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Multimorbidity and access to major cancer surgery at high-volume hospitals in a regionalized era

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Abstract

BACKGROUND—The Institute of Medicine has recently prioritized access of quality cancer care to vulnerable persons including multimorbid patients. Despite promotional efforts to regionalize major surgical procedures to high-volume hospitals (HVHs), little is known about change in access to HVH over time among multimorbid patients in need of major cancer surgery. We performed a time-trend appraisal of access of multimorbid persons to HVH for major cancer surgery within a large nationally representative cohort.

METHODS—We identified 168,934 patients who underwent 6 major cancer surgeries from the Nationwide Inpatient Sample (1998 to 2010). Comorbidities were identified using Elixhauser's method. HVHs were defined as hospitals of highest procedure volumes that treated 1/3 of all the patients. Logistic regression models and predictive margins were used to assess the adjusted effects of comorbidity on receiving major cancer surgeries at HVH.

RESULTS—Of all, 45.7% of the patients had 2 comorbidities or more. Multimorbidity predicted decreased access to HVH for esophagectomy, total gastrectomy, pancreatectomy, hepatectomy, and proctectomy, but not for distal gastrectomy, after controlling for covariates. A comorbidity level by year interaction analysis also showed that little disparity existed for receiving distal gastrectomy at an HVH, whereas the predicted difference in probability of receiving any of the other 5 major cancer procedures remained prominent between the years 1998 and 2010.

CONCLUSIONS—In this large 12-year time-trend study, multimorbid cancer patients have sustained low access to HVH for major cancer surgery across many oncologic resections. These results continue to reinforce and highlight the need for policy targeted research and intervention aimed at improving these access gaps.

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Keywords

Multimorbidity; High-volume hospitals; Cancer surgery; Regionalized era

Multiple studies have documented the positive association between high-volume centers and improved surgical outcome. Consequently, hospital volume as a surrogate metric for quality has fostered regionalization of major cancer surgery to high-volume hospitals (HVHs) specializing in specific complex surgical procedures.¹⁻⁴ However, with regionalization has come the concerns of access to care at these HVH.^{5,6} It has been reported that substantial disparities exist with regards to access to HVH.⁷ Although multiple studies have shown that access to HVH and hospital outcomes may be affected by socioeconomic status and race,^{7,8} a paucity of studies have analyzed the role of multimorbidities in access to HVH for major cancer surgery. To what extent, and how this drive for regionalization has affected access to high-quality cancer care at HVH for multimorbid patients, has not been well documented.

The prevalence of multimorbidity and cancer has been shown to increase with age, with over 60 % of patients diagnosed with cancer aged 65 or older and many having associated multimorbidity.⁹⁻¹¹

As the average life expectancy in the United States increases, the proportion of adults older than 65 diagnosed with cancer is expected to increase.¹² An analysis of Medicare beneficiaries showed that 64% of the participants had 2 or more conditions, and 24% had 4 or more conditions.¹³ It has been projected that between 2000 and 2020, the number of Americans with multimorbidity is expected to rise from 60 million to 81 million, this changing demographics in the United States is expected to place new demands on the cancer care delivery system.¹⁴⁻¹⁶

Unfortunately, increasing multimorbidity has been linked to the increased risk of complications¹⁷⁻¹⁹ and steadily declining surgical management regardless of cancer site and disease stage.²⁰⁻²³ Probably, negatively impacting referral of this cohort of patients to HVHs for complex cancer surgery and subsequent acceptance of this cohort of patient for treatment at HVHs. Other factors such as low socioeconomic status, advanced age, and ethnic minority, which have been shown to detrimentally impact access to HVH, have also been intricately linked with multimorbidity.^{24,25}

Intuitively, if the prevalence of multimorbidity is higher in the vulnerable and underserved populations; racial and ethnic minorities, older adults, individuals living in rural and urban underserved areas and populations of lower socioeconomic status, then access of multimorbid patients to HVH for complex cancer would probably also be detrimentally impacted as a result of this association.

Our objectives in this study were twofold: (1.) To assess the relationship between multimorbidity and access to major cancer surgery at HVH, (2.) Perform a time-trend appraisal of the association between multimorbidity and access to HVH for major cancer surgery. With the aim of defining gaps in accessing HVH for major cancer surgery and identifying potential public policy targets that may improve access for this cohort of

patients. We hypothesize that multimorbid patients are less likely to receive major cancer surgery at HVH over time.

