Identifying Latent Classes of Adults at Risk for Skin Cancer Based on Constitutional Risk and Sun Protection Behavior

Alana D. Steffen,[1] Karen Glanz,[2] and Lynne R. Wilkens[1]

[1]Cancer Research Center of Hawaii, University of Hawaii, Honolulu, Hawaii and [2]Rollins School of Public Health, Emory University, Atlanta, Georgia

Abstract

Objective: **This study used latent class analysis (LCA) to identify homogeneous subgroups of individuals at risk for skin cancer on the basis of their risk factors and sun protection habits to understand patterns of sun exposure and sun protection behaviors.**
Method: **Adults (*n* = 725), screened to be at risk for skin cancer, were recruited through primary care physicians and completed the mailed baseline survey as part of a skin cancer prevention trial. LCA was used to identify homogeneous subgroups, on the basis of skin cancer risk and usual sun habits, by sex. LCA solutions were then validated by assessing if class predicted differences in sun exposure, recent sunburn, outdoor activities, attitudes toward tanning, and demographics.**
Results: **Females and males were divided into four and three classes, respectively, that reflected the level of sun protection habits and showed that these habits were greater for those with higher constitutional risk for skin cancer. The classes seemed to represent a continuum of sun protection efforts rather than distinct patterns of protection behaviors. Females were distinguished on their use of all habits assessed whereas males, who reported less use of sun protection overall, only differed in their use of sunscreen. Females using more protection reported less sunburn whereas males using less protection reported less sunburn. However, all subgroups reported significant annual prevalence of sunburn (including mild) of 48% to 83%.**
Conclusion: **LCA can distinguish subgroups of at-risk adults that are relevant and valid. This technique is recommended for targeting intervention efforts when individual tailoring is not feasible.** (Cancer Epidemiol Biomarkers Prev 2007;16(7):1422–7)

Introduction

Skin cancer is the most commonly diagnosed cancer in the United States. In 2006, it is estimated that >1 million new cases of nonmelanoma skin cancers (basal cell 80%, squamous cell 20%) and ∼62,000 new cases of cutaneous malignant melanoma, the third most common and most fatal type of skin cancer, will be diagnosed (1-3). Exposure to UV radiation, UVB in particular, is associated with risk for these skin cancers, although the pattern of harmful exposure is complex and not fully understood. Cumulative UV exposure is associated with squamous cell carcinoma whereas childhood and intense intermittent (e.g., beach, recreational) exposure is associated with basal cell carcinoma and cutaneous malignant melanoma (4-7). It is not clear whether sunburn is an indicator for highly intermittent exposure or an independent risk factor for cutaneous malignant melanoma (5). It is believed that many of the skin cancer cases could be prevented by following recommendations to reduce UV radiation exposure through sun protection habits. These habits include limiting or avoiding sunlight during peak midday hours (10 a.m. -4 p.m.), and, when outside, covering up with long-sleeved shirts, long pants, hats that shade the face, neck, and ears, applying sunscreen with a sun protection factor ≥15, and wearing sunglasses to protect periocular skin and eyes (2, 8, 9).

Because individuals may differ with regard to their risk level and the types of sun protection habits they use, it behooves us to examine existing data to learn how individuals are currently exposed and protecting themselves in an effort to understand these patterns. Insights gained may help guide future interventions to target those most at risk for skin cancer. Whereas variable-centered approaches like factor analysis and regression are useful in describing relationships between variables and with outcomes, person-centered approaches such as cluster analysis and latent class analysis (LCA) make it possible to group individuals who are similar to each other and different from other groups (10, 11). These approaches are used in alcohol, drug, and mental health research where heterogeneity is evident within diagnostic groups as well as market research where the goal is to find subgroups of similar individuals to target for advertising and sales (12-14). In sun protection–related disease prevention research, person-centered approaches can be useful for identifying at-risk groups who have similar sun protection behaviors and, consequently, similar needs for educational information.

In this study, we examine data from a skin cancer prevention trial to determine if the at-risk respondents were heterogeneous with regard to risk and sun protection behavior, and whether they could be divided into homogeneous subgroups using LCA. To validate the solution of latent classes, we test to see if the subgroups differ reliably on demographics, attitudes, and sunburn history.

Materials and Methods

Participants and Procedures. Participants were recruited for a randomized controlled trial evaluating the effect of tailored mailed intervention materials on skin cancer prevention and skin self-examination behaviors among adults, ages 18 to 65 years, at high and moderate risk for skin cancer. The study occurred over two summers (1999-2000) in Hawaii and Long Island, New York. Participants were recruited in-person in the waiting rooms of cooperating primary care practices in Hawaii and Long Island, New York. Prospective participants were screened for skin cancer risk using a brief skin cancer assessment tool (15). Those who were at moderate risk or

Received 11/13/06; revised 4/2/07; accepted 4/30/07.

Grant support: National Cancer Institute grants R01 CA74619 and R25 CA90956.

The costs of publication of this article were defrayed in part by the payment of page charges. This article must therefore be hereby marked *advertisement* in accordance with 18 U.S.C. Section 1734 solely to indicate this fact.

Requests for reprints: Alana Steffen, Cancer Research Center of Hawaii, 1960 East-West Road, Biomed C-105, Honolulu, HI 96822. Phone: 808-441-8197; Fax: 808-586-3077. E-mail: asteffen@crch.hawaii.edu

doi:10.1158/1055-9965.EPI-06-0959

greater (score ≥27) and did not indicate ''always'' practicing sun precautions were invited to participate. Persons undergoing treatment for melanoma, non–English-speaking persons, and those who expected to be away from home for more than 2 weeks during the summer were excluded. University of Hawaii and Stony Brook University Institutional Review Boards reviewed and approved all study protocols. Approximately 25% of those screened were ineligible due to low risk for skin cancer, whereas another 8% were excluded for other reasons. No one was excluded for always practicing sun protection. Of the 1,371 eligible, 725 (52.9%) completed the baseline sun habits survey and were included in the current analyses.

Measures

Brief Skin Cancer Risk Assessment Tool. This survey, administered by the recruiting research staff, included demographic information such as sex, date and place of birth, ethnicity, and education, in addition to the risk factor questions of personal and family history of skin cancer, number of moles 1/4 in. or larger in diameter, freckles as a child, state or country of residence during childhood, history of severe (blistering) sunburns, skin type, and hair color (15). The brief skin cancer risk assessment tool (BRAT) has good face validity as it was systematically developed from the epidemiologic literature and available sun sensitivity measures. The test-retest reliabilities (Spearman correlations) for the individual BRAT items are acceptable to good (0.58-0.97).

Sun Habits Survey. This self-administered questionnaire was mailed to the participants and completed at baseline. Only those behavioral and attitudinal items used for this study are described, many of which have been used in previous research (16). The survey assessed usual sun habits by asking ''When outdoors in the sun, in warm weather, how often do you do each of the following?'' with response options on a four-point scale of rarely/never, sometimes, usually, and always. The six habits were (*a*) wear a shirt with sleeves, (*b*) wear sunglasses, (*c*) stay in the shade or under an umbrella, (*d*) use sunscreen, (*e*) limit your time in the sun during midday hours, and (*f*) wear a hat. Regarding sunscreen, the survey asked when it is applied (i.e., before going outside, when outside, and after being outside for 30 min or more) and to what body parts sunscreen is usually applied. The survey asked average number of hours per day spent in the sun last summer between 10 a.m. and 4 p.m. for weekdays and weekend days and ''Last summer, did you get a sunburn—or reddening of the skin—from being out in the sun?'' with choices of no; yes, once; yes, twice; and yes, more than twice. The questionnaire asked about involvement in outdoor activities during the past year with four response choices of (*a*) rarely/never; (*b*) occasionally; (*c*) fairly often, at least once a week; and (*d*) very often, more than thrice a week; these responses were dichotomously coded as occasionally or less versus at least weekly. Activities included household chores, walking, water sports, vigorous outdoor land sports, ball sports, and beach activities. Other items asked about time spent outdoors at work and current marital status. In addition, participants were asked to rate their degree of agreement with the statement ''People are more attractive if they have a tan'' on a five-point scale. The question ''How much does it help to have a good base suntan to protect yourself from the harmful effects of the sun?'' was asked on a four-point scale ranging from not at all to a great deal.

Statistical Methods. The LCA model assigns membership to a set number k of groups based on independent variables by maximum likelihood. It allows for continuous and categorical input data and adjustment for covariates (17). M-Plus was used initially to test a two-class model and evaluate the solution using the Lo-Mendell-Rubin adjusted likelihood ratio test that compares the k class to a $k-1$ class solution (17, 18) as well as considering entropy (range, 0-1), a measure of how well the classes can be distinguished (19). Then, incremental models were tested with an additional class until the model with k classes was not significantly better than the $k-1$ class model. Once the best model was fit, classification by posterior probabilities was used to test further the validity of the solution by comparing class responses on variables not used to create the classes.

Males and females were analyzed in separate LCA models to identify groups of individuals similar to each other but heterogeneous across groups. These groups were formed using indicators of risk for skin cancer based on the BRAT tool (ordinal, coded into tertiles), when sunscreen is usually applied (ordinal), and the six sun habits which were entered continuously. The variables were chosen to identify homogeneous groups at similar risk from both their personal attributes and behavioral practices. Covariates, adjusted for because they were found to differ across classes in preliminary LCA, were age, education, and geographic location. Because the sample size for males was small, only one dummy coded indicator was included for education separating persons completing graduate school from others, whereas four levels of education were used for females.

LCA has an assumption of conditional independence among variables after accounting for the latent classes. For the final solutions for both sexes, correlations were found within classes, especially for the two sunscreen items and the two avoidance items (i.e., seeking shade and limiting exposure during peak hours). The final k-class solution was tested with added parameters allowing the correlation of the avoidance items within each class (the model was not estimable when correlations were allowed between the two sunscreen items). The solution yielded approximately equal parameter estimates by class and had comparable proportions for the classes. Given the adequacy of the models without the added parameters and the similarity of solutions allowing conditional dependence, the more parsimonious models are presented here.

After determining the number of classes, the LCA solutions were further validated and described by examining class differences on demographic variables and the class derivation measures using the Kruskal-Wallis test for continuous measures and χ^2 statistics for categorical variables (Tables 1 and 2). Class membership, based on posterior probabilities, was used to predict differences on prevalence of sunburn, attitudes toward tanning, usual sun exposure, and outdoor activities using multiple linear and logistic regression adjusting for covariates of age, education, and geographic location.

Results

Sample Characteristics. Most of the participants were female (77%), White (82%), and married (67%), with a mean age of 42 years (SD, 11; range, 20-65 years). Non-Whites were Asian (7%), part Hawaiian (6%; usually mixed with Caucasian or Asian), and other groups (4%), and most lived and grew up in Hawaii. Individuals who live in sunny southern locations during childhood have an increased risk for skin cancer due to greater potential UV exposure. All participants were considered to be at increased risk for skin cancer due to their BRAT assessment scores. Demographic, risk characteristics, and sun protection habits are shown, by sex, for the total sample in column 2 of Tables 1 and 2. Among males, a higher proportion had college and graduate degrees (than females), and males were more likely recruited from Hawaii than females. Females and males differed in their level of risk; females were more likely to be White, have had blistering sunburns (females, 83.6%; males, 74.4%), and be in the highest tertile of constitutional risk as measured by the BRAT. Males

Table 1. Female characteristics for total sample and by latent class

	Total sample (n = 561)	Class 1 [n = 57 (10.2%)]	Class 2 [n = 239 (42.6%)]	Class 3 [n = 125 (22.3%)]	Class 4 [n = 140 (25.0%)]	P*
Demographics						
Age† [mean (SD); range, 20-65]	41.9 (11.0)	33.9 (10.5)	39.2 (10.2)	45.8 (11.3)	46.2 (8.8)	<0.0001
Race (% White)	83.8	87.7	84.9	72.8	90.0	0.0012
Education† (% with college degree or more)	44.4	29.8	44.8	40.0	53.6	0.0004
Marital status (% married)	67.3	52.7	67.7	71.0	69.3	0.0965
Area† (% from Hawaii)	48.1	19.3	42.3	60.8	58.6	<0.0001
Personal risk characteristics from BRAT						
Color of untanned skin (% very fair)	28.7	21.1	25.9	24.0	40.7	0.0033
Severe (blistering) sunburns (% with >10)	11.4	1.8	9.2	12.0	18.7	0.1184
Derivation variables: used to define latent classes						
Usual sun habits [mean (SD); range, 1-4]						
Sunglass	3.00 (1.07)	1.68 (0.47)	3.60 (0.49)	1.60 (0.49)	3.77 (0.42)	<0.0001
Sunscreen	2.76 (0.90)	2.18 (0.73)	2.66 (0.84)	2.60 (0.90)	3.32 (0.79)	<0.0001
Limit exposure 10-4	2.60 (0.85)	1.81 (0.58)	2.32 (0.74)	2.74 (0.78)	3.29 (0.63)	<0.0001
Shade	2.34 (0.83)	1.41 (0.53)	2.08 (0.63)	2.48 (0.78)	3.03 (0.71)	<0.0001
Shirt	2.00 (0.97)	1.44 (0.71)	1.64 (0.74)	2.13 (1.02)	2.72 (0.93)	<0.0001
Hat	1.75 (0.88)	1.19 (0.40)	1.56 (0.72)	1.60 (0.78)	2.45 (0.97)	<0.0001
Apply sunscreen before going outside (%)	53.9	28.6	45.1	60.0	74.6	<0.0001
Risk (% in top tertile of BRAT scores)	33.7	3.5	28.9	44.0	45.0	<0.0001

*Continuous variables were tested using Kruskal-Wallis test and categorical variables using χ^2 statistic.
†Covariate used in LCA models.

and females also differed on their use of sun protection habits, with males reporting more hat use and females reporting more use of all of the other habits. Only shirt use was not significantly different, yet showed a trend that was marginal. Males and females did not differ in percent being sunburned last summer (69% reported one or more); however, males reported more sunburns last summer than females.

Latent Class Solutions. LCA modeling led to selection of a four-class solution for females and three classes for males. All models included covariates of age, geographic location, and education. The Lo-Mendell-Rubin likelihood ratio test and entropy measure were both considered and supported the final k-class models selected. A less stringent probability level ($P < 0.10$) was used for the Lo-Mendell-Rubin test for males due to the small sample size. Entropy increased for each of the successive k-class models, ranging from 0.67 to 0.82 for females and from 0.70 to 0.99 for males. The $k + 1$ class models for both sexes did not converge properly and were potentially non-identified.

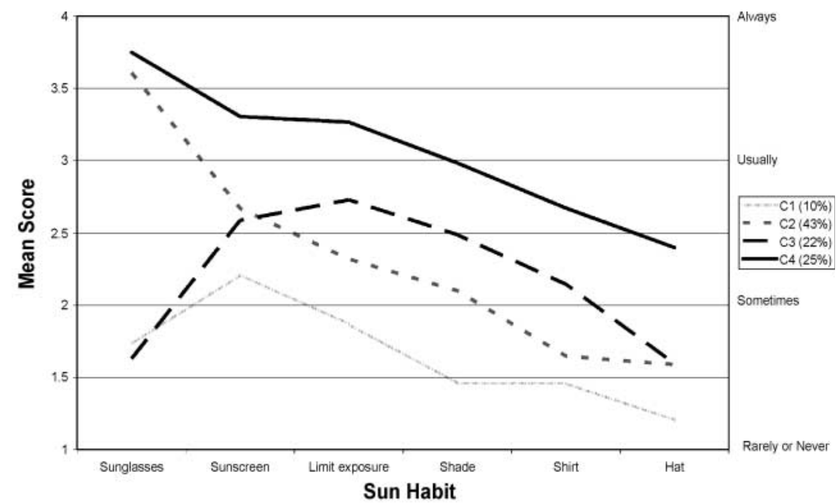
Variables that were useful in distinguishing the subgroups were markedly different in females and males. For females, all variables were used to derive the latent classes and were important in distinguishing the subgroups (see Table 1 for the differences between clustering variables by posterior class). In contrast, only sunscreen use items, risk (in tertiles), and, to a lesser extent, limiting exposure were important for deriving the latent clusters among males (see Table 2). For both sexes, each class is numbered to indicate its level of sun protection, with a higher number representing better sun protection habits.

Figure 1 shows the average scores of sun habits for each of the four female latent classes from Table 1 graphically, arranged by the prevalence of the sun protection behavior, as estimated by the model. Wearing sunglasses, the most commonly reported sun protection behavior, was reported nearly always by classes 2 and 4 and never to sometimes for classes 1 and 3. This was the only habit not congruent with the level of sun protection indicated by class number. Sunscreen had next highest use with classes 2 and 3 having similar

Table 2. Male characteristics for total sample and by latent class

	Total sample (n = 164)	Class 1 [n = 34 (20.7%)]	Class 2 [n = 58 (35.4%)]	Class 3 [n = 72 (43.9%)]	P*
Demographics					
Age† [mean (SD); range, 20-65]	42.6 (11.1)	45.6 (10.6)	41.4 (11.2)	42.1 (11.1)	0.1535
Race (% White)	76.8	67.7	77.6	80.6	0.3344
Education† (% with college degree or more)	57.3	41.2	48.3	72.2	0.0033
Marital status (% married)	64.0	61.8	65.5	63.9	0.9361
Area† (% from Hawaii)	62.2	55.88	51.7	73.6	0.0264
Personal risk characteristics from BRAT					
Color of untanned skin (% very fair)	25.6	17.7	25.9	29.2	0.4467
Severe (blistering) sunburns (% with >10)	9.2	5.9	10.3	9.7	0.116
Derivation variables: used to define latent classes					
Usual sun habits [mean (SD); range, 1-4]					
Sunglass	2.60 (1.09)	2.41 (1.10)	2.66 (1.00)	2.64 (1.15)	0.533
Limit exposure 10-4	2.41 (0.94)	2.15 (0.99)	2.34 (0.93)	2.58 (0.90)	0.0589
Sunscreen	2.34 (0.92)	1.00 (0.00)	2.00 (0.00)	3.24 (0.43)	<0.0001
Hat	2.19 (0.99)	2.06 (1.13)	2.12 (0.92)	2.31 (0.99)	0.3388
Shade	2.04 (0.74)	2.09 (0.75)	1.96 (0.80)	2.09 (0.70)	0.4884
Shirt	1.87 (1.02)	1.56 (0.79)	1.84 (0.93)	2.04 (1.16)	0.1501
Apply sunscreen before going outside (%)	40.4	6.1	38.9	58.0	<0.0001
Risk (% in top tertile of BRAT scores)	28.7	8.8	25.9	40.3	0.0192

*Continuous variables were tested using Kruskal-Wallis test and categorical variables using χ^2 statistic.
†Covariate used in LCA models.



Note: C1-C4 indicates class number, % is the percent of sample in each class. Class means are plotted.

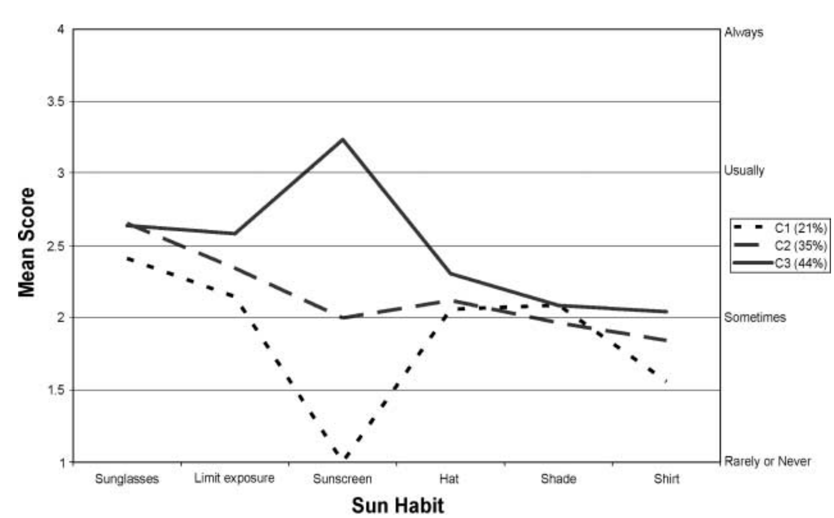
Figure 1. Female class profiles of usual sun protection use.

means; however, when timing of sunscreen application is considered (Table 1), class 3 is showing more propensity toward effective use of this habit. The other behaviors, in order of use, were limiting exposure during peak hours, using shade, and wearing a shirt and hat. These four behaviors showed a nearly parallel pattern across the four latent classes, suggesting these classes reflect a continuum of sun protection rather than unique patterns of practice by class.

For males, the prevalence of habits differed from females and less variability was noted (Fig. 2). Males also reported wearing sunglasses as the most prevalent behavior, but limiting exposure was the second most used strategy. Sunscreen use, which ranked third, had the most variability with the most protected (class 3) ''usually'' wearing sunscreen and the least protected (class 1) ''rarely or never'' wearing sunscreen. Again, the timing of sunscreen application corresponded to the amount of use (Table 2). Hat, shade, and shirt were the remaining habits, in order of use.

Skin cancer risk followed the pattern of the class labels for both men and women, with higher numbers indicating greater risk in the class (Tables 1 and 2). Risk and sun protection patterns were congruent; classes with lower risk reported less sun protection and those with higher risk reported greater sun protection practices.

Latent Class Validation. The LCA solutions were tested further by using class membership assigned by posterior probabilities to predict response to other survey items related to UV exposure, sunburn, attitudes, and outdoor activities (Tables 3 and 4). These models were tested with adjustment for the same covariates used in deriving the classes. The LCA solution was predictive of sunburns last summer for both sexes; this was not due to a correlation with the BRAT tertile score that includes sunburn history. For the female class 4, which was composed of the highest risk-best protected women, prevalence of sunburn (48%) was significantly less than for all other classes (74%). In contrast, the male class 1, which was composed of the lowest risk-least protected, had the lowest prevalence of sunburn (59%) compared with class 2 (83%), which was composed of the individuals in the intermediate risk-sun protection group. Class 3 was not significantly different than classes 1 and 2, with a sunburn prevalence of 71%. The LCA solution was also predictive of weekly beach activities/leisure recreation for females and showed a trend for males. In general, the best-protected males (class 3) were engaging in the most outdoor activities whereas the best-protected females (classes 3 and 4) were engaging in the least outdoor activities. Sun exposure hours per day on weekends and weekdays also support this trend. Latent class was also predictive of tanning attitude for females, with the better protected classes (3 and 4) viewing tans as less attractive than the less protected classes (1 and 2).



Note: C1-C3 indicates class number; % is the percent of sample in each class. Class means are plotted.

Figure 2. Male class profiles of usual sun protection use.

Table 3. Female latent class associations with behavioral outcomes and attitudes

Variables	Class 1 [*n* = 57 (10.2%)]	Class 2 [*n* = 239 (42.6%)]	Class 3 [*n* = 125 (22.3%)]	Class 4 [*n* = 140 (25.0%)]	*P**
Dichotomous measures [OR (95% CI)]					
≥1 sunburns last summer	2.8 (1.2-6.2)	2.7 (1.7-4.3)	2.4 (1.4-4.0)	1	0.0003
Outdoor activities done at least weekly in the past year					
Household chores, lawn work, home repair	2.1 (1.0-4.2)	1.7 (1.1-2.7)	1.1 (0.7-1.9)	1	0.0728
Walking for leisure/transport, doing errands	1.0 (0.5-2.1)	1.5 (0.9-2.4)	0.9 (0.5-1.5)	1	0.1976
Water sports (swimming, sailing, surfing, water skiing, snorkeling, etc.)	1.1 (0.5-2.3)	1.5 (0.9-2.4)	0.9 (0.5-1.6)	1	0.1889
Vigorous outdoor land sports (running/jogging, cycling, hiking, etc.)	0.9 (0.4-2.2)	1.4 (0.8-2.4)	0.8 (0.5-1.6)	1	0.2368
Ball sports (baseball, tennis, soccer, etc.) and golf	1.3 (0.3-4.8)	2.9 (1.3-6.7)	1.6 (0.6-4.1)	1	0.0386
Beach activities and leisure relaxation (sunbathing, picnic, etc.)	1.9 (0.9-4.1)	2.4 (1.4-4.0)	0.7 (0.4-1.4)	1	0.0001
Weekday exposure >1 h per day	1.6 (0.8-3.3)	1.8 (1.1-2.9)	1.8 (1.1-3.1)	1	0.0529
Work outside	2.4 (0.9-6.4)	1.9 (1.0-3.5)	1.2 (0.6-2.5)	1	0.1719
Have a good base tan believed to protect skin	1.1 (0.5-2.2)	1.0 (0.6-1.5)	0.9 (0.5-1.5)	1	0.9283
Continuous measures [mean (SE)]†					
Hours per day on weekends in the sun from 10 a.m. to 4 p.m. (range, 1-6)	2.98 (0.20)	3.10 (0.09)	2.87 (0.13)	2.65 (0.13)	0.0411
People are more attractive if they have a tan (range, 1-5)	3.37 (0.14)	3.16 (0.07)	2.95 (0.09)	2.96 (0.09)	0.0349

Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval.
**P* values represent type 3 effects for the latent class variable after adjusting for covariates of location, age, and education.
†Means are adjusted for covariates.

Discussion

This analysis sought to determine whether persons at elevated risk for skin cancer were heterogeneous, if they could be divided into homogeneous subgroups or classes, and if class membership would predict behaviors or attitudes related to risk. LCA found four distinct classes for females and three for males. Patterns differed substantially between men and women, supporting our a priori decision to analyze men and women separately. For both sexes, we found that subgroups were identified that were also validated by differences in relevant external criteria. In general, those with higher constitutional risk attributes were more likely to use more sun protection, as might be expected. The exception to this rule was wearing sunglasses for females. A less protected class (class 2) reported high use of sunglasses, which may have been used for purposes other than to protect the periocular skin and eyes from sun exposure, such as to reduce glare or for fashion.

The results suggest that some subgroups of females are engaging in more sun protection habits which were fairly effective in avoiding sunburn. In males; on the other hand, fewest sunburns occurred among those reporting the least amount of sun protection (class 1), which is likely due to lower constitutional risk (e.g., darker skin color and less severe sunburns in the past). Males reporting intermittent sunscreen use (class 2) are the ones getting the most sunburns, and these individuals may be good candidates for intervention because they need only increase a behavior they already practice. However, regardless of latent class and sex, all groups in this high-risk population reported a significant prevalence of sunburn the previous summer (48-83%), suggesting that prevention messages need to reach all persons having an elevated risk for skin cancer, such as those in our sample. For comparison, the annual prevalence of getting one or more sunburns for all U.S. adults in 2000 was 36%, and for White non-Hispanics, 44% (20).

In considering the prevalence of the various sun habits, it seems that whereas sunglass use is reported most often, it is an always (classes 2 and 4) or never (classes 1 and 3) phenomenon for women and thus may not be related to a goal of sun protection. This was verified by the three-class LCA solution excluding sunglasses, which has a lower entropy value and did not clearly distinguish a class of the most motivated women and a class who engage in more beach activities with a more

Table 4. Male latent class associations with behavioral outcomes and attitudes

Variables	Class 1 [*n* = 34 (20.7%)]	Class 2 [*n* = 58 (35.4%)]	Class 3 [*n* = 72 (43.9%)]	*P**
Dichotomous measures [OR (95% CI)]				
≥1 sunburns last summer	0.7 (0.3-1.7)	2.3 (0.9-5.9)	1	0.0429
Outdoor activities done at least weekly in the past year				
Household chores, lawn work, home repair	0.4 (0.2-1.1)	0.6 (0.3-1.4)	1	0.184
Walking for leisure/transport, doing errands	0.5 (0.2-1.3)	0.5 (0.2-1.1)	1	0.2073
Water sports (swimming, sailing, surfing, water skiing, snorkeling, etc.)	0.3 (0.1-0.9)	0.6 (0.3-1.4)	1	0.1007
Vigorous outdoor land sports (running/jogging, cycling, hiking, etc.)	0.9 (0.3-2.6)	0.8 (0.3-1.9)	1	0.8762
Ball sports (baseball, tennis, soccer, etc.) and golf	0.6 (0.2-2.1)	0.6 (0.2-1.6)	1	0.5414
Beach activities and leisure relaxation (sunbathing, picnic, etc.)	0.5 (0.2-1.5)	0.3 (0.1-0.9)	1	0.0723
Weekday exposure >1 h per day	0.6 (0.2-1.7)	1.1 (0.5-2.5)	1	0.5055
Work outside	1.0 (0.4-2.6)	1.4 (0.6-3.1)	1	0.6797
Have a good base tan believed to protect skin	1.1 (0.5-2.8)	1.6 (0.7-3.5)	1	0.4869
Continuous measures [mean (SE)]†				
Hours per day on weekends in the sun from 10 a.m. to 4 p.m. (range, 1-6)	2.88 (0.26)	3.09 (0.20)	3.38 (0.19)	0.2833
People are more attractive if they have a tan (range, 1-5)	3.52 (0.16)	3.30 (0.12)	3.25 (0.11)	0.3728

**P* values represent type 3 effects for the latent class variable after adjusting for covariates of location, age, and education.
†Means are adjusted for covariates.

pro-tanning attitude (data not shown). Sunscreen use also has been found to be used sometimes during sunbathing (21) and may not be associated with prevention of sunburn (20). The two least protected female classes reported sunscreen as their most commonly used sun protection habit after sunglasses. Although these classes viewed tans as more attractive, a question about intentional tanning may have helped clarify how sunscreen is being used. Males reported more hat use than females, consistent with a trend previously reported (22).

We found two other examples of person-centered analysis in the sun protection literature. One studied Midwest beachgoers clustered on perceived risk, tanning importance, