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RESEARCH ARTICLE

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Accessing surgical care for pancreaticoduodenectomy: Patient variation in travel distance and choice to bypass hospitals to reach higher volume centers

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Abstract

Background: While better outcomes at high-volume surgical centers have driven regionalization of complex surgical care, access to high-volume centers often requires travel over longer distances. We sought to evaluate travel patterns of patients undergoing pancreaticoduodenectomy (PD) for pancreatic cancer to assess willingness of patients to travel for surgical care.

Methods: The California Office of Statewide Health Planning database was used to identify patients who underwent PD between 2005 and 2016. Total distance traveled, as well as whether a patient bypassed the nearest hospital that performed PD to get to a higher-volume center was assessed. Multivariate analyses were used to identify factors associated with bypassing a local hospital for a higher-volume center.

Results: Among 23 014 patients who underwent PD, individuals traveled a median distance of 18.0 miles to get to a hospital that performed PD. The overwhelming majority (84%) of patients bypassed the nearest providing hospital and traveled a median additional 16.6 miles to their destination hospital. Among patients who bypassed the nearest hospital, 13,269 (68.6%) did so for a high-volume destination hospital. Specifically, average annual PD volume at the nearest "bypassed" vs final destination hospital was 29.6 vs 56 cases, respectively. Outcomes at bypassed vs destination hospitals varied (incidence of complications: 39.2% vs 32.4%; failure-to-rescue: 14.5% vs 9.1%). PD at a high-volume center was associated with lower mortality (OR = 0.46 95% CI, 0.22-0.95). High-volume PD (> 20 cases) was predictive of hospital bypass (OR = 3.8 95% CI, 3.3-4.4). Among patients who had surgery at a low-volume center, nearly 20% bypassed a high-volume hospital in route. Furthermore, among patients who did not bypass a high-volume hospital, one-third would have needed to travel only an additional 30 miles or less to reach the nearest high-volume hospital.

Conclusion: Most patients undergoing PD bypassed the nearest providing hospital to seek care at a higher-volume hospital. While these data reflect increased regionalization of complex surgical care, nearly 1 in 5 patients still underwent PD at a low-volume center.

KEYWORDS
access, pancreaticoduodenectomy, surgery, travel

1 | INTRODUCTION

Americans face an increasing and diverse number of barriers to access healthcare. Potential barriers include insurance status, health literacy, and cost, all of which have been extensively examined.[1-3] Another less studied barrier is the distance needed to travel to obtain care.[4,5] Specifically, with increased emphasis on centralization of healthcare networks and particularly surgical services, rural hospitals are at an increased risk of foreclosure.[6-10] While the number of major surgical hospitals increased over the decade from 2005 to 2015, there was an 82% increase in the number of people who lived further than an hour from any hospital, let alone a high-volume surgical center.[4] In fact, up to 10% of the United States population resides outside a 30 mile radius of a hospital with the capacity to perform adult inpatient surgery.[5] While access to surgical services has been examined through the lens of insurance, race, and health literacy, the relationship of travel distance to access, in the context of surgical cancer care, has only more recently become an area of closer focus.[11,12]

Surgical services are a large part of curative-intent therapy for patients with cancer. High-volume surgical centers have lower morbidity and mortality compared with low-volume centers, especially among patients undergoing more complex and high-risk cancer-related surgical procedures.[13-15] These high-volume centers are often located, however, in urban areas, which compounded by the closure of existing rural hospital-based surgical services, may hinder rural community access to high-quality surgical care.[13,15-17] For example, although the number of hospitals that provided surgical services with an approved American College of Surgeons (ACS) cancer program slightly increased since 2005, the number of people living greater than 60 minutes has increased from 6% to 11%.[18]

The call to centralize complex surgical procedures, including operations associated with cancer treatment, to high-volume centers has the potential to create a significant barrier of increased travel burden on potentially vulnerable populations.[16,19] Understanding the characteristics of patients and travel burden experienced by individuals who must travel to receive surgical cancer care is, therefore, important. The objective of the current study was to characterize travel patterns among patients who underwent pancreaticoduodenectomy (PD) for cancer. In particular, we sought to determine the travel distance burden among patients undergoing PD, as well as examine whether patients were likely to bypass a closer hospital that performed PD to access a different center.

2 | METHODS

2.1 | Data and study population

A cohort analysis of the California Office of State-wide Health Planning and Development[20] (OSHPD) hospital discharge database from 2005 to 2016 was performed. As a department within the California Health and Human Services Agency, the OSHPD oversees the collection and dissemination of healthcare information from licensed practitioners and hospitals within California, resulting in complete capture of all hospital stays for California patients. The data were appropriately deidentified with encrypted ID assignments.

The International Classification of Diseases, ninth and tenth Revision (ICD-9 and ICD10) diagnosis and procedure codes were utilized to define the population of interest. Specifically, patients with a diagnosis of pancreatic, duodenal, or biliary neoplasm (See Appendix 1 for ICD codes) who underwent a PD (See Appendix 1 for ICD codes) were included in the analytic cohort (n = 23 014). Patient-specific variables selected for analysis included age, race/ethinicity, sex, and insurance type. Hospital variables included teaching hospital status, number of beds, number of operating rooms, and annual PD hospital volume and in-hospital all-cause mortality for PD. Outcomes of interest were total real driving distance traveled to reach destination hospitals, as well as the incidence of patients who bypassed a hospital that performed PD to reach a different center that performed PD surgery.

2.2 | Geospatial analysis

Data were imported into QGIS 2.18 statistical package for geospatial analysis (QGIS Development Team, 2009. QGIS Geographic

TABLE 1 Patient and hospital level characteristics for patients undergoing pancreaticoduodenectomy, 2005-2016

Patient characteristics (N = 23 014)		
Median distance traveled (Miles) (IQR)	18.0	7.6-42.0
Bypassed nearest providing hospital (%)	19 327	83.9%
Age (Mean) [SD]	65.54	11.37
Sex		
Male	12 026	52.3%
Female	10 988	47.7%
Race (%)		
White	14 505	63.0%
African American	1294	5.6%
Hispanic	3738	16.2%
Asian	2632	11.4%
Other	845	3.7%
Insurance (%)		
Self pay	289	1.3%
Medicaid	1796	7.8%
Medicare	11 902	51.7%
Private	8536	37.1%
Other	289	1.3%
Destination hospital characteristics (n = 189)		
Annual procedure volume (mean SD)	10.17	20.7
High volume (> 20 PD per y)	14 510	63.05
In-hospital mortality rate (mean SD)	3.7	0.19
LOS (days) (mean SD)	15.16	12.08
Charge $USD (mean SD)	220 496	265 755
Total admissions (mean SD)	21 335.87	9398.36
Total beds (mean SD)	432.58	191.87
Total operating rooms (mean SD)	25.58	11.47
Academic Medical Center (Total, %)	17 803	77.36
Full time nurses (mean SD)	1404.1	674.37

Abbreviations: LOS, length-of-stay; PD, pancreaticoduodenectomy.

TABLE 2 Unadjusted comparison of patient and hospital characteristics based on hospital bypass status

	Nearest hospital (n = 3687)		Bypassed hospital (n = 19 327)		*P*
Median miles traveled (IQR)	4.72	2.91-11.44	21.34	10.04-49.18	< .001
Age	67.07	66.71-67.43	65.25	65.09-65.41	< .001
Race					
White	2412	65.4%	12 093	62.6%	< .001
Black	235	6.3%	1059	5.5%	
Hispanic	575	15.6%	3163	16.3%	
Asian	337	9.1%	2295	11.9%	
Other	128	4.4%	717	3.7%	
Sex					
Male	4380	51.4%	7665	52.7%	< .001
Female	4136	48.6%	6877	47.3%	
Insurance					
Self pay	43	1.2%	246	1.3%	< .001
Medicaid	281	7.6%	1515	7.9%	
Medicare	2136	57.9%	9766	51.0%	
Private	1176	31.9%	7360	38.5%	
Other	51	1.4%	246	1.3%	
Destination hospital characteristics					
Annual procedure volume (mean SD)	29.57	28.29-30.84	55.99	55.35-56.62	< .001
High volume (> 20 PD per y)	33.7%	32.13-35.18	68.6%	68.0-69.31	
In-hospital mortality rate (mean SD)	6.08%	5.30-6.84	3.21%	2.96-3.46	< .001
LOS (days)	17.1	16.65-17.46	14.8	14.63-14.97	< .001
Charge ($USD)	229 951.70	221 595-238 308	218 692	214 927-222 457	.0184
Complication	39.2%	37.59-40.74	32.4%	31.69-33.01	< .001
Failure to rescue	14.47%	12.66-16.29	9.1%	8.43-9.86	< .001
Academic medical center	60.4%	58.77-61.93	80.6%	80.04-81.16	< 0.001
Total admissions	18 956	18 628-19 284	21 774	21 640-21 908	< .001
Total beds	371.52	365.01-378.04	443.83	441.09-446.57	< .001
Total operating rooms	20.9	20.48-21.37	26.4	26.20-26.55	< .001
Full time RN	1120.1	1091.16 – 1148.98	1449.6	1439.03-1460.13	< .001

Abbreviations: LOS, length-of-stay; PD, pancreaticoduodenectomy.

Information System. Open Source Geospatial Foundation). Hospitals were geocoded using the reported address. Using OpenStreetMaps road and traffic data and osm2po routing engine, travel distances were calculated to each hospital.[21] The nearest hospital assigned to each patient was determined by the shortest driving distance between the patient's corresponding residential zip code and a given hospital location. Patients were defined as bypassing the nearest providing facility if the actual travel distance surpassed the shortest calculated travel distance. Differential distance was then calculated as the difference in distance between the destination and nearest hospitals.

2.3 | Statistical methods

Unadjusted analyses were performed for comparison of patients who did and did not bypass a hospital for PD using $\chi^2$and t test for categorical and continuous variables, respectively. Multivariate analysis was utilized to identify factors associated with bypassing a hospital while controlling for patient demographics, hospital teaching status, PD volume, as well as mortality of the destination hospital. All statistical analyses were performed using Stata statistical software version 16 (College Station, TX). All tests were two-sided, and *P* values of less than .05 were considered to indicate statistical significance.

3 | RESULTS

Among the 23 014 patients who underwent PD for a neoplasm of the pancreas, duodenum, or bile duct in California between 2005 and 2016, mean patient age was 65 years and roughly one-half (52.3%) of patients were male. The majority of patients were White (63%), followed by Hispanic (16.2%), Asian (11.4%), and African American (5.6%). Half the cohort was insured by Medicare (51.7%), whereas other patients had private insurance (37.1%), Medicaid (7.8%), or were self-pay (1.3%). Among the 189 hospitals that performed PD, overall mean annual PD volume was 10; 23 hospitals were identified as high-volume centers, defined using the Leap Frog criteria as an average annual PD volume > 20 (Table 1).[22] Roughly two-thirds of patients (n = 14 510, 63.1%) underwent PD at a high-volume center. Following PD, overall mean length-of-stay (LOS) was 15.2 days (IQR 8.0-17.0) (low-volume centers: mean LOS, 17.0 days vs high-volume center: mean LOS, 14.1 days) with a 30-day mortality of 3.7% (low-volume centers: in hospital mortality, 5.9% vs high-volume centers: in hospital mortality, 2.4%) (both $P < .05$). Mean number of hospital beds was 432.6 (low-volume: 295.9 vs high-volume: 500.8), mean number of operating rooms 25.6 (low-volume: 16.2 vs high-volume: 29.1), and most hospitals (77.4%)

TABLE 3 Multivariable analysis of patient and hospital characteristics as predictors for bypassing nearest providing hospital

	OR	95% CI	*P*
Total distance traveled	3.46	3.27-3.67	< .001
Age	0.99	0.98-0.99	< .001
Race/Ethnicity			
White	Ref		
African American	1.28	1.02-1.60	< .001
Hispanic	1.53	1.31-1.79	< .001
Asian	1.86	1.57-2.21	< .001
Sex			
Male	Ref		
Female	0.94	0.85-1.05	.262
Insurance			
Medicare	Ref		
Medicaid	1.15	0.91-1.44	.236
Private	0.99	0.86-1.16	.989
Self pay	1.26	0.82-1.95	.293
Other	1.29	0.85-1.94	.234
In-hospital mortality	1.06	0.83-1.37	.626
Complications	0.98	0.87-1.10	.756
High volume (> 20 cases)	3.82	3.31-4.41	< .001
Charge	1.00	0.99-1.00	.485
Academic medical center	1.13	0.99-1.30	.077
Total admission	1.00	0.99-0.99	< .001
Total beds	1.00	1.00-1.00	< .001
Total operating rooms	1.00	0.99-1.01	.674
Full time RN	1.00	0.99-0.99	< .001

were academic medical centers (low-volume: 52.5% vs high-volume: 91.9%) (all $P < .05$).

Comparing travel patterns among patients undergoing PD, 3687 (16.0%) patients underwent surgery at the nearest hospital available whereas 19 327 (84.0%) patients bypassed the nearest hospital to travel to a different center (Table 2). On average, patients traveled 18.0 (IQR: 7.64-42.00) miles to the hospital at which PD was performed (final destination low-volume hospital: 10.8 miles vs final destination high-volume hospital: 23.5 miles) (Table 1). Specifically, among patients who bypassed a closer hospital, 13 269 (68.6%) individuals underwent PD at a high-volume center vs 6058 (31.34%) patients who had a PD at a low-volume center ($P < .05$). Patients who underwent PD at the nearest hospital had a median travel distance of 4.7 miles vs a travel distance of 21.3 miles among patients who bypassed the closest hospital to undergo PD at a more distant center ($P < .05$). Of note, the annual PD volume at closer hospitals vs destination hospitals was considerably lower (29.6 vs 56.0, respectively) ($P < .05$). The odds of undergoing PD at a high-volume hospital was higher among patients who had bypassed the nearest hospital (OR, 3.82, 95% CI, 3.31–4.41) (Table 3).

Compared with the nearest hospital, destination PD hospitals were likely to be academic medical centers (nearest: 60.4% vs destination: 80.6%), had more mean annual admissions (nearest: 21,774 vs destination: 18 956), more hospital beds (nearest: 372 vs destination: 444), more operating rooms (nearest: 21 vs destination: 26.4), as well as more full time nurses (nearest: 1120 vs destination: 1450) (all $P < .05$) (Table 2). In turn, peri-operative morbidity (nearest: 32.4% vs destination: 39.2%), failure-to-rescue (nearest: 14.5% vs destination: 9.1%), as well as mortality (nearest: 6.1% vs destination: 3.2%) were all lower among patients who had bypassed a closer hospital to travel to a further destination hospital that performed PD (all $P < .05$). Of note, among a subset analysis of 8503 patients who underwent PD at a low-volume hospital, 1459 (17.2%) patients had actually bypassed a high-volume hospital to have surgery at a low-volume center. In this subset of patient, there was no difference in the distance traveled among Medicare beneficiaries and privately insured patients (54.7 vs 50.4 miles); Medicaid beneficiaries (33.6 miles, $P < .001$) traveled shorter distances. Among the 7044 individuals who did not bypass a high-volume hospital, roughly one-third (n = 2379, 33.8%) would have needed to travel an additional 30 miles or less to reach the nearest high-volume hospital; 922 (13.1%) patients would have needed to travel an additional 100 miles or greater to reach the nearest high-volume hospital (Table 4).

On multivariable analysis, African American (OR, 1.28, 95% CI, 1.02-1.60), Hispanic (OR, 1.53 95% CI, 1.31-1.79), and Asian (OR, 1.86, 95% CI, 1.57-2.21) patients were more likely to have bypassed the nearest hospital to go to a different center. Among African American, Hispanic, and Asian patients who did bypass a closer hospital, more than half (59.8.%, 61.2%, and 68.4%) bypassed a low-volume center to go to high-volume center for PD. However, roughly 1 in 3 African American (40.2%), Hispanic (38.8%), and Asian (31.8%) patients bypassed a closer hospital to undergo PD simply at a different low-volume hospital. Of note, age, sex, or insurance type were not associated with odds of a patient bypassing the nearest hospital (all $P > .05$).

4 | DISCUSSION

Access to high-quality inpatient oncologic surgical services is a major population health priority. Access to care may be limited by a number of factors including, but not limited to, insurance status, ability to pay, availability of hospital/provider, and ability to take time off from work. While travel time and distance may also impact access to subspecialty, complex surgical services, this topic has not been well-studied. The current study was important because we specifically examined both travel distance, as well as the incidence of bypassing closer hospitals, to receive PD surgery. In particular, unlike previous studies, true travel distance was assessed using geocoding software and traffic data. Of note, among the over 23 000 patients who underwent PD in California between 2005 and 2016, 84% bypassed the closest hospital to their home to travel a median distance of 18 miles for surgery (Figure 1). While the odds of undergoing PD at a high-volume hospital was higher among patients who had bypassed the nearest hospital, a significant number of patients who bypassed a closer hospital still underwent PD at a low-volume hospital. In fact,

TABLE 4 Patient characteristics for patients undergoing pancreaticoduodenectomy at low-volume hospitals

Patient characteristics (N = 8503)							
Bypassed high-volume hospital (%)			1459				17.2
Median Miles traveled (IQR)			6.89				2.50-13.35
Did not bypass high-volume hospital (%)			7044				82.8
Median additional miles HVH (IQR)			56.76				15.78-82.38
Range of additional miles traveled	**< 30**		**30-100**		**> 100**		**Total**
Total (%)	2379	(33.8)	3743	(53.1)	922	(13.1)	7044
Age (mean) [SD]	66.00	(10.9)	65.82	(11.07)	66.05	(11.11)	
Sex							
Male	1225	(33.7)	1958	(53.9)	451	(12.4)	3634
Female	1154	(33.8)	1785	(52.35)	471	(13.8)	3410
Race							
White	1308	(30.3)	2352	(54.4)	664	(15.4)	4324
African American	162	(33.7)	275	(57.2)	44	(9.2)	481
Hispanic	588	(44.5)	595	(45.0)	138	(10.5)	1321
Asian	256	(35.3)	407	(56.1)	62	(8.6)	725
Other	65	(33.7)	114	(59.1)	14	(7.3)	193
Insurance							
Self pay	25	(28.4)	55	(62.5)	8	(9.1)	88
Medicaid	245	(37.9)	332	(51.4)	69	(10.7)	646
Medicare	1218	(32.6)	2020	(54.0)	501	(13.4)	3739
Private	860	(35.6)	1229	(50.8)	329	(13.6)	2418
Other	31	(20.3)	107	(69.9)	15	(9.8)	153

nearly 20% of patients actually bypassed a high-volume hospital in route to have surgery at a low-volume center. Furthermore, among patients who did not bypass a high-volume hospital, one-third would have needed to travel only an additional 30 miles or less to reach the nearest high-volume hospital (Figure 2).

Data from the current study demonstrated that patients were indeed willing to travel longer distances and bypass closer hospitals to receive certain types of complex medical care such as PD. Interestingly, these data differed from other studies that had suggested that patients preferred to seek medical care closer to their home.[23,24] The reason for these disparate results was undoubtedly multifactorial and may have been related to differences in surgical procedures being considered. For example, patients may prefer to seek medical care, as well as be referred to local surgeons, for certain operations generally considered lower risk (eg, distal gastrectomy and colectomy).[23,24] In contrast, complex surgical procedures such as PD that involve more potential morbidity and mortality may often cause local physicians to refer patients to regional high-volume centers.[25] In addition, patients may self-select more experienced centers when faced with a disease that requires more specialized surgical care.[26] While local referrals to low-cost hospitals for some procedures may be associated with acceptable morbidity and mortality, referral to high-volume centers may provide more value for other types of complex operations.[25,27,28] Regionalization of care can, however, force patients to travel longer distances. To this point, patients who underwent PD at the nearest hospital had a median travel distance of 4.7 miles vs a travel distance of 21.3 miles among patients who bypassed the closest hospital to undergo PD at a more distant center. Perhaps of even more interest was the finding that a large subset of patients actually traveled past a closer high-volume hospital ultimately to undergo PD at a low-volume center. Specifically, this phenomenon was most pronounced among underrepresented minority patients as roughly 1 in 3 African American, Hispanic, and Asian patients bypassed a closer hospital to undergo PD simply at a different low-volume hospital. Of note, other investigators have similarly noted that some patients may have a tendency to travel beyond high-volume centers in favor of seeking surgery at low-volume hospitals, despite a higher chance of surgery-related mortality at these centers.[19,29] Patients willingness to travel for higher level of care can improve both short- and long-term outcomes, especially for patients with complex diseases such as liver and pancreatic cancer.[30-32] The decision to where to have ones complex oncologic operation is certainly a complex one. While we have shown that patients are willing to travel longer distances for their PD operation, there are several unmeasured variables that may also be influencing a patients decision to travel further. For example, a patients' relationships with previous providers matter a great deal and therefore referral patterns would certainly have a major influence as to where patients may ultimately choose to have their operation. In addition, a patients insurance and more importantly whether a hospital or provider is covered by the patients insurance provider will more likely than not play a large role in the patients decision to where to have surgery. Hospital systems, and insurance networks are in the unique position to centralize care so that their patients can receive their operation at the hospital that offers the greatest chance at a good outcome with the highest value.

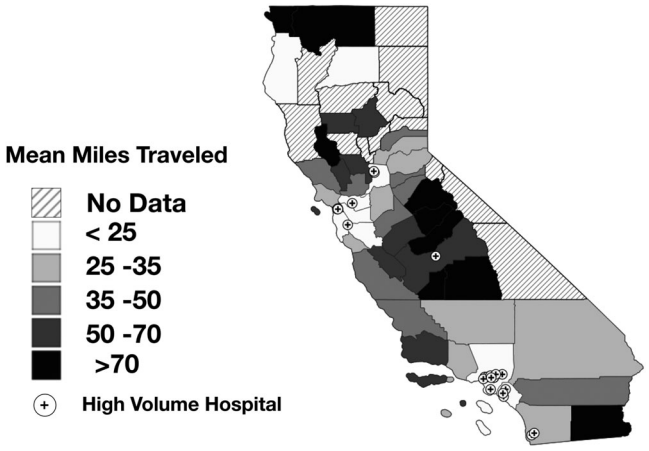

FIGURE 1 Total patient travel distance to reach destination hospitals to undergo PD by California County

The volume-outcome relationship related to complex surgical procedures has been well-documented.[13-15] In the current centers, it was interesting to note that destination PD hospitals were likely to be academic medical centers, had more mean annual admissions, more hospital beds, more operating rooms, as well as more full time nurses (Table 2). In aggregate, patients who bypassed a closer hospital to be treated at a destination had lower peri-operative morbidity and failure-to-rescue, as well as an incidence of peri-operative mortality that was almost one-half lower. Previous work from our group and others have demonstrated that high-volume centers, especially centers with a teaching designation, have improved outcomes associated with high-risk surgical procedures.[33] For example, Hyder et al[34] noted that quality metrics such as length-of-stay and mortality following complex hepatopancreaticobiliary surgery were also better at high-volume academic medical centers. Our group has previously characterized the association between travel distance and hospital volume relative to outcomes following resection of cholangiocarcinoma, gallbladder cancer, and hepatocellular carcinoma.[35-38] Both increasing travel distance and hospital volume were associated with improved overall survival; however, adjusted models demonstrated that the impact of travel distance was largely mediated through hospital volume. Collectively, the data strongly suggest that bypassing a closer hospital to travel to a destination hospital that is higher volume should generally be encouraged for patients seeking PD as surgical treatment.

While longer travel distances may translate into more patients receiving surgical care at high-volume regional centers, other aspects of the multimodality care of the cancer patient also need to be considered. For example, Idrees et al[39] reported that centralization of surgery for cholangiocarcinoma to high-volume hospitals increased compliance with National Comprehensive Cancer Network guidelines. Other studies, however, have suggested that longer travel distances can impede a patients ability to receive other nonsurgical therapies. For example, patients with prostate cancer in both urban and rural settings were less likely to receive radiation therapy rather than surgery the farther away they lived from a treatment center. These findings raise the possibility that the geographic availability of radiation treatment centers may be an important determinant of whether patients are able to choose radiation rather than surgery for localized prostate cancer.[40] In a different study, Lin et al[41] reported that increased travel burden was associated with a decreased likelihood of receiving adjuvant chemotherapy. In addition, increased travel burden may also be associated with decreased likelihood of receiving adjuvant radiation therapy for a variety of cancers.[42] Of note, the travel distance burden may affect vulnerable populations disproportionately. For example, among patients undergoing pancreatectomy, the elderly, racial minorities, and patients with self-pay or Medicaid payer status were most sensitive to travel burden.[14] Access to comprehensive oncologic care at major cancer programs is important because delays in treatment may lead to worse oncologic outcomes.[43-45]

Several limitations should be considered when interpreting the results. While the California database allowed for 100% capture with

