12-1-2022

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Gynecologic Oncology Reports 44 (2022) 101075

Contents lists available at ScienceDirect

Gynecologic Oncology Reports

journal homepage: www.elsevier.com/locate/gynor

Community access to primary care is an important geographic disparity among ovarian cancer patients undergoing cytoreductive surgery

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ARTICLE INFO

Keywords:
Ovarian cancer
Geographic disparities
Primary care access
Postoperative complications

ABSTRACT

Objective: Given the importance of understanding neighborhood context and geographic access to care on individual health outcomes, we sought to investigate the association of community primary care (PC) access on postoperative outcomes and survival in ovarian cancer patients.
Methods: This was a retrospective cohort study of Stage III-IV ovarian cancer patients who underwent surgery at a single academic, tertiary care hospital between 2012 and 2015. PC access was determined using a Health Resources and Services Administration designation. Outcomes included 30-day surgical and medical complications, extended hospital stay, ICU admission, hospital readmission, progression-free and overall survival. Descriptive statistics and chi-squared analyses were used to analyze differences between patients from PC-shortage vs not PC-shortage areas.
Results: Among 217 ovarian cancer patients, 54.4 % lived in PC-shortage areas. They were more likely to have Medicaid or no insurance and live in rural areas with higher poverty rates, significantly further from the treating cancer center and its affiliated hospital. Nevertheless, 49.2 % of patients from PC-shortage areas lived in urban communities. Residing in a PC-shortage area was not associated with increased surgical or medical complications, ICU admission, or hospital readmission, but was linked to more frequent prolonged hospitalization (26.3 % vs 14.1 %, $p = 0.04$). PC-shortage did not impact progression-free or overall survival.
Conclusions: Patients from PC-shortage areas may require longer inpatient perioperative care in order to achieve the same 30-day postoperative outcomes as patients who live in non-PC shortage areas. Community access to PC is a critical factor to better understanding and reducing disparities among ovarian cancer patients.

1. Introduction

Ovarian cancer is the fifth leading cause of cancer-related deaths among women and has the highest mortality rate of gynecologic cancers, with a 5-year relative survival of 49.7 % (NIH, 2020). Despite the evolving landscape of ovarian cancer therapeutics over recent years and continued improvement in outcomes, unequal access to care still exists and drives disparities in overall survival (Villanueva et al., 2019; Weeks et al., 2020; Stewart et al., 2014). Numerous studies have shown that where patients receive their initial ovarian cancer care affects their prognosis (Bristow et al., 2015; Ricci et al., 2017). High-volume cancer centers that provide specialized gynecologic oncology care often have higher rates of adherence to National Comprehensive Cancer Network guidelines, optimal surgical cytoreduction, and thus improved ovarian

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https://doi.org/10.1016/j.gore.2022.101075
Received 2 September 2022; Received in revised form 26 September 2022; Accepted 29 September 2022
Available online 3 October 2022

cancer survival compared to other treatment sites (Stewart et al., 2014; Bristow et al., 2015; Cowan et al., 2016; Wright et al., 2017). However, access to this level of care is not equitable for all patients. Furthermore, even within single academic institutions, patient outcomes have differed based on race, distance lived from the institution, and rural community status (Dilley et al., 2018; Petersen et al., 2021; Lutgendorf et al., 2021).

This has sparked interest in examining social determinants of ovarian cancer treatment, particularly factors related to cancer care access (Lutgendorf et al., 2021; Petersen et al., 2021; Weeks et al., 2021; Daruvala et al., 2021). The public health literature has shown that even after controlling for a patient's individual socioeconomic and health characteristics, their neighborhood environment can independently impact their health outcomes (Pickett and Pearl, 2001; Prentice, 2006). Indeed, increasing Area Deprivation Index (ADI) rank and disadvantaged neighborhood socioeconomic status (based on six census variables—percent below poverty, percent unemployed, percent receiving public assistance, percent female-headed households with children under 18 years, percent under 18 years, and percent non-Hispanic Black race) has been shown to negatively impact ovarian cancer survival (Brewer et al., 2015; Hufnagel et al., 2021). However, very few other neighborhood socioeconomic factors have been explored. Poor community access to primary care (PC) is one such neighborhood factor that remains understudied in ovarian cancer, but has been shown to be associated with poor surgical outcomes in other disease sites (Shifman et al., 2022).

Our primary objective was to investigate the effect of community PC-shortage on postoperative outcomes in ovarian cancer patients undergoing cytoreductive surgery. Coordination of care between surgical subspecialists, PC physicians and anesthesia teams to optimize both acute and chronic medical conditions preoperatively is a priority to ensure patient safety and good clinical outcomes. Minimizing perioperative morbidity is critical to both hospital quality improvement to decrease length of stay and readmission rates, and to ovarian cancer outcomes, as complications may delay adjuvant treatment, decrease quality of life and shorten overall survival. We hypothesized that community access to PC would decrease postoperative complication rates and hospital length of stay at a high-volume cancer center and ultimately improve ovarian cancer survival.

2. Methods

We performed a retrospective cohort study of Stage III-IV ovarian cancer patients who underwent cytoreductive surgery, either primary or interval, between 1/1/12 and 12/31/15 at a single academic, tertiary care hospital in the Midwest. The associated National Cancer Institute (NCI)-designated cancer center has a catchment area that spans 82 counties across Missouri and Illinois. Twenty percent of the population identifies as a racial minority, 29 % lives in a medically underserved area, and 15 % lives in a rural area ("Program for the Elimination of Cancer Disparities (PECaD): Siteman Cancer Center's Community Outreach and Engagement Report to the Stakeholders July 2019 - December 2020"). Patient demographics and information on medical history, cancer diagnosis, and hospital course were abstracted from electronic medical records. Addresses as listed in the medical record were geocoded to an address level, using ESRI ArcMap 10.6.1 ("Esri, 2019. ArcGIS Desktop: Release 10.6.1"). Each patient's geocoded address was categorized as within or outside of a Medically Underserved Areas (MUA) and within or outside of a Health Professional Shortage Area for Primary Care (HPSA-PC); both are defined by the Health Resources and Services Administration (HRSA) to guide programmatic efforts to improve care to all populations (Foundation). The primary factor used to determine a HPSA-PC is the number of health professionals relative to the population with consideration of high need. Federal regulations stipulate that for primary care geographic designations, the population to provider ratio must be at least 3,500 to 1; and in areas with unusually high needs, the threshold is 3,000 to 1 (Foundation; Workforce and Services, 2022). The HRSA was also used to designate the percentage of each patient's community with income below the poverty level. Rurality for each patient was determined using ZIP code level rural–urban commuting area (RUCA) code (Cromartie, 2019), where metropolitan or micropolitan were 1–6, and rural was 7 to 10. The Area Deprivation Index (ADI) score was assigned based on home address; it is a measure of neighborhood disadvantage using information on education, income/employment, housing and household characteristics, with higher scores indicating greater disadvantage (Messer et al., 2006; 'Area deprivation index' May 1, 2018). Distance and time from patient address to the hospital were calculated using ESRI Network Analyst extension ("Esri, 2019. ArcGIS Desktop: Release 10.6.1").

Comorbidity and oncologic/surgical information were abstracted from electronic medical records. The previously validated modified frailty index (mFI) was calculated for each patient from the following 11 comorbidities: diabetes mellitus, congestive heart failure, hypertension requiring medication, history of a transient ischemic attack or cerebrovascular accident (CVA), history of CVA with neurological deficit, Eastern Cooperative Oncology Group functional status ≥ 2 (unable to carry out work activities), history of myocardial infarction, peripheral vascular disease, chronic obstructive pulmonary disease (COPD) or pneumonia, history of prior percutaneous coronary intervention, cardiac surgery or angina, and impaired sensorium (Uppal et al., 2015). A score ≥ 2 indicates frailty. This score has been shown to be predictive of intensive care unit admission and 30-day mortality after gynecologic surgery (Uppal et al., 2015; Mullen et al., 2020). The American Society of Anesthesiology (ASA) score is routinely assessed preoperatively and reflects a patient's physical status (score range 1–6; 1 = healthy patient vs 6 = brain dead) (Owens, Felts, and Spitznagel, 1978). Consistent with other literature dedicated to radical cytoreductive surgery for ovarian cancer (Wright et al., 2011), the type and number of radical cytoreductive procedures were abstracted from the operative report. Radical procedures of interest included splenectomy, small bowel resection, rectosigmoid colectomy, diaphragm peritonectomy, and liver resection.

Modeled after previously published studies on postoperative outcomes in ovarian cancer surgery (Wright et al., 2011; Cham et al., 2019; Kumar et al., 2016), the primary outcome was a 30-day morbidity composite, which included surgical complications (wound complication, intraperitoneal abscess, ileus, small bowel obstruction, bowel perforation, and reoperation within 30 days) and medical complications (venous thromboembolism, arrhythmia, myocardial infarction, pneumonia, cardiopulmonary arrest, and acute renal failure). Secondary outcomes were measures of increased healthcare utilization, including an extended hospital stay (defined as > 7 days) (Mardock et al., 2020), intensive care unit admission, and 30-day hospital readmission; as well as progression-free and overall survival.

We also evaluated use of hospital services during the postoperative inpatient stay, including evaluation by Physical or Occupational Therapy (PT/OT), inpatient social work assistance, discharge with home health services, and discharge to a nursing facility. Our institution conducts daily discharge preparation rounds with a dedicated social worker, case manager, nurse manager, gynecologic oncology nurses and physicians on the gynecologic oncology service. Therefore, it is our group's practice that each patient's discharge plan is discussed to assess the need for any of these dedicated services. Use of these hospital services was quantified based on review of progress notes and social work documentation in the patient's electronic medical record.

