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INNOVATIONS, QUALITY & OUTCOMES

ORIGINAL ARTICLE

Emergency Department Visits Before Cancer Diagnosis Among Women at Mayo Clinic

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Abstract

Objective: To determine associations of incident cancer diagnoses in women with recent emergency department (ED) care.

Patients and Methods: A retrospective cohort study analyzing biological females aged 18 years and older, who were diagnosed with an incident primary cancer (12 cancer types studied) from January 1, 2015, to December 31, 2021, from electronic health records. The primary outcome was a cancer diagnosis within 6 months of a preceding ED visit. Secondary outcomes included patient factors associated with a preceding ED visit.

Results: Of 25,736 patients (median age of 62 years, range 18-101) diagnosed with an incident primary cancer, 1938 (7.5%) had an ED visit ≤6 months before a diagnosis. The ED-associated cancer cases were highest in lung cancer (n=514, 14.7%) followed by acute lymphoblastic leukemia (n=22, 13.3%). Patient factors increasing the likelihood of ED evaluation before diagnosis included 18-50 years of age (OR=1.32; 95% CI, 1.09-1.61), Elixhauser score (measure of comorbidities) >4 (OR=17.90; 95% CI, 14.21-22.76), use of Medicaid or other government insurance (OR=2.10; 95% CI, 1.63-2.69), residence within the institutional catchment areas (OR=3.18; 95% CI, 2.78-3.66), non-Hispanic Black race/ethnicity (OR=1.41; 95% CI, 1.04-1.88), and established primary care provider at Mayo Clinic (OR=1.45; 95% CI, 1.28-1.65). The ED visits were more likely in those who died within 6 months of diagnosis (n=327, 37.8%) than those who did not die (n=1611, 6.5%).

Conclusion: Patient characteristics identified in this study offer opportunities to provide cancer risk assessment and health navigation, particularly among individuals with comorbidities and limited health care access.

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Utilization of emergency departments (EDs) in the United States is increasing, whereas annual primary care visits are decreasing.[1-3] Increased use of the ED has accelerated in states that expanded Medicaid through the adoption of the Affordable Care Act.[4] From 2002 to 2015, there was a 67% decrease in acute care visits to primary care practices and a 12% increase in ED visit rates.[5] This is especially true of underserved populations who face barriers to adequate health care.[6] Physical location and transportation obstacles, cost of care, limitations in the availability and accessibility of primary care appointments, and health conditions only relevant to women (eg, fibroids and pregnancy) influence the rising utilization of emergency departments and the falling use of primary care among women.[3,7]

These issues are further compounded when a cancer diagnosis occurs after an ED visit. An ED presentation is linked to increased cancer stage at presentation and increased mortality compared to non-ED-associated cancer diagnosis.[8-12] Factors increasing the odds of a cancer diagnosis following a preceding ED visit include lower socioeconomic status, lack of health insurance, and absence of a usual place to go for medical care.[8,11,13] Patients who do not have routine primary care face the risk of undetected cancer due to the absence of regular wellness check-ups or screening tests, potentially leading to advanced-stage cancer at diagnosis and subsequent decreased survival rate. Nonadherence to cancer screenings is exacerbated by the COVID-19 pandemic, with an estimated 9.4 million screening tests missed in 2020, and recovery to prepandemic levels is uncertain.[14] Treatment outcomes are also worse among non-affluent women, magnifying harms related to delayed diagnosis.[8]

Our goal was to analyze factors associated with cancer diagnosis within 6 months of ED visits to understand opportunities for early detection among women seeking emergency care within 3 geographically diverse primary sites in Minnesota, Arizona, and Florida that are part of Mayo Clinic. The setting provides a novel perspective of 12 representative incident, primary cancer cases in a higher resourced, tertiary, multispecialty practice across diverse geographic sites. The study was restricted to women because of historical exclusion from research and to address health care utilization, diagnosis pathways, and biology specific to women.[15]

METHODS

Setting

Mayo Clinic is a nonprofit, specialty group practice with integrated research, education, and clinical practice activities. The Mayo Clinic Comprehensive Cancer Center includes Minnesota, Arizona, and Florida sites. Each site has a hospital and ED. The Minnesota ED is designated as a level I trauma center, which provides the highest level of surgical care for trauma patients. Arizona and Florida's sites are hospital EDs without a trauma designation. The study was submitted to the Mayo Clinic institutional review board and deemed exempt (IRB# 22-000316).

