2019

# Impact of rural versus urban geographic location on length of stay after carotid endarterectomy

Samantha D. Minc
*West Virginia University*, samantha.minc@wvumedicine.org

Ranjita Misra
*West Virginia University*

Sari D. Holmes
*West Virginia University*

Yue Ren
*West Virginia University*

Luke Marone
*West Virginia University*

HHS Public Access

Author manuscript

*Vascular*. Author manuscript; available in PMC 2020 August 01.

Published in final edited form as:

*Vascular*. 2019 August ; 27(4): 390–396. doi:10.1177/1708538119835402.

# Impact of rural versus urban geographic location on length of stay after carotid endarterectomy

**Samantha D Minc**[1], **Ranjita Misra**[2], **Sari D Holmes**[1], **Yue Ren**[1], **Luke Marone**[1]

[1]WVU Heart and Vascular Institute, Morgantown, WV, USA

[2]School of Public Health, West Virginia University, Morgantown, WV, USA

## Abstract

**Background—**Reducing the incidence of extended length of stay (ELOS) after carotid endarterectomy (CEA), defined as LOS > I day, is an important quality improvement focus of the Vascular Quality Initiative (VQI). Rural patients with geographic barriers pose a particular challenge for discharge and may have higher incidences of ELOS as a result. The purpose of this study was to examine the impact of patients' home geographic location on ELOS after CEA.

**Methods—**The VQI national database for CEA comprised the sample for analyses $(N = 66{,}900)$. Rural-Urban Commuting Area (RUCA) codes, a validated system used to classify the nation's census tracts according to rural and urban status, was applied to the VQI database and used to indicate patients' home geographic location. LOS was categorized into two groups: LOS ≤ 1 day (66%) and LOS > 1 day (ELOS) (34%). Multivariable logistic regression was conducted to examine the effect of geographic location on ELOS after adjustment for age, gender, race, and comorbid conditions.

**Results—**A total of 66,900 patients were analyzed and the mean age of the sample was 70.5 ± 9.3 years (40% female). After adjustment for covariates, the urban group had increased risk for ELOS (OR = 1.20, $p < 0.001$). Other factors that significantly increased risk for ELOS were non-White race/Latinx/Hispanic ethnicity (OR = 1.44, $p < 0.001$) and nonelective status (OR =3.31, $p < 0.001$). In addition, patients treated at centers with a greater percentage of urban patients had greater risk for ELOS (OR = 1.008, $p < 0.001$).

**Conclusions—**These analyses found that geographic location did impact LOS, but not in the hypothesized direction. Even with adjustment for comorbidities and other factors, patients from urban areas and centers with more urban patients were more likely to have ELOS after CEA. These findings suggest that other mechanisms, such as racial disparities, barriers in access to care, and disparities in support after discharge for urban patients may have a significant impact on LOS.

### Keywords

Carotid endarterectomy; length of stay; rural

---

**Corresponding author:** Samantha D Minc, WVU School of Medicine, Division of Vascular and Endovascular Surgery, Heart and Vascular Institute, Morgantown, WV, USA., samantha.minc@wvumedicine.org.

Declaration of conflicting interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## Introduction

Extended length of stay (ELOS) after carotid endarterectomy (CEA), defined as LOS > 1 day, is associated with an increased risk of hospital-acquired infections, cost, resource utilization, and decreased patient satisfaction.[1] As a result, a LOS ≤ 1 day has been cited as a quahty metric to reduce cost as well as hospital-acquired morbidity[2,3] and has been recognized by the Vascular Quality Initiative (VQI) as an important quality measure for CEA. In addition, the recognition of LOS ≤ 1 day as a quahty measure may have implications for future quality-based reimbursement models by third-party payers.[2,4,5] Despite the potential benefits, LOS ≤ 1 day may not be realistic for rural patients, who may present a unique set of challenges surrounding hospital discharge and health system navigation. Rural residents tend to be older and poorer, report more risky health behaviors[6] and have worse health status and health outcomes than do their urban and suburban counterparts.[6,7] In addition, rural patients have poor access to quality health care and have significant geographic and cultural barriers to accessing care.[8] Based on these issues, we hypothesized that rural patients are more likely to have ELOS after CEA than their urban counterparts and that centers treating larger percentages of rural patients will be burdened with a greater percentage of patients with ELOS.

