Age-Related Differences in Characteristics, Performance Measures, Treatment Trends, and Outcomes in Patients With Ischemic Stroke

Gregg C. Fonarow, MD; Mathew J. Reeves, PhD; Xin Zhao, MS; DaiWai M. Olson, PhD, RN; Eric E. Smith, MD, MPH; Jeffrey L. Saver, MD; Lee H. Schwamm, MD; for the Get With the Guidelines–Stroke Steering Committee and Investigators

Background—Prior studies have suggested lower use of guideline-recommended therapy and worse poststroke outcomes in older patients. We sought to examine age-related differences in characteristics, performance measures, temporal trends, and early clinical outcomes for acute ischemic stroke in a large contemporary cohort.

Methods and Results—The relationships between age and clinical characteristics, performance measures, and in-hospital outcomes were analyzed in 502 036 ischemic stroke admissions from 1256 hospitals in the Get With the Guidelines–Stroke program from 2003 to 2009. Data were analyzed by age groups (<50, 50 to 59, 60 to 69, 70 to 79, 80 to 89, and ≥90 years) and with age as a continuous variable. Seven predefined performance measures and 2 summary measures were analyzed. Mean age of ischemic stroke patients was 71.0±14.6 years; 52.5% were women. Older patients were more likely to have a history of atrial fibrillation or hypertension and less likely to be black, Hispanic, or current/recent smokers. Although modest age-related differences in each individual performance measure were identified, there were substantial temporal improvements in performance measures from 2003 to 2009 in each age group, and many age-related treatment gaps were narrowed or eliminated over time. Older patients were less likely to be discharged home (adjusted odds ratio, 0.69; 95% confidence interval, 0.68 to 0.69) and more likely to die in hospital (adjusted odds ratio, 1.27; 95% confidence interval, 1.25 to 1.29) for each 10-year age increase.

Conclusions—Older patients with ischemic stroke differ in clinical characteristics and experience higher in-hospital mortality than younger patients. Performance measure–based treatment rates improved substantially over time for ischemic stroke patients in all age groups, resulting in smaller age-related treatment gaps. **(*Circulation*. 2010;121:879-891.)**

Key Words: aging ■ mortality ■ outcome assessment ■ registries ■ stroke

Stroke is the third-leading cause of death and a leading cause of disability in the United States. There are an estimated 795 000 stroke cases and 137 000 stroke deaths annually in the United States.[1] The burden of stroke is borne disproportionately by older patients who have a greater incidence and prevalence of ischemic stroke than younger individuals.[1,2] Age is the most important unmodifiable risk factor for all stroke types, including ischemic stroke.[3,4] For each successive 10 years after 55 years of age, the stroke rate more than doubles in both men and women.[4] Population-based studies indicated that 65% of all strokes occur in individuals >65 years of age.[1,4] Older ischemic stroke patients also have worse functional outcomes after stroke than younger patients, and these differences remain despite adjustment for baseline differences in stroke risk factors and other comorbidities.[5–9] Improved understanding of age-related differences in stroke presentation, quality of care, and outcomes will become even more important as the number of stroke-related events in older persons increases dramatically over forthcoming decades as a result of the aging of the population in the United States and elsewhere.[2]

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Prior studies have also suggested that older patients receive fewer guideline-recommended diagnostic studies and treatments compared with younger patients.[6–8] However, uncertainty remains about the magnitude of these age-related differences in care and their causes. Furthermore, prior studies have examined selected patient populations outside the United States, lacked detailed data on diagnosis and care, and did not always collect complete data on contraindications.[4–6] Whether temporal improvements in care of ischemic

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From the Divisions of Cardiology (G.C.F.) and Neurology (J.L.S.), University of California, Los Angeles; Department of Epidemiology, Michigan State University, East Lansing (M.J.R.); Duke Clinical Research Center, Durham, NC (X.Z., D.M.O.); Department of Clinical Neurosciences, University of Calgary, Calgary, Alberta, Canada (E.E.S.); and Division of Neurology, Massachusetts General Hospital, Boston (L.H.S.).

Correspondence to Gregg C. Fonarow, MD, Ahmanson–UCLA Cardiomyopathy Center, UCLA Medical Center, 10833 LeConte Ave, Room 47-123 CHS, Los Angeles, CA 90095-1679. E-mail gfonarow@mednet.ucla.edu

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stroke patients extend to all age groups has also not been well studied. Older acute ischemic stroke patients experience poorer poststroke outcomes compared with younger patients, and it is unclear to what degree these previously reported age-related differences in clinical outcomes reflect differences in pathophysiology, comorbid conditions, divergent responses to treatment, differences in care provided, or patient preferences. The objective of this study was to examine age-related differences in patient demographics, clinical characteristics, performance measures, temporal treatment trends, and early clinical outcomes in the Get With the Guidelines–Stroke (GWTG-Stroke) population with acute ischemic stroke.

Methods

Details of the design and conduct of the GWTG-Stroke program have been previously described.[10,11] In brief, the American Heart Association and American Stroke Association launched the GWTG-Stroke initiative, which was focused on the redesign of hospital systems of care to improve the quality of care of patients with stroke and transient ischemic attack (TIA). GWTG uses the Web-based Patient Management Tool (Outcome, Cambridge, Mass) to collect clinical data, to provide decision support, and for real-time online reporting features. After an initial pilot phase conducted in 8 states starting in 2001, the GWTG-Stroke program was made available in April 2003 to any hospital in the United States.[10] Data from hospitals that joined the program anytime between April 2003 and March 2009 were included in this analysis. Each participating hospital received either human research approval to enroll cases without individual patient consent under the common rule or a waiver of authorization and exemption from subsequent review by their Institutional Review Board. Outcome Sciences, Inc serves as the data collection and coordination center for GWTG. The Duke Clinical Research Institute serves as the data analysis center and has an agreement to analyze the aggregate deidentified data for research purposes.

Case Identification and Data Abstraction

Trained hospital personnel were instructed to ascertain consecutive acute stroke admissions by prospective clinical identification, retrospective identification using discharge codes from the *International Classification of Diseases*, ninth revision, or a combination. Methods used for prospective identification varied but included regular surveillance of emergency department records (ie, presenting symptoms and chief complaints), ward census logs, and/or neurological consultations.[10,11] The eligibility of each acute stroke admission was confirmed at chart review before abstraction.

Patient data were abstracted by trained hospital personnel. Data included demographics, medical history, initial head computerized tomography findings, in-hospital treatment and events, discharge treatment and counseling, mortality, and discharge destination. The data abstraction tool included predefined logic features and user alerts to identify potentially invalid format or values. Required fields are structured so that valid data must be entered before the data can be saved as a complete record and entered into the database. Range checks were used for inconsistent or out-of-range data and prompted the user to correct or review data entries that were outside a predefined range. Training in the use of the tool and coding instructions was provided for all users. Sites received individual data quality reports to promote data completeness and accuracy. Additional descriptions of the data collection and quality auditing methods have been previously published.[10] All patient data were deidentified before submission. Data on hospital-level characteristics (ie, bed size, academic or nonacademic status, annual volume of stroke discharges, and geographical region) were obtained from the American Hospital Association.[12]

Patient Population

Among all ischemic stroke admissions from hospitals that participated in the program between April 2003 and March 2009, we excluded 10 322 cases (2.0%) from 38 hospitals that had incomplete medical history data and 492 (<0.1%) cases because of missing information on sex or age. The final analysis sample consisted of 502 036 ischemic stroke admissions from 1256 hospitals.

