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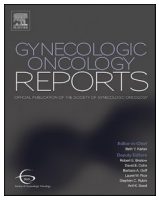

The effect of food deserts on gynecologic cancer survival

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ABSTRACT

Objective: Living in a food desert is a known negative health risk, with recent literature finding an associated higher mortality in patients with cancers. Gynecologic cancers have not specifically been studied. We aimed to describe patients with gynecologic cancers who live in a food desert and determine if there is an association between living in a food desert and gynecologic cancer mortality.

Methods: The 2013–2019 California Cancer Registry (CCR) was used to identify patients with endometrial, ovarian, or cervical cancers. Patient residential census tract was linked to food desert census tracts identified by the 2015 United States Department of Agriculture Food Access Research Atlas. Comorbidity data were obtained from the California Office of Statewide Health Planning and Development database (OSHPD). Treatment, diagnosis, and survival outcomes were obtained from the CCR's variables and compared by food desert status. Five-year disease-specific survival was analyzed by applying Cox proportional hazards analysis.

Results: 40,340 gynecologic cancer cases were identified. 60.1 % had endometrial cancer, 23.2 % had ovarian cancer, and 15.9 % had cervical cancer. The average age of the cohort was 59.4 years, 48.0 % was non-Hispanic White, 50.3 % was privately insured, and 6.8 % of lived in a food desert. Living in a food desert was associated with higher disease-specific mortality for patients with gynecologic cancers (endometrial cancer HR 1.43p $<$ 0.001 95 % CI 1.22–1.68; ovarian cancer HR 1.47p $<$ 0.001 95 % CI 1.27–1.69; cervical cancer HR 1.24p $=$ 0.045 95 % CI 1.01–1.54).

Conclusion: Patients living in food deserts had worse disease-specific survival, making access to food a modifiable risk factor that may result in mitigating gynecologic cancer disparities.

1. Introduction

Despite the significant improvements to cancer care in the United States over the past three decades, cancer remains the country's second leading cause of death with an estimated 609,360 cancer related deaths to occur 2022 (Siegel et al., 2022). In that same year, gynecologic cancers are rated third in estimated cancer related incidents and fifth in estimated cancer related mortality (Siegel et al., 2022). These highly prevalent and aggressive tumors have been found to affect women of color and patients of lower socioeconomic status more often than their white and affluent counterparts (Whetstone et al., 2022 Apr 1; Yu et al., 2019 Jun). The national reckoning surrounding racism has spotlighted discussions of health inequity and the role institutions have in upholding the status quo. These discussions, which aim to resolve structural causes of health inequity, have provided opportunities to study and address health disparities in cancer care (Adsul et al., 2022). We sought to determine whether certain environmental variables may be associated with cancer related health and survival.

Significant differences in social determinants of health have resulted in disparate care and treatment in patients with gynecologic cancers, leading to worse outcomes. While certain risk factors may be multifactorial and not as easily modifiable, several others can be more easily defined and targeted in the interest of mitigating health disparities in cancer care (Yvonne Collins, 2014). Factors reported as leading to inequities in care for patients with gynecologic cancers include socioeconomic status, cultural differences between providers and their

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patients, lack of access to care, higher rates of medical comorbidities, inequity in treatment, and tumor biological factors (Yvonne Collins, 2014).

The goal of present research in health disparities and inequities is to improve patient outcomes for at risk populations. The Society of Gynecologic Oncology (SGO) has proposed a health equity framework, which includes the evaluation of environmental factors as a contributor to health inequities (Temkin and B. a., 2018). One of such unstudied environmental factors is the relation of discrepant food access and residence in a food desert, and how it may be associated to gynecologic cancer survival.

The United States Department of Agriculture (USDA) has defined food deserts as census tracts or neighborhoods that are low income with either a poverty rate that exceeds 20 % or a family median income that does not exceed 80 % of the median national income (xxxx). In addition to being low income, communities are also required to have significant distance to affordable fresh foods and supermarkets to be deemed a food desert (1 mile for urban communities and 10 miles for rural communities) (Report Number 140 August, 2012;xxxx). Health care outcomes associated to residence in a food desert include worse cardiovascular risk, higher obesity rates, worse glycemic control in patients with type 2 diabetes, and worse obstetrical and neonatal outcomes (Testa et al., 2021 Jan; Ghosh-Dastidar et al., 2014 Nov; Berkowitz et al., 2018 Jun; Tipton et al., 2020; Pires Augusto et al., 2020).

The first association of oncologic outcomes and food deserts, reported by Fong et al, found worse overall survival for patients with breast and colon cancer who lived in a food desert (Fong et al., 2021 Mar). At the time of this report there have been no previous studies with a focus on food deserts and their specific impact on patients with gynecologic cancers. The aims of this study were to describe the characteristics of patients living in a food desert with gynecologic cancers and determine if residence in a food desert affects the disease-specific survival of patients with gynecologic cancer in the state of California.

2. Methods

The 2013–2019 California Cancer Registry (CCR) data set was queried for adult female patients with endometrial, ovarian, or cervical cancers at all stages of disease. Cases were selected if they met the American Joint Committee on Cancer (AJCC) 7th Edition criteria by site and histology codes for endometrial, ovarian cancer, or cervical cancer. Additionally, cases were eligible if they were classified as analytic cases, were histologically confirmed, were the only or first primary cancer, and were adults aged 18 or older. Cases were excluded if they were diagnosed at autopsy, or diagnosed in convalescent or hospice care, were missing a diagnosis date, were missing a follow-up date, and if the patient died within 30 days of diagnosis. The use of these data was approved by our institutional review board (IRB) and by the California state Committee for the Protection of Human Subjects.

