Original Article

Impact of Care at Comprehensive Cancer Centers on Outcome: Results From a Population-Based Study

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BACKGROUND: Rigorous processes ensure quality of research and clinical care at National Cancer Institute-designated comprehensive cancer centers (NCICCCs). Unmeasurable elements of structure and process of cancer care delivery warrant evaluation. To the authors' knowledge, the impact of NCICCC care on survival and access to NCICCCs for vulnerable subpopulations remain unstudied. **METHODS:** The current study's population-based cohort of 69,579 patients had newly diagnosed adult-onset (aged 22-65 years) cancers reported to the Los Angeles County cancer registry between 1998 and 2008. Geographic information systems were used for geospatial analysis. **RESULTS:** With regard to overall survival across multiple diagnoses, patients not receiving their first planned treatment at NCICCCs experienced poorer outcomes compared with those treated at NCICCCs; differences persisted on multivariable analyses after adjusting for clinical and sociodemographic factors (hepatobiliary: hazard ratio [HR], 1.5; 95% confidence interval [95% CI], 1.4-1.7 [$P<.001$]; lung: HR, 1.4; 95% CI, 1.3-1.6 [$P<.001$]; pancreatic: HR, 1.5; 95% CI, 1.3-1.7 [$P<.001$]; gastric: HR, 1.3; 95% CI, 1.1-1.7 [$P = .01$]; breast: HR, 1.3; 95% CI, 1.1-1.5 [$P<.001$]; and colorectal: HR, 1.2; 95% CI, 1.0-1.4 [$P = .05$]). With regard to barriers to care, multivariable analyses revealed that a lower likelihood of treatment at NCICCCs was associated with race/ethnicity (African-American: OR range across diagnoses: 0.4-0.7 [$P<.03$]; Hispanic: OR range, 0.5-0.7 [$P<.04$]); lack of private insurance (public: OR range, 0.6-0.8 [$P<.004$]; uninsured: OR range, 0.1-0.5 [$P<.04$]); less than high socioeconomic status (high-middle: OR range, 0.4-0.7 [$P<.02$]; middle: OR range, 0.3-0.5 [$P<.001$]; and low: OR range, 0.2-0.6 [$P<.01$]), and residing >9 miles from the nearest NCICCC (OR range, 0.5-0.7 [$P<.02$]). **CONCLUSIONS:** Among individuals aged 22 to 65 years residing in Los Angeles County with newly diagnosed adult-onset cancer, those who were treated at NCICCCs experienced superior survival compared with those treated at non-NCICCC facilities. Barriers to care at NCICCCs included race/ethnicity, insurance, socioeconomic status, and distance to an NCICCC. ***Cancer* 2015;121:3885-93**. © *2015 American Cancer Society*.

KEYWORDS: cancer, cancer centers, National Cancer Institute, outcomes.

INTRODUCTION

Despite therapeutic and supportive care advances, the prognosis for many cancers remains poor. Outcome is assessed along the lines of disease biology, therapy, and patient-specific sociodemographic factors (race/ethnicity[1,2]); nevertheless, sociodemographic factors necessitate consideration within the construct of the health care delivery system. Donabedian deconstructed health care delivery into structure, process, and outcome,[3] with structure connoting the scaffolding on which the health care delivery system is built (from physical and information systems to payor structure), whereas process encompassed the provision of care (from decision-making to implementation). Elements of structure have been evaluated, including insurance and socioeconomic status (SES).[4,5] Facility and the volume relationship with surgical diseases has been evaluated,[6] as have surgical outcomes and facility safety net status,[7] size, technology, and academic status.[8] Elements of process that have been evaluated include guideline compliance,[9,10] enrollment on clinical trials,[11] and organizational affiliation[12] in isolated malignancies. Many elements have been measured in the surgical setting with numerous unmeasured elements especially in the medical facets of oncology, including supportive care, multidisciplinary decision-making, and mechanism of therapy delivery. Without validated, systematic, and widely available measures at the granular level of the structure and process of cancer care delivery, we conceptually dichotomized care into that which is delivered at centers with a National Cancer Institute (NCI) designation of comprehensiveness and that which is not. According to the NCI, "To facilitate discovery and its translation into direct benefit to patients and the general public, the NCI awards [the designation of comprehensive cancer center] to institutions that critically mass excellent cancer-relevant research; [NCICCC]

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focus on research derives from the belief that a culture of discovery, scientific excellence, transdisciplinary research and collaboration yields tangible benefits extending far beyond the generation of new knowledge."[13] To our knowledge, the impact of care at National Cancer Institute-designated comprehensive cancer centers (NCICCCs) on survival remains unstudied outside of pediatric/adolescent cancer,[14] postoperative mortality,[15,16] and older patients.[17] Within this framework, access to NCICCCs for vulnerable populations (underrepresented minorities, those with low SES, those with public or no insurance, and those with a significant distance to care) warrants comprehensive evaluation despite examination in isolated malignancies[18] because sociodemographic factors are intrinsically linked to both health care delivery[19] and quality,[20] and impact where a patient receives general[21] or cancer health care.[22]

Pending the widespread development and implementation of detailed measures in response to the Institute of Medicine's (IOM) call to action to measure quality,[23,24] a surrogate measure was used to evaluate the outcome for patients in Los Angeles County (LAC) diagnosed between the ages of 22 and 65 years with adult-onset cancers by assessing care at NCICCCs compared with non-NCICCC facilities. We further aimed to explore access to NCICCCs for patients from racial/ethnic minority groups, those without private insurance, those with low SES, or those facing potential geographic barriers to care.

MATERIALS AND METHODS

Patients

We assembled a population-based cohort of 75,987 patients who were newly diagnosed between 1998 and 2008 at 22 to 65 years of age with adult-onset cancers (breast, cervical, colorectal, gastric, hepatobiliary, lung, oral, and pancreatic) using the LAC cancer registry (Cancer Surveillance Project [CSP]) (see online Supporting Information). Eligible patients resided and received care at facilities within LAC. This project was approved by the Institutional Review Boards of the state of California and the City of Hope.

Clinical Prognostic Variables

Cases were selected using *International Classification of Diseases for Oncology, 3rd Edition*-based histology codes with appropriate site codes; in situ disease was excluded. Clinical variables included primary diagnosis, age at diagnosis, sex, and stage of disease. CSP summary staging was used, which is based on the Collaborative Staging System integrating TNM categories, stage groupings, and Surveillance, Epidemiology, and End Results Extent of Disease coding. A histology variable accounted for differences between breast cancer histologies with a poor prognosis (inflammatory, sarcoma) and others.

Sociodemographic Predictors

A combined race/ethnicity variable yielded the following categories: non-Hispanic white, Hispanic, African American (AA), and Asian/Pacific Islander. Due to their small numbers (334 cases; 0.4%), patients classified as Alaska Native/Other and those with unknown/missing ethnicity were excluded. We collapsed insurance into 3 categories: public, private, and no insurance; patients were excluded (2551 patients; 3.4%) if the payor was missing or unknown. The SES variable was collapsed into 4 levels, combining the lowest SES levels.

Treatment Site

The systematic definition of care identified the facility associated with each episode of care. We prioritized the facility at which the patient received all or part of the first course of treatment (detailed in the Supporting Information). Patients were considered treated at NCICCCs if they were cared for at 1 of the 3 NCICCCs located within LAC (University of California at Los Angeles/Jonsson, University of Southern California/Norris, and City of Hope). All other patients were considered to have received care at non-NCICCC sites.

Geography

The CSP provided the patient's address at the time of diagnosis. Geographic information systems (ArcMap 10.1; Esri, Redlands, Calif) were used to geocode the hospital address and measure the straight-line distance between the patient's residence and the nearest NCICCC. Euclidean distance is highly correlated with drive time,[25] and has been used in distance-to-cancer-care investigations in California.[18]

Statistical Analysis

Overall survival (OS) was calculated using Kaplan-Meier survival analysis (log-rank tests detected differences between groups). Cox regression techniques determined the hazard ratios (HRs) of mortality with associated 95% confidence intervals (95% CIs). Logistic regression analysis was used to determine the odds ratios (ORs) with associated 95% CIs for multivariable modeling of the likelihood of receiving care at an NCICCC. Unless otherwise noted, multivariable models of survival were adjusted for age at diagnosis, sex, race/ethnicity, stage of disease,

SES, and payor whereas multivariable models for the likelihood of receiving care at NCICCCs included the above variables and distance to the nearest NCICCC. Two-sided tests with a $P < .05$ were considered statistically significant. SAS statistical software (version 9.3; SAS Institute Inc, Cary, NC) was used for all analysis. Patients with missing/unknown sociodemographic data comprised a small percentage of the cohort. Parallel univariable and multivariable analyses were performed in a cohort; including these patients was found to have no impact on the HR or statistical significance (see online Supporting Information), and therefore they were excluded in the final analysis.

RESULTS

Patients

Characteristics of the cohort (69,579 patients) are detailed in Table 1, both overall and by treatment site. Racial and ethnic minorities, those with low SES, and publicly insured and uninsured patients were well represented.

Treatment Site

Clinical and sociodemographic details by treatment site are presented in Table 1. A majority of the cohort received their first planned treatment at a non-NCICCC facility. There was no difference noted with regard to the percentage of newly diagnosed patients treated at non-NCICCC versus NCICCC facilities by clinical stage of disease for breast, cervical, gastric, and oral cancers. Among patients with colorectal cancer, there was a higher representation of lower-stage cancers at the non-NCICCC facilities; in patients with hepatobiliary, lung, and pancreatic disease, there was a higher representation of lower-stage cancers at the NCICCCs.

Survival by site of care

Patients with the following cancers who were treated at non-NCICCC facilities had poorer outcomes compared with those treated at NCICCCs (Fig. 1) (Table 2): hepatobiliary, lung, pancreatic, gastric, oral, and breast. After adjusting for clinical and sociodemographic factors, patients treated at non-NCICCC facilities continued to experience a higher likelihood of mortality for all cancers but oral cancer. A group of patients with breast cancer had hormone receptor (HR) (estrogen and progesterone) and human epidermal growth factor receptor 2 (HER2) status available (15,545 patients; 48.9%); a combined HR variable (HR positive/HER2 negative, HR positive/HER2 positive, HR negative/HER2 negative, HR negative/HER2 positive, and borderline/unknown) informed a subset analysis in these patients with identical results (Supporting Information Table 1). Stratified by histology (non-small cell, small cell), patients with lung cancer had identical findings.

Among patients with colorectal disease, those treated at non-NCICCC and NCICCC facilities were found to have similar outcomes on univariable analysis; however, after adjusting for sociodemographic and clinical characteristics, patients with colorectal cancer who were treated at non-NCICCC facilities experienced a higher likelihood of mortality (Table 2). These findings persisted in parallel analyses stratified by SES (Supporting Information Table 2).

In patients with cervical cancer, patients had similar outcomes at both facilities; adjustment for sociodemographic and clinical factors revealed a trend toward an increased risk of mortality in patients treated at non-NCICCC facilities (Table 2).

Likelihood of care at an NCICCC

Across most diagnoses, patients were less likely to be treated at NCICCCs (Table 3) if they were from an underrepresented minority group (AA or Hispanic). There was a "dose effect" in SES in which the patients with the lowest SES had the lowest likelihood of being treated at NCICCCs and those with the highest SES had the highest likelihood; this was the case in all cancers except for oral and cervical. Uninsured patients were less likely to receive care at NCICCCs in all cancers (trend in breast); publicly insured patients were less likely to receive NCICCC care in the full patient cohort along with those with hepatobiliary, gastric, and oral cancer. Patients residing >9 miles from the nearest NCICCC were less likely to be treated at an NCICCC for the majority of cancers; distance did not impact the likelihood of treatment at NCICCCs among patients with hepatobiliary or oral cancers. Older patients (those aged 40-65 years) were less likely to be treated at an NCICCC compared with younger patients (those aged 22-39 years) among individuals with oral and breast cancers, whereas age did not appear to have a similar impact in patients with other cancers.

Interactions were examined between distance and the following: SES, race/ethnicity, and stage of disease. The only significant interaction was noted between distance and SES in patients with oral cancer, among whom those living closer to the NCICCCs were less likely to receive treatment at NCICCCs if they were in the low SES rather than the high SES group.

TABLE 1. Patient Characteristics Overall and by Treatment Site

	Total (n = 69,579)	NCICCC (n = 4428)	Non-NCICCC (n = 65,151)	*P*
Age, y				
22-39	5873 (8.4%)	429 (9.7%)	5444 (8.4%)	.002
40-65	63,706 (91.6%)	3999 (90.3%)	59,707 (91.6%)	
Sex				
Female	50,005 (71.9%)	3141 (70.9%)	46,864 (71.9%)	.15
Male	19,574 (28.1%)	1287 (29.1%)	18,287 (28.1%)	
Race/ethnicity				
NHW	32,040 (46.1%)	2601 (58.7%)	29,439 (45.2%)	<.001
Black	9532 (13.7%)	314 (7.1%)	9218 (14.1%)	
Hispanic	17,412 (25.0%)	702 (15.9%)	16,710 (25.7%)	
API	10,595 (15.2%)	811 (18.3%)	9784 (15.0%)	
Payor				
Private	46,843 (67.3%)	3468 (78.3%)	43,373 (66.6%)	<.001
Public	17,585 (25.3%)	852 (19.3%)	16,733 (25.7%)	
Uninsured	5151 (7.4%)	108 (2.4%)	5043 (7.7%)	
SES				
High	16,058 (23.1%)	1810 (40.9%)	14,248 (21.9%)	<.001
High-middle	15,294 (22.0%)	1086 (24.5%)	14,208 (21.8%)	
Middle	14,357 (20.6%)	723 (16.3%)	13,634 (20.9%)	
Low	23,870 (34.3%)	809 (18.3%)	23,061 (35.4%)	
Distance to nearest NCICCC, miles				
Median (IQR)	9.1 (5.8-13.9)	7.5 (5.0-12.7)	9.2 (5.9-14.0)	<.001
Mean (SD)	10.8 (7.3)	9.8 (7.4)	10.9 (7.2)	
Primary diagnosis				
Breast (n = 31,762)				
Localized/regional extension	18,583	1199 (57.9%)	17,384 (58.6%)	.58
Regional LNs ± extension	11,738	770 (37.2%)	10,968 (36.9%)	
Remote	1441	103 (4.9%)	1338 (4.5%)	
Colorectal (n = 12,298)				
Localized/regional extension	6082	216 (43.2%)	5866 (49.7%)	.01
Regional LNs ± extension	3242	144 (28.8%)	3098 (26.3%)	
Remote	2974	140 (28.0%)	2834 (24.0%)	
Lung (n = 10,844)				
Localized/regional extension	1957	101 (21.7%)	1856 (17.9%)	.05
Regional LNs ± extension	1663	78 (16.7%)	1585 (15.3%)	
Remote	7224	287 (61.6%)	6937 (66.8%)	
Hepatobiliary (n = 4181)				
Localized/regional extension	2619	488 (78.3%)	2131 (59.9%)	<.001
Regional LNs ± extension	239	27 (4.3%)	212 (6.0%)	
Remote	1323	108 (17.4%)	1215 (34.1%)	
Cervical (n = 3691)				
Localized/regional extension	2876	108 (75.5%)	2768 (78.0%)	.78
Regional LNs ± extension	421	18 (12.6%)	403 (11.4%)	
Remote	394	17 (11.9%)	377 (10.6%)	
Gastric (n = 2664)				
Localized/regional extension	550	29 (23.6%)	521 (20.5%)	.65
Regional LNs ± extension	810	38 (30.9%)	772 (30.4%)	
Remote	1304	56 (45.5%)	1248 (49.1%)	
Pancreas (n = 2317)				
Localized/regional extension	504	84 (33.6%)	420 (20.3%)	<.001
Regional LNs ± extension	358	51 (20.4%)	307 (14.9%)	
Remote	1455	115 (46.0%)	1340 (64.8%)	
Oral cancer (n = 1822)				
Localized/regional extension	978	132 (52.6%)	846 (53.8%)	.93
Regional LNs ± extension	628	88 (35.1%)	540 (34.4%)	
Remote	216	31 (12.3%)	185 (11.8%)	

Abbreviations: API, Asian/Pacific Islander; IQR, interquartile range; LNs, lymph nodes; NCICCC, National Cancer Institute-designated comprehensive cancer center; NHW, non-Hispanic white; SD, standard deviation; SES, socioeconomic status.

DISCUSSION

The population-level findings of the current study demonstrate that patients in LAC newly diagnosed between the ages of 22 to 65 years with specific adult-onset cancers have superior survival when receiving initial therapy at NCICCCs rather than at non-NCICCC facilities. We identified race/ethnicity, lack of private insurance, low SES, and distance from the nearest NCICCC as barriers to receiving treatment at NCICCCs.

TABLE 2. Survival at NCICCC Versus Non-NCICCC Facilities

Primary Diagnosis	5-Year OS[a]		Likelihood of Mortality[a]	
	OS (95% CI)	*P*	HR (95% CI)	*P*
Full cohort				
NCICCC	**64.3% (62.7%-65.8%)**	**<.001**	1.0	**<.001**
Non-NCICCC	**60.7% (60.3%-61.1%)**		**1.3 (1.2-1.3)**	
Hepatobiliary				
NCICCC	**33.8% (29.5%-38.0%)**	**<.001**	1.0	**<.001**
Non-NCICCC	**18.7% (17.3%-20.2%)**		**1.5 (1.3-1.7)**	
Lung				
NCICCC	**27.7% (23.3%-32.1%)**	**<.001**	1.0	**<.001**
Non-NCICCC	**16.5% (15.7%-17.3%)**		**1.4 (1.3-1.6)**	
Pancreas				
NCICCC	**12.5% (7.8%-17.3%)**	**<.001**	1.0	**<.001**
Non-NCICCC	**6.2% (5.0%-7.4%)**		**1.5 (1.3-1.7)**	
Gastric				
NCICCC	**30.7% (22.0%-39.4%)**	**.007**	1.0	**.01**
Non-NCICCC	**22.2% (20.4%-24.0%)**		**1.3 (1.1-1.7)**	
Breast[b,c]				
NCICCC	**88.6% (87.0%-90.1%)**	**<.001**	1.0	**<.001**
Non-NCICCC	**85.9% (85.5%-86.3%)**		**1.3 (1.1-1.5)**	
Cervical[c]				
NCICCC	76.9% (69.3%-84.4%)	.27	1.0	.14
Non-NCICCC	73.3% (71.7%-74.9%)		1.3 (0.9-1.9)	
Oral				
NCICCC	**68.5% (62.3%-74.7%)**	**.009**	1.0	.09
Non-NCICCC	**58.8% (56.2%-61.4%)**		1.2 (1.0-1.5)	
Colorectal				
NCICCC	62.8% (58.1%-67.5%)	.31	1.0	**.05**
Non-NCICCC	62.6% (61.6%-63.5%)		**1.2 (1.0-1.4)**	

Abbreviations: 95% CI, 95% confidence interval; HR, hazard ratio; NCICCC, National Cancer Institute-designated comprehensive cancer center; OS, overall survival. Bold values indicate statistically significant findings.

[a] Multivariable Cox regression analysis adjusted for age, sex, stage of disease, race/ethnicity, socioeconomic status, and payor. For full cohort, the model also adjusted for diagnosis.

[b] Adjusted for histology.

[c] Among females.

In 2013, the IOM deemed the US cancer care system to be in crisis with evolving disparities.[24,26] Recommendations thus included 1) national quality measurement and 2) a reduction in disparities in access for vulnerable and underserved populations. Quality measurement is integral to achieving these objectives,[24] but current measurement systems fall short in breadth and specificity.[26] We used NCICCC designation as an externally validated, peer-reviewed, and rereviewed population-level surrogate measure to encompass unmeasurable facets of health care delivery's structure and process. This designation is based in breadth of research capabilities in which clinical, laboratory, and population cancer research are integrated into a transdisciplinary approach, and serves as an externally validated, rigorous designation. Key elements also include state-of-the-art facilities, translation of findings from bench to bedside and then curbside, and outreach to underserved populations.[13] The current investigation represents a hypothesis-generating, preliminary assessment of quality of care.

After adjusting for key sociodemographic and clinical variables, there was a 20% to 50% increased risk of mortality associated with treatment at non-NCICCC facilities rather than NCICCCs among patients with newly diagnosed hepatobiliary, lung, pancreatic, gastric, breast, and colorectal cancers. The trend toward superior survival in patients with cervical cancer who were treated at an NCICCC did not achieve statistical significance, primarily due to a small number of these patients seeking initial treatment at NCICCCs. The impact of treatment at an NCICCC on outcome is likely multifactorial; whereas some of these factors have been measured (surgical outcome,[15] organizational affiliation,[12] and guideline compliance[10]), there are many aspects that have not and these include aspects of comprehensiveness of care, therapy, clinical trial availability, supportive care, and other elements of the designation that contribute to the structure and process of health care delivery. Disease entities for which care models have shown disparities in outcome between centers of excellence and community care include genetic diseases (cystic fibrosis[27] and hemophilia[28]), for which outcomes likely reflect provider/staff expertise, comprehensiveness of care, and institution of quality

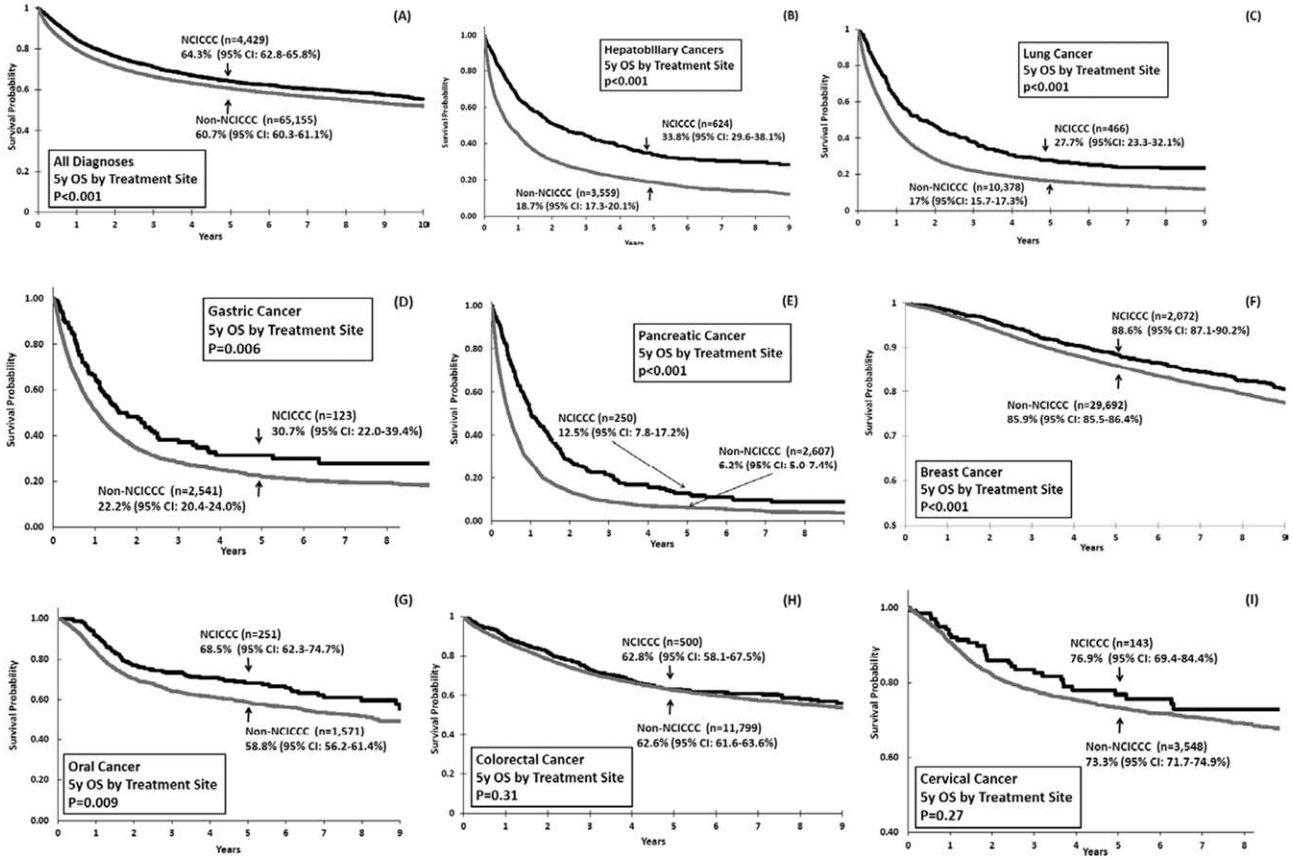

Figure 1. Five-year overall survival (OS) by treatment site among patients with adult-onset cancers diagnosed and treated in Los Angeles County. The curves compare 5-year OS between patients aged 22 to 65 years cared for at National Cancer Institute-designated comprehensive cancer centers (NCICCC) versus patients cared for in the community (Non-NCICCC). (A) Overall cohort. (B-I) Survival by disease entity. 95% CI indicates 95% confidence interval.

metrics; surgical volume stands on solid evidence.[6,29] The examined diseases are not purely surgical nor guideline-dependent, and thus current data support the hypothesis that currently unmeasurable differences contribute to outcome disparities between facilities operating on a model of NCICCC designation and those that are not.

With NCICCC care significantly predicting outcome, access to care warranted exploration. Compared with non-Hispanic white patients, Hispanic and AA patients were less likely to receive treatment at NCICCCs across all cancers. This contradicts the attention that NCICCCs direct toward underserved populations[13] and previous investigations in older patients,[18] thereby underlining the IOM recommendation to ameliorate disparities in access for vulnerable and underserved populations. With evidence demonstrating that patients from underrepresented minorities and other underserved populations lack equal access to centers providing comparable outcomes, the evaluation of cancer care provision within the NCICCC system and the greater cancer community is crucial.

A lack of private insurance was associated with a lower likelihood of treatment at an NCICCC; uninsured status was significant across cancers and public insurance was noted in many cases. Insurance influences the location of health care delivery in different ways; current data were obtained from an era of evolving health care and insurance frameworks. Payor/organizational contracts establish initial contact points within the system, but numerous factors drive referrals from that point, with insurance being only one of them. To this end, the "dose effect" of SES, in which the lowest SES was associated with the lowest likelihood of treatment at NCICCCs and the highest SES with the highest likelihood, points to the importance of the multiple facets of this variable. With insurance emerging as a predictor independent of SES, the significance of SES and its "dose effect" represents income and educational status; education likely impacts health literacy, including

TABLE 3. Likelihood of Receiving Care at an NCICCC Versus a Non-NCICCC Facility[a]

Primary Diagnosis	Race/Ethnicity (Reference: NHW)			Payor (Reference: Private)		SES (Reference: High)			Age (Reference: 22-39), Years	Distance (Reference: ≤9 Miles)
	Black	Hispanic	API	Public	Uninsured	High-Middle	Middle	Low	40-65 Years	>9 Miles
Full cohort										
OR (95% CI)	**0.6 (0.5-0.7)**	**0.7 (0.6-0.8)**	1.0 (0.9-1.1)	**0.8 (0.8-0.9)**	**0.3 (0.3-0.4)**	**0.6 (0.6-0.7)**	**0.5 (0.4-0.5)**	**0.3 (0.3-0.4)**	**0.7 (0.6-0.8)**	**0.6 (0.55-0.63)**
P	**<.001**	**<.001**	.48	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
Hepatobiliary										
OR (95% CI)	**0.7 (0.5-0.9)**	0.8 (0.6-1.0)	0.9 (0.7-1.1)	**0.7 (0.6-0.9)**	**0.2 (0.1-0.3)**	**0.7 (0.5-0.8)**	**0.5 (0.4-0.6)**	**0.4 (0.3-0.5)**	0.9 (0.6-1.4)	0.9 (0.7-1.1)
P	**.02**	.10	.20	**<.001**	**<.001**	**.001**	**<.001**	**<.001**	.71	.17
Lung										
OR (95% CI)	**0.4 (0.3-0.6)**	**0.6 (0.4-0.9)**	**1.3 (1.0-1.7)**	0.8 (0.7-1.0)	**0.2 (0.1-0.4)**	**0.6 (0.5-0.8)**	**0.4 (0.3-0.5)**	**0.3 (0.2-0.4)**	0.6 (0.4-1.1)	**0.6 (0.5-0.7)**
P	**<.001**	**.01**	**.04**	.11	**<.001**	**<.001**	**<.001**	**<.001**	.11	**<.001**
Pancreatic										
OR (95% CI)	**0.4 (0.2-0.7)**	**0.5 (0.3-0.7)**	1.0 (0.7-1.6)	0.8 (0.6-1.1)	**0.5 (0.2-1.0)**	**0.4 (0.3-0.6)**	**0.4 (0.2-0.5)**	**0.3 (0.2-0.4)**	0.8 (0.4-1.7)	**0.7 (0.6-1.0)**
P	**.001**	**.001**	.83	.23	**.04**	**<.001**	**<.001**	**<.001**	.65	**.02**
Gastric										
OR (95% CI)	0.4 (0.2-1.0)	0.6 (0.3-1.0)	1.2 (0.8-1.9)	**0.5 (0.3-0.8)**	**0.1 (0.03-0.5)**	**0.5 (0.3-0.9)**	0.6 (0.4-1.0)	**0.3 (0.1-0.4)**	0.9 (0.5-1.6)	**0.6 (0.4-0.8)**
P	.06	.06	.44	**.004**	**.002**	**.02**	.07	**<.001**	.63	**.003**
Oral cancer										
OR (95% CI)	**0.6 (0.3-1.0)**	**0.6 (0.4-1.0)**	1.0 (0.6-1.6)	**0.6 (0.4-0.9)**	**0.2 (0.1-0.4)**	0.7 (0.5-1.0)	**0.5 (0.3-0.8)**	**0.6 (0.4-0.9)**	**0.4 (0.3-0.7)**	1.0 (0.8-1.4)
P	**.05**	**.04**	.93	**.005**	**<.001**	.08	**.001**	**.01**	**<.001**	.83
Breast[b,c]										
OR (95% CI)	**0.6 (0.5-0.8)**	**0.7 (0.6-0.8)**	1.1 (1.0-1.2)	0.9 (0.8-1.1)	0.8 (0.6-1.1)	**0.7 (0.6-0.8)**	**0.5 (0.4-0.6)**	**0.3 (0.3-0.4)**	**0.7 (0.6-0.8)**	**0.5 (0.4-0.5)**
P	**<.001**	**<.001**	.24	.27	.055	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
Colorectal										
OR (95% CI)	**0.6 (0.4-0.8)**	**0.7 (0.5-0.9)**	0.9 (0.7-1.2)	0.9 (0.7-1.2)	**0.5 (0.3-0.8)**	**0.5 (0.4-0.6)**	**0.3 (0.3-0.4)**	**0.2 (0.2-0.3)**	0.7 (0.5-1.0)	**0.7 (0.6-0.8)**
P	**<.001**	**.007**	.58	.61	**.002**	**<.001**	**<.001**	**<.001**	.06	**<.001**
Cervical[c]										
OR (95% CI)	0.8 (0.4-1.6)	**0.5 (0.3-0.8)**	0.6 (0.3-1.0)	0.7 (0.5-1.1)	**0.1 (0.04-0.4)**	0.6 (0.4-1.1)	0.7 (0.4-1.2)	**0.4 (0.3-0.8)**	0.8 (0.5-1.1)	**0.6 (0.4-0.8)**
P	.61	**.003**	.055	.13	**<.001**	.10	.19	**.004**	.17	**.002**

Abbreviations: 95% CI, 95% confidence interval; API, Asian/Pacific Islander; NCICCC, National Cancer Institute-designated comprehensive cancer center; NHW, non-Hispanic white; OR, odds ratio; SES, socioeconomic status. Bold values indicate statistically significant findings.

[a] Logistic regression analysis adjusted for all variables in addition to sex and stage of disease. For full cohort, the model also adjusted for diagnosis.

[b] Adjusted for histology.

[c] Among females.

the ability to self-refer and/or discuss options with one's initial point of contact within the system.

Finally, distance from an NCICCC was found to be associated with a lower likelihood of using an NCICCC in all but hepatobiliary and oral cancers. This most likely represents familiarity in treating the examined cancers without needing to refer to NCICCCs; hepatobiliary and oral cancers represent either a therapeutic or surgical niche requiring a perceived expertise available at NCICCCs. How to apply the statistically significant, yet modest, difference in absolute distance between groups to other counties will vary; LAC has more NCICCCs than most states, and is physically challenging to navigate within 9 miles, thereby representing a transportation challenge and time commitment distinct from other regions, as presented in other distance evaluations.[18,30] Studying LAC alone provides a geographic and sociodemographic landscape with a robust multiethnic population, 3 NCICCCs within 4752 square miles spanning rural and urban areas, and a population that would rank as the eighth most populous state.

Clinical characteristics were comparable between patients treated at NCICCCs and non-NCICCCs. The anecdotal belief that referral bias leads toward a dominance of high-grade cancers at NCICCCs was not unilaterally confirmed in data regarding newly diagnosed patients. We observed a higher representation of lower-stage colorectal cancers in non-NCICCCs, with a higher representation of lower-stage hepatobiliary, lung, and pancreatic disease at NCICCCs, and no differences in the remaining diseases. Colorectal cancer staging may be influenced by community-based screening strategies and referrals. It is plausible that surgical expertise in less disseminated stages of hepatobiliary, pancreatic, and lung cancers requires specialized surgical services, and that nonspecific symptoms in these entities may be associated with earlier evaluations in patients more often treated at NCICCCs (those with private insurance and of high SES), and who thus present with lower stages of disease.

The conceptual model driving this investigation is that NCICCC treatment yields superior survival not otherwise explained by disease severity or structure or process variables; several unmeasurable variables would contribute to a full case mix control model if available, including comorbidity, lifestyle, environment, and nutrition in terms of outcome and lifestyle and deprivation, English proficiency, and physician referral patterns in terms of access. Population-level cancer registry data enabled us to study a large sample size across institution types and cancer diagnoses, without the bias of data collection occurring only at research institutions; nevertheless, registry data lack granularity. Minimally detailed treatment data preclude the examination of therapeutic differences. Without comorbidity data, limiting the current study to adults aged <65 years aimed to limit comorbidities. The findings are generalizable to newly diagnosed patients.

The question emerges, how do NCICCCs deliver superior outcomes? We hypothesized this encompasses multiple aspects of comprehensiveness, because the findings span cancer stages (localized to remote) and diagnoses (with/without a role for surgery and with/without clear guidelines). To this end, guideline compliance,[9,10] enrollment on clinical trials,[11] organizational affiliation,[12] and surgical expertise[6] likely contribute in select malignancies along with supportive care, multidisciplinary decision-making, mechanism of therapy delivery, and availability of investigator-initiated clinical trials allowing the direct benefit of cutting-edge research. We posit that requirements for high-quality research[13] are associated with the delivery of high-quality clinical care, with clinicians and administrators serving either as investigators or alongside investigators; these sites are mandated to lead clinical trials, exchange ideas, disseminate findings, and maintain facility requirements. The NCI operates on the belief that a culture of discovery, scientific excellence, transdisciplinary research, and collaboration yields tangible benefits extending far beyond the generation of new knowledge.[13]

These population-level findings indicate the presence of significant differences in outcome according to care at NCICCCs in several newly diagnosed cancers and highlight the need for ongoing investigations into the structure and process of cancer care delivery. Prior studies addressing the payor, socioeconomic, or surgical volume elements have been integral to piecing together the model, but drawing broad conclusions from one facet of the model ignores the interconnectedness that Donabedian et al[31] laid out for health care delivery. Each element contributes to overall outcome, and is not mutually exclusive. The identification of barriers to receiving treatment at specialized cancer centers underscores a crucial gap in the provision of cancer care for vulnerable populations. The evolving health care delivery system has been separately focused on providing access and improving quality; these findings suggest that the IOM recommendations regarding the development and implementation of robust cancer-focused quality measures are crucial, and that such measurements should delve into granular measures as they continue to assess whether all patients have access to cancer care that promises comparable outcomes.

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