Methods

Data source and study population

We obtained discharge data from the Nationwide Inpatient Sample (NIS) from 1998 to 2010. The NIS database is a part of Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality. NIS contains all the discharges from a stratified 20% sample of all nonfederal community hospitals in the United States, regardless of type or status of insurance. We identified 8,655 esophagectomies, 27,018 distal gastrectomies, 13,855 total gastrectomies, 7,851 hepatectomies, 27,422 pancreatectomies, and 84,133 proctectomies on patients 18 years or older, using primary procedure code on the discharge record via *International Classification of Diseases, 9th Revision, Clinical Modification* procedure codes (Volume 326).²⁶

Variables of interest

Our outcome variable was the volume status of the hospital that performed the surgery. The procedure volume of a hospital was dichotomized into high and low so that HVHs performed one-third of all the procedures of a specific type (Stitzenberg), that is, the overall probability of receiving operation at HVH was 33.3%. Hospital volume status and categorization cut-off values were assigned for each procedure each year.

Our primary explanatory variable was the level of comorbidity. Comorbidity is defined as “any additional clinical entity that has existed or that may occur during the clinical course of a patient with an index disease under study”.^{27,28} In this study, it is measured by number of comorbidities included in Elixhauser’s algorithm present on the discharge record (Elixhauser, others). The comorbidities were identified using the Healthcare Cost and Utilization Project Comorbidity Software based on *International Classification of Diseases, 9th Revision* diagnosis codes (ref). Year of admission was used as a continuous variable in time-trend analysis.

Covariates

Information on patients’ sex, age, race, and primary insurance was extracted from the discharge records. Type and region of the admission was also obtained from NIS. Missing information on a covariate was coded as a separate category in that variable.

Statistical analyses

Distributions of all covariates were calculated by volume status of the operative hospital and by comorbidity status, respectively. Chi-square tests were used to test homogeneity of the distributions. Multivariable logistic regressions were then performed to quantify the effect of comorbidity on access to high-volume hospital after adjusting for all covariates previously described (full model). To test whether the association between comorbidity and care at HVH has changed over time, we took 2 approaches. First, we added an interaction term between year of admission and dichotomized level of comorbidity (0 or 1 vs 2 or more) to

the full model. Second, we assessed the level of disparity between patients with 2 or more comorbidities and their healthier counterpart by calculating predictive margin associated with comorbidity from the full model in 3-time periods (1998 to 2002, 2003 to 2006, and 2007 to 2010).

All analyses were procedure-specific, controlled for the sampling scheme, and weighted using discharge weights provided by NIS. All tests were 2 sided with $\alpha = .05$. All analyses were performed in SAS 9.4 (Cary, NC).

Results

Patient characteristics

Patients who received major cancer surgery at an HVH were significantly younger ($P < .0001$), much more likely to have private insurance ($47.1\% \pm .7\%$ vs $37.7\% \pm .3\%$, $P < .0001$), and less likely to be admitted via nonelective routes ($17.6\% \pm 1.0\%$ vs $27.9\% \pm .5\%$, $P < .0001$). The distribution of sex (proportion of males: $52.0\% \pm .5\%$ vs $52.8\% \pm .2\%$, $P = .3$) and race ($P = .1$) were not significantly different between the 2 groups. Patients with less comorbidity (0 to 1 comorbidity) were also younger ($P < .0001$), more likely to be male ($54.4\% \pm .2\%$ vs $50.3\% \pm .3\%$, $P < .0001$), less likely to be black ($5.2\% \pm .2\%$ vs $7.8\% \pm .3\%$), to be admitted via nonelective routes ($19.3\% \pm .6\%$ vs $30.4\% \pm .7\%$, $P < .0001$), and to be a Medicare beneficiary ($38.6\% \pm .4\%$ vs $59.2\% \pm .4\%$, $P < .0001$). The proportion of patients operated at an HVH was 6.3% higher among those with 0 to 1 comorbidity than among those with 2 or more comorbidities ($37.1\% \pm 1.9\%$ vs $30.8\% \pm 1.6\%$, $P < .0001$) (Tables 1 and 2).

Odds of receiving cancer surgery at HVH decrease as comorbidity increases

After controlling for age, sex, race, primary payer, route of admission, and region, we saw a gradient in odds ratios associated with level of comorbidity with regard to operation at HVH for 5 of 6 procedures, with the exception of distal gastrectomy. For total gastrectomy, the odds ratios for operation at HVH dropped from .90 (95% confidence interval [CI] = .81 to 1.01) in patients with 1 comorbidity, to .81 (95% CI = .71 to .93) in patients with 2 comorbidities, and to .68 (95% CI = .57 to .85) in patients with 3 or more comorbidities, with patients with 0 comorbidity as the reference. Similar gradient was seen in patients of esophagectomy, hepatectomy, pancreatectomy, and proctectomy. Among these 5 procedures, the odds ratio between patients with 3 or more comorbidities and patients with 0 comorbidity ranged from .67 (95% CI = .50 to .91) for esophagectomy to .81 (95% CI = .74 to .89) proctectomy. No significant difference was observed between patients with varying levels of comorbidity in regard to access to HVH for distal gastrectomy (odds ratio between 3+ comorbidities vs 0 comorbidity = .95, 95% CI = .83 to 1.09) (Table 3).

