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Factors Associated with Time to Surgery in Melanoma:
An Analysis of the National Cancer Database

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By

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An abstract of
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Abstract

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By Marissa Baranowski

Timely treatment for melanoma may affect survival and characterizing predictors of treatment delay may inform intervention strategies. The objective of this study was to determine patient- and facility-level characteristics associated with time to treatment in melanoma. The National Cancer Database was used to examine factors associated with the interval between diagnosis and definitive surgical treatment among 205,665 patients with Stage I, II, or III cutaneous melanoma.

Among privately insured patients, delay in surgical treatment was significantly associated with older age. By contrast, in patients without private insurance, the association with age was weaker and in the opposite direction. Other factors associated with a longer interval from diagnosis to surgery included non-white race, less education, higher comorbidity burden, more advanced stage, and head or neck melanoma location. Limitations include use of zip-code level data for patient income and education level. Melanoma patients experience disparities in timely receipt of surgery.

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The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. The data used in the study are derived from a de-identified NCDB file. The American College of Surgeons and the Commission on Cancer have not verified and are not responsible for the analytic or statistical methodology employed, or the conclusions drawn from these data by the investigator.

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INTRODUCTION

Lifetime risk of melanoma in the United States is one in 27 males and one in 42 females.[1] Overall incidence is rising, and most rapidly among those aged 50 and older.[1-3] Survival decreases with higher disease stage; five-year relative survival rates are 99%, 63%, and 20% for localized, regional, and distant disease, respectively.[1,4,5]

A recent National Cancer Database (NCDB) analysis demonstrated the interval between diagnosis and treatment receipt is a determinant of melanoma survival.[6] This was especially true for early stage disease; compared to stage I melanoma patients who received surgical treatment within 1 month after biopsy, those who waited 30-59, 60-89, 90-119, and at least 120 days experienced decreases in overall survival by 5%, 16%, 29%, and 41%, respectively.[6]

As delay of definitive surgery may impact survival, it is imperative we identify possible targets for interventions aimed at improving pathways to timely care. While an earlier NCDB-based publication highlighted the prognostic value of timely surgery, it did not examine factors affecting wait time.[6] This study aimed to ascertain patient-, provider-, and disease-related independent predictors of the interval between melanoma diagnosis and definitive surgical treatment.

METHODS

Database and Patient Selection

NCDB is a large, facility-based, prospectively acquired database, and a joint project of the American College of Surgeons and the American Cancer Society.[7-9] NCDB was queried for patients with diagnosis of melanoma reported between January 1, 2004 and December 31, 2015. Target population was patients with stage I, II, or III melanoma who received definitive surgical therapy. Patients with AJCC Pathologic Stage Group 0, IV, or unknown were excluded (Figure 1). Patients were excluded if missing data for the primary outcome, defined as days between diagnosis and definitive surgical procedure, or had a value of 0 days. Patients were also excluded if missing data for important covariates: race, insurance type, residence, education, site, or Breslow depth. This exclusion only applied to variables with <3% missing data.

Each study participant was characterized with respect to age (<50 "younger", 50-70 "middle", >70 years "older"), sex, race (white, non-white), insurance status (not insured, private insurance, Medicaid, Medicare, other government), residence (metro, urban, rural), distance to facility (≤25, >25 miles), income, education, and comorbidities as assessed by Charlson-Deyo score (0, 1, ≥2). Household income and educational attainment were estimated by matching patient zip code to 2012 American Community Survey data, then categorized into quartiles based on all US zip codes, and for income only, adjusted for inflation to 2012 U.S. dollar values.

Disease characteristics of interest included site (head and neck, trunk, upper extremity and shoulder, lower extremity and hip), stage (1, 2, 3), laterality (right, left, midline, or not paired, not specified, or bilateral), histologic subtype, Breslow depth (≤1 mm, 1.01-2.00 mm, 2.01-4.00 mm, or ≥4.01 mm), ulceration, mitoses, lymph vascular invasion, and year of

diagnosis (2004-2006, 2007-2009, 2010-2012, 2013-2015). Ulceration, mitoses and lymphovascular invasion were each categorized as not present, present, or unknown.

NCDB suppresses data on facility type and location for patients less than 40 years of age. Facility location was categorized into Northeast, South, Midwest, or West.

Statistical Methods

All statistical analyses were performed in SAS 9.4 (Cary, North Carolina). The unadjusted association between patient age and time from diagnosis to definitive surgery was examined by constructing Kaplan Meier survival curves accompanied by the corresponding log-rank test. Multivariable Cox proportional hazards models were used to examine the same association after controlling for patient characteristics, area-based socioeconomic variables and disease-related factors. Results of Cox models were expressed as adjusted hazard ratios (HRs) and the corresponding 95% confidence intervals (CIs). A HR greater than 1 signifies a greater probability of definitive surgery (shorter time interval) than the control group, while a HR less than 1 means a lower probability of definitive surgery (longer time interval) than the control group.

The proportional hazard assumption was tested for each variable by evaluating log-log survival plots. Residency categories violated the proportional hazard assumption, prompting data-driven reclassification. Data on residence and proximity to the nearest hospital facility were subsequently combined to create a single variable with four categories: metro ≤25 miles, non-metro ≤25 miles, metro >25 miles, and non-metro >25 miles.

