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Why Do Long-Distance Travelers Have Improved Pancreatectomy Outcomes?

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Abstract

BACKGROUND—Centralization of complex surgical care has led patients to travel longer distances. Emerging evidence suggested a negative association between increased travel distance and mortality after pancreatectomy. However, the reason for this association remains largely unknown. We sought to unravel the relationships among travel distance, receiving pancreatectomy at high-volume hospitals, delayed surgery, and operative outcomes.

STUDY DESIGN—We identified 44,476 patients who underwent pancreatectomy for neoplasms between 2004 and 2013 at the reporting facility from the National Cancer Database. Multivariable analyses were performed to examine the independent relationships between increments in travel distance mortality (30-day and long-term survival) after adjusting for patient demographics, comorbidity, cancer stage, and time trend. We then examined how additional adjustment of procedure volume affected this relationship overall and among rural patients.

RESULTS—Median travel distance to undergo pancreatectomy increased from 16.5 to 18.7 miles (p for trend < 0.001). Although longer travel distance was associated with delayed pancreatectomy, it was also related to higher odds of receiving pancreatectomy at a high-volume hospital and lower postoperative mortality. In multivariable analysis, difference in mortality among patients with varying travel distance was attenuated by adjustment for procedure volume.

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Author Contributions

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However, longest travel distance was still associated with a 77% lower 30-day mortality rate than shortest travel among rural patients, even when accounting for procedure volume.

CONCLUSIONS—Our large national study found that the beneficial effect of longer travel distance on mortality after pancreatectomy is mainly attributable to increase in procedure volume. However, it can have additional benefits on rural patients that are not explained by volume. Distance can represent a surrogate for rural populations.

The documented volume to outcomes relationship in complex surgery, including pancreatectomy, has prompted increasing referrals to surgical centers with large case volumes. As a result, the percentage of pancreatic resections performed at hospitals with 20 or more cases/year has increased.¹ This quest for quality might compromise patient-centeredness of care—evidence has shown that regionalization has led to an overall 40% increase in travel distance to receive pancreatic cancer surgery, and can substantially lengthen their travel time.^{2,3} In addition, travel requirement is typically more onerous for patients who are socially disadvantaged and those who live in rural areas.⁴ For instance, our group reported recently that younger and white patients tend to travel longer distances.⁵ Therefore, regionalization and travel burden also caused concern about equity of healthcare delivery, among other unintended consequences.^{6–11}

To date, the literature remains inconclusive about the effect of travel distance on surgical outcomes. Emerging evidence links greater travel distance with improved pancreatectomy outcomes^{12,13} and speculates that high-volume hospitals are the reason patients travel. In contrast to that, other investigations revealed worse short- and long-term operative outcomes.^{14,15} However, little research has focused on uncovering factors leading to increased travel, and it has not been elucidated why outcomes improve (or not) as travel distance increases. In particular, it remains unclear why this association is solely attributable to the role of hospital volume, or if travel distance also has an independent effect. In this current era of an expanding trend of regionalization nationwide and contradicting emphasis on patient-centered care, these questions necessitate careful evaluation.

With these gaps in the literature, we intend to provide an in-depth analysis of the intertwined relationships among travel distance, case volume, and post-pancreatectomy operative outcomes. We used a decade of data from the National Cancer Database to explore 3 related hypotheses. First, travel distance varies widely by patient demographic and geographical characteristics. Second, increase in travel distance has both positive and negative effects on outcomes of pancreatectomy. Third, receiving pancreatic cancer surgery at high-volume centers is the main reason travel distance is correlated with lower mortality of pancreatectomy.

METHODS

Data source and study population

The National Cancer Database (NCDB) is a clinical oncology database composed of registry information on patients treated in more than 1,500 Commission on Cancer-accredited facilities nationwide for malignant neoplastic diseases. It is estimated that the NCDB includes around 70% of all newly diagnosed cancer cases in the US.¹⁶ Using the NCDB, we

identified adult patients diagnosed with pancreatic neoplasms between 2004 and 2013 who had partial pancreatectomy, total pancreatectomy, or Whipple procedure as the first course of treatment at the reporting facility for benign or malignant tumors. Patients whose travel distance was missing from the database (n ¼ 935 [2.0%]) were removed from the analysis. The analytic sample consisted of 44,476 patients.

Variable of primary interest

The variable of primary interest in this study is the travel distance, which is defined as the great circle distance between the centroid of the patient's ZIP code area and the facility's address. We categorized travel distance into quartiles, resulting in 4 equally sized groups—patients whose great circle distances were 6.9 miles or shorter, 7.0 to 17.7 miles, 17.8 to 49.2 miles, and 49.3 miles or longer.

Outcomes (dependent) variables

Our 3 outcomes (dependent) variables were delayed surgery (more than 30 days after diagnosis); 30-day mortality; and survival time, defined as time from pancreatectomy to death or end of follow-up. To minimize the confounding effect of operative mortality as a result of operative complication on long-term survival, we excluded those who survived after 30 days from the surgery.

Covariates

Covariates included demographics (age, sex, race/ethnicity, insurance status, median household income and percentage of adults without high school degree for the patient's ZIP code area, and rurality of patient's residence), clinical factors (level of comorbidity, extent of pancreatic resection [distal pancreatectomy vs Whipple/total pancreatectomy], and stage of cancer), and hospital characteristics where appropriate (hospital's Commission on Cancer category, area of the US, and case volume). The categories used for median income and education level came from corresponding variables in the NCDB data set, where they were categorized based on national quartiles.¹⁷

Case volume was calculated based on the entire study period; it was categorized into low, medium, and high, so that each category had roughly one-third of all pancreatectomy cases.

Location of diagnosis was recoded into a binomial indicator from the NCDB class of case variable; it distinguished patients who were diagnosed at the reporting and operating facility or offices of its affiliated physicians from those who were diagnosed elsewhere.

Statistical methods

We first cross-tabulated and compared the distribution of covariates and patient outcomes by travel distance using chi-square tests. To evaluate each patient factor's independent association with travel distance, we used them as predictors in a multivariable linear model where log-converted travel distance was the end point. The regression coefficients can be interpreted as approximate percentage changes in travel distance associated with level change in the predicting factor independent of covariates. Next, we developed a logistic model for each patient end point to estimate the effect of travel distance. A Cox

proportional-hazard model was used to examine long-term survival; patients who died within 30 days of surgery were excluded from the analysis. Predictors were selected a priori based on likely causal relationship to the outcomes. All significant covariates were included in these models without selection about model fit because the primary purpose of these models was to obtain unbiased estimates of the association. Finally, we estimated the effect of travel distance on mortality specifically among patients living in rural areas. All analyses were performed using SAS, version 9.4 (SAS Institute). All statistical tests used a 2-sided significance level of 0.05.

RESULTS

Between 2004 and 2013, the median travel distance to undergo pancreatectomy increased from 16.5 to 18.7 miles (p value for trend < 0.001). Table 1 exhibits the characteristics and surgical outcomes of pancreatectomy patients by distance traveled to undergo surgery. Age of patients was similarly distributed across the spectrum of distance traveled. Compared with patients in the first (lowest) quartile of travel distance, those in the fourth (highest) quartile were more likely to be men (52.8% vs 47.4%), non-Hispanic white (87.1% vs 68.7%), and healthy (Charlson-Deyo comorbidity score of 0 [67.4% vs 64.0%]).

There is a nonlinear relationship between travel distance and socioeconomic status of a patient's residential neighborhood. Patients in the second quartile of travel distance were most likely to live in neighborhoods with top-quartile median household income (48.5%). This percentage was lowest among very-long-distance travelers (16.0%).

Travel distance also varied substantially by geography. Compared with patients in the first quartile of travel distance, those in the fourth quartile were more likely to have undergone pancreatic surgery at a hospital in southern US (45.0% vs 29.2%) and less likely in northeastern US (11.1% vs 26.1%). They were also more likely to live in rural counties not adjacent to any metropolitan areas (18.5% vs 0.5%) and less likely to live in metropolitan counties with population of more than 1 million (13.6% vs 67.8%).

Predictors of travel distance to undergo pancreatectomy

Table 2 shows estimates from the log-transformed multivariable linear model of travel distance. Predictors for shorter distance traveled for pancreatectomy included older age, non-white race, Medicaid insurance, no insurance, multimorbidity, or advanced stage of pancreatic cancer at diagnosis. On the other hand, predictors for longer travel distance included geography and location of diagnostic facility. For example, when compared with patients who live in metropolitan counties with more than 1 million in population, those who lived in non-metropolitan areas traveled 141.6% to 190.8% longer; meanwhile, patients in the southern US traveled 36.3% longer than those in northeastern US, on average (95% CI 33.3% to 39.3%). Lastly, patients diagnosed at facilities other than the operating hospital traveled 49.1% longer than their counterparts who were diagnosed and operated on at the same hospital (95% CI 46.5% to 51.7%).

Association between travel distance and delayed pancreatic surgery

After adjusting for all covariates, longer travel distance was incrementally associated with receiving delayed pancreatic surgery. Compared with patients in the first quartile of travel distance, others were more likely to undergo delayed pancreatic surgery (odds ratio [OR] 1.05 for second quartile; 95% CI 0.99 to 1.26; OR 1.16 for third quartile; 95% CI 1.09 to 1.25; OR 1.36 for the fourth quartile; 95% CI 1.26 to 1.46) (Table 3).

Association between travel distance and 30-day mortality and long-term survival

In Model 1 of Table 4, patients with greater travel distance experienced lower 30-day mortality rates than those who traveled shorter. The association between travel distance and long-term survival was weaker, but patients traveling the longest distance (fourth quartile) had a 6% lower hazard of death than those traveling the shortest distance (first quartile: hazard ratio 0.94; 95% CI 0.89 to 0.98). Additionally, moderate reductions in 30-day and long-term mortality were also associated with having a delayed pancreatectomy. Associations between mortality and travel distance were attenuated after procedure volume of the operating hospital was added to the model; only the difference in 30-day mortality between the highest and lowest quartile remained significant (OR 0.82; 95% CI 0.67 to 1.00) but substantially weaker than the previous model without adjusting for procedure volume (OR 0.62; 95% CI 0.51 to 0.75). At the same time, higher 30-day and long-term mortality rates were significantly associated with low and medium procedure volume of the operating hospital (Table 4, Model 2).

Among patients who lived in non-metropolitan counties that were also not adjacent to metropolitan areas, those in the fourth quartile of travel distance were 77% less likely to die within 30 days of pancreatectomy than those in the first quartile (OR 0.23; 95% CI 0.09 to 0.59). This association persisted after additional adjustment for hospital procedure volume (OR 0.28; 95% CI 0.11 to 0.73).

Similar analyses were also performed to test the relationship between travel distance increments and long-term survival. Travel distance did not predict long-term post-pancreatectomy survival even after excluding patients who died within 30 days from surgery (Table 5).

DISCUSSION

The current multi-hospital study uncovered both determinants and consequences of greater distance traveled by patients who underwent pancreatectomy. Longer travel distance is associated with favorable post-pancreatectomy operative outcomes, as well as delayed time to undergo surgery. Although travel distance is also associated with patient-level factors, such as race and insurance, the strongest predictors of longer travel distance are living in rural areas and certain geographical areas of the US. The observed reduction in operative mortality with longer travel distance was mediated by hospital-volume status. However, among rural patients, mortality reduced with increased travel distance, even after adjustment for hospital volume. The current work offers deeper understanding into the interface

between increasing travel distance and outcomes of complex surgery. It also highlights concerns about the possible negative effects on surgical patients.

In agreement with our results, previous and recent literature also reported the association between longer travel distance and lower mortality. In a pivotal study, Ballard and colleagues¹⁸ reported a 33% decrease in 30-day mortality among Medicare patients traveling to Mayo Clinic-affiliated hospitals from outside Olmstead county. However, this study did not adjust for patient factors. Similarly, a recent study using NCDB supports our findings that increased travel distance is associated with improved perioperative mortality and shorter hospitalization. This study also reported the influence of hospital volume on this association.¹³

In contrast to our results, increased travel distance was found to be associated with higher postoperative complications, readmissions, and emergency department visits, leading to worse long-term survival in patients with bladder, lung, pancreas, or esophageal cancer.^{15,19} Similar trends were also revealed in recipients of elective coronary artery bypass grafts.¹⁴ Increased travel distance was also associated with increased hospital length of stay after an elective pancreatic and colorectal surgery. The author speculated the most likely reasons to be concerns about travel time, pain control, complications, availability of transportation, local weather and road conditions, and the time needed to organize multiple services should the patient be geographically isolated.²⁰ These findings warrant additional examination into patient and provider perceptions of traveling long distances to receive complex cancer care. These results also indicate that increased travel distance can have a different effect in different populations.

To expand the understanding of the phenomenon of increased travel distance, our results have also identified factors predictive of travel distance. As mentioned, our previous study found that younger patients, white patients, and those undergoing pancreatic and esophageal resections tend to travel longer distances.⁵ Another recent article reported similarly that elderly (older than 80 years) patients, Medicaid beneficiaries, African Americans, and patients from counties with high socioeconomic indicators were less likely to travel longer distances for surgery.¹² Previous literature indicate that educated and wealthy individuals are more resourceful in finding high-quality care centers and are motivated to travel farther to receive treatment. Elderly patients and patients with higher comorbidities tend to stay local, as they are more comfortable receiving care from and near their primary care physicians and lack a support system away from home.¹²

The lack of a strong association between travel distance and long-term survival outcomes is an interesting observation. This observation persisted even after adjusting for volume across all or rural populations. In contrast to our findings, patients who traveled longer distance to undergo pancreaticoduodenectomy for cancer predicted reduced risk of long-term mortality (hazard ratio 0.75; $p < 0.01$).¹³ In addition, those who traveled farther and underwent esophageal cancer surgery also experienced improved 5-year survival rates.²¹ We speculate that the inclusion of benign pancreatic tumors and distal pancreatic resections in our large and heterogeneous cohort might have contributed to this contrast in long-term survival. We also speculate that the inclusion of patients who died within 30 days of pancreatectomy, a

likely end point of an operative complication, might have contributed to this positive association between longer travel distance and worse long-term outcomes in other publication. These mixed findings call for additional work on the relationship between travel distance and long-term survival after complex or regionalized surgery.

The positive impact of travel distance on operative mortality among rural patients irrespective of hospital volume is an important finding worthy of additional exploration. Previous literature demonstrated that rural patients are disproportionately older, of white race, have low income and fewer comorbidities, and tend to travel longer distances to receive complex surgical care.^{4,22} However, we found no published study examining the impact of volume on rural patients traveling to urban areas to receive complex cancer care. It is unclear why the relationship between increased travel distance in rural patients and improved surgical outcomes is independent of hospital volume. We speculate that longer travel distance selects out relatively healthy over multi-morbid persons in their ability to travel farther to receive complex surgical care at high-volume hospitals. Additionally, longer travel distance by rural patients can address a phenomenon of patients “bypassing” no hospitals along the way to receiving their complex cancer care. For example, although 2 patients could have traveled the same absolute travel distance, 1 patient would have bypassed no hospitals and the other would have potentially bypassed 1 or more hospitals along the way, depending on the regional structure of hospital locations and population density. It is plausible that rural patients can travel long distance without bypass effect and receive care at their nearest hospital, which would be a low-volume hospital.⁶

The implication of our results for disadvantaged populations is equally important. We found that Medicaid beneficiaries or other public insurance holders and those with less education traveled considerably less. Selective contracting, referral patterns, and patient preference might have contributed to these disparate findings.^{23,24} Additionally, Medicaid patients might have encountered state-level coverage limitation in access to high-volume institutions. As a result, the closest location might be the best option in their state and a short travel distance can inaccurately assume poorer care. Together, our findings and those of others continue to reinforce the possible unintended consequences of regionalization of complex surgical care on disadvantaged populations, including ethnic and racial minorities and those who are underinsured.

Our study should be interpreted in light of several limitations. First, it is a retrospective cohort study based on registry data. Travel distances in the database were great circle distance based on ZIP area centroids; without taking transportation and geographic features into account, it might not perfectly reflect the travel burden experienced by those patients. Second, there might be unmeasured patient factors that can influence patients to travel farther to receive surgery at a high-volume hospital, such as patient choice (or lack of), transportation means, and availability of social support. Third, the current work did not account for patients who received neoadjuvant therapy for 2 main reasons: our cohort included patients with benign and malignant pancreatic neoplasms who underwent pancreatectomy as their main method of therapy, and we recognize the ongoing variations in uptake of neoadjuvant therapy to patients with pancreatic cancer. Fourth, this observational study could not rule out all possibilities of biases and confounding, such as potentially

varying patterns of small and critical access hospitals closure and residual confounding by comorbidity that was not captured by the data source. Despite these limitations, our study stems from a large multi-hospital database that is nationally representative of cancer incidence in the US.

The current findings have important implications for maximizing the benefits of regionalization of complex surgical care for disadvantaged surgical patients. Specifically, future efforts by the stakeholders of healthcare should try to address the challenge of travel for vulnerable patients. As an example, the State of Maryland approved Maryland Health Improvement and Disparities Reduction Act (the “Act”) in 2012 and established health enterprise zones. Health enterprise zones are geographic areas where the population experiences poor outcomes that contribute to racial/ethnic and geographic health disparities. Identifying such geographical zones helped focus resources, such as shuttle rides, cost reimbursements from health insurances or hospitals, and use of telephone and electronic communication for optimization of hospital visits and medical appointments.²⁵ Future studies should explore the effect of early identification of patients who must travel long distances to receive their surgical cancer care and assist with their travel needs.

CONCLUSIONS

The current large multi-state national study identified both the reasons behind and consequences of greater distance traveled by patients who received pancreatectomy. Greater travel distance is associated with favorable post-pancreatectomy operative outcomes but delayed time to surgery. Patient-level factors, such as living in rural areas, geography, race, and insurance, strongly predicted longer travel. The observed reduction in operative mortality with longer travel distance was mediated by hospital-volume status expected for rural patients. Travel distance can also represent a surrogate for rural population who travel farther. Our findings offer future implications for widening the benefits of regionalization of complex surgical care to a large cohort including vulnerable surgical patients.

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Characteristics among Patients with Pancreatic Cancer Who Received Pancreatectomy as First Course of Treatment by Travel Distance, National Cancer Database 2004 to 2013 (N = 44,476)

Table 1

Characteristic	1st quartile (n = 11,152)	2nd quartile (n = 11,091)	3rd quartile (n = 11,152)	4th quartile (n = 11,081)	Chi-square p Value
Age at diagnosis, y, median (IQR)	67 (58–75)	66 (57–74)	65 (57–73)	66 (57–73)	0.0014
Sex					
Male	5,322 (47.7)	5,600 (50.5)	5,720 (51.3)	5,854 (52.8)	
Female	5,830 (52.3)	5,491 (49.5)	5,432 (48.7)	5,227 (47.2)	
Race/ethnicity					<0.0001
Non-Hispanic white	7,661 (68.7)	8,708 (78.5)	9,665 (86.7)	9,655 (87.1)	
Non-Hispanic black	2,025 (18.2)	1,171 (10.6)	735 (6.6)	670 (6.1)	
Hispanic	849 (7.6)	677 (6.1)	365 (3.3)	313 (2.8)	
Asian	355 (3.2)	250 (2.3)	142 (1.3)	85 (0.8)	
Primary payer					<0.0001
Private insurance	4,051 (36.3)	4,716 (42.5)	4,795 (43.0)	4,279 (38.6)	
Medicaid	749 (6.7)	448 (4.0)	405 (3.6)	437 (3.9)	
Medicare	5,791 (51.9)	5,357 (48.3)	5,418 (48.6)	5,705 (51.5)	
Uninsured	355 (3.2)	322 (2.9)	246 (2.2)	260 (2.4)	
Charlson-Deyo score					<0.0001
0	7,137 (64.0)	7,207 (65.0)	7,375 (66.1)	7,470 (67.4)	
1	3,106 (27.9)	3,033 (27.4)	2,987 (26.8)	2,888 (26.1)	
2	909 (8.2)	851 (7.7)	790 (7.1)	723 (6.5)	
American Joint Committee on Cancer analytic stage					<0.0001
0	306 (2.7)	314 (2.8)	341 (3.1)	405 (3.7)	
I	2,141 (19.2)	2,008 (18.1)	1,992 (17.9)	1,978 (17.9)	
II	6,997 (62.7)	7,137 (64.4)	7,247 (65.0)	7,103 (64.1)	
III	355 (3.2)	323 (2.9)	287 (2.6)	284 (2.6)	
IV	589 (5.3)	559 (5.0)	542 (4.9)	516 (4.7)	
Median income in patient's ZIP code area, 2008 to 2012					<0.0001

Characteristic	1st quartile (n = 11,152)	2nd quartile (n = 11,091)	3rd quartile (n = 11,152)	4th quartile (n = 11,081)	Chi-square p Value
<\$38,000	2,492 (22.4)	864 (7.8)	1,218 (10.9)	2,749 (24.8)	
\$38,000 to \$47,999	2,259 (20.3)	1,689 (15.2)	2,435 (21.8)	3,648 (32.9)	
\$48,000 to \$62,999	2,739 (24.6)	3,152 (28.4)	3,138 (28.1)	2,891 (26.1)	
\$63,000+	3,658 (32.8)	5,382 (48.5)	4,355 (39.1)	1,771 (16.0)	
No high school degree in patient's ZIP code area, 2008 to 2012					
21%	2,203 (19.8)	1,230 (11.1)	1,520 (13.6)	1,945 (17.6)	<0.0001
13% to 20%	2,682 (24.1)	2,254 (20.3)	2,999 (26.9)	3,426 (30.9)	
7.0% to 12.9%	3,291 (29.5)	3,710 (33.5)	3,830 (34.3)	3,655 (33.0)	
<7%	2,973 (26.7)	3,894 (35.1)	2,798 (25.1)	2,044 (18.5)	
Location of reporting facility					
Northeast	2,913 (26.1)	2,683 (24.2)	2,440 (21.9)	1,232 (11.1)	
South	3,255 (29.2)	3,779 (34.1)	4,306 (38.6)	4,988 (45.0)	
Midwest	2,743 (24.6)	2,481 (22.4)	2,668 (23.9)	2,958 (26.7)	
West	1,961 (17.6)	1,818 (16.4)	1,420 (12.7)	1,616 (14.6)	
Rurality of patient's county of residence					
Metro area, 1 million population	7,559 (67.8)	8,107 (73.1)	6,093 (54.6)	1,511 (13.6)	<0.0001
Metro area, <1 million population	3,256 (29.2)	2,521 (22.7)	2,552 (22.9)	4,304 (38.8)	
Non-metro, adjacent to a metro area	85 (0.8)	215 (1.9)	1,996 (17.9)	2,946 (26.6)	
Non-metro, not adjacent to a metro area	59 (0.5)	33 (0.3)	257 (2.3)	2,047 (18.5)	

Values are n (%) unless otherwise noted.

IQR, interquartile range.

Table 2

Adjusted Association Between Risk Factors and Travel Distance for Pancreatectomy among Patients with Pancreatic Cancer Who Received Pancreatectomy as First Course of Treatment by Travel Distance, National Cancer Database 2004 to 2013 (N = 44,476)

Variable, level	Percentage change (95% CI)	p Value
Intercept, miles	12.4 (11.5 to 13.4)	<0.0001
Age (reference, 18 to 44 y)		
45 to 54 y	-9.8 (-17.0 to -2.6)	0.007
55 to 64 y	-13.5 (-20.5 to -6.6)	0.0001
65 to 74 y	-15.5 (-22.8 to -8.2)	<0.0001
75 to 84 y	-26.4 (-33.9 to -18.9)	<0.0001
85+ y	-33.6 (-43.8 to -23.5)	<0.0001
Sex, female (reference, male)	-3.7 (-5.8 to -1.5)	0.0008
Race (reference, non-Hispanic white)		
Asian	-32.2 (-40.2 to -24.3)	<0.0001
Hispanic	-23.1 (-28.3 to -17.8)	<0.0001
Non-Hispanic black	-46.2 (-49.9 to -42.5)	<0.0001
Other	14.2 (-4.7 to 33.2)	0.14
Insurance status (reference, private insurance)		
Medicare	-3.2 (-6.4 to 0.1)	0.06
Medicaid	-25.3 (-30.8 to -19.7)	<0.0001
Other government	15.4 (4.8 to 26.1)	0.005
Not insured	-18.4 (-25.4 to -11.4)	<0.0001
Charlson-Deyo score (reference, 0)		
1	-6.1 (-8.6 to -3.6)	<0.0001
2 or more	-12.6 (-16.7 to -8.5)	<0.0001
American Joint Committee on Cancer analytic stage (reference, stage II)		
0	19.5 (13.2 to 25.8)	<0.0001
I	-1.9 (-4.8 to 1.1)	0.21
III	-14.0 (-20.5 to -7.5)	<0.0001
IV	-10.2 (-15.2 to -5.1)	<0.0001
Extent of pancreatectomy, total/Whipple (reference, distal pancreatectomy)	8.3 (5.6 to 11.0)	<0.0001
No high school degree in patient's ZIP code area to 2008 to 2012 (reference, <7.0%)		
7.0% to 12.9%	3.4 (0.5 to 6.2)	0.02
13% to 20%	-1.1 (-4.3 to 2.0)	0.47
21%	-12.9 (-16.6 to -9.2)	<0.0001
Rurality of patient's county of residence (reference, metro area, 1 million population)		
Metro area, <1 million	58.6 (56.1 to 61.1)	<0.0001
Non-metro, next to metro	141.6 (138.0 to 145.2)	<0.0001
Non-metro, not next to metro	190.8 (185.9 to 195.7)	<0.0001