SAS version 9.4 (SAS institute, Cary, NC) was used to perform all statistical analyses. Descriptive statistics and Chi-squared analyses were then used to analyze clinical and social demographic differences between women who lived in HPSA-defined PC-shortage vs non-PC-shortage areas. Logistic regression was used predict perioperative morbidity and increased hospital length of stay from community PC-shortage, adjusting for relevant covariates that have previously been shown to impact surgical morbidity (BMI (Bohlin et al., 2016; Shah, Vitonis, and Missmer, 2015), smoking (Bohlin et al., 2016)), ovarian cancer mortality (race, rural population designation, distance to hospital, insurance coverage (Cole et al., 2019)), or were neighborhood factors that have yet to be explored (MUA designation, PC-shortage, community poverty rate, ADI rank). Differences in progression-free and overall survival between patients who lived in PC-shortage areas and those who did not were compared using Kaplan-Meier curves and log-rank tests. All tests were two-sided with the significance level set at 0.05.

3. Results

3.1. Community access to primary care among ovarian cancer patients

Two hundred and seventeen patients underwent cytoreductive surgery for ovarian cancer at our institution during the 48-month study period. Of these, 118 (54.4 %) were from PC-shortage areas (seeFig. 1). Median age of all patients was 63, and 90.8 % were white. As shown in Table 1, 37.4 % of all patients had a BMI $\geq$ 30, 20.3 % were considered frail (MFI $\geq$ 2) at the time of surgery, and the majority had significant medical comorbidities including cardiovascular disease (58.1 %), chronic lung disease (18.0 %) and diabetes (10.6 %). Most patients were diagnosed with stage III (75.6 %) and with high-grade serous histology (85.3 %). Ninety-seven patients (44.7 %), underwent neoadjuvant chemotherapy followed by interval cytoreduction. The remainder underwent primary cytoreductive surgery followed by adjuvant chemotherapy. Approximately 85 % of patients underwent at least one radical procedure, and 77.9 % achieved no gross residual disease. There were no differences in the clinical characteristics of patients from PC-shortage areas and those not. However, at the time of initial consultation by a gynecologic oncologist at our cancer center, there was a greater proportion of PC-shortage area patients who were uninsured or had Medicaid insurance than those from non-shortage areas (20.3% vs 5.1 %, $p < 0.01$).

3.2. A closer look into primary care shortage areas: Why neighborhood context matters

There were considerable geographic disparities in distance, travel time, and rural community designation among our cohort based on their residence in a PC-shortage area (Table 1). Patients from PC-shortage areas lived a median of 69.8 miles from our cancer center compared to just 18.1 miles away for the non-PC-shortage area patients ($p < 0.01$). Notably, the maximum distance travelled was over 300 miles. As expected, the estimated median travel time was also significantly increased for these patients (101.9 vs 29.5 min, $p < 0.01$). 50.8 % of the PC-shortage area patients were also from areas designated as rural by RUCA code, compared to 7 % of the non-PC shortage areas ($p < 0.01$). However, 49.2 % of patients from PC-shortage areas lived in urban communities, indicating that the shortage of PC is not unique to rural locations. PC-shortage area patients also lived in more impoverished communities (median community poverty rate of 12.7 % vs 5.3 %, $p < 0.01$) with higher area of deprivation indices (median ADI 67.0 vs 36.0, $p < 0.01$).

3.3. Postoperative outcomes: Overall and stratified by primary care shortage area

A total of 81 patients (37.3 %) experienced a postoperative complication, including 64 patients (29.5 %) with surgical complications and 26 (12.0 %) with medical complications (Table 2). The most frequent complications were ileus (18.9 %) and wound infections (11.1 %). Approximately 4 % of all patients were admitted to the ICU following surgery. Most patients (58.5 %) required a physical and/or occupational therapy (PT/OT) evaluation to prepare for discharge, 20.3 % received social work assistance, and 28.6 % were discharged with home health services (Table 1).

Among patients from a PC-shortage area, 41.5 % experienced a postoperative complication, compared to 32.3 % from non-shortage areas, though this difference was not significant. However, we found

