Utilization of Speech-Language Pathology and Audiology Services in Stroke Patients

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The purpose of this study was to investigate biographical and medical factors associated with utilization of speech-language pathology and audiology services provided to stroke patients in the hospital setting. Moreover, the study sought to identify possible subgroups of stroke patients that might be under served by speech-language pathologists and audiologists. Discharge data for over 91,000 stroke patients from the years 1996 to 2000 were examined. Using a relatively new statistical approach—a novel decision tree—the analyses revealed an association between medical diagnostic complexity, hospital setting, hospital location, and increased utilization of rehabilitation services. Biographical factors such as age, race, and gender were not related to the amount of services rendered.

The impact of stroke on personal as well as national resources is well documented; stroke is the number three cause of death and the leading cause of severe, long-term disability in the United States (Center for Disease Control and Prevention, 2001). National data indicate that by the year 2010, 40 million Americans will be over the age of 65 (US Census Bureau, 2000). Given that higher age is a strong predictor of occurrence of stroke (Bonow, Smaha, Smith, Mensah, & Lenfant, 2002), it is probable that the number of strokes is on the rise. Data collected in the Framingham Health Study revealed that among stroke survivors who were 65 years or older 19% had aphasia and 26% were dependent on caregivers for completion of activities of daily living (Kelly-Hayes et al., 2003). Furthermore, for 2005 the estimated cost of stroke care in the United States was projected to reach $56 billion (American Heart Association, 2005). This high financial impact on the nation includes both direct costs for services of over $35 billion and the indirect cost of lost productivity of over $20 billion. Although speech-language pathologists and audiologists (SpAS) are not directly involved in preventative measures to decrease the incidence of stroke, they can reduce its personal and national impact through correct diagnosis and treatment of communication and feeding problems commonly associated with stroke.

Only minimal information is available regarding the utilization of rehabilitative care at the national level, particularly concerning services provided by

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SpAS to stroke patients (Horn, Yoels, & Bartoulucci, 2000). More specifically, little is known about the association between SpAS utilization and demographic and biomedical factors such as race, age, education, insurance coverage, socioeconomic status (SES), medical diagnoses, type of medical setting, or days of hospitalization. Increased insight into this relationship could determine possible underutilization of SpAS in specific subgroups of stroke patients. Thus, the main goal of this research was to use a bivariate and novel decision tree model to analyze these demographic and biomedical factors and their relationship to patient utilization of inpatient SpAS services after stroke. The dataset was generated from comprehensive hospital discharge data established by the state of South Carolina, designated as a "stroke belt" state, which has one of the highest incidence and prevalence rates of stroke in the nation (American Heart Association, 2005; Howard et al., 1995). Using this unique dataset, the principal research question was: What is the relationship between utilization of SpAS services and stroke patients' age, race, SES, medical diagnosis, type of medical setting, and length of hospitalization?

METHOD

Participants

The study population included patients with a primary diagnosis of stroke admitted at hospitals in South Carolina during the period between 1996 and 2000. These data are maintained by the South Carolina Department of Statistics and include all hospital admissions, procedures, and discharges for every hospital in the state.

Variables Used in the Analysis

The database listed 175 variables for each patient. About 80 variables were related to different hospital charges (in dollars). These charges had no relation to SpAS as all charges were considered outcome variables for this study and were not included in the final analysis, excluding Total Hospital Charges and Charges for SpAS. Approximately 40 variables reflecting detailed hospital and medical procedure descriptions were also excluded from the analysis as irrelevant to SpAS. Data for date of admission and other time-related variables were used to calculate the length of stay, but the original date variables were not relevant for the analysis. A group of 15 variables contained neighborhood information for each patient, such as poverty level of the census track, percent unemployment, and so forth. The statistical analysis using series of logistic regression models revealed that these variables were not related to the SpAS, and thus they were not included in the analyses. This preliminary selection yielded 13 major variables of interest for this study: age, gender, race, number of diagnoses, number of procedures, sequence number of hospital visit (1 = first visit), setting (inpatient, emergency, or rehabilitation), length of stay (days), total hospital charges ($), urban or rural hospital, type of insurance, major diagnostic category, and speech-language pathology and audiology charges as percent of the total charges.