Cohort

This is a retrospective cohort study of females (aged 18 years or older) diagnosed with primary cancer diagnosed from January 1, 2015, to December 31, 2021. Twelve cancers representative of hematologic and solid organ tumors were studied, including breast, endometrial, cervical, colorectal, head and neck, kidney and bladder, lung, brain, ovarian, acute lymphoblastic leukemia, and non-Hodgkin lymphoma. We aimed to select cancers based on clinical relevance or associated recommended cancer screening tests at Mayo Clinic among women with an adequate sample size and to compare our data to the least (melanoma 2.1%) and most likely to be diagnosed following ED visits (acute lymphoblastic leukemia 79.1%) from the United Kingdom Routes to Diagnosis project.[16] Some of the reasons other cancers were not reported were based on too small of sample size (pancreatic cancer, thyroid cancer, and liver cancer) and hematologic malignancies other than acute lymphoblastic leukemia and non-Hodgkin's lymphoma. We were concerned that the number of hematologic cancers would be overrepresented if they were all included and we therefore chose 2 in which the investigators have personal and clinical experience. The data used in this study were obtained from the institution's electronic health record (EHR). Cancer cases were determined from the primary international classification of disease diagnosis codes (Supplemental Table 1, available online at http://www.mcpiqojournal.org). The patient list obtained from the EHR was cross-referenced with data from the Mayo Clinic cancer registry to ensure accuracy and completeness. The Mayo Clinic cancer registry is a specialized information system used to collect, manage, analyze, and distribute data related to patients diagnosed with cancer or specific benign conditions. We validated patients diagnosed for 2020-2021 to improve the accurate inclusion of recent cases not finalized in the cancer registry. Only patients with a cancer diagnosis documented in the pathology reports were included in the final analysis. The pathology report was in most cases not available at the time of initial presentation to the ED but was used to validate the diagnosis code associated with the ED encounter. The inclusion criteria for the study required that patients had their first cancer incident case after January 1, 2015. Patients with known previously diagnosed cancers were excluded. Only the first incident case was included if patients had multiple cancers after the first incident case. Patients younger than 18 years old, those diagnosed at Mayo Clinic Health System (nonprimary Minnesota, Arizona, or Florida sites) or unknown diagnosis settings, and whose diagnosis could not be confirmed through pathology reports or were not listed in the cancer registry were excluded.

Primary Dependent Variable

The primary dependent variable for the study was whether a patient had a cancer diagnosis with a preceding ED visit within 6 months before diagnosis versus a cancer diagnosis without a preceding ED visit. The ED visits were identified from the administrative data using the following HCPCS codes: 99281, 99282, 99283, 99284, 99285, 99291.[17]

Demographic Characteristics and Clinical Factors

Demographic characteristic independent variables included age at diagnosis, site, year of diagnosis, race/ethnicity, body mass index (BMI, calculated as the weight in kilograms divided by the height in meters squared), marital status, primary care physician at Mayo Clinic, catchment area, Elixhauser score, area deprivation index (ADI), insurance type, driving distance from residence to Mayo Clinic and whether the patient had an established status (ie, had previously been seen at Mayo). Race/ethnicity was grouped into 4 categories: non-Hispanic White, non-Hispanic Black, Hispanic, and other. The body mass index was categorized into 4 groups: ≤18.5, 18.6-24.9, 25-29.9, and ≥30. Marital status was categorized into 3 groups: married/life partnership, unknown, and other. The variable primary care physician (PCP) at Mayo Clinic was created if information on a patient's PCP was available in the EHR.

As a National Cancer Institute-designated comprehensive cancer center, Mayo Clinic has a defined catchment area that it serves. In our study, we identified whether a patient's residence fell within this catchment area during the years studied to assess the effect of residence proximity.[18] An Elixhauser score was used based on the investigator's previous experience with the score at our institution and previous literature showing advantages in the score.[19-21] The score was calculated for each patient by summing the individual weights of comorbidities, except for solid tumors, metastatic cancer, and obesity.[22] Cancers were excluded from the score to eliminate the possibility that the score included newly diagnosed primary cancer. These 3 conditions were separately studied for the cohort. The resulting Elixhauser score was then categorized into 4 groups: 0, 1-2, 3-4, and >4.

The ADI is a measure used to assess socioeconomic deprivation in a geographic area and is calculated at the patient's zip code level.[23,24] Travel distance in miles and hours between the patient's residence and the hospital was calculated using data from search engine maps. Catchment area was used in the model and not travel distance because of colinearity and the importance of the catchment area in informing institution and national stakeholders of the results. The type of insurance was categorized into 4 groups: Medicare, Medicaid, commercial, and others, including miscellaneous government, self-pay, worker's compensation, and unknown. Age at diagnosis was stratified into 18-50, 51-65, and >65 years. In addition, we identified whether a patient was an established patient at the Mayo Clinic before their cancer diagnosis based on documentation of the first procedure date in administrative claims. Timing and number of ED visit(s) were ascertained. The stage of diagnosis (relevant for solid organ tumors but not hematologic malignancies) was determined after diagnosis from the cancer registry.

Analysis

We analyzed the demographic and clinical characteristics of patients diagnosed with cancer following a preceding ED visit and compared them to patients diagnosed with cancer without a preceding ED visit. We reported the frequency and percentages for categorical variables and the mean, standard deviation, median, and interquartile range for continuous variables. Furthermore, we employed a multivariate logistic regression model to determine the odds of an ED visit preceding cancer diagnosis adjusted for patient characteristics as possible confounders.