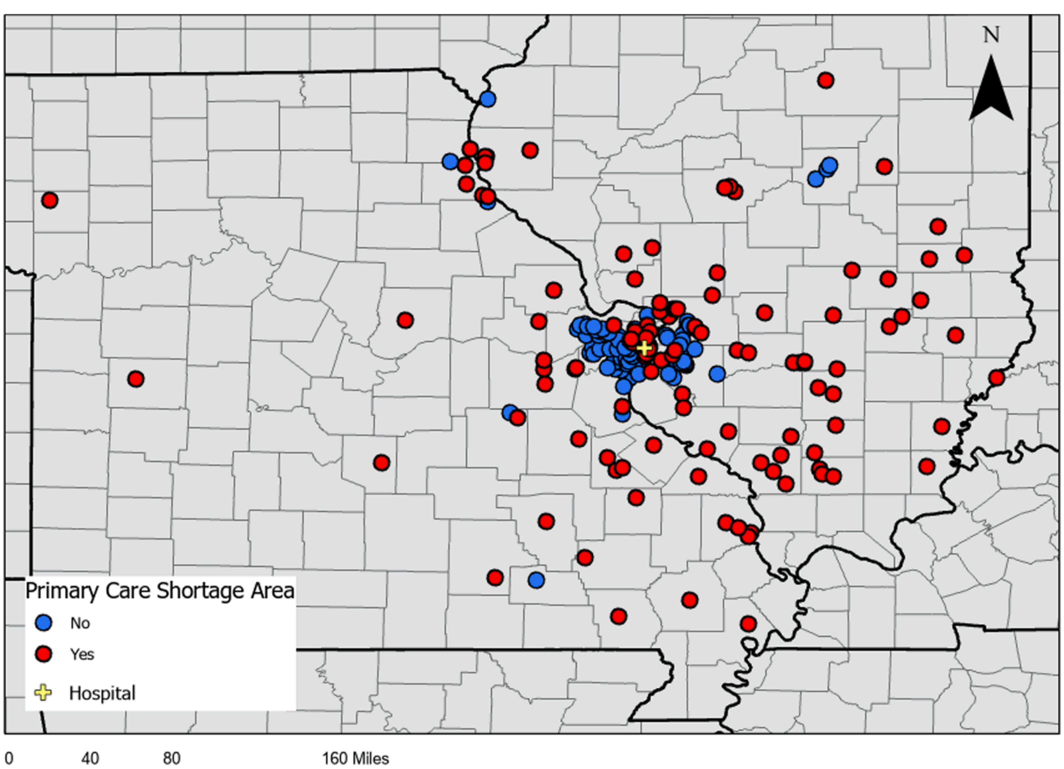

Fig. 1. Geographic spread of operative ovarian cancer patients.

Table 1
Patient Characteristics.

	Total cohort N = 217	Non PC-Shortage N = 99	PC-Shortage N = 118	p-value
Age, median (min, max)	63 (56, 69)	62 (54, 70)	63 (56, 69)	0.59
Race (n, %)				0.72
White	197 (90.8)	90 (90.9)	107 (90.7)	
Black	11 (5.1)	4 (4.0)	7 (5.9)	
Other	9 (4.1)	5 (5.1)	4 (3.4)	
Insurance Status, (n, %)				**<0.01**
Medicare/Commercial	188 (86.6)	94 (94.9)	94 (79.7)	
Medicaid/Self-Pay	29 (13.4)	5 (5.1)	24 (20.3)	
Community Poverty Rate, median % (min, max)	8.6 (0.3, 60.8)	5.3 (0.3, 26.5)	12.7 (1.8, 60.8)	**<0.01**
Area Deprivation Index, median (min, max)	52.0 (0.0, 98.0)	36.0 (1.0, 91.0)	67.0 (0.0, 98.0)	**<0.01**
Distance to Hospital, median miles (min, max)	26.9 (1.0, 304.3)	18.1 (3.0, 176.5)	69.8 (1.0, 304.3)	**<0.01**
Estimated Time to Hospital, median minutes (min, max)	47.3 (2.6, 432.2)	29.5 (7.4, 239.9)	101.9 (2.6, 432.2)	**<0.01**
Rural vs Urban Population Designation (by RUCA code) (n, %)				**<0.01**
Urban	204 (94.0)	92 (92.9)	58 (49.2)	
Rural	67 (30.9)	7 (7.1)	60 (50.8)	
COMORBIDITIES				
Modified Frailty Index calculation (mFI), median (min, max)	1.0 (0.0, 6.0)	0.0 (0.0, 5.0)	1.0 (0.0, 6.0)	0.28
Modified Frailty Index ≥ 2	44 (20.3)	17 (17.2)	27 (22.9)	0.38
ASA score, median (min, max)	3 (1, 4)	3 (2, 4)	3 (1, 4)	0.82
BMI (kg/m^2)				0.77
<29 (n, %)	132 (62.6)	63 (64.9)	69 (60.5)	
30–39 (n, %)	64 (30.3)	27 (27.8)	37 (32.5)	
≥40 (n, %)	15 (7.1)	7 (7.2)	8 (7.0)	
Smoking				0.83
Current (n, %)	23 (10.6)	10 (10.1)	13 (11.0)	
Former (n, %)	55 (25.3)	27 (27.3)	28 (23.7)	
Never (n, %)	139 (64.1)	62 (62.6)	77 (65.3)	
Diabetes	23 (10.6)	9 (9.1)	14 (11.9)	0.66
Chronic lung disease (asthma and COPD[i])	39 (18.0)	19 (19.2)	20 (16.9)	0.80
Cardiac disease (CAD[ii], angina, CHF[iii])	126 (58.1)	57 (57.6)	69 (58.5)	>0.99
Stroke	11 (5.1)	4 (4.0)	7 (5.9)	0.76
Liver disease	5 (2.3)	3 (3.0)	2 (1.7)	0.66
Dementia	1 (0.5)	0 (0.0)	1 (0.8)	>0.99
Chronic kidney disease	13 (6.0)	4 (4.0)	9 (7.6)	0.39
Prior pelvic or abdominal radiation	4 (1.8)	2 (2.0)	2 (1.7)	>0.99
ECOG performance status > 2	0			
Hypertension	116 (53.5)	53 (53.5)	63 (53.4)	>0.99
Atrial fibrillation	9 (4.1)	2 (2.0)	7 (5.9)	0.19
Peripheral vascular disease	11 (5.1)	2 (2.0)	9 (7.6)	0.07
ONCOLOGIC AND SURGICAL CHARACTERISTICS				
Cancer stage (n, %)				0.17
III	164 (75.6)	70 (70.7)	94 (79.7)	
IV	53 (24.4)	29 (29.3)	24 (20.3)	
Histology (n, %)				0.95
Serous	185 (85.3)	85 (85.9)	100 (84.7)	
Carcinosarcoma	8 (3.7)	4 (4.0)	4 (3.4)	
Clear cell	4 (1.8)	2 (2.0)	2 (1.7)	
Endometrioid	3 (1.4)	1 (1.0)	2 (1.7)	
Mixed	10 (4.6)	4 (4.0)	6 (5.1)	
Other	2 (0.9)	1 (1.0)	1 (0.8)	
Adenocarcinoma NOS	3 (1.4)	2 (2.0)	3 (2.5)	
Neoadjuvant chemotherapy + Interval cytoreductive surgery (n, %)	97 (44.7)	44 (44.4)	53 (44.9)	>0.99
Number of chemotherapy cycles completed prior to surgery, median (min, max)	3 (3, 7)	3 (3, 7)	3 (3, 7)	0.93
Number of radical procedures[iv]				0.54
0	134 (61.8)	60 (60.6)	74 (62.7)	
1	54 (24.9)	23 (23.2)	31 (26.3)	
2+	29 (13.4)	16 (16.2)	13 (11.0)	
Cytoreductive outcome (n, %)				0.62
Optimal	169 (77.9)	79 (79.8)	90 (76.3)	
Suboptimal	48 (22.1)	20 (20.2)	28 (23.7)	
Operative time > 180 min (n, %)	112 (52.3)	48 (48.5)	64 (55.7)	0.34
Postoperative Care				
Physical or Occupational Therapy evaluation	127 (58.5)	55 (55.6)	72 (61.0)	0.50
Social Work assistance	44 (20.3)	17 (17.2)	27 (22.9)	0.38
Discharged with home health	62 (28.6)	23 (24.0)	35 (30.2)	0.39
Discharged to a facility	8 (3.7)	5 (5.1)	3 (2.5)	0.33

