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ORIGINAL WORK

Rural–Urban Disparities in Intracerebral Hemorrhage Mortality in the USA: Preliminary Findings from the National Inpatient Sample

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Abstract

Objectives: To compare in-hospital mortality between intracerebral hemorrhage (ICH) patients in rural hospitals to those in urban hospitals of the USA.

Methods: We used the National Inpatient Sample to retrospectively identify all cases of ICH in the USA over the period 2004–2014. We used multivariable-adjusted models to compare odds of mortality between rural and urban hospitals. Joinpoint regression was used to evaluate trends in age- and sex-adjusted mortality in rural and urban hospitals over time.

Results: From 2004 to 2014, 5.8% of ICH patients were admitted in rural hospitals. Rural patients were older (mean [SE] 76.0 [0.44] years vs. 68.8 [0.11] years in urban), more likely to be white and have Medicare insurance. Age- and sex-adjusted mortality was greater in rural hospitals (32.2%) compared to urban patients (26.5%) (p value < 0.001). After multivariable adjustment, patients hospitalized in rural hospitals had two times the odds of in-hospital death compared to patients in urban hospitals (OR 2.07, 95% CI 1.77–2.41. p value < 0.001). After joinpoint regression, mortality declined in urban hospitals by an average of 2.8% per year (average annual percentage change, [AAPC] − 2.8%, 95% CI − 3.7 to − 1.8%), but rates in rural hospitals remained unchanged (AAPC − 0.54%, 95% CI − 1.66 to 0.58%).

Conclusions: Despite current efforts to reduce disparity in stroke care, ICH patients hospitalized in rural hospitals had two times the odds of dying compared to those in urban hospitals. In addition, the ICH mortality gap between rural and urban centers is increasing. Further studies are needed to identify and reverse the causes of this disparity.

Keywords: Intracerebral hemorrhage, Mortality, Healthcare disparity

Introduction

Intracerebral hemorrhage (ICH) is the deadliest form of stroke [1] and accounts for at least 10% of all strokes in the USA. ICH-associated deaths in the USA have declined markedly over the last decade [2], but mortality rates may differ substantially between counties [3]. Ischemic stroke patients hospitalized in rural areas are less likely to receive thrombolysis [4] and more likely to die after their strokes [5]. We sought to determine whether similar rural–urban differences in ICH mortality may also exist.

The primary aims of this study were to (1) compare in-hospital mortality between ICH patients hospitalized in urban to those in rural hospitals in various regions of the USA and (2) determine whether trends

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in ICH mortality over the last decade differed between rural and urban health centers.

Methods

This is a retrospective study conducted using the 2004–2014 National Inpatient Sample (NIS). The NIS is the largest all-payer inpatient care database in the USA and comprises a 20% stratified random sample of all US hospital discharges. Hospital discharges in the NIS are de-identified so the unit of this analysis is each discharge rather than each individual patient. Further details on the NIS design are available at https://www.hcup-us.ahrq.gov.

Standard Protocol Approvals, Registrations and Patient Consents

We received the exemption status to conduct this study from the University of Miami institutional review board.

Study Population

We identified all adult admissions (age ≥ 18 years) with a primary diagnosis of ICH and contained in the 2004–2014 NIS using the International Classification of Disease Clinical Modification, 9th revision (ICD-9 CM) code 431. This code has a positive predictive value of 79–97% and a sensitivity of 81–85% for ICH [6]. Study inclusions are shown in supplementary Fig. 1. To ensure that only acute spontaneous ICH cases were captured, we excluded observations designated as elective admissions and those

