Melanoma screening using patient self-assessed risk and total body photography

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Abstract

The current standard of care for high-risk melanoma patients is a two-step process using Total Body Photography (TBP) followed by dermoscopy and is limited to a select group of patients. A cross-sectional study of patient characteristics and self-reported melanoma risk factors associated with TBP usage and pathology-confirmed outcomes was conducted on a sample of 4,692 patients in a single practitioner private dermatology setting. TBP patients were significantly more likely to be male, partnered, tobacco users, highly educated, and have increased self-reported risk factors (such as fair skin, personal history of skin cancer or melanoma, family history of skin cancer, numerous moles, or previous history of sunburn, $P<0.05$). Personal history of skin cancer and melanoma, male gender, ≥40 moles, Medicare insurance, and increasing age were positively associated with malignancy outcomes, whereas higher education, family history of melanoma, and traditional (private) insurance were associated with reduced prevalence of malignant lesions. Patients' self-assessed skin cancer risk and access to skin detection modalities can result in detection of melanoma at early, curable stages. Higher level of education and partner status may result in a greater awareness of risk factors associated with melanoma.

Keywords: melanoma screening, skin cancer screening, self-assessment of skin cancer risk, total body photography, skin cancer in minorities

Introduction

The search for a comprehensive, efficient, and cost-effective method to reduce the persistent increase in melanoma incidence continues. Increased public awareness and improvements in screening techniques have the potential to address the skin cancer needs of our increasingly diverse population.

Studies suggest a marked rise in the rate of skin cancer among darker-skinned populations in California, New Mexico, Texas, Arizona, Nevada, Georgia, New York, and Florida [1]. The US population is predicted to be 50% people of color (black, Hispanic, and Asian American) by the year 2050 [2]. Studies consistently show that people of color, compared to whites, are more likely to die from this curable disease [3]. A recent epidemiological review published by the *American Academy of Dermatology* showed that the 5-year survival rate for the non-white population is 70%, which is significantly lower than that of whites (92%), [4–6]. Studies reveal that people of color receive little or no education from their doctors concerning the risks and prevention of the disease [7]. Furthermore, people of color often assume that darker skin is fully protected from the sun's harmful rays, a misconception that contributes to skin cancer detection at advanced and potentially fatal stages [8, 9].

Self-assessment of melanoma risk

Primary prevention efforts have focused on behaviors associated with UV exposure, but have not translated into improvements in patient knowledge [10]. Targeted screening of high-risk individuals, compared to mass population screening, is believed to be more feasible, while minimizing cost, the number of false positives, unnecessary procedures, and patient anxiety [11]. Studies suggest that

patients most commonly detect their own lesions, either incidentally or during a deliberate skin self-examination (SSE), [12]. The potential to increase knowledge and modify behavior using a scored, electronic self-assessment tool has been demonstrated recently using the Williams model [13].

Total body photography (TBP) followed by dermatoscopy is a two-step process limited to a select group of patients, often only those with a history of melanoma. TBP sessions are usually repeated after several years and images are compared with lesions of concern on the patient's body. However, automated TBP using a simultaneous capture camera array and enhanced by serial dermoscopy efficiently provides sequential standardized images, which can be used to detect new and changed lesions as well as focal changes using follow-up dermoscopy, yielding an enriched population of small, early stage melanomas [14].

This study describes the demographic and self-assessed risk factors, utilization of a semi-automated TBP system, and histopathological outcomes of patients seen in a general dermatology practice. This process has the potential to accommodate a broader segment of the population in awareness and earlier detection of skin cancer.

Methods

This cross-sectional study describes data extracted from a proprietary electronic health record and image capture database of all patients over the age of 18 who came to a single-practitioner general dermatology practice between January 1, 2016 and July 1, 2017. All patients routinely complete electronic health records, including risk assessment for skin cancer, at the first visit. Health records are updated at subsequent visits by the clinical staff.

Development and numerical weighting of responses to questions were based on a review of the melanoma risk factor literature (**Table 1**), [15]. Scores ranged from 0 to 36 (categories were defined as follows: low risk, 0-9; medium risk, 10-19; and high risk, 20-36). Those with medium or high risk were encouraged to consider baseline TBP. Qualification for CPT code 96904 (personal or family history of melanoma and dysplastic nevi) reimbursement was determined for each patient by clinical staff. In cases where qualifications for CPT 96904 were met but insurance companies did not reimburse, patients were encouraged to pay $120.00. Insurance information was available as either private (traditional) or Medicare. The two-step process of time-lapse TBP followed by dermoscopy has

Table 1. *Risk factor score distribution.*

Variable	Categories	Score
Education	None	0
	Elementary	1
	College	2
	Grad School	3
Hair Color	Black	0
	Brown	1
	Blonde	2
	Red	3
Eye Color	Brown	0
	Green/Hazel	1
	Blue/Grey	2
Fitzpatrick Skin type	VI	0
	V	1
	IV	2
	III	3
	II	4
	I	5
Self-History Skin Cancer	No	0
	Yes	3
Self-History Melanoma	No	0
	Yes	5
Family History Skin Cancer	No	0
	Yes	1
Family History Melanoma	No	0
	Yes	2
Moles (> 3 mm)	None	0
	Less than 20	1
	20 to 29	2
	30 to 39	3
	40 to 49	4
	50 or more	5
Moles (> 6 mm)	None	0
	1 to 5	1
	6 to 9	2
	10 or more	3
Sunburns (> 5 years)	No	0
	Yes	1
Sunburns (<5 years)	Never	0
	Sometimes	1
	Frequently	2

Table 2. *Total demographic variables, stratified by total body photography scans.*

Demographics	Total	n = 4692	TBP[a] (n = 2,473)		p^a	OR (95% CI)	p^b
Variable	Categories	n (%)	No TBP n (%)	TBP n (%)			
Gender	Female Male ***Missing***	2417 (51.9) 2242 (48.1) ***33***	1182 (53.7) 1020 (46.3)	1235 (50.3) 1222 (49.7)	**0.02**	ref 1.15 (1.02, 1.29)	-- **0.02**
Age	Med[c] (+/-iqr[d])	54 (29)	50 (32)	56 (24)	**<0.01**	1.02 (1.01, 1.02)	**<0.01**
Number of Scans	Med[c] (+/-iqr[d])	0 (0)	0 (0)	3 (5)	--	--	--
Tobacco use	No Yes	3,779 (80.5) 913 (19.5)	1,835 (82.7) 384 (17.3)	1,944 (78.61) 529 (21.39)	**<0.01**	ref 1.30 (1.12, 1.50)	-- **<0.01**
Education	None Elementary Highschool College Graduate ***Missing***	66 (1.4) 149 (3.3) 915 (20.1) 2069 (45.4) 1356 (29.8) ***137***	59 (2.8) 114 (5.3) 579 (27.2) 895 (42.1) 480 (22.6)	7 (0.3) 35 (1.4) 336 (13.8) 1174 48.3) 876 (36.2)	**<0.01**	ref 0.39 (0.16, 0.92) 1.89 (1.26, 2.82) 4.27 (2.90, 6.30) 5.94 (4.00, 8.21)	-- **0.03** **<0.01** **<0.01** **<0.01**
Education (stratified)[e]	Below College College Graduate ***Missing***	1130 (24.8) 2069 (45.4) 1356 (29.8) ***137***	752 (35.4) 895 (42.1) 480 (22.5)	378 (15.6) 1174 (48.3) 876 (36.1)	**<0.01**	ref 2.39 (1.66, 3.43) 6.14 (4.35, 8.66)	 **<0.01** **<0.01**
Marital Status	No Partner Partner	2034 (43.4) 2658 (56.6)	1207 (54.4) 1012 (45.6)	827 (33.4) 1646 (66.6)	**<0.01**	ref 2.37 (2.10, 2.67)	-- **<0.01**
Insurance (private)	No Yes	970 (20.7) 3722 (79.3)	433 (19.5) 1786 (80.5)	537 (21.7) 1936 (78.3)	0.06	ref 0.87 (0.76, 1.01)	-- 0.06
Insurance (Medicare)	No Yes	3618 (77.1) 1074 (22.9)	1749 (78.8) 470 (21.2)	1869 (75.6) 604 (24.4)	**<0.01**	ref 1.20 (1.05, 1.38)	**<0.01**

[a] P-value: 0.05 Wilcoxon Rank-Sum (continuous), Chi-square statistic (categorical); Significant p-values appear in bold text.
[b] P-value: 0.05 Odds Ratios; Significant p-values appear in bold text.
[c] Median.
[d] Interquartile Range.
[e] Stratified for biopsy group comparisons.

routinely been used in this practice since 2002. As has been described previously [15–18], automation of TBP is achieved by simultaneous image capture using an array of 25 cameras housed in a phototherapy booth of choreographed patient poses. Computer assisted comparison of time-lapse images exposes new and changed lesions, which are then photographed dermoscopically. TBP frequency was assessed in terms of years of TBP and number of TBP sessions. Histopathological biopsy outcomes of pigmented lesions were extracted from the electronic health record and the TBP database.

Statistical analyses were performed using STATA, StataCorp (2015) statistical software, release 14, College Station, TX, and continuous variables were assessed for normality prior to testing. A P value of 0.05 was used for statistical significance.

Results

Of 4,692 patients, 51.9% were female, with a median age 54 and an interquartile range of 29. 2,473 (52.7%) had TBP at least once during the study period. The median number of scans for the scan group was three with an interquartile range of 5 (**Table 2**). Those in the TBP group were more likely to be male, older, have a history of tobacco use, have more education, and have a partner, P<0.05 (**Table 2**). Those with Medicare insurance were 1.2 times as likely to have TBP (95% CI: 1.05, 1.38), but this effect disappeared after adjusting for age.

In our cohort, 63.1% of patients were designated at medium or high risk and 84.7% of those underwent TBP at least once. Only 1.4% of those that did not have TBP were defined as high risk (Table 3).

Patients who underwent TBP were more likely to have increased self-reported risk factors (personal and family history of melanoma, light eyes, hair and skin, numerous moles, and previous history of sunburn) than patients who did not undergo TBP (Table 3). Furthermore, 218 (4.6%) patients, scanned at least once, underwent 268 biopsies for pigmented lesions, averaging 1.23 biopsies per person and 65 (30%) of the 218 had at least one malignant lesion. An analysis of the most serious lesion category revealed that 39 (60%) were melanoma in situ (MIS) and 26 (40%) were invasive (INV). The number needed to excise (NNE) for all 268 lesions was 3.1, and the MIS:INV ratio was 1.56:1[14]. Personal history of skin cancer and melanoma, male gender, having 40 or more moles, having Medicare insurance, and increasing age were positively associated with malignancy outcomes, whereas higher education and private insurance were associated with a reduced prevalence of malignant lesions (Tables 4, 5).

Of the patient population, approximately 45% were self-defined as Fitzpatrick type IV - VI (skin color before sun exposure): olive or light brown, dark brown, or deeply pigmented dark brown to darkest brown. Of these, 1,289 (63%) were in the low risk group, but 758 (37.0%) were self- defined as medium or high risk. Of those who self-defined as Fitzpatrick IV – VI, 9% reported a personal history of skin cancer and 4% reported a personal history of melanoma. In addition, 18% reported a family history of skin cancer and 9% reported a family history of melanoma.

Discussion

The United States Preventative Task Force (USPTF) states that there is insufficient evidence to support mass screening [19] for melanoma and efforts to identify those at high risk are limited to the population from which the models are constructed [4]. Even if patients do realize they are at risk, increasing disparities in the geographic distribution of dermatologists presents access barriers [20]. Furthermore, the medical community is aware of the need to address knowledge gaps in skin cancer awareness and skin cancer surveillance by primary care physicians and other healthcare providers who are more likely to encounter a broader segment of the population [21].

Strengths of this study include the high rate of compliance from a defined patient population, practical application of self-assessed skin cancer risk, access to time-lapse TBP and dermoscopy, and high yield of early melanoma while minimizing unnecessary biopsies. An NNE of 3.1 compares favorably with reports of 20 to 40 for general practitioners at non-specialized clinics, 19–28 for general practitioners at skin cancer clinics, and as low as four for dermatologists at specialized clinics [22, 23]. The majority of patients who underwent TBP were those who had increased self-reported risk factors, suggesting that patients can self-assess risk. We speculate that this influenced their decisions to seek care, ultimately guiding them to a screening process in which time-lapse image comparison supports melanoma detection efficiently and effectively, as evidenced by the high MIS:INV (1.56:1) ratio compared to the estimation for 2018 (87,290 MIS:91,270 INV), [24].

Even patients who have insurance that does not accept CPT code 96904 with criteria of self or family history of melanoma or more than four dysplastic nevi are willing to take measures to monitor skin cancer if they consider themselves to be at risk. By removing cost and logistic barriers, patients are motivated to take preventive measures and at least obtain baseline TBP to use at a future point in time.

Skin cancer risk has been traditionally focused on people with lighter skin (Fitzpatrick types I & II), missing risk factors unique to different distributions of skin cancer outcomes observed in those with darker skin tones. Our results suggest that routine self-assessed risk for skin cancer can raise awareness about risk factors that would not necessarily be of concern in patients with darker skin. Self-reported skin color is influenced by psychological, cultural, societal, and biological factors that complicate skin cancer risk determination. These results underscore the importance of modifying skin cancer awareness messages and risk assessment tools to be more comprehensive.

The observation that patients who consider themselves to be partnered (live with someone or married) are more likely to opt for TBP suggests that these patients may have been motivated to seek professional care by others and were receptive to using supportive technology to monitor their skin. However, we didn't determine if the initial reason for visiting the dermatologist was motivated by a partner. Although an association between marriage status and skin cancer detection has been reported [25], we did not see an association between partner status and malignancy among those who underwent TBP. One explanation for this outcome may be that once patients undergo TBP, they are less apt to rely on others to monitor their skin. Alternatively, sample size may have been a limitation.

In terms of education, we found a direct positive increase in the odds of TBP use with level of education. We also found that education is a protective factor for malignancy outcome. We were surprised to find that 66 (1.5%) of the total population reported "none" for education, which may relate to the sensitive nature of the question. We included the education variable because of studies suggesting a possible association between higher education as a surrogate for higher socioeconomic status and intermittent exposure to low latitude UV exposure [26]. The protective effect of higher education on malignancy outcome may relate to more rigorous attention to prevention and monitoring in those with higher education and better access to healthcare.

Limitations include a lack of generalizability of the study population as well as the use of a risk factor questionnaire that was neither derived from a statistical model nor validated. Additional limitations relate to the nature of the cross-sectional design. The complexity and heterogeneity of melanoma subtypes along with their associated appearances and growth characteristics make it difficult to accurately assess outcomes in the limited time frame given in this study.

Conclusion

Although the results of this study are of limited generalizability, the process by which patients self-assess risk and have access to automated time-lapse TBP followed by dermoscopy offers a low cost and efficient process for managing the persistent increase in melanoma incidence. Ensuring access to automated time-lapse TBP followed by dermoscopy and including risk factors specific to people of color (i.e. lesions on the palms, soles, fingernails, and toenails, along with the inner surface of the mouth and genitals [8]) in a self-assessed risk tool has the potential to decrease access barriers and accommodate screening for a greater proportion of the population.

Potential conflicts of interest

Rhett Drugge MD, is the inventor and holder of the intellectual property rights (US patent 7,359,748) of the Melanoscan system. Dr. E. Drugge is a first-degree relative of Dr. R. Drugge. The other authors have no conflicts of interest to declare.

References

1. Gupta AK, Bharadwaj M, Mehrotra R. Skin Cancer Concerns in People of Color: Risk Factors and Prevention. *Asian Pac J Cancer Prev*. 2016;17:5257–5264. [PMID: 28125871].
2. Gloster HM Jr, Neal K. Skin cancer in skin of color. *J Am Acad Dermatol*. 2006;55:741–60. [PMID: 17052479]
3. Merrill SJ, Subramanian M, Godar DE. Worldwide cutaneous malignant melanoma incidences analyzed by sex, age, and skin type over time (1955-2007): Is HPV infection of androgenic hair follicular melanocytes a risk factor for developing melanoma exclusively in people of European-ancestry? *Dermatoendocrinol*. 2016;8:e1215391. [PMID: 27588159].
4. Wu X-C, Eide MJ, King J, Saraiya M, Huang Y, Wiggins C, et al. Racial and ethnic variations in incidence and survival of cutaneous melanoma in the United States, 1999-2006. *J Am Acad Dermatol. 2011;65:S26–37*. [PMID: 22018064].
5. Gohara MA. Skin cancer in skins of color. J Drugs Dermatol. 2008;7:441–445. [PMID: 18505135].
6. Battie C, Gohara M, Verschoore M, Roberts W. Skin cancer in skin of color: an update on current facts, trends, and misconceptions. *J Drugs Dermatol*. 2013;12:194–198. [PMID: 23377393].
7. Kim M, Boone SL, West DP, Rademaker AW, Liu D, Kundu RV. Perception of skin cancer risk by those with ethnic skin. *Arch Dermatol*. 2009;145:207–208. [PMID: 19221276].
8. Madankumar R, Gumaste PV, Martires K, Schaffer PR, Choudhary S, Falto-Aizpurua L,Arora H, Kallis PJ, Patel S, Damanpour S, Sanchez MI, Yin N, Chan A, Sanchez M, Polsky D, Kanavy H,

Grichnik JM, Stein JA. Acral melanocytic lesions in the United States: Prevalence, awareness, and dermoscopic patterns in skin-of-color and non-Hispanic white patients. *J Am Acad Dermatol.* 2016;74: 724–30. e1. [PMID: 26803347].

9. Jacobsen AA, Galvan A, Lachapelle CC, Wohl CB, Kirsner RS, Strasswimmer J. Defining the Need for Skin Cancer Prevention Education in Uninsured, Minority, and Immigrant Communities. *JAMA Dermatol.* 2016;152(12):1342–1347. [PMID: 27626892].
10. Levin AA, Nguyen BM. Knowledge of melanoma and non-melanoma skin cancer among general dermatology patients. *J Am Acad Dermatol.* 2018;79:964-966. [PMID: 29753063].
11. Williams LH, Shors AR, Barlow WE, Solomon C, White E. Identifying Persons at Highest Risk of Melanoma Using Self-Assessed Risk Factors. *J Clin Exp Dermatol Res*. 2011; 2.pii: 1000129. [PMID: 22229112].
12. Hamidi R, Peng D, Cockburn M. Efficacy of skin self-examination for the early detection of melanoma. *Int J Dermatol.* 2010;49:126–134. [PMID: 29465635].
13. Usher-Smith JA, Kassianos AP, Emery JD, Abel GA, Teoh Z, Hall S, et al. Identifying people at higher risk of melanoma across the U.K.: a primary-care-based electronic survey. *Br J Dermatol.* 2017;176:939–948. [PMID: 28009060].
14. Drugge ED, Volpicelli ER, Sarac RM, Strang SR, Elston DM, Drugge RJ. Micromelanomas identified with time-lapse total body photography and dermoscopy. *J Am Acad Dermatol.* 2018;78:182–183. [PMID: 29241777].
15. Drugge RJ, Naylor M. Society of Investigative Dermatology, poster presentation. 2006.
16. Drugge RJ, Nguyen C, Drugge ED, Gliga L, Broderick PA, McClain SA, Brown CC. Melanoma screening with serial whole body photographic change detection using Melanoscan technology. *Dermatol Online J.* 2009;15:1. [PMID: 19723476].
17. Drugge RJ, Nguyen C, Gliga L, Drugge ED. Clinical pathway for melanoma detection using comprehensive cutaneous analysis with Melanoscan. *Dermatol Online J.* 2010;16:1. [PMID: 20804678].
18. Rosendahl CO, Drugge ED, Volpicelli ER, Drugge RJ. Diagnosis of a Minute Melanoma Assisted by Automated Multi-Camera-Array Total Body Photography. *Australas J Dermatol.* 2016;57:242–243. [PMID: 27469484].
19. US Preventive Services Task Force, Bibbins-Domingo K, Grossman DC, Curry SJ, Davidson KW, Ebell M, Epling JW, Garcia FA, Gillman MW, Kemper AR, Krist AH, Kurth AE, Landefeld CS, Mangione CM, Phillips WR, Phipps MG, Pignone MP, Siu AL. Screening for Skin Cancer: US Preventive Services Task Force Recommendation Statement. *JAMA.* 2016;316:429–435. [PMID: 27458948].
20. Feng H, Berk-Krauss J, Feng PW, Stein JA. Comparison of Dermatologist Density Between Urban and Rural Counties in the United States. *JAMA Dermatol.* 2018;154:1265-1271. [PMID: 30193349]
21. Eide MJ, Asgari MM, Fletcher SW, Geller AC, Halpern AC, Shaikh WR, Alexander GL, Altschuler A, Dusza SW, Marghoob AA, Quigley EA, Weinstock MA, INFORMED (Internet course FOR Melanoma Early Detection) Group. Effects on skills and practice from a web-based skin cancer course for primary care providers. *J Am Board Fam Med.* 2013;26:648–657. [PMID: 24204061].
22. Carli P, De Giorgi V, Crocetti E, Mannone F, Massi D, Chiarugi A. Improvement of malignant/benign ratio in excised melanocytic lesions in the "dermoscopy era": a retrospective study 1997-2001. *Br J Dermatol*. 2004;150:687–692. [PMID: 15099362].
23. Hansen C, Wilkinson D, Hansen M, Argenziano G. How good are skin cancer clinics at melanoma detection? Number needed to treat variability across a national clinic group in Australia. *J Am Acad Dermatol.* 2009;61:599–604. [PMID: 19664848].
24. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2018. *CA Cancer J Clin.* 2018;68:7–30. [PMID: 29313949].
25. Sharon CE, Sinnamon, AJ, Ming, ME, Chu EY, Fraker DL, Karakousis GC. Association of Marital Status With T Stage at Presentation and Management of Early-Stage Melanoma. *JAMA Dermatol.* 2018;154:574-580. [PMID: 29710174].
26. Singh SD, Ajani UA, Johnson CJ, Roland KB, Eide M, Jemal A, Negoita S, Bayakly RA, Ekwueme DU. Association of cutaneous melanoma incidence with area-based socioeconomic indicators-United States, 2004–2006. *J Am Acad Dermatol.* 2011;65(5 Suppl 1):S58–68. [PMID: 22018068].

Table 3. *Total self-reported melanoma risk factors stratified by total body photographs scans.*

Self-reported Melanoma Risk Factors	Total	n = 4692	TBP[a] (n = 2,473)		*P*	OR (95% CI)	*P*[d]
Variables	Categories	n[b] (%)	No TBP n (%)	TBP n (%)			
Risk Score Total	Med[d] (+/-iqr[e])	11 (7)	8 (5)	14 (7)	**<0.01**	1.30 (1.28, 1.32)	**<0.01**
Risk Level	Low Moderate High	1722 (36.7) 2561 (54.6) 409 (8.7)	1343 (60.5) 845 (38.1) 31 (1.4)	379 (15.3) 1716 (69.4) 378 (15.3)	**<0.01**	ref 7.20 (6.25, 8.28) 43.21 (29.44, 63.40)	-- **<0.01** **<0.01**
Hair Color	Black Brown Blonde Red ***Missing***	801 (17.9) 2749 (61.3) 818 (18.2) 116 (2.6) ***208***	629 (30.2) 1172 (56.2) 261 (12.5) 22 (1.1)	172 (7.2) 1577 (65.7) 557 (23.2) 94 (3.9)	**<0.01**	ref 4.92 (4.09, 5.92) 7.80 (6.24, 9.76) 15.63 (9.54, 25.60)	-- **<0.01** **<0.01** **<0.01**
Eye Color	Brown Green/Hazel Blue/Grey ***Missing***	2118 (46.8) 1098 (24.2) 1314 (29.0) ***162***	1320 (62.2) 415 (19.5) 388 (18.3)	798 (33.1) 683 (28.4) 926 (38.5)	**<0.01**	ref 2.72 (2.34, 3.16) 3.95 (3.41, 4.58)	-- **<0.01** **<0.01**
Skin-type[e]	VI V IV III II I ***Missing***	338 (7.4) 1181 (25.9) 528 (11.6) 1422 (31.24) 245 (5.4) 338 (7.2) ***140***	307 (14.5) 699 (32.9) 259 (12.2) 524 (24.7) 242 (11.4) 93 (4.4)	31 (1.3) 482 (19.9) 269 (11.1) 898 (37.0) 596 (24.6) 152 (6.3)	**<0.01**	ref 6.83 (4.64, 10.06) 10.29 (6.85, 15.45) 16.19 (10.31, 25.40) 24.39 (16.37, 36.33) 16.97 (11.55, 24.94)	-- **<0.01** **<0.01** **<0.01** **<0.01** **<0.01**
Self-History Skin Cancer	No Yes ***Missing***	3916 (86.0) 639 (14.0) ***137***	2052 (96.4) 77 (3.6)	1864 (76.8) 562 (23.2)	**<0.01**	ref 8.03 (6.28, 10.28)	-- **<0.01**
Self-History Melanoma	No Yes ***Missing***	4266 (93.9) 275 (6.1) ***151***	2105 (99.2) 16 (0.8)	2161 (89.3) 259 (10.7)	**<0.01**	ref 15.77 (9.48, 26.22)	-- **<0.01**
Family History Skin Cancer	No Yes ***Missing***	3263 (71.7) 1290 (28.3) ***139***	1835 (86.2) 293 (13.8)	1428 (58.9) 997 (41.1)	**<0.01**	ref 4.37 (3.77, 5.07)	-- **<0.01**
Family History of Melanoma	No Yes ***Missing***	3809 (84.9) 677 (15.1) ***206***	1990 (93.9) 130 (6.1)	1819 (76.9) 547 (23.1)	**<0.01**	ref 4.60 (3.76, 5.63)	-- **<0.01**
Moles (>3 mm)	None Less than 20 20 to 29 30 to 39 40 or more ***Missing***	1985 (43.8) 2071 (45.7) 258 (5.7) 105 (2.3) 28 (2.5) ***154***	1262 (59.6) 766 (36.2) 55 (2.6) 18 (0.9) 1 (0.7)	723 (29.9) 1305 (54.0) 203 (8.4) 87 (3.6) 27 (4.1)	**<0.01**	ref 2.97 (2.62, 3.38) 6.44 (4.72, 8.80) 8.44 (5.04, 14.13) 10.80 (6.32, 18.46)	-- **<0.01** **<0.01** **<0.01** **<0.01**
Moles (>6 mm)	None 1 to 5 6 to 9 10 or more ***Missing***	3161 (69.9) 1177 (26.0) 91 (2.0) 94 (2.1) ***169***	1694 (80.2) 376 (17.8) 18 (0.8) 25 (1.2)	1467 (60.9) 801 (33.2) 73 (3.0) 69 (2.9)	**<0.01**	ref 2.46 (2.14, 2.83) 4.68 (2.78, 7.88) 3.19 (2.01, 5.06)	-- **<0.01** **<0.01** **<0.01**
Sunburns (>5 years)	No Yes ***Missing***	3312 (72.9) 1234 (27.1) ***146***	1763 (83.0) 361 (17.0)	1549 (64.0) 873 (36.0)	**<0.01**	ref 2.75 (2.39, 3.17)	-- **<0.01**