[i] COPD: chronic obstructive pulmonary disease.
[ii] CAD: coronary artery disease.
[iii] CHF: congestive heart failure.
[iv] Radical procedures: small or large bowel resection, diaphragm peritonectomy, liver resection, splenectomy (Wright et al., 2011).

that despite no difference in surgical complexity (Table 1) or increase in postoperative complications, patients from PC-shortage areas were significantly more likely to have a prolonged hospital stay (26.3 % vs 14.1 %, p = 0.04, Table 2).

Readmission rates among the entire cohort were low at 15.7 % and not different between PC-shortage groups. Among patients who were readmitted, there were no differences in the frequency of evaluation by PT/OT, discharge with home health or receipt of social work assistance in their original admission.

The one death within 30 days of surgery was a patient from a PC-shortage area who died due to cardiogenic shock in the setting of known baseline congestive heart failure, chronic obstructive pulmonary disease and atrial fibrillation. She was readmitted on postoperative day 23 with altered mental status after receiving her first cycle of adjuvant chemotherapy the day prior. She subsequently developed acute respiratory failure and cardiogenic shock and expired five days later despite aggressive interventions.

Median progression-free survival of patients from PC-shortage areas was 16.5 months, compared to 17.9 months in non-PC shortage areas (p = 0.28, Fig. 2A). Median overall survival was also similar between the groups (42.5 vs 42.0 months, p = 0.62, Fig. 2B).

Table 2
30-day outcomes.

	Total cohort N = 217	Non PC-Shortage N = 99	PC-Shortage N = 118	p-value
Any complication (n, %)	81 (37.3)	32 (32.3)	49 (41.5)	0.21
Surgical complication composite (n, %)	64 (29.5)	25 (25.3)	39 (33.1)	0.27
Wound complication	24 (11.1)	7 (7.1)	17 (14.4)	0.13
Intraperitoneal abscess	3 (1.4)	1 (1.0)	2 (1.7)	>0.99
Ileus	41 (18.9)	17 (17.2)	24 (20.3)	0.68
Small bowel obstruction	6 (2.8)	4 (4.0)	2 (1.7)	0.42
Reoperation within 30 days	4 (1.8)	2 (2.0)	2 (1.7)	>0.99
Medical complication composite (n, %)	26 (12.0)	12 (12.1)	14 (11.9)	>0.99
Thromboembolic event	12 (5.5)	7 (7.1)	5 (4.2)	0.39
Arrhythmia	7 (3.2)	2 (2.0)	5 (4.2)	0.46
Myocardial infarction	1 (0.5)	1 (1.0)	0 (0.0)	0.46
Pneumonia	6 (2.8)	3 (3.0)	3 (2.5)	>0.99
Cardiopulmonary arrest	1 (0.5)	0 (0.0)	1 (0.8)	>0.99
Acute renal failure	13 (6.0)	6 (6.1)	7 (5.9)	>0.99
ICU admission (n, %)	8 (3.7)	4 (4.0)	4 (3.4)	>0.99
Prolonged hospital stay > 7 days (n, %)	**45 (20.7)**	**14 (14.1)**	**31 (26.3)**	**0.04**
Readmission within 30 days	34 (15.7)	15 (15.2)	19 (16.1)	0.99
PT/OT evaluation during stay	21 (61.8)	8 (53.3)	13 (68.4)	0.59
Discharged with Home Health	10 (29.4)	5 (33.3)	5 (26.3)	0.72
Social Work assistance	9 (26.5)	4 (26.7)	5 (26.3)	>0.99
Mortality, 30-day (n, %)	1 (0.5)	0 (0.0)	1 (0.9)	0.36

