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ORIGINAL ARTICLE – HEALTH SERVICES RESEARCH AND GLOBAL ONCOLOGY

Association of Primary Language with Outcomes After Operations Typically Performed to Treat Cancer: Analysis of a Statewide Database

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ABSTRACT

Background. Few studies have evaluated the effect of primary language on surgical outcomes, and no studies have addressed operations typically performed for cancer diagnoses. This study aimed to determine the effect of primary languages other than English on outcomes after surgical oncology operations.

Methods. This study retrospectively analyzed adults undergoing operations typically performed to treat cancer using the NJ Healthcare Cost and Utilization Project State Inpatient Database during the interval of 2009–2014. Language was grouped according to English-, Spanish-, and non-English/non-Spanish (NENS)-speaking groups. The study evaluated in-hospital mortality, 7-day readmission, and hospital length of stay (LOS). Logistic and negative binomial regression methods were applied, and generalized linear mixed models were used to account for nesting within a hospital.

Results. This study analyzed 37,531 cases. Non-English speakers were of lower economic status, more likely to be admitted on the weekend, and more likely to undergo higher-risk operations. The likelihood of death in the risk-adjusted multi-level models did not differ between Spanish speakers (odds ratio [OR], 0.67; 95% confidence interval [CI], 0.41–1.10) and NENS speakers (OR, 1.16; 95% CI, 0.77–1.75). Readmission rates exhibited high inter-hospital variability (intra-class correlation, 53%). The odds of readmission among Spanish speakers in the non-hierarchical model was increased (OR, 1.50; 95% CI, 1.11–2.02), but this was ameliorated in the multilevel modeling that accounted for variability between hospitals (OR, 1.29; 95% CI, 0.93–1.80). No changes in LOS were observed.

Conclusions. No independent association was observed between primary language and outcomes after operations typically performed to treat cancer in the study population. The higher proportion of weekend admissions may suggest more acute or advanced presentations for non-English speakers. Long-term outcomes may be necessary to discern an impact.

The United States has a heterogeneous multicultural population. As reported, 60 million people speak a language other than English, 25 million (8.6% of the U.S. population) speak English "not well," and up to 20% of the population in some states cannot speak English "well".[1] Patients with limited English proficiency have less of their care provided by a regular PCP, are less likely to have insurance, are less likely to have an education at the high school level or higher, and are less likely to understand discharge instructions well.[2]

Language barriers present a unique challenge for surgeons when communicating complex diagnoses, treatment plans, and postoperative care instructions. Evidence shows that surgeons both recognize and are concerned about providing care to those who are have limited English

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proficiency.[3] Despite this, relatively few studies have evaluated the effects of limited English proficiency on patient outcomes, particularly after surgery.

Studies of medical patients in a single center have reported an increase in readmission but not mortality or hospital length of stay (LOS),[4] whereas studies of surgery patients have found mixed results[5,6] or no change in any outcome metric.[7] However, the surgical series have involved only one to three academic institutions and a limited scope of operations analyzed. Therefore, we aimed to better understand the influence of limited English proficiency on surgical outcomes in a broader context.

This study aimed to evaluate the impact of non-English primary language on outcomes after commonly performed surgical oncology operations. Our hypothesis was that a reduced ability to communicate makes every step in the care delivery pathway more difficult to navigate. Furthermore, we hypothesized that an association of language with outcomes depends on the communication barriers both before and after surgery, and that for the short-term outcomes measured in our study, this would not necessarily require a confirmed cancer diagnosis. Therefore, we predicted that non-English-speaking patients would have measurable differences in LOS, mortality, and readmission.

METHODS

Database

The Healthcare Cost and Utilization Project (HCUP) New Jersey Statewide Inpatient Database (NJ SID) was used. Data were included from years 2009 to 2014. The NJ SID contains information from inpatient discharge records at 68 of the 70 non-rehabilitation hospitals in New Jersey and includes more than 98% of total hospital admission records.[8]

The SID is a comprehensive database containing diagnosis and procedural International Classification of Diseases-9 (ICD-9) codes, comorbidities, financial and billing information, location (e.g., ZIP code), and hospital information. In addition, unlike most other state inpatient databases, the NJ SID includes a variable for patient primary language, which is required for each patient in New Jersey. This study was deemed exempt by our institutional review board as nonhuman subject research.

Case Selection

A complete case analysis was performed under the assumption that missing data are missing completely at random. Cases were included if the patient was 18 years old or older and had at least one procedural code that matched one or more ICD-9 codes for operations typically performed to treat cancer in the seven following general anatomic sites: pancreas, breast, thyroid, adrenal gland, stomach, and liver/biliary tract (see "Appendix A").

The ICD-9 codes were selected based on case requirements for the Complex General Surgical Oncology Fellowship and screened by consensus among the senior authors.[9] This investigation did not include colorectal surgery operations. Cases from a hospital with five or fewer total cases were excluded from the analysis.

Calculation of Case Risk

Due to the variety of cases included in the analysis, a weighted variable was created to stratify the risk of each procedure relative to the others. The baseline risk for each operation was first estimated using the National Surgical Quality Improvement Program (NSQIP) Surgical Risk Calculator.[10,11] The risks of mortality, any morbidity, major morbidity, readmission, and reoperation were calculated for the average patient for each case listed in "Appendix A", and an aggregate risk score then was created and used to categorize risk into six classes. "Appendix A" lists the calculated overall risk score for the average patient for each ICD-9 code.

Exposure and Outcomes

The exposure variable (hospital-reported primary language) was defined as English, Spanish, or non-English/non-Spanish (NENS). The primary outcomes evaluated were in-hospital all-cause mortality (death), 7-day readmission after discharge (readmission), and LOS (measured in days). Short-term outcomes for mortality and readmission are the only variables available in the NJ SID.

Baseline Statistics

Univariate statistics were calculated to analyze frequency and proportion of baseline characteristics across language proficiency. The Pearson Chi-square test was used to evaluate categorical predictors, and an analysis of variance (ANOVA) test was used to evaluate continuous variables. Statistical analysis was performed using Stata MP version 15 (Statacorp, College Station, TX, USA)[12] and R version 3.4.3.[13–21] An alpha of 0.05 was used unless otherwise specified. All statistical tests were two-sided.

Variable Selection and Regression Models

The study included variables for modeling if they were potential confounders regardless of differences in baseline statistics. We were not interested in having primary language act as a surrogate marker for socioeconomic status, access to care, or baseline health status, and included potential confounders in the models to prevent this. A variable for county of residence was created using ZIP code data. The dataset bases income quartile on the median income for the ZIP code of the patient's home address. The variables included in the models are listed in "Appendix B".

Nonlinearity of age was tested using polynomials. Logistic regression was used to model death and readmission. Because negative binomial regression is not normally distributed and the variance is larger than the mean, it was used to model LOS. The area under the receiver operator curve (AUROC) was used to assess concordance of the logistic regression models.

Data also were modeled using two-level generalized linear mixed models to account for intra-hospital correlation based on the assumption that observations were nested within hospitals. Intra-class correlation (ICC), which models the proportion of variance attributable to between-group (i.e., between-hospital) observations, was calculated for death, readmission, and LOS.[21,22] A high ICC means that a high proportion of observed variability is due to between-group (i.e., between-hospital) differences. Likelihood ratio tests evaluated the goodness of fit of mixed-effects models relative to regression without mixed effects.

Interaction effects were determined a priori and included into models in a stepwise fashion to evaluate for effect modification between language and age, race, insurance status, income, sex, county of residence, number of operations performed, cancer diagnosis, risk class, and hospital. To reduce type 1 error, the significance threshold for an included interaction effect was Bonferroni-corrected to 0.005. Interaction effects were considered positive and included if they were less than the corrected threshold.

Sensitivity Analysis

Sensitivity analysis was performed for outcomes with large numbers of missing values to determine whether the effect estimate and associated conclusions would change if all values were included in the analysis. Multiple imputation with chained equations was performed using the "mice" package in R, and the hierarchical nature of the data was accounted for in the imputation modeling.

RESULTS

Baseline Results

This study included 37,531 observations. The baseline descriptive statistics are shown in Table 1. As recorded by the patients, 34,133 spoke English, 1747 spoke Spanish, and 1651 spoke a language other than English or Spanish as their primary language. The top 10 NENS languages in descending order of frequency were Korean, Portuguese, Arabic, Italian, Chinese, Russian, Polish, Tagalog, Hindi, and Gujarati. Our data subset had no missing values for primary language.

The English speakers had a higher proportion of psychiatric illness, obesity, chronic lung disease, and cancer with and without metastases. The majority of the English speakers were white, and they were less likely to be admitted to the hospital during a weekend. The non-English speakers were more likely to be uninsured/self-pay patients and less likely to have private insurance. They were more likely to be admitted on a weekend ($\sim$ 9 vs. 6.8%). The Spanish speakers defined themselves overwhelmingly as non-white/non-black, whereas the NENS speakers were evenly split between white and non-white/non-black. Overall, in this cohort, non-English speakers underwent riskier operations (mean risk score, 2.75 vs. 2.5; $p < 0.001$).

The English-speaking patients were evenly distributed among New Jersey's four income quartiles, but the Spanish-speaking and NENS-speaking patients were more likely to fall into a lower income quartile ($p < 0.001$). For instance, 61% of the Spanish-speaking patients were in quartile 1 (poorest). This is consistent with insurance data, in which English-speaking patients were significantly more likely to have private insurance than Spanish- or NENS-speaking patients (50% vs. 30% and 36%, respectively). The non-English-speaking patients were significantly more likely to be listed as self-pay patients than the English-speaking patients ($p < 0.001$; Table 1).