All statistical analyses were completed with SAS version 9.4 (SAS Institute, Inc) or R, version 3.6.2 (R Foundation for Statistical Computing). P-values were considered significant ≤.05.

RESULTS

The study included 25,736 patients identified with a first incidence of one of 12 cancers from January 1, 2015, to December 31, 2021. Of the total cancers diagnosed, 1938 (7.5%)

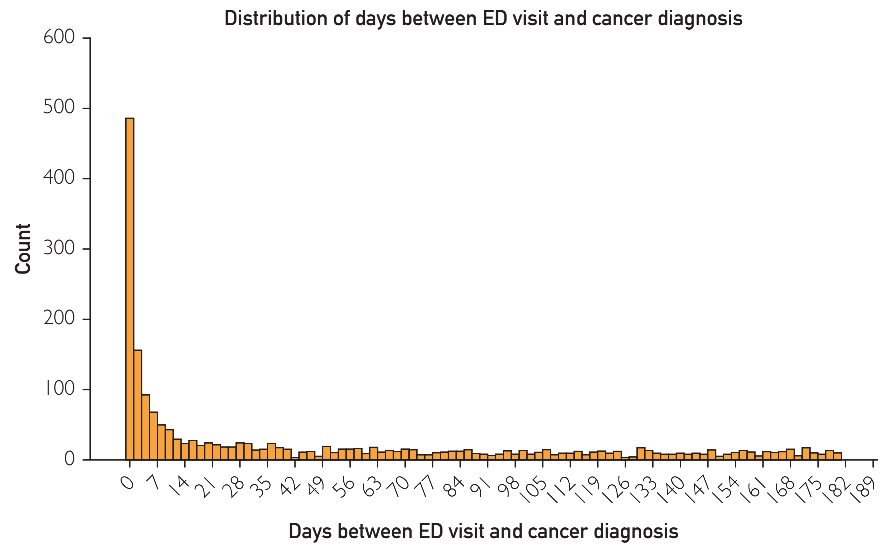

FIGURE. Distribution of days between ED visit and cancer diagnosis. ED, emergency department.

were preceded by an ED visit, including 639 (33.0%) discovered at that encounter. The Figure reports the distribution of days between ED visits and cancer diagnosis. The 5 most common reasons for ED presentation among patients diagnosed with cancer were shortness of breath (n=1827, 16.8%), abdominal pain (n=1324, 12.2%), general weakness (n=870, 8%), chest pain (n=566, 5.2%), and nausea (n=445, 4.1%).

Demographic Characteristics

Table 1 compares the demographic and other characteristics of patients who had an ED visit before cancer diagnosis versus those who did not. The patients who were diagnosed after an ED visit resided in a more deprived area with a state-specific decile of block group ADI score (mean 5.2, std. dev=3.0) compared to those who were not diagnosed after an ED visit, with a score (mean=4.5, std. dev=2.8, $P<.001$). In addition, the patients diagnosed after an ED visit had a shorter travel distance (mean=127.6, std. dev=314.8) in miles to the medical center than those not diagnosed after an ED visit (mean=264.7, std. dev=410.5) miles ($P<.001$). Finally, a higher proportion of patients already established at Mayo Clinic (n=1816, 13.9%) had an ED visit before their cancer diagnosis than those not established at Mayo Clinic (n=122, 1.0%, $P<.001$).

Regression Results

The findings of the multivariate logistic regression model assessing the association among various patient characteristics and the odds of having an ED visit before receiving a cancer diagnosis are displayed in Table 2. In multivariate analyses, factors associated with ED-related cancer diagnosis included age 18-50 years (OR=1.32; 95% CI, 1.09-1.61), Elixhauser score >4 (OR=17.90; 95% CI, 14.21-22.76), Medicaid or other government insurance (OR=2.10; 95% CI, 1.63-2.69), residence within the Mayo Clinic catchment area (OR=3.18; 95% CI, 2.78-3.66), and relationship with a PCP at Mayo Clinic (OR=1.45; 95% CI, 1.28-1.65). Non-Hispanic Black race/ethnicity (OR=1.41; 95% CI, 1.04-1.88) were more likely to have an ED visit before cancer diagnosis. The ED-associated cancers included acute lymphoblastic leukemia (OR=3.98; 95% CI, 2.27-6.72), endometrial (OR=1.89; 95% CI, 1.51-2.35), cervical (OR=4.92; 95% CI, 3.28-7.24), colorectal (OR=3.92; 95% CI, 3.23-4.75), kidney/bladder (OR=2.94; 95% CI, 2.38-3.63), lung (OR=3.81; 95% CI, 3.23-4.50), brain (OR=5.14; 95% CI, 3.53-7.36), non-Hodgkin lymphoma (OR=2.98;

