Evaluating the Effects of Food Deserts and Food Swamps in an Urban Burn Patient Population

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Poverty is a known risk factor for burn injury and is associated with residency in food deserts and food swamps. Our aim was to determine the prevalence of residency in food deserts and food swamps and to investigate the relationship between food environment, comorbidities, and wound healing in patients with burns. We performed a retrospective chart review of all patients with burns aged ≥ 18 seen in the emergency department or admitted to the burn service at an American Burn Association-verified urban academic center between January 2016 and January 2022. Patient GeoIDs were used to classify residency in food deserts and food swamps, and comorbidities and demographics were recorded. A subset of patients with <20% total body surface area burns who underwent single-operation split-thickness skin grafting was identified for wound healing analysis. A total of 3063 patients were included, with 206 in the heal time analysis. In total, 2490 (81.3%) lived in food swamps and 96 (3.1%) lived in food deserts. Diabetes, hypertension, and tobacco smoking were more prevalent in food swamps than in food deserts or good access areas. While there was no significant effect of the food environment on wound healing, diabetes was associated with longer healing times. Most patients with burns reside in food swamps, which are associated with a higher prevalence of hypertension, diabetes, and smoking. The food environment was not significantly associated with wound healing. Not having diabetes was associated with a shorter time for wound healing.

Key words: food desert; food swamp; food environment; social determinants of health; burn injury.

INTRODUCTION

Recently, there has been an increased focus on social determinants of health (SDOH) and their association with outcomes in surgical patients. The World Health Organization describes many examples of SDOH, including income and social protection, education, unemployment and job insecurity, working life conditions, food insecurity, and basic amenities.[1] Housing environment is one such determinant in which food access plays a key role. The socioeconomic conditions of a neighborhood, which constitutes a crucial aspect of the housing environment, often dictate the accessibility and quality of food resources, thereby playing a pivotal role in the overall health outcomes of its residents.

Access to healthy, nutrient-dense food has been increasingly studied in relation to surgical outcomes. Food deserts are defined as neighborhoods in the United States with limited access to affordable and nutritious foods.[2] These areas have low access to food of any kind. Recent research indicates that there may be a link between residence in a food desert and increased postoperative readmissions in patients with esophageal cancer[3] and poorer outcomes for colorectal and breast cancer.[4] Hong et al. demonstrated that pediatric patients with scald burns were more likely to have lower food access.[5] In contrast, food swamps are areas with a disproportionate availability of nutrient-poor foods compared to nutritionally beneficial foods.[6] Such areas have a relative abundance of fast food restaurants, gas stations, and small corner stores and relative paucity of grocery stores and supermarkets. Some existing research suggests associations between food deserts and obesity[7] as well as between residency in low-income census tracts and rates of reoperation.[8] However, to our knowledge, no data exists examining the relationship between surgical outcomes and residency in a food swamp.

Adequate nutrition is central to supporting the high-energy requirements in patients with burns, and preburn malnutrition has been found to be associated with higher

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postoperative mortality,[9] increased length of stay, and increased duration of mechanical ventilation.[10] While the effects of nutrition and wound healing have been studied extensively in the burn population, the link between food accessibility and burn wound healing is not yet characterized. This study aimed to describe characteristics of the neighborhood food environment among burn-injured patients treated at an urban academic American Burn Association (ABA) verified burn center and to examine associations between their food accessibility, clinical characteristics, and wound healing. We hypothesized that patients living in either food swamps or food deserts would have longer healing times compared with patients who resided in areas with better access to nutritious food.

METHODS

Subjects

Following the Institutional Review Board study approval, a retrospective review was performed on the charts of all patients treated for burn injuries at our ABA-verified regional burn center between January 2016 and January 2022. The electronic medical record was queried for all patients over the age of 18 who were seen by or admitted to the surgical burn service. Patients were excluded if they were undomiciled or if the level of food access could not be determined for their census tract. A subgroup of patients was identified to evaluate the effect of food access on wound healing. Inclusion criteria for this subgroup included single-operation split-thickness skin grafting (STSG) for <20% total body surface area (TBSA) burns performed on or after September 14, 2018, after which all STSGs were performed by 1 of 2 fellowship-trained burn surgeons. All STSGs in this group were taken at a standard 10/1000ths of an inch. Donors were dressed initially in a topical silver dressing and were changed to dry xeroform between postoperative days 2 and 5. Heal time was determined by evaluating the donor site, which was accomplished by 1 of the 2 burn surgeons in an inpatient or outpatient setting. The donor site was considered to be healed when >95% epithelialization had occurred, and no additional follow-up was necessary to evaluate wound healing. Postoperative patients who are discharged generally follow up in our clinic once per week until their donor sites are healed.