Patient identification numbers were used to link CCR data to inpatient or ambulatory surgery center discharge records acquired from the California Office of Statewide Health Planning and Development (OSHPD). These records contain principal diagnosis and procedure codes were in ICD-9 or ICD-10 format and used to create variables associated with specific diagnoses. Such diagnoses include smoking, obesity, type II diabetes mellitus (TIIDM), and metabolic syndrome. Metabolic syndrome is defined by the American Heart Association as having at least 3 of the following conditions: high blood glucose, low levels of HDL cholesterol, high levels of triglycerides, large waist circumference, and high blood pressure. Satisfying this syndrome criteria increases the individual risk of diabetes, heart disease, stroke, and atherosclerosis ([2]). Metabolic syndrome was specified in our database by applying an algorithm described by Akinemiju and colleagues (Akinyemiju et al., 2018) using ICD-9 diagnosis codes. Translation of ICD-9 codes into their corresponding ICD10 equivalent codes was conducted using a web-based crosswalk (https://www.icd10data.com/Convert). We used the Deyo modification of the Charlson Comorbidity Index (CCI) was used to measure comorbidity (Deyo et al., 1992) and omitted cancer-related sub-scores from the CCI to avoid artificially inflated comorbidity scores among this set of patients.

Patient residential census tract at time of diagnosis was linked to food desert census tracts identified by the 2015 USDA Food Access Research data set. Socioeconomic status for patients was also defined at the census tract level using a composite of several variables including tract-level measures of income, employment, and education. This measure was created and validated by CCR (Yost et al., 2001).

We used a Cox proportional hazard model to estimate the five-year disease-specific survival, defined as the percentage of people in a disease group who have not died from a specific disease in a period of time, associated with food desert residential status. From plots of residuals obtained from initial survival analyses, we observed that the food desert survival curves (not-desert vs. desert) crossed each other, indicating violation of the proportional hazard's assumption. As a result, we included a time-dependent version of food desert by multiplying food desert status (no/yes) by a binary variable (no/yes) if patients had follow-up time lasting from at least 1 month and up to 60 months. This time-dependent version met the proportional hazards assumption, and for all further analyses we used the time-dependent version of food desert.

Treatment, diagnosis, and survival outcomes were obtained from CCR variables and compared by food desert status. Univariable analyses comparing residents by food desert status were analyzed by Student's *t*-test or chi square analysis. Five-year disease-specific survival was analyzed by applying univariable Cox proportional hazards analysis, then subsequently modeled by applying Cox hazards analysis for multivariable models. All analyses were conducted using Stata MP version 14.2 (StataCorp, College Station, TX).

3. Results

3.1. Description of patients living in a food desert with gynecologic cancers

Of the 40,340 patients with gynecologic cancer, 6.8 % resided in food deserts at time of diagnosis. When compared to those not living in food desert, patients living in a food desert were more likely to be Hispanic (32.6 % vs 23.1 %) or Black (7.8 % vs 6.3 %), be obese (50.8 % vs 41.6 %), have T2DM (15.2 % vs 12.9 %) or metabolic syndrome (24.3 % vs 21.2 %), be part of a low or very low SES (30.7 % vs 16.1 % and 36.1 % vs 11.9 % respectively), and have public (Medicaid or Medicare) health insurance as their primary source of insurance (51.5 % vs 48.7 %). There were no significant cancer stage differences in the disease groups. Patients with endometrial cancer and ovarian cancer were less likely to receive surgery as part of their initial treatment if they resided in a food desert. Patients with cervical cancer were more likely to receive chemotherapy if they resided in a food desert. Table 1 summarizes the individual cohort demographics.

3.2. Univariable analysis

Univariable Cox proportional hazard analyses demonstrated that patients with endometrial, ovarian, and cervical cancer who lived in a food desert had a greater five-year mortality risk than those who did not live in a food desert (endometrial: 1.97, $p < 0.01$ CI 1.75–2.23; ovarian: HR 1.83, $p < 0.001$ CI 1.61–2.08; cervical: HR 1.62, $p < 0.001$ CI 1.36–1.93). Other factors associated with a worse five-year mortality by univariable analysis for all cancer types included: age, Black race, smoking, TIIDM, and metabolic syndrome, higher stage of disease, a higher comorbidity index, and very low or low socioeconomic status.

Table 1
Demographic description of patients living in a food desert with (A) endometrial cancer (B) ovarian cancer, and (C) cervical cancer.