Few studies have examined the impact of geographic area of residence (particularly rurality) on ELOS due to confidentiality issues surrounding the use of zip code data in database research. Our research used a novel method to identify patient status of residence without requiring the release of zip code data. The Rural- Urban Commuting Area (RUCA) code system is a classification of US census tracts using measures of population density, urbanization, and daily commuting.[9] The RUCA code system was created by researchers from the US Department of Agriculture Economic Research Service (USDA ERS) and the Center for Rural Health and has been used in a variety of health-related research and program development and implementation.[10] RUCA codes are divided into 33 subcategories based on commuting patterns and are aggregated into various categories depending on use.[11] For example, the “Categorization A” approach aggregates the codes into four categories: urban focused, large rural city/town (micropolitan) focused, small rural town focused, and isolated small rural town focused.[12] Data crosswalks are available between RUCA codes and zip codes, and these were provided to the VQI analysts to convert zip codes to RUCA codes prior to releasing the VQI data for this research, which allowed for the protection of patient confidentiality while also providing important data on the rural status for the area of residence of patients.

Using the national VQI prospectively-maintained database, this retrospective study examined the impact of rural residence on LOS after CEA. Our hypothesis was that patients from more rural and isolated areas would be more likely to have ELOS than patients from micropolitan and urban areas, and that centers treating larger percentages of rural patients would be more hkely to have ELOS after CEA.

## Methods

This study was reviewed by the West Virginia University Institutional Review Board. Need for approval and consent of the patient was waived because of the retrospective nature of the study design and completely deidentified dataset that qualified as "not human subjects research".

### VQI data

Data obtained from the VQI national database for CEA were retrospectively analyzed. Our target population was all adult patients who underwent CEA procedures and were discharged alive from the hospital in 2011 2017. Patients with missing or outlier values for attributes used in this study were excluded ($n = 17,793$). This dataset comprised the sample for analyses ($N = 66,900$) on the procedure level to examine the primary outcome of interest, ELOS.

### Rural-Urban Commuting Area codes

RUCA codes, a validated classification system of 33 codes used to classify national census tracts according to rural and urban status, were applied to the VQI database and used to indicate patient home geographic location. Zip codes were translated into RUCA codes by the VQI analysts before releasing the data to maintain patient confidentiality. The RUCA code aggregation model used for this study was "Categorization C", which aggregates the 33 codes into two groups, rural and urban.[12] This categorization was used to evaluate the dichotomous effect of rural or urban status.

### Statistical analysis

Continuous variables are presented as mean ± standard deviation and categorical variables are presented as frequency (percent). Demographics, comorbidities, socioeconomic characteristics, preoperative risk factors, and postoperative outcomes were compared between the rural and urban groups with Student's independent- samples f-tests for continuous variables and chi- square tests for categorical variables. The LOS data were right-skewed with a mode near 0 and heavy tail, therefore we categorized this outcome into two groups based on the VQI quality initiative guideline, LOS < 1 day and LOS > 1 day (ELOS), to define shorter and longer LOS. Multivariable logistic regression was conducted to examine the effect of rural status on ELOS after adjustment for age, gender, race/ethnicity (non- Hispanic White vs. non-White or Latinx/Hispanic), body mass index (BMI), elective status of surgery, living status (home vs. nursing home or homeless), preoperative ambulatory status (ambulatory vs. ambulatory with assistance or wheelchair or bedridden), insurance (commercial vs. Medicare vs. Medicaid/ Other), diabetes, coronary artery disease (CAD), prior congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), hypertension (HTN), smoking status (current vs. prior vs. nonsmoker), and end-stage renal disease (ESRD) on dialysis.

