687 [$73,489–$136,431] compared with patients who did not $77,350 [$58,487–$117,581], $p < 0.001$). Mortality was also related to areas with higher median household income ($84,145 [$6,466,375–$136,112] vs $77,378 [$58,669–$11,921,525] in patients discharged alive, $p = 0.01$, eTable 1, links.lww.com/WNL/D344). There was a higher percentage of households with incomes of $200,000 or more in patients who had WLST (15.2 [9.6–31.2] vs 13.7 [7.2–24.6]) or died before discharge (15.2 [9.3–30.7] vs 13.7 [7.2–24.6], $p < 0.01$ for both, Table 1 and eTable 1). Patients who lived in neighborhoods in which the household income was less than the median US household income were more likely to be alive at discharge (40% vs 27%, $p < 0.01$) and to not have WLST (40% vs 24%, $p < 0.001$). There was no significant difference in income levels by zip code in discharge mRS nor in discharge home. However, patients who went to SNF/LTACH were more likely to be from areas with lower income ($77,031 [$58,487–$107,088] vs $84,002 [$58,850–$122,078], $p = 0.02$; Figure 1).

In multivariable analysis following backward elimination of covariates and adjusting for age, ICH score, hospital LOS, and ventilator days, residence in areas with higher median household income levels was still associated with WLST (aOR 1.88; 95% CI 1.29–2.74; Table 3). The relationship between higher income by zip code was also still associated with mortality (aOR 1.5; 95% CI 1.06–2.13). There was no significant association between discharge mRS and income by zip code. The area under the curve for median household income was 0.61 for WLST (Figure 3).

Among patients living in zip codes with incomes lower than the national median (eTable 2, links.lww.com/WNL/D344), WLST was higher in patients of Hispanic/Latino ethnicity (OR 4.65; 95% CI 1.94–11.17), and lower in patients with primary English language (OR 0.24; 95% CI 0.1–0.55), and these relationships remained significant after adjusting for age, ICH score, ventilator days, and LOS (aOR 13.3; 95% CI 3.2–55.46 and aOR 0.1; 95% CI 0.02–0.49). Religion was also significantly associated with WLST in this subset of patients, and the aOR was 5.11 (95% CI 1.33–19.52) in Catholic patients.

Discussion

The correlation between income, education, and occupation within neighborhoods has been well-established.[3] Previous work demonstrated a relationship between neighborhood socioeconomic measures and both health

Table 2 Factors Associated With Poor Discharge Outcome

	Good mRS (n = 298)	Poor mRS (n = 570)	*p* Value
Age, y, median (IQR)	61 (49–73)	70 (59–80)	<0.001
Female	126 (42)	252 (44)	0.6
English primary[a]	226 (76)	399 (70)	0.1
Race/ethnicity[a]			0.8
Asian	50 (17)	98 (18)	0.8
Black, non-Hispanic	56 (19)	85 (15)	0.2
White, non-Hispanic	125 (42)	236 (42)	1.0
Hispanic or Latino	47 (16)	85 (16)	1.0
Marital status[b]			0.1
Married	134 (45)	286 (51)	0.1
Partner	9 (3)	20 (4)	0.7
Any companion	143 (48)	306 (55)	0.1
Single	94 (32)	133 (24)	0.01
Widowed	34 (11)	76 (14)	0.4
Divorced or separated	24 (8)	40 (7)	0.6
Lives in a zip code in which			
Real median household income <$70,784	113 (38)	211 (37)	0.8
% of households with income >$200,000, median (IQR)	13.9 (7.2–25.1)	13.9 (7.5–24.9)	0.6
Median household income of zip code, $, median (IQR)	81,142 (58,669–120,699)	81,857 (58,669–123,401)	0.6
Religion[c]			0.04
None	79 (27)	88 (16)	<0.001
Any Christian denomination	151 (52)	330 (60)	0.04
Catholicism	95 (33)	209 (38)	0.2
Other Christian denomination	56 (19)	121 (22)	0.4
Judaism	29 (10)	69 (13)	0.3
Buddhism, Taoism, or Hinduism	6 (2)	28 (5)	0.04
Islam	6 (2)	15 (3)	0.6
Other religion	13 (5)	13 (2)	0.1
Employment[b]			
Unemployed	76 (26)	172 (31)	0.1
Employed	116 (40)	107 (19)	<0.001
Retired	101 (34)	279 (50)	<0.001
Insurance[d]			
Medicare	120 (41)	313 (57)	<0.001
Private	129 (44)	160 (29)	<0.001
Medicaid	67 (23)	126 (23)	1.0
Dual	11 (4)	28 (5)	0.4
None or self-insured	6 (2)	10 (2)	0.8

Continued

Table 2 Factors Associated With Poor Discharge Outcome *(continued)*

	Good mRS (n = 298)	Poor mRS (n = 570)	*p* Value
Comorbidities[a]			
CAD or MI	119 (41)	312 (57)	<0.001
Hypertension	258 (87)	531 (94)	<0.01
Diabetes	81 (28)	203 (38)	<0.01
Admission NIHSS, median (IQR)	3 (1–7)	10 (7–20)	<0.001
Admission ICH score, median (IQR)	1 (0–1)	1 (1–3)	<0.001
Ventilator days, median (IQR)	1.5 (1–3)	7 (2–16)	<0.001
Hospital LOS, d, median (IQR)	4 (2–6)	9 (4–19)	<0.001

Abbreviations: CAD = coronary artery disease; ICH = intracerebral hemorrhage; IQR = interquartile range; LOS = length of stay; MI = myocardial infarction; mRS = modified Rankin Scale; NIHSS = NIH Stroke Scale.
Data are presented as n (%) unless otherwise indicated. Poor mRS defined by a modified Rankin score of 4–6 points.
[a] n = 859.
[b] n = 852.
[c] n = 839.
[d] n = 846.

traits (e.g., hypertension, smoking status, dementia, and stroke incidence) and outcome (e.g., mortality in multiple sclerosis, outcome after carotid procedures).[4,5,10,12,20-22] Exploration into the relationship between SDoH and WLST usage can allow us to understand why mortality discrepancies exist in certain patient populations. Although mortality has been associated with the socioeconomic features of neighborhoods in patients with acute ischemic stroke,[23] there is limited research on the relationship between SDoH and both WLST and mortality after ICH. A recent study that demonstrated low socioeconomic status was associated with increased 30-day mortality in neurologic patients assessed ischemic and hemorrhagic stroke together,[12] which is problematic because ICH and ischemic stroke mortality trends differ.[24] Our study is novel because we focused on the relationship between SDoH and WLST and mortality in patients with ICH only.

It is well-known that age, NIHSS admission score, ICH score, and LOS are associated with ICH mortality.[25] Here, we showed that patients with higher nSES have higher rates of WLST. On univariable analysis, we found that WLST and mortality were more common in older patients, patients who lived in zip codes with higher median household incomes, and patients on Medicare and less common in patients who were Black non-Hispanic or had private insurance. In a sequential empirical model including all SDoH, ICH score, admission NIHSS, ventilator days, and hospital LOS, nSES remained associated with WLST.

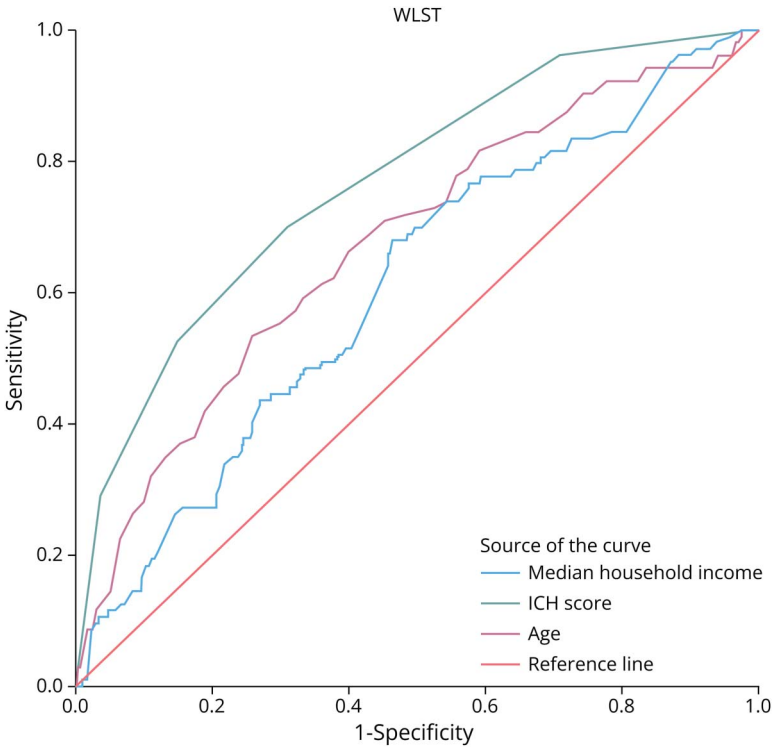
There are numerous potential reasons why nSES is related to outcome after stroke. Lack of access to healthy food, longer distance to acute care hospitals, limited access to safe exercise areas, and reduced social and neighborly interaction, and cohesion have all been associated with worse stroke outcomes.[26] nSES is associated with delayed stroke recognition,[27] which affects treatment and mortality.[28] In addition, patients with lower nSES are less likely to receive appropriate inpatient therapy after stroke.[29] Outcome disparities are thus a direct result of differences in access to clinical care and societal resources among communities, potentially stemming from systemic practices of racism and segregation; for example, there is a higher stroke prevalence in areas associated with a history of redlining[30] and a higher stroke mortality in counties that participated in slavery in the United States.[31] Factors such as exposure to heavy metals, pesticides, and exhaust established within systems of inequity may also contribute to increased comorbidities and perpetuate health disparities.[32]

Table 3 SDoH Associated With Mortality, WLST, and Poor Clinical Outcome

	aOR (95 CI)[a]	*p* Value
Median income by zip code	1.88 (1.29–2.74)	0.001
Race/ethnicity	1.12 (0.92–1.35)	0.2
Sex	0.44 (0.2–0.97)	0.04
Employment	0.66 (0.39–1.1)	0.1
Insurance	1.04 (0.76–1.41)	0.8
English primary language	0.78 (0.34–1.8)	0.6
Marriage status	0.93 (0.7–1.23)	0.6
Religion[b]	0.91 (0.75–1.11)	0.4

Abbreviations: aOR = adjusted odds ratio; ICH = intracerebral hemorrhage; SDoH = social determinant of health; WLST = withdrawal of life-sustaining therapy.
[a] The multivariable model included age, ICH score, hospital length of stay, and ventilator days.
[b] Jewish patients were less likely to have WLST (aOR 0.15, 95% CI 0.03–0.78).

Figure 3 Receiver Operating Characteristic Curve



ICH = intracerebral hemorrhage; WLST = withdrawal of life-sustaining therapy.

Our study corroborated previous literature suggesting Black non-Hispanic patients were less likely to undergo WLST.[7,8] However, although some literature suggests similar or higher mortality rates in Black non-Hispanic patients after ischemic and hemorrhagic stroke compared with patients of other race/ethnicities,[26] we observed a lower incidence of mortality in Black non-Hispanic patients in our cohort, similar to studies that examined interactions of age.[25,33] Our group previously reported that in a different cohort of patients with ICH or subarachnoid hemorrhage, Black or Hispanic race/ethnicity was associated with a lower likelihood of a code status of do-not-resuscitate,[34] indicating that race/ethnicity may affect goals-of-care decision-making after ICH. That study also showed lower rates of palliative care consultation for Black and Hispanic patients, meriting consideration of the need for cultural sensitivity and equity when approaching goals-of-care discussions. One explanation for this disparity might stem from a mistrust of the medical profession reported by Black patients, possibly based on an experience of epistemic injustice and racism within health care.[35]

In patients living in zip codes comprising patients with lower incomes, WLST was higher in patients of Hispanic/Latino ethnicity and in patients whose primary language was not English. This is consistent with a survey of inner-city Latino population in which focus groups described the importance of preserving patient dignity.[36] However in a study in the general intensive care unit population, WLST was actually lower in patients with limited English proficiency, although this study did not assess the impact of nSES.[37] Whether the gap between non-Hispanic Black and Hispanic/Latino patients' use of WLST in neighborhoods with low nSES is a result of differing culture and traditions, religious influence or language barriers remains to be explored.