TABLE 1. Comparing Demographic and Other Characteristics of Patients who had an ED Visit Before Cancer Diagnosis Versus Those who did not

Total (N=25,736)	ED Visit: Yes (n=1938)	ED Visit: No (n=23,798)	*P*
Age at diagnosis (y)			<.001
65+ (n=10,036)	1069 (10.7%)	8967 (89.3%)	
51-65 (n=9895)	581 (5.9%)	9314 (94.1%)	
18-50 (n=5805)	288 (5.0%)	5517 (95.0%)	
Site			.001
RST (n=14,851)	1154 (7.8%)	13,697 (92.2%)	
FLA (n=5639)	362 (6.4%)	5277 (93.6%)	
ARZ (n=5246)	422 (8.0%)	4824 (92.0%)	
Year of diagnosis			<.001
2021 (n=3422)	323 (9.4%)	3099 (90.6%)	
2020 (n=3417)	302 (8.8%)	3115 (91.2%)	
2019 (n=3333)	230 (6.9%)	3103 (93.1%)	
2018 (n=3967)	274 (6.9%)	3693 (93.1%)	
2017 (n=4054)	286 (7.1%)	3768 (92.9%)	
2016 (n=3929)	285 (7.3%)	3644 (92.7%)	
2015 (n=3614)	238 (6.6%)	3376 (93.4%)	
Race/ethnicity			<.001
Missing (n=667)	40	627	
Non-Hispanic White (n=22,223)	1721 (7.7%)	20,502 (92.3%)	
Non-Hispanic Black (n=898)	72 (8.0%)	826 (92.0%)	
Hispanic (n=1014)	65 (6.4%)	949 (93.6%)	
Other (n=934)	40 (4.3%)	894 (95.7%)	
BMI category			<.001
Missing (n=14404)	200	14,204	
≥30 (n=3988)	698 (17.5%)	3290 (82.5%)	
25-29.9 (n=3342)	461 (13.8%)	2881 (86.2%)	
18.6-24.9 (n=3748)	523 (14.0%)	3225 (86.0%)	
≤18.5 (n=254)	56 (22.0%)	198 (78.0%)	
Marital status			<.001
Married/life partnership (n=17,246)	1009 (5.9%)	16,237 (94.1%)	
Unknown (n=126)	2 (1.6%)	124 (98.4%)	
Other (n=8364)	927 (11.1%)	7437 (88.9%)	
PCP at Mayo			<.001
PCP: no (n=20,749)	945 (4.6%)	19,804 (95.4%)	
PCP: yes (n=4987)	993 (19.9%)	3994 (80.1%)	
Catchment area			<.001
Outside catchment area (n=14,926)	413 (2.8%)	14,513 (97.2%)	
Within catchment area (n=10,810)	1525 (14.1%)	9285 (85.9%)	
Elixhauser category			<.001
Missing (n=5886)	2	5884	
0 (n=7064)	96 (1.4%)	6968 (98.6%)	
1-2 (n=5988)	338 (5.6%)	5650 (94.4%)	
3-4 (n=3123)	412 (13.2%)	2711 (86.8%)	
>4 (n=3675)	1090 (29.7%)	2585 (70.3%)	
Type of insurance			<.001
Commercial (n=14062)	927 (6.6%)	13,135 (93.4%)	
Medicaid/other government (n=804)	122 (15.2%)	682 (84.8%)	
Medicare (n=7605)	810 (10.7%)	6795 (89.3%)	
Other (n=421)	58 (13.8%)	363 (86.2%)	

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TABLE 1. Continued

Total (N=25,736)	ED Visit: Yes (n=1938)	ED Visit: No (n=23,798)	*P*
Type of insurance, continued			
Unknown (n=2844)	21 (0.7%)	2823 (99.3%)	
National percentile of block group ADI scores			<.001
Missing (n=2028)	136	1892	
Mean (std.dev) (n=23,708)	47.3 (24.4)	45.0 (23.8)	
Median (Q1, Q3)	45.5 (29.0, 66.0)	43.0 (27.0, 63.0)	
Range	1.0-100.0	1.0-100.0	
State-specific decile of block group ADI score			<.001
Missing (n=2028)	136	1892	
Mean (std.dev) (n=23,708)	5.2 (3.0)	4.5 (2.8)	
Median (Q1, Q3)	5.0 (2.2, 8.0)	4.0 (2.0, 7.0)	
Range	1.0-10.0	1.0-10.0	
Country of residence			<.001
United States (n=25,736)	1938 (7.5%)	23,798 (92.5%)	
Distance driven from origin to destination (in miles)			<.001
Missing (n=151)	5	146	
Mean (std.dev) (n=25,585)	127.6 (314.8)	264.7 (410.5)	
Median (Q1, Q3)	34.0 (13.6, 82.3)	106.7 (35.4, 307.4)	
Range	0.0-3015.8	0.0-4651.3	
Duration of drive from origin to destination (in hours)			<.001
Missing (n=151)	5	146	
Mean (std.dev) (n=25,585)	2.1 (4.7)	4.1 (6.2)	
Median (Q1, Q3)	0.7 (0.3, 1.4)	1.8 (0.7, 4.8)	
Range	0.0-50.0	0.0-102.0	
Mayo clinic patient before diagnosis			<.001
No (n=12,676)	122 (1.0%)	12,554 (99.0%)	
Yes (n=13,060)	1816 (13.9%)	11,244 (86.1%)	

ADI, area deprivation index; ARZ, Arizona; BMI, body mass index; ED, emergency department; FLA, Florida; PCP, primary care physician; RST, Rochester.

95% CI, 2.28-3.89), and ovarian cancers (OR=4.17; 95% CI, 3.24-5.34).

Age-Stratified Regression

Table 3 reports an age-stratified multivariate logistic regression model, examining the relationship between patient characteristics and the odds of visiting the ED before cancer diagnosis. The results indicate that having a PCP at Mayo Clinic was associated with a significantly higher likelihood of ED visit in all age groups. However, the odds of ED visits among those with a Mayo PCP were somewhat higher for women aged 18-50 years (OR=2.60; 95% CI, 1.83-3.70) versus those 65 years of age and older (OR=1.34; 95% CI, 1.13-1.59).

Cancers and ED visits

Table 4 shows the distribution of cancer types based on whether an ED visit preceded the diagnosis. Among the 25,736 patients studied, lung cancer had the highest percentage of cases (n=514, 14.7%) diagnosed after an ED visit, whereas breast cancer had the lowest percentage (n=328, 3.4%). Other cancers with a relatively high proportion of cases diagnosed after an ED visit included kidney/bladder cancer (n=187, 10.2%), ovarian cancer (n=120, 10.0%), and endometrial cancer (n=149, 6.7%). As represented in Table 5, ED visits were more likely in those who died within 6 months of diagnosis (n=327, 37.8%) than those who did not die (n=1611, 6.5%). Similarly,

TABLE 2. Multivariate Logistic Regression Model Examining the Association Between Patient Characteristics and the Likelihood of Having an ED Visit Before Cancer Diagnosis

Predictor	OR (95% CI)	*P*
Year of cancer diagnosis	1.00 (0.98-1.03)	.755
Age at diagnosis (65+)	REF	REF
Age at diagnosis (51-65)	0.97 (0.83-1.12)	.665
Age at diagnosis (18-50)	1.32 (1.09-1.61)	.004
Elixhauser category (0)	REF	REF
Elixhauser category (1-2)	3.49 (2.76-4.44)	<.001
Elixhauser category (3-4)	7.39 (5.83-9.45)	<.001
Elixhauser category (>4)	17.90 (14.21-22.76)	<.001
Site (RST)	REF	REF
Site (FLA)	1.05 (0.91-1.22)	.477
Site (ARZ)	1.22 (1.06-1.40)	.006
Type of insurance (commercial)	REF	REF
Type of insurance (Medicare)	1.08 (0.94-1.25)	.268
Type of insurance (unknown)	1.11 (0.67-1.73)	.679
Type of insurance (Medicaid/other government)	2.10 (1.63-2.69)	<.001
Type of insurance (other)	2.44 (1.70-3.46)	<.001
Catchment area (outside catchment area)	REF	REF
Catchment area (within catchment area)	3.18 (2.78-3.66)	<.001
Race/ethnicity (non-Hispanic White)	REF	REF
Race/ethnicity (non-Hispanic Black)	1.41 (1.04-1.88)	.023
Race/ethnicity (Hispanic)	1.20 (0.88-1.61)	.241
Race/ethnicity (other)	0.94 (0.65-1.34)	.738
Cancer category (breast cancer)	REF	REF
Cancer category (acute lymphoblastic leukemia)	3.98 (2.27-6.72)	<.001
Cancer category (endometrial cancer)	1.89 (1.51-2.35)	<.001
Cancer category (cervical cancer)	4.92 (3.28-7.24)	<.001
Cancer category (colorectal cancer)	3.92 (3.23-4.75)	<.001
Cancer category (head and neck cancer)	1.38 (0.76-2.34)	.263
Cancer category (kidney and bladder cancer)	2.94 (2.38-3.63)	<.001
Cancer category (lung cancer)	3.81 (3.23-4.50)	<.001
Cancer category (malignant brain cancer)	5.14 (3.53-7.36)	<.001
Cancer category (melanoma)	1.12 (0.90-1.39)	.316
Cancer category (non-Hodgkins Lymphoma)	2.98 (2.28-3.89)	<.001
Cancer category (ovarian cancer)	4.17 (3.24-5.34)	<.001
Primary care physician at Mayo (PCP: No)	REF	REF
Primary care physician at Mayo (PCP: Yes)	1.45 (1.28-1.65)	<.001

ED visits were more likely before diagnosis of stage III/IV cancer (n=714, 13.7%) compared to stage I/II (n=662, 5.8%). Cancer stage data are limited to solid organ tumors and is limited by a high number of missing values.