Secondary analyses evaluated whether patients treated at centers with a greater percent of urban patients were at greater risk for ELOS, regardless of the patient home residence classification. Centers that had fewer than 50 cases were excluded from these analyses. A continuous variable, center urban percent, was assigned to each center, and represented the percentage of urban patients within the cases performed at each center. Patients treated at each center were assigned the center urban percent value to define the urban classification of their treating center rather than the urban classification of their home residence.

Multivariable logistic regression was conducted to examine the effect of center urban percent on ELOS after adjustment for the same covariates as in the primary analyses. All analyses were conducted with SAS Version 9.4 (SAS Institute Inc., Cary, NC, USA) and significance was set at $p < 0.05$, two-tailed.

## Results

The sample that met all inclusion and exclusion criteria comprised 66,900 CEA procedures from 2011 to 2017 in total, which were categorized into two groups, urban ($n = 57{,}537$) and rural ($n = 9363$). The mean age of the sample was 70.5 ±9.3 years with 39.4% female patients. Patients in the urban group were older, more likely to be non-White/Latinx/Hispanic, and had lower BMI (Table 1). Regarding the comorbidities, the urban group had higher prevalence of prior CHF and HTN, and lower prevalence of CAD and COPD compared to the rural group. There were also fewer current smokers and more patients on dialysis before the procedure in the urban group. The postoperative outcomes did not show significant differences between the urban and rural groups, although return to the operating room (OR) approached significance with 1.9% in urban patients versus 1.6% in rural patients ($p = 0.051$; Table 2).

The incidence of ELOS was 34% ($n = 22{,}466$). As expected, the incidence of perioperative complications was significantly higher for patients with ELOS, including intravenous medication for hypertension (29% vs. 13%, $p < 0.001$), intravenous medication for hypotension (16% vs. 7%, $p < 0.001$), neurologic event (5% vs. 0.2%, $p < 0.001$), major adverse cardiovascular events (MACE; 7% vs. 0.4%, $p < 0.001$), wound infection (0.1% vs. 0.02%, $p < 0.001$), reperfusion symptoms (0.3% vs. 0.02%, $p < 0.001$), and return to the OR (5% vs. 0.3%, $p < 0.001$).

Based on the results of the primary multivariable logistic regression (Table 3), the urban group had greater odds for ELOS compared to the rural group (OR =1.20, $p < 0.001$) after adjustment for demographics, comorbidities, socioeconomic characteristics, and preoperative risk factors. Other factors that were associated with a significantly increased risk of ELOS included female gender (OR =1.26, $p < 0.001$), Medicaid status (OR =1.32, $p < 0.001$), non-White race/Latinx/Hispanic ethnicity (OR =1.44, $p < 0.001$), ESRD on dialysis (OR= 1.64, $p < 0.001$), and nonelective status (OR = 3.31, $p < 0.001$).

The results of the multivariable logistic regression in secondary analyses (Table 4) showed that patients who were treated at centers with a greater percentage of urban patients were associated with greater risk for LOS > 1 day (OR= 1.008, $p < 0.001$). The independent effect of race/ethnicity on the odds for ELOS with center urban percent added to the model was slightly lower than in the primary analysis (OR = 1.37, $p < 0.001$).

## Discussion

In this retrospective study of the national YQI database, we evaluated the impact of rural residence on the risk of ELOS after CEA. Our findings revealed that patients residing in rural areas were significantly less likely to have ELOS than urban patients. Rural status was not only associated with a decreased risk for ELOS in univariate analyses, but also remained significant after adjustment for preoperative risk factors. On secondary analysis, we found that patients treated at centers with larger percentages of urban patients (regardless of their original place of residence) were more likely to have ELOS than patients treated at centers treating larger percentages of rural patients.

Previous studies on carotid LOS have focused on multiple factors, including surgeon and patient-level predictors of increased LOS, as well as institution level barriers to early discharge. Surgeon level predictors that have been evaluated include annual carotid case volume,[2,3,13] duration of procedure,[2,3,13] type of anesthesia used,[3,14] CEA technique (patch plasty vs. primary closure vs. eversion, use of shunt),[2,3] drain use,[2] and the use of preadmission.[13] Institution level predictors have focused on time of day and day of the week of surgery,[2,3,13,15] Foley catheter practices, and use of ICU.[14] Finally, patient level predictors that have been investigated include pre-existing medical comorbidities, standard demographic information (age, race, gender, and insurance status), indication for surgery, reoperation status, and urgency of surgery.[2–4,13,15]

To our knowledge, this is the first study to explore the relationship between rural residence and ELOS after CEA. This novelty is likely because studying rural residence as an independent variable requires zip code information, which is considered protected patient information by the Health Insurance Portability and Accountability Act (HIPAA). We were able to overcome this issue by using the RUCA code system. In our literature review, we identified one article that discussed the impact of patient geographic distance from referral centers on ELOS after CEA, which was the Ho et al.[13] study on contemporary predictors of ELOS after CEA. In their discussion section, Ho et al. argued that their institution's higher than average percentage of patients with ELOS (46.2%) may be related to referral patterns and the fact that they treat many patients who live outside of their local area.[13] Results from our study suggest that the proportion of urban patients treated at their center may play a more important role than the geographic distance to the hospital.

In order to further understand why geographic location was an independent risk factor for ELOS, we examined the descriptive differences between the rural and urban patient population in the study. While the large volume of the sample size resulted in statistically significant differences for many variables, most of the effect sizes were modest. Notable significant differences included racial/ethnic composition (urban patients were 12% non-White/Latinx/Hispanic and rural patients were 6% non-White/Latinx/Hispanic), and current smoking status (26% in urban patients and 29% in rural patients), although this variable does not include the use of smokeless tobacco or exposure to second hand smoke, which may significantly underrepresent tobacco exposure in rural populations.[16] Additional descriptive differences included a higher prevalence of CAD, COPD, and preoperative ambulatory status in rural patients and a higher prevalence of CHF, ESRD, and HTN in urban patients.

The prevalence of diabetes, Medicaid status, and nonelective cases were not significantly different between rural and urban patients and are therefore unlikely to have contributed to our study findings. Interestingly, the incidence of perioperative complications, which included the need for intravenous medication for blood pressure control (a highly significant predictor for ELOS in other studies[2–4]), post-operative neurologic event, MACE, wound infection, reperfusion symptoms, and return to the OR were not significantly different between rural and urban patients.

One possible explanation for rural residents having reduced risk for ELOS in this study is that rural patients are being discharged earlier, not because they are more appropriate for discharge than their urban counterparts, but because rural patients may be more likely to want to return home faster than urban patients. Rural patients often find themselves in a distant city from their home, away from family and friends and may be anxious to return to a familiar environment, or they may also need to return home to a ranch or farmland that cannot run without theirpresence.[17] As a result, their desire to get home may make them more motivated to be discharged and more willing to overlook certain discomforts or symptoms that would otherwise be brought to a physician's attention and lead to ELOS.

Another explanation is that rural patients who are able to access YQI-participating hospitals have already self-selected themselves with regards to more practical discharge-related concerns that the YQI does not currently measure, such as homelessness and lack of transportation. Despite these being important factors for consideration in rural health in general, in the VQI population, the odds of a homeless urban patient without transportation accessing a hospital is likely to be better than that of a rural patient, simply because of physical barriers to accessing care from distant rural locations. As such, there is a greater possibility that urban patients may have socially-related discharge barriers that lead to a greater risk of ELOS.