Time trend in disparities associated with comorbidity

Test for interaction between year of admission and dichotomized level of comorbidity in a logistic model showed no significance (all $P > .05$). Predicted difference in probability of receiving operation at HVH between patients with 2 or more comorbidities and patients with 0 or 1 comorbidity indicates that little disparity associated with comorbidity exist for

receiving distal gastrectomy in HVH (predicted differences of different time periods ranged from $.3\% \pm .1\%$ to $2.1\% \pm .6\%$), whereas the disparity is prominent for other procedures (eg, predicted difference was $5.0\% \pm 1.7\%$ to $6.1\% \pm 1.7\%$ in total gastrectomy, $4.9\% \pm 1.1\%$ to $5.8\% \pm 1.6\%$ in pancreatectomy). The time trends shown by the predicted differences echoes with the interaction analysis that no clear change over time was observed in the disparity associated with comorbidity with regards to access to HVH for major cancer surgery (Table 4.)

Comments

In this large time-trend study, multimorbid cancer patients have sustained low access to HVH for major cancer surgery across many oncologic resections. In the background of documented improved surgical outcomes at HVH for major cancer surgeries, this result reinforces and highlights the need for policy targeted research and intervention aimed at improving these access gaps. Disparities in access to care have been well documented; however, the effect of multimorbidity on access to HVH for major cancer surgery procedures is unclear. Based on these considerations, we examined the effect of multimorbidity on access to HVHs in a large, contemporary, and national cohort of individuals undergoing 1 of 6 major cancer surgeries. To the best of our knowledge, we do believe that this is one of the 1st studies to specifically address this issue.

In support of our results, other studies have documented that the odds of receiving cancer surgery at an HVH decreased with increased associated comorbidity. Study by Al-Refaie et al²⁹ showed that in addition to race, ethnicity, and insurance status, higher rates of comorbidities was a predictor of receiving complex cancer surgery at a low volume hospital as opposed to an HVH. Trinh et al³⁰ likewise demonstrated that patients with a Charlson Comorbidity Index of 1, 2, or greater than 3 were 18%, 17%, and 19% less likely to be treated at a high-volume institution, respectively.

Interestingly, in our study no change in time trend was observed in the disparity associated with comorbidity with regards to access to HVH for major cancer surgery for 5 of 6 major cancer surgeries assessed; esophagectomy, total gastrectomy, pancreatectomy, hepatectomy, and proctectomy, but not for distal gastrectomy. This disparity remained consistent over the time period studied.

Chang et al,³¹ in their study of variations in referral patterns to HVHs for pancreatic cancer documented a significant increase in overall referral and odds of referral to a high-volume center being observed over time (22.2% in 2000% to 44.4% in 2005). In this study, patients referred to high-volume centers were younger and more likely to be Caucasian. This overall trend toward improved referral over time was driven by improved referral among Caucasians. They conclude that unlike Caucasians, improvement in referral for minorities has not occurred.

Our study showed a statistically significant association between race and level of comorbidity, a finding that has been extensively documented in the literature. We do believe that the lack of significant improvement in access for multimorbid patients to HVHs seen for

esophagectomy, total gastrectomy, hepatectomy, and proctectomy in our study in spite of the drive for regionalization of major cancer procedures, may also be driven by racial factors intricately tied to multimorbidity.

From a practical perspective, our results indicate that, access to HVHs for major cancer surgery is decreased for multimorbid patients. However, this study has a number of limitations; 1st, it is an administrative data set that does not collect patient level information such as; performance status, severity of comorbidities, smoking status, serum albumin, and ASA status or hospital factors (eg, interhospital variations in local practice patterns) making risk adjustment based on administrative data imperfect.^{32,33} Secondly in the NIS, comorbidity was measured using diagnosis codes from only 1 discharge and may underestimate level of comorbidity, and finally, our sample captured only those who did receive surgery.

However, this study has strengths that include: we assessed 6 major cancer surgical procedures and used a national population-based sample representative of the USA population.

Our study, which is exploratory in nature, points to the need for additional research to identify potential mitigators and interventions to reduce this trend for multimorbid patients. Actionable interventions such as; role of patient navigators to help improve access, assessing patient level, and hospital level factor with a goal of determining there degree of impact on patient access to HVH should be prioritized.

In conclusion, multimorbid cancer patients have low access to HVH for major cancer surgery across many oncologic resections and this disparity has remained consistent overtime.

