ORIGINAL RESEARCH

Racial/Ethnic Disparities in Mortality Among Medicare Beneficiaries in the FL-PR CReSD Study

Hannah Gardener, ScD; Erica C. Leifheit, PhD; Judith H. Lichtman, PhD, MPH, FAHA; Yun Wang, PhD; Kefeng Wang, MS; Carolina M. Gutierrez, PhD; Maria A. Ciliberti-Vargas, MPH; Chuanhui Dong, PhD; Sofia Oluwole, MPH; Mary Robichaux, MPH, MBA; Jose G. Romano, MD; Tatjana Rundek, MD, PhD; Ralph L. Sacco, MD, MS; for the FL-R CReSD Investigators and Collaborators*

***Background*—**Racial/ethnic disparities in acute stroke care may impact stroke outcomes. We compared outcomes by race/ethnicity among elderly Medicare beneficiaries in hospitals participating in the FL-PR CReSD (Florida–Puerto Rico Collaboration to Reduce Stroke Disparities) registry with those in hospitals not participating in any quality improvement programs (non-QI) in Florida and Puerto Rico (PR).

***Methods and Results*—**The population included fee-for-service Medicare beneficiaries age 65+ in Florida and PR, discharged with primary diagnosis of ischemic stroke (*International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM],* codes 433, 434, 436) in 2010–2013. We used mixed logistic models to assess racial/ethnic differences in outcomes (in-hospital, 30-day, and 1-year mortality, and 30-day readmission) for CReSD and non-QI hospitals, adjusted for demographic and clinical characteristics. The study included 62 CReSD hospitals (N=44 013, 84% white, 9% black, 4% Florida Hispanic, 1% PR Hispanic) and 113 non-QI hospitals (N=14 422, 78% white, 7% black, 5% Florida Hispanic, 8% PR Hispanic). For patients treated at CReSD hospitals, there were no differences in risk-adjusted in-hospital mortality by race/ethnicity; blacks had lower 30-day mortality versus whites (odds ratio, 0.86; 95% confidence interval, 0.77–0.97), but higher 30-day readmission (hazard ratio, 1.09; 1.00–1.18) and 1-year mortality (odds ratio, 1.13; 1.04–1.23); Florida Hispanics had lower 30-day readmission (hazard ratio, 0.87; 0.78–0.98). PR Hispanic and black stroke patients treated at non-QI hospitals had higher risk-adjusted in-hospital, 30-day and 1-year mortality, but similar 30-day readmission versus whites treated in non-QI hospitals.

***Conclusions*—**Disparities in outcomes were less common in CReSD than non-QI hospitals, suggesting the benefits of quality improvement programs, particularly those focusing on racial/ethnic disparities. **(*J Am Heart Assoc*. 2019;8:e009649. DOI: 10.1161/JAHA.118.009649)**

Key Words: disparities • Medicare • mortality • race and ethnicity • stroke

Racial/ethnic disparities in outcomes following stroke have been documented, with blacks and Hispanics having a higher rate of mortality and stroke recurrence as compared with whites.[1] Hospital participation in quality improvement programs, such as the Get With the Guidelines-Stroke (GWTG-Stroke) program, has been shown to improve adherence to evidence-based best stroke care practices.[2] Participation in this type of quality improvement program has also been associated with reduced postdischarge mortality in elderly fee-for-service Medicare patients treated at GWTG-Stroke hospitals.[3] Less is known about whether quality improvement programs specifically designed and targeted to reduce racial/ethnic disparities in stroke care are associated with improved outcomes for stroke patients.

We created the FL-PR CReSD stroke registry (Florida–Puerto Rico Collaboration to Reduce Stroke Disparities), a voluntary stroke registry among Florida and Puerto Rico (PR) hospitals, designed to identify and address racial/ethnic and geographic disparities in acute stroke care performance metrics. In previous publications, we have reported both racial/ethnic and geographic disparities in stroke care, including defect-free care, in this study population. We observed improved stroke

From the Department of Neurology, University of Miami Miller School of Medicine, Miami, FL (H.G., K.W., C.M.G., M.A.C.-V., C.D., S.O., M.R., J.G.R., T.R., R.L.S.); Department of Epidemiology, Yale School of Public Health, New Haven, CT (E.C.L., J.H.L., Y.W.).

Accompanying Appendix S1 and Tables S1, S2 are available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.118.009649

*A complete list of hospitals that contributed FL-PR CReSD Stroke Registry data used can be found in the Supplemental Material.

Correspondence to: Hannah Gardener, ScD, Department of Neurology, University of Miami Miller School of Medicine, 1120 NW 14th Street, Miami, FL 33136. E-mail: hgardener@med.miami.edu

Received May 4, 2018; accepted October 2, 2018.

Clinical Perspective

What Is New?

- This study adds to the literature on short-term and long-term outcomes after hospitalization for ischemic stroke.
- Racial/ethnic disparities in mortality were more pronounced in non–quality improvement hospitals compared with hospitals participating in the Collaboration to Reduce Stroke Disparities.

What Are the Clinical Implications?

- This study illustrates the potential benefits of stroke quality improvement programs, particularly those focused on racial/ethnic disparities.

care among all racial/ethnic groups and lessening disparities over time (2010–2014), but Hispanics living in PR still receive less adequate care as compared with all groups living in Florida.[4] Though disparities in care exist in this study population, less is known about racial/ethnic disparities in posthospitalization outcomes following stroke. Accordingly, the primary goal of the current study is to evaluate racial/ethnic differences for in-hospital, 30-day, and 1-year mortality as well as 30-day hospital readmission among Medicare beneficiaries treated at CReSD hospitals, compared with Medicare beneficiaries treated at hospitals not participating in the CReSD quality improvement program.

Methods

The data, analytic methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure.

CReSD Registry

The FL-PR CReSD registry is a voluntary stroke registry that uses data collected by the GWTG-Stroke system and adds some additional questions (eg, ethnicity, language, education). GWTG-Stroke is a national quality improvement initiative by the American Heart Association to monitor stroke care performance metrics across the country. Though there are substantial differences in hospital-level characteristics between those participating and not participating in GWTG-Stroke, data suggest that on an individual level, Medicare beneficiaries treated for acute stroke at GWTG-Stroke participating hospitals are representative of the national Medicare ischemic stroke population.[5] Hospitals in Florida and PR already participating in the ongoing GWTG-Stroke data collection system were invited to join the CReSD registry. As of March 2015, the CReSD registry included 74 hospitals; 65 in Florida and 9 in PR. Retrospective and prospective hospital-collected GWTG-Stroke data were available for patients with a primary diagnosis of ischemic stroke, transient ischemic attack, subarachnoid hemorrhage, intracerebral hemorrhage, and stroke not otherwise specified.

Study Population

The study included Medicare fee-for-service beneficiaries aged ≥65 years who were discharged from a Florida or PR acute care hospital between 2010 and 2013 with a principal diagnosis of ischemic stroke (*International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM]*, codes 433, 434, and 436). To ensure complete claims history, only patients with ≥12 continuous months of Medicare fee-for-service enrollment before the index hospitalization were included in analyses. We excluded those treated at GWTG-Stroke hospitals that did not participate in CReSD, as the aim was to compare hospitals participating in the registry with those hospitals not currently enrolled in a quality improvement program. We excluded patients discharged from non–acute care facilities, discharged within 1 day of admission, or who left the hospital against medical advice. Patients transferred from one acute care hospital to another were required to have had a principal discharge diagnosis of ischemic stroke at both hospitals. We randomly selected one ischemic stroke hospitalization for patients with multiple ischemic stroke admissions during the study period. Cases were categorized by hospital type: CReSD versus no quality improvement programs (non-QI). Race/ethnicity was categorized as whites (non-Hispanic) (reference), blacks, Hispanics living in Florida, Hispanics living in PR, and other race.

Data were obtained from the Medicare Inpatient and Master Beneficiary Summary Files, and they are protected through a data use agreement with the Centers for Medicare and Medicaid Services (CMS). The study was approved by the institutional review boards of the University of Miami and Yale University.

Outcomes

The primary outcomes included in-hospital, 30-day, and 1-year all-cause mortality measured from the date of the index ischemic stroke hospital admission and 30-day all-cause readmission measured from the date of discharge. Patients who were transferred from the admitting hospital to another acute care hospital and those who died during the index hospitalization were excluded from the readmission analyses. For mortality analyses, outcomes of transferred patients were attributed to the initial admitting hospital. Additional outcomes included discharge disposition, length of hospital stay, and Medicare payment for the index hospitalization.

Table. Description of the Study Population by Hospital Type

Variable	CReSD	Non-QI	*P* Value
Total stroke discharges	44 013	14 422	
Age, y, mean (SD)	79.8 (8.3)	79.7 (8.1)	0.21
Women, n (%)	23 618 (53.7)	7840 (54.4)	0.14
Race, n (%)			<0.001
White	37 129 (84.4)	11 190 (77.6)	
Black	3769 (8.6)	1002 (6.9)	
Other race	968 (2.2)	405 (2.8)	
Congestive heart failure, n (%)	5727 (13.0)	1747 (12.1)	0.01
Prior myocardial infarction, n (%)	1290 (2.9)	393 (2.7)	0.20
Unstable angina, n (%)	620 (1.4)	337 (2.3)	<0.001
Chronic atherosclerosis, n (%)	16 368 (37.2)	5329 (37.0)	0.61
Respiratory failure, n (%)	1724 (3.9)	533 (3.7)	0.23
Hypertension, n (%)	34 528 (78.4)	11 434 (79.3)	0.03
Prior stroke, n (%)	3539 (8.0)	1212 (8.4)	0.17
Cerebrovascular disease, n (%)	5973 (13.6)	1744 (12.1)	<0.001
Renal failure, n (%)	5510 (12.5)	1694 (11.7)	0.01
Chronic obstructive pulmonary disease, n (%)	7137 (16.2)	2649 (18.4)	<0.001
Pneumonia, n (%)	4053 (9.2)	1555 (10.8)	<0.001
Protein-calorie malnutrition, n (%)	2285 (5.2)	664 (4.6)	0.01
Dementia, n (%)	6753 (15.3)	2567 (17.8)	<0.001
Functional disability, n (%)	3088 (7.0)	912 (6.3)	0.004
Peripheral vascular disease, n (%)	3442 (7.8)	1074 (7.4)	0.15
Cancer, n (%)	3327 (7.6)	950 (6.6)	<0.001
Trauma, n (%)	4130 (9.4)	1150 (8.0)	<0.001
Psychiatric disorder, n (%)	1538 (3.5)	612 (4.2)	<0.001
Liver disease, n (%)	264 (0.6)	86 (0.6)	0.96
Depression, n (%)	3233 (7.3)	1066 (7.4)	0.86
Diabetes mellitus, n (%)	14 640 (33.3)	5567 (38.6)	<0.001

CReSD indicates Collaboration to Reduce Stroke Disparities; Non-QI, non–quality improvement.

Covariates

Demographic information included patient age and sex. Race/ethnicity was derived from the Master Beneficiary Summary File data, which are drawn from the Medicare enrollment database. Comorbidities and other clinical variables (eg, hypertension, diabetes mellitus, renal failure; see Table for a complete list) were derived from the index admission secondary diagnoses and the primary diagnosis, secondary diagnosis, and procedure codes from inpatient claims submitted in the 12 months before the index hospitalization, based on the Hierarchical Condition Categories.[6]

Statistical Analysis

We fit mixed models with a logit link function and hospital-specific random intercepts to assess racial/ethnic differences in the odds of in-hospital, 30-day, and 1-year mortality, adjusting for the patient demographic and clinical characteristics in Table and stratifying by hospital type (CReSD and non-QI). We constructed Cox proportional hazards models with death as a censoring event to compare rates of 30-day readmission by race/ethnicity, adjusting for the same patient characteristics and stratifying by hospital type. In additional adjusted models, we compared the overall mortality and readmission outcomes by hospital type. Analyses were

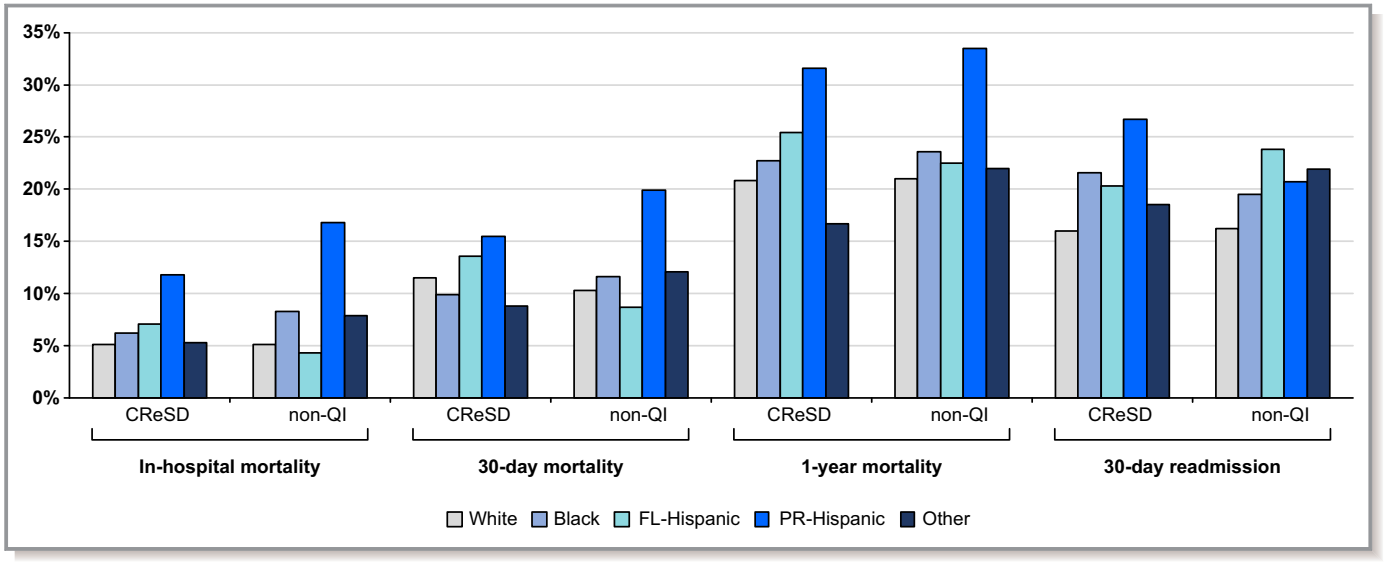

Figure 1. Unadjusted racial/ethnic differences in mortality and readmission by hospital type.* *In both CReSD and non-QI hospitals, all $P<0.001$ for the comparison of outcomes by race. CReSD indicates Collaboration to Reduce Stroke Disparities; Florida Hispanic, Hispanics living in Florida; non-QI, non–quality improvement; PR Hispanic, Hispanics living in Puerto Rico.

conducted using SAS v9.4 (SAS Institute, Cary, NC), and statistical tests used a 2-sided alpha of 0.05.

Results

The overall study population included 44 013 ischemic stroke cases from 62 CReSD registry hospitals (9% Florida black, 4% Florida Hispanic, 86% Florida white, 1% PR Hispanic), and 14 422 cases from 113 non-QI hospitals (7% Florida black, 5% Florida Hispanic, 80% Florida white, 8% PR Hispanic). The demographic characteristics and risk factors by hospital type are shown in Table. The mean age (80±8) and sex distribution (54% female) were similar across hospital types. Tables S1 and S2 show the risk factors stratified by race/ethnicity in each of the hospital groups.

Observed outcomes differed by race/ethnicity in analyses stratified by CReSD and non-QI hospitals (all $P<0.001$; Figure 1). In particular, PR Hispanic and black stroke patients treated at non-QI hospitals had higher in-hospital, 30-day, and 1 year mortality versus those treated in CReSD hospitals (Figure 1). In risk-adjusted comparisons, patients treated at CReSD hospitals had lower in-hospital mortality (odds ratio [OR], 0.74; 95% confidence interval [CI], 0.58–0.94) and 1-year mortality (OR, 0.89; 95% CI, 0.81–0.87) as compared with patients treated at non-QI hospitals, and the reduced rate of 30-day readmission was of borderline significance (OR, 0.95; 95% CI, 1.00) (Figure 2).

Figure 3 shows the risk-adjusted associations between race/ethnicity and outcomes, stratified by hospital type. Among CReSD hospitals, there were no race/ethnic