Models were examined for interaction between age and each covariate by evaluating the corresponding product terms. Additional analyses were conducted to compare stratum-specific

results for statistically significant interaction terms. However, many of these terms were a reflection of a large sample size rather than meaningful effect modification. The only exception was the interaction between age and insurance status, which revealed pronounced differences across stratum specific results. The association between age and time to surgery did not differ significantly between those on Medicaid, Medicare, other government insurance, and those without insurance, but all did differ from private insurance. For this reason, multivariable analyses were conducted separately for persons with and without private health insurance.

RESULTS

Study Cohort Characteristics

The analytic cohort included 205,665 melanoma patients representing 87.2% of the target population (Figure 1). Median patient age at diagnosis was 61 years (range 18 – 90 years). Stage I, II, and III disease was found in 65%, 21%, and 14% of the cohort, respectively. A majority of patients were male (57%) and had private insurance (56%). Nearly all subjects (99%) were of white race. Table 1 further describes the patient-, disease-, and facility-related characteristics of the study cohort by age category.

Overall time-to-surgery analysis

As shown in Figure 2 the surgical wait time was longest in the older age group. The median interval between diagnosis and surgery was 29 days among patients less than 50 years of age, 29 days in 50- to 70-year-olds, and 32 days in those over the age of 70. The difference in surgical interval across these three groups was statistically significant (log rank $p < 0.0001$).

Patients with Private Insurance

Among 115,461 patients with private insurance, the average wait time was longer for those 50 to 70 years of age (HR 0.97 [95% CI 0.96, 0.98], $p < 0.0001$) and those 50 to 70 years of age (HR 0.85 [95% CI 0.82, 0.87], $p < 0.0001$), compared with those under the age of 50.

Other patient-related characteristics associated with longer interval from diagnosis to surgery included non-white race, living in a zip code with higher proportion of population without a high school diploma, residence in a city suburb (i.e. metropolitan area not in close proximity to a hospital), and greater number of comorbidities. A longer wait time was also

observed in patients with head or neck melanoma site and higher stage. No discernable associations were seen with sex or year of diagnosis.

Patients without Private Insurance

Unlike privately insured patients, those with other types of insurance (n = 90,204) had a shorter surgical wait time if they were older. Using patients under the age of 50 as a reference, the HR for those 50 to 70 years of age and those older than 70 was similar (HR 1.09 [95% CI 1.06, 1.12], $p < 0.0001$; HR 1.08 [95% CI 1.05, 1.11], $p < 0.0001$).

The associations of most patient-related factors with surgical wait time did not differ by insurance status; however, racial differences and associations with lower area-based levels of educational attainment were more pronounced. Similarly, while most associations with disease-related characteristics were similar in patients with and without private insurance, the results for stage were stronger in the second group.

Results of Subgroup Analysis for Patients 40 Years and Older

The results of analyses controlling for facility location and type are presented in Supplemental Tables 1 and 2. These analyses were limited to cohort members who were 40 years of age or older at the time of diagnosis (82% of privately insured patients and 97% patients without a private insurance). Compared to those diagnosed and treated in the Northeastern US, patients in other regions experienced shorter surgical intervals with greatest differences seen in the Midwest and South. Patients who used facility types other than academic research centers had a shorter surgical wait time. Previously observed results for age, sex, area-based educational

attainment, year of diagnosis, disease stage, and melanoma site did not change with the addition of facility-related characteristics to the model.

DISCUSSION

Median time to definitive melanoma surgery differed between age groups, with older people experiencing the longest delay. On further analysis, a meaningful interaction between age and insurance type was observed. Among patients with private insurance, older age was associated with a longer time to surgery while controlling for other factors. Conversely, older age was associated with a shorter time to surgery among patients without private insurance. Among either insurance type, factors associated with a longer time to surgery included non-white race, less education, farther distance from hospital facility, head or neck site, higher disease stage, and greater comorbidity burden.

Lott et al. investigated delay of surgery, defined as greater than six weeks between biopsy and surgical excision, for melanoma among Medicare beneficiaries using the linked Surveillance, Epidemiology, and End Results—Medicare database.[10] After adjustment, the incidence of surgical delay was found to be highest among patients older than 85 years, with a history of previous melanoma, and greater number of comorbidities.[10] More recently, Adamson et al. examined how surgical delays vary by insurance type among melanoma patients in North Carolina.[11] The patients most likely to experience delay, defined as surgery longer than six weeks after diagnosis, included those with Medicaid, of non-white race, and those who did not have diagnosis or surgical treatment performed by a dermatologist.[11]

The impact of wait time from diagnosis to treatment on survival in melanoma remains an area of uncertainty. In a retrospective analysis of 986 Scottish patients, the time between biopsy and excision was found to have no affect on overall, disease-free, or recurrence-free survival after adjustment for patient and tumor factors.[12] Carpenter et al. performed a study of a prospectively acquired database at Mayo Clinic Scottsdale with similar results; using a

benchmark of 28 days from biopsy to surgery, no difference in overall survival was seen.[13] However, a trend of decreased overall survival was observed in patients with an interval greater than 56 days.[13] More recently Conic et al. revealed that time to definitive surgical treatment greater than 90 days is associated with decreases in overall survival in the NCDB.[6] For patients with Stage I melanoma, a higher risk of mortality was seen for every group treated beyond 30 days post biopsy.[6] Outside of mortality benefit, the time to treatment interval is an important quality measure and represents an area for improvement in melanoma care.