A. Endometrial Cancer				
		FOOD DESERT RESIDENCE	**P value**	
		YES (6 %)	NO (94 %)	
AGE (yrs, mean)		61	61.9	0.6013
RACE/ETHNICITY			**<0.001**	
	Non-Hispanic White	50.6 %	52.7 %	
	Black	7.8 %	6.3 %	
	Hispanic	**32.6 %**	**23.1 %**	
	Asian/ Pacific Islander	6.5 %	14.8 %	
	Other	2.5 %	3.2 %	
SMOKING STATUS			**<0.001**	
	Yes	5.2 %	3.2 %	
	No	94.9 %	96.8 %	
OBESITY (BMI > 30) **<0.001**				
	Yes	50.8 %	41.6 %	
	No	49.2 %	58.4 %	
TYPE II DIABETES				**0.007**
	Yes	15.2 %	12.9 %	
	No	84.8 %	87.1 %	
METABOLIC SYNDROME				**0.003**
	Yes	24.3 %	21.2 %	
	No	75.7 %	78.8 %	
COMORBIDITY SCORE				**<0.001**
	Zero	62.7 %	68.0 %	
	One	26.1 %	22.3 %	
	Two or more	11.2 %	9.7 %	
SOCIOECONOMIC STAUS				**<0.001**
	Very Low	36.1 %	11.9 %	
	Low	30.7 %	16.1 %	
	Middle	14.2 %	18.7 %	
	High	5.7 %	20.1 %	
	Very High	1.4 %	17.7 %	
INSURANCE STATUS				**<0.001**
	Private Insurance	41.4 %	47.6 %	
	Medicare/ Medicaid	51.5 %	48.7 %	
	Uninsured	1.9 %	2.1 %	
	Other	3.7 %	3.6 %	
DISEASE STAGE				0.074
	I	71.5 %	74.3 %	
	II	5.6 %	4.8 %	
	III	14.4 %	12.9 %	
	IV	8.5 %	7.9 %	
TREATMENT-SURGERY				<0.001
	Yes	93.1 %	95.4 %	
	No	6.9 %	4.6 %	
TREATMENT-CHEMOTHERAPY				0.315
	Yes	24.3 %	22.9 %	
	No	75.0 %	76.3 %	
TREATMENT-RADIATION				0.342
	Yes	27.3 %	26.2 %	
	No	72.8 %	73.8 %	
B. Ovarian Cancer				
		Food Desert Residence	P value	
		YES (7 %)	NO (93 %)	
Age (yrs, mean)		60.1	60.6	0.9995
Race/Ethnicity				**<0.001**
	Non-Hispanic White	52.5 %	53.2 %	
	Black	**6.3 %**	**4.5 %**	
	Hispanic	**31.3 %**	**24.1 %**	
	Asian/ Pacific Islander	7.1 %	15.7 %	
	Other	2.2 %	3.3 %	
Smoking Status				0.08
	Yes	6.8 %	5.1 %	
	No	93.2 %	94.9 %	
Obesity (BMI > 30)				**<0.001**
	Yes	**28.6 %**	**20.7 %**	
	No	71.5 %	79.4 %	
Type II Diabetes				**<0.001**
	Yes	**14.5 %**	**8.6 %**	
	No	85.5 %	91.4 %	
Metabolic Syndrome				**<0.001**
	Yes	**16.4 %**	**11.5 %**	
	No	83.6 %	88.5 %	
Comorbidity Score				**0.006**
	Zero	68.2 %	74.2 %	
	One	**20.8 %**	**16.9 %**	
	Two or more	**11.0 %**	**8.9 %**	
Socioeconomic status				**<0.001**
	Very Low	**37.7 %**	**11.5 %**	
	Low	**27.7 %**	**14.1 %**	
	Middle	16.9 %	18.5 %	
	High	5.7 %	19.8 %	
	Very High	0.7 %	20.2 %	
Insurance Status				**<0.001**
	Private Insurance	41.4 %	47.6 %	
	Medicare/ Medicaid	**51.5 %**	**48.7 %**	
	Uninsured	1.9 %	2.1 %	
	Other	3.7 %	3.6 %	
Disease Stage				0.132
	I	22.3 %	25.3 %	
	II	8.6 %	9.3 %	
	III	35.0 %	35.6 %	
	IV	34.1 %	29.9 %	
Treatment -Surgery				**0.004**
	Yes	**80.1 %**	**84.5 %**	
	No	20.0 %	15.5 %	
Treatment-Chemotherapy				0.041
	Yes	75.5 %	75.4 %	
	No	21.5 %	22.9 %	
Treatment-Radiation				0.724
	Yes	1.3 %	1.5 %	
	No	98.7 %	98.5 %	
C. Cervical Cancer				
		Food Desert Residence	P value	
		YES (8 %)	NO (92 %)	
Age (yrs, mean)		49.8	50.4	0.841
Race/Ethnicity				**<0.001**
	Non-Hispanic White	42.20 %	39.40 %	
	Black	**8.10 %**	**6.10 %**	
	Hispanic	**40.10 %**	**34.90 %**	
	Asian/ Pacific Islander	6.50 %	17.00 %	
	Other	3.00 %	2.70 %	
Smoking Status				**0.025**
	Yes	12.00 %	9.00 %	
	No	88.00 %	91.00 %	
Obesity (BMI > 30)				**0.02**

(*continued on next page*)

Table 1 (*continued*)

A. Endometrial Cancer				
	Yes	**25.20 %**	**19.60 %**	
	No	74.90 %	80.50 %	
Type II Diabetes				**0.054**
	Yes	**8.80 %**	**6.60 %**	
	No	91.20 %	93.40 %	
Metabolic Syndrome				0.605
	Yes	**7.90 %**	**7.20 %**	
	No	92.10 %	92.80 %	
Comorbidity Score				0.846
	Zero	79.80 %	78.90 %	
	One	**14.00 %**	**14.20 %**	
	Two or more	**6.30 %**	**6.90 %**	
Socioeconomic status				**<0.001**
	Very Low	**47.90 %**	**17.70 %**	
	Low	**32.20 %**	**18.70 %**	
	Middle	7.10 %	19.00 %	
	High	4.50 %	17.20 %	
	Very High	0.60 %	13.50 %	
Insurance Status				**<0.001**
	Private Insurance	39.10 %	49.30 %	
	Medicare/ Medicaid	**51.70 %**	**28.40 %**	
	Uninsured	2.60 %	3.00 %	
	Other	1.40 %	1.40 %	
Disease Stage				**<0.001**
	I	45.80 %	48.90 %	
	II	14.70 %	14.90 %	
	III	25.30 %	20.40 %	
	IV	14.20 %	15.90 %	
Treatment -Surgery				0.412
	Yes	57.00 %	58.80 %	
	No	43.00 %	41.20 %	
Treatment-Chemotherapy				**0.016**
	Yes	**57.80 %**	**51.20 %**	
	No	41.50 %	47.60 %	
Treatment-Radiation				0.067
	Yes	59.10 %	54.90 %	
	No	40.10 %	45.10 %	

3.3. Multivariable analysis

Multivariable survival analysis of food desert residential status was constructed for each disease site to determine 5-year disease-specific survival. Living in a food desert was associated with greater mortality risk for all gynecologic cancers even after controlling for known co-predictors (endometrial cancer HR 1.43p < 0.001 95 % CI 1.22–1.68; ovarian cancer HR 1.47p < 0.001 95 % CI 1.27–1.69; cervical cancer HR 1.24p = 0.045 95 % CI 1.01–1.54; Table 2, Fig. 1).

4. Discussion

Food desert residential status and food insecurity are social and demographic phenomena that have been identified as conferring significant negative health outcomes. Reports on how these factors may be associated with worse outcomes for patients living with cancer have only just begun to appear in the literature, finding worse cancer mortality in these communities. In recent years, growing attention has been placed on these factors as being consequences of systemic inequities in the United States that can affect a patient's ability to receive adequate healthcare (Siegel et al., 2022; Yost et al., 2001). While gynecologic cancers have been previously associated with significant discrepant socioeconomic factors that lead to worse outcomes in certain patients, food desert residential status has yet to be reported on as an environmental factor. We aimed to distinguish which patients with gynecologic cancers were more likely to live in a food desert and determine if there was an associated worse survival for these patients.

This study's results concur with recently published studies on food deserts and cancer survival. A cross-sectional study regarding the association of high obesity-related cancer mortality rates and low-income food desert environments found a 77 % increased odds of high obesity-related cancer mortality (Bevel et al., 2023). This study included both endometrial and ovarian cancers, which raises concern as ovarian cancer ranks fifth in female cancer-related mortality (Siegel et al., 2022; Wood et al., 2023). Fong et al reported how survival, despite treatment for late-stage breast and colorectal cancers, was worse for those living in a food desert (Fong et al., 2021 Mar). Similarly, we report a worse disease-specific five-year survival for patients living in a food desert with endometrial (43 %), ovarian (47 %), and cervical cancer (24 %). We were able to identify all individuals with gynecologic cancers in California and were able to match their specific medical and treatment history, food dessert residential status, and cancer mortality.

Like previously reported associations in other disease sites, we were able to report that food desert residential status was associated with Black race, low socioeconomic status, obesity and its associated comorbidities, smoking history, and public health insurance. This concurs with previous reports that some food deserts exist due to the persisting effects of discriminatory practices, such as redlining, that have historically denied services to people of color (Bevel et al., 2023). Residents of these communities have been reported as experiencing worse overall health and insufficient cancer care due to these conditions (Siegel et al., 2022).

Despite there being no differences in disease stages between the groups, there were treatment discrepancies observed in patients who lived in a food desert. Patients were less likely to receive surgical treatment as part of their initial therapy if they had endometrial and ovarian cancer, and patients with cervical cancer were more likely to receive chemotherapy as their initial treatment. This may speak to guideline non-adherent care being provided to or received by patients living in food deserts. However, despite controlling for treatment differences, food desert residence was still an independent variable associated with mortality.

Some possible reasons as to why residing in a food desert may be associated with worse gynecologic cancer outcomes incudes access to foods with higher inflammatory potential, such as processed meat and sugary drinks (Wood et al., 2023), previously reported by to be independently associated with higher risk of gynecologic cancer incidence and mortality (Wood et al., 2023). In addition, persons living in a food desert may lead more sedentary lifestyles, with higher incidences of obesity, diabetes, and metabolic syndrome, known risk factors for certain gynecologic cancers. This may be related to not having access to healthy foods, but also having significant access to fast-food restaurants and unhealthy food sources, described in the literature as a worse food environment or "food swamp" (Babey et al., (2008, December 22).).

Certain literature also indicates that access is not the only barrier that may be associated with worse nutritional outcomes. Stern reports how what type of establishment individuals shop at are not associated with the nutrient quality of purchased foods for any racial-ethnic group in the United States (Stern et al., 2016 Apr). Shopping at grocery stores was not associated with a better nutrient profile as compared to smaller corner stores. This was consistent across all racial-ethnic groups. African American households were more likely to purchase foods with higher energy, total sugar, and higher sodium than their other racial counterparts, regardless of where they shopped. They hypothesize that food preferences, budget constraints, differences in price sensitivities, car ownership, and food marketing are likely to influence food-shopping behaviors (Stern et al., 2016 Apr). This speaks to the multifactorial nature of why food deserts can confer negative health outcomes, and how a simple solution of providing more access to fresh foods and vegetables is not enough to mitigate this disparity. Community-based educational

Table 2
Disease-specific survival at 5 years for patients with (A) endometrial cancer, (B) ovarian cancer, and (C) cervical cancer.

A. Endometrial cancer, disease-specific survival at five years							
		All stages (n = 24,333)		Early stage (n = 19,215)		Late stage (n = 5,118)	
Variables	Categories	HR (95 % CI)	*P*	HR (95 % CI)	*P*	HR (95 % CI)	*P*
Age		1.03 (1.03–1.04)	<0.001	1.06 (1.05–1.06)	<0.001	1.02 (1.01–1.02)	<0.001
Race	NH-White (reference)						
	NH-Black	1.63 (1.43–1.85)	<0.001	1.63 (1.28–2.08)	<0.001	1.44 (1.24–1.69)	<0.001
	Hispanic	1.08 (0.97–1.20)	0.181	1.22 (1.01–1.47)	0.039	0.97 (0.85–1.11)	0.692
	NH-Asian/PI	1.04 (0.92–1.18)	0.541	1.21 (0.98–1.49)	0.079	0.95 (0.82–1.11)	0.520
	NH-Other	0.98 (0.78–1.24)	0.895	0.80 (0.51–1.25)	0.319	1.02 (0.76–1.36)	0.913
Smoking	No (reference)						
	Yes	1.31 (1.07–1.61)	0.010	1.54 (1.11–2.13)	0.010	1.21 (0.95–1.54)	0.119
Obesity	No (reference)						
	Yes	0.95 (0.86–1.05)	0.295	0.87 (0.74–1.02)	0.094	1.04 (0.92–1.16)	0.536
Diabetes II	No (reference)						
	Yes	1.23 (1.08–1.40)	0.001	1.16 (0.92–1.46)	0.198	1.27 (1.09–1.49)	0.002
Metabolic syndrome	No (reference)						
	Yes	0.95 (0.84–1.08)	0.435	0.98 (0.80–1.21)	0.868	0.94 (0.81–1.09)	0.436
Comorbidity score	Zero (reference)						
	One	1.02 (0.91–1.14)	0.734	1.00 (0.83–1.21)	0.982	0.99 (0.87–1.14)	0.929
	≥Two	1.27 (1.12–1.45)	<0.001	1.20 (0.96–1.51)	0.111	1.27 (1.09–1.49)	0.003
SES	Very low (reference)						
	Low	1.03 (0.89–1.18)	0.699	1.08 (0.85–1.37)	0.544	1.02 (0.86–1.22)	0.791
	Middle	1.01 (0.88–1.17)	0.845	1.05 (0.82–1.34)	0.719	1.00 (0.84–1.19)	0.970
	High	1.01 (0.88–1.15)	0.894	1.01 (0.80–1.27)	0.963	1.03 (0.87–1.21)	0.759
	Missing	1.03 (0.89–1.20)	0.659	0.98 (0.76–1.28)	0.904	1.07 (0.89–1.28)	0.499
Insurance	Private/PPO/HMO (ref.)						
	Medicare	0.94 (0.85–1.04)	0.215	1.07 (0.91–1.27)	0.398	0.9 (0.80–1.02)	0.098
	Medicaid	1.27 (1.10–1.45)	0.001	1.38 (1.06–1.80)	0.016	1.17 (1.00–1.37)	0.057
	Uninsured	1.15 (0.87–1.52)	0.331	0.95 (0.52–1.73)	0.857	1.12 (0.82–1.55)	0.472
	Other	1.24 (1.03–1.51)	0.024	1.37 (0.96–1.96)	0.087	1.09 (0.85–1.40)	0.507
Stage	I (reference)						
	II	4.03 (3.38–4.81)	<0.001	2.5 (2.06–3.04)	<0.001		
	III	6.76 (5.81–7.86)	<0.001				
	IV	19.55 (16.69–22.90)	<0.001			2.76 (2.48–3.08)	<0.001
Surgery	No surgery (reference)						
	Surgery	0.33 (0.29–0.37)	<0.001	0.23 (0.18–0.31)	<0.001	0.36 (0.31–0.41)	<0.001
Chemotherapy	None (reference)						
	Chemo	1.02 (0.89–1.16)	0.796	2.89 (2.42–3.45)	<0.001	0.63 (0.56–0.71)	<0.001
	Unknown	1.35 (0.99–1.83)	0.055	2.32 (1.15–4.71)	0.019	0.79 (0.57–1.10)	0.161
Radiation-any	No (reference)						
	Yes	0.81 (0.73–0.89)	<0.001	1.24 (1.06–1.47)	0.009	0.6 (0.54–0.67)	<0.001
Food desert	No (reference)						
	Yes	1.43 (1.22–1.68)	<0.001	1.87 (1.40–2.51)	<0.001	1.33 (1.10–1.60)	0.003
B. Ovarian cancer disease-specific survival at five years							
		All stages (n = 9,750)		Early stage (n = 3,339)		Late stage (n = 6,411)	
Variables	Categories	HR (95 % CI)	*P*	HR (95 % CI)	*P*	HR (95 % CI)	*P*
Age		1.02 (1.02–1.02)	<0.001	1.03 (1.02–1.05)	<0.001	1.02 (1.01–1.02)	<0.001
Race	NH-White (reference)						
	NH-Black	1.17 (0.99–1.38)	0.059	1.18 (0.66–2.12)	0.582	1.17 (0.99–1.39)	0.071
	Hispanic	0.95 (0.87–1.05)	0.351	1.05 (0.77–1.45)	0.750	0.94 (0.85–1.05)	0.274
	NH-Asian/PI	1.02 (0.91–1.15)	0.734	1.25 (0.91–1.73)	0.169	0.99 (0.88–1.13)	0.918
	NH-Other	0.72 (0.57–0.91)	0.006	0.90 (0.39–2.04)	0.797	0.71 (0.55–0.91)	0.006
Smoking	No (reference)						
	Yes	1.20 (1.03–1.40)	0.017	1.14 (0.68–1.91)	0.621	1.21 (1.03–1.41)	0.019
Obesity	No (reference)						
	Yes	1.05 (0.95–1.16)	0.320	1.18 (0.87–1.62)	0.285	1.04 (0.93–1.15)	0.491
Diabetes II	No (reference)						
	Yes	1.15 (1.01–1.32)	0.040	0.85 (0.51–1.41)	0.526	1.19 (1.03–1.37)	0.017
Metabolic syndrome	No (reference)						
	Yes	1.03 (0.90–1.18)	0.684	1.13 (0.74–1.74)	0.567	1.03 (0.89–1.19)	0.687
Comorbidity score	Zero (reference)						
	One	1.05 (0.95–1.17)	0.328	0.98 (0.68–1.40)	0.906	1.06 (0.95–1.18)	0.316
	≥Two	1.16 (1.03–1.32)	0.019	1.10 (0.70–1.72)	0.693	1.15 (1.01–1.32)	0.033
SES	Very low (reference)						
	Low	1.07 (0.93–1.22)	0.370	1.01 (0.65–1.57)	0.967	1.07 (0.93–1.24)	0.343
	Middle	1.03 (0.90–1.18)	0.644	0.78 (0.49–1.25)	0.301	1.05 (0.91–1.21)	0.518
	High	1.01 (0.89–1.14)	0.883	0.85 (0.56–1.29)	0.443	1.02 (0.90–1.16)	0.751
	Missing	1.01 (0.88–1.17)	0.857	1.00 (0.62–1.62)	0.997	1.02 (0.88–1.18)	0.796