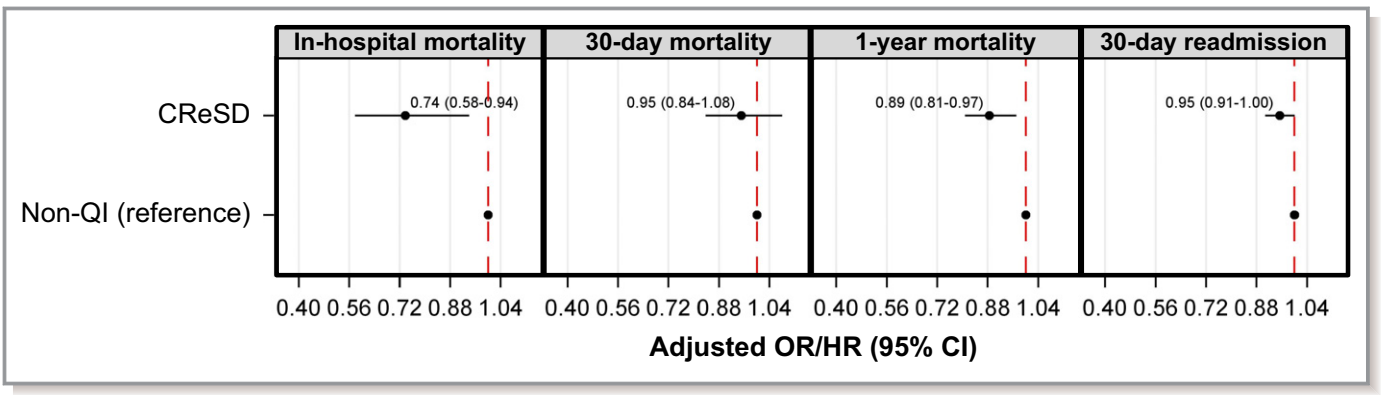

Figure 2. Mortality and readmission in CReSD vs non-QI hospitals. Models adjusted for demographic characteristics and comorbid conditions. CRESD indicates Collaboration to Reduce Stroke Disparities; HR, hazard ratio; non-QI, non–quality improvement; OR, odds ratio.

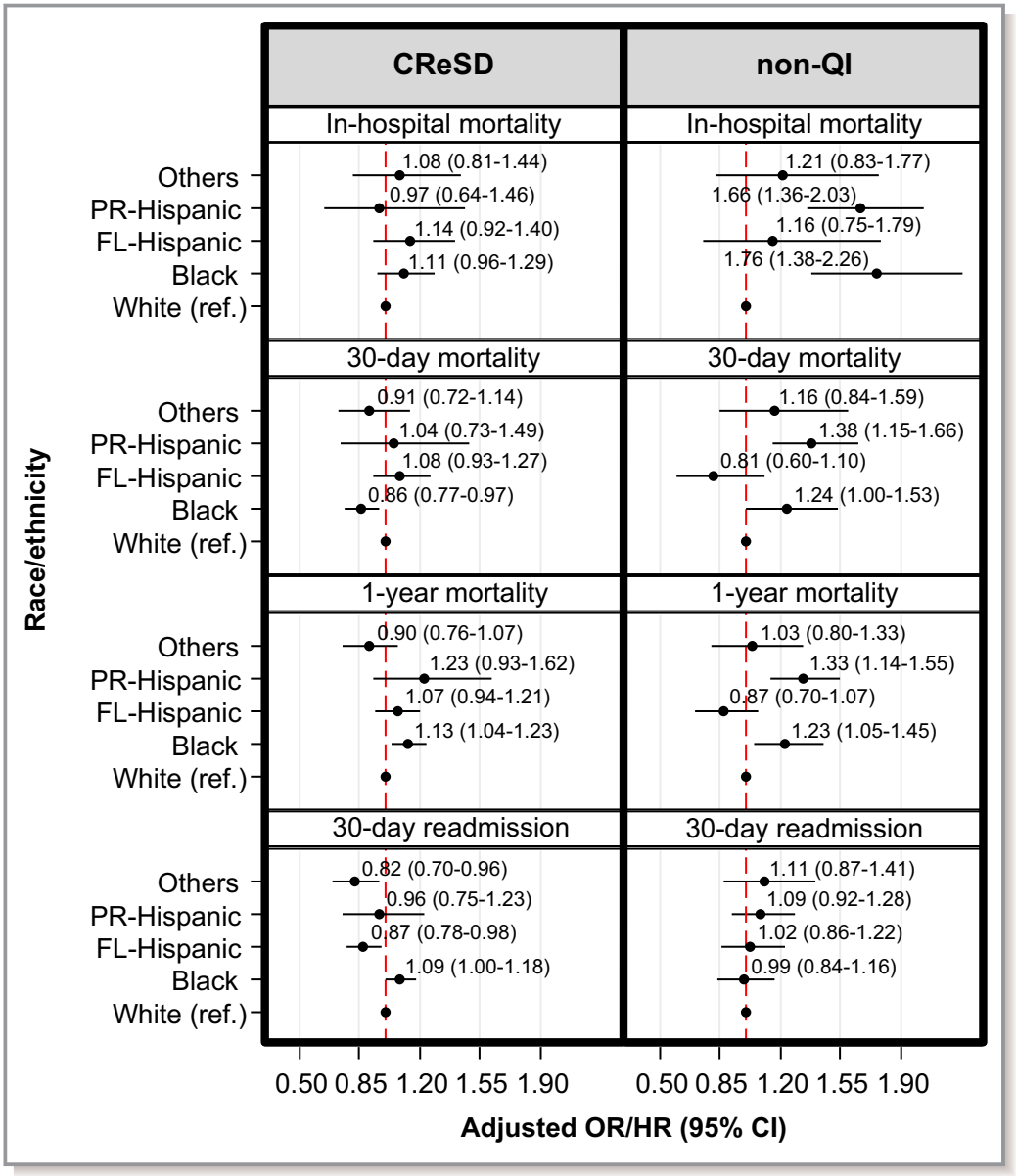

Figure 3. Adjusted racial/ethnic differences in mortality and readmission by hospital type. Models adjusted for demographic characteristics and comorbid conditions. CRESD indicates Collaboration to Reduce Stroke Disparities; Florida Hispanic, Hispanics living in Florida; non-QI, non–quality improvement; PR Hispanic, Hispanics living in Puerto Rico.

disparities observed for in-hospital mortality. Blacks had lower 30-day mortality (OR, 0.86; 95% CI, 0.77–0.97) but higher 1-year mortality versus whites (OR, 1.13; 95% CI, 1.04–1.23), and Florida Hispanic residents had lower rates of 30-day readmission compared with whites (OR, 0.87; 95% CI, 0.78–0.98), while blacks had higher rates (OR, 1.09; 95% CI, 1.00–1.18). In the non-QI hospitals, PR Hispanic (OR, 1.66; 95% CI, 1.36–2.03) and black patients (OR, 1.76; 95% CI, 1.38–2.26) had higher in-hospital mortality compared with whites. In addition, 30-day and 1-year mortality were also elevated for PR Hispanics and Florida blacks versus whites, but there were no racial/ethnic disparities in 30-day readmission rates.