A notable finding of this study is the difference in effect of age on surgical interval by insurance status. Older patients experience a delay to surgery more frequently than younger patients among the privately insured, but this result is the opposite among those without private insurance. This finding may be due to differences in the coverage provided by Medicare (without supplement) and Medicaid, and access among people with these insurance types. A previous study found that only 41% of dermatologists surveyed would accept new patients with Medicaid.[14] Among dermatology practices, the new patient acceptance rate is lower and mean appointment wait time is 13 days longer for patients with Medicaid compared to Medicare or private insurance.[15] It has been shown that melanoma patients less than 65 years who have Medicaid or are uninsured have worse all cause and cause-specific survival,[16] and perhaps a longer surgical interval along with poor access is contributing to this disparity.

Non-white patients are more likely to experience surgical delay than white patients. Despite comprising a small proportion of melanoma diagnoses, non-white patients have poorer survival outcomes and present with more advanced disease, often attributed to low suspicion for melanoma in non-white patients and health care providers.[17-19] Equalizing the surgical interval for

non-white patients could be a step in improving melanoma care for all patients, regardless of skin color.

In all analyses, patients who lived closer to the hospital experienced shorter time to surgery, perhaps due to patient-related and logistical factors. Longer travel distances mean more time away from work, greater transportation expenses, and conceivably less psychosocial support. Increasing distance from a health care provider has been shown in association with greater tumor depth at presentation and reflects overall access to care.[20,21] Remote care such as telemedicine may help in this regard, especially for pre-operative visits.

While income bracket was not a significant predictor after adjustment for facility level factors, education appeared to play a role. Among patients newly diagnosed with melanoma, those with a high school education are more likely to believe their diagnosis was not serious when compared to college-educated patients.[22] Similarly, they are less likely to report that a physician had discussed melanoma risk factors, screening, or detection – reflecting suboptimal communication and health education practices.[22] Perhaps the importance of timely surgery for melanoma is also not communicated.

Increasing time to surgery was seen in patients with more comorbidities, higher disease stage, and melanoma located on the head or neck. These factors may lead to complicated surgical approaches, perhaps limiting who can perform the surgery. It could also be that patients with greater comorbidity burdens require additional anesthesia workup. Further research is warranted to identify specific roadblocks that patients face when navigating the health care system between diagnosis and surgical treatment.

Limitations

Although NCDB captures almost 50% of new melanoma diagnoses in the United States,[8] it is a hospital-based registry and thus may not include cases of melanoma diagnosed and treated in community-based private practice settings.[9,23] However, most melanomas treated in such outpatient settings are in situ or Stage I, and have low impact on mortality. Limitations include the use of zip-code level data on income and education, which may not provide an accurate measure of patient level characteristics. Additionally, we did not analyze if the patients' biopsy and definitive surgery were performed at the same institution, which could be an important factor. It is reasonable to assume that a patient with a second primary melanoma would be more easily linked to care and thus timely surgery.

Despite these limitations, our sample size makes this analysis, the largest and first nationwide study of the surgical interval. The use of time to event analysis with Cox proportional hazard regression is novel when addressing this question, as is treating the surgical interval as a continuous instead of binary measure.

Conclusion

Patients with melanoma who are of non-white race, live farther from the health care facility, have less educational attainment, with more comorbidities, higher AJCC stage, or melanoma located on the head or neck are more likely to have a longer wait time from diagnosis to definitive surgical treatment than their peers. Elderly patients with private insurance experienced a longer time to surgery than non-elderly patients with private insurance, while those without private insurance experienced a shorter surgical interval than their younger counterparts. Public health intervention is warranted to address patient-, provider-, and facility-

level factors contributing to surgical delay in order to improve care for all patients with melanoma.