We found a lower rate of WLST in Jewish patients after adjusting for confounders. There is a diversity of perspectives about WLST within and across different faiths. Patients who report a religious affiliation practice with varying adherence to the same laws and customs across a spectrum ranging from strictly observant to cultural identity. A religious moral argument for WLST has been based on balancing of good intention and burden of treatment. Followers of Roman Catholicism might adhere to the concept developed by Thomas Aquinas, in that the good intention should be greater than an evil arising from the action. This was further elaborated on by Francisco DiVitoria, who proposed that the burden of treatment does not prolong death (as opposed to prolonging life). The Lutheran, Anglican, and Presbyterian Church all support WLST.[38] In Judaism some sects are strongly against the concept of WLST while others allow for removal of "ineffective therapy."[38] Withdrawal of futile treatment and unnecessarily burdensome care is supported by Islam. Eastern religions, such as Hindu traditions, focus less on bodily function and might support the avoidance of artificial life support.[38] These religious differences ought to be considered when discussing the patient's family and cultural values during goals-of-care discussions.

Although neurology-trained neurointensivists led the goals-of-care discussions in our study and this training background

is associated with good ability to predict poor outcome,[39] we cannot exclude the possibility that unconscious bias contributed to our findings that WLST was more common for patients from neighborhoods with higher median household income levels and less common for Black non-Hispanic patients and patients with private insurance. WLST affects mortality, so unconscious bias when discussing end of life care may affect mortality differences leading to the potential for a self-fulfilling prophecy that certain groups of patients will have worse outcomes. These findings demand attention by clinicians conducting goals-of-care discussions after ICH. For example, using a race and socioeconomic conscious framework that can also give credence to holistic well-being of the patient, familial duties, concern for caregiver burden, and differing practices and needs for spiritually should be considered.[36] Exploration of core values is paramount. While financial considerations should not dictate life or death decisions, it is also important to acknowledge the cost of care after ICH, particularly for families who live in neighborhoods with inequitable resources.

The strength of this study is the cohort size and demographic diversity. However, the patients were all hospitalized in 1 metropolitan city. One limitation is that we do not have systematically collected data on how many patients had appointed a health care proxy or completed advance directives and who participated in the goals-of-care discussions. Another important limitation is the lack of self-reported race and ethnicity, preferred sex, and precise methods of determining individual economic status (i.e., income on a personal level rather than median household income by zip code). Unfortunately, education was not captured in our data set, and it is, therefore, difficult to draw any conclusions regarding how education or cultural values relate to the decision to undergo WLST. However, previous studies comparing WLST found that education level was not associated with WLST decision-making.[39]

SDoH, including nSES, are associated with WLST and mortality after ICH. Further research is required to investigate the relationship between mortality and WLST and the structural and social environments that can influence systemic health and hemorrhagic stroke in various neighborhoods. In addition, it is essential to examine how the utilization of WLST may affect outcomes in patients from diverse socioeconomic and racial/ethnic backgrounds. Understanding these associations is crucial for comprehending the broader consequences and factors influencing health outcomes in different populations. The strong association with insurance and mortality on univariable analysis has major implications for practice and policy. The association between mortality and areas with higher median household income suggests SDoH have important repercussions for the care and management of patients with ICH. Considering how to tailor our perspective and our language might be 1 step toward creating a more equitable approach to goals-of-care discussions after ICH.

Acknowledgment

The authors thank Victoria Lam, MS, Nathan Klapheke, BS, and Yousef Darwish, Clinical Data Management/Programming from the DATACORE, Research IT, MCIT for their technical expertise in data retrieval methods and Chen Lyu, PhD, Associate Research Scientist from the Division of Biostatistics for her statistical guidance.

Study Funding

No targeted funding reported.

Disclosure

The authors report no relevant disclosures. Go to Neurology.org/N for full disclosures.

Publication History

Received by *Neurology* July 20, 2023. Accepted in final form November 7, 2023. Submitted and externally peer reviewed. The handling editor was Editor-in-Chief José Merino, MD, MPhil, FAAN.

Appendix Authors

Name	Location	Contribution
Kara R. Melmed, MD	Department of Neurology and Neurosurgery, NYU Langone Health and NYU Grossman School of Medicine, New York	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design; analysis or interpretation of data
Ariane Lewis, MD	Department of Neurology and Neurosurgery, NYU Langone Health and NYU Grossman School of Medicine, New York	Drafting/revision of the manuscript for content, including medical writing for content; study concept or design; analysis or interpretation of data
Lindsey Kuohn, MD	Department of Neurology, NYU Langone Health and NYU Grossman School of Medicine, New York	Major role in the acquisition of data
Joanna Marmo, BSN, RN, SCRN	Department of Neurology, NYU Langone Health, New York	Major role in the acquisition of data
Nirmala Rossan-Raghunath, MSN, SCRN	Department of Neurology, NYU Langone Health, New York	Major role in the acquisition of data
Jose Torres, MD	Department of Neurology, NYU Langone Health and NYU Grossman School of Medicine, New York	Drafting/revision of the manuscript for content, including medical writing for content; study concept or design; analysis or interpretation of data
Rajanandini Muralidharan, MD	Department of Neurology, NYU Langone Health and NYU Grossman School of Medicine, New York	Drafting/revision of the manuscript for content, including medical writing for content
Aaron S. Lord, MD, MSc	Department of Neurology, NYU Langone Health and NYU Grossman School of Medicine, New York	Analysis or interpretation of data
Koto Ishida, MD	Department of Neurology, NYU Langone Health and NYU Grossman School of Medicine, New York	Drafting/revision of the manuscript for content, including medical writing for content; analysis or interpretation of data

Appendix *(continued)*

Name	Location	Contribution
Jennifer A. Frontera, MD	Department of Neurology, NYU Langone Health and NYU Grossman School of Medicine, New York	Drafting/revision of the manuscript for content, including medical writing for content; major role in the acquisition of data; study concept or design; analysis or interpretation of data