Influence of Individual Factors

Logistic regression models were used to determine the influence of individual factors. The predicted variable for these models was presence or absence of SpAS, and the predictor variables were all factors described above. The effect size of each factor's influence was measured by the odds ratio (OR). OR greater than one would indicate greater likelihood of receiving SpAS for the reference category. Statistical significance for the ORs and their confidence intervals were considered as well.

Classification Patterns

A classification and regression tree (CART) approach (Breiman, Friedman, Olsen, & Stone, 1984; Steinberg & Colla, 1997) was applied to determine the different patterns associated with receiving SpAS. CART is a nonparametric, binary recursive partitioning procedure that is robust to outliers and distribution problems and is effective for assessing the reliability of new data predictions. Steadman et al. (2000) showed that the recursive partitioning on average improves the accuracy of the conventional models like logistic regression by 10–15%. CART is particularly appropriate for finding context dependence and interaction effects because one variable can appear many times in a tree in different contexts. Recursive partitioning methods, including CART, have been used successfully in other areas of research. For example, extensive research in the areas of mental health and violence has successfully relied on recursive partitioning (Callahan & Silver, 1998; Monahan et al., 2000; Steadman et al., 2000).

One of the greatest advantages of recursive partitioning methods, including CART, is that they assimilate what clinicians do when talking to patients. First, they ask one question, then, depending on the answer ask another question, and so forth. Thus, not all patients are asked the same set of questions because not all are relevant to every patient. CART uses similar partitioning in a recursive way.

The optimal classification tree model for the dataset with outcome variable SpAS (Yes/No) and all available predictor variables from the dataset were obtained. Building a tree starts with one binary split and continuous splitting until a maximum large tree is built. The tree is pruned until the optimal tree is identified, with the optimality driven by the minimal amount of error and the number of nodes. One tree can have a large number of nodes—some might not be necessary or statistically significant. The tree is similar to a logistic regression model where one can include a very large number of predictor variables and lose degrees of freedom without gaining enough explanatory power. The advantage of the CART approach is that variables do not need to be excluded from the whole model—single nodes can be eliminated or pruned while others that have statistically significant contribution are maintained.

Gini impurity coefficient was used as splitting criterion, and optimality was based on the predictive accuracy and the penalty for a larger tree. The Gini coefficient estimates all possible splits at a certain node and evaluates which one creates the greatest diversity. For example, a split that creates two nodes with similar percentages of SpAS has no value for a successful model and is excluded from consideration. On the other hand, assuming that another split (variable) yields maximum diversity by producing two nodes, one with 2% SpAS and the other with 70% SpAS, then in this case the latter division is selected based on the Gini coefficient as the best split.

The final CART tree was validated by building a model using nine tenths of the dataset and estimating the error based on one tenth of the data using 10-way crossvalidation procedure (Steinberg & Colla, 1995). Then, nine tenths of the data were reselected to build another model and test its validity using the remaining one tenth of the data. Following 10 such partitions, the results of each analysis were averaged at the end.

As a result of the CART procedure a "best optimal" tree is created. This means that the resulting tree is optimal according to the selected statistical criterion for building the tree. It is best because it gives the smallest error for misclassification and the most parsimonious tree. The relative error is corrected with penalty for the number of the nodes included in the model and thus gives the optimality. If we intervene and manually remove some of the nodes or force splitting on more nodes, the resulting tree will present a weaker model than the best optimal tree.

Using the CART approach, combinations of factors were discovered to determine different levels of services received. According to the best optimal tree, patients were classified into three groups based on low, average, and high use of SpAS, using a rule established in the literature (Steadman et al., 2000) based on the actual rate of receiving SpAS in the whole population (16.2%). Nodes with less than half the rate of services were classified as low, and nodes with more than twice the rate were classified as high. The rest of the nodes were classified as medium.