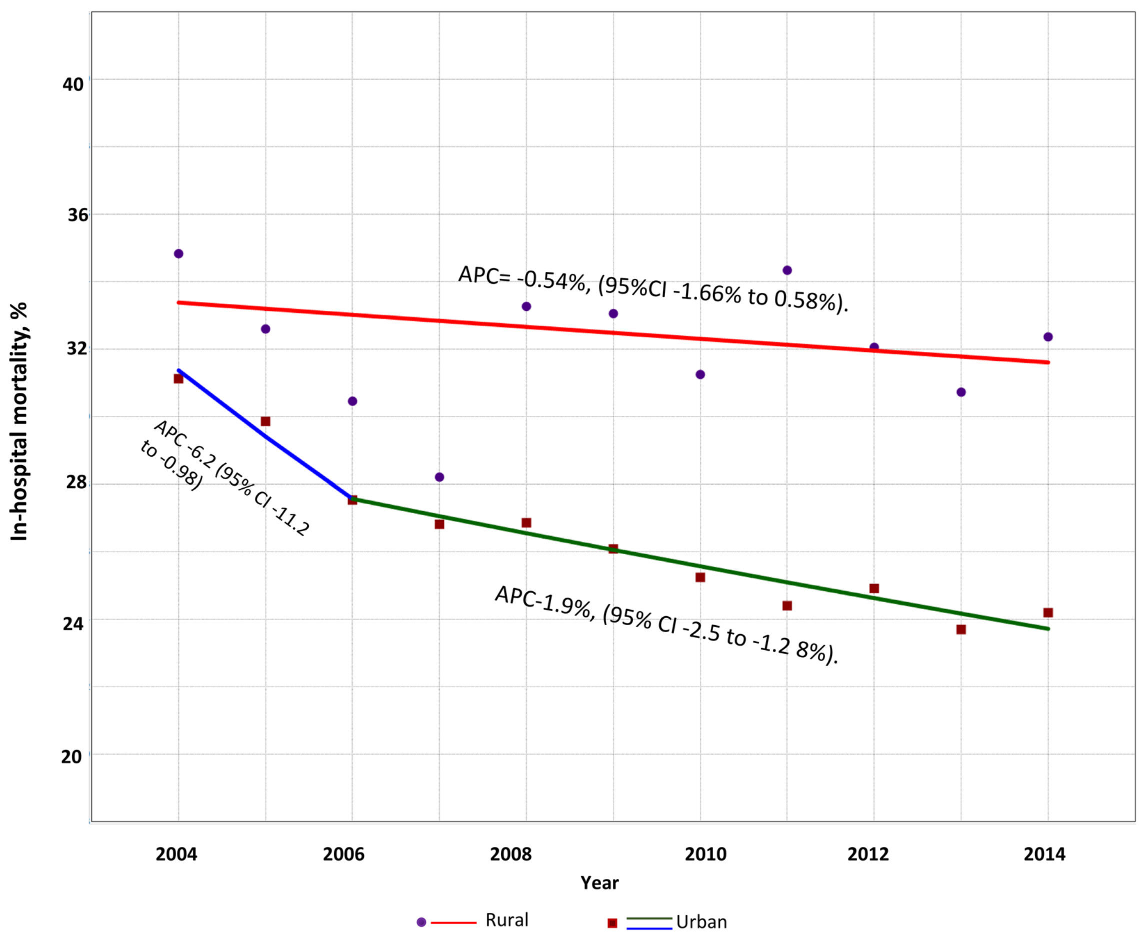

Fig. 1 Trends in weighted age- and sex-adjusted in-hospital mortality of intracerebral hemorrhage patients admitted in urban and rural hospitals of the USA from 2004–2014. Mortality estimates for rural estimates are depicted by purple circles, and bright line in red represents the slope of the regression line for rate of change from 2004 to 2014. APC represents annualized percentage change, and for rural hospitals, mortality did not change significantly across the entire study period (APC = − 0.54%, 95% CI − 1.66–0.58%). Squares represent mortality estimates for urban patients. Blue and green lines represent the slope of the regression lines for rate of change in urban hospitals from 2004 to 2006 and 2006 to 2014, respectively (Color figure online)

with coexisting codes for brain tumor, trauma, arteriovenous malformations or aneurysm treatment during the same hospitalization. To minimize the potential for double counting, we further excluded hospitalizations with length-of-stay of < 24 h and discharge was to home, another acute care hospital or skilled/other facilities (supplementary Fig. 1). Inter-hospital transfers beyond 24 h of hospitalization were included as these were considered to have received significant care in the transferring hospital.

Hospital Characteristics

NIS variables HOSP_LOCATION (from 2004 to 2011) and HOSP_LOCTEACH (2012–2014) were used to identify patients hospitalized in rural versus urban hospitals. Beginning with the 2004 data, the classification of urban or rural hospital location in the NIS used Core-Based Statistical Area (CBSA) codes. CBSA groups were based on 2000 Census data from 2004 to 2013 and on the 2010 Census for 2014 NIS data. Hospitals in counties with a CBSA type of "Division" or "Metro" were considered urban in the NIS, while hospitals with a CBSA type of "Rural" or "Micropolitan" were classified as rural. Similarly, NIS variables PL_NCHS and PL_UR_CAT4 were used to categorize patients as residing in rural and urban locations.