Outcomes

Descriptive statistics for outcomes are displayed in Table 2. The proportion of deaths did not differ across primary languages. The Spanish-speaking patients had a slightly higher percentage of 7-day readmission than the English or NENS speakers (3.7% vs. 3.3% and 2.6%). The NENS speakers had the lowest proportion of 7-day readmission. Readmission had the highest proportion of missing values (38.4%). No distinct pattern of missing data was evident. When readmission was evaluated by quartile of readmission rate, the Spanish speakers tended to cluster at higher-readmission-rate hospitals, whereas the English

TABLE 1 Baseline characteristics in the population captured by the New Jersey (NJ) State Inpatient Database (SID)

	Overall *n* (%)	English *n* (%)	Spanish *n* (%)	Other (NENS) *n* (%)	*p* Value[a]
n (%)	37,531	34,133 (90.9)	1747 (4.7)	1651 (4.4)	
Mean age	59.48 ± 15.50	59.50 ± 15.50	56.65 ± 15.78	62.13 ± 14.77	< 0.001
Females	27,696 (73.8)	25,313 (74.2)	1252 (71.7)	1131 (68.5)	< 0.001
Race					< 0.001
White	24,478 (65.2)	23,502 (68.9)	117 (6.7)	859 (52.0)	
Black	5445 (14.5)	5335 (15.6)	2 (0.1)	108 (6.5)	
Other	7608 (20.3)	5296 (15.5)	1628 (93.2)	684 (41.4)	
Insurance status					< 0.001
Self-pay, no charge	3075 (8.2)	2266 (6.6)	523 (29.9)	286 (17.3)	
Private insurance	18,016 (48.0)	16,898 (49.5)	521 (29.8)	597 (36.2)	
Medicare	14,002 (37.3)	12,845 (37.6)	490 (28.0)	667 (40.4)	
Medicaid	2438 (6.5)	2124 (6.2)	213 (12.2)	101 (6.1)	
Quartile of income					< 0.001
1st Quartile (lowest)	9479 (25.3)	8025 (23.5)	1067 (61.1)	387 (23.4)	
2nd Quartile	9803 (26.1)	8860 (26.0)	363 (20.8)	580 (35.1)	
3rd Quartile	9453 (25.2)	8892 (26.1)	190 (10.9)	371 (22.5)	
4th Quartile (highest)	8467 (22.6)	8057 (23.6)	111 (6.4)	299 (18.1)	
Missing	329 (0.9)	299 (0.9)	16 (0.9)	14 (0.8)	
Diabetes with complications	662 (1.8)	610 (1.8)	24 (1.4)	28 (1.7)	0.431
Obesity diagnosis	3393 (9.0)	3129 (9.2)	127 (7.3)	137 (8.3)	0.015
Psychiatric illness	761 (2.0)	723 (2.1)	24 (1.4)	14 (0.8)	< 0.001
History of alcohol abuse	701 (1.9)	649 (1.9)	33 (1.9)	19 (1.2)	0.089
Hypertension (complicated or uncomplicated)	17,643 (47.0)	16,048 (47.0)	761 (43.6)	834 (50.5)	< 0.001
Cancer with metastases	4212 (11.2)	3861 (11.3)	176 (10.1)	175 (10.6)	0.199
Chronic lung disease	4854 (12.9)	4528 (13.3)	163 (9.3)	163 (9.9)	< 0.001
Peripheral vascular disease	979 (2.6)	909 (2.7)	27 (1.5)	43 (2.6)	0.017
Renal failure	1831 (4.9)	1699 (5.0)	58 (3.3)	74 (4.5)	0.005
Median no. of chronic conditions (IQR)	3 (2–5)	3 (2–5)	3 (1–5)	3 (2–5)	< 0.001
Weekend admission	2648 (7.1)	2335 (6.8)	164 (9.4)	149 (9.0)	< 0.001
Median admission hour (IQR)	800 (600–1300]	0800 (0600–1200)	0900 (0600–1400)	0900 (0600–1400)	<0.001
Mean no. of procedures during admission (SD)	3 (2–5)	3 (2–5)	2 (1–4)	2 (1–5)	< 0.001
Cancer diagnosis	20,016 (53.3)	18,356 (53.8)	815 (46.7)	845 (51.2)	< 0.001
Calculate risk class					< 0.001
Lowest	7725 (20.6)	7074 (20.7)	371 (21.2)	280 (17.0)	
Minimal	12,870 (34.3)	11,978 (35.1)	402 (23.0)	490 (29.7)	
Low	11,169 (29.8)	9926 (29.1)	652 (37.3)	591 (35.8)	
Moderate	869 (2.3)	788 (2.3)	45 (2.6)	36 (2.2)	
High	2672 (7.1)	2364 (6.9)	158 (9.0)	150 (9.1)	
Highest	2226 (5.9)	2003 (5.9)	119 (6.8)	104 (6.3)	

