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Spatial access to health care and elderly ambulatory care sensitive hospitalizations

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ABSTRACT

Objectives: Ambulatory care sensitive condition (ACSC) admission rates have been widely used as indicators of access to and quality of primary care as well as the efficiency of health systems. This study examines associations of spatial access to health care with both inpatient hospital admissions and emergency department (ED) visits for ACSCs for older adults. This study also compares inpatient hospitalization admissions and ED visits for elderly ACSCs by spatial access to health care.

Study design: This is a complete hospital discharge dataset study.

Methods: Hospital discharge data were obtained from all hospital systems in the Coastal Bend area of Texas from September 1, 2009, to August 31, 2012. The enhanced two-step floating catchment area method was adopted to measure spatial access to health care, including primary health care and hospitals. Multivariable regression methods were used to measure the associations between spatial access to health care and ACSC rates of both inpatient hospitalizations and ED visits.

Results: Spatial access to primary care has a statistically significant positive relationship with both rates of inpatient hospitalization admissions and ED visits for ACSCs for the elderly. Spatial access to hospitals has a statistically significant negative relationship with both rates. Spatial access to primary care has a significantly negative contribution to the likelihood of inpatient hospitalizations compared with the likelihood of ED visits for elderly ACSCs, whereas spatial access to hospitals has a significantly positive contribution.

Conclusions: Spatial access to health care contributes to elderly ACSC hospitalizations. A poorer access to primary care or a better access to hospitals increases both rates of inpatient hospitalizations and ED visits for elderly ACSCs. Seniors living in areas where residents had poor access to primary care or easy access to hospitals were more likely to visit EDs instead of being inpatients for ACSC conditions. Policy action is needed to improve spatial access to primary care for the elderly.

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Introduction

Certain health conditions may prevent or reduce the need for hospitalizations through timely and effective use of outpatient primary or preventive care. These ambulatory care sensitive conditions (ACSCs), often referred to as potentially preventable conditions, include, for example, diabetes, congestive heart failure, and bacterial pneumonia. Admission rates of ACSCs have been used extensively as indicators of access to and quality of primary care as well as the efficiency of health systems.¹ Limited access to health care increases admission rates of ACSCs. Barriers to access include a number of non-spatial and spatial factors. The non-spatial factors, such as the availability of health insurance and costs associated with health care, have been well studied.² In this study, we focus on spatial factors that are often measured as spatial accessibility to health care by taking location, distribution, and capacity of health care into account.

Despite growing research on spatial access to health care and ACSCs in recent years, most focus is on primary care.^{3,4} For example, the studies consistently have shown that higher rates of hospitalization for ACSCs are strongly associated with poorer spatial access to primary health.^{5–7} Examining the relationship between ACSCs and spatial access to hospitals, another main component of health care facilities, will provide a more complete understanding of the impact of health care on ACSCs.

Similar to inpatient hospital admissions for ACSCs, many patients also seek emergency care for ACSCs. The inappropriate use of emergency departments (EDs) for ACSCs is an expensive burden on hospitals and payers, particularly for older adults. The impacts of spatial and non-spatial factors in reducing ACSC inpatient hospitalizations are well-documented,^{8–10} yet the factors influencing ED visits for ACSCs have not received the same thorough attention. One study found disproportionately higher use of EDs for ACSC care exists for many minority populations among adults aged 16 years and older, particularly for those who are black, Hispanic, Medicare-covered, and older than 50 years.¹¹ Moreover, most ACSC studies used a secondary analysis of survey data such as the National Hospital Ambulatory Medical Care Survey for both inpatient hospitalizations and ED visits. Hospital discharge data might provide a better comprehensive dataset.

In this paper, we examine associations of spatial access to health care with both inpatient hospital admissions and ED visits for ACSCs for older adults from a complete hospital discharge dataset from hospital systems. The adults aged 65 years and older are a well-known high-risk group for ACSCs. They often experience more hospitalizations and ED visits than younger adults. We also investigate differences in spatial access to primary care and hospitals on inpatient hospital admissions and ED visits for elderly ACSCs. Our overarching goal is to provide a more complete understanding of the impact of health care in reducing ACSC hospitalization rates for the elderly.