Discussion

Elderly fee-for-service Medicare beneficiaries treated for stroke in CReSD hospitals had lower in-hospital and 1-year mortality compared with those treated in non-QI hospitals, highlighting the short- and long-term value of participation in QI initiatives. This was particularly true for Hispanics living in PR and for blacks. Our findings are consistent with a previous study demonstrating lower postdischarge mortality among Medicare beneficiaries treated for stroke in GWTG-Stroke participating hospitals compared with non–GWTG-Stroke hospitals in a national sample.[3] A unique contribution of the current study is

the finding that racial/ethnic disparities in short- and long-term mortality after stroke also appeared to be more pronounced in non-QI hospitals versus CReSD hospitals, suggesting that participation in CReSD may not only improve outcomes but may also help reduce inequality in stroke outcomes.

In the FL-PR CReSD registry, we observed racial differences in long-term mortality following stroke, but not in in-hospital mortality. In particular, we observed lower 30-day mortality among blacks compared with whites, in contrast to higher 1-year mortality in blacks compared with whites. We have previously reported racial/ethnic and geographic disparities in acute stroke care, specifically defect-free care, such that care in PR was inferior to that provided in Florida across racial/ethnic groups. However, in the current study among elderly Medicare beneficiaries, we did not observe any differences in mortality or readmission rates for PR Hispanics. Overall, our findings underscore the importance of continued efforts to identify inequality in acute and long-term care to eliminate disparities in stroke outcomes in this region. Racial/ethnic disparities for in-hospital mortality were not observed in the CReSD registry, which was specifically created to target racial/ethnic disparities in stroke care, as compared with significant racial/ethnic disparities for in-hospital mortality observed among patients treated at Florida and PR non-QI hospitals. Adherence to evidence-based guidelines as promoted through GWTG-Stroke improves overall stroke outcomes, as well as helps reduce racial/ethnic stroke disparities.

There are differences among hospitals participating in quality improvement programs compared with those that do not participate. Analysis of the national GWTG-Stroke data set revealed that GWTG-Stroke participating hospitals are larger, urban teaching centers compared with non–GWTG-Stroke hospitals.[5] Some hospitals have dedicated stroke-focused programs with personnel trained in vascular neurology, neurosurgery, and endovascular procedures; 24/7 availability of imaging, operating room, and endovascular facilities; and expertise in treating various stroke types.[7] These certified stroke centers are associated with better outcomes such as lower 30-day and 1-year mortality compared with noncertified centers.[8] If the proportion of stroke certified centers differs between CReSD and non-QI hospitals, this may account for some residual confounding. A greater proportion of FL-PR CReSD hospitals may be large, academic centers[9] compared with GWTG-Stroke hospitals.[5] Although we were unable to assess non–CReSD GWTG-Stroke participating hospitals as a comparison group due to the data use agreement, we acknowledge that these hospitals may differ from CReSD GWTG-Stroke hospitals.

Racial/ethnic disparities in long-term outcomes, including mortality and rehospitalization, were also examined in a national sample of 200 900 Medicare beneficiaries age 65 and older who were treated for ischemic stroke at hospitals participating in GWTG-Stroke.[10] This nationwide study did not focus on specific geographic areas, which is important, as there can be heterogeneity in trends across the country. However, they also demonstrated disparities in long-term outcomes after adjusting for stroke severity and clinical and hospital characteristics. In fact, they also observed a lower 30-day mortality and a higher 1-year mortality among blacks compared with whites, consistent with our observations in the Florida and PR CReSD registry hospitals. Hispanics had a lower 30-day mortality as compared with whites, although there was no difference in 1-year mortality between whites and Hispanics in their study. In contrast, we did not observe differences in 30-day or 1-year mortality in Florida Hispanics compared with whites in either of the hospital groups, which may reflect regional differences in trends, as well as differences between Florida Hispanics and those in other parts of the United States. PR Hispanics treated in non-QI hospitals had higher 30-day and 1-year mortality as compared with Florida whites, but the comparison was not significant among patients treated at CReSD hospitals.

In the national sample of Medicare patients treated at GWTG-Stroke hospitals, rehospitalization in the first year was also more common among blacks and Hispanics as compared with whites.[10] Our study, focused on readmission within the first 30 days, also found a higher rate among blacks compared with whites in the CReSD hospitals. In our FL-PR CReSD registry hospitals, we observed lower 30-day readmission for Florida Hispanics compared with whites, but no difference among the non-QI hospitals, which is inconsistent with the trends observed in the national sample. The greater in-hospital mortality among blacks treated at non-QI hospitals could also have led to a greater proportion of lower-risk patients being discharged and a subsequent lower 30-day readmission rate.

Racial/ethnic differences in posthospitalization outcomes following ischemic stroke may reflect differences in the stroke pathologies, clinical characteristics between groups, and treatments and interventions received after discharge. While it is possible that a greater proportion of small-vessel infarcts among blacks could account for lower in-hospital mortality, it has also been suggested that short-term survival may be higher in blacks due to more intensive life-sustaining interventions received.[11] A 2010 study, however, using national GWTG-Stroke data showed that blacks received fewer evidence-based care processes as compared with whites, including intravenous thrombolysis, deep vein thrombosis prophylaxis, smoking cessation counseling, discharge antithrombotics, anticoagulants for atrial fibrillation, and lipid therapy.[12] Such differences in the quality of acute stroke care may be partly responsible for increases in 30-day readmission rates. In the Northern Manhattan Study, blacks and Hispanics had a higher rate of all stroke subtypes as compared with whites, but the elevation was particularly apparent for intracranial atherosclerotic stroke,[13] and 30-day recurrence has been shown to be higher

for patients with intracranial atherosclerotic stroke.[14,15] Future research is needed to examine racial/ethnic differences in process-of-care measures in relationship to postdischarge outcomes.

The study has several limitations. First, the study includes elderly fee-for-service Medicare beneficiaries, and the results may not be generalizable to younger patients or those enrolled in Medicare Advantage. Some studies have observed greater stroke disparities among younger populations.[16–18] Misclassification or coding errors are possible, as demographic and clinical information were derived from administrative data, and information regarding race/ethnicity included self-report or recording by the admitting clinician or administrators. Historically, ethnicity data in the Centers for Medicare and Medicaid Services has been less accurate than race data.[19] Consequently, Hispanic ethnicity may be underreported. This misclassification is likely nondifferential, as it is unlikely to be related to the outcomes of interest. Stroke severity is a significant predictor of mortality after stroke.[20] Similarly, hospital characteristics such as larger annual volume of ischemic stroke cases,[21] academic status,[22] and stroke center certification[8] are associated with lower mortality after stroke. These patient and hospital characteristics are not captured in the administrative Centers for Medicare and Medicaid Services data yet they may contribute to some of the observed differences between CReSD and non-QI hospitals in our study. Finally, given the scope of our data use agreement, we were unable to include GWTG-Stroke/non-CReSD hospitals as a comparison group for the analyses.

In summary, 30-day and 1-year outcomes were better for the CReSD registry hospitals compared with non-QI hospitals. Racial/ethnic differences for in-hospital mortality were observed among Florida and PR non-QI hospitals but not among hospitals participating in CReSD. Racial/ethnic disparities for postdischarge mortality were observed among patients treated in CReSD hospitals but were larger for patients treated at non-QI hospitals. Results support the benefits of quality improvement programs, particularly those focusing on racial/ethnic disparities. These observations also demonstrate the need to design and implement evidence-based interventions that continue beyond the acute hospitalization period in order to reduce disparities in longer-term outcomes after stroke.

Acknowledgments

We acknowledge our collaborators: the American Heart Association, HIMA–San Pablo Hospitals, the University of Puerto Rico, FL-PR CReSD Investigators, and the FL-PR Stroke registry participating hospitals.

Sources of Funding

This study is supported by the NIH/NINDS Grant U54-NS081763.

Disclosures

Dr Romano is a PI of the Florida–Puerto Rico Collaboration to Reduce Stroke Disparities (NIH/NINDS U54NS081763) and a PI for the Transition of Care Stroke Disparity Study (NIH/NIMHD 1R01MD012467). Dr Rundek is a PI for the Transition of Care Stroke Disparity Study (NIH/NIMHD 1R01MD012467). The remaining authors have no disclosures to report.

References

1. Cruz-Flores S, Rabinstein A, Biller J, Elkind MS, Griffith P, Gorelick PB, Howard G, Leira EC, Morgenstern LB, Ovbiagele B, Peterson E, Rosamond W, Trimble B, Valderrama AL. Racial-ethnic disparities in stroke care: the American experience: a statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2011;42:2091–2116.
2. Schwamm LH, Fonarow GC, Reeves MJ, Pan W, Frankel MR, Smith EE, Ellrodt G, Cannon CP, Liang L, Peterson E, Labresh KA. Get With the Guidelines–Stroke is associated with sustained improvement in care for patients hospitalized with acute stroke or transient ischemic attack. *Circulation*. 2009;119:107–115.
3. Song S, Fonarow GC, Olson DM, Liang L, Schulte PJ, Hernandez AF, Peterson ED, Reeves MJ, Smith EE, Schwamm LH, Saver JL. Association of Get With the Guidelines–Stroke Program Participation and clinical outcomes for Medicare beneficiaries with ischemic stroke. *Stroke*. 2016;47:1294–1302.
4. Sacco RL, Gardener H, Wang K, Dong C, Ciliberti-Vargas MA, Gutierrez CM, Asdaghi N, Burgin WS, Carrasquillo O, Garcia-Rivera EJ, Nobo U, Oluwole S, Rose DZ, Waters MF, Zevallos JC, Robichaux M, Waddy SP, Romano JG, Rundek T. Racial-ethnic disparities in acute stroke care in the Florida–Puerto Rico Collaboration to Reduce Stroke Disparities Study. *J Am Heart Assoc*. 2017;6:e004073. DOI: 10.1161/JAHA.116.004073.
5. Reeves MJ, Fonarow GC, Smith EE, Pan W, Olson D, Hernandez AF, Peterson ED, Schwamm LH. Representativeness of the Get With the Guidelines–Stroke Registry: comparison of patient and hospital characteristics among Medicare beneficiaries hospitalized with ischemic stroke. *Stroke*. 2012;43:44–49.
6. Pope GC, Ellis RP, Ash AS, Ayanian JZ, Bates DW, Burstin H, Iezzoni LI, Marcantonio E, Wu B. *Diagnostic Cost Group Hierarchical Condition Category Models for Medical Risk Adjustment: Final Report*. Baltimore, MD: Health Care Financing Administration; 2000.
7. Gorelick PB. Primary and comprehensive stroke centers: history, value and certification criteria. *J Stroke*. 2013;15:78–89.
8. Man S, Schold JD, Uchino K. Impact of stroke center certification on mortality after ischemic stroke: the Medicare cohort from 2009 to 2013. *Stroke*. 2017;48:2527–2533.
9. Ciliberti-Vargas MA, Gardener H, Wang K, Dong C, Yi L, Romano JG, Robichaux M, Waddy SP, Nobo U, Diaz-Acosta S, Rundek T, Waters MF, Sacco RL. Stroke hospital characteristics in the Florida–Puerto Rico Collaboration to Reduce Stroke Disparities Study. *South Med J*. 2017;110:466–474.
10. Qian F, Fonarow GC, Smith EE, Xian Y, Pan W, Hannan EL, Shaw BA, Glance LG, Peterson ED, Eapen ZJ, Hernandez AF, Schwamm LH, Bhatt DL. Racial and ethnic differences in outcomes in older patients with acute ischemic stroke. *Circ Cardiovasc Qual Outcomes*. 2013;6:284–292.
11. Xian Y, Holloway RG, Noyes K, Shah MN, Friedman B. Racial differences in mortality among patients with acute ischemic stroke: an observational study. *Ann Intern Med*. 2011;154:152–159.
12. Schwamm LH, Reeves MJ, Pan W, Smith EE, Frankel MR, Olson D, Zhao X, Peterson E, Fonarow GC. Race/ethnicity, quality of care, and outcomes in ischemic stroke. *Circulation*. 2010;121:1492–1501.
13. White H, Boden-Albala B, Wang C, Elkind MS, Rundek T, Wright CB, Sacco RL. Ischemic stroke subtype incidence among whites, blacks, and Hispanics: the Northern Manhattan Study. *Circulation*. 2005;111:1327–1331.
14. Petty GW, Brown RD Jr, Whisnant JP, Sicks JD, O'Fallon WM, Wiebers DO. Ischemic stroke subtypes: a population-based study of functional outcome, survival, and recurrence. *Stroke*. 2000;31:1062–1068.
15. Lovett JK, Coull AJ, Rothwell PM. Early risk of recurrence by subtype of ischemic stroke in population-based incidence studies. *Neurology*. 2004;62:569–573.
16. Pathak EB, Sloan MA. Recent racial/ethnic disparities in stroke hospitalizations and outcomes for young adults in Florida, 2001–2006. *Neuroepidemiology*. 2009;32:302–311.