DISCUSSION

We found a preceding ED visit in the 6 months before cancer diagnosis in 1938 (7.5%) of patients diagnosed with cancer from January 1, 2015, to December 31, 2021 at the 3 geographically diverse sites. Preceding

TABLE 3. Age-Stratified Multivariate Logistic Regression Model Examining the Association Between Patient Characteristics and the Likelihood of having an ED Visit Before Cancer Diagnosis

	≥65 Y		51-65 Y		18-50 Y	
Predictor	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Year of cancer diagnosis	1.00 (0.96-1.04)	.989	1.00 (0.95-1.05)	.903	1.04 (0.97-1.12)	.303
Elixhauser category (0)[a]	REF		REF		REF	
Elixhauser category (1-2)	2.96 (1.92-4.73)	<.001	3.49 (2.46-5.05)	<.001	3.75 (2.41-5.99)	<.001
Elixhauser category (3-4)	7.39 (4.89-11.65)	<.001	6.24 (4.31-9.18)	<.001	8.88 (5.48-14.73)	<.001
Elixhauser category (>4)	19.42 (13.06-30.22)	<.001	14.44 (10.07-21.12)	<.001	17.58 (10.59-29.85)	<.001
Site (RST)	REF	REF	REF	REF	REF	REF
Site (FLA)	1.00 (0.82-1.22)	.98	1.26 (0.97-1.62)	.08	0.88 (0.58-1.31)	.53
Site (ARZ)	1.23 (1.02-1.49)	.03	1.22 (0.94-1.56)	.128	1.22 (0.82-1.80)	.321
Type of insurance (Commercial)	REF	REF	REF	REF	REF	REF
Type of insurance (Medicare)	1.13 (0.96-1.34)	.137	0.85 (0.58-1.22)	.392	1.78 (0.70-4.22)	.206
Type of insurance (unknown)	3.77 (1.43-8.59)	.003	0.60 (0.25-1.24)	.208	1.35 (0.54-2.93)	.481
Type of insurance (Medicaid/other government)	1.18 (0.40-.01)	.74	2.38 (1.70-3.29)	<.001	2.00 (1.27-3.13)	.003
Type of insurance (other)	3.29 (1.51-6.99)	.002	1.93 (1.11-3.25)	.016	2.79 (1.44-5.22)	.002
Catchment area (outside catchment area)	REF	REF	REF	REF	REF	REF
Catchment area (within catchment area)	3.04 (2.53-3.67)	<.001	3.31 (2.59-4.26)	<.001	3.59 (2.46-5.32)	<.001
Race/ethnicity (non-Hispanic White)	REF	REF	REF	REF	REF	REF
Race/ethnicity (non-Hispanic Black)	1.01 (0.59-1.65)	.976	1.51 (0.93-2.39)	.082	2.09 (1.11-3.81)	.019
Race/ethnicity (Hispanic)	1.08 (0.58-1.87)	.807	1.33 (0.81-2.10)	.237	1.15 (0.64-2.00)	.628
Race/ethnicity (other)	0.98 (0.55-1.64)	.933	0.89 (0.44-1.63)	.72	1.05 (0.45-2.19)	.894
Cancer category (breast cancer)	REF	REF	REF	REF	REF	REF
Cancer category (acute lymphoblastic leukemia)	1.96 (0.43-6.36)	.313	4.10 (1.61-9.48)	.002	7.56 (3.06-17.67)	<.001
Cancer category (endometrial cancer)	1.83 (1.31-2.53)	<.001	1.83 (1.29-2.60)	<.001	3.14 (1.69-5.69)	<.001
Cancer category (cervical cancer)	7.04 (2.74-16.35)	<.001	6.12 (3.06-11.77)	<.001	3.98 (2.05-7.44)	<.001
Cancer category (colorectal cancer)	4.27 (3.28-5.57)	<.001	3.62 (2.53-5.14)	<.001	3.09 (1.85-5.11)	<.001
Cancer category (head and neck cancer)	0.98 (0.37-2.19)	.969	2.85 (1.21-6.06)	.010	0.52 (0.03-3.02)	.547
Cancer category (kidney and bladder cancer)	2.68 (2.00-3.58)	<.001	3.10 (2.12-4.48)	<.001	4.31 (2.52-7.28)	<.001
Cancer category (lung cancer)	3.90 (3.13-4.88)	<.001	3.98 (2.96-5.37)	<.001	2.91 (1.56-5.30)	<.001
Cancer category (malignant brain cancer)	5.68 (3.21-9.74)	<.001	4.72 (2.18-9.43)	<.001	5.83 (2.78-11.72)	<.001
Cancer category (melanoma)	1.38 (1.01-1.87)	.044	0.69 (0.43-1.07)	.108	1.10 (0.69-1.74)	.670
Cancer category (non-Hodgkin's lymphoma)	4.20 (2.96-5.94)	<.001	2.30 (1.31-3.88)	.003	1.37 (0.60-2.87)	.420
Cancer category (ovarian cancer)	3.25 (2.23-4.69)	<.001	5.81 (3.94-8.50)	<.001	3.98 (1.81-8.19)	<.001
Primary care physician at Mayo (PCP: No)	REF	REF	REF	REF	REF	REF
Primary care physician at Mayo (PCP: Yes)	1.34 (1.13-1.59)	<.001	1.30 (1.03-1.64)	.029	2.60 (1.83-3.70)	<.001