With regard to socially-related discharge barriers it is essential to discuss the role of the social determinants of health (SDOH), which represent several important risk factors associated with ELOS regardless of geographic location of patient residence. The SDOH include the conditions in the places where people live, learn, work, and play and are closely linked to socioeconomic status, access to quality education, stable housing, safe neighborhoods, exposure to stressors (both psychological and physical), and their additive effect on health over a person's lifetime.[18] Examples of SDOH-related issues that can directly affect a person's health include homelessness, food insecurity, and lack of transportation. The SDOH comprise 75% of the risk factors that affect our health[19] and these "upstream" risk factors have been shown to have a more powerful effect on population morbidity and mortality than the downstream factors (i.e. the diseases that are the sequelae of these risk factors) that are managed in the current health care system.[20] In our study, significant factors associated with ELOS that are related to access to care and the SDOH, included income status (using Medicaid as a proxy variable), urgency of surgery, and use of intravenous blood pressure medication postoperatively (an indication of poorly managed HTN preoperatively). Non-White race/Latinx/ Hispanic ethnicity and female gender—which are closely connected to different experiences related to the SDOH—were also significantly associated with ELOS, even after adjusting for known predictors of ELOS. Of all these variables, only the percentage of non-White/Latinx/Hispanic patients was significantly different between the rural and urban groups. Therefore it is possible that the racial/ethnic composition of urban patient populations may play a significant role in the increased risk of ELOS present in urban patients. This finding contributes to the extensive body of literature demonstrating the impact of race and ethnicity on health care disparities.[21]

Our secondary analyses findings, that patients treated at centers with larger percentages of urban patients are at greater risk of ELOS, regardless of their original place of residence, are important, as they validate the concern that centers that have a disproportionate number of urban residents will have a higher number of patients with ELOS. This has important economic and quality improvement ramifications and should be considered when planning resource allocation for CEA and when assessing quality measures. In addition, it is interesting to note that the independent effect of race/ethnicity on the odds for ELOS with center urban percent added to the model was slightly lower than in the primary analysis (OR =1.37, $p < 0.001$ compared to OR =1.44, $p < 0.001$), suggesting that centers that treat larger numbers of urban patients may be better equipped to handle the specific discharge needs of a more diverse population then those that do not. These findings merit further research on this topic.

Our findings have several important implications for discharge expectations and planning for CEA patients. First, geographic area of residence should be considered in the current risk calculators for expected LOS after CEA. Including this factor will help set more accurate expectations for outcome measurements on ELOS, and may help hospitals to plan for more realistic resource allocation for CEA patients. Second, the SDOH are powerful factors that must be considered at all levels of patient care, including operative planning for CEA patients. Consideration of these factors at an institutional level, before patients are even admitted to the hospital will increase the likelihood of a smooth hospital course that transitions into an effective discharge. An example of an institutional-based approach that considers the SDOH in patient care management is the re-engineered discharge (RED) process, created by researchers at Boston University for the Agency for Healthcare Research and Quality (AHRQ).[22] RED focuses on the implementation of effective discharge processes that reduce complications and readmission rates and is particularly focused on delivering culturally competent care to populations of diverse backgrounds to improve outcomes.

Our study is strengthened hy the use of the national VQI database; however, this also leads to certain limitations. These limitations include the cross-sectional nature of the data as well as limitations in variable selection and their attributes. An example of variable limitation is the number of patient-level variables available to explain differences in LOS for rural versus urban patients. Variables that may help to further shed light on this issue include documentation on patient distance to the hospital, caregiver support, and accessibility and effectiveness of follow-up care by providers. Another limitation is the risk of type I error and the challenges inherent to identifying clinically significant differences when dealing with large sample sizes that yield large numbers of statistically significant findings. In addition, database research makes it challenging to identify complications after discharge from the index procedure, and although the VQI has been increasing its focus on patient followup, it is still difficult to identify complications after discharge, particularly in rural patients who are more likely to be readmitted to an institution other than the one that performed the index operation.[23] Finally, these data do not represent the outcomes of all CEAs performed across the country, only those that were performed in hospitals that have the resources and motivation to participate in the VQI. This factor may affect the number of rural patients being represented in our sample and the overall outcomes. As previously discussed, rural patients may be underrepresented in this study due to lack of access to health care and to surgeons trained in and capable of performing this procedure. Therefore, our results may be biased towards lower risk of ELOS for these patients, as only rural patients who have the ability to access the health care system and those who are healthy enough to make the transfer to a tertiary center may be receiving CEA.