RESULTS

Participants

Based on the dataset, over 91,000 individual patients were admitted for stroke related problems at hospitals in South Carolina during the 1996–2000 period. Among these patients, 76,777 were nonemergency patients, and they formed the basis for the analysis. The emergency patients, constituted a special group with almost no SpAS (0.1%) and were not subject to further analysis. Description of the hospital population is included in Tables 1 and 2. For determining the average value and the variation of different patient characteristics, the study used the median value and the interquartile range (IQR), which is the difference between the third quartile and the first quartile. These measures were selected because they are not influenced by outliers.

From all nonemergency patients, 54.2% were female, 28.0% were African-American, 71.1% were White, and 0.9% were of other race. On their first hospital visit, the patients were on average 72 years old (IQR = 17) with ages ranging from 15 to 100 years old.

Some patients had multiple hospital visits during this period. The number of visits varied between 1 and 126, with an average of 2 visits (IQR = 2). Nearly half (47.9%) had single visits, and 90.3% had up to five visits for the whole period. The length of stay varied between 1 day and 699 days, with an average stay of 5 days (IQR = 6). In total,

TABLE 1. Hospital population description (continuous variables).

Variable	Median	IQR	Minimum	Maximum
Number of hospital visits	2	2	1	126
Age (at first hospital visit)	72	17	15	100
Length of stay (days)	5	6	1	699
Total hospital charges ($)	9,500	11,100	100	1,007,400
SpAS ($)	300	500	100	17,900
Number of diagnoses	7	3	1	10
Number of procedures (for patients who had at least one procedure)	2	2	1	10

TABLE 2. Hospital population description (categorical variables).

Variable	Description
Gender	Female 54.2%
	Male 45.8%
Race	African-American 28.0%
	White 71.1%
	Other race 0.9%
Insurance	Medicare 76.4%
	Commercial insurance/HMO 14.8%
	Medicaid 4.8%
	Self pay 2.2%
	Other insurance 1.8%
Urban/Rural setting	Urban 75.3%
	Rural -24.7%
Hospital Setting	Inpatient 96.4%
	Rehabilitation 3.6%

there were 160,524 nonemergency hospital visits registered in the database. Of them, 29,160 in 1996, 31,654 in 1997, 32,555 in 1998, 32,848 in 1999 and 33,832 in 2000.[1] The percentage of patients who received SpAS was 14.5 in 1996, 15.8 in 1997, 15.7 in 1998, 17.8 in 1999, and 16.9 in 2000. All analyses were based on the nonemergency group of patients, or 160,524 hospital visits.

The total hospital charges per visit ranged from $100 to $1,007,400 with an average amount of $9,500 (IQR = $11,100). The charges for SpAS varied between $100 and $17,900, with an average amount of $300 (IQR = 500). Charges for SpAS were on average 1% of the total hospital charges. There were 26,020 cases of individual charges for SpAS, which represented 16.2% of the total number of visits. Most of the patients were insured by Medicare (76.4%) and commercial insurance/HMO (14.8%), while the remaining patients were covered by Medicaid (4.8%), self-pay (2.2%), or had other type of insurance, for example, worker's compensation, indigent/charitable organizations (1.8%).

Almost all patients (98.0%) had more that one diagnosis when admitted to the hospital. The number

[1]Due to some missing dates of admission, the total number of patients' distribution by year is 160,049, not 160,524.

of diagnoses ranged from 1 to 10, with an average of 7 (IQR = 3.0). During their stay at the hospital, almost half of the sample (47.6%) did not receive any procedures, whereas the rest received between 1 and 10 procedures, with an average of 2 (IQR = 2) per stay at the hospital. The majority of the patients (75.3%) were treated at hospitals located in urban areas. The most common admission setting was inpatient (96.4%), followed by rehabilitation (3.6%).