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FIGURES

Figure 1. Flow diagram depicting exclusions to arrive at the analytic data set

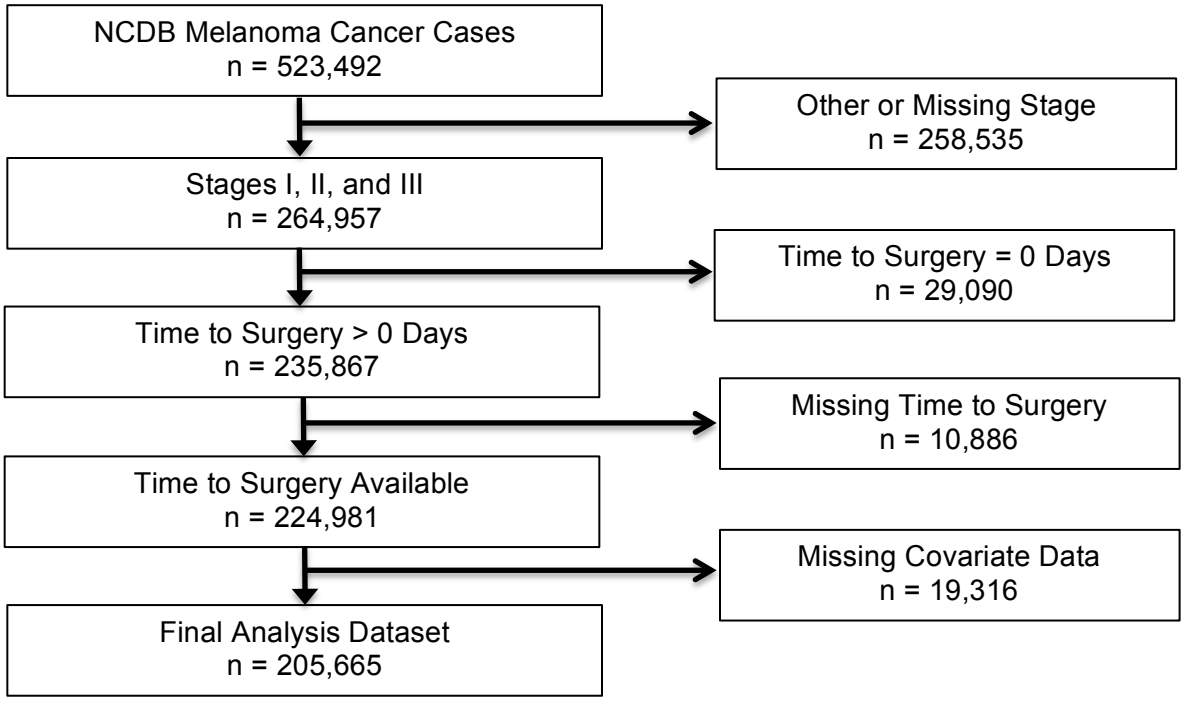
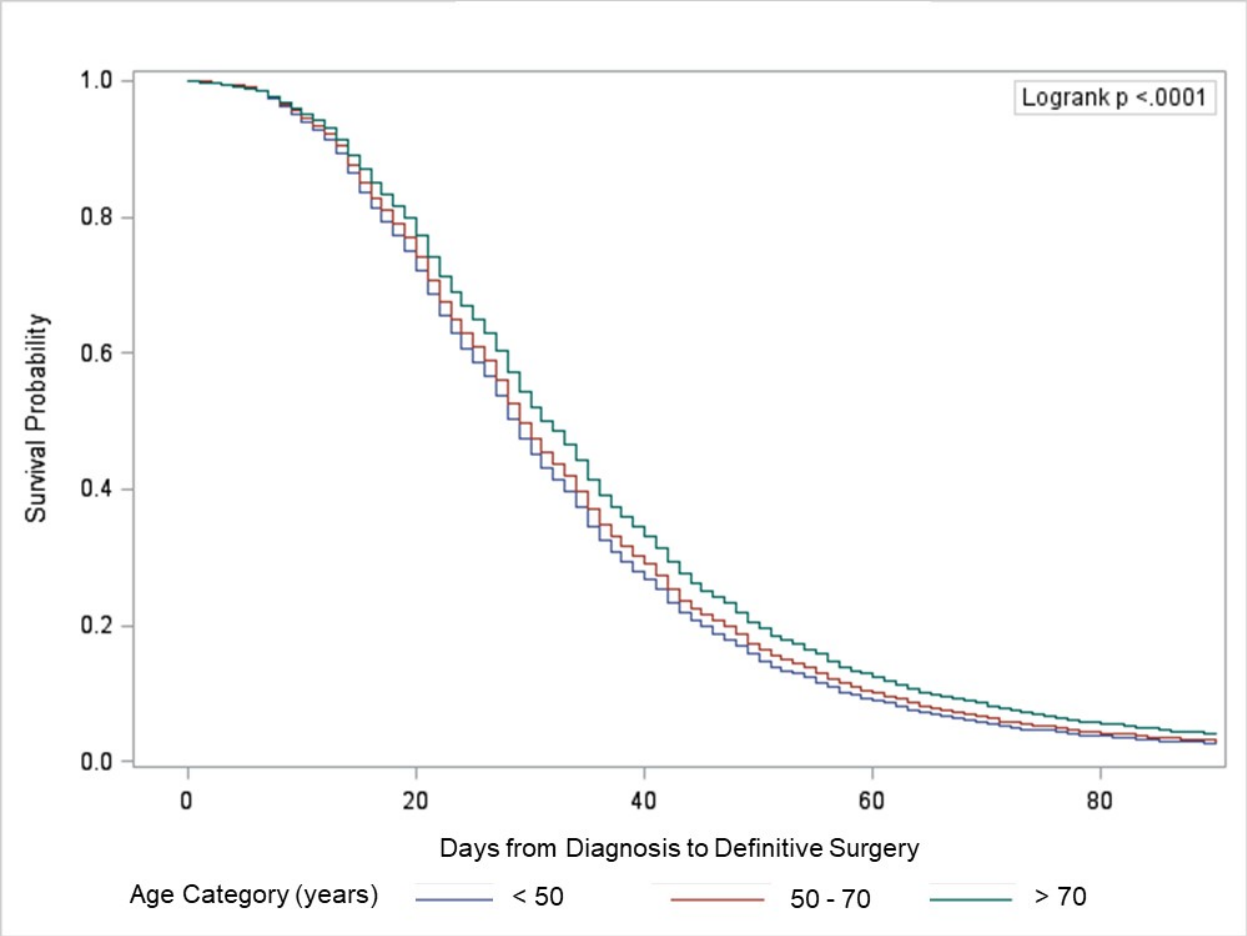