## Conclusions

This study demonstrated that rural residence did impact the risk of ELOS after CEA, but not in the hypothesized direction. Even with adjustment for comorbid conditions and other factors, patients from urban areas and centers with more urban patients were more likely to have ELOS after CEA than their rural counterparts. These findings demonstrate that in vascular surgery patients, other mechanisms, such as the SDOH, racial disparities, barriers in access to care, and disparities in support after discharge are significant predictors for ELOS and should be considered to improve outcomes.

## Acknowledgements

The authors would like to acknowledge Gary Hart, PhD, director of the Center for Rural Health for his guidance in the use of RUCA codes and the zip code crosswalk. The authors would also like to acknowledge Dan Neal, MS, director of analytics at the Society for Vascular Surgery Patient Safety Organization for his assistance with applying the zip code crosswalk to the VQI database prior to releasing the data.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

## References

1. VQI. SVS VQI 2016 Detailed Annual Report vascular, org, 2016.
2. Mehaffey JH, LaPar DJ, Tracci MC, et al. Modifiable factors leading to increased length of stay after carotid endarterectomy. Ann Vase Surg 2017; 39: 195–203.
3. Glaser J, Kuwayama D, Stone D, et al. Factors that determine the length of stay after carotid endarterectomy represent opportunities to avoid financial losses. J Vase Surg 2014; 60: 966–972. e961.
4. Roddy SP, Estes JM, Kwoun MO, et al. Factors predicting prolonged length of stay after carotid endarterectomy. J Vase Surg 2000; 32: 550–554.
5. Sharma G, Wong D, Amaoutakis DJ, et al. Systematic identification and management of barriers to vascular surgery patient discharge time of day. J Vase Surg 2017; 65: 172–178.
6. Meit M, Knudson A, Gilbert T, et al. The 2014 update of the rural-urban chartbook. Grand Forks, ND: Rural Health Reform Policy Res. Cent., 2014.
7. Harris JK, Beatty K, Leider JP, et al. The double disparity facing rural local health departments. Annu Rev Public Health 2016; 37: 167–184. [PubMed: 26735428]
8. Misra R, Fitch C, Roberts D, et al. Community-based diabetes screening and risk assessment in rural West Virginia. J Diabetes Res 2016; 2016: 2456518. [PubMed: 26881242]

9. USDA Documentation - 2010 Rural Urban Commuting Area (RUCA) Codes. 2016 https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes/documentation/ (accessed 2018).

10. Rosenblatt RA, Andrilla CH, Curtin T, et al. Shortages of medical personnel at community health centers: implications for planned expansion. JAMA 2006; 295: 1042–1049. [PubMed: 16507805]

11. Rural Health Research Center. RUCA News, http://depts.washington.edu/uwruca/ruca-news.php (accessed 22 July 2018).

12. Rural Health Research Center. RUCA Data: using RUCA data, http://depts.washington.edu/uwruca/ruca-uses.php (accessed 25 June 2018).

13. Ho KJ, Madenci AL, McPhee JT, et al. Contemporary predictors of extended postoperative hospital length of stay after carotid endarterectomy. J Vase Surg 2014; 59: 1282–1290.

14. Angevine PD, Choudhri TF, Huang J, et al. Significant reductions in length of stay after carotid endarterectomy can be safely accomplished without modifying either anesthetic technique or postoperative ICU monitoring. Stroke 1999; 30: 2341–2346. [PubMed: 10548668]

15. Cheng TW, Farber A, Kalish JA, et al. Carotid endarterectomy performed before the weekend is associated with increased length of stay. Ann Vase Surg 2017; 48: 119–126.

16. Roberts ME, Doogan NJ, Kurti AN, et al. Rural tobacco use across the United States: how rural and urban areas differ, broken down by census regions and divisions. Health Place 2016; 39: 153–159. [PubMed: 27107746]

17. Seekins T, Boehm H, Wong J, et al. Providing patient- centered enhanced discharge planning and rural transition support: building rural transitions network between regional referral and critical access hospitals. Missoula, MT: Rural Institute for Inclusive Communities, University of Montana, 2017.