Additional information on hospital characteristics obtained in this study includes hospital geographic region categorized as 4 census regions; and hospital teaching status: teaching and nonteaching hospitals.

Outcome Ascertainment

Primary outcome of interest was in-hospital mortality, and this was defined using the Healthcare Cost and Utilization Project (HCUP)variable DIED. We defined good outcome as any routine home discharge to home, and this was ascertained using HCUP variable DISPUNIFORM.

Covariate Assessment

Comorbidities associated with ICH hospitalization were identified by Agency for Healthcare Research and Quality (AHRQ) comorbidity measures available in the NIS. AHRQ comorbidity measures identify different comorbidities using ICD-9-CM diagnoses and the diagnosis-related group (DRG) that are likely to have been present prior to hospitalization. The Elixhauser comorbidity index [7], a validated weighted comorbid disease severity, was calculated for all participants, and patients were categorized into tertiles per their Elixhauser scores.

We identified mechanically ventilated patients using ICD-9 procedural codes 967, 967.1 and 967.2. To capture patients that were mechanically ventilated likely from their initial ICH as opposed to those that were intubated secondary to other events during their hospitalization course, we defined mechanical ventilation status as positive only if patients were intubated within 48 h of admission and as negative otherwise. Other clinical covariates including coma, dysphagia, hydrocephalus, aphasia and hemiplegia were determined using either the HCUP recommended constellation of ICD-9 codes corresponding to these variables and contained in the HCUP clinical classification software or the individual codes corresponding to these variables.

Craniotomy/craniectomy was identified using ICD-9 codes 01.23 or 01.24 and hydrocephalus requiring external ventricular drain or ventriculoperitoneal shunt defined using ICD-9 procedural codes 02.2, 02.21 or HCUP clinical classification software procedural code 2 for insertion, replacement or removal of extracranial ventricular shunt.

Patients with Do-not-resuscitate (DNR) orders at any point during their hospitalization were identified using ICD-9 code V49.86 and those undergoing palliative care identified using code V66.7. ICD-9 code V66.7 is to be used in situations of “palliative care,” “end-of-life care,” “hospice care” or “terminal care” and has been shown previously to have high sensitivity and specificity for identifying stroke patients who underwent withdrawal of life-sustaining therapy [8]. The all-patient refined diagnosis-related group (APR-DRG) for severity of illness representing “extent of physiologic decompensation or organ system loss of function” and APR-DRG mortality representing “likelihood of dying” were also extracted for all patients [9, 10]. APR-DRGs have been used as an index of ICH severity in multiple prior studies [11–13] and have been shown to be a reliable predictor of in-hospital mortality in administrative databases [14]. APR-DRG for mortality has an area under the curve of 0.73 for predicting mortality in critically ill patients [14] and a C-statistic of 0.77 for predicting mortality in stroke patients [15].

Statistical Analysis

Baseline characteristics of participants according to rural/urban status were summarized using descriptive statistics. Sampling weights provided in the NIS allow for calculation of total national estimates from the 20% of all admissions in the NIS [16]. We used these weights to compute the overall weighted age- and sex-adjusted risk of in-hospital death of ICH patients in subgroups categorized by rural/urban status and by hospital census division.

We used a series of multivariable logistic regression models, adjusted for patient demographic, clinical and hospital level variables to compare overall odds of in-hospital mortality between patients admitted in rural to those in urban hospitals and to control for potential confounding factors. Models were constructed for the entire country, for each census division and with home discharge as outcome variable. Because the latter years are more likely to reflect current practice, we restricted analysis in our primary mortality models to the last 5 years (2010–2014). Analysis done using the entire study period yielded similar results. We used the Elixhauser comorbidity index as a measure of the overall condition of patients in these models including baseline risk of mortality and used clinical factors such as coma, hemiplegia, hydrocephalus, craniotomy/craniectomy, hydrocephalus requiring external ventricular drain (EVD) placement, tracheostomy, APR-DRGs for severity of illness and mortality as surrogate measures for ICH severity. Because the presence of DNR orders and withdrawal of care may increase in-hospital risk of ICH mortality, we checked for possible effect modification by DNR/palliative care status by constructing additional models stratified by DNR/palliative care status.