Methods

Data sources

The hospital discharge dataset was obtained from all hospital systems in the 15 counties in the Coastal Bend area in the state of Texas (Fig. 1), with a total population of more than 599,000 in 2010, consisting of 56% of Hispanics, 38% of whites, and 6% of other minorities. Majority of the areas (77.8%) are considered nonmetropolitan or rural. According to the health need assessments of 2010, 2013, and 2016 and other reports,¹² this area has limited access to healthcare services, particularly for older adults, and a high hospitalization rate for ACSCs for older adults. The health insurance coverage disparities also vary spatially in this area.¹³

The hospital discharge data include both inpatient and ED discharge data for the period of September 1, 2009, to August 31, 2012. Although patients who travel out of the Coastal Bend area for hospitalization do not appear in the area's hospital systems, this dataset should represent elderly patients, and therefore, they are considered as a 100% discharge data system in this area. The data include the patient's home zip code, home county, discharge data, age, principal diagnosis code, principal diagnosis description, secondary diagnosis description, and so on. To protect the confidentiality of hospitals and patients, the data do not include any information that identifies the patients, so some of the cases may be repeat patients.

Individual-level data on healthcare facilities were obtained from InfoUSA, which is a residential and business database. For each facility, in addition to its address, the dataset also includes actual employee size, sales volume, primary standard industrial classification (SIC), and so on. All hospitals (namely, SIC code is 806) from InfoUSA are included, and primary health care includes offices and clinics of doctors excluding those not for senior patients, such as pediatricians. A total of 36 hospitals and 476 primary healthcare facilities were identified during the study period.

The full list of potentially preventable hospitalization diagnoses and their International classification of diseases (ICD-9) codes proposed by the Agency for Healthcare Research and Quality's prevention quality indicators¹⁴ are included in this study except those related to prenatal care and delivery and predominantly reflect children's morbidity. The ACSC inpatient hospitalizations were identified mainly based on their primary diagnosis. The ACSC ED visits were also identified based on their primary ED diagnosis.¹¹

The hospitalization data are only available at the zip code level because of privacy and confidentiality restrictions. Owing to this limitation, ACSC rates for both inpatient hospitalizations and ED visits were calculated by zip code, which is the total number of ACSC admissions at a zip code divided by the total senior population at the zip code, where senior population data were extracted from the 2010 Census Summary File 1.

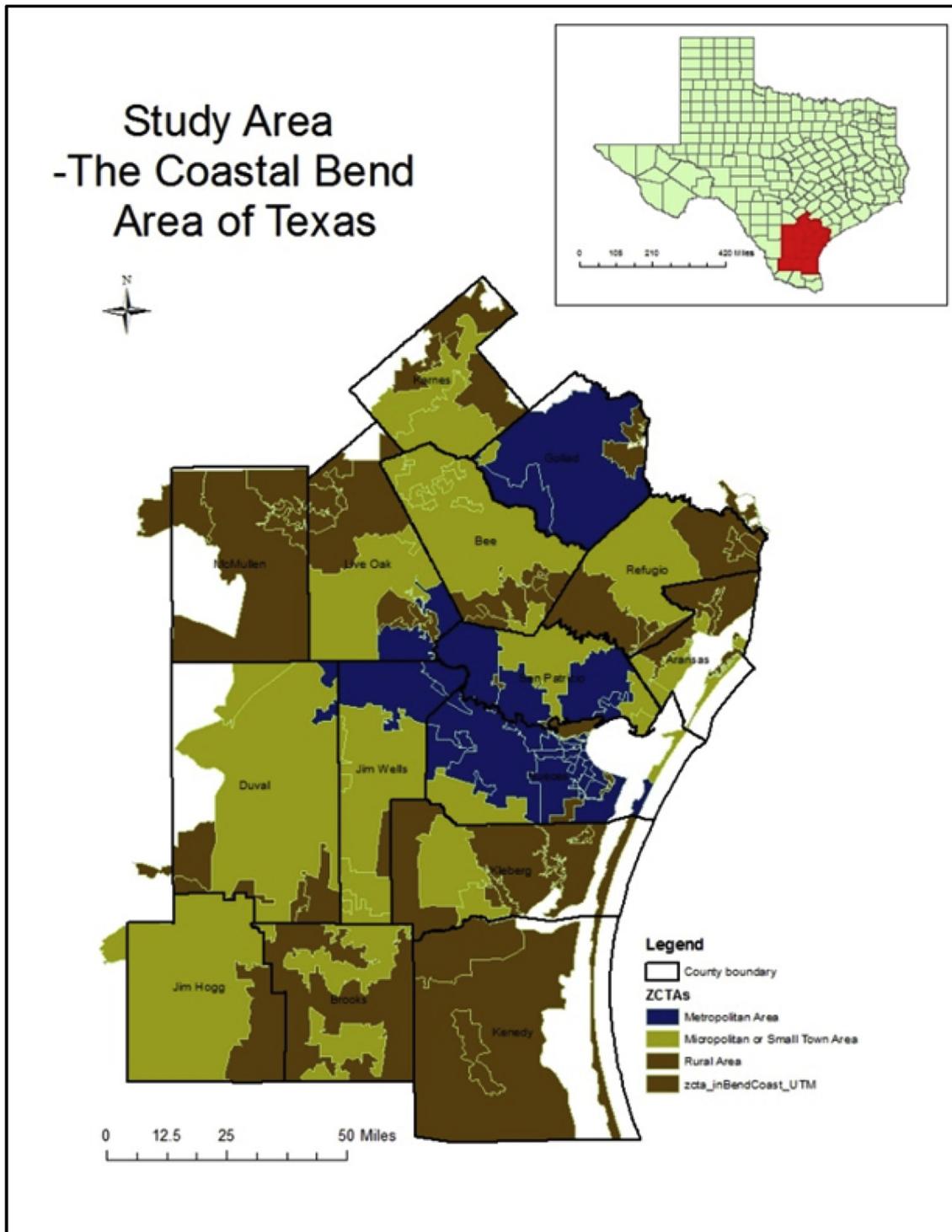


Fig. 1 – Study area: the Coastal Bend area of Texas.

Spatial accessibility measurement to health care

We examined both primary care physicians (hereafter, referred to as primary care) and hospitals. Primary care includes family and general practitioners and general internists.¹⁵ The enhanced two-step floating catchment area (E2SFCA) method,¹⁶ a commonly used method to measure spatial access, was adopted to measure both spatial

accessibility of primary care and hospitals by zip code. The original E2SFCA method⁶ takes both availability and accessibility into account. The E2SFCA method is better than the original method by accounting for distance decay in catchments for both facilities and population areas.^{16,17}

First, we computed the physician-to-population ratio, R , within the facility catchment area for each facility, j , through searching all zip codes that are within a threshold travel

distance (Eq. (1)). In this step, the center of each zip code was represented by population weight center at the zip code, which was calculated from the block-level population data. The number of physicians at each facility was used to represent the facility's capacity.^{6,16} A 30-min driving zone was used for the maximum catchment of primary care.^{6,16,18} The maximum catchment of hospitals was within a 60-min driving zone because the golden hour is a common standard, particularly in emergency care.¹⁹

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} \leq d_{oj}\}} P_k} \quad (1)$$

where P_k is the senior population at zip code k , and S_j is the capacity for facility j , d_{oj} is the maximum catchment associated with facility j , and d_{kj} is the travel time between facility j and zip code k .

Next, we calculated the access value, A , for each zip code, i , by summing up the calculated ratio in the previous step for facilities that are within the maximum catchment area of the zip code (Eq. (2)). In this step, similar to the previous step, a 30-min driving zone for primary care and 60-min driving zone for hospitals were applied to urban/metropolitan areas. In small towns or rural areas, however, the size of maximum catchments was doubled to include some isolated areas in the analysis.^{19,20} The urban and rural areas were determined based on the 2012 Rural–Urban Commuting Area Codes.²¹ We considered the distance decay in both steps, that is, there was no decay within the first 10 min.¹⁶ In the areas between 10 min and the corresponding maximum catchment, however, a commonly used continuous decay function was adopted.¹⁹ Travel time was calculated using StreetMap Premium road network. Owing to the space limit, the details of the E2SFCA method are not provided here. For more details of the E2SFCA method, see Luo and Qi.¹⁶

$$A_i = \sum_{j \in \{d_{ij} \leq d_{oi}\}} R_j \quad (2)$$

where R_j is the physician-to-population ratio for facility j , which is calculated from Step 1. d_{oi} is the maximum catchment associated with zip code i , and d_{ij} is the travel time between zip code i and facility j .

Statistical analysis

Ordinary least squares (OLS), a common global linear regression, was used to examine the relations between spatial access to health care and elderly ACSC admissions by zip code. More specifically, ACSC rates for both inpatient hospitalizations and ED visits were the dependent variable, depending on whether we examined inpatient hospitalizations (model 1) or ED visits (model 2). The two measured spatial accessibility values, one for primary care and the other for hospitals, were the explanatory variables. Both of them were log-transformed using $-\ln(x)$ because of the fact that a higher score represents a better spatial accessibility whereas a lower score represents a poorer accessibility. To further compare inpatient hospitalizations and ED visits for elderly ACSCs by health care, a binomial logistic regression (Eq. (3)) was used to compare the

likelihood of inpatient hospitalizations and the likelihood of ED visits for elderly ACSCs by both spatial access to primary care and hospitals. OLS was performed in ArcGIS 10.4.1, and the binomial logistic regression was conducted in R package.

$$\ln\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 \quad (3)$$

where, π is the probability of being inpatient hospitalizations, $1-\pi$ is the probability of being ED visits, x_1 is the spatial access to primary care, and x_2 is the spatial access to hospitals. The ratio between π and $1-\pi$ is the odds of visiting a hospital, which is an alternative way of expressing probability. It tells how many times a patient is more likely to visit a hospital than seeking ED services. If odds equals to 1, it is equally likely for a patient to visit a hospital and seek ED services; if odds is greater than 1, it is more likely for a patient to visit a hospital than seek ED services.

Results

Table 1 summarizes overall inpatient hospitalizations and ED visits for older adults in the Coastal Bend area between September 1, 2009, and August 31, 2012. A total of 58,395 elderly inpatient hospital discharges and 66,878 elderly ED visits were identified, including 14,136 (24.2%) inpatient hospital discharges and 13,686 (20.5%) ED visits for ACSCs. Fig. 2 (a) and (b) shows the geographic distribution of rates of inpatient hospitalizations and ED visits, respectively, for ACSCs for older adults. The rates varied across the study. Overall, southern areas have a higher rate than the northern areas.

Fig. 3(a) and (b) present the variations of spatial accessibility to primary care and hospitals, respectively, at the zip code level. Lower values represent a poorer access whereas higher values correspond to better access to health care. Jenks natural breaks, a common method used to find the best arrangement of values into different classes, is used to classify the accessibility values into five groups. Not surprising, the two maps show some similar patterns, that is, the areas with a better spatial access usually are located in the places that have a high concentration of primary care or hospitals. Lower accessibility scores were observed in areas with scarce facilities and mostly in rural areas.

Table 2 reports the results of the two OLS models, one for the rate of inpatient hospitalizations (model 1) and the other for ED visits (model 2). The variance inflation factor for each variable in the two models is less than 7.5, indicating no redundancy in the two spatial access variables. The P -value of a robust test (Robust_Pr) was used to determine coefficient significance because the Koenker (BP) Statistics is statistically significant. The Moran's I values on the residuals are 0.065 and 0.05 for model 1 and model 2, respectively, indicating no clustering on the residuals.

Not surprising, both spatial accessibility of primary care and hospitals is significantly associated with rates of inpatient hospitalizations and of ED visits for elderly ACSCs. Interestingly, spatial access to primary care has a statistically significant positive relationship with both rates whereas spatial access to hospitals has a statistically significant negative

Table 1 – Characteristics of inpatient hospitalization admissions and emergency department visits for older adults (65 years and older) (Sept. 1, 2010–August 31, 2012).

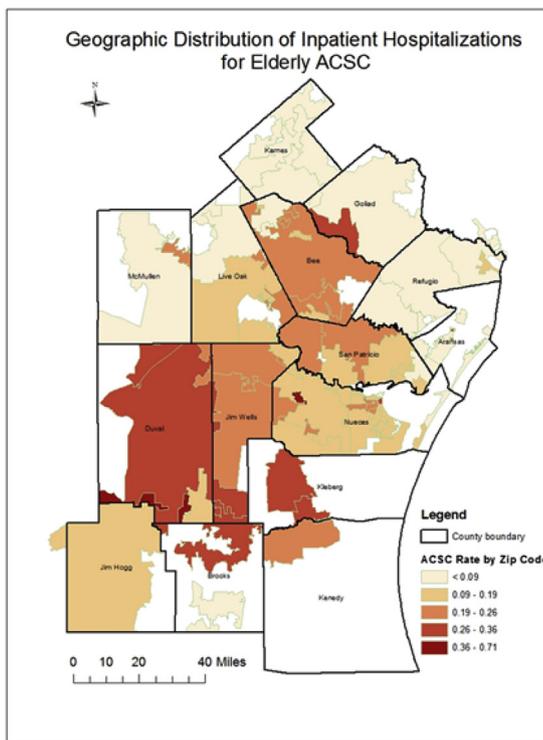
Characteristic	Inpatient hospitalizations				Emergency department visits				
	All admissions		ACSC admissions		All visits		ACSC visits		
	No.	%	No.	%	No.	%	No.	%	
Total	58,395		14,136 (24.2%)		66,878		13,686 (20.5%)		
Age in years	<79	35,334	60.5%	7785	55.1%	43,550	65.1%	8838	64.6%
	≥80	23,061	39.5%	6351	44.9%	23,328	34.9%	4848	35.4%
Gender	Female	31,919	54.7%	7984	56.5%	40,939	61.2%	8848	64.7%
	Male	26,476	45.3%	6152	43.5%	25,939	38.8%	4838	35.3%
Race	White	16,481	28.2%	3659	25.9%	15,173	22.7%	2966	21.7%
	Hispanic	13,468	23.1%	3191	22.6%	17,844	26.7%	3724	27.2%
	Others	1831	3.1%	423	3.0%	2227	3.3%	437	3.2%
	Unknown	26,615	45.6%	6863	48.5%	31,634	47.3%	6559	47.9%
Occupation	Retired	47,201	80.8%	11,721	82.9%	50,180	75.0%	10,363	75.7%
	Unemployed	6388	10.9%	1533	10.8%	9842	14.7%	2155	15.7%
	Others	4806	8.2%	882	6.2%	6856	10.3%	1168	8.5%

ACSC, ambulatory care sensitive condition.

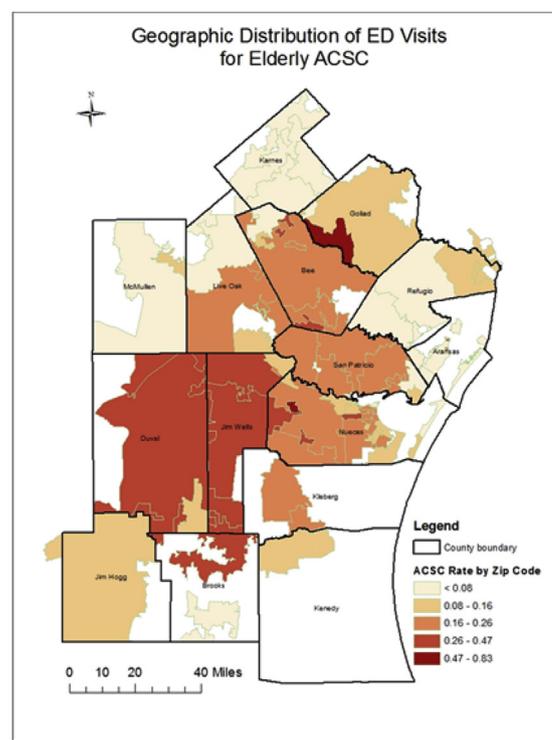
relationship with both rates, that is, a poorer access to primary care or a better access to hospitals increases both rates of inpatient hospitalizations and ED visits for elderly ACSCs.

Table 3 reports the binomial logistic regression results of the comparison of inpatient hospitalizations and visits for elderly ACSCs by spatial access to health care. Interestingly, both spatial access to primary health care and hospitals are statistically significant and contribute to the comparison between the likelihood of inpatient hospitalizations and ED visits for elderly ACSCs. They play different roles; however,

spatial access to primary care has a negative coefficient, whereas spatial access to hospitals has a positive coefficient. This result shows that a senior from a zip code area with a poorer access to primary care (namely, a higher value) or a better access to hospitals (namely, a lower value) is more likely to visit EDs for ACSCs. Specifically, when the value of spatial access to hospitals is fixed, for a one unit increase (getting poorer access) in variable ‘access to primary care’, the log odds of inpatient hospitalizations decreases by -0.2369 . In this case, the probability of inpatient hospitalizations



(a)



(b)

Fig. 2 – Geographic distributions of hospitalization rates of ACSCs for older adults. ACSC, ambulatory care sensitive condition; ED, emergency department.