Variable, level	Percentage change (95% CI)	p Value
Location of reporting facility (reference, Northeast)		
Midwest	13.6 (10.4 to 16.8)	<0.0001
South	36.3 (33.3 to 39.3)	<0.0001
West	15.5 (11.9 to 19.2)	<0.0001
Class of case, diagnosed elsewhere (reference, diagnosed at reporting facility or affiliated physician office)	49.1 (46.5 to 51.7)	<0.0001

Table 3

Adjusted Odds Ratios Associated with Delayed Surgery among Patients with Pancreatic Tumors Who Received Pancreatectomy as First Course of Treatment by Travel Distance, National Cancer Database 2004 to 2013 (N = 44,476)

Travel distance (reference, 1st quartile)	Odds ratio (95% CI)	p Value
2nd quartile	1.05 (0.99–1.26)	0.13
3rd quartile	1.16 (1.09–1.25)	<0.0001
4th quartile	1.36 (1.26–1.46)	<0.0001

Table 4

Adjusted Odds Ratios Associated with Postoperative Mortality among Patients with Pancreatic Tumors who Received Pancreatectomy as First Course of Treatment by Travel Distance, National Cancer Database 2004 to 2013 (N = 38,591)

Variable	Model 1				Model 2			
	30-d mortality		Long-term survival		30-d mortality		Long-term survival	
	OR (95% CI)	p Value	HR (95% CI)	p Value	OR (95% CI)	p Value	HR (95% CI)	p Value
All pancreatectomy patients (n = 36,707)								
Travel distance (reference, 1st quartile)								
2nd quartile	0.85 (0.73–0.98)	0.024	0.97 (0.93–1.01)	0.088	0.89 (0.77–1.03)	0.12	0.98 (0.95–1.02)	0.34
3rd quartile	0.76 (0.65–0.89)	0.0006	0.98 (0.94–1.02)	0.36	0.86 (0.73–1.01)	0.069	1.01 (0.97–1.06)	0.51
4th quartile	0.62 (0.51–0.75)	<0.0001	0.94 (0.89–0.98)	0.0048	0.82 (0.67–1.00)	0.047	1.00 (0.95–1.05)	0.97
Location of diagnosis, elsewhere (reference, reporting facility or staff physician office)	0.87 (0.75–1.01)	0.063	1.07 (1.03–1.10)	0.0002	0.89 (0.77–1.04)	0.14	1.07 (1.04–1.11)	<0.0001
Days from diagnosis to operation, >30 d (reference, 0 to 30 d)	0.81 (0.71–0.94)	0.0038	0.86 (0.83–0.89)	<0.0001	0.82 (0.71–0.94)	0.0054	0.86 (0.83–0.89)	<0.0001
Procedure volume of reporting facility (reference, high)								
Low	—	—	—	—	2.15 (1.80–2.56)	<0.0001	1.20 (1.15–1.25)	<0.0001
Medium	—	—	—	—	1.43 (1.22–1.68)	<0.0001	1.07 (1.04–1.11)	<0.0001
Rural pancreatectomy patients (n = 1,794)								
Travel distance (reference, 0 to 10 miles)								
2nd quartile	0.85 (0.21–3.50)	0.82	0.83 (0.46–1.49)	0.54	0.88 (0.22–3.64)	0.87	0.85 (0.47–1.52)	0.58
3rd quartile	0.59 (0.22–1.61)	0.30	1.18 (0.80–1.73)	0.40	0.59 (0.22–1.62)	0.31	1.19 (0.81–1.75)	0.34
4th quartile	0.23 (0.09–0.59)	0.0023	0.88 (0.61–1.27)	0.50	0.28 (0.11–0.73)	0.0093	0.96 (0.61–1.36)	0.81
Location of diagnosis (reference, reporting facility or staff physician office), elsewhere	1.51 (0.84–2.72)	0.17	1.03 (0.89–1.20)	0.68	1.44 (0.80–2.59)	0.23	1.03 (0.89–1.19)	0.70

Variable	Model 1				Model 2			
	30-d mortality		Long-term survival		30-d mortality		Long-term survival	
	OR (95% CI)	p Value	HR (95% CI)	p Value	OR (95% CI)	p Value	HR (95% CI)	p Value
Days from diagnosis to operation, >30 d (reference, 0 to 30 d)	0.67 (0.36–1.28)	0.23	0.78 (0.67–0.91)	0.0014	0.69 (0.36–1.31)	0.26	0.78 (0.67–0.90)	0.0010
Procedure volume of reporting facility (reference, high)								
Low	—	—	—	—	1.56 (0.65–3.77)	0.32	1.36 (1.12–1.65)	0.0023
Medium	—	—	—	—	0.63 (0.27–1.50)	0.3	1.07 (0.91–1.25)	0.40

HR, hazard ratio; OR, odds ratio.

Process and Outcomes of Surgical Treatments among Patients with Pancreatic Tumors Who Received Pancreatectomy as First Course of Treatment by Travel Distance, National Cancer Database 2004 to 2013 (N = 44,476)

Table 5

Variable	0 to 10 miles (n = 39,967)	10 to 30 miles (n = 5,425)	30 to 100 miles (n = 39,967)	100 miles (n = 5,425)	Chi-square p Value
Location of diagnosis					
Reporting facility/staff physician office	9,777 (87.7)	8,841 (79.7)	8,281 (74.3)	7,905 (71.3)	<0.0001
Elsewhere	1,375 (12.3)	2,250 (20.3)	2,871 (25.7)	3,176 (28.7)	
Type of cancer program at reporting facility					
Academic/research program	4,998 (44.8)	6,114 (55.1)	7,335 (65.8)	8,561 (77.3)	<0.0001
Comprehensive community program	4,204 (37.7)	3,263 (29.4)	2,630 (23.6)	1,787 (16.1)	
Integrated network program	1,057 (9.5)	1,040 (9.4)	693 (6.2)	369 (3.3)	
Community program	598 (5.4)	308 (2.8)	160 (1.4)	76 (0.7)	
Operation to discharge, d, median (IQR)	9 (7–15)	9 (6–13)	8 (6–13)	8 (6–13)	<0.0001
Total pancreatectomy volume of operating hospital, n, median (IQR)	80 (33–177)	145 (67–280)	219 (98–435)	295 (163–648)	
Procedure volume of reporting facility					
Low or medium	9,453 (84.8)	8,070 (72.8)	6,901 (61.9)	5,050 (45.6)	
High	1,699 (15.2)	3,021 (27.2)	4,251 (38.1)	6,031 (54.4)	<0.0001
From diagnosis to operation, d, median (IQR)	9 (0–27)	12 (0–29)	14 (0–32)	15 (0–34)	
Had operation within 30 d of diagnosis					
Yes	8,754 (78.5)	8,423 (75.9)	8,177 (73.3)	7,897 (71.3)	
No	2,398 (21.5)	2,668 (24.1)	2,975 (26.7)	3,184 (28.7)	0.001
Died within 30 d of operation					
No	8,624 (93.9)	8,529 (95.39)	8,531 (95.56)	8,470 (95.5)	
Yes	463 (5.04)	330 (3.69)	305 (3.42)	283 (3.19)	
Unknown	97 (1.06)	82 (0.92)	91 (1.02)	116 (1.31)	<0.0001
Died within 90 d of operation					
No	8,140 (88.63)	8,184 (91.53)	8,159 (91.4)	8,081 (91.12)	
Yes	910 (9.91)	644 (7.2)	629 (7.05)	580 (6.54)	
Unknown	134 (1.46)	113 (1.26)	139 (1.56)	208 (2.35)	

Variable	0 to 10 miles (n = 39,967)	10 to 30 miles (n = 5,425)	30 to 100 miles (n = 39,967)	100 miles (n = 5,425)	Chi-square p Value
Readmission within 30 d of surgical discharge					
Not readmitted	9,616 (86.2)	9,609 (86.6)	9,779 (87.7)	9,840 (88.8)	<0.0001
Index readmission	951 (8.5)	1005 (9.1)	973 (8.7)	847 (7.6)	
Non-index readmission	313 (2.8)	255 (2.3)	228 (2.0)	224 (2.0)	
Both index and non-index readmissions	22 (0.2)	35 (0.3)	28 (0.3)	35 (0.3)	
Unknown	250 (2.2)	187 (1.7)	144 (1.3)	135 (1.2)	

Values are n (%) unless otherwise noted.

IQR, interquartile range.