To compare trends in age- and sex-adjusted ICH mortality over time between rural and urban hospitals, joinpoint regression models with permutation model selection method and pairwise comparison were fitted. In joinpoint regression, a series of Monte Carlo permutation-based tests are used to identify points of change in trends (joinpoints) in a dataset. The program starts with the minimum number of joinpoint (e.g., 0, which is a straight line) and tests whether more joinpoints are statistically significant and must be added to the model. The annual percentage change (APC) is then computed for each of the identified trends by fitting a regression line to the natural logarithm of the rates using calendar year as a regressor variable.

A two-tailed alpha of < 0.05 was required for statistical significance. All analyses were performed using Stata 14 (StataCorp, LP, College Station, Texas). Joinpoint regression was done using Joinpoint software version 4.5.0.1 (Bethesda, Maryland). We took into account the weighting, clustering and stratification needed in the complex NIS survey design in all analysis by use of Stata's SVY suite of commands with use of the hospital as the primary sampling unit and applying relevant probability sampling weights for robust variance estimation to all models. NIS trend weights were used in all analysis to make data comparable before and after the NIS redesign in 2012 as recommended [17].

Missing Variables

Most variables had missing values in < 1% of participants except for race that was missing in 19.1% of participants. Missing data were imputed to the dominant category for categorical variables and the median for continuous variables. Missing insurance status for those aged ≥ 65 years was imputed to Medicare. Missing race data were handled using multiple imputation as recommended by Healthcare Cost and Utilization Project (HCUP) [18].

Results

Of 85,399,326 hospitalizations contained in the NIS from 2004 to 2014, we identified 131,992 ICH admissions meeting our study inclusions criteria. These admissions represent 636,705 weighted ICH hospitalizations in the USA over this period. 5.8% of all admissions (weighted $n = 37{,}405$) were in rural hospitals, but the proportion of patients admitted in rural hospitals declined by 59.6% over time (8.5% in 2004 to 3.4% in 2014) (supplementary Fig. 2). 17.2% of all ICH patients resided in rural locations. Of all patients residing in rural locations, 68.0% were hospitalized in urban locations and 32.0% in rural hospitals (Table 1). Conversely, 99.5% of all ICH patients residing in urban locations were hospitalized in urban hospitals and 0.5% in rural locations (Table 1). Only 5.9% of hospitalizations in rural hospitals were transferred to other hospitals.

Patients admitted in rural hospitals were relatively older, more likely to be white and more likely to have Medicare insurance compared to urban patients (Table 1). Hypertension, diabetes and drug abuse were more prevalent in urban hospital patients but atrial fibrillation, congestive heart failure and dementia more prevalent in rural patients. A disproportionately greater percentage of patients admitted in urban hospitals had severe ICH as measured by the APR-DRG for severity of illness and for mortality. Proportion of patients with secondary codes for coma did not differ between both groups, but proportion of urban patients who underwent EVD/ventriculoperitoneal shunt placement, craniotomy and mechanical ventilation were at least two times those of rural patients (all p values < 0.05). There was no difference in the proportion of DNR or palliative care utilization between rural or urban ICH patients on univariate comparison (Table 1).

Total Mortality

Across the study period, 26.7% of all patients died during their ICH hospitalization, but age- and sex-adjusted mortality in rural hospitals for the entire period (32.2%) and from 2010 to 2014 (32.0%) was higher than those in urban hospitals (26.5% and 24.6%, respectively) (p value for comparison < 0.001) (data not shown). After further multivariable adjustment for all demographic, clinical and severity factors, the odds of in-hospital mortality in rural hospitalizations was approximately two times that of urban hospitalizations (OR 2.07, 95% CI 1.77–2.41)

Table 1 Baseline characteristics of intracerebral hemorrhage patients in the USA from 2004–2014 according to hospital location

Variable	Description	Urban hospital	Rural hospital	*p* value
Number*		7832	124,160	N/A
Weighted number (national)[†]		37,187	599,518	N/A
Age (%)				< 0.001
	18–39 years	3.6	1.2	
	40–59 years	24.8	11.4	
	60–79 years	42.2	38.9	
	≥ 80 years	29.4	48.5	
Female (%)		49.3	56.7	< 0.001
Urban patient location (%)		99.5	0.5	< 0.001
Rural patient location (%)		68.0	32.0	< 0.001
Transferred from outside hospital (%)	Admission source	6.2	3.3	< 0.001
Transferred to outside hospital (%)	Hospital disposition	3.2	5.9	< 0.001
Race (%)				< 0.001
	White	64.5	85.5	
	Black	17.5	7.9	
	Hispanic	9.4	2.8	
	Other	8.6	3.8	
Primary payer (%)				< 0.001
	Medicare	60.5	80.2	
	Medicaid	9.2	3.5	
	Private	20.7	11.1	
	Self-pay	6.5	3.3	
	Other	3.1	1.8	
Median income (%)				< 0.001
	$1–$38,999	26.9	45.8	
	$39,000–$47,999	26.5	40.4	
	$48,000–$62,999	23.8	10.6	
	≥ $63,000	22.8	3.2	
Hospital region (%)				< 0.001
	Northeast	18.9	15.7	
	Midwest	20.4	29.1	
	South	38.8	42.7	
	West	22.0	12.5	
Hospital bedsize[‡] (%)				< 0.001
	Small	7.0	12.9	
	Medium	21.9	14.6	
	Large	71.1	72.6	
Vascular risk factors (%)	Dyslipidemia	29.5	25.3	< 0.001
	Diabetes	26.1	23.6	0.004
	Hypertension	80.6	73.1	< 0.001
	Obesity	6.4	4.2	< 0.001
	Chronic renal failure	11.1	8.4	< 0.001
Cardiovascular diseases (%)	Congestive heart failure	10.4	12.3	< 0.001
	Atrial fibrillation	18.4	21.0	< 0.001
	Valvular disease	5.5	5.7	0.316
	Coronary artery disease	19.6	21.1	0.048
	Peripheral vascular disease	4.9	5.3	0.172

Table 1 (continued)

Variable	Description	Urban hospital	Rural hospital	*p* value
Lifestyle risk factors (%)	Drug abuse	3.8	1.2	< 0.001
	Tobacco smoking	10.5	7.7	< 0.001
Other chronic diseases (%)	Chronic lung disease	12.4	14.7	< 0.001
	Pulmonary circulation disease	1.9	1.3	< 0.001
	Liver disease	2.5	1.5	< 0.001
	Alcohol abuse	6.3	3.4	< 0.001
	Coagulopathy	6.6	3.8	< 0.001
	Dementia	7.2	9.5	< 0.001
Elixhauser comorbidity index (%)				< 0.001
	Score < = 2	36.3	45.0	
	Score 3–4	40.6	39.1	
	Score > = 5	23.0	15.9	
Clinical factors (%)	Coma	9.4	8.7	0.148
	MV	30.0	14.8	< 0.001
	MV within 48 h	23.2	11.6	< 0.001
	Aphasia	12.7	9.4	< 0.001
	Dysphagia	11.8	7.6	< 0.001
	Craniotomy/craniectomy	1.1	0.4	0.012
	Hydrocephalus	10.9	4.1	< 0.001
	External ventricular drain/VP shunt	8.2	2.1	< 0.001
APR-DRG for severity of illness (%)				< 0.001
	Mild	7.5	12.9	
	Moderate	31.1	42.5	
	Severe	36.6	34.8	
	Extreme	24.8	9.8	
APR-DRG risk for mortality (%)				< 0.001
	Mild	0.3	0.05	
	Moderate	45.9	62.0	
	Severe	23.0	19.2	
	Extreme	30.8	18.8	
Do-not-resuscitate (%)		8.3	7.8	0.399
Palliative (%)		10.3	11.4	0.132

APR-DRG all patient refined diagnosis-related group, *MV* Mechanical ventilation; *VP* ventriculoperitoneal

* Represents actual number of patients contained in the National Inpatient Sample

† Represents projected total national estimates obtained by applying sampling weights to the Nationwide Inpatient Sample dataset

‡ Bedsize categories are defined using region of the USA, the urban–rural designation of the hospital, in addition to the teaching status. Details present at https://www.hcup-us.ahrq.gov/db/vars/hosp_bedsize/nisnote.jsp

(Table 2, model 1). This disparity in mortality remained after exclusion of patients with DNR/palliative care utilization during hospitalization (Table 2, model 2). Inclusion of inter-hospital transfers within the first 24 h did not significantly change study estimates (data not shown).