18. CDC. Social determinants of health: know what affects health. 2018 https://www.cdc.gov/socialdeterminants/ (accessed 22 July 2018).

19. Lowry M Want healthier communities? Address social factors. Voices 2018; http://www.publichealthnewswire.org/?p=20607 (accessed 21 August 2018).

20. Bierman AS and Dunn JR. Swimming upstream. Access, health outcomes, and the social determinants of health. J Gen Intern Med 2006; 21: 99–100. [PubMed: 16423133]

21. Nelson A Unequal treatment: confronting racial and ethnic disparities in health care. J Natl Med Assoc 2002; 94: 666–668. [PubMed: 12152921]

22. Jack B, Passche-Orlow M, Mitchel S, et al. An overview of the re-engineered discharge (RED) toolkit. Rockville, MD: Agency for Healthcare Research and Quality, 2013.

23. Saunders RS, Femandes-Taylor S, Kind AJ, et al. Rehospitalization to primary versus different facilities following abdominal aortic aneurysm repair. J Vase Surg 2014; 59: 1502–1510.

**Table 1.**

Patient characteristics by urban and rural groups.

| Characteristic[a] | Urban *N* = 57,537 | Rural *N* = 9363 | *p*-Value |
|---|---|---|---|
| Age | 70.6 ± 9.3 | 70.0 ± 9.1 | <0.001 |
| Body mass index | 28.4 ± 5.7 | 28.7 ± 5.7 | <0.001 |
| Female | 22,700 (39) | 3683 (39) | 0.830 |
| Non-White race/Latinx/Hispanic ethnicity | 6781 (12) | 545 (6) | <0.001 |
| Diabetes | 20,535 (36) | 3334 (36) | 0.878 |
| Coronary artery disease | 15,431 (27) | 2732 (29) | <0.001 |
| Prior CHF | 6193 (11) | 929 (10) | 0.014 |
| COPD | 12,663 (22) | 2285 (24) | <0.001 |
| Hypertension | 51,273 (89) | 8210 (88) | <0.001 |
| Living at home | 56,792 (99) | 9258 (99) | 0.165 |
| Ambulatory | 51,863 (90) | 8549 (91) | <0.001 |
| Insurance | | | |
| Medicare | 32,916 (57) | 6022 (64) | <0.001 |
| Medicaid/Other | 3438 (6) | 623 (7) | 0.011 |
| Commercial | 21,183 (37) | 2718 (29) | <0.001 |
| Nonelective | 7291 (13) | 1128 (12) | 0.091 |
| Smoking | | | |
| Prior | 27,709 (48) | 4430 (47) | 0.129 |
| Current | 15,164 (26) | 2749 (29) | <0.001 |
| None | 14,664 (25) | 2184 (23) | <0.001 |
| Dialysis | 664 (1.2) | 85 (0.9) | 0.036 |

[a]Data presented as mean ± SD or frequency (percent).

CHF: congestive heart failure; COPD: chronic obstructive pulmonary disease.

**Table 2.**

Postoperative outcomes by urban and rural groups.

| | Urban *N* = 57,537 | Rural *N* = 9363 | *p*-Value |
|---|---|---|---|
| IV drugs for hypertension | 10,479 (18) | 1758 (19) | 0.191 |
| IV drugs for hypotension | 5634 (10) | 918 (10) | 0.970 |
| Neurologic event | 997 (2) | 172 (2) | 0.475 |
| MACE | 1485 (3) | 220 (2) | 0.188 |
| Wound infection | 38 (0.1) | 2 (0.02) | 0.101 |
| Reperfusion symptoms | 67 (0.1) | 10 (0.1) | 0.799 |
| Return to OR | 1084 (1.9) | 149 (1.6) | 0.051 |

IV: intravenous; MACE: major adverse cardiovascular event (myocardial infarction, new dysrhythmia, or congestive heart failure); OR: operating room.