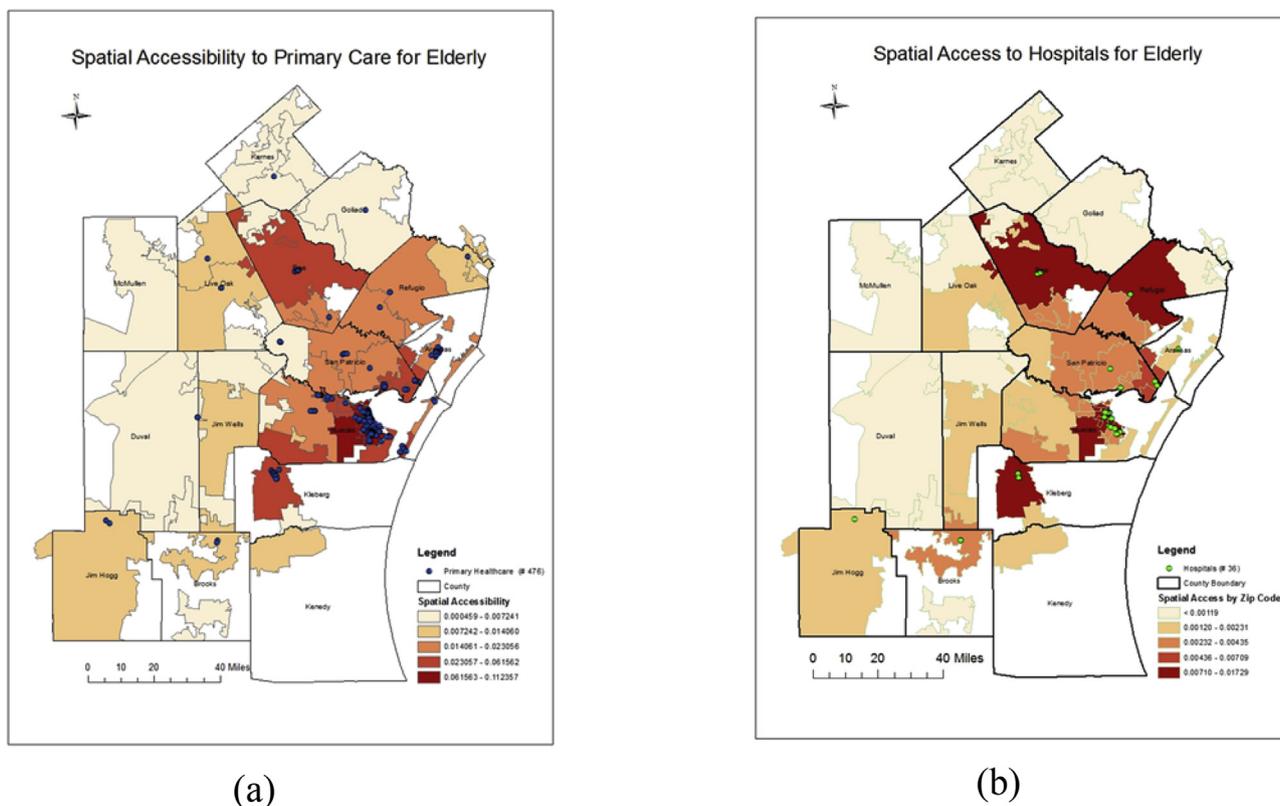


Fig. 3 – Spatial access to health care.

decreased whereas the probability of ED visits increased. Conversely, when the value of spatial access to primary care is fixed, for a one unit increase (getting poorer access) in variable ‘access to hospitals’, the log odds of being inpatients increased by 0.22653.

Discussion

This study found a statistically significant positive relationship between spatial access to primary care and the rate of inpatient hospitalizations for ACSCs among older adults. This finding conforms with the results of previous studies showing that less access to primary care in an area increases the rate of inpatient hospitalizations for ACSCs.^{6,22,23} This study also confirmed a significant positive association between spatial access to primary care and the rate of ED visits for ACSCs among older adults.²⁴ The findings suggest that timely and

effective use of outpatient primary care facilities should decrease both rates of inpatient hospitalizations and ED visits for ACSCs among the elderly.