In subgroup analysis restricted to patients residing in rural locations, rural patients hospitalized in rural hospitals also had approximately two times the odds of in-hospital mortality compared to those hospitalized in urban locations (OR 2.36, 95% CI 1.84–3.02). Among patients surviving their ICH hospitalization, there was no difference in odds of good outcome defined as routine home discharge between rural and urban patients after multivariable adjustment (OR 0.97, 95% CI 0.83–1.12) (Table 2).

The increased odd of in-hospital mortality in patients hospitalized in rural hospitals was present in multiple census divisions. In analysis stratified by census region (Table 3), patients hospitalized in rural hospitals in the Midwest, South and Western regions also had greater than two times the odds of in-hospital death compared to those admitted in urban hospitals in the same regions

Table 2 Association between hospital rural status and odds of mortality or good outcome in intracerebral hemorrhage patients admitted to US hospitals from 2010–2014

Variable	Rural hospitals versus urban hospitals							
	All patients (model 1)				Patients without DNR/palliative care (model 2)			
	Weighted N	OR	95% CI	*p* value	Weighted N	OR	95% CI	*p* value
In-hospital mortality								
All patients	292,960	2.07	1.77–2.41	< 0.001	217,691	2.29	1.82–2.88	< 0.001
Patients residing in rural locations	49,681*	2.36	1.84–3.02	< 0.001	36,185*	2.70	1.94–3.77	< 0.001
Patients residing in urban locations	240,004*	1.72	1.11–2.68	0.015	179,100*	1.54	0.93–2.55	0.092
Good outcome (defined as routine home discharge)								
All patients	219,963	0.97	0.83–1.12	0.664	189,863	0.96	0.83–1.13	0.687

DNR Do-not-resuscitate orders

All models adjusted for age, sex, race, income, insurance status, Elixhauser score, atrial fibrillation, coronary artery disease, dementia, obesity, aphasia, cranial nerve palsy, coma, craniectomy, dysphagia, external ventricular drain/ventriculoperitoneal shunt, hemiplegia, any hydrocephalus, dyslipidemia, do not resuscitate, palliative care, smoking, tracheostomy, gastrostomy, mechanical ventilation, year, chronic alcohol abuse, coagulopathy, weekend admission, all patient refined diagnosis-related groups (APR-DRG) for mortality, APR-DRG for severity of illness, hospital teaching status, yearly intracerebral hemorrhage volume, hospital region, hospital bedsize

* Weighted N does not add up to that of all patients because county of residence was unknown in 1.4% of patients

Table 3 Association between hospital rural status and odds of mortality in intracerebral hemorrhage patients admitted to US hospitals from 2010–2014 according to census regions

Hospital region	All patients			
	Weighted N	OR	95% CI	*p* value
Northeast	52,879	1.66	0.93–2.98	0.087
Midwest	62,030	2.03	1.54–2.68	< 0.001
South	114,769	2.20	1.78–2.74	< 0.001
West	63,218	1.98	1.34–2.90	0.001

Model adjusted for age, sex, race, income, insurance status, Elixhauser comorbidity score, atrial fibrillation, coronary artery disease, dementia, obesity, aphasia, cranial nerve palsy, coma, craniectomy, dysphagia, external ventricular drain/ventriculoperitoneal shunt, hemiplegia, any hydrocephalus, dyslipidemia, do not resuscitate, palliative care, smoking, tracheostomy, gastrostomy, mechanical ventilation, year, chronic alcohol abuse, coagulopathy, weekend admission, all patient refined diagnosis-related groups (APR-DRG) for mortality, APR-DRG for severity of illness, hospital teaching status, yearly intracerebral hemorrhage volume, hospital bedsize, inter-hospital transfer

(Table 3). No difference in mortality was noted between rural and urban hospitals in the Northeast (Table 3).