[a]The Elixhauser score is calculated by summing the weights assigned to the following comorbidities: congestive heart failure, cardiac arrhythmias, valvular disease, pulmonary circulation disorders, peripheral vascular disorders, hypertension (uncomplicated and complicated), paralysis, other neurological disorders, chronic pulmonary disease, diabetes (uncomplicated and complicated), hypothyroidism, renal failure, liver disease, peptic ulcer disease (excluding bleeding), AIDS/HIV, lymphoma, rheumatoid arthritis/collagen vascular disease, coagulopathy, weight loss, fluid and electrolyte disorders, blood loss anemia, deficiency anemia, alcohol abuse, drug abuse, and psychoses (excluding solid tumor, metastatic cancer, and obesity), and the resulting score was then categorized into 4 groups: 0, 1-2, 3-4, and >4.

ED visits were lowest in patients diagnosed with breast cancer (3.4%) and highest in those diagnosed with lung cancer (14.7%). Although the timeframe and locations differ, incident cancer diagnosis prevalence with a previous ED visit is lower in the current study compared to previous studies locally,[8] nationally,[9] and internationally.[16] The most common reasons for presentation to ED (shortness of breath, abdominal pain, general weakness, chest pain, and nausea) were symptoms that could have been related to cancer or noncancer (not symptom signatures for cancer) revealing the importance of initiating a diagnostic evaluation that would be inclusive of a cancer diagnosis (eg, imaging studies, laboratory tests, or procedures based on an index of suspicion for cancer).

Similar to previous studies, cancer type, race, insurance status, age, and Elixhauser category are all associated with cancer diagnosis following ED visits. Patients established within Mayo Clinic and with PCP were most likely to receive a diagnosis following an ED visit, suggesting utilization of the Mayo Clinic ED to expedite the evaluation and management of patients with complex comorbidities based on most diagnoses generated on the same day as the ED visit. These findings contrast with literature showing a lack of establishment with a PCP as a risk factor for an ED-related cancer diagnosis.[13,25-28] A study reviewing ED-related cervical cancer diagnosis in a Dallas safety net hospital showed 194 (78.8%) of 246 patients with incident cervical cancer following a previous ED visit were not previously established with the hospital system.[13] The discrepancy in these results may be because of Mayo Clinic's primary function as a tertiary care facility focused on subspecialty care, in contrast to current literature that predominantly explores safety net hospital systems focused on care for those with fewer resources. The age-stratified multivariate logistic regression model revealed different patterns in cancer diagnosis suggesting different pathways taken for diagnosis among ages. This requires additional investigation. When ambiguous symptoms develop, clinicians may be more likely to send patients to the ED for the work-up to expedite the evaluation.

The Elixhauser comorbidity index categorizes comorbidities of patients based on reporting codes from the International Classification of Diseases.[22] The index had the most profound association with cancer diagnosis following an ED visit. Among 3675 patients with an Elixhauser category >4 diagnosed with cancer, 1090 (29.7%) were diagnosed following an ED visit. Among 7064 patients with an Elixhauser category of 0, only 96 (1.4%) were diagnosed following an ED visit. These results are consistent with a 2013 study in the United Kingdom[10] and a 2012 study in Michigan study[27] showing the association of a Charlson comorbidity index of 3 with ED-associated colorectal and lung cancer. To date, no study has assessed the relationship between the Elixhauser Comorbidity Index and an ED-associated cancer diagnosis. These data support the need to facilitate the evaluation and management of patients with multiple comorbidities in the outpatient settings of health systems to decrease the utilization of the ED for cancer diagnosis. It also suggests opportunities to ascertain previous cancer screening and prevention in the ED with outpatient follow-up as described previously utilizing research associates.[29,30]

Advanced-stage cancer and mortality within 6 months of cancer diagnosis were more common among patients presenting to the ED than those diagnosed outside of the ED. The findings in this study are consistent with several studies assessing the risk factors of an ED diagnosis. Notably, a 2016 Jacksonville, Florida, study found patients with ED-identified cancer, defined as a cancer diagnosis within 30 days of an ED visit, were 58% more likely to be diagnosed with stage 4 cancer versus stage 1 when compared with patients who received a non-ED-associated cancer diagnosis, RR=1.58 (95% CI, 1.42-1.72), $P<.001$.[8] Similar results are reported in the United Kingdom for multiple cancers,[10] lung cancer in Nova Scotia,[28] lung cancer in the state of Indiana in the United States,[25] cervical cancer in the state of Texas in the United States,[13] cervical cancer in the state of California in the United States, and colorectal cancer in the State of New York in the United States.[9]

Potential opportunities for intervention could target patients at high risk of cancer before ED visits with novel care coordination, improvement in documentation of cancer screening and use of care gap dashboards in the ED and acute care settings, and post-acute cancer care, health navigation, and research recruitment.

TABLE 4. Distribution of Cancer Type by Whether an ED Visit Preceded the Diagnosis

	ED Visit: Yes (n=1938)	Odds Ratio (95% CI)
Cancer category		
Acute lymphoblastic leukemia (n=166)	22 (13.3%)	4.30 (2.64-6.68)
Breast cancer (n=9558)	328 (3.4%)	REF
Endometrial cancer (n=2219)	149 (6.7%)	2.03 (1.66-2.47)
Cervical cancer (n=462)	45 (9.7%)	3.04 (2.16-4.17)
Colorectal cancer (n=2701)	268 (9.9%)	3.10 (2.62-3.66)
Head and neck cancer (n=375)	16 (4.3%)	1.25 (0.72-2.03)
Kidney and bladder cancer (n=1839)	187 (10.2%)	3.19 (2.64-3.84)
Lung cancer (n=3485)	514 (14.7%)	4.87 (4.22-5.63)
Brain cancer (n=566)	51 (9.0%)	2.79 (2.03-3.76)
Melanoma (n=2301)	137 (6.0%)	1.78 (1.45-2.18)
Non-Hodgkin lymphoma (n=868)	101 (11.6%)	3.71 (2.92-4.67)
Ovarian cancer (n=1196)	120 (10.0%)	3.14 (2.51-3.89)

Abbreviation: ED, emergency department.

Limitations

Reporting bias is an important limitation in this retrospective study using administrative databases. In some cases, patients may have had multiple cancer types even though the patient was listed as having a primary cancer within the timeframe. We addressed these limitations by cross-checking the EHR and pathology reports and manually reviewing cases when discrepancies arose. The continuum of cancer from cancer precursors (eg, hyperplasia or dysplasia) to cancer is difficult to discern in administrative databases, making it possible that a diagnosis code for cancer was generated when a cancer precursor was evaluated and billed as cancer, although this potential misclassification would be similar in the ED-associated cancer group versus the non-ED-associated cancer group. Finally, the cohort was selected from a tertiary referral center with demographic characteristics different from the general population. This introduces selection bias and referral biases based on clinical practice and patient expectations making the results less generalizable to EDs that serve lower-resourced communities and vulnerable patient populations. However, this was addressed by including all 3 sites in 3 different geographic regions, which showed similar results and points toward experiences and expectations that are likely biased toward receiving an efficient diagnosis to new signs and symptoms for patients with PCPs There is also the possibility that a patient had an ED encounter outside of Mayo and then presented to Mayo and was diagnosed with a malignancy. This would be documented as a non-ED-associated cancer diagnosis as we do not have data from outside of Mayo. As the United States Healthcare System becomes increasingly fragmented without a single database inclusive of all health care encounters, this limitation will continue to exist in administrative databases of the United States.

TABLE 5. Distribution of Cancer Stage at Diagnosis and Mortality by Presence of ED Visit Before Diagnosis

	ED visit: Yes (n=1938)	ED Visit: No (n=23,798)	*P*
Death within 6 months			<.001[a]
No (n=24,872)	1611 (6.5%)	23,261 (93.5%)	
Yes (n=864)	327 (37.8%)	537 (62.2%)	
Cancer stage at diagnosis			<.001[a]
Missing (n=9078)	562	8516	
Stage I and II (n=11,453)	662 (5.8%)	10,791 (94.2%)	
Stage III and IV (n=5205)	714 (13.7%)	4491 (86.3%)	

CONCLUSION

Despite practice and population differences among Arizona, Minnesota, and Florida, the ED remains an important albeit suboptimal setting for the initial cancer diagnosis. This study provides baseline data as quality improvement efforts and interventions are designed and implemented to improve the care of women before, during, and after the unexpected cancer diagnosis.

POTENTIAL COMPETING INTERESTS

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SUPPLEMENTAL ONLINE MATERIAL

Supplemental material can be found online at http://www.mcpiqojournal.org. Supplemental material attached to journal articles has not been edited, and the authors take responsibility for the accuracy of all data.

Abbreviations and Acronyms: **ADI,** area deprivation index; **ED,** emergency department; **EHR,** electronic health record; **PCP,** primary care provider

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