Our study further demonstrated the significant associations between spatial access to hospitals and ACSCs, including both rates of inpatient hospitalizations and ED visits, for older adults, where the relations between them are not previously documented. Interestingly, seniors living in areas where residents had easy access to hospitals had high rates of both. This finding may indicate inappropriate use of emergency services for ACSCs for the elderly. Owing to the cost, hospitals benefit more when EDs are focused on providing emergency care. Elderly patients, however, often visit the ED instead of primary care providers.²⁵ Previous studies have shown a significant number of ED visits for ACSCs and they are related to demographic characteristics and socio-economically disadvantaged neighborhoods.^{11,26} Considering the US healthcare system that provides services

Table 2 – Ordinary least squares (OLS) analysis: association effects of spatial accessibility on rates of elderly inpatient hospitalizations and elderly ED visits for ACSCs.

Variables	Inpatient Hospitalizations				ED Visits			
	Coefficient	Standard error	Robust_Pr	VIF	Coefficient	Standard error	Robust_Pr	VIF
	Model 1				Model 2			
Access to primary care	0.033	0.014	0.045**	3.553	0.056	0.016	0.002***	3.553
Access to hospitals	-0.050	0.019	0.019**	3.553	-0.071	0.022	0.002***	3.553

ED, emergency department; VIF, variance inflation factor.

* An asterisk next to a number indicates a statistically significant p-value (p < 0.01): *, p < 0.1, **, p < 0.05, ***, p < 0.01, ****: p < 0.001.

Table 3 – Comparison of rates of inpatient hospitalizations and ED visits for ACSCs for the elderly by spatial access to health care: coefficients.

Characteristic	Estimate	Standard error	Z value	Pr (> z)
Access to primary care	−0.2369	0.01281	−10.689	<2e-16 ***
Access to hospitals	0.22653	0.01663	7.007	2.44e-12 ***

ACSC, ambulatory care sensitive condition; ED, emergency department. * An asterisk next to a number indicates a statistically significant p-value ($p < 0.01$): *: $p < 0.1$, **: $p < 0.05$, ***: $p < 0.01$, ****: $p < 0.001$.

to seniors based on need, rather than on the ability to pay, seniors who have easy access to hospitals might be more likely to visit hospitals or EDs rather than seeking primary health service.

To the best of our knowledge, this study is the first to compare inpatient hospitalizations and ED visits for elderly ACSCs by spatial access to health care. We observed that seniors living in areas where residents had poor access to primary care or easy access to hospitals were more likely to visit EDs instead of being inpatients for ACSCs. Reducing ED visits for ACSCs by elderly patients has significant implications for reducing cost, improving quality, and enhancing efficiency.²⁷ To better understand hospitalization admission rates for elderly ACSCs, both inpatient hospitalizations and ED visits should be considered. Fingar²⁸ showed that the rate of ED visits for ACSCs by the elderly was increased although the rate of inpatient hospitalizations for the same condition was decreased. This study confirms that the elderly who are unable to obtain timely outpatient care often seek care in EDs.²⁹

Our study has several limitations. First, inpatient hospital admissions were probably overestimated by including patients who were transferred from ED visits as we were not able to identify treat-and-release ED visits. Second, similar to other research that used hospital discharge dataset, we could not determine the repeat patients because of data confidentiality laws. Third, the study area of the Coastal Bend area in Texas in this study may have limited the study's power to detect significant associations at a national level. The findings, however, are consistent with the previous research. Finally, we selected and identified ACSCs based on ICD-9 codes. Undiagnosed ACSCs may not be included in the analysis.

In conclusion, despite these limitations, our study documents the contribution of primary care physicians to elderly health and efficiency of healthcare systems. Primary care is in the great position to detect the occurrence of ACSCs. Improvement in healthcare systems to achieve better spatial access to primary care is imperative, especially for the elderly. On the one hand, it improves the quality of life for the elderly by reducing their hospitalizations for ACSCs. On the other hand, it provides more efficient uses and better quality of EDs through effective primary or preventive health care. Research into strategies that increase access to primary health care for elderly living may help decrease use of EDs for primary care. Health providers and policy makers should work together to increase equitable access to primary healthcare to decrease

ACSC hospitalizations and ED usage. This could provide elders with an opportunity for health and well-being.

Author statements

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Ethical approval

Protocol approval for the Coastal Bend Health Needs Assessment was obtained through the International Review Board process in our campus. The data for this study were taken from this project.

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Competing interests

None declared.

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