Variables

The primary residence for each subject was used to determine the residential census tract (eg, neighborhoods of 4000-8000 people) at the time of admission to the hospital. Subject census tracts were then linked to the Centers for Disease Control and Prevention (CDC) data from the modified Retail Food Environment Index (mRFEI)[11] to determine the level of healthy food accessibility for each location. mRFEI is calculated by dividing the number of healthy food retailers in or within 1/2 miles of a given census tract by the sum of healthy food retailers and less healthy food retailers within the same area. A score of 0 is considered a food desert, while very low scores (0.1 to ≤6.6; median) indicate that the tract is a food swamp.[12] Tracts with a score greater than the median (6.6-100) were categorized as good access. Depending on the mRFEI score for their census tract, each subject was placed into one of these groups.

Patient demographic information was collected, and pertinent patient comorbidities were recorded, including a history of diabetes, hypertension, hyperlipidemia, heart failure, smoking status, and morbid obesity. In addition to the variables already noted, burn percent TBSA has been recorded for the heal time subpopulation. The primary outcome measure for the subpopulation was time to donor site healing in days, as determined from clinic follow-up visit notes.

Subject frequency by census tract was mapped to illustrate the geographic distribution of the patients (Figure 1). This map illustrates 98% of the subjects included in the analysis. We determined that expanding the map to demonstrate geographical outliers would have taken focus from the central area of interest.

Statistical analysis

All statistical tests were 2-sided, with $P < .05$ deemed statistically significant. Chi-square and one-way analysis of variance (ANOVA) analyses were conducted to determine differences in demographics and patient history between the food desert, food swamp, and good access groups. Separate analyses were run for the total population and the heal time subgroup. A multivariable Cox proportional hazard regression model was performed on the heal time subgroup to estimate adjusted hazard ratios (aHRs) and 95% CIs, and determine factors associated with poor wound healing. Tests for linear trends were performed on age, BMI, and TBSA before including them as continuous variables. Schoenfeld's residual plot was evaluated and suggested no evidence of violation of the proportional hazard assumptions. Kaplan–Meier survival curve was generated to compare the healing time between the 3 groups and any factor that was significantly associated with poor wound healing. All statistical analyses were conducted with SAS version 9.4 (SAS Institute, Cary, NC, USA).

RESULTS

A total of 3063 patients with burn injuries were included in the chi-square and one-way ANOVA analyses comparing food deserts, food swamps, and good access areas. Figure 1 depicts patient density by census tract and demonstrates that a majority of patients reside in the Philadelphia metropolitan area. Patient demographics are shown in Table 1. In terms of healthy food accessibility, 2490 (81.3%) subjects resided in food swamps, 96 (3.1%) individuals lived in food deserts, and 477 (15.6%) lived in good access areas. There were no statistically significant differences between the 3 groups regarding age, sex, or BMI. A significantly higher percentage of subjects living in food swamps had diabetes (15.0%) as compared to residents of good access areas (11.7%) and food deserts (8.3%; $P = .04$). Hypertension was also significantly more prevalent among residents of food swamps (24.8%) than among the food desert (20.8%) and good access groups (19.3%; $P = .03$). Residents of food swamps and food deserts were significantly more likely to have been diagnosed with hyperlipidemia (16.2% and 14.6%, respectively) than those of good access

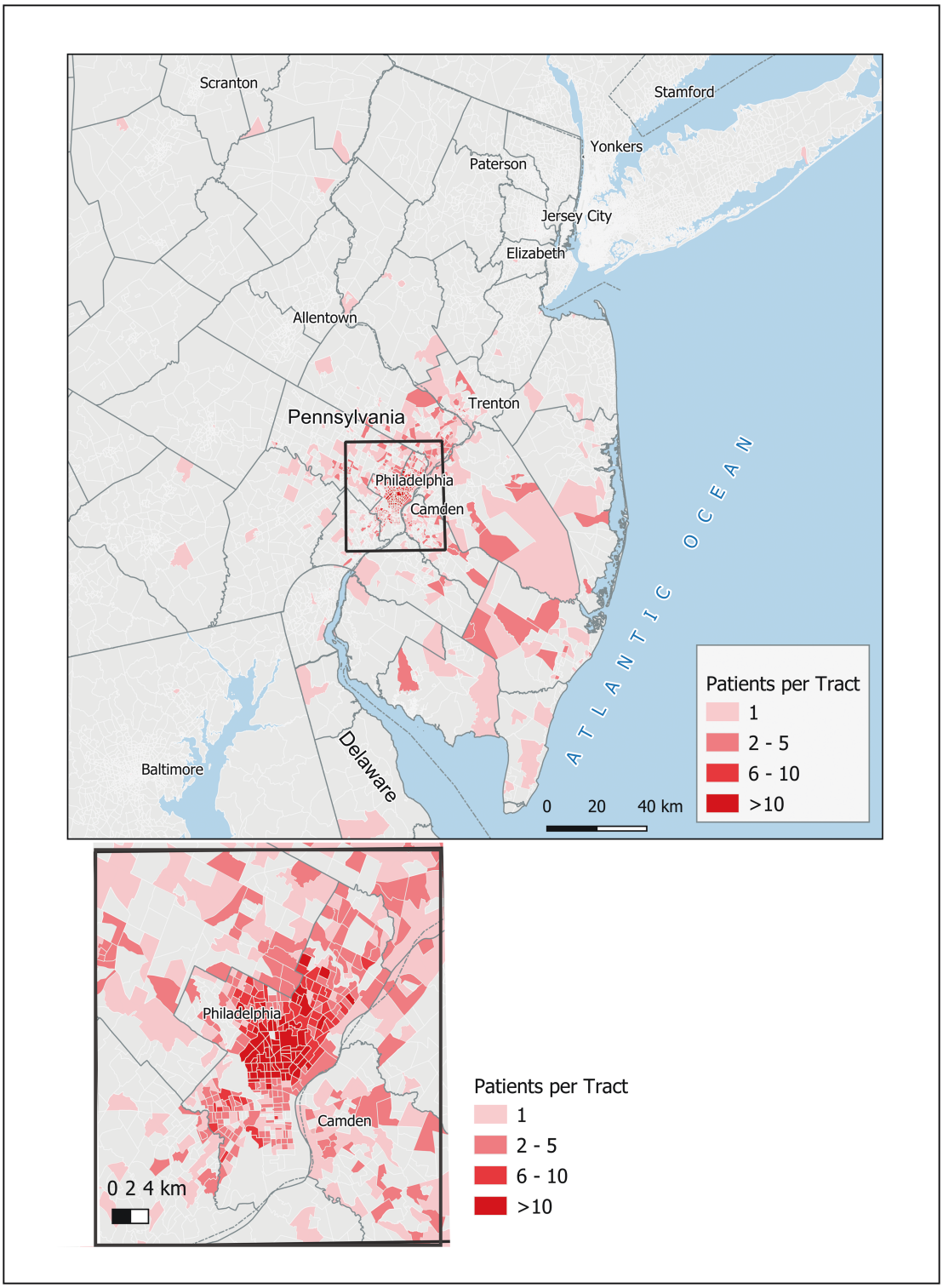

Figure 1. Patient Density by Census Tract

areas (11.1%; $P = .02$). Subjects in the food swamp group were more likely to be current smokers (45.3%) than those living in good access areas (40.4%), who in turn were more likely to be current smokers than those living in food deserts (27.9%; $P = .003$).

A total of 206 patients who underwent STSG were included in our heal time subgroup analysis, as shown in Table 2. A total of 159 (77.2%) subjects lived in food swamps, 9 (4.4%) resided in food deserts, and 38 (18.5%) were categorized as having good access. There were no statistically significant

Table 1 Patient Demographics

	Food desert	Food swamp	Good access	*P*-value
	N = 96 (3.1%)	*N* = 2,490 (81.3%)	*N* = 477 (15.6%)	
Sex (*n* [%])				.08
Female	43 (44.8)	1,136 (45.6)	191 (40.0)	
Male	53 (55.2)	1,354 (54.4)	286 (60.0)	
Age (mean [SD])	44.0 [18.6]	43.5 [16.1]	42.6 [16.9]	.52
BMI (mean [SD])	29.2 [6.8]	29.1 [7.8]	28.4 [6.3]	.26
Comorbidities (*n* [%])				
Diabetes mellitus	8 (8.3)	373 (15.0)	56 (11.7)	**.04**
Hypertension	20 (20.8)	617 (24.8)	92 (19.3)	**.03**
Hyperlipidemia	14 (14.6)	404 (16.2)	53 (11.1)	**.02**
Heart failure	2 (2.1)	138 (5.5)	20 (4.2)	.18
Current smoker (*n* [%])	22 (27.9)	913 (45.3)	152 (40.4)	**.003**

The boldface numbers represent statistically significant findings.

Table 2 Heal Time Subgroup Demographics and Outcomes

	Food desert	Food swamp	Good access	
	N = **9 (4.4%)**	*N* = **159 (77.2%)**	*N* = **38 (18.5%)**	*P*-value
Sex (*n* [%])				.06
Female	7 (77.8)	70 (44.0)	22 (57.9)	
Male	2 (22.2)	89 (56.0)	16 (42.1)	
Age (mean [SD])	42.4 [13.8]	48.0 [15.5]	49.8 [14.9]	.44
BMI (mean [SD])	26.2 [5.3]	28.5 [6.4]	29.0 [9.0]	.54
Comorbidities (*n* [%])				
Diabetes mellitus	3 (33.3)	36 (22.6)	7 (18.4)	.62
Hypertension	4 (44.4)	78 (49.1)	14 (36.8)	.40
Hyperlipidemia	1 (11.1)	35 (22.0)	8 (21.0)	.74
Heart failure	0 (0)	8 (5.0)	0 (0)	.29
Current smoker (*n* [%])	2 (22.2)	68 (42.8)	16 (42.1)	.48
TBSA (mean [SD])	3.1 [3.7]	3.7 [3.3]	3.7 [3.2]	.86
Days to donor site healing (mean [SD])	27.6 [19.4]	26.8 [17.8]	23.3 [9.8]	.50

differences between these 3 groups in demographics or medical history. The percentage of TBSA burns was also not found to differ between the 3 groups. The mean time to donor site healing was 27.6 days (SD 19.4) in the food desert group, 26.8 days (SD 17.8) in the food swamp group, and 23.3 days (SD 9.8) in the good access group. These differences in donor site healing time were not statistically significant ($P = .50$).

Table 3 shows the results of the healing time analysis. Age, sex, BMI, and percentage of TBSA burn did not have a significant effect on the time of donor site healing. Diabetes was the only medical comorbidity that conferred an increased risk of prolonged time to wound healing (aHR: 1.868, 95% CI, 1.231-2.835, $P = .003$), which can be seen in the Kaplan–Meier curve in Figure 2. Accessibility to healthy food (ie, mRFEI category) was not found to significantly affect wound healing, as shown in the Kaplan–Meier curve in Figure 3.

DISCUSSION

While the importance of nutrition in wound healing in patients with burns is well established, the effects of geographical access to healthy, nutritious foods have not been characterized. The purpose of this study was to investigate the effect of healthy food accessibility on clinical characteristics and outcomes in patients with burn injuries. To our knowledge, no prior studies have examined the epidemiology of geographical access to food and its effect on wound healing in patients with burns.

We found that the majority of our patients at an urban academic burn center resided in food access areas categorized as food swamps or food deserts, with only a minority of patients having good food access. We found that patients with burns who reside in food swamps have a higher likelihood of being diagnosed with hypertension, diabetes, hyperlipidemia, and tobacco use disorder. While this may not be surprising, this is the first time, to our knowledge, that this link has been established in patients with burns. We also found that patients who resided in food swamps and food deserts had a trend toward increased wound healing time, although this did not ultimately reach statistical significance. Given the significant differences in the prevalence of comorbidities between the 3 groups for all patients included in the analysis and the lack thereof for the heal time subpopulation, this trend raises a question of whether significant differences would be seen in

Table 3 Multivariable Cox Proportional Hazard Model Analysis for Wound Healing

	Hazard ratio	95% CI	*P*-value
Age	0.995	0.983-1.007	.444
Sex (ref: male)	1.011	0.753-1.358	.940
BMI	1.019	0.996-1.043	.107
TBSA[a]	0.963	0.921-1.006	0.091
Absence of comorbidities			
Diabetes	1.868	1.231-2.835	**.003**
Hypertension	1.094	0.732-1.635	.661
Hyperlipidemia	0.827	0.528-1.296	.408
Heart failure	0.984	0.463-2.094	.967
Current nonsmoker	1.055	0.787-1.415	.720
mRFEI[b]			
Desert vs. Swamp	1.205	0.584-2.487	.615
Healthy food vs. Swamp	1.196	0.821-1.742	.352

The boldface denotes a statistically significant *P*-value.
[a]Total body surface area.
[b]modified Retail Food Environment Index.

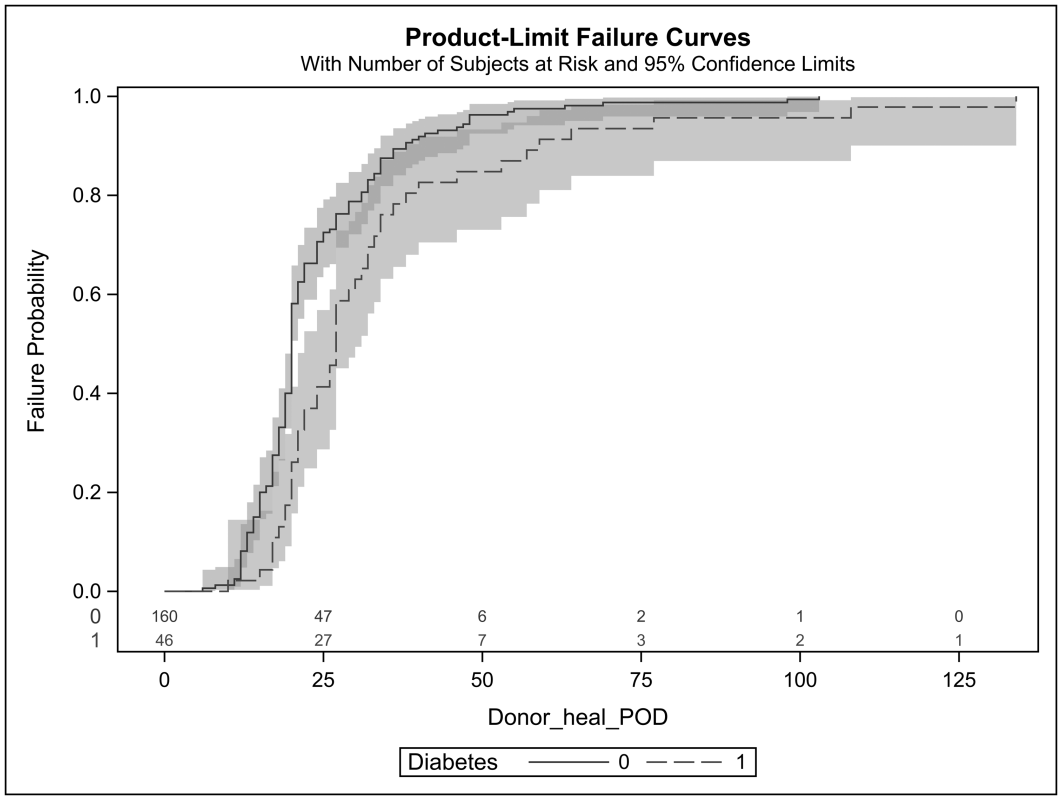

Figure 2. Comparison of Healing Time by Kaplan–Meier Survival Analysis for Diabetes

the subgroup if it had a higher power. Finally, patients with diabetes had a significantly increased time for wound healing. This finding is congruent with previous research in which patients with a diagnosis of diabetes were at an elevated risk of prolonged wound healing compared to their nondiabetic counterparts.[13] Although this is not a novel finding, it does lend validity to our results.

Social determinants of health have become increasingly studied to understand their impact on outcomes in surgical patients. The World Health Organization defines SDOH as non-medical factors that influence health outcomes.[1] Burn injury often requires intense therapy, with a potentially significant portion of this therapy performed on an outpatient basis. Thus, the environment in which patients with burns live may impact the care they receive and their ultimate outcomes.[14]

Food access is a significant part of the environment in which people live, and it has been increasingly studied with

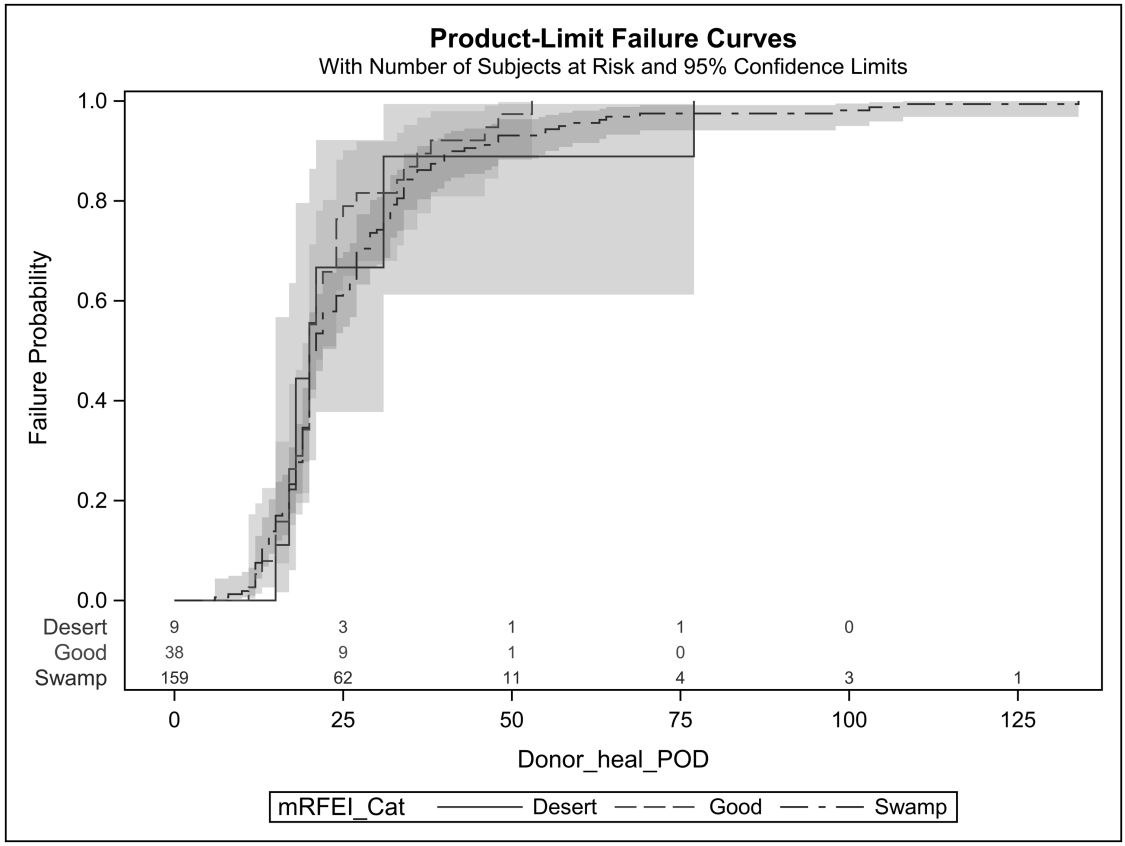

Figure 3. Comparison of Healing Time by Kaplan–Meier Survival Analysis for mRFEI Status

regard to surgical outcomes. Philips et al. demonstrated that residence in food deserts was related to higher readmission rates following esophagectomy. Their study varied from ours in numerous ways, primarily in the method used to measure food access. They defined food deserts using the USDA Food Access Research Atlas utilizing zone improvement plan (ZIP) codes. Our study used the patient's census tract at the time of admission in conjunction with the modified retail food index. ZIP codes include larger geographical areas and are, by definition, at higher risk of heterogeneity, thus limiting their generalizability. The United States Department of Agriculture's (USDA) Food Access Research Atlas also does not differentiate between areas of low access to nutritious food and high access to unhealthy, nonnutritious foods, ie, food swamps. While their study failed to establish a causal effect on residence in food deserts and higher postoperative admissions, it nevertheless is an important contribution to our knowledge about food access and postsurgical outcomes.

Hong et al. demonstrated an association between residency in a food desert and scald burns in pediatric patients.[5] Additionally, they demonstrated an association between low-income and non-White races with pediatric burn injury. While their work is important in establishing an association between food access and burn injury, they did not examine whether there was an association between SDOH and outcomes in their patients. Furthermore, they did not consider the impact of food deserts on their burn-injured population.

Research pertaining to residency in a food swamp is sparse at best, particularly with regard to surgical patients. Cooksey-Stowers et al. demonstrated that residency in food swamps predicts obesity rates better than in food deserts.[7] However, the available evidence is mixed with regard to obesity and outcomes following burn injury.[15,16] Bayne et al. demonstrated no association between patients who resided in either limited food access census tracts or food swamp tracts and repeat intervention for kidney stones.[8] To our knowledge, this study is among the first to depict the relationship between burn-injured patients and residency in food swamps.

While we believe access to healthy food is an important environmental factor and SDOH, it is a population-based measure limited by its ability to determine whether individuals seeking care in hospitals actually have food insecurity and, ultimately, adequate pre- and postinjury nutrition. For instance, a patient who resides in a designated food swamp may not have consistent access to healthy, nutritious food, thus making them food insecure. However, their neighbor may have a bus pass allowing them to consistently travel further to a healthy grocery store, thus rendering this patient food secure. Recent evidence does support an association between food insecurity and other forms of traumatic injury. An analysis of patients with trauma at a Level I urban trauma center demonstrated that living in areas with high rates of food insecurity, using Map the Meal Gap data,[17] was associated with an increased risk of firearm injury at the state level.[18] While food security and food access have not been directly correlated, both factors

may be related and are considerable markers of socioeconomic status, such as poverty.[19,20] As more research is needed to establish this relationship, and while we ultimately hope they are related to patients' underlying pre- and postinjury nutritional status, it may, in fact, be as simple as that food security and food access and ultimately nutritional state are just proxies for socioeconomic status.

Limitations

Our study has several limitations. First, this is a single-center retrospective study performed on hospitalized patients, which introduces bias on both a patient and population level. Second, we only measured food accessibility, which does not necessarily dictate the food security of individual patients. Furthermore, while census tract data collection yields greater specificity than geographic delineations such as ZIP code or county, the most accurate measure of food accessibility, and especially consumption behavior, would be to collect information at the individual subject level. Third, biomarkers of nutritional status were not measured in this study, although the reliability of these in the acute setting is debatable. Fourth, while our 2 burn surgeons take the donor site at a standard depth of 10/1000 inches, there is inevitably some variability in the true depth of the donor site taken. Finally, donor sites are not evaluated on a daily basis following discharge, and this can lead to an overestimation of time to wound healing.

CONCLUSION

Our findings demonstrate that a majority of our patients live in food swamps while very few live in true food deserts. Residency in food swamps imparts a higher risk of diabetes, hypertension, hyperlipidemia, and tobacco smoking for burn-injured patients. Although diabetes is more common in food swamps and was associated with increased time to donor site healing, the neighborhood food environment did not have a significant effect on healing time. This is the first study to investigate food environment and accessibility in patients with burns as it relates to patient characteristics and wound healing. Future investigations should seek to evaluate patients with burns for food insecurity and nutritional status through information taken directly from study subjects. This information can then be used in conjunction with geographical information, biochemical markers of nutritional status, and wound healing data to elucidate the complex relationships between geographical food access, food insecurity, nutrition, and wound healing in burns.

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