Figure 2. Time to Definitive Surgical Procedure by Age Category



Age Group (years)	No. Subject	Event	Censored	Median Survival (95% CI)	30 Day Survival	60 Day Survival
< 50	52,383	51,010 (97%)	1,373 (3%)	29 (28, 29)	45.1% (44.7%, 45.5%)	8.9% (8.7%, 9.2%)
50 - 70	94,545	91,723 (97%)	2,822 (3%)	29 (29, 30)	47.5% (47.2%, 47.8%)	10.0% (9.8%, 10.2%)
> 70	58,737	56,359 (96%)	2,378 (4%)	32 (31, 32)	52.1% (51.7%, 52.5%)	12.4% (12.1%, 12.6%)

TABLES

Table 1. Patient, Facility, and Disease Characteristics by Age Category

Variables	Total N (%)	<50 years N (%)	50-70 years N (%)	>70 years N (%)
Sex				
Male	117,656 (57.2)	21,910 (41.8)	57,226 (60.5)	38,520 (65.6)
Female	88,009 (42.8)	30,473 (58.2)	37,319 (39.5)	20,217 (34.4)
Race				
White	203,206 (98.8)	51,682 (98.7)	93,442 (98.8)	58,082 (98.9)
Non-White	2,459 (1.2)	701 (1.3)	1,103 (1.2)	655 (1.1)
Insurance Type				
Private	115,461 (56.1)	45,820 (87.5)	63,284 (66.9)	6,357 (10.8)
Medicaid	4,912 (2.4)	2,536 (4.8)	1,993 (2.1)	383 (0.7)
Medicare	78,433 (38.1)	1,154 (2.2)	25,829 (27.3)	51,450 (87.6)
Other Government	2,063 (1.0)	615 (1.2)	1,103 (1.2)	345 (0.6)
Uninsured	4,796 (2.3)	2,258 (4.3)	2,336 (2.5)	202 (0.3)
Area and Proximity to Hospital				
Metro & Far**	37,897 (18.4)	10,248 (19.6)	17,928 (19.0)	9,721 (16.6)
Non-Metro & Far	24,444 (11.9)	5,806 (11.1)	11,784 (12.5)	6,854 (11.7)
Metro & Close	135,459 (65.9)	34,386 (65.6)	61,210 (64.7)	39,863 (67.9)
Non-Metro & Close	7,865 (3.8)	1,943 (3.7)	3,623 (3.8)	2,299 (3.9)
Area Based Income Category†				
$63,000 +	84,543 (41.1)	22,292 (42.6)	39,549 (41.8)	22,702 (38.7)
$48,000 - $62,999	56,695 (27.6)	14,395 (27.5)	25,849 (27.3)	16,451 (28.0)
$38,000 - $47,999	42,016 (20.4)	10,219 (19.5)	19,111 (20.2)	12,686 (21.6)
<$38,000	22,411 (10.9)	5,477 (10.5)	10,036 (10.6)	6,898 (11.7)
Percent of Residents without HS Degree†				
<7.0%	69,622 (33.9)	18,035 (34.4)	32,370 (34.2)	19,217 (32.7)
7.0-12.9%	72,125 (35.1)	18,207 (34.8)	33,022 (34.9)	20,896 (35.6)
13-20%	43,875 (21.3)	11,114 (21.2)	20,035 (21.2)	12,726 (21.7)
≥21%	20,043 (9.8)	5,027 (9.6)	9,118 (9.6)	5,898 (10.0)
Comorbidities (Charlson-Deyo Score)				
0	178,289 (86.7)	49,596 (94.7)	81,955 (86.7)	46,738 (79.6)
1	22,772 (11.1)	2,531 (4.8)	10,697 (11.3)	9,544 (16.25)
2	4,604 (2.2)	256 (0.5)	1,893 (2.0)	2,455 (4.18)
Facility Location††				
Northeast	39,997 (19.5)	6,042 (11.5)	20,481 (21.7)	13,474 (22.9)
Midwest	47,256 (23.0)	8,060 (15.4)	24,801 (26.2)	14,395 (24.5)
South	62,778 (30.5)	9,371 (17.9)	32,414 (34.3)	20,993 (35.7)
West	31,413 (15.3)	4,689 (9.0)	16,849 (17.8)	9,875 (16.8)
Missing	24,221 (11.8)	24,221 (46.2)	0	0
Facility Type				
Academic/Research Program	88,703 (43.1)	14,354 (27.4)	47,292 (50.0)	27,057 (46.1)
Community Cancer Program	10,179 (5.0)	1,544 (3.0)	5,138 (5.4)	3,497 (6.0)
Comprehensive Community Cancer Program	64,523 (31.4)	9,323 (17.8)	32,789 (34.7)	22,411 (38.2)
Integrated Network Cancer Program	18,039 (8.8)	2,941 (5.6)	9,326 (9.9)	5,772 (9.8)
Missing	24,221 (11.8)	24,221 (46.2)	0	0
Stage				
1	134,373 (65.3)	37,403 (71.4)	63,282 (66.9)	33,688 (57.4)
2	43,017 (20.9)	6,935 (13.2)	18,309 (19.4)	17,773 (30.3)
3	28,275 (13.8)	8,045 (15.4)	12,954 (13.7)	7,276 (12.4)