[a]All *p* values are from group-wise comparisons

NENS non-English/non-Spanish-speaking, *IQR* interquartile range, *SD* standard deviation

speakers tended to cluster at lower-readmission-rate hospitals (Fig. S1). Furthermore, the readmission rates for each language group were comparable within each readmission rate quartile (Fig. S2). That is, for high-readmission-rate hospitals, the English speakers, Spanish speakers, and NENS speakers all had higher readmission rates, with a similar finding among low-readmission-rate hospitals, in which patients of all the language groups had lower readmission rates.

TABLE 2 Baseline statistics for outcomes in the New Jersey (NJ) State Inpatient Database (SID)

	English *n* (%)	Spanish *n* (%)	Other (NENS) *n* (%)	*p* Value	Total missing *n* (%)
n (%)	34,133 (90.9)	1747 (3.9)	1651 (4.4)		
In-patient mortality	693 (2.0)	26 (1.5)	43 (2.6)	0.23	3 (0.0)
Missing values	3 (0.0)	0 (0.0)	0 (0.0)		
7-Day readmission	1133	63	43	< 0.001	14,414 (38.4)
Percentage of total	3.3	3.6	2.6		
Percentage of non-missing	5.3	7.1	4.3		
Missing values	12,908 (37.8)	855 (48.9)	651 (39.4)		
LOS (days)				< 0.001	0 (0.0)
Median (IQR)	3.00 (1–7)	4.00 (1–8)	4.00 (1–8)		
Mean (variance)	6.17 (105)	6.42 (138)	6.56 (71)		
Missing values	0 (0.0)	0 (0.0	0 (0.0)		

Proportions of outcomes and missing values across primary language groups are shown

LOS hospital length of stay, *IQR* interquartile range

The LOS was right-skewed and highly over-dispersed (Table 2) . The English speakers had a 1-day shorter median LOS than the non-English speakers. The LOS showed variation between hospitals (Fig. 1a), but exhibited no distinct pattern when the language groups were compared separately (Fig. 1b).

Unadjusted and Adjusted Regression

Regression results are shown in Table 3. The unadjusted odds of death in the Spanish- and NENS-speaking groups showed no change compared with the English speakers. In the unadjusted analysis, the odds of readmission increased among the Spanish speakers versus the English speakers, and the findings showed a 6% increase in the LOS for the NENS versus the English speakers.