In a multivariable model to assess the relative impact of socioeconomic factors on perioperative outcomes, only living in a PC-shortage area was significant (Table 3). Living in a PC-shortage area was associated with a four-fold increased risk of a prolonged hospitalization after surgery compared to living in a non-PC-shortage area (HR 3.94, 95 % CI 1.47, 10.58). However, this neighborhood variable was not associated with increased odds of medical or surgical complications or readmission. Notably, no other individual or neighborhood socioeconomic factors were associated with an increased odds of complications, prolonged hospitalization, or readmission.

4. Discussion

Living in a PC-shortage area emerged as a strong predictor of increased length of hospital stay even after adjusting for other individual and neighborhood socioeconomic factors such as rurality, distance to hospital, insurance coverage, community poverty rate, and ADI rank. Given no differences in medical comorbidities or surgical complications between patients who did versus did not live in PC-shortage areas, our findings suggest that attention to unmeasured social needs aimed at preventing readmissions may come at the expense of a longer postoperative hospital stay. Future studies are needed to further evaluate any causal relationship so as to best develop methods to narrow this disparity.

At our institution, a multidisciplinary team engages in daily discharge preparation rounds to identify and address patients' medical and social needs after surgery. Hospital initiatives to improve quality metrics such as surgical site infection, perioperative complication rates, and hospital length of stay are ongoing priorities across the country. However, as we gain forward momentum to address these issues, we must be thoughtful to design interventions that are culturally sensitive, improve access and coordination of care with PC physicians in the community after hospital discharge, and mitigate geographic disparities so that all patients have an equal opportunity to achieve improved outcomes.

Our study helps to expand the current literature on geographic disparities among ovarian cancer patients, which is predominately dedicated to examining the impact of distance or rurality on surgical outcomes and survival. Improved ovarian cancer survival has been demonstrated in urban compared to rural patients (Lutgendorf et al., 2021), and in patients who live close to their treating institution (Daruvala et al., 2021). However, this data is inconsistent, and a recent study found that ovarian cancer patients who lived within 10 miles of their cancer center had a 1.61 increased risk of death over those that lived further away (Petersen et al., 2021). This highlights the fact that analyses of cancer disparities must look beyond the rural/urban dichotomy and evaluate other neighborhood factors, such as local access to medical care. Furthermore, the concept of a "distance bias," as demonstrated in many diseases including pancreatic (Lidsky et al., 2017), gastrointestinal (Wasif et al., 2016), and esophageal cancer (Speicher et al., 2017), suggests that patients with socioeconomic privilege choose to travel further to specialized care. In our study, given the higher frequencies of Medicaid or no insurance, higher community poverty rates, and higher median ADI, it is unlikely that patients in PC-shortage areas who traveled long distances did so out of choice or an abundance of resources.

Our study sheds insight into the complexity of geographic disparities by uniquely studying patients' community access to PC as determined by their home address. Understanding neighborhood context and geographic access to care on individual health outcomes is critical for cancer care delivery, and we hope our findings stimulate future research that supports more equitable, but personalized cancer care. Strengths of our study include our large, diverse patient catchment. As an NCI-designed cancer center, over half of ovarian cancer surgery patients we serve have poor access to PC and travel great distances from rural and impoverished communities for treatment. Importantly, we also have high retention rates in our practice and are able to report reliable postoperative complication rates and follow-up, as our postoperative patients are almost uniformly transferred to our tertiary hospital for postoperative admissions. Though it is still possible that patients presented to out-of-network hospitals with postoperative complications, we had 100 % return rate for outpatient postoperative visits and therefore feel that the risk of bias is less than it may be in some larger metropolitan areas with more hospital systems.

Limitations of our study are inherent to its small sample size, retrospective design, and use of population health factors to predict individual-level outcomes. While this is useful to design quality care for large groups, it risks incorrectly identifying patients who could benefit from an intervention (Cottrell et al., 2020). In addition, while we have demonstrated an association between lack of neighborhood access to PC and longer surgical hospital stay, we cannot assess causality. It is possible that patients with poor access to PC required additional time in the hospital to address social issues, such as rides home. It is also possible that while comorbidity frequencies were similar between the two groups, patients from PC-shortage areas had comparatively more poorly managed comorbidities and thus required additional time to arrange for appropriate outpatient care. However, we were unable to quantify personal indications such as these in a retrospective study design. We were also unable to measure if there were differences in postoperative follow-up care with PC physicians for either new or chronic medical conditions between patients who lived in PC-shortage areas and those that did not. Lastly, we acknowledge that as an academic, tertiary care hospital, our multidisciplinary team services dedicated to inpatient discharge planning may look very different from other hospital settings, thus limiting the generalizability of our results. Nevertheless, because one's neighborhood environment, including community access to medical care, can independently affect their individual health outcomes (Pickett and Pearl, 2001; Prentice, 2006), we feel that this neighborhood analysis holds additional value to a patient's personal access. Third, multiple studies have demonstrated racial disparities in ovarian cancer treatment and outcomes (Dilley et al., 2018; Bristow et al., 2013). However, our study was limited by the low number of non-white patients to adequately examine the role that race plays in this analysis.