Performance Measures

The following 7 predefined performance measures, selected by the GWTG-Stroke program as primary targets for stroke quality improvement efforts[10,11] and endorsed by the National Quality Forum, were used to compare the care processes in acute ischemic stroke admissions: early performance measures, including intravenous recombinant tissue plasminogen activator (tPA) in patients who arrive <2 hours after symptom onset and treated within 3 hours of symptom onset (intravenous tPA <2 hours), antithrombotic medication (antiplatelet or anticoagulant) prescribed within 48 hours of admission (early antithrombotics), and deep venous thrombosis (DVT) prophylaxis (warfarin, heparin, low-molecular-weight heparin, other anticoagulants, pneumatic compression devices) within 48 hours of admission in patients at risk for DVT (nonambulatory) (DVT prophylaxis); and discharge performance measures, including antithrombotic medication (antiplatelet or anticoagulant) prescribed at discharge (antithrombotics), anticoagulation prescribed at discharge in patients with documented atrial fibrillation (anticoagulation for AF), lipid-lowering medication prescribed at discharge if low-density lipoprotein (LDL) was >100 mg/dL, if patient was treated with lipid-lowering agent before admission, or if LDL was not documented (LDL 100 or ND), and smoking cessation intervention (counseling or medication) at discharge for current or recent smokers (smoking cessation).

Performance measures were applied only to eligible patients in the absence of documented contraindications, intolerance, comfort measures only, or any other rationale as to why therapy was not provided. Two different measures were used to summarize the overall processes of care by patient age.[10,11,13] An all-or-none measure of care,[13] which is defined as the proportion of patients who received all of the performance measure interventions for which they were eligible, was used. A composite measure of care,[10,13] defined as the total number of performance measure interventions provided among eligible patients divided by the total number of possible interventions among eligible patients, was also calculated. Detailed descriptions of these summary measures have previously been published.[10,13] The in-hospital outcome measures assessed in this study were in-hospital mortality, discharge to home (discharge status home versus other), and hospital length of stay.

Statistical Analysis

Contingency tables were generated to explore the relationship between age, other demographic and clinical variables, and hospital-level characteristics. For these analyses, data were analyzed by age groups (<50, 50 to 59, 60 to 69, 70 to 79, 80 to 89, ≥90 years). Similarly, contingency tables were generated to explore the relationship between age groups and compliance with the individual and summary performance measures. Tests for statistical associations with age category were performed with the Pearson χ^2 rank correlation (for comparisons with continuous or ordinal variables) and χ^2 group means score (for comparisons with categorical variables). Age category was treated as an ordinal variable; therefore, the resulting probability value reflects a test for increasing or decreasing trend across age categories. Because of the large size of the data set, statistical significance was defined as $P \leq 0.01$.

The relationship between age and compliance with individual performance measures was further examined through multivariable logistic regression models. To account for within-hospital clustering, generalized estimating equations (GEEs) were used to generate models both unadjusted and adjusted for potential confounding

variables. For these analyses, age was assessed as a continuous variable per 10-year interval. Given the large data set, traditional model building approaches that identify independent predictors based on statistical significance were not used. Instead, the final models were adjusted for the following prespecified potential confounders identified in prior GWTG-Stroke studies: sex, race, past medical history and risk factors (including AF, previous stroke/TIA, coronary heart disease or prior myocardial infarction, carotid stenosis, diabetes, peripheral vascular disease, hypertension, dyslipidemia, and current smoking), and hospital size and type. An identical modeling approach was used to explore the relationship between age and 3 binary outcome measures: in-hospital mortality, discharged status (home versus other), and length of stay (>4 versus ≤4 days; this cut point represented the median length of stay). We examined the relationship between age and the 2 summary measures of care using separate multivariable logistic regression models adjusted for the same prespecified set of potential confounders. Because the composite measure was skewed and not normally distributed, we used a previously developed modeling approach[10] in which each care opportunity for which a patient was eligible contributed an observation to the logistic regression model (value=1 if measure was met, 0 if not). The output of this model was the probability of an individual care opportunity being fulfilled. Each type of opportunity is weighted equally because each opportunity contributes 1 observation to the model regardless of the measure from which the opportunity is drawn. GEE-based models were used to account for within-hospital clustering. Because National Institutes of Health Stroke Scale (NIHSS) score was not uniformly available, stroke severity could not be adjusted for the entire cohort. We performed sensitivity analyses to assess the contribution of stroke severity to performance measures and outcomes using 2 strategies. First, we restricted the analyses to those patients who were discharged to home as a proxy for stroke severity to identify the patients with milder strokes. Second, all analyses were repeated in the cohort of patients who had NIHSS recorded (44.1% of total).

Temporal trends in performance measures from 2003 to 2009 were analyzed for each age group for each 1-year interval using χ^2 rank-based group means score statistics. GEE multivariable logistic regression models were developed to quantify how the individual performance measure and the all-or-none care measure changed over this time period. Finally, we also explored interaction effects between age and calendar time for the individual performance measures and all-or-none care. Interactions with values of $P \leq 0.01$ were deemed statistically significant. All statistical analyses were performed with SAS version 9.1 software (SAS Institute, Cary, NC).

The authors had full access to and take full responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.

Results

Of the 502 036 ischemic stroke admissions, the mean patient age was 71.0±14.6 years. Of these patients, 44 728 (8.9%) were <50 years of age, 68 796 (13.7%) were 50 to 59 years, 95 095 (18.9%) were 60 to 69 years of age, 124 955 (24.9%) were 70 to 79 years of age, 132 783 (26.4%) were 80 to 89 years of age, and 35 679 (7.1%) were ≥90 years of age. In this cohort of ischemic stroke patients, just over half (52.5%) were women. Table 1 compares the demographic and clinical characteristics by age group. Older patients were more often female (Figure 1). There were striking differences in race and ethnicity by age of presentation with ischemic stroke. Black patients represented 27.0% of the patients with ischemic stroke <50 years of age but only 6.4% of patients ≥90 years of age ($P<0.0001$). Older patients were more likely to present by ambulance and to have a medical history of AF, hypertension, coronary heart disease or prior myocardial infarction, and prior stroke/TIA (Table 1). Older patients were substantially less likely to have current or recent smoking history. The frequency of a past medical history of diabetes mellitus peaked in patients 60 to 69 years of age and then declined, whereas the frequency of dyslipidemia peaked in the 70- to 79-year-old group and then declined. Among those patients in whom NIHSS was documented, older patients presented with increased stroke severity. There were only minor differences in hospital characteristics between the age groups of ischemic stroke patients, with older patients being more likely to be treated in smaller, nonacademic hospitals (Table 1).