References

1. Sheth KN. Spontaneous intracerebral hemorrhage. *N Engl J Med*. 2022;387(17):1589-1596. doi:10.1056/NEJMra2201449
2. Cordonnier C, Demchuk A, Ziai W, Anderson CS. Intracerebral haemorrhage: current approaches to acute management. *Lancet*. 2018;392(10154):1257-1268. doi:10.1016/S0140-6736(18)31878-6
3. Diez-Roux AV, Kiefe CI, Jacobs DR, et al. Area characteristics and individual-level socioeconomic position indicators in three population-based epidemiologic studies. *Ann Epidemiol*. 2001;11(6):395-405. doi:10.1016/s1047-2797(01)00221-6
4. Krieger N. Overcoming the absence of socioeconomic data in medical records: validation and application of a census-based methodology. *Am J Public Health*. 1992;82(5):703-710. doi:10.2105/ajph.82.5.703
5. Azap RA, Nolan TS, Gray DM II, et al. Association of socioeconomic status with ideal cardiovascular health in black men. *J Am Heart Assoc*. 2021;10(23):e020184. doi:10.1161/jaha.120.020184
6. Howard VJ, McClure LA, Kleindorfer DO, et al. Neighborhood socioeconomic index and stroke incidence in a national cohort of blacks and whites. *Neurology*. 2016;87(22):2340-2347. doi:10.1212/wnl.0000000000003299
7. Fraser SM, Torres GL, Cai C, Choi HA, Sharrief A, Chang TR. Race is a predictor of withdrawal of life support in patients with intracerebral hemorrhage. *J Stroke Cerebrovasc Dis*. 2018;27(11):3108-3114. doi:10.1016/j.jstrokecerebrovasdis.2018.07.006
8. Ormseth CH, Falcone GJ, Jasak SD, et al. Minority patients are less likely to undergo withdrawal of care after spontaneous intracerebral hemorrhage. *Neurocrit Care*. 2018;29(3):419-425. doi:10.1007/s12028-018-0554-4
9. Faigle R, Marsh EB, Llinas RH, Urrutia VC, Gottesman RF. Race-specific predictors of mortality in intracerebral hemorrhage: differential impacts of intraventricular hemorrhage and age among blacks and whites. *J Am Heart Assoc*. 2016;5(8):e003540. doi:10.1161/jaha.116.003540
10. Vogel TR, Kruse RL, Kim RJ, Dombrovskiy VY. Racial and socioeconomic disparities after carotid procedures. *Vasc Endovascular Surg*. 2018;52(5):330-334. doi:10.1177/1538574418764063
11. Garcia RM, Prabhakaran S, Richards CT, Naidech AM, Maas MB. Race, socioeconomic status, and gastrostomy after spontaneous intracerebral hemorrhage. *J Stroke Cerebrovasc Dis*. 2020;29(2):104567. doi:10.1016/j.jstrokecerebrovasdis.2019.104567
12. Lusk JB, Hoffman MN, Clark AG, Bae J, Luedke MW, Hammill BG. Association between neighborhood socioeconomic status and 30-day mortality and readmission for patients with common neurologic conditions. *Neurology*. 2023;100(17):e1776-e1786. doi:10.1212/WNL.0000000000207094
13. de Havenon A, Zhou LW, Johnston KC, et al. Twenty-year disparity trends in United States stroke death rate by age, race/ethnicity, geography, and socioeconomic status. *Neurology*. 2023;101(5):e464-e474. doi:10.1212/WNL.0000000000207446
14. US Census Bureau. B19013: median household income in the past 12 months (in 2021 inflation-adjusted dollars). In: *2021 American Community Survey 5-Year Estimates*. US Census Bureau ACSO, 2021.
15. US Census Bureau. DP03: selected economic characteristics. In: *2021 American Community Survey 5-Year Estimates*. US Census Bureau ACSO, 2021.
16. Pierre-Louis YS, Perla KMR, Perez GM, et al. The insurance coverage paradox: characterizing outcomes among dual-eligible hemorrhagic stroke patients. *J Clin Neurosci*. 2022;97:99-105. doi:10.1016/j.jocn.2021.12.023
17. Brott T, Adams HP, Olinger CP, et al. Measurements of acute cerebral infarction: a clinical examination scale. *Stroke*. 1989;20(7):864-870. doi:10.1161/01.str.20.7.864
18. Hemphill JC, Bonovich DC, Besmertis L, Manley GT, Johnston SC. The ICH score: a simple, reliable grading scale for intracerebral hemorrhage. *Stroke*. 2001;32(4):891-897. doi:10.1161/01.str.32.4.891
19. Berkelmans GFN, Read SH, Gudbjörnsdottir S, et al. Population median imputation was noninferior to complex approaches for imputing missing values in cardiovascular prediction models in clinical practice. *J Clin Epidemiol*. 2022;145:70-80. doi:10.1016/j.jclinepi.2022.01.011