Influence of Individual Factors

The effects of individual factors on the likelihood of receiving SpAS were estimated using *odds ratios* (OR). Table 3 presents the odds ratios from logistic regression models for the individual factors.

The most influential factor was rehabilitation/inpatient setting. Patients in the rehabilitation setting were 14.7 times (OR = 14.7) more likely to receive SpAS than patients in other inpatient settings. Patients in urban hospitals on average were two times more likely (OR = 1.99) to receive SpAS than those in rural hospitals. The odds ratios for some of the factors, although statistically significant, were close to 1 and thus without limited practical impact.

Classification Patterns

Employing CART, an optimal classification tree was built using an outcome/dependent variable as the presence or absence of SpAS (Figure 1). The 13 factors used in the final tree were patient's age, race, and gender; urban/rural hospital, number of hospital visits, number of procedures, number of diagnoses, presence of major diagnosis (Yes/No), year of admission, total hospital charges ($), length of hospital stay (days), type of insurance, and rehabilitation or inpatient setting. In the final model, only five of the above 13 factors were included as statistically significant: urban/rural hospital, number of hospital visits, major diagnosis, length of hospital stay, and rehabilitation/inpatient setting. The remaining factors were not deemed statistically significant by the CART procedure. Based on the

TABLE 3. Bivariate relationships outcome: Speech and audiology services received (Y/N).

Factor	Odds Ratio	*p*	95% CI
Age	1.002	<0.0001	1001–1.003
Gender (Ref: Female)	0.988	0.3600	0.962–1.014
Race (Ref: African-American and Other)	1.208	<0.0001	1.174–1.242
Length of Stay (Days)	1.082	<0.0001	1.081–1.084
Major Diagnostic Category (Ref: Nervous, Respiratory, Circulatory, or Digestive System Diseases)	1.034	0.0432	1.001–1.068
Insurance (Ref: Medicare)	0.925	<0.0001	0.897–0.954
Insurance (Ref: Medicaid)	0.973	0.3850	0.914–1.329
Insurance (Ref: Commercial or HMO)	1.075	<0.0001	1.036–1.115
Insurance (Ref: Self-Pay)	1.220	<0.0001	1.120–1.329
Insurance (Ref: Other—worker's compensation, indigent/charitable organizations, etc.)	1.094	0.0690	0.993–1.205
Number of Diagnosis at Admission	1.108	<0.0001	1.102–1.115
Number of Procedures during Stay	1.092	<0.0001	1.084–1.100
Setting (Ref: Rehabilitation)	14.741	<0.0001	13.903–15.629
Hospital Location (Ref: Urban Area)	1.989	<0.0001	1.920–2.062
Sequence Number of Hospital Visit (1 = First visit, 2 = Second visit, etc.)	0.899	<0.0001	0.893–0.9.05

Note. None of the 15 neighborhood level variables (e.g., education, school population, unemployment, and poverty) and "Total hospital charges" had any statistical influence on SpAS with all odds ratios equal to 1.

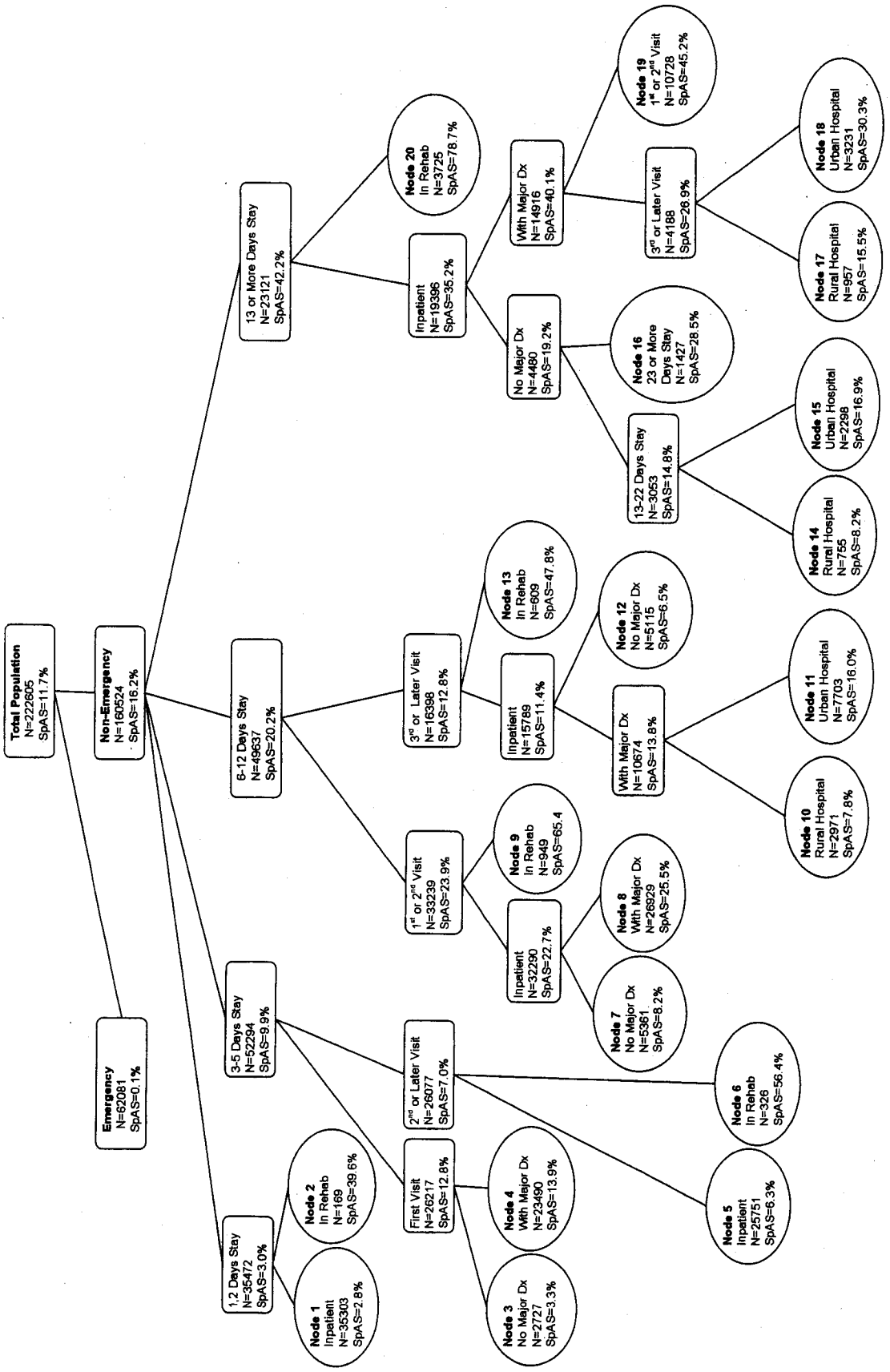

Figure 1. Classification tree for SpAS.

CART measure of variable importance, the length of hospital stay was the most relevant variable (100%) for the SpAS. Next by importance was rehabilitation/inpatient setting (29.9%), presence of major diagnosis (14.2%), number of visits (11.2%), followed by hospital setting (urban/rural; 4.7%). The best optimal tree had 20 end-nodes that represented 20 different patterns for receiving SpAS. The patterns/groups of patients receiving low, medium, and high amount of SpAS are presented in Table 4.

On the low end, patients who stayed 1 or 2 days in the inpatient hospital setting had marginal chance (node 1, 2.8% SpAS) of receiving SpAS regardless of their diagnosis, number of diagnoses, type of insurance, age, gender, race, or type of hospital. Their chances did not improve (node 3, 3.3% SpAS) even when they stayed 3–5 days in the hospital on their first visit and did not have major diagnosis (diseases of the nervous system, respiratory system, circulatory system, or digestive system). Their chances were also low (node 5, 6.3% SpAS) when they were on their second, or subsequent, visit to the hospital, or stayed 3–5 days in an inpatient setting. Even with a 6- to 12-day stay, the chance of getting SpAS was low (node 12, 6.5% SpAS) if the

TABLE 4. Association between SpAS and length of stay.

Node Number	SpAS %	Patients Who Received *Low* Amount of SpAS
1	2.8	Stayed one or two days in hospital in inpatient setting.
3	3.3	Stayed 3–5 days in hospital on their first visit without major diagnosis.
5	6.3	Stayed 3–5 days in hospital as inpatient, on their second or later visit.
12	6.5	Stayed 6–12 days on their third or later hospital visit as inpatient without major diagnosis.
10	7.8	Stayed 6–12 days on their third or later visit in rural hospital as inpatient with major diagnosis.
7	8.2	Stayed 6–12 days in hospital, on their first or second visit as inpatient without major diagnosis.
14	8.2	Stayed 13–22 days in rural hospital as inpatient without major diagnosis.
		Patients Who Received *Medium* Amount of SpAS
4	13.9	Stayed 3–5 days in hospital on their first visit with major diagnosis.
17	15.5	Stayed 13 or more days in rural hospital, on their third or later visit as inpatient with major diagnosis.
11	16.0	Stayed 6–12 days in urban hospital as inpatient, on their third or later visit with major diagnosis.
15	16.9	Stayed 13–22 days as inpatient in urban hospital without major diagnosis.
8	25.5	Stayed 6–12 days in hospital on their first or second visit with major diagnosis in inpatient setting.
16	28.5	Stayed 23 or more days as inpatient without major diagnosis.
18	30.3	Stayed 13 or more days in urban hospital, on their third or later visit as inpatient with major diagnosis.
		Patients Who Received *High* Amount of SpAS
2	39.6	Stayed 1–2 days in hospital in rehabilitation.
19	45.2	Stayed 13 or more days in hospital on their first or second visit as inpatient with major diagnosis.
13	47.8	Stayed 6–12 days in hospital on their third or later visit in rehabilitation setting.
6	56.4	Stayed 3–5 days in hospital in rehabilitation setting on their second or later visit.
9	65.4	Stayed 6–12 days in hospital, on their first or second visit in rehabilitation setting.
20	78.7	Stayed 13 or more days in rehabilitation.

stay was their third or subsequent visit without major diagnosis.

On the higher end, more than 78% of the patients who stayed 13 or more days in a rehabilitation setting received SpAS (node 20, 78.7% SpAS). About two thirds of the patients with a 6- to 12-day stay on their first or second visit in a rehabilitation setting received SpAS (node 9, 65.4% SpAS). The group with a medium amount of SpAS received between 13.9% and 30.3%.

DISCUSSION

The present study employed a novel decision tree model to define factors related to utilization of SpAS among hospitalized stroke patients. For the 5-year study period, a gradual increase in SpAS service rates from 14.5% in 1996 to 16.9% in 2000 was noted. The primary utilization for speech-language services occurred in the rehabilitative setting among patients with longer hospital stays. Although SpAS utilization increased during this period, the total cost of this rehabilitative care represented only about one percent of total hospital costs.

Insurance coverage was primarily provided by Medicare, followed at a lower level by commercial/HMO insurance, Medicaid, and self-pay. The professional organization for speech-language pathologists in the United States, ASHA, has reported similar funding source data, suggesting that the current dataset including discharges in one state was similar to national data regarding insurance coverage (Rosenfeld, 2002).

Health policy analysts have advocated health care utilization based on medical facts alone, rather than on economic considerations (Harrison, 1995). In this study, health care utilization was not driven by economic considerations; however, the proportion (2.2%) of patients who paid directly (self-pay) for their services was considerably lower than would be expected based on the number of people without insurance coverage. According to the U.S. Census Bureau (1999), 16.6% of the population in South Carolina did not have health insurance between 1997 and 1999.