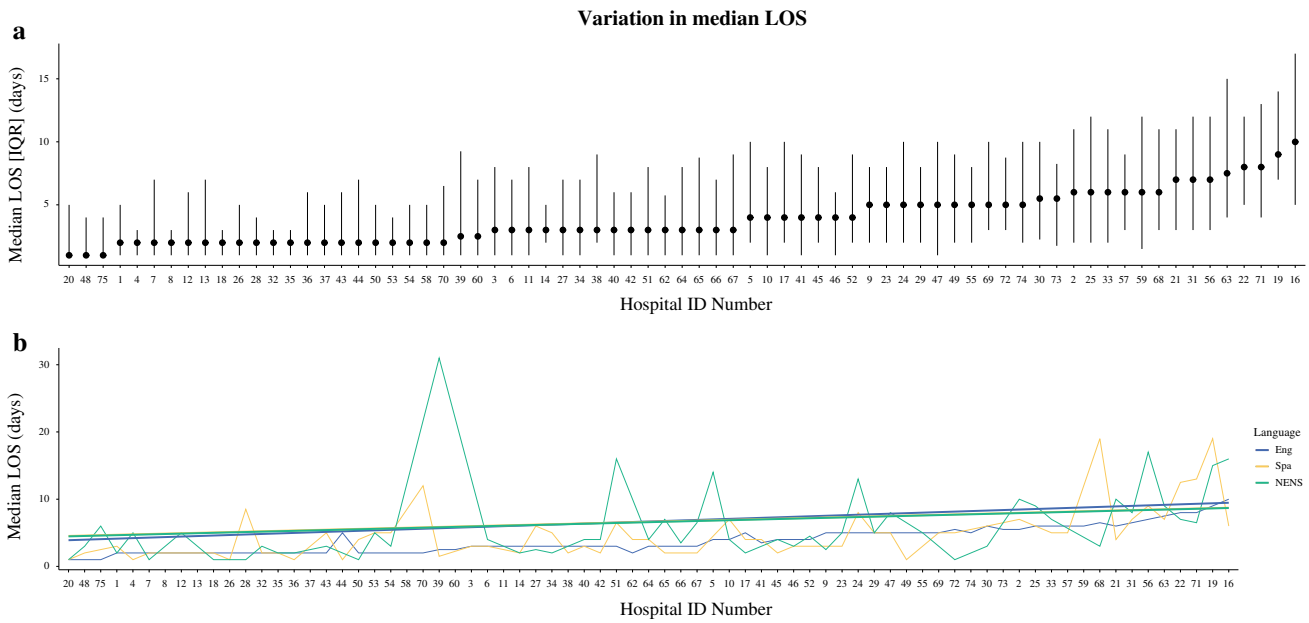

FIG. 1 Variation in hospital length of stay (LOS) among hospitals. **a** Overall median LOS with interquartile range plotted for each hospital. **b** LOS plotted by primary language groups. The medians for all the groups are connected by lines, illustrating variation from hospital to hospital. The linear regression line for each language group is overlaid to show trends. The hospital identification (ID) is ordered by increasing the overall median hospital LOS

TABLE 3 Regression analysis results

	Generalized linear models			Multilevel models		
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	AUROC	Adjusted OR (95% CI)	LRT	ICC
In-patient mortality			0.93		< 0.001	0.12
Spanish versus English	0.73 (0.49–1.08)	0.75 (0.47–1.20)		0.67 (0.41–1.10)		
Other versus English	1.30 (0.94–1.76)	1.30 (0.91–1.87)		1.16 (0.77–1.75)		
Readmittance			0.66		< 0.001	0.53
Spanish versus English	**1.35 (1.04–1.75)**	**1.50 (1.11–2.02)**		1.29 (0.93–1.80)		
Other versus English	0.80 (0.58–1.09)	0.74 (0.54–1.02)		0.80 (0.54–1.18)		
			χ^2 deviance GOF			
LOS, IRR			$p < 0.001$		< 0.001	0.02
Spanish versus English	1.04 (0.99–1.10)	1.01 (0.97–1.05)		1.02 (0.98–1.06)		
Other versus English	**1.06 (1.01–1.12)**	1.05 (0.995–1.11)		1.03 (0.99–1.07)		

Generalized linear models and multilevel model results are shown. Results with confidence intervals that exclude the null value are in bold type

OR odds ratio, *CI* confidence interval, *AUROC* area under receiver operator curve, *LRT* likelihood ratio test (compares multilevel model with non-multilevel model), *ICC* intraclass correlation, *GOF* deviance goodness of fit (indicates how well the negative binomial model fits data compared with the Poisson model), *LOS* hospital length of stay, *IRR* incident rate ratio

No a priori interaction effect reached our threshold for inclusion in modeling. The adjusted odds of death showed no change among the Spanish and NENS speakers compared with the English speakers. The Spanish speakers exhibited a 50% increase in the adjusted odds of readmission compared with the English speakers (OR, 1.50; 95% CI, 1.11–2.02]), but the readmission among the NENS speakers did not differ from that among the English speakers. Furthermore, no evidence of a change in LOS was observed when any non-English-speaking group was compared with the English-speaking group. The AUROC values for death and readmission were respectively 0.93 and 0.66.

Multilevel Regression

Because the observations in the SID database are nested within hospitals, the data have a natural hierarchy leading to intra-hospital correlation between observations, and we used generalized linear mixed models to perform multilevel modeling. Table 3 shows the results of the multi-level modeling. After accounting for within-hospital correlation, the study showed no effects of language on the outcomes of death, readmission, or LOS. The results of multi-level modeling are supported by the ICC values. In-hospital mortality, particularly readmission, demonstrated a higher ICC, with 13% of the variability in mortality and 53% of the variability in readmission due to between-hospital variation. There was a lower ICC value of 2% for LOS, suggesting that variability in LOS between hospitals was minimal.

Sensitivity analysis with imputed readmission outcomes did not change the effect estimates or confidence intervals. Furthermore, a sensitivity analysis was performed that treated missing values for readmission as a "no readmission," and this also did not change the results.

DISCUSSION

Using a large statewide database cataloging inpatient stays in New Jersey from 2009 to 2014, we evaluated the association of primary language proficiency with inpatient stays, postoperative mortality, readmission, and LOS after operations frequently performed to treat cancer. We saw no change in the likelihood of death, but using traditional regression, we saw a substantial increase in 7-day readmission among the Spanish-speaking individuals compared with the English-speaking individuals. However, analysis using hierarchical multilevel models abrogated that effect. Additionally, regression modeling demonstrated no independent association of language with LOS.

To our knowledge, this is the first study to evaluate the effect of language on short-term outcomes after a wide variety of operations typically performed to treat cancer that represent a broad spectrum of risk. The results address an important question about whether primary language is independently associated with differences in postoperative outcomes.

Although our data represent a large set of observations from New Jersey hospitals, this is not a population-based dataset, and thus may not be representative of the New Jersey population. Our observations must be understood with this important caveat: within this large cohort, non-

English-speaking groups tend to be economically disadvantaged and have less insurance coverage. We also observed that the non-English speakers had a higher proportion of weekend admissions than the English speakers, and that the English speakers had a higher proportion of lower-risk operations than the non-English speakers. Taken together, the combination of more weekend admissions and higher-risk operations may indicate that non-English speakers present with more advanced disease. Nevertheless, after adjustment for confounders and intra-hospital correlation, there was no difference in terms of death.

In the aggregate, readmission was increased among the Spanish speakers, but we found no independent association between language and readmission after we accounted for intra-hospital correlation. One possible reason for this was that the Spanish speakers tended to cluster at hospitals with higher overall readmissions, whereas the English speakers tended to cluster at hospitals with lower overall readmissions. Furthermore, the readmission rates for all the language groups were similar even as overall readmissions (per hospital) increased. Put more plainly, the Spanish speakers and the English speakers both tended to have low readmission rates at low-readmission hospitals, and both had higher readmission rates at high-readmission hospitals. This supports our observation that hospital variation was the driver of the aggregate difference in readmission between the Spanish speakers and the English speakers, not the primary language of the patients. Thus, when patient clustering is accounted for, the effect goes away. It is critical to note that without multi-level modeling, we would have concluded a strong independent association between Spanish as the primary language and risk of readmission. In this case, with readmission intra-hospital correlation for readmission as high as 53%, multi-level models likely offer an estimate closer to reality. This highlights the fact that large database studies need to consider intra-hospital correlation and that averaging across hospitals may produce invalid results.

The median LOS was increased in the non-English-speaking groups by 1 day in the univariate analysis. However, when we adjusted for multiple variables, the difference in LOS disappeared between the Spanish- and the NENS-speaking patients compared with the English-speaking patients. In other words, although non-English-speaking patients stay in the hospital longer, this appears to be driven by variables other than the language they speak.

Due to the variety of the hospitals in the statewide dataset, it is difficult to make a direct comparison of our findings with the prior literature on the topic because the cohorts in the literature were limited to a single tertiary center or a small number of them were located in major metropolitan areas.[4–7] Studies that include surgical patients show conflicting results regarding a difference in LOS between English-proficient patients and non-English-proficient patients, with two series showing an increase in LOS for the latter group[5,6] and a third series showing no difference.[7]

A significant strength of our study was the large sample covering 98% of admissions for the state of New Jersey during 5 years. Furthermore, the database is comprehensive, with multiple variables to account for socioeconomic factors. Nevertheless, this analysis also was limited by many of the inherent aspects of a retrospective analysis of an administrative database. For example, data may be misclassified, and factors such as interpreter utilization and multilingual capacity of care providers are lacking. Furthermore, the “primary language” variable fails to measure English proficiency. As a result, it is possible for a patient to report a non-English primary language while still fluent in English, although in our experience, this is uncommon. It also is possible, that because reporting for this variable was required for the state of New Jersey, some misclassification was related to recording English as a default when no information on patient language was available. Despite numerous cases with missing data regarding readmissions, our sensitivity analyses addressing this did not lead to changes in results.

The data presented in this report reflect shorter-term outcomes, which is another limitation to understanding the full relationship, if any, between language and surgical oncology outcomes. Additional information of relevant interest to surgeons would include 30-day mortality, stage at presentation, and cancer-specific survival. Visits to non-hospital care settings for postoperative complications are not included. Additionally, the dataset tracks only visits to New Jersey hospitals, so it is possible that outmigration for postoperative care affected our estimates (e.g., readmission to hospitals in Philadelphia or New York city, given their proximity to the state). However, we believe that seeking care in a facility separate from the initial treatment center is the exception and not the norm, particularly for these very short-term outcomes.

Finally, this is only one state’s data, and New Jersey has a diverse, heterogenous population.[1] It is possible that the lack of a detectable clinical impact of poor English proficiency in this analysis is a function of some hospitals in New Jersey being adept at treating patients with varying English language skills, and that different results may be seen in other places and other populations.

CONCLUSION

In the study cohort, which is a subset of all the patients in New Jersey, Spanish speakers were more likely to face socioeconomic disadvantage (lower income, less insurance

coverage) than other non-English speakers and English speakers, and undergo proportionally more high-risk operations than English-speaking patients. Multi-level, multivariable modeling indicates that for operations commonly performed to treat cancer, primary language has no independent association with short-term outcomes such as inpatient death, LOS, or readmission rates. Our data exhibited high inter-hospital variation that influenced the findings, which should be considered in other large database studies. Additional studies focused on longer-term outcomes, such as 30-day mortality and survival, and more precise data on language fluency are necessary to evaluate further whether primary language has an independent impact on outcomes after general surgical oncology operations.

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DISCLOSURES Timothy Feeney, Michael Cassidy, Yorghos Tripodis, David McAneny, Maureen Kavanah, Teviah Sachs, Jennifer F. Tseng, Frederick Thurston Drake have no conflicts of interest to declare.

APPENDIX A

Risk class	ICD 9	CPT	Description	Total weighted risk (%)
Minimal	85.12	19120	Open biopsy of breast	13.6
	85.21	19120	Local excision of breast lesion	14.1
	06.4	60240	Complete thyroidectomy	17.8
	6.39	60210	Partial thyroidectomy	18.3
	85.23	19301	Subtotal mastectomy	19.4
	06.3		Other partial thyroidectomy	
	06.2		Unilateral thyroid lobectomy	
	06.6		Excision of lingual thyroid	
Lowest	85.41	19303	Unilateral simple mastectomy	51.6
	85.42	19303	Bilateral simple mastectomy	51.6
	34.4	19260	Excision or destruction of chest wall lesion	53.2
	85.46	19307	Bilateral radical mastectomy	53.3
	85.45	19307	Unilateral radical mast	53.3
	07.41	60650	Incision of adrenal gland	35.9
	85.43		Unilateral extended simple mastectomy	
	85.44		Bilateral extended simple mastectomy	
	85.4		Mastectomy	
	85.47		Unilateral extended radical mastectomy	
Low	06.50	60270	Substernal thyroid, sternal split	59.5
	06.51		Partial substernal thyroidectomy	
	06.52		Complete substernal thyroidectomy	
	40.40	38724	Radical neck dissection	65.5
	07.21	60540	Excision of lesion of adrenal gland	86.9
	51.22	47600	Cholecystectomy (non-laparoscopic)	106.8
	51.21		Partial cholecystectomy (non-laparoscopic)	
	50.22	47120	Partial hepatectomy	124.2
	07.12		Open biopsy of adrenal gland	
	07.01		Unilateral exploration of adrenal field	
	07.02		Bilateral exploration of adrenal field	
	07.0		Exploration of adrenal gland	
	40.41		Unilateral neck dissection	
	40.42		Radical neck dissection, bilateral	

Risk class	ICD 9	CPT	Description	Total weighted risk (%)
Moderate	51.03/04	47480	Cholecystostomy	156.4
	51.9	47715	Other operations on biliary tract	125.7
	43.6	43631	Partial gastrectomy with anastomosis to duodenum	144.4
	50.3	47125	Hepatic lobectomy	161.3
	51.8		Other operations on biliary ducts and sphincter of Oddi	
High	43.5	43633	Partial gastrectomy with anastomosis to esophagus	179.8
	52.53	48145	Radical subtotal pancreatectomy	187
	43.8	43632	Other partial gastrectomy	195.7
	43.7	43632	Partial gastrectomy with anastomosis to jejunum	195.7
	52.52	48146	Distal pancreatectomy	197.6
	52.6	48155	Total pancreatectomy	224.3
	52.59		Other operations on biliary tract	
	43.81		Partial gastrectomy with anastomosis to duodenum	
	52.1		Hepatic lobectomy	
	52.9		Other operations on biliary ducts and sphincter of Oddi	
Highest	52.51	48153	Proximal pancreatectomy	232.8
	43.99	43622	Other total gastrectomy	243.2
	43.91	43620	Total gastrectomy with intestinal interposition	246.5
	43.9	43621	Total gastrectomy	249.2
	52.7	48150	Radical pancreaticoduodenectomy	252.2
	43.42		Local excision of other lesion or tissue of Stomach	

Classification of cases into risk class sextiles. ICD-9-CM procedural codes and names are shown for all cases included in the analysis. Corresponding CPT codes, if available, also are listed. The CPT code is used as input for the National Surgical Quality Improvement Program (NSQIP) risk calculator. Cases with an ICD-9-CM code and no CPT code were classed with cases most similar based on the title. Risk class is determined by total risk, which is calculated based on a weighted summation of the risk of death, major and minor morbidity, readmission, and return to the operating room for the average individual in the NSQIP surgical risk calculator. Mortality and Major Morbidity were weighted the most, and readmission and return to the operating room were weighted the least

ICD-9-CM: International Classification of Disease, Ninth Revision, Clinical Modification; CPT: Current Procedural Terminology

APPENDIX B

Outcome	Death	Readmission	LOS
Variables	Full model	Full model	Full model
	Language	Language	Language
	Age	Age	Age
	Age^2	Female	Age^2
	Female	Race	Female
	Race	Insurance status	Race
	Insurance status	Income quartile	Insurance status
	Income quartile	Diabetes with complications	Income quartile
	Diabetes with complications	Obesity	Diabetes with complications
	Obesity	Psychiatric illness	Obesity
	Psychiatric illness	Alcohol abuse	Psychiatric illness
	Alcohol abuse	Hypertension	Alcohol abuse
	Hypertension	Cancer with Metastasis	Hypertension
	Cancer with metastasis	Chronic Lung Disease	Cancer with metastasis
	Chronic lung disease	Peripheral vascular disease	Chronic lung disease

Outcome	Death	Readmission	LOS
	Peripheral vascular disease	Renal failure	Peripheral vascular disease
	Renal failure	No. of chronic conditions	Renal failure
	No. of chronic conditions	No. of in hospital procedures	No. of chronic conditions
	No. of in-hospital procedures	Risk class	No. of in-hospital procedures
	LOS	County of residence	Risk class
	Risk class	Cancer	County of residence
	County of Residence	Hospital ID	Cancer
	Cancer	Weekend admission	Hospital ID
	Hospital ID	Admission hour	Weekend admission
		Admission hour	

Age^2 = age squared

Variables are included in regression models for each outcome

LOS hospital length of stay, *ID* identification

REFERENCES

1. United States Census Bureau-Language Use. Retrieved 5 June 2018 at https://www.census.gov/topics/population/language-use.html.
2. Tuot DS, Lopez M, Miller C, Karliner LS. Impact of an easy-access telephonic interpreter program in the acute care setting: an evaluation of a quality improvement intervention. *Jt Comm J Qual Patient Saf.* 2012;38:81–8.
3. Sillo T, Joshi M. Surgeons' perceptions on the impact of language barriers in the delivery of healthcare. *Int J Surg.* 2015;23:S42.
4. Karliner LS, Kim SE, Meltzer DO, Auerbach AD. Influence of language barriers on outcomes of hospital care for general medicine inpatients. *J Hosp Med.* 2010;5:276–82.
5. John-Baptiste A, Naglie G, Tomlinson G, et al. The effect of English language proficiency on length of stay and in-hospital mortality. *J Gen Intern Med.* 2004;19:221–8.
6. Tang EW, Go J, Kwok A, et al. The relationship between language proficiency and surgical length of stay following cardiac bypass surgery. *Eur J Cardiovasc Nurs.* 2016;15:438–46.
7. Inagaki E, Farber A, Kalish J, et al. Role of language discordance in complication and readmission rate after infrainguinal bypass. *J Vasc Surg.* 2017;66:1473–8.
8. Project HCaU. Overview of the State Inpatient Databases (SID). Retrieved 13 June 2018 at https://www.hcup-us.ahrq.gov/sidoverview.jsp.
9. Oncology TCotSoS. Program Requirements. Retrieved from http://www.surgonc.org/training-fellows/fellows-education/surgical-oncology/program-requirements.
10. Bilimoria KY, Liu Y, Paruch JL, et al. Development and evaluation of the universal ACS NSQIP surgical risk calculator: a decision aid and informed consent tool for patients and surgeons. *J Am Coll Surg.* 2013;217:833–42 e1–3.
11. ACS-NSQIP. Surgical Risk Calculator. Retrieved 26 April 2018 at https://riskcalculator.facs.org/RiskCalculator/index.jsp.
12. Statacorp. *Stata Statistical Software: Release 15.*: Statacorp LP, College Station, TX, 2017.
13. R Core Team. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria, 2017.
14. Wickham H. *tidyverse: Easily Install and Load the 'Tidyverse'*. R package version 1.2.1. 2017. https://CRAN.R-project.org/package=tidyverse.
15. Wickham H, Miiller E. *haven: Import and Export "SPSS," "Stata," and "SAS" Files*. R package version 1.1.1. 2018. Retrieved at https://CRAN.R-project.org/package=haven.
16. Harrell FEJ. *hmisc: Harrell Miscellaneous*. R package version 4.1-1. 2018. https://CRAN.R-project.org/package=Hmisc.
17. Yoshida K, Bohn. J. *tableone: Create "Table 1" to Describe Baseline Characteristics*. R package version 0.8.1. 2017. https://CRAN.R-project.org/package=tableone.
18. Kassambara A. *ggpubr: "ggplot2"-Based Publication Ready Plots*. R package version 0.1.6. 2017. Retrieved at https://CRAN.R-project.org/package=ggpubr.
19. Wickham H. Reshaping data with the {reshape} package. *J Stat Softw.* 2007;21:1–20.
20. Tierney N, Cook D, McBain M, Fay C. *naniar: Data Structures, Summaries, and Visualisations for Missing Data*. R package version 0.3.1. 2018. Retrieved at https://CRAN.R-project.org/package=naniar.
21. Ludecke D. *sjstats: Statistical Functions for Regression Models*. R package version 0.15.0. 2018. https://CRAN.R-project.org/package=sjstats.
22. Aly SS, Zhao J, Li B, Jiang J. Reliability of environmental sampling culture results using the negative binomial intraclass correlation coefficient. *Springerplus.* 2014;3:40.