Site				
Head and Neck	43,827 (21.3)	7,004 (13.4)	18,272 (19.3)	18,551 (31.6)
Upper Extremity and Shoulder	54,000 (26.3)	11,661 (22.3)	25,599 (27.1)	16,740 (28.5)
Lower Extremity and Hip	40,926 (19.9)	13,710 (26.2)	18,028 (19.1)	9,188 (15.6)
Trunk	66,912 (32.5)	20,008 (38.2)	32,646 (34.5)	14,258 (24.3)
Breslow Depth (mm)				
≤1.00	109,395 (53.2)	31,430 (60.0)	51,032 (54.0)	26,933 (45.9)
1.01-2.00	47,470 (23.1)	11,933 (22.8)	22,377 (23.7)	13,160 (22.4)
2.01-4.00	28,834 (14.0)	5,744 (11.0)	12,564 (13.3)	10,526 (17.9)
≥4.01	19,966 (9.7)	3,276 (6.3)	8,572 (9.1)	8,118 (13.8)
Year of Diagnosis				
2004-2006	39,066 (18.9)	12,274 (23.4)	16,611 (17.6)	10,181 (17.3)
2007-2009	44,779 (21.8)	12,680 (24.2)	20,136 (21.3)	11,963 (20.4)
2010-2012	54,594 (26.7)	13,151 (25.1)	25,487 (27.0)	15,956 (27.2)
2013-2015	67,226 (32.7)	14,278 (27.3)	32,311 (34.2)	20,637 (35.1)
Laterality				
Right	83,023 (40.4)	21,762 (41.5)	38,296 (40.5)	22,965 (39.1)
Left	88,492 (43.0)	22,961 (43.8)	40,770 (43.1)	24,761 (42.2)
Midline	14,162 (6.9)	3,877 (7.4)	6,702 (7.1)	3,583 (6.1)
Other‡	19,988 (9.7)	3,783 (7.2)	8,777 (9.3)	7,428 (12.7)
Histology				
Not Specified	91,274 (44.4)	23,871 (45.6)	41,638 (44.0)	25,765 (43.9)
Nodular	22,791 (11.1)	4,760 (9.1)	10,187 (10.8)	7,844 (13.4)
Amelanotic	449 (0.2)	54 (0.1)	214 (0.2)	181 (0.3)
Lentigo Maligna	10,265 (5.0)	509 (1.0)	4,531 (4.8)	5,225 (8.9)
Superficial Spreading	69,466 (33.8)	21,322 (40.7)	32,919 (34.8)	15,225 (25.9)
Acral Lentiginous	3,207 (1.6)	549 (1.1)	1,478 (1.6)	1,180 (2.0)
Desmoplastic	3,470 (1.7)	388 (0.7)	1,489 (1.6)	1,593 (2.7)
Other	4,743 (2.3)	930 (1.8)	2,089 (2.2)	1,724 (2.9)
Ulceration				
Absent	160,854 (78.2)	43,393 (82.8)	75,044 (79.4)	42,417 (72.2)
Present	39,361 (19.1)	7,474 (14.3)	17,084 (18.1)	14,803 (25.2)
Unknown or Missing	5,450 (2.7)	1,516 (2.9)	2,417 (2.6)	1,517 (2.6)
Mitoses				
Absent	41,677 (20.3)	9,919 (18.9)	20,279 (21.5)	11,479 (19.5)
Present	66,968 (32.6)	14,595 (27.9)	31,395 (33.2)	20,978 (35.7)
Unknown or Missing	97,020 (47.2)	27,869 (53.2)	42,871 (45.3)	26,280 (44.7)
Lymph Vascular Invasion				
Absent	94, 954 (46.2)	21,329 (40.7)	45,312 (47.9)	28,313 (48.2)
Present	5,405 (2.6)	1,058 (2.0)	2,429 (2.6)	1,918 (3.3)
Unknown or Missing	105,306 (51.2)	29,996 (57.3)	46,804 (49.5)	28,506 (48.5)

* Includes patients on Medicaid or Medicare without supplement, those with other government insurance, and the uninsured
** 'Far' defined as residence >25 miles from the nearest facility
† Based on ZIP code-level data
†† Northeast (CT, MA, ME, NH, RI, VT, NY, NJ, PA), South (DC, DE, FL, GA, MD, NC, SC, VA, WV, AL, KY, MS, TN, AR, LA, OK, TX), Midwest (IL, IN, MI, OH, WI, IA, KS, MN, MO, ND, NE, SD), West (AZ, CO, ID, MT, NM, NV, UT, WY, AK, CA, HI, OR, WA)
‡ Not Paired, Not Specified, or Bilateral

Table 2. Factors Associated with Interval between Diagnosis to Definitive Melanoma Surgery among Privately Insured Patients (n = 115,461)

Variables	Categories	Hazard Ratio	95% Confidence Interval		p-value
Age Category (years)	Under 50	Ref.			
	50 to 70	0.97	0.96	0.98	<.0001
	Over 70	0.85	0.82	0.87	<.0001
Sex	Male	Ref.			
	Female	1.01	1.00	1.03	0.0428
Race	White	Ref.			
	Non-White	0.89	0.84	0.95	0.0001
Area and Proximity to Hospital	Metro & Far*	Ref.			
	Non-Metro & Far*	1.11	1.08	1.13	<.0001
	Metro & Close	1.23	1.21	1.25	<.0001
	Non-Metro & Close	1.43	1.38	1.48	<.0001
Area Based Income Category**	$63,000 +	Ref.			
	$48,000-$62,999	1.09	1.07	1.10	<.0001
	$38,000-$47,999	1.10	1.08	1.13	<.0001
	<$38,000	1.10	1.07	1.13	<.0001
Percent of Residents without High School Degree**	<7%	Ref.			
	7.0-12.9%	0.90	0.89	0.92	<.0001
	13-20%	0.89	0.87	0.91	<.0001
	>=21%	0.90	0.88	0.93	<.0001
Comorbidities (Charlson-Deyo Score)	0	Ref.			
	1	0.96	0.94	0.99	0.0011
	2	0.91	0.86	0.97	0.0021
Stage	1	Ref.			
	2	0.96	0.94	0.98	<.0001
	3	0.89	0.87	0.91	<.0001
Site	Head and Neck	Ref.			
	Upper Extremity and Shoulder	1.27	1.24	1.30	<.0001
	Lower Extremity and Hip	1.24	1.22	1.27	<.0001
	Trunk	1.26	1.23	1.29	<.0001
Year	2004-2006	Ref.			
	2007-2009	0.96	0.94	0.98	<.0001
	2010-2012	1.01	0.98	1.05	0.5665
	2013-2015	1.00	0.96	1.04	0.9917

* 'Far' defined as residence >25 miles from the nearest facility
** Based on ZIP code-level data

Table 3. Factors Associated with Interval between Diagnosis to Definitive Melanoma Surgery among Patients without a Private Insurance† (n = 90,204)

Variables	Categories	Hazard Ratio	95% Confidence Interval		p-value
Age Category	Under 50	Ref.			
	50 to 70	1.09	1.06	1.12	<.0001
	Over 70	1.08	1.05	1.11	<.0001
Sex	Male	Ref.			
	Female	0.97	0.96	0.99	0.0004
Race	White	Ref.			
	Non-White	0.81	0.76	0.87	<.0001
Area and Proximity to Hospital	Metro & Far*	Ref.			
	Non-Metro & Far*	1.11	1.08	1.14	<.0001
	Metro & Close	1.20	1.18	1.22	<.0001
	Non-Metro & Close	1.33	1.28	1.38	<.0001
Area Based Income Category**	$63,000 +	Ref.			
	$48,000-$62,999	1.09	1.07	1.11	<.0001
	$38,000-$47,999	1.11	1.08	1.13	<.0001
	<$38,000	1.09	1.06	1.12	<.0001
Percent of Residents without High School Degree**	<7%	Ref.			
	7.0-12.9%	0.89	0.87	0.91	<.0001
	13-20%	0.86	0.84	0.88	<.0001
	>=21%	0.87	0.85	0.90	<.0001
Comorbidities (Charlson-Deyo Score)	0	Ref.			
	1	0.97	0.95	0.99	0.0004
	2	0.90	0.87	0.94	<.0001
Stage	1	Ref.			
	2	0.91	0.90	0.93	<.0001
	3	0.84	0.82	0.86	<.0001
Site	Head and Neck	Ref.			
	Upper Extremity and Shoulder	1.28	1.26	1.31	<.0001
	Lower Extremity and Hip	1.22	1.19	1.25	<.0001
	Trunk	1.26	1.23	1.29	<.0001
Year	2004-2006	Ref.			
	2007-2009	0.94	0.91	0.96	<.0001
	2010-2012	0.98	0.94	1.02	0.3097
	2013-2015	0.96	0.92	1.00	0.0276

† Includes patients on Medicaid or Medicare without supplement, those with other government insurance, and the uninsured
* 'Far' defined as residence >25 miles from the nearest facility
** Based on ZIP code-level data

Supplemental Table 1. Factors Associated with Interval between Diagnosis to Definitive Melanoma Surgery among Privately Insured Patients 40 Years and Older (n = 94,429)

Variables	Categories	Hazard Ratio	95% Confidence Interval		p-value
Age Category (years)	Under 50	Ref.			
	50 to 70	0.97	0.95	0.98	<.0001
	Over 70	0.86	0.83	0.88	<.0001
Sex	Male	Ref.			
	Female	1.01	1.00	1.03	0.0777
Race	White	Ref.			
	Non-White	0.92	0.86	0.98	0.0097
Area and Proximity to Hospital	Metro & Far*	Ref.			
	Non-Metro & Far*	1.08	1.06	1.11	<.0001
	Metro & Close	1.16	1.14	1.18	<.0001
	Non-Metro & Close	1.25	1.20	1.30	<.0001
Area Based Income Category**	$63,000 +	Ref.			
	$48,000-$62,999	1.04	1.02	1.06	<.0001
	$38,000-$47,999	1.03	1.00	1.05	0.0357
	<$38,000	1.01	0.98	1.05	0.4311
Percent of Residents without High School Degree**	<7%	Ref.			
	7.0-12.9%	0.91	0.89	0.92	<.0001
	13-20%	0.88	0.86	0.90	<.0001
	>=21%	0.90	0.87	0.93	<.0001
Comorbidities (Charlson-Deyo Score)	0	Ref.			
	1	0.94	0.92	0.97	<.0001
	2	0.89	0.84	0.94	0.0001
Stage	1	Ref.			
	2	0.96	0.94	0.98	0.0001
	3	0.89	0.87	0.91	<.0001
Site	Head and Neck	Ref.			
	Upper Extremity and Shoulder	1.26	1.23	1.30	<.0001
	Lower Extremity and Hip	1.24	1.20	1.27	<.0001
	Trunk	1.25	1.22	1.28	<.0001
Year	2004-2006	Ref.			
	2007-2009	0.95	0.93	0.97	<.0001
	2010-2012	0.99	0.95	1.03	0.5258
	2013-2015	0.98	0.94	1.02	0.2427
Location††	Northeast	Ref.			
	Midwest	1.28	1.25	1.30	<.0001
	South	1.26	1.24	1.29	<.0001
	West	1.08	1.06	1.11	<.0001
Facility Type	Academic/Research Program	Ref.			
	Community Cancer Program	1.24	1.20	1.28	<.0001
	Comprehensive Community Cancer Program	1.26	1.24	1.28	<.0001
	Integrated Network Cancer Program	1.05	1.02	1.07	0.0002

* 'Far' defined as residence >25 miles from the nearest facility

** Based on ZIP code-level data

†† Northeast (CT, MA, ME, NH, RI, VT, NY, NJ, PA), South (DC, DE, FL, GA, MD, NC, SC, VA, WV, AL, KY, MS, TN, AR, LA, OK, TX), Midwest (IL, IN, MI, OH, WI, IA, KS, MN, MO, ND, NE, SD), West (AZ, CO, ID, MT, NM, NV, UT, WY, AK, CA, HI, OR, WA)

Supplemental Table 2. Factors Associated with Interval between Diagnosis to Definitive Melanoma Surgery among Patients without a Private Insurance 40 Years and Older[†] (n = 87,015)

Variables	Categories	Hazard Ratio	95% Confidence Interval		p-value
Age Category	Under 50	Ref.			
	50 to 70	1.10	1.06	1.15	<.0001
	Over 70	1.09	1.05	1.13	<.0001
Sex	Male	Ref.			
	Female	0.98	0.96	0.99	0.0030
Race	White	Ref.			
	Non-White	0.83	0.78	0.89	<.0001
Area and Proximity to Hospital	Metro & Far*	Ref.			
	Non-Metro & Far*	1.08	1.06	1.11	<.0001
	Metro & Close	1.13	1.11	1.15	<.0001
	Non-Metro & Close	1.17	1.12	1.21	<.0001
Area Based Income Category**	$63,000 +	Ref.			
	$48,000-$62,999	1.04	1.02	1.06	0.0002
	$38,000-$47,999	1.02	1.00	1.05	0.0691
	<$38,000	0.99	0.96	1.02	0.5524
Percent of Residents without High School Degree**	<7%	Ref.			
	7.0-12.9%	0.89	0.88	0.91	<.0001
	13-20%	0.85	0.83	0.87	<.0001
	>=21%	0.87	0.84	0.90	<.0001
Comorbidities (Charlson-Deyo Score)	0	Ref.			
	1	0.95	0.93	0.97	<.0001
	2	0.88	0.85	0.91	<.0001
Stage	1	Ref.			
	2	0.91	0.89	0.93	<.0001
	3	0.84	0.82	0.86	<.0001
Site	Head and Neck	Ref.			
	Upper Extremity and Shoulder	1.26	1.24	1.29	<.0001
	Lower Extremity and Hip	1.22	1.19	1.25	<.0001
	Trunk	1.25	1.22	1.28	<.0001
Year	2004-2006	Ref.			
	2007-2009	0.93	0.91	0.95	<.0001
	2010-2012	0.96	0.92	1.00	0.0445
	2013-2015	0.93	0.90	0.97	0.0010
Location[††]	Northeast	Ref.			
	Midwest	1.21	1.18	1.23	<.0001
	South	1.28	1.25	1.31	<.0001
	West	1.08	1.05	1.10	<.0001
Facility Type	Academic/Research Program	Ref.			
	Community Cancer Program	1.24	1.20	1.27	<.0001
	Comprehensive Community Cancer Program	1.26	1.24	1.28	<.0001
	Integrated Network Cancer Program	1.07	1.05	1.10	<.0001

[†] Includes patients on Medicaid or Medicare without supplement, those with other government insurance, and the uninsured

* 'Far' defined as residence >25 miles from the nearest facility

** Based on ZIP code-level data

[††] Northeast (CT, MA, ME, NH, RI, VT, NY, NJ, PA), South (DC, DE, FL, GA, MD, NC, SC, VA, WV, AL, KY, MS, TN, AR, LA, OK, TX), Midwest (IL, IN, MI, OH, WI, IA, KS, MN, MO, ND, NE, SD), West (AZ, CO, ID, MT, NM, NV, UT, WY, AK, CA, HI, OR, WA)