17. Howard VJ, Kleindorfer DO, Judd SE, McClure LA, Safford MM, Rhodes JD, Cushman M, Moy CS, Soliman EZ, Kissela BM, Howard G. Disparities in stroke incidence contributing to disparities in stroke mortality. *Ann Neurol*. 2011;69:619–627.

18. Morgenstern LB, Smith MA, Sanchez BN, Brown DL, Zahuranec DB, Garcia N, Kerber KA, Skolarus LE, Meurer WJ, Burke JF, Adelman EE, Baek J, Lisabeth LD. Persistent ischemic stroke disparities despite declining incidence in Mexican Americans. *Ann Neurol*. 2013;74:778–785.

19. Eicheldinger C, Bonito A. More accurate racial and ethnic codes for Medicare administrative data. *Health Care Financ Rev*. 2008;29:27–42.

20. Adams HP Jr, Davis PH, Leira EC, Chang KC, Bendixen BH, Clarke WR, Woolson RF, Hansen MD. Baseline NIH Stroke Scale score strongly predicts outcome after stroke: a report of the Trial of Org 10172 in Acute Stroke Treatment (TOAST). *Neurology*. 1999;53:126–131.

21. Hall RE, Fang J, Hodwitz K, Saposnik G, Bayley MT. Does the volume of ischemic stroke admissions relate to clinical outcomes in the Ontario stroke system? *Circ Cardiovasc Qual Outcomes*. 2015;8(6 suppl 3):S141–S147.

22. Burke LG, Frakt AB, Khullar D, Orav EJ, Jha AK. Association between teaching status and mortality in US hospitals. *JAMA*. 2017;317:2105–2113.

SUPPLEMENTAL MATERIAL

Appendix

The following hospitals contributed FL-PR CReSD Stroke Registry data that was used in the present study:

Florida

Bayfront Medical Center

Mease Countryside Hospital

Morton Plant Hospital

West Florida Hospital

Good Samaritan Medical Center

Hialeah Hospital

Saint Mary's Medical Center

West Boca Medical Center

North Shore Medical Center

Palm Beach Gardens Medical Center

Palmetto General Hospital

Cleveland Clinic

Coral Gables Hospital

Delray Medical Center

Jackson North Medical Center

Saint Anthony's Hospital

Mease Dunedin Hospital

Northside Hospital and Tampa Bay Heart Institute

Tampa General Hospital

North Bay Hospital

Gulf Coast Medical Center

Florida Hospital Tampa

Florida Hospital North Pinellas

Baptist Hospital of Miami

Saint Joseph's Hospital

Sacred Heart Hospital

Bayfront Health Punta Gorda

Holy Cross Hospital

Jackson Memorial Hospital

Holmes Regional Medical Center

Winter Haven Hospital

Florida Hospital Memorial Medical Center

Munroe Regional Medical Center

Orlando Regional Medical Center

Citrus Memorial Health

Mt. Sinai Medical Center

Doctors Hospital of Sarasota

Baptist Medical Center JAX

Bethesda Memorial Hospital

North Broward Medical Center/Broward Health North

Lee Memorial Hospital

Cape Coral Hospital

Health Park Medical Center

Lakeland Regional Medical Center

Baptist Medical Center South

Tallahassee Memorial Hospital

Sarasota Memorial Hospital

Broward Health Medical Center

Florida Hospital Altamonte

Florida Hospital Apopka

Florida Hospital Celebration Health

Winter Park Memorial Hospital

Florida Hospital Orlando

Florida Hospital East Orlando

Florida Hospital Kissimmee

South Florida Baptist Hospital

Shands Hospital-University of Florida

Baptist Medical Center

Shands-Jacksonville

Imperial Point Medical Center

Florida Hospital Zephyrhills, Inc.

Pasco Regional Medical Center (Bayfront Health-Dade City)

Mayo Clinic Jacksonville

University of Miami Hospital

Broward Health Coral Springs Medical Center

Doctor P. Philips Hospital

NCH Downtown Naples Hospital

Puerto Rico

Hospital HIMA San Pablo (Caguas)

Puerto Rico Medical Center

Hospital HIMA-San Pablo (Bayamon)

Manati Medical Center

Hospital HIMA San Pablo (Fajardo)

University of Puerto Rico Hospital

Hospital Santa Rosa

Hospital Menonita Caguas

Table S1. Risk factors by race/ethnicity among patients treated at CReSD hospitals.

Variable	FL-Black	FL-Hispanic	PR-Hispanic	FL-White
Total stroke discharges	3769	1843	304	37129
Age, mean (SD), y	77.0 (8.2)	81.3 (8.0)	82.4 (8.2)	80.0 (8.3)
Women, n (%)	2187 (58.0)	1118 (60.7)	165 (54.3)	19677 (53.0)
Congestive heart failure, n (%)	635 (16.8)	335 (18.2)	30 (9.9)	4644 (12.5)
Prior myocardial infarction, n (%)	124 (3.3)	65 (3.5)	19 (6.3)	1065 (2.9)
Unstable angina, n (%)	29 (0.8)	33 (1.8)	17 (5.6)	527 (1.4)
Chronic atherosclerosis, n (%)	1104 (29.3)	784 (42.5)	92 (30.3)	14068 (37.9)
Respiratory failure, n (%)	143 (3.8)	143 (7.8)	6 (2.0)	1391 (3.7)
Hypertension, n (%)	2967 (78.7)	1512 (82.0)	236 (77.6)	29048 (78.2)
Prior stroke, n (%)	396 (10.5)	171 (9.3)	26 (8.6)	2860 (7.7)
Cerebrovascular disease, n (%)	593 (15.7)	228 (12.4)	8 (2.6)	5006 (13.5)
Renal failure, n (%)	696 (18.5)	308 (16.7)	24 (7.9)	4370 (11.8)
Chronic obstructive pulmonary disease, n (%)	420 (11.1)	387 (21.0)	22 (7.2)	6214 (16.7)
Pneumonia, n (%)	388 (10.3)	253 (13.7)	49 (16.1)	3291 (8.9)
Protein-calorie malnutrition, n (%)	288 (7.6)	104 (5.6)	4 (1.3)	1834 (4.9)
Dementia, n (%)	697 (18.5)	458 (24.9)	34 (11.2)	5417 (14.6)
Functional disability, n (%)	451 (12.0)	156 (8.5)	11 (3.6)	2415 (6.5)
Peripheral vascular disease, n (%)	327 (8.7)	167 (9.1)	15 (4.9)	2882 (7.8)
Cancer, n (%)	315 (8.4)	134 (7.3)	23 (7.6)	2804 (7.6)
Trauma, n (%)	198 (5.3)	160 (8.7)	9 (3.0)	3689 (9.9)
Psychiatric disorder, n (%)	150 (4.0)	153 (8.3)	8 (2.6)	1200 (3.2)

Liver disease, n (%)	34 (0.9)	18 (1.0)	1 (0.3)	196 (0.5)
Depression, n (%)	157 (4.2)	159 (8.6)	3 (1.0)	2876 (7.7)
Diabetes, n (%)	1872 (49.7)	816 (44.3)	120 (39.5)	11411 (30.7)

Table S2. Risk factors by race/ethnicity among patients treated at non-QI hospitals.

Variable	FL-Black	FL-Hispanic	PR-Hispanic	FL-White
Total stroke discharges	1002	743	1082	11190
Age, mean (SD), y	77.3 (8.2)	82.3 (7.8)	83.6 (7.0)	79.4 (8.1)
Women, n (%)	564 (56.3)	455 (61.2)	574 (53.0)	6036 (53.9)
Congestive heart failure, n (%)	153 (15.3)	149 (20.1)	103 (9.5)	1302 (11.6)
Prior myocardial infarction, n (%)	24 (2.4)	32 (4.3)	20 (1.8)	302 (2.7)
Unstable angina, n (%)	18 (1.8)	19 (2.6)	44 (4.1)	246 (2.2)
Chronic atherosclerosis, n (%)	323 (32.2)	335 (45.1)	305 (28.2)	4234 (37.8)
Respiratory failure, n (%)	45 (4.5)	56 (7.5)	13 (1.2)	400 (3.6)
Hypertension, n (%)	800 (79.8)	613 (82.5)	810 (74.9)	8873 (79.3)
Prior stroke, n (%)	78 (7.8)	91 (12.2)	86 (7.9)	917 (8.2)
Cerebrovascular disease, n (%)	143 (14.3)	127 (17.1)	75 (6.9)	1359 (12.1)
Renal failure, n (%)	153 (15.3)	150 (20.2)	82 (7.6)	1259 (11.3)
Chronic obstructive pulmonary disease, n (%)	131 (13.1)	169 (22.7)	123 (11.4)	2172 (19.4)
Pneumonia, n (%)	85 (8.5)	102 (13.7)	115 (10.6)	1202 (10.7)
Protein-calorie malnutrition, n (%)	48 (4.8)	65 (8.7)	21 (1.9)	518 (4.6)
Dementia, n (%)	177 (17.7)	234 (31.5)	228 (21.1)	1857 (16.6)
Functional disability, n (%)	89 (8.9)	77 (10.4)	48 (4.4)	669 (6.0)
Peripheral vascular disease, n (%)	85 (8.5)	81 (10.9)	56 (5.2)	832 (7.4)
Cancer, n (%)	61 (6.1)	52 (7.0)	63 (5.8)	749 (6.7)
Trauma, n (%)	63 (6.3)	80 (10.8)	56 (5.2)	935 (8.4)
Psychiatric disorder, n (%)	35 (3.5)	93 (12.5)	41 (3.8)	424 (3.8)
Liver disease, n (%)	3 (0.3)	4 (0.5)	7 (0.6)	71 (0.6)

Depression, n (%)	50 (5.0)	102 (13.7)	23 (2.1)	877 (7.8)
Diabetes, n (%)	517 (51.6)	370 (49.8)	457 (42.2)	4041 (36.1)