Mortality Trend Over Time

On joinpoint regression, age- and sex-adjusted ICH mortality in urban hospitals declined by −6.2% yearly from 2004 to 2006 (APC −6.2, 95% CI −11.2 to −0.98, p value 0.028) and continued to decline significantly albeit at a slower pace of −1.9% from 2006 to 2014 (APC −1.9%, 95% CI −2.5 to −1.2, p value < 0.001). Across the entire period, the average annual percentage change in urban hospitals was −2.8% (95% CI −3.7% to −1.8%). In comparison, in-hospital mortality risk in rural hospitals did not change significantly over the study period (APC −0.54, 95% CI −1.66 to 0.58, p value = 0.301) (Fig. 1). Pairwise comparison accessing whether the two regression mean functions are not parallel (test of parallelism) was significant (p value = 0.002) indicating that the mortality gap between rural and urban centers increased significantly over time.

Discussion

During the period 2004–2014, the proportion of ICH patients in the USA treated in rural hospitals declined by > 50%. While greater than 1 in 4 patients with ICH died during their acute ICH hospitalization, we noted rural–urban differences in care and outcome over time. After multivariable adjustment, patients hospitalized in rural centers had two times the odds of in-hospital mortality compared to those hospitalized in urban centers. Although ICH mortality in urban centers declined significantly across the period 2004–2014, mortality rates in rural hospitals have remained largely unchanged leading to a widening mortality gap between rural and urban hospitals over time. These findings raise questions about persistent widespread inequalities in the quality of ICH care between rural and urban hospitals despite current national efforts to reduce disparities in stroke care.

A few studies have evaluated trends in ICH mortality in the USA over the last decade and have yielded conflicting results. Whereas some regional studies have reported no change in ICH mortality over time [19], other national studies have reported declining overall mortality [2, 20]. This study provides new evidence to suggest that rural–urban differences in ICH mortality may explain some of these inconsistencies.

Our results are consistent with those of a recent Centers for Disease Control publication reporting higher stroke mortality in rural compared to urban patients [21] and are particularly remarkable because the higher mortality was in spite of rural hospitals treating patients with less severe ICH as measured by APR-DRGs. Prior studies have shown that emergency medical services may systematically transfer the sickest ICH patients to stroke centers most of which are in urban communities [22], so it is not surprising that patients hospitalized in urban centers had more severe ICH. However, before now, excess mortality in rural areas has been thought to be secondary to higher stroke incidence (new cases of stroke) alone with no major contribution from case fatality (proportion of patients dying from stroke) [23]. *Mortality = incidence X case-fatality rate* [24]. This study provides salient information illustrating that among the subset of stroke patients with ICH, differing case fatality between rural and urban centers is also playing a significant role.

Unlike ischemic stroke, where timely utilization of thrombolysis or mechanical thrombectomy may significantly improve outcome, no acute intervention has been shown to alter outcome for ICH. Rural residents have traditionally been known to be more likely to have poorer control of ICH risk factors including hypertension, an important determinant of early post-ICH neurologic deterioration [25]. Late recognition of stroke symptoms [26], geographic dispersion of hospitals in rural areas with increased transit time to care hospitals and delays in triaging stroke patients may all result in delayed management in rural residents [27]. The resultant time delays could increase the risk of brain edema, hematoma expansion and other negative sequelae of ICH. Previously identified systemic factors such as lack of established stroke treatment protocols or suboptimal ancillary medical care, in addition to paucity of human resources including emergency response personnel, neurologist, neurosurgeons, radiologist and neuroimaging services in rural areas, may also contribute to the poorer ICH outcome [28].

Admission to specialized neurointensive care units has been shown to lower ICH mortality [29]. Whereas neurocritical care as a specialty has expanded over the last decade and there has been diffusion of neurocritical expertise to medical and surgical intensive care units across the country, most centers with neurocritical care expertise are in urban locations. Increased adherence to American Heart Association guidelines recommending stroke patients be treated in centers equipped for emergency stroke care [30] is most likely a major contributor to declining ICH hospitalization in rural hospitals as rural patients may have been increasingly diverted to designated stroke centers in urban areas for their care. With fewer patients treated at rural hospitals over time, physicians and other healthcare workers at these centers may have slowly become less experienced or less competent in managing ICH over time. Bolstering neurocritical care support to rural hospitals through telemedicine technology may provide an avenue to bridge some of the clinical gaps in care and improve ICH outcome in these centers.

This study uses a national database to assess rural–urban variations in ICH mortality in the USA. Despite the strengths of ICH case ascertainment by use of clinically diagnosed ICH as opposed to self-reported stroke and the generalizability of our results to the entire US population, there remain limitations. Although we relied on previously validated codes for ICH and for major covariates, we cannot exclude potential inaccuracies due to coding errors. Our results represent those across all hospitals in specific regions and the entire country and do not necessarily reflect the quality of care in individual hospitals or states. Our results likely underestimate true mortality gaps between patients residing in rural and urban areas because definition of rural location was based on hospital location and not residential area of patients. The sickest rural ICH patients may have been transferred to designated stroke centers usually in urban locations for care and therefore misclassified under this group. The converse is also possible: that is the sickest ICH patients who are too unstable for transfer, those who choose hospice care or have DNR orders may remain in rural hospitals and potentially increase in-hospital mortality estimates for rural hospitals. However, given the small percentage of rural hospitalizations that are transferred to other hospitals (5.9%), the magnitude of any effect from this on study estimates is likely minimal. DNR is often the initial process of the negotiations (clinical pathway) relating to withdrawal/withholding of life sustaining therapies [31]. Prior studies have shown after multivariable analysis, that urban hospital location is an independent predictor of palliative care utilization [32], but in the absence of temporal data on the implementation of these orders, we are unable to comprehensively evaluate the influence of DNR or palliative care orders on outcome.

Definition of rural hospital location in the NIS was relatively constant across most of the study period from 2004 to 2013, but changes in CBSA codes in 2014 to utilize 2010 Census data may have resulted in reclassification of a few rural hospitals as urban in the last year of the study. ICH patients hospitalized in Joint commission-certified stroke centers have lower odds of mortality compared to those in non-certified stroke centers [33]. Information on stroke center designation or Get with the Guidelines affiliation is not available in the NIS, so we are unable to compare outcomes between designated stroke centers in rural areas to those in urban areas. We are also unable to adjust for other important factors such as mode of transportation, neurosurgical coverage or intensive care unit status because this information is not available in our dataset. Our study evaluated mortality risk in hospitalized acute ICH patients alone. However, many patients die before ICH hospitalization and others continue to die after acute ICH hospitalization, so this study does not capture total ICH mortality for the entire population. Thirty-day and 90-day outcome measures are still needed to more accurately estimate short-term mortality. We were unable to differentiate between first-ever and recurrent ICH and could not provide information on radiological severity of ICH by virtue of inherent limitations in our database. Disparity in the recognition/treatment of hydrocephalus and utilization of craniotomy noted in this study may be indicative of some areas where care between rural and urban hospitals differs but in the absence of radiological information on ICH characteristics, no definite conclusions can be drawn from our findings. The APR-DRGs used as one of the indices of ICH severity have shown good predictive performance for stroke and critical care mortality but have not been validated specifically in ICH patients. Other surrogate measures of ICH severity used in this study such as ventilator status, tracheostomy and gastrostomy may also reflect differences in the care received between rural and urban patients. Although we adjusted for an extensive list of covariates in our multivariable models, we cannot exclude residual confounding due to uncontrolled factors. For example, because information on hematoma size or hematoma expansion was unavailable in the NIS, these variables could not be included in the models and thus may represent a potential source of residual confounding.

Conclusion

In conclusion, we show that ICH patients hospitalized in rural hospitals are more likely to die compared to those hospitalized in urban centers in most census regions. This rural–urban mortality divide appears to be widening as rural centers fail to show the improvements over time in ICH mortality seen at urban centers. Further studies are needed to identify the causes and reverse this disparity.

Electronic supplementary material

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Author Contributions

FOO had full access to all of the study data and takes responsibility for the integrity and accuracy of the data analysis. FOO, EA and JR were involved in study concept and design. All authors acquired, analyzed and interpreted the data. FOO drafted the manuscript. All authors critically revised the manuscript for important intellectual content. FOO was involved in statistical analysis. None obtained fund. AMM and SC provided administrative, technical or material support. JR supervised the study.

Conflict of Interest

Drs. Otite, Akano, Akintoye, Khandelwal, Malik and Chaturvedi report no conflict of interest relevant to this manuscript. Dr. Rosand receives research funding from the National Institutes of Health and reports no conflicts of interest relevant to this manuscript.

Ethical approval

According to the Agency for Healthcare Research and Quality, this study done using a deidentified dataset does not require ethical approval by an Institutional Review Board.

Informed consent

No informed consents were obtained as the dataset contains no personally identifiable information.

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