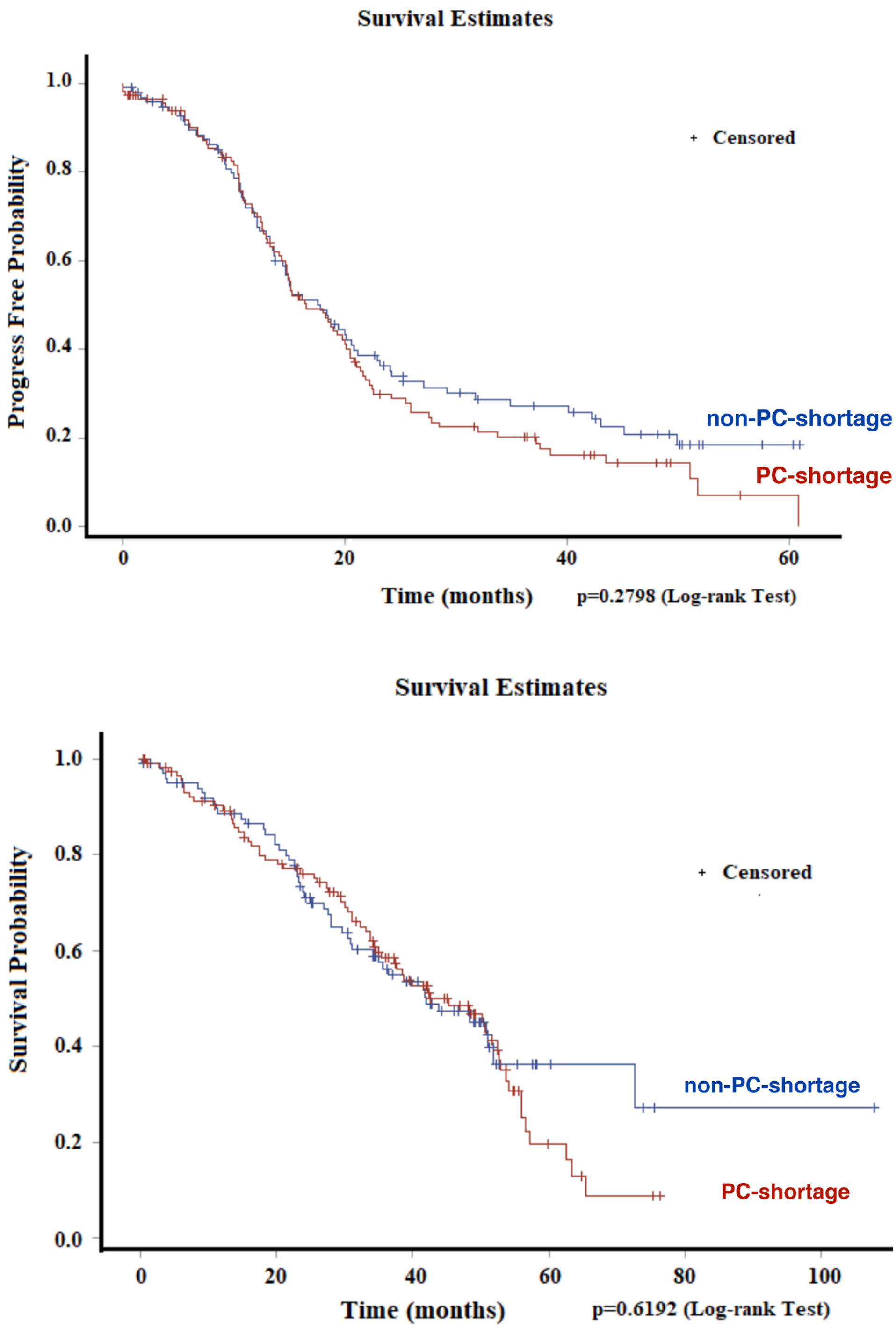

Fig. 2. Kaplan- Meier plot of (A) progression-free survival and (B) overall survival from surgery date in patients from primary care (PC)-shortage areas vs. non-PC-shortage areas.