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Table 1

Demographic characteristics of patients of major cancer surgery by hospital volume status (Nationwide Inpatient Sample 1998–2010)

Patient characteristics	High volume (n = 57,105)	Nonhigh volume (n = ,111,829)	P value
	% (SE)	% (SE)	
Comorbidity count			<.0001
2	41.1 (.8)	48.0 (.3)	
Sex			.3
Male	52.0 (.5)	52.8 (.2)	
Age (y)			<.0001
<50	19.9 (.5)	15.4 (.2)	
50–65	36.3 (.4)	34.2 (.2)	
66–80	34.7 (.5)	38.6 (.2)	
>80	9.1 (.3)	11.8 (.2)	
Race			.1
White	62.1 (2.4)	60.1 (.9)	
Black	5.5 (.5)	6.9 (.3)	
Hispanic	5.0 (.7)	5.6 (.3)	
Asian/Pacific Islander	2.7 (.3)	2.7 (.2)	
Route of admission			<.0001
Nonelective	17.6 (1.0)	27.9 (.5)	
Primary payer			<.0001
Medicare	43.6 (.6)	50.3 (.3)	
Medicaid	4.8 (.3)	6.2 (.2)	
Private	47.1 (.7)	37.7 (.3)	
Self-pay	2.0 (.2)	2.9 (.2)	

SE = standard error.

Table 2

Demographic characteristics of patients of major cancer surgery by level of comorbidity (Nationwide Inpatient Sample 1998–2010)

Characteristics	Level of comorbidity		<i>P</i> value
	0 or 1	2 or more	
	Percentage (SE)		
Age (y)			<.0001
<50	22.8 (.3)	10.0 (.2)	
50–65	37.9 (.2)	31.4 (.3)	
66–80	31.8 (.3)	43.7 (.3)	
>80	7.6 (.2)	14.8 (.2)	
Sex			<.0001
Female	45.4 (.2)	49.7 (.3)	
Male	54.4 (.2)	50.3 (.3)	
Race			<.0001
White	60.8 (1.3)	60.7 (1.1)	
Black	5.2 (.2)	7.8 (.3)	
Hispanic	5.2 (.3)	5.6 (.3)	
Asian/Pacific Islander	2.9 (.2)	2.4 (.2)	
Route of admission			<.0001
Nonelective	19.3 (.6)	30.4 (.7)	
Hospital volume			<.0001
High volume	37.1 (1.9)	30.8 (1.6)	
Primary payer			<.0001
Medicare	38.6 (.4)	59.2 (.4)	
Medicaid	5.5 (.2)	5.9 (.2)	
Private	49.7 (.5)	30.4 (.4)	
Self-pay	3.0 (.2)	2.1 (.1)	
Region			.0003
Northeast	22.7 (1.8)	21.0 (1.3)	
Midwest	22.3 (1.4)	23.5 (1.1)	
South	34.3 (1.6)	36.4 (1.3)	
West	20.7 (1.3)	19.1 (1.1)	

SE = standard error.

Adjusted odds ratios of receiving major cancer surgery at high-volume hospital associated with level of comorbidity (Nationwide Inpatient Sample 1998–2010)

Table 3

Comorbidity count (ref = 0)	Esophageal (n = 8,655)	Distal gastric (n = 27,018)	Total gastric (n = 13,855)	Liver (n = 7,851)	Pancreatic (n = 27,422)	Rectal (n = 84,133)
	Odds ratio (95% CI)					
1	.83 (.73,.96)	1.06 (.95,1.18)	.90 (.81,1.01)	.87 (.73,1.03)	.94 (.88,1.01)	.93 (.89,.98)
2	.81 (.67,.97)	1.03 (.91,1.16)	.81 (.71,.93)	.87 (.70,1.07)	.82 (.74,.91)	.87 (.82,.93)
3+	.67 (.50,.91)	.95 (.83,1.09)	.68 (.57,.83)	.79 (.59,1.05)	.69 (.59,.82)	.81 (.74,.89)

CI = confidence interval.

Predicted difference in probability of receiving major cancer surgery at high-volume hospital between patients with 2 or more comorbidities and patients with 0 or 1 comorbidity (Nationwide Inpatient Sample 1998–2010)

Table 4

Time period	Esophageal	Distal gastric	Total gastric	Liver	Pancreatic	Rectal
	Predicted difference in probability of operation at HVH (standard deviation)					
1998–2003	5.1% (1.5%)	.3% (.1%)	5.2% (1.5%)	3.7% (.8%)	5.8% (1.6%)	2.1% (.7%)
2003–2007	4.7% (1.0%)	2.1% (.6%)	5.0% (1.7%)	.8% (.2%)	4.9% (1.1%)	2.7% (.7%)
2007–2010	4.3% (.8%)	.1% (.0%)	6.1% (1.7%)	4.7% (1.2%)	5.0% (1.0%)	2.9% (.9%)

HVH = high-volume hospital.