(*continued on next page*)

Table 2 (*continued*)

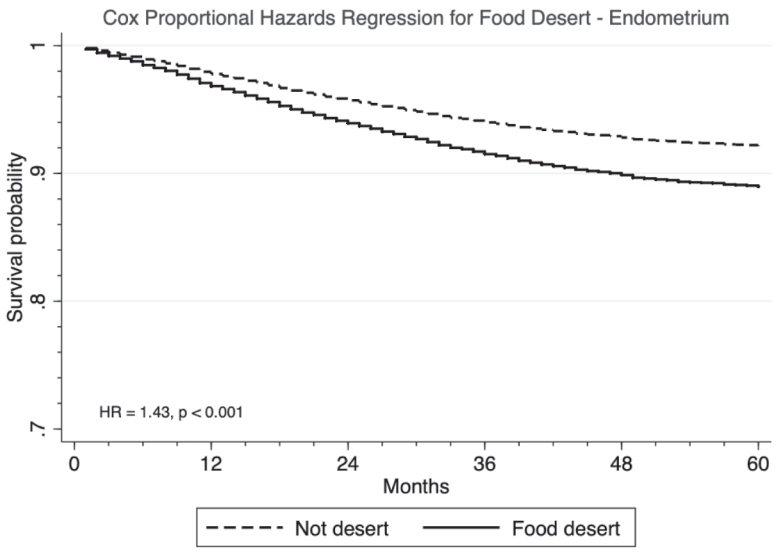
A. Endometrial cancer, disease-specific survival at five years							
Insurance	Private/PPO/HMO (ref.)						
	Medicare	0.92 (0.84–1.00)	0.062	0.86 (0.62–1.20)	0.383	0.91 (0.83–1.01)	0.065
	Medicaid	1.10 (0.97–1.25)	0.135	1.26 (0.84–1.90)	0.266	1.07 (0.93–1.23)	0.321
	Uninsured	1.09 (0.85–1.40)	0.509	1.59 (0.71–3.53)	0.258	1.04 (0.80–1.35)	0.791
	Other	1.06 (0.88–1.26)	0.560	1.65 (1.04–2.63)	0.035	1.00 (0.83–1.21)	0.990
Stage	I (reference)						
	II	3.32 (2.62–4.23)	<0.001	2.22 (1.68–2.92)	<0.001		
	III	8.61 (7.09–10.45)	<0.001				
	IV	11.36 (9.29–13.88)	<0.001			1.35 (1.24–1.47)	<0.001
Surgery	No surgery (reference)						
	Surgery	0.31 (0.28–0.34)	<0.001	0.10 (0.06–0.16)	<0.001	0.33 (0.30–0.36)	<0.001
Chemotherapy	None (reference)						
	Chemotherapy	0.54 (0.49–0.61)	<0.001	1.23 (0.92–1.64)	0.157	0.48 (0.43–0.54)	<0.001
	Unknown	0.73 (0.54–0.99)	0.046	0.69 (0.26–1.82)	0.458	0.72 (0.52–1.00)	0.048
Food desert	No (reference)						
	Yes	1.47 (1.27–1.69)	<0.001	1.40 (0.76–2.57)	0.275	1.50 (1.29–1.74)	<0.001
C. Cervical cancer cases disease-specific survival at five years							
		All stages (n = 6,157)		Early stage (n = 3,903)		Late stage (n = 2,254)	
Variables	Categories	HR (95 % CI)	*P*	HR (95 % CI)	*P*	HR (95 % CI)	*P*
Age		1.01 (1.00–1.01)	0.016	1.00 (0.99–1.01)	0.770	1.00 (1.00–1.01)	0.096
Race	NH-White (reference)						
	NH-Black	1.14 (0.93–1.39)	0.204	1.26 (0.80–2.01)	0.320	1.12 (0.90–1.39)	0.321
	Hispanic	0.87 (0.76–1.00)	0.046	1.05 (0.79–1.39)	0.749	0.86 (0.73–1.00)	0.051
	NH-Asian/PI	0.86 (0.72–1.02)	0.079	1.11 (0.79–1.56)	0.535	0.82 (0.67–1.01)	0.061
	NH-Other	0.67 (0.47–0.97)	0.034	0.54 (0.22–1.34)	0.185	0.79 (0.54–1.17)	0.244
Smoking	No (reference)						
	Yes	1.23 (1.04–1.46)	0.013	1.17 (0.78–1.76)	0.449	1.27 (1.06–1.52)	0.010
Obesity	No (reference)						
	Yes	1.00 (0.86–1.16)	0.956	1.11 (0.82–1.50)	0.506	0.97 (0.81–1.15)	0.715
Diabetes II	No (reference)						
	Yes	1.26 (1.03–1.56)	0.028	1.15 (0.74–1.81)	0.532	1.26 (0.99–1.61)	0.066
Metabolic syndrome	No (reference)						
	Yes	1.31 (1.04–1.64)	0.02	1.04 (0.66–1.63)	0.873	1.40 (1.07–1.82)	0.013
Comorbidity score	Zero (reference)						
	One	1.11 (0.94–1.31)	0.225	1.16 (0.81–1.65)	0.427	1.09 (0.90–1.31)	0.382
	≥Two	1.32 (1.10–1.60)	0.003	1.72 (1.11–2.67)	0.016	1.21 (0.98–1.49)	0.072
SES	Very low (reference)						
	Low	0.90 (0.76–1.06)	0.187	0.98 (0.69–1.40)	0.921	0.87 (0.72–1.05)	0.151
	Middle	0.93 (0.78–1.11)	0.435	1.15 (0.80–1.66)	0.453	0.90 (0.73–1.10)	0.300
	High	0.79 (0.67–0.94)	0.007	0.75 (0.51–1.08)	0.125	0.83 (0.68–1.00)	0.049
	Missing	0.90 (0.75–1.09)	0.302	1.14 (0.76–1.70)	0.524	0.88 (0.71–1.09)	0.228
Insurance	Private/PPO/HMO (ref.)						
	Medicare	1.17 (0.99–1.39)	0.068	1.64 (1.15–2.34)	0.006	1.05 (0.87–1.27)	0.605
	Medicaid	1.20 (1.04–1.38)	0.01	1.16 (0.86–1.57)	0.332	1.15 (0.99–1.35)	0.070
	Uninsured	1.24 (0.91–1.68)	0.171	1.01 (0.53–1.95)	0.965	1.25 (0.87–1.81)	0.227
	Other	1.27 (0.99–1.63)	0.056	1.26 (0.77–2.05)	0.361	1.26 (0.95–1.67)	0.109
Stage	I (reference)						
	II	4.34 (3.19–5.90)	<0.001	1.69 (1.18–2.43)	0.004		
	III	9.67 (7.28–12.86)	<0.001				
	IV	20.48 (15.43–27.18)	<0.001			2.04 (1.79–2.33)	<0.001
Surgery	No surgery (reference)						
	Surgery	0.41 (0.35–0.49)	<0.001	0.28 (0.19–0.42)	<0.001	0.52 (0.44–0.61)	<0.001
Chemotherapy	None (reference)						
	Chemo	0.56 (0.47–0.67)	<0.001	0.83 (0.50–1.38)	0.466	0.45 (0.38–0.53)	<0.001
	Unknown	1.06 (0.71–1.56)	0.787	1.68 (0.62–4.53)	0.307	0.85 (0.56–1.28)	0.441
Radiation-any	No (reference)						
	Yes	0.67 (0.57–0.79)	<0.001	1.62 (0.97–2.71)	0.064	0.55 (0.47–0.64)	<0.001
Food desert	No (reference)						
	Yes	1.24 (1.01–1.54)	0.045	1.60 (1.04–2.46)	0.031	1.23 (0.97–1.56)	0.081

interventions and buy-in are critical to ensure access-based interventions are effective and well received. The need for education to mitigate this disparity is evidenced by findings from Chai et al, describing how individual socioeconomic status, specifically, education status, was linked to better quality home food availability (Chai et al., 2018 May).

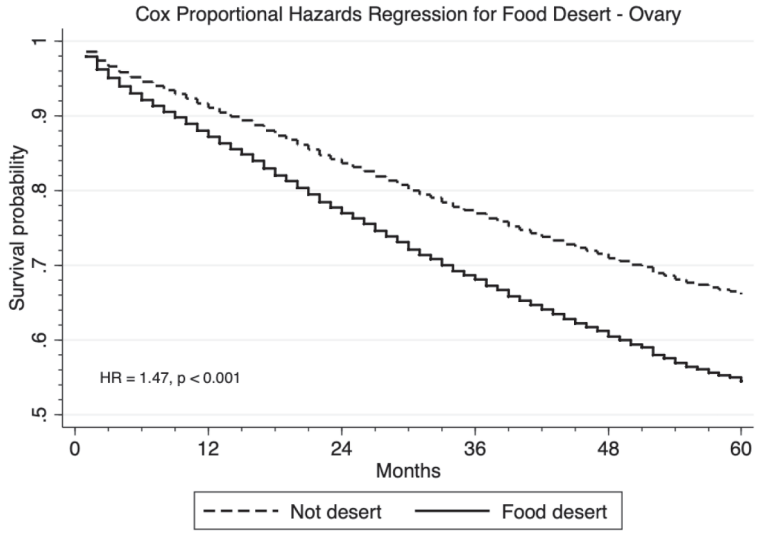
Although the ultimate cause as to why food desert residential status confers negative cancer outcomes is not yet clearly elucidated, it is likely multifactorial. Certain interventions may help reduce its impact on patients with gynecologic cancers.

We recommend working with community leaders and policy makers to develop sustainable solutions to help mitigate this disparity. Possible solutions include government incentives for cooperative markets in rural communities and local supermarkets in urban communities. Heath

A. Endometrial Cancer



B. Ovarian Cancer



C. Cervical Cancer

Fig. 1. Disease-Specific Survival Curves.

care providers and institutions could identify patients who live in food deserts and engage in community outreach programs to provide them with resources such as nutritional classes and guidance as well as food gardens. As it appears to be that these are community-based problems, associated with historic and ongoing structural inequity, the proposed solutions should focus on the community and its material conditions.

Some additional government-based interventions that may assist community wealth and equity building includes providing business classes and monetary incentives to individuals who wish to partake in the cooperative programs, improving access to those who would otherwise not have the opportunity to run their own businesses.

Additionally, patients, providers, professional societies, and affected communities should be encouraged to advocate for awareness of this important health disparity that leads to funding of these disparity-mitigating programs.

Next research steps for our group includes mapping our current gynecologic oncology patients, identifying which patients live in a food desert, and engage them with additional food vouchers and nutritional resources and education.

Certain limitations to our study include its retrospective nature,

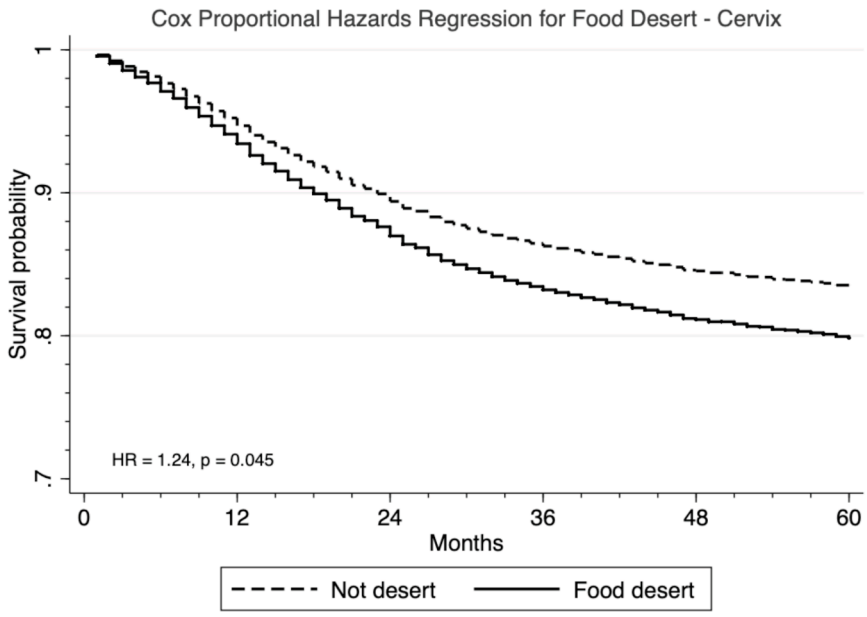


Fig. 1. (*continued*).

hindering an ability to determine causality. Missing or unknown data is a common occurrence with these large database studies. We did not calculate the relative severity of food desert status among participants. It is possible that some food deserts provide access to less inflammatory foods than others, however this needs to be further evaluated. In addition, food desert residential status are census tract specific metrics, and do not account for individual income nor duration of residence. Our study also focused on the state of California and did not report on a national level due to database limitations. However, California has been extensively used in the literature as a cancer epidemiology case study, representative of the United States due to its variety in socioeconomic statuses, ethnicities, and population density (Yu et al., 2019 Jun; Martin et al., 2020 Jun; Mendez et al., 2023 Nov; Villanueva et al., 2021 Oct).

The strengths of our study include a large population-base that was able to account for patient specific comorbidities and clinical information. Our findings of worse outcomes for gynecologic cancers in patients living in a food desert are consistent with previously reported associations of other cancers, solidifying it as a targetable intervention in the pursuit of oncologic health disparities.

5. Conclusions

Our study found that living in a food desert confers worse survival for patients with gynecologic cancers, supporting previous reports that identify food desert residence as a negative determinant of general oncologic health. These are previously unstudied socioeconomic and environmental factors that disproportionately affect vulnerable communities. While there are other unmodifiable determinants of health that affect these communities, the existence of food deserts can potentially be mitigated. As such, it is crucial that we capitalize on the momentum of recent studies by continuing efforts to understand and mitigate the health inequity caused by food deserts.

Conflict of Interest Statement.

All authors have shared their disclosures. Dr Ana Tergas has served as a Merck Advisory Board member. No additional disclosures to share.

CRediT authorship contribution statement

Nicole Lugo Santiago: Writing – original draft, Formal analysis, Data curation, Conceptualization. **Philip H.G. Ituarte:** . **Adrian Kohut:** Conceptualization. **Rosemary Senguttuvan:** Writing – review & editing. **Nora Ruel:** Writing – review & editing, Formal analysis, Data curation. **Rebecca Nelson:** Writing – review & editing, Formal analysis, Conceptualization. **Ana Tergas:** Writing – review & editing, Methodology, Conceptualization. **Lorna Rodriguez:** Writing – review & editing, Methodology, Conceptualization. **Mihae Song:** Writing – review & editing, Project administration, Methodology, Conceptualization.

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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