Although each participant in this study had a primary diagnosis of stroke, the dataset indicated that patients with a diagnosis of stroke presented with a complex level of care. For example, the average number of medical diagnoses on admission was seven, and most patients had at least one diagnosis pertaining to the nervous, respiratory, circulatory, or digestive system. Most patients had one or two visits to the hospital and stayed in the hospital on average 5 days. On a bivariate level, the most important factor for receiving speech-language services was the admission to a rehabilitation setting. Patients with a diagnosis of stroke could require SpAS services to address disorders including aphasia, dysarthria, apraxia, or dysphagia. This study was unable to separate the type of SpAS service rendered; however, patients with one or more of these disorders could require rehabilitative service utilization and extended hospitalization required for longer-term rehabilitation activities.

Demographic variables like age, gender, and race did not appear to influence the likelihood of receiving SpAS. However, there was a strong relationship between hospital location and the likelihood of receiving rehabilitative services. If an individual was treated in an urban-based hospital, he or she was two times more likely to receive SpAS rehabilitative services than if treated at a rural hospital. This finding is likely related to urban hospitals offering higher quality and more comprehensive care compared to rural hospitals (Keeler et al., 1992; Sheikh & Bullock, 2001).

For the multivariate model analysis, we opted to use a new approach, namely the CART approach, which had been successful in other research areas. The results here confirmed the value and applicability of this method, especially in discovering the complex structure of the data and the different patterns related to receiving SpAS.

An examination of factors that grouped patients by the amount of speech-language service utilization revealed specific trends. Patients in the rehabilitation setting received more SpAS than those in other settings, particularly if the patient had a longer hospital stay. Over 78% of patients who stayed 13 or more days in the hospital in a rehabilitation setting utilized speech-language services. Among rehabilitation patients, utilization rates ranged from 40% to 78% depending on the number of days in the hospital. Patients who stayed 13 or more days in a rehabilitation setting received the greatest amount of SpAS followed by patients with 6- to 12- and, finally, 3- to 5-day stays in rehabilitation.

This difference in service by length of stay supports conclusions regarding the barriers to good patient care cited by the 2002 Omnibus Survey of 5,000 speech-language pathologists in health care settings. According to Rosenfeld (2002), the most frequent barrier to providing adequate patient care was reduced length of patient stay. Our study indicated that length of stay, particularly in the rehabilitation setting, provided the greatest opportunity for patients to receive SpAS. However, it is important to point out that the most likely facilities

to provide SpAS are rehabilitation hospitals and that smaller rural hospitals are probably less likely to employ staff speech-language pathologists and audiologists. Therefore, the likelihood of receiving SpAS services during longer hospitalizations is influenced by the availability of SpAS as staying longer at a hospital that does not provide SpAS is clearly not going to increase the likelihood of receiving services.

The complexity of diagnoses among patients receiving SpAS was reinforced by the CART tree. Patients who enter the hospital with a major diagnosis frequently received additional SpAS treatment in a rehabilitative setting. Therefore, hospitals that designate their mission as service to patients with more complex diagnoses would appear to require the largest number of rehabilitative specialists to provide SpAs services. The primary number of these services appeared to be provided in urban rather than rural hospitals.

The results of this study have implications for targeting the rehabilitation workforce resources and financial cost expectations. Within the health care system, the number of rehabilitative service visits is increasing gradually, and this increase would be expected to continue due to the increased life expectancy. The highest utilization need for speech-language pathologists appears to be in urban hospitals explicitly targeting rehabilitation as part of their mission.

This study presented a novel approach to examining a large, comprehensive dataset to determine factors affecting speech-language and audiology rehabilitative care. This approach was a valuable and effective tool in determining the factors that influenced speech-language and audiology rehabilitation utilization. Findings indicated that diagnostic complexity, rehabilitative setting, and urban location of hospital facilities rather than demographic variables primarily affected utilization of services. Consideration of these factors should be included in decisions in rehabilitative care utilization.

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