Performance on all individual process measures was lower in older patients (80 to 89 and ≥90 years) compared with younger patients as shown in Table 2. Overall, the largest differences were seen in the proportion of eligible patients treated with intravenous tPA (51.1% for ≥90 years of age versus 61.6% for <50 years of age; $P<0.001$) and treated with lipid-lowering medication (54.2% for ≥90 years of age versus 71.7% for <50 years of age; $P<0.001$). The smallest differences in care between older and younger ischemic stroke patients were for use of antithrombotic therapy within 48 hours of admission and at discharge. The 2 summary measures demonstrated that older patients (80 to 89 and ≥90 years) received all-or-none care or composite care less often than younger ischemic stroke patients (Table 2). An exception to the finding that older patients received fewer guideline-recommended therapies was that patients <50 years of age were less, rather than more, likely to be treated with lipid-lowering drugs at discharge than patients 50 to 79 years of age.

We observed important age differences in unadjusted ischemic stroke-related outcomes at discharge (Table 3). Older patients had a higher in-hospital case fatality rate compared with younger patients (10.3% for ≥90 years of age versus 3.0% for <50 years of age; $P<0.001$). Older patients were also less likely to be discharged home and were more likely to be discharged to a skilled nursing facility (42.1% for ≥90 years of age versus 5.3% for <50 years of age; $P<0.001$) or hospice (12.0% for ≥90 years of age versus 0.5% for <50 years of age; $P<0.001$). At discharge, 40.1% of patients ≥90 years of age were unable to ambulate compared with only 9.6% of those <50 years of age ($P<0.001$). Median hospital length of stay was the same (4.0 days) for each age group.

After multivariable GEE adjustment, the age differences (when modeled as a continuous variable) in the compliance with individual performance measures remained. For each 10-year increase in age, the adjusted odds ratios (ORs) for receiving any of the 7 individual measures were all <1.0, varying from 0.79 (95% confidence interval [CI], 0.77 to 0.81; anticoagulation for AF) to 0.95 (95% CI, 0.94 to 0.96; early antithrombotics; Table 4). The adjusted OR for the all-or-none measure of care was 0.93 (95% CI, 0.92 to 0.93) for every 10-year increase in age.

Adjustment for potential confounding variables collected in this study moderately attenuated the age-related differences for stroke-related outcomes. The OR for every 10-year

Table 1. Demographics, Clinical Characteristics, and Hospital Characteristics by Age Group Among Ischemic Stroke Admissions

Variable	All	<50 y of Age	50–59 y of Age	60–69 y of Age	70–79 y of Age	80–89 y of Age	≥90 y of Age	*P*
Total, n	502 036	44 728	68 796	95 095	124 955	132 783	35 679	
Demographics								
Female sex, %	52.5	46.9	40.6	43.2	51.6	62.4	74.0	<0.0001
Race/ethnicity, %								
White	73.5	58.0	61.4	68.5	76.1	83.2	84.9	<0.0001
Black	14.9	27.1	24.9	18.6	12.5	7.7	6.4	
Hispanic	4.9	7.7	6.4	5.7	4.8	3.3	3.0	
Body mass index, median, kg/m^2	26.6	28.7	28.8	28.1	26.7	24.9	23.3	<0.0001*
Arrival mode, EMS from home/scene, %	60.7	50.4	51.2	54.1	60.1	69.5	78.0	<0.0001
Time from symptom onset to arrival, median (25th to 75th percentile), min	156 (61–449)	163 (60–525)	189 (65–547)	175 (64–495)	151 (60–430)	140 (60–387)	130 (60–357)	<0.0001
Percentage <180 min	53.0	51.8	48.6	50.4	53.7	55.9	57.9	<0.001
NIH Stroke Scale, median	5	4	4	4	5	6	8	<0.0001*
25th to 75th percentile	2–11	1–9	2–9	2–9	2–11	2–14	3–17	
Missing	55.9	54.5	54.1	54.9	55.8	57.2	59.3	
Medical history, %								
Previous stroke/TIA	32.7	24.5	27.5	31.3	34.4	36.4	34.6	<0.0001
AF/flutter	19.7	3.2	5.5	10.7	20.7	31.8	39.3	<0.0001
CAD/Prior MI	30.0	13.0	21.6	28.8	34.2	35.3	32.4	<0.0001
Carotid stenosis	4.8	1.7	3.3	5.0	6.0	5.5	4.1	<0.0001
Diabetes mellitus	33.0	29.4	38.5	41.1	36.2	26.6	17.0	<0.0001
PVD	5.6	2.3	4.0	5.8	6.6	6.3	5.1	<0.0001
Hypertension	81.2	65.7	77.8	81.7	83.8	84.0	83.3	<0.0001
Smoker	20.7	52.4	43.3	29.6	14.0	5.4	1.9	<0.0001
Dyslipidemia	40.2	29.3	39.9	45.4	45.7	38.5	25.1	<0.0001
Hospital characteristics								
Stroke discharges, n								
≥301	46.0	47.8	47.4	47.1	46.0	44.7	43.2	<0.0001*
101–300	44.6	44.3	44.0	44.0	44.6	45.1	45.5	
0–100	9.4	7.9	8.6	8.9	9.5	10.1	11.3	
Beds, median, n	374	418	400	383	369	355	348	<0.0001*
Region								
West	17.7	16.3	16.1	16.8	17.6	19.2	19.8	<0.0001
South	37.2	41.0	41.5	40.3	36.9	33.3	31.2	
Midwest	20.0	20.5	20.9	19.6	20.1	19.7	19.4	
Northeast	25.1	22.2	21.5	23.2	25.3	27.9	29.7	
Hospital								
Nonacademic	38.3	33.1	35.2	37.3	39.0	40.7	42.1	<0.0001
Academic	61.7	66.9	64.8	62.7	61.0	59.3	57.9	

EMS indicates emergency medical service; CAD, coronary artery disease; MI, myocardial infarction; and PVD, peripheral vascular disease. *P* values are based on χ^2 rank-based group means score statistics for all categorical row variables (equivalent to Kruskal-Wallis test for row variables with ≥3 levels and Wilcoxon test for 2 levels).
**P* values are based on χ^2 1-*df* rank correlation statistics for all continuous/ordinal row variables. All tests treat the column variable as ordinal.

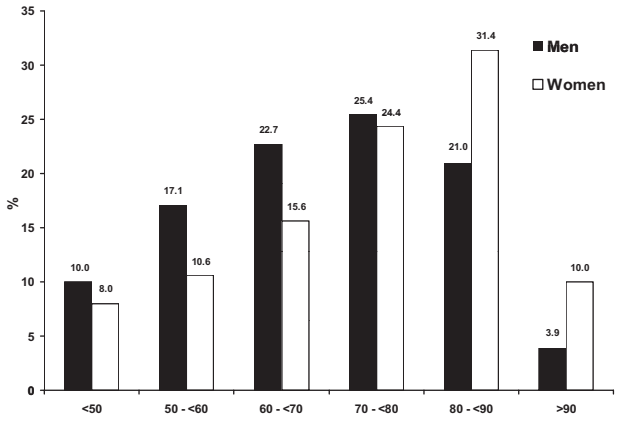

Figure 1. Age distribution by sex of 502 036 ischemic stroke admissions in the GWTG-Stroke program.

increase in age for discharge home changed from 0.67 (unadjusted) to 0.69 (adjusted) in the final multivariable GEE model (Table 4). The unadjusted OR for in-hospital mortality was 1.39 per 10-year increase and remained significantly elevated after adjustment (adjusted OR, 1.27; 95% CI, 1.25 to 1.29; $P<0.001$). After adjustment, the odds of being hospitalized >4 days was slightly elevated in older patients (adjusted OR, 1.06; 95% CI, 1.05 to 1.07 per 10-year age increase; $P<0.001$).

There were substantial improvements in the individual performance measures in each age group from 2003 to 2009 (Table 5 and Figure 2). The absolute increases in performance measure conformity from 2003 to 2009 for patients ≥90 years of age ranged from 8.91% for early antithrombotics to 60.0% for smoking cessation counseling. The intravenous tPA measure increased by 41.9% from 2003 to 2009 in patients ≥90 years of age. By 2009, many of the age-related differences in care had narrowed or were eliminated. Although there were substantial improvements in the use of intravenous tPA over time in eligible patients in each age group, the conformity rates in 2009 for this measure remained substantially lower than those observed for the other 6 performance measures (Table 5). Multivariate GEE analysis showed that there was an increase in the odds of receiving guideline-recommended care for each performance measure and the all-or-none care measure in each age group for each year of time between 2003 and 2009 that was independent of patient and hospital characteristics (Table 6). For the all-or-none measure, the adjusted OR per year ranged from 1.46 (95% CI, 1.42 to 1.50) to 1.50 (95% CI, 1.45 to 1.54) among the different age groups.

There was a significant interaction between age group and calendar time for the intravenous tPA, lipid treatment, smoking cessation, and discharge antithrombotic performance measures, with greater odds of improvement over time for older groups (Table 6). For example, the adjusted OR for intravenous tPA per each 1-year increase in time was 1.31 (95% CI, 1.23 to 1.39) in patients <50 years of age compared with 1.42 (95% CI, 1.32 to 1.54) in patients ≥90 years of (age-by-time interaction, $P<0.0001$). Therefore, the odds of fulfilling this performance measure increased with each year in time in each age group, but the increase was more pronounced in older patients. The discharge antithrombotic, smoking cessation, and lipid treatment measures also showed a significant age-by-time interaction. For the other performance measures and the all-or-none care measure, the age-by-time interactions were not significant at the $P<0.01$ level.

In the sensitivity analyses restricted to those patients who were discharged to home to assess the contribution of stroke severity to performance measures and outcomes, age-related differences in care processes persisted for 3 of the 4 discharge performance measures in these adjusted analyses: anticoagulation for AF, lipid treatment, and smoking cessation (data not shown). In the sensitivity analyses restricted to the cohort of patients in whom NIHSS was recorded, even after adjustment for NIHSS and other covariates, there were similar age-related differences in discharge home and in-hospital mortality. The adjusted OR for in-hospital mortality was 1.15 (95% CI, 1.13 to 1.18; $P<0.001$) per 10-year age increase.

Discussion

Ischemic stroke greatly affects the aged.[1–4] In this analysis of >500 000 acute ischemic stroke admissions in the United States, >58% of patients were ≥70 years of age,

Table 2. Individual and Summary Performance Measures for Ischemic Stroke Care by Age Groups

Performance Measures	Overall	<50 y of Age	50–59 y of Age	60–69 y of Age	70–79 y of Age	80–89 y of Age	≥90 y of Age	*P*
IV tPA 2 h	56.9	61.7	61.3	58.1	56.6	53.8	51.1	<0.0001
Early antithrombotics	95.0	94.7	95.5	95.6	95.4	94.6	92.8	<0.0001
DVT prophylaxis	88.2	91.2	90.6	89.7	88.6	86.9	83.6	<0.0001
Antithrombotics	95.6	95.4	96.2	96.2	95.9	95.0	93.5	<0.0001
Anticoagulation for AF	90.5	93.6	92.8	92.1	91.9	89.9	84.5	<0.0001
LDL 100 or ND	75.8	71.7	80.7	81.7	78.6	70.7	54.2	<0.0001
Smoking cessation	88.4	89.8	90.3	88.9	85.1	82.1	80.6	<0.0001
All-or-none measure	71.5	71.0	75.0	75.2	73.0	68.3	60.9	<0.0001
Composite score	88.4	88.1	90.2	90.2	89.1	86.9	82.6	<0.0001

P values are based on χ^2 rank-based group means score statistics for all categorical row variables (equivalent to Kruskal-Wallis test for row variables with ≥3 levels and Wilcoxon test for 2 levels). Missing observations were <2% of the total. See Methods and Reference 10 for each performance measure definition.

Table 3. Clinical Outcomes Among Ischemic Stroke Admissions By Age Group

Variable	Total	<50 y of Age	50–59 y of Age	60–69 y of Age	70–79 y of Age	80–89 y of Age	≥90 y of Age	*P*
Total admissions, n	502 036	44 728	68 796	95 095	124 955	132 783	35 679	
Discharge status								
Died†	5.6	3.0	3.3	4.1	5.4	7.7	10.3	<0.0001
Discharge destination								
Home	45.9	66.7	62.2	55.6	45.3	31.2	19.6	<0.0001
Skilled nursing facility	20.5	5.4	8.5	12.7	20.3	31.7	42.7	
Rehabilitation	21.2	18.8	20.7	22.7	23.4	21.3	13.6	
Hospice	3.5	0.5	0.8	1.4	2.6	5.9	12.2	
Transfer to acute care facility	2.8	4.1	3.4	3.0	2.8	2.2	1.5	
AMA/other	0.5	1.6	1.1	0.6	0.3	0.2	0.1	
Ambulatory status‡								
Independent	47.2	68.7	63.4	56.4	46.2	32.9	19.7	<0.0001
With assistance	29.9	18.9	22.5	26.5	31.6	36.5	36.9	
Unable	19.8	9.6	11.3	14.1	19.0	27.3	40.1	
Not documented	3.1	2.8	2.8	3.0	3.3	3.3	3.3	
Length of stay, d§								
Median	4.0	4.0	4.0	4.0	4.0	4.0	4.0	<0.001*
Mean	5.8	5.8	5.7	5.8	5.8	5.9	5.6	
>4 d	45.6	42.9	41.5	43.2	45.9	49.3	48.2	<0.001*

P values are based on χ^2 rank-based group means score statistics for all categorical row variables (equivalent to Kruskal-Wallis test for row variables with ≥3 levels and Wilcoxon test for 2 levels).

**P*values are based on χ^2 1-*df* rank correlation statistics for all continuous/ordinal row variables.

†Excludes patients with missing information of discharge status and those transferred out.

‡Excludes patients transferred in or transferred out.

§Excludes subjects who were transferred to another facility or did not have a valid admission or discharge date.

and >33% were ≥80 years of age. Older patients exhibited a different pattern of stroke risk factors and comorbid conditions compared with younger patients. Despite older patients being at high risk for short-, intermediate-, and long-term morbidity and mortality from ischemic stroke, prior studies have shown that older patients are less likely to be treated with guideline-recommended stroke therapies than younger patients.[6–8] This study demonstrated in a broad cohort of ischemic stroke patients from all regions of the United States that most performance measure–based care opportunities were fulfilled among eligible patients regardless of age. Furthermore, performance measure–based treatment rates increased substantially over time in each age group and for many measures; although older patients received fewer performance measure care processes compared with younger patients in 2003, many of these differences were reduced or eliminated by 2009.

Older patients hospitalized with ischemic stroke have distinctive clinical characteristics, most notably a high prevalence of AF, hypertension, prior coronary heart disease, and prior history of stroke/TIA; a lower prevalence of smoking; and more severe stroke deficits at presentation.[3,4] In our study, the racial/ethnic composition of patients <50 years of age hospitalized for acute ischemic stroke was remarkable. Black and Hispanic patients represented 27.0% and 7.7% of this population, respectively, compared with only 6.4% and 3.0% of patients ≥90 years of age. Prior studies have shown that black and Hispanic patients present with ischemic stroke at younger ages compared with white patients.[1,14] There were also important age-related differences in the distribution of patient sex, with women constituting the majority of older patients with stroke. Current or recent smoking was strongly associated with a younger age for acute ischemic stroke presentation. These age-related differences in clinical characteristics provide insight into which factors and comorbid conditions may be associated with ischemic stroke in different age groups.[4]

Previous studies, mostly from Europe, that have examined age differences in the care of acute stroke patients have been relatively modest in size and have examined only a few quality metrics. Some of these studies reported differences in the use of specific diagnostic and treatment procedures and have suggested that there may be age-related differences in the quality of in-hospital care.[6–8] For example, the Danish National Indicator Project (DNIP) found an inverse association between age and care measures, and the age-related differences were substantial for only 2 measures: oral anticoagulant therapy and early evaluation of nutritional status.[8] A joint European study found a less intensive effort for diagnosis and rehabilitation of stroke patients ≥75 years compared with patients <75 years of age, with lower proportions examined with computed tomography scan or echo-

Table 4. Unadjusted and Adjusted ORs for Age Differences (per 10-y Increase) in Performance Measures and Outcome Measures

		Unadjusted			Adjusted*		
Outcome	Total, n†	OR	95% CI	*P*	OR	95% CI	*P*
Performance measures							
IV tPA 2 h	33 820	0.93	0.91–0.94	<0.001	0.94	0.92–0.96	<0.001
Early antithrombotics	308 467	0.95	0.94–0.96	<0.001	0.95	0.94–0.96	<0.001
DVT prophylaxis	238 834	0.92	0.91–0.93	<0.001	0.89	0.88–0.90	<0.001
Antithrombotics	408 277	0.94	0.92–0.95	<0.001	0.93	0.92–0.95	<0.001
Anticoagulation for AF	58 049	0.81	0.79–0.84	<0.001	0.79	0.77–0.81	<0.001
LDL 100 or ND	315 389	0.90	0.89–0.91	<0.001	0.91	0.90–0.92	<0.001
Smoking cessation	77 265	0.86	0.85–0.88	<0.001	0.87	0.85–0.89	<0.001
All-or-none measure	455 702	0.94	0.93–0.94	<0.001	0.93	0.92–0.93	<0.001
Composite score measure	1 440 101 (478 960)‡	0.94	0.93–0.94	<0.001	0.94	0.93–0.94	<0.001
Outcomes							
Length of stay (>4 d)	395 444	1.10	1.09–1.10	<0.001	1.06	1.05–1.07	<0.001
Discharge home	452 114	0.67	0.66–0.68	<0.001	0.69	0.68–0.69	<0.001
Mortality (all patients)	478 960	1.39	1.36–1.41	<0.001	1.27	1.25–1.29	<0.001

*Variables included in multivariable models were sex, race, medical history of AF, stroke/TIA, coronary heart disease or myocardial infarction, carotid stenosis, diabetes mellitus, peripheral vascular disease, hypertension, dyslipidemia, smoking, hospital size, and hospital type.

†Number of care opportunities in the unadjusted and adjusted analyses.

‡Number of patients contributing care opportunities.

cardiography and lower rates of transfer to rehabilitation ward on discharge.[6] Prior studies have shown that patient age is a significant predictor of intravenous tPA use among eligible patients.[15–17] A Michigan registry study found an age difference in the use of statin drugs at discharge.[18] Our study found evidence of only small age-related differences in the use of intravenous tPA, DVT prophylaxis, smoking cessation, and the use of 2 stroke-related medications at discharge: anticoagulation for AF and cholesterol treatments. During the 2003 to 2009 period, all age groups experienced substantial increases in each of the performance measures. Thus, age-related differences in care decreased substantially or were eliminated completely by the end of the study period. The patterns observed in this GWTG-Stroke study differ from those in prior studies by showing reductions in treatment gaps for evidence-based therapies in older ischemic stroke patients. These findings thereby suggest that clinicians may have become more adherent with guideline-based therapeutic recommendations for their older patients, particularly in the framework of a performance improvement program.

Consistent with prior reports, older patients in our study had a higher in-hospital case fatality than younger patients.[6–9,19,20] Although there were some age-related differences in performance measures, they appear unlikely to explain much or all of the substantially higher in-hospital mortality among older patients. Potential contributing factors for the excess mortality evident in older patients in these data include increased stroke severity, greater frequency of AF, and higher prevalence of medical comorbidities. A higher frequency of AF in older patients is important because it is associated with cardioembolic stroke, which has a higher mortality than penetrating-artery or large-artery atherosclerotic infarcts.[21] In a study of 26 676 patients with ischemic stroke admitted to 606 hospitals across Canada, in-hospital case fatality was much higher in patients age ≥80 years of age (24.2%) compared with those <59 years of age (5.7%).[19] The DNIP reported that 30-day stroke mortality increased with age and that adjusting for the age-related differences in care did not alter the magnitude of the increase.[8] Older ischemic stroke patients in our study were substantially less likely to be ambulatory at discharge or discharged home, as has been previously reported.[16,19,20]

The reasons why age-related differences in certain performance measures persisted after the exclusion of noneligible patients and adjustment for baseline differences need further study. One possible explanation is that these differences are due to residual confounding by unmeasured factors. There may be physician uncertainty about risks versus benefits in treating older patients who are underrepresented in randomized controlled trials.[7,8] Perceptions of contraindications and lack of tolerability to medications in older patients may also contribute to age-related treatment differences. The impact of limited life expectancy and competing risks in the older groups is also relevant to the interpretation of the lower use of evidence-based interventions. The clinical management of ischemic stroke in older patients is associated with several distinct challenges, including increased prevalence of comorbidities such as renal dysfunction and coronary artery disease, greater concerns about polypharmacy, socioeconomic burdens, including the lack of a suitable caregiver at home, and difficult end-of-life or palliative-care issues.[8] Concern that older ischemic stroke patients may be particularly vulnerable to tPA-related hemorrhage may have played a role in the age-related difference seen for the tPA measure. This is reflected in the fact that in the initial protocol design of the National Institutes of Neurological Disorders and Stroke t-PA trial, patients >80 years of age were excluded because of concerns about risk of hemorrhage; however, this age limit

Table 5. Time Trends in Performance Measures for Each Age Group

Variable	n (n=502 036)	2003 (n=12 177)	2004 (n=25 345)	2005 (n=59 063)	2006 (n=100 667)	2007 (n=129 595)	2008 (n=154 595)	2009 (n=20 594)	*P*
IV tPA 2 h									
Overall	35 321	29.59	38.84	46.59	56.10	60.33	62.65	66.82	<0.0001
Age <50 y	3487	31.40	52.90	55.20	58.85	65.47	65.94	66.24	<0.0001
Age 50–59 y	4778	36.28	45.79	46.55	60.77	65.83	65.84	70.00	<0.0001
Age 60–69 y	6558	30.30	44.20	47.59	58.54	60.71	63.20	68.82	<0.0001
Age 70–79 y	9100	29.77	36.00	47.53	57.09	59.66	62.68	67.41	<0.0001
Age 80–89 y	9288	27.08	31.63	42.53	51.62	57.77	60.73	64.71	<0.0001
Age ≥90 y	2110	20.45	28.38	41.59	46.74	51.61	57.55	62.39	<0.0001
Early antithrombotics									
Overall	319 286	89.84	92.59	92.90	94.58	95.84	96.01	95.69	<0.0001
Age <50 y	26 169	88.58	91.90	92.94	94.55	95.47	95.37	96.21	<0.0001
Age 50–59 y	41 285	90.31	92.94	94.17	95.06	96.17	96.39	95.54	<0.0001
Age 60–69 y	58 257	91.12	93.89	93.69	95.23	96.42	96.45	95.95	<0.0001
Age 70–79 y	79 262	90.89	93.88	93.49	95.00	96.15	96.29	96.24	<0.0001
Age 80–89 y	89 812	89.35	91.80	92.24	94.24	95.70	95.82	95.41	<0.0001
Age ≥90 y	24 501	85.26	88.13	89.58	92.20	93.85	94.68	94.17	<0.0001
Antithrombotics discharge									
Overall	422 289	92.73	94.06	93.85	94.10	95.44	97.57	97.52	<0.0001
Age <50 y	49 418	92.30	95.23	93.67	93.97	95.56	96.88	97.71	<0.0001
Age 50–59 y	61 078	93.80	94.60	94.94	95.42	96.04	97.50	97.28	<0.0001
Age 60–69 y	83 658	94.70	95.24	94.67	94.87	96.04	97.78	97.46	<0.0001
Age 70–79 y	106 776	93.48	94.41	94.40	94.61	95.70	97.75	97.83	<0.0001
Age 80–89 y	106 307	91.48	92.82	92.99	92.92	94.98	97.62	97.44	<0.0001
Age ≥90 y	25 052	86.86	91.21	90.15	91.47	92.56	97.12	97.18	<0.0001
Anticoagulation for AF									
Overall	60 246	59.88	84.39	87.75	88.52	90.00	94.11	93.04	<0.0001
Age <50 y	1000	88.89	95.83	89.36	92.38	93.54	95.07	96.36	0.0404
Age 50–59 y	3105	75.00	94.67	90.75	91.98	92.17	94.36	95.07	0.0013
Age 60–69 y	8107	69.37	85.92	89.99	89.59	91.00	95.62	94.76	<0.0001
Age 70–79 y	18 049	65.59	87.82	89.68	90.11	91.59	94.95	93.81	<0.0001
Age 80–89 y	24 365	53.71	82.58	87.28	87.99	89.51	93.77	92.77	<0.0001
Age ≥90 y	5620	45.45	72.61	78.60	81.32	83.77	90.35	87.25	<0.0001
DVT prophylaxis									
Overall	245 865	69.87	81.75	83.38	86.28	89.85	92.42	92.89	<0.0001
Age <50 y	16 694	76.69	85.79	87.50	90.04	91.94	94.00	94.97	<0.0001
Age 50–59 y	27 580	73.09	86.55	86.30	89.19	91.90	93.33	95.15	<0.0001
Age 60–69 y	41 343	73.57	83.37	85.79	87.83	91.31	92.94	93.16	<0.0001
Age 70–79 y	61 688	70.23	82.66	84.15	87.50	90.43	92.46	92.49	<0.0001
Age 80–89 y	76 188	66.86	80.39	81.91	84.45	88.80	91.90	92.32	<0.0001
Age ≥90 y	22 372	64.24	73.41	75.89	80.17	85.24	90.42	90.70	<0.0001
LDL 100 or ND									
Overall	326 760	43.34	58.89	65.06	71.79	78.60	84.16	87.06	<0.0001
Age <50 y	27 544	41.64	56.49	60.99	67.65	74.22	79.60	84.50	<0.0001
Age 50–59 y	48 624	50.80	67.49	71.84	77.52	82.65	87.16	89.47	<0.0001
Age 60–69 y	67 970	54.41	68.12	72.14	77.85	84.04	88.49	91.06	<0.0001

(*Continued*)

Table 5. Continued

Variable	n (n=502 036)	2003 (n=12 177)	2004 (n=25 345)	2005 (n=59 063)	2006 (n=100 667)	2007 (n=129 595)	2008 (n=154 595)	2009 (n=20 594)	*P*
Age 70–79 y	85 252	46.71	63.10	68.56	75.67	81.93	86.32	88.64	<0.0001
Age 80–89 y	80 167	34.62	49.70	59.23	65.88	74.18	80.88	84.59	<0.0001
Age ≥90 y	17 203	15.58	28.87	36.54	46.77	56.70	69.31	71.65	<0.0001
Smoking cessation									
Overall	80 075	45.40	60.45	77.58	87.27	92.87	95.04	95.87	<0.0001
Age <50 y	15 962	44.59	64.07	82.39	88.49	93.97	95.74	96.82	<0.0001
Age 50–59 y	23 363	52.93	64.55	81.55	89.05	94.13	95.69	96.16	<0.0001
Age 60–69 y	22 244	49.89	62.85	77.62	88.05	92.65	95.06	96.23	<0.0001
Age 70–79 y	13 222	34.89	53.62	70.87	83.96	91.42	93.78	95.38	<0.0001
Age 80–89 y	4923	30.77	41.52	64.17	81.02	88.60	92.97	91.16	<0.0001
Age ≥90 y	361	40.00	33.33	51.92	84.52	88.66	90.10	100.00	<0.0001
All-or-none measure									
Overall	471 407	41.11	55.16	60.58	67.03	73.84	80.43	82.66	<0.0001
Age <50 y	42 308	39.83	53.68	60.45	67.19	73.25	78.84	83.20	<0.0001
Age 50–59 y	65 442	44.96	58.57	64.74	71.05	77.30	82.63	85.28	<0.0001
Age 60–69 y	90 335	46.18	59.98	64.48	70.88	77.56	83.22	85.08	<0.0001
Age 70–79 y	118 075	43.22	57.96	62.75	69.33	75.72	81.65	83.66	<0.0001
Age 80–89 y	123 466	36.81	51.04	57.21	63.30	70.69	78.36	80.49	<0.0001
Age ≥90 y	31 781	30.51	42.22	46.74	53.68	62.24	73.11	74.54	<0.0001

P values are based on χ^2 rank-based group means score statistics for all categorical row variables.

was subsequently removed, and the drug is approved for use in the United States for adults ≥18 years of age. Analyses of the risk of hemorrhage after intravenous tPA have not shown an independent effect of age, and recent registry data suggest little increased risk in older patients.[16,22] The increases in the use of intravenous tPA over calendar time were greater in older compared with younger patients. Nevertheless, throughout the study period, there were lower rates of intravenous tPA measure conformity relative to the 6 other performance measures in every age group, which deserves further study.

Decisions about the extent and intensity of medical care in older patients may also be heavily influenced by the presence of previously expressed limitations of care delivery (ie, comfort measures only or do-not-resuscitate orders). In GWTG-Stroke patients identified as having significant limitations placed on care delivery, "comfort measures only" are excluded from the denominator of the performance measures, so this factor should not explain the observed age disparities unless inadequately documented.[10] Less frequent use of evidence-based care may be the choice of the patient or family or may be a reflection of physician-related factors. In-depth exploration of stroke healthcare professionals' values, attitudes, and beliefs about care of older ischemic stroke patients, their ability to

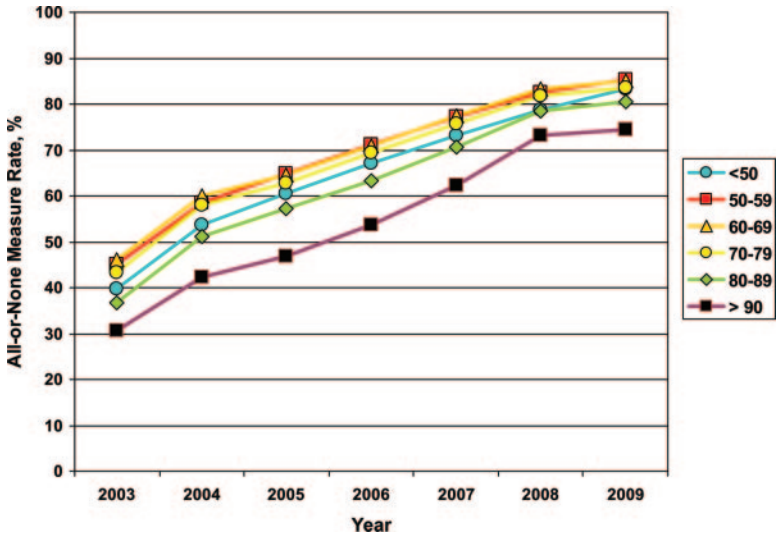

Figure 2. Performance measure conformity in patients with ischemic stroke by age group.

Table 6. Unadjusted and Adjusted Analyses for Time Trends in Performance Measures for Each Age Group

	Unadjusted				Adjusted*			
Outcome and Category per 1-y Increase	OR	Lower (95% CI)	Upper (95% CI)	*P*	OR	Lower (95% CI)	Upper (95% CI)	*P*
IV tPA 2 h								
Age-by-time interaction	. . .	. . .	. . .	0.002	. . .	. . .	. . .	0.003
Overall	1.364	1.311	1.419	<0.001	1.373	1.320	1.428	<0.001
Age <50 y	1.295	1.222	1.373	<0.001	1.308	1.233	1.388	<0.001
Age 50–59 y	1.329	1.264	1.398	<0.001	1.346	1.279	1.417	<0.001
Age 60–69 y	1.335	1.269	1.404	<0.001	1.338	1.272	1.408	<0.001
Age 70–79 y	1.376	1.312	1.443	<0.001	1.385	1.321	1.453	<0.001
Age 80–89 y	1.437	1.372	1.505	<0.001	1.444	1.379	1.511	<0.001
Age ≥90 y	1.415	1.307	1.532	<0.001	1.422	1.315	1.539	<0.001
Early antithrombotics								
Age-by-time interaction	. . .	. . .	. . .	0.637	. . .	. . .	. . .	0.832
Overall	1.264	1.232	1.296	<0.001	1.264	1.231	1.298	<0.001
Age <50 y	1.248	1.198	1.299	<0.001	1.256	1.203	1.311	<0.001
Age 50–59 y	1.269	1.224	1.314	<0.001	1.275	1.228	1.324	<0.001
Age 60–69 y	1.252	1.213	1.293	<0.001	1.254	1.212	1.298	<0.001
Age 70–79 y	1.258	1.219	1.297	<0.001	1.255	1.215	1.296	<0.001
Age 80–89 y	1.270	1.234	1.307	<0.001	1.264	1.226	1.302	<0.001
Age ≥90 y	1.288	1.241	1.336	<0.001	1.280	1.233	1.329	<0.001
Antithrombotics discharge								
Age-by-time interaction	. . .	. . .	. . .	<0.001	. . .	. . .	. . .	0.003
Overall	1.298	1.271	1.326	<0.001	1.298	1.269	1.326	<0.001
Age <50 y	1.258	1.217	1.301	<0.001	1.265	1.221	1.310	<0.001
Age 50–59 y	1.275	1.235	1.316	<0.001	1.281	1.239	1.325	<0.001
Age 60–69 y	1.275	1.239	1.311	<0.001	1.277	1.240	1.315	<0.001
Age 70–79 y	1.292	1.260	1.325	<0.001	1.288	1.256	1.322	<0.001
Age 80–89 y	1.333	1.302	1.365	<0.001	1.326	1.294	1.359	<0.001
Age ≥90 y	1.359	1.314	1.405	<0.001	1.349	1.303	1.397	<0.001
Anticoagulation for AF								
Age-by-time interaction	. . .	. . .	. . .	0.057	. . .	. . .	. . .	0.068
Overall	1.357	1.292	1.426	<0.001	1.354	1.287	1.423	<0.001
Age <50 y	1.226	1.038	1.448	0.017	1.224	1.036	1.446	0.017
Age 50–59 y	1.258	1.146	1.381	<0.001	1.255	1.142	1.380	<0.001
Age 60–69 y	1.413	1.324	1.509	<0.001	1.412	1.321	1.508	<0.001
Age 70–79 y	1.402	1.328	1.480	<0.001	1.397	1.322	1.476	<0.001
Age 80–89 y	1.432	1.351	1.517	<0.001	1.426	1.345	1.512	<0.001
Age ≥90 y	1.428	1.343	1.518	<0.001	1.423	1.338	1.513	<0.001
DVT prophylaxis								
Age-by-time interaction	. . .	. . .	. . .	0.054	. . .	. . .	. . .	0.391
Overall	1.344	1.306	1.382	<0.001	1.361	1.320	1.403	<0.001
Age <50 y	1.310	1.262	1.360	<0.001	1.337	1.283	1.392	<0.001
Age 50–59 y	1.333	1.290	1.378	<0.001	1.357	1.308	1.408	<0.001
Age 60–69 y	1.331	1.291	1.372	<0.001	1.349	1.305	1.395	<0.001
Age 70–79 y	1.351	1.309	1.395	<0.001	1.367	1.321	1.414	<0.001
Age 80–89 y	1.354	1.313	1.397	<0.001	1.364	1.320	1.410	<0.001
Age ≥90 y	1.384	1.335	1.435	<0.001	1.391	1.339	1.445	<0.001
LDL 100 or ND								

(*Continued*)

Table 6. Continued

Outcome and Category per 1-y Increase	Unadjusted				Adjusted*			
	OR	Lower (95% CI)	Upper (95% CI)	*P*	OR	Lower (95% CI)	Upper (95% CI)	*P*
Age-by-time interaction	. . .	. . .	. . .	<0.001	. . .	. . .	. . .	<0.001
Overall	1.505	1.470	1.541	<0.001	1.555	1.515	1.596	<0.001
Age <50 y	1.435	1.391	1.480	<0.001	1.500	1.450	1.551	<0.001
Age 50–59 y	1.457	1.417	1.498	<0.001	1.543	1.493	1.594	<0.001
Age 60–69 y	1.478	1.439	1.518	<0.001	1.559	1.512	1.608	<0.001
Age 70–79 y	1.489	1.451	1.529	<0.001	1.536	1.490	1.584	<0.001
Age 80–89 y	1.526	1.485	1.568	<0.001	1.547	1.502	1.594	<0.001
Age ≥90 y	1.656	1.602	1.712	<0.001	1.649	1.593	1.707	<0.001
Smoking cessation								
Age-by-time interaction	. . .	. . .	. . .	0.001	. . .	. . .	. . .	0.001
Overall	2.005	1.892	2.124	<0.001	2.009	1.895	2.129	<0.001
Age <50 y	1.961	1.858	2.070	<0.001	1.965	1.862	2.074	<0.001
Age 50–59 y	1.880	1.784	1.981	<0.001	1.883	1.788	1.983	<0.001
Age 60–69 y	1.884	1.794	1.978	<0.001	1.888	1.797	1.983	<0.001
Age 70–79 y	2.003	1.895	2.117	<0.001	2.009	1.900	2.124	<0.001
Age 80–89 y	2.079	1.940	2.229	<0.001	2.086	1.946	2.236	<0.001
Age ≥90 y	2.243	1.748	2.879	<0.001	2.243	1.747	2.879	<0.001
All-or-none measure								
Age-by-time interaction	. . .	. . .	. . .	0.099	. . .	. . .	. . .	0.062
Overall	1.455	1.424	1.486	<0.001	1.476	1.443	1.510	<0.001
Age <50 y	1.438	1.400	1.478	<0.001	1.472	1.430	1.515	<0.001
Age 50–59 y	1.450	1.416	1.485	<0.001	1.488	1.449	1.529	<0.001
Age 60–69 y	1.447	1.415	1.480	<0.001	1.479	1.443	1.516	<0.001
Age 70–79 y	1.443	1.411	1.476	<0.001	1.459	1.424	1.495	<0.001
Age 80–89 y	1.456	1.422	1.492	<0.001	1.463	1.426	1.500	<0.001
Age ≥90 y	1.495	1.451	1.540	<0.001	1.495	1.451	1.540	<0.001

*Variables in the model included calendar year, age group, age-by-time interaction, gender, race, medical history of AF, stroke/TIA, coronary artery disease/prior myocardial infarction, carotid stenosis, diabetes mellitus, PVD, hypertension, dyslipidemia, smoking, number of beds, and academic hospital versus not.

recover, and anticipated response to guideline recommended therapies is needed.[23]

This study has several limitations. The GWTG-Stroke program is voluntary, and the hospitals that participate are more likely to be larger teaching hospitals with a strong interest in stroke care and quality improvement. However, the population of GWTG-Stroke is similar in makeup to the global US population and has a similar proportion of older patients and stroke risk factors compared with other stroke registries.[6–8,18] Data were collected by medical chart review and are dependent on the accuracy and completeness of documentation and abstraction; the eligibility and conformity with performance measures are based on this documentation. As such, a proportion of patients reported to be eligible for treatment but not treated may have had contraindications, intolerance, or other reasons for not treating that were present but not documented. Participating hospitals are instructed to include all consecutive admissions for stroke or to take a systematic sample after selecting a random starting point. However, because these processes are not audited, the potential exists for selection bias. Only in-hospital performance measures and mortality were assessed, so age differences in postdischarge care and outcomes could not be determined. Discharge home was included as a stroke-related outcome in this study, but it should be noted that many factors beyond those directly related to the stroke event and its treatment, eg, the availability of caregivers, influence whether a given patient is discharged home. Because of the large sample size, some results may be statistically significant but not clinically meaningful. Each patient contributes several measures to the composite performance measure, and the GEE model may not fully account for the within-patient correlation of data. Because GWTG-Stroke does not collect data on postdischarge outcomes, the full implications of these observed improvements in performance measure treatment rates for older patients over time could not be directly explored. Finally, care processes were quantified with only 7 predefined stroke performance measures, which have been primary targets of ongoing quality improvement efforts in these participating GWTG-Stroke hospitals. Age differences and temporal trends in other interventions and treatments such as the time to critical in-hospital events (eg, door-to-doctor and door-to-image times), stroke education, or surgical interventions

such as endarterectomy could also exist and should be studied further.[24]

Conclusions

This study has demonstrated that among patients hospitalized with acute ischemic stroke, key demographics and clinical characteristics differ greatly as a function of patient age. Older ischemic stroke patients were at higher risk for adverse clinical outcomes, including in-hospital mortality. Among GWTG-Stroke participating hospitals, there have been substantial improvements over time in performance measures for ischemic stroke patients, including pharmacological and nonpharmacological management in each age group, with many of the age-related treatment differences substantially reduced or eliminated over time. These findings suggest that GWTG-Stroke may have contributed to these improvements in care. Expansion of national strategies for the hospital-based implementation of performance improvement in ischemic stroke should be considered a plausible strategy to facilitate eligible patients with acute ischemic stroke in receiving optimal care regardless of age in the absence of contraindications or patient preferences. Additional research is needed to identify factors accounting for age-related differences in ischemic stroke outcomes.

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CLINICAL PERSPECTIVE

Stroke is the third-leading cause of death and a leading cause of disability in the United States. The burden of stroke is borne disproportionately by older patients who have a greater incidence, mortality, and prevalence of ischemic stroke than younger individuals. Improving the understanding of age-related differences in acute ischemic stroke, quality of care, and outcomes is important because the number of stroke-related events in older persons is expected to increase dramatically over forthcoming decades as the population ages in the United States and elsewhere. This study analyzed 502 036 acute ischemic stroke admissions from 1256 hospitals that participated in the American Heart Association/American Stroke Association's Get With the Guidelines–Stroke Program from 2003 to 2009. This study found that demographic and clinical characteristics differed greatly as a function of patient age in this population. Although modest age-related differences in each individual stroke performance measure were identified, there were substantial temporal improvements in performance measures from 2003 to 2009 in each age group, so that age-related treatment gaps were narrowed or eliminated over time for most measures. Older ischemic stroke patients were at substantially higher risk for adverse clinical outcomes, including in-hospital mortality. Expansion of national strategies for the hospital-based implementation of performance improvement in ischemic stroke should be considered to facilitate eligible patients with acute ischemic stroke in receiving optimal care regardless of age.

Age-Related Differences in Characteristics, Performance Measures, Treatment Trends, and Outcomes in Patients With Ischemic Stroke

Gregg C. Fonarow, Mathew J. Reeves, Xin Zhao, DaiWai M. Olson, Eric E. Smith, Jeffrey L. Saver and Lee H. Schwamm
for the Get With the Guidelines Stroke Steering Committee and Investigators

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