In summary, ovarian cancer patients from areas with poor access to PC had a significantly greater frequency of prolonged hospital stays after cytoreductive surgery, despite no increase in baseline medical comorbidities, surgical complexity, or 30-day medical or surgical post-operative complications. We also found that half of the patients from PC-shortage areas lived in an urban setting and their distance to the hospital spanned 1 to 300 miles, demonstrating that neighborhood access to PC, as a population-based metric of disparity, may bridge the gap in disparities research between other geographic analyses, including distance and rural designation. This study therefore identifies access to PC as an important variable in the expanding field of research identifying and addressing geographic disparities among ovarian cancer patients. We recommend clinicians caring for patients with ovarian cancer be aware of PC-shortage areas in their catchment and that patients from those areas be flagged for early initiation of discharge planning. Given the implications of cancer care costs at every level—patient, provider and practice, employer, insurer/payer, and even state and national policies—it is important that future research evaluates the benefit-cost ratio of providing increased primary care in underserved areas. Future research efforts should also seek to explore the causality of PC shortage and hospital length of stay, as well as explore similar relationships after surgery for other gynecologic malignancies or other inpatient stays

Table 3
Multivariable Analysis of Individual and Neighborhood Sociodemographic Factors Affecting Postoperative Outcomes.

	Any Complication[i]	Surgical Complication[ii]	Medical Complication[iii]	Prolonged Hospital Stay	Readmission within 30 days
Race					
White	Reference	Reference	Reference	Reference	Reference
Black	3.57	1.65	2.88	2.31	1.27
	(0.85, 14.95)	(0.37, 7.29)	(0.57, 14.48)	(0.48, 11.2)	(0.2, 8.2)
Other	1.39	1.21	0.88	1.88	2.24
	(0.3, 6.41)	(0.22, 6.64)	(0.1, 8.03)	(0.32, 11.23)	(0.38, 13.14)
BMI (kg/m^2)					
<29	Reference	Reference	Reference	Reference	Reference
30–39	0.95	0.94	0.97	1.15	1.06
	(0.50, 1.8)	(0.47, 1.89)	(0.42, 2.21)	(0.54, 2.49)	(0.46, 2.46)
≥40	1.59	1.12	1.12	0.51	0.32
	(0.51, 5.02)	(0.33, 3.77)	(0.27, 4.64)	(0.10, 2.76)	(0.04, 2.8)
Smoking					
Never	Reference	Reference	Reference	Reference	Reference
Current	1.89	1.63	0.89	0.55	1.19
	(0.73, 4.84)	(0.62, 4.29)	(0.26, 3.03)	(0.14, 2.13)	(0.34, 4.15)
Former	1.29	1.17	1.01	1.08	1.07
	(0.67, 2.52)	(0.57, 2.41)	(0.42, 2.4)	(0.48, 2.42)	(0.44, 2.58)
Insurance Status					
Medicare/Commercial (private) insurance	Reference	Reference	Reference	Reference	Reference
Medicaid/no insurance	1.14	1.02	1.33	1.88	0.88
	(0.50, 2.6)	(0.42, 2.49)	(0.47, 3.75)	(0.72, 4.91)	(0.27, 2.81)
Resides in a Medically Underserved Area					
No (%)	Reference	Reference	Reference	Reference	Reference
Yes (%)	1.85	1.92	2.07	1.69	2.29
	(0.91, 3.77)	(0.9, 4.09)	(0.82, 5.22)	(0.71, 4.02)	(0.91, 5.75)
Resides in a PCP shortage area					
No (%)	Reference	Reference	Reference	Reference	Reference
Yes (%)	1.44	1.55	0.92	**3.96**	1.18
	(0.68, 3.04)	(0.67, 3.54)	(0.35, 2.43)	**(1.48, 10.62)**	(0.41, 3.4)
Community Poverty Rate (median %)	0.99	0.99	0.97	0.96	1
	(0.94, 1.03)	(0.95, 1.04)	(0.91, 1.02)	(0.91, 1.02)	(0.95, 1.05)
Distance to BJH[iv]	1	0.98	1.01	0.98	0.95
	(0.96, 1.03)	(0.94, 1.02)	(0.97, 1.05)	(0.93, 1.03)	(0.88, 1.02)
ADI Rank[v]	0.99	0.99	0.99	0.99	0.99
	(0.97, 1)	(0.98, 1.01)	(0.98, 1.01)	(0.97, 1.01)	(0.98, 1.01)
Rural vs Urban Population Designation					
Urban	Reference	Reference	Reference	Reference	Reference
Rural	1.28	1.37	0.89	0.89	1.94
	(0.57, 2.88)	(0.56, 3.35)	(0.30, 2.64)	(0.33, 2.38)	(0.58, 6.43)

[i] Medical or surgical complication.
[ii] Surgical complications: wound complication, intraperitoneal abscess, ileus, small bowel obstruction, bowel perforation, and reoperation within 30 days.
[iii] Medical complications: venous thromboembolism, arrhythmia, myocardial infarction, pneumonia, cardiopulmonary arrest, and acute renal failure.
[iv] Odds ratio for every 10Km traveled.
[v] Odds ratio for every 1-point increase in Area Deprivation Index.

indications.

Funding Disclosure

(1) Angela Mazul, PhD MPH is supported by a National Institute of Health K award (K01MD013897). (2) Lindsey Kuroki, MD MSCI is supported by the Doris Duke Foundation as a Doris Duke Fund to Retain Clinical Scientists Program Scholar (2015215) and has received a Washington University Implementation Science Center for Cancer Control pilot grant (P50CA244431). The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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