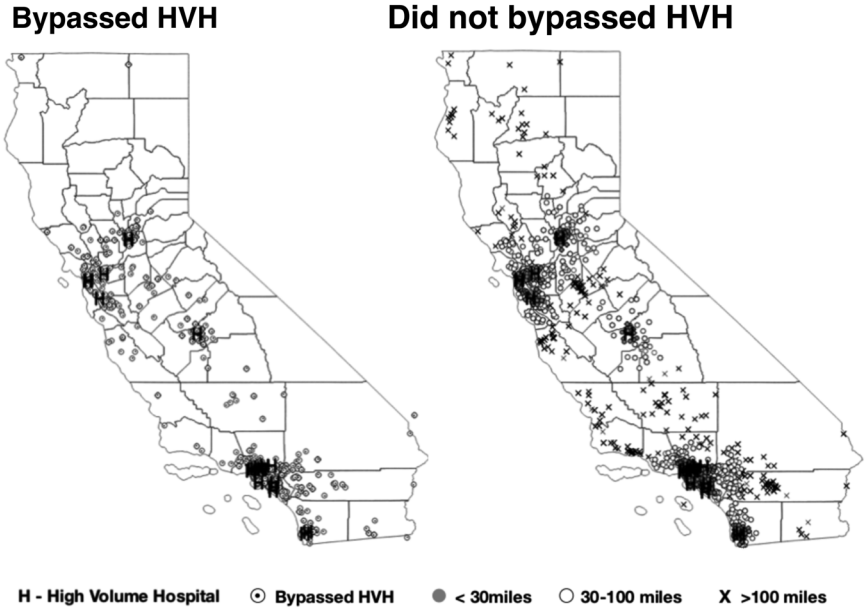

FIGURE 2 Total distance to nearest high-volume center for patients who underwent surgery at a low-volume center

complete evaluation of travel for all patients receiving surgery at California-licensed facilities, the data were limited to one state and therefore the data may not be generalizable to other geographically distinct states. While possible reasons for traveling could include personal preferences, level of education, financial constraints for both medical and nonmedical expenses, or referral practices of diagnosing providers, we were not able to define specific reasons why patients did or did not bypass a hospital or travel further distances. For example, an important missing variable is patient income, which would likely affect a patient's ability and tolerance for increased travel. Volume and mortality data were also analyzed at the hospital level, thus making it difficult to understand how patient travel decisions were influenced by individual surgeon outcomes. Finally, the California state database lacked certain cancer-specific information and therefore we were not able to examine if and where patients received chemotherapy or other cancer-specific treatments.

In conclusion, most patients undergoing PD bypassed the nearest providing hospital to seek care at a higher-volume hospital. While the data demonstrated increased regionalization of complex surgical care, nearly 1 in 5 patients still underwent PD at a low-volume center. Importantly, nearly half of patients who had PD at a low-volume center could have undergone surgery at a high-volume center with minimal increase in travel burden. These data would support the facilitation of patient travel to destination high-volume centers for patients in need of PD. Such data support employer-based plans that offer employees the opportunity to receive care at regional centers of excellence with no additional personal travel cost.[46,47]

CONFLICT OF INTERESTS

The authors of this study have no conflict of interests to report.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in California's Office of Statewide Health Planning and Development at https://oshpd.ca.gov/data-and-reports/request-data/

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APPENDIX: ICD 9 and ICD 10 diagnosis and procedure codes

Pancreatic resection for cancer

- Diagnosis codes
  a. ICD9
    - 152 - Malignant neoplasm of small intestine including duodenum.
    - 156 - Malignant neoplasm of gallbladder and extrahepatic bile ducts.
    - 157 - Malignant neoplasm of pancreas.

  b. ICD10
    - C23 Malignant neoplasm of gallbladder.
    - C240 Malignant neoplasm of extrahepatic bile duct.
    - C241 Malignant neoplasm of ampulla of Vater.
    - C248 Malignant neoplasm of overlapping sites of biliary tract.
    - C249 Malignant neoplasm of biliary tract, unspecified.
    - C250 Malignant neoplasm of head of pancreas.
    - C251 Malignant neoplasm of body of pancreas.
    - C252 Malignant neoplasm of tail of pancreas.
    - C253 Malignant neoplasm of pancreatic duct.
    - C254 Malignant neoplasm of endocrine pancreas.
    - C257 Malignant neoplasm of other parts of pancreas.
    - C258 Malignant neoplasm of overlapping sites of pancreas.
    - C259 Malignant neoplasm of pancreas, unspecified.
    - C170 Malignant neoplasm of duodenum.

- Procedure codes
  a. ICD9
    - 5252 - distal pancreatectomy.
    - 5259 - other partial pancreatectomy.
    - 5251 - proximal pancreatectomy.
    - 5253 - radical subtotal pancreatectomy/whipple.
    - 527 - radical pancreatoduodenectomy.
    - 526 - total pancreatectomy.

  b. ICD10
    - 0FTG0ZZ - Resection of Pancreas, Open Approach.
    - 0FTG4ZZ - Resection of Pancreas, Percutaneous Endoscopic Approach.