### Table 3.

Results of the multivariable logistic regression for primary analyses examining factors associated with ELOS including home residence urban classification.

| | Odds ratio | 95% Confidence interval | | *p*-Value |
|---|---|---|---|---|
| Urban | 1.20 | 1.14 | 1.26 | <0.001 |
| Age | 1.02 | 1.01 | 1.02 | <0.001 |
| Body mass index | 1.01 | 1.00 | 1.01 | <0.001 |
| Female | 1.26 | 1.22 | 1.31 | <0.001 |
| Non-White race/Latinx/Hispanic ethnicity | 1.44 | 1.36 | 1.51 | <0.001 |
| Diabetes | 1.21 | 1.17 | 1.26 | <0.001 |
| Coronary artery disease | 1.23 | 1.18 | 1.27 | <0.001 |
| Prior CHF | 1.39 | 1.32 | 1.47 | <0.001 |
| COPD | 1.19 | 1.14 | 1.24 | <0.001 |
| Hypertension | 1.17 | 1.10 | 1.24 | <0.001 |
| Living at home | 0.59 | 0.51 | 0.68 | <0.001 |
| Ambulatory | 0.58 | 0.55 | 0.62 | <0.001 |
| Insurance | | | | |
| Medicare | 1.02 | 0.99 | 1.06 | <0.001 |
| Medicaid/Other | 1.32 | 1.23 | 1.42 | <0.001 |
| Nonelective | 3.31 | 3.15 | 3.47 | <0.001 |
| Smoking | | | | |
| Prior | 0.96 | 0.92 | 1.00 | 0.017 |
| Current | 1.01 | 0.96 | 1.06 | 0.242 |
| Dialysis | 1.64 | 1.41 | 1.91 | <0.001 |

ELOS: extended length of stay (length of stay > 1 day); CHF: congestive heart failure; COPD: chronic obstructive pulmonary disease.

**Table 4.**

Results of the multivariable logistic regression for secondary analyses examining effect of treating center urban classification on ELOS rather than home residence urban classification.

| | Odds ratio | 95% Confidence interval | | *p*-Value |
|---|---|---|---|---|
| Center urban percent | 1.008 | 1.007 | 1.009 | <0.001 |
| Age | 1.02 | 1.01 | 1.02 | <0.001 |
| Body mass index | 1.01 | 1.00 | 1.01 | <0.001 |
| Female | 1.26 | 1.22 | 1.31 | <0.001 |
| Non-White race/ Latinx/ Hispanic ethnicity | 1.37 | 1.30 | 1.44 | <0.001 |
| Diabetes | 1.21 | 1.17 | 1.26 | <0.001 |
| Coronary artery disease | 1.24 | 1.19 | 1.28 | <0.001 |
| Prior CHF | 1.39 | 1.31 | 1.46 | <0.001 |
| COPD | 1.20 | 1.15 | 1.25 | <0.001 |
| Hypertension | 1.16 | 1.10 | 1.23 | <0.001 |
| Living at home | 0.59 | 0.51 | 0.69 | <0.001 |
| Ambulatory | 0.59 | 0.56 | 0.62 | <0.001 |
| Insurance | | | | |
| Medicare | 1.03 | 0.99 | 1.07 | <0.001 |
| Medicaid/Other | 1.32 | 1.22 | 1.42 | <0.001 |
| Nonelective | 3.32 | 3.16 | 3.48 | <0.001 |
| Smoking | | | | |
| Prior | 0.97 | 0.93 | 1.01 | 0.018 |
| Current | 1.01 | 0.96 | 1.07 | 0.171 |
| Dialysis | 1.61 | 1.38 | 1.88 | <0.001 |

Center urban percent, continuous variable representing percentage of urban patients at the patient's treating center (center-specific urban classification); ELOS: extended length of stay (length of stay > 1 day); CHF: congestive heart failure; COPD: chronic obstructive pulmonary disease.