20. Mobley TM, Shaw C, Hayes-Larson E, et al. Neighborhood disadvantage and dementia incidence in a cohort of Asian American and non-Latino White older adults in Northern California. *Alzheimers Dement*. 2023;19(1):296-306. doi:10.1002/alz.12660
21. Wilson S, Calocer F, Rollot F, et al. Effects of socioeconomic status on excess mortality in patients with multiple sclerosis in France: a retrospective observational cohort study. *Lancet Reg Health Eur*. 2023;24:100542. doi:10.1016/j.lanepe.2022.100542
22. Kim Y, Twardzik E, Judd SE, Colabianchi N. Neighborhood socioeconomic status and stroke incidence: a systematic review. *Neurology*. 2021;96(19):897-907. doi:10.1212/wnl.0000000000011892
23. Brown AF, Liang LJ, Vassar SD, et al. Neighborhood socioeconomic disadvantage and mortality after stroke. *Neurology*. 2013;80(6):520-527. doi:10.1212/WNL.0b013e31828154ae
24. Andersen KK, Olsen TS, Dehlendorff C, Kammersgaard LP. Hemorrhagic and ischemic strokes compared: stroke severity, mortality, and risk factors. *Stroke*. 2009;40(6):2068-2072. doi:10.1161/strokeaha.108.540112
25. Woo D, Comeau ME, Venema SU, et al. Risk factors associated with mortality and neurologic disability after intracerebral hemorrhage in a racially and ethnically diverse cohort. *JAMA Netw Open*. 2022;5(3):e221103. doi:10.1001/jamanetworkopen.2022.1103
26. Rosendale N. Social determinants of health in neurology. *Neurol Clin*. 2022;40(1):231-247. doi:10.1016/j.ncl.2021.08.012
27. Niklasson A, Herlitz J, Jood K. Socioeconomic disparities in prehospital stroke care. *Scand J Trauma Resusc Emerg Med*. 2019;27(1):53. doi:10.1186/s13049-019-0630-6
28. Salwi S, Kelly KA, Patel PD, et al. Neighborhood socioeconomic status and mechanical thrombectomy outcomes. *J Stroke Cerebrovasc Dis*. 2021;30(2):105488. doi:10.1016/j.jstrokecerebrovasdis.2020.105488
29. Kapral MK, Wang H, Mamdani M, Tu JV. Effect of socioeconomic status on treatment and mortality after stroke. *Stroke*. 2002;33(1):268-273. doi:10.1161/hs0102.101169
30. Jadow BM, Hu L, Zou J, et al. Historical redlining, social determinants of health, and stroke prevalence in communities in New York City. *JAMA Netw Open*. 2023;6(4):e235875. doi:10.1001/jamanetworkopen.2023.5875
31. Esenwa C, Ilunga Tshiswaka D, Gebregziabher M, Ovbiagele B. Historical slavery and modern-day stroke mortality in the United States stroke belt. *Stroke*. 2018;49(2):465-469. doi:10.1161/STROKEAHA.117.020169
32. Habeeb E, Aldosari S, Saghir SA, et al. Role of environmental toxicants in the development of hypertensive and cardiovascular diseases. *Toxicol Rep*. 2022;9:521-533. doi:10.1016/j.toxrep.2022.03.019
33. Miyares LC, Falcone GJ, Leasure A, et al. Race/ethnicity influences outcomes in young adults with supratentorial intracerebral hemorrhage. *Neurology*. 2020;94(12):e1271-e1280. doi:10.1212/wnl.0000000000008930
34. Lillemoe K, Lord A, Torres J, Ishida K, Czeisler B, Lewis A. Factors associated with DNR status after nontraumatic intracranial hemorrhage. *Neurohospitalist*. 2020;10(3):168-175. doi:10.1177/1941874419873812
35. Brown CE, Marshall AR, Snyder CR, et al. Perspectives about racism and patient-clinician communication among black adults with serious illness. *JAMA Netw Open*. 2023;6(7):e2321746. doi:10.1001/jamanetworkopen.2023.21746
36. Born W, Greiner KA, Sylvia E, Butler J, Ahluwalia JS. Knowledge, attitudes, and beliefs about end-of-life care among inner-city African Americans and Latinos. *J Palliat Med*. 2004;7(2):247-256. doi:10.1089/109662104773709369
37. Barwise A, Jaramillo C, Novotny P, et al. Differences in code status and end-of-life decision making in patients with limited English proficiency in the intensive care unit. *Mayo Clin Proc*. 2018;93(9):1271-1281. doi:10.1016/j.mayocp.2018.04.021
38. Setta SM, Shemie SD. An explanation and analysis of how world religions formulate their ethical decisions on withdrawing treatment and determining death. *Philos Ethics Humanit Med*. 2015;10:6. doi:10.1186/s13010-015-0025-x
39. Weimer JM, Nowacki AS, Frontera JA. Withdrawal of life-sustaining therapy in patients with intracranial hemorrhage: self-fulfilling prophecy or accurate prediction of outcome? *Crit Care Med*. 2016;44(6):1161-1172. doi:10.1097/CCM.0000000000001570