Sunburns (<5 years)	Never Sometimes Frequently ***Missing***	1960 (43.1) 2458 (54.0) 132 (2.9) ***142***	1138 (53.6) 939 (44.2) 47 (2.2)	822 (33.9) 1519 (62.6) 85 (3.5)	**<0.01**	ref 2.24 (1.98, 2.53) 2.50 (1.73, 3.62)	-- **<0.01** **<0.01**

[a] Total Body Photography Screening: stratified by no scans vs 1 or more scan.
[b] n = frequency.
[c] P-value: 0.05 Wilcoxon Rank-Sum (continuous), Chi-square statistic (categorical); Significant P-values bolded.
[d] P-value: 0.05 Odds Ratio; Significant P-values bolded.
[e] Skin type: Skin tone and response to sun exposure, I least risk, IV most risk.

Table 4. *Total demographic variables, stratified biopsy results.*

Demographics	Total	Biopsy Results (n = 218)		P^A	OR (95% CI)	P^B
Variable	Categories	Benign n (%)	Malignant n (%)			
Gender	Female Male ***Missing***	75 (49.0) 78 (51.0)	18 (28.1) 46 (71.9)	**<0.01**	ref 2.46 (1.31, 4.62)	**<0.01**
Age	Med[c]. (+/-iqr[d])	49 (21)	59 (28)	**<0.01**	1.04 (1.02, 1.06)	**<0.01**
Number of Scans	Med[c]. (+/-iqr[d])	5 (5)	6 (5)	0.56	1.01 (0.92, 1.11)	0.86
Tobacco Use	No Yes	122 (79.7) 31 (20.3)	55 (84.6) 10 (15.4)	0.40	ref 0.72 (0.33, 1.56)	-- 0.62
Education	None Elementary Highschool College Graduate	-- 1 (0.7) 15 (10.0) 76 (51.0) 57 (38.3)	-- 1 (1.5) 15 (23.1) 31 (47.7) 18 (27.7)	0.06	--	--
Education (stratified)[d]	Below College College Graduate	16 (10.7) 76 (51.0) 57 (38.3)	16 (24.6) 31 (47.7) 18 (27.7)	**0.03**	ref 0.41 (0.18, 0.92) 0.32 (0.13, 0.76)	-- **0.03** **0.01**
Marital Status	No Partner Partner	55 (36.0) 98 (64.0)	18 (27.7) 47 (72.3)	0.24	ref 1.46 (0.78, 2.77)	-- 0.24
Insurance (private)	No Yes	18 (11.8) 135 (88.2)	15 (23.1) 50 (76.9)	**0.03**	ref 0.44 (0.21, 0.95)	-- **0.04**
Insurance (Medicare)	No Yes	133 (86.9) 20 (13.1)	44 (67.7) 21 (32.3)	**<0.01**	ref 3.17 (1.57, 6.40)	-- **<0.01**

[a] P-value: 0.05 Wilcoxon Rank-Sum (continuous), Chi-square statistic (categorical); Significant P-values appear in bold text.
[b] P-value: 0.05 Odds Ratios; Significant p-values appear in bold text.
[c] Median.
[d] Interquartile Range.
[e] Stratification adjustments for biopsy group comparisons.

Table 5. *Total self-reported melanoma risk factors stratified biopsy results*

Self-reported Melanoma Risk Factors	Total	Biopsy Results (n = 218)		P^C	OR (95% CI)	P^D
Variables	Categories	Benign n (%)	Malignant n (%)			
Risk Score Total	Med[d]. (+/-iqr[e])	14 (7)	17 (9)	**0.03**	1.07 (1.01, 1.12)	**0.02**
Risk Level	Low Moderate High	20 (13.1) 99 (64.7) 34 (22.2)	4 (6.1) 38 (58.5) 23 (35.4)	0.07	ref 1.92 (0.62, 5.98) 3.38 (1.02, 11.19)	-- 0.26 0.05
Hair Color	Black Brown Blonde Red	18 (12.2) 86 (58.1) 39 (26.3) 5 (3.4)	6 (9.7) 45 (72.6) 10 (16.1) 1 (1.6)	0.25	ref 1.57 (0.58, 4.23) 0.77 (0.24, 2.44) 0.60 (0.06, 6.21)	-- 0.37 0.66 0.67
Eye Color	Brown Green/Hazel Blue/Grey	50 (33.6) 47 (31.5) 52 (34.9)	21 (33.3) 15 (23.8) 27 (42.9)	0.44	ref 0.76 (0.35, 1.65) 1.24 (0.62, 2.46)	-- 0.49 0.55
Skin-type[e]	VI V IV III II I	-- 24 (16.1) 19 (12.8) 67 (45.0) 32 (21.5) 7 (4.7)	-- 13 (20.0) 5 (7.7) 23 (35.5) 20 (30.8) 4 (6.1)	0.38	-- ref 0.49 (0.15, 1.60) 0.63 (0.28, 1.45) 1.15 (0.48, 2.77) 1.05 (0.26, 4.29)	-- -- 0.24 0.28 0.75 0.94
Self-History Skin Cancer	No Yes	111 (77.1) 33 (22.9)	36 (51.4) 34 (48.6)	**<0.01**	ref 2.59 (1.41, 4.79)	-- **<0.01**
Self-History Melanoma	No Yes	124 (86.1) 20 (13.9)	41 (59.4) 28 (40.6)	**<0.01**	ref 3.13 (1.60, 6.10)	-- **<0.01**
Family History Skin Cancer	No Yes	82 (56.9) 62 (43.1)	40 (58.0) 29 (42.0)	0.69	ref 0.88 (0.49, 1.60)	-- 0.69
Family History of Melanoma	No Yes	102 (72.3) 39 (27.7)	53 (77.9) 15 (22.1)	0.43	ref 0.76 (0.38, 1.52)	-- 0.43
Moles (>3 mm)	Less than 20 20 to 29 30 to 39 40 to 49 50 or more	32 (21.6) 84 (56.7) 21 (14.2) 7 (4.7) 4 (2.7)	9 (13.8) 32 (49.2) 9 (13.8) 7 (10.7) 8 (12.3)	**0.02**	ref 1.35 (0.58, 3.15) 1.52 (0.52, 4.47) 3.56 (0.98, 12.81) 7.11 (1.74, 29.12)	-- 0.48 0.44 0.05 **<0.01**
Moles (>6 mm)	None 1 to 5 6 to 9 10 or more	79 (53.4) 57 (38.5) 5 (3.4) 7 (4.7)	29 (44.6) 27 (41.5) 7 (10.8) 2 (3.1)	0.14	ref 1.29 (0.69, 2.41) 3.81 (1.12, 12.97) 0.78 (0.15, 3.96)	-- 0.42 **0.03** 0.76
Sunburns (>5 years)	No Yes	91 (63.1) 53 (36.8)	39 (55.7) 31 (44.3)	0.45	ref 1.26 (0.69, 2.27)	-- 0.45
Sunburns (<5 years)	Never Sometimes Frequently	34 (23.6) 107 (71.5) 7 (4.9)	21 (30.0) 44 (62.9) 5 (7.1)	0.31	ref 0.65 (0.34, 1.26) 1.25 (0.35, 4.46)	-- 0.21 0.73

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[d] P-value: 0.05 Odds Ratio; Significant P-values appear in bold text.
[e] Skin type: Skin tone and response to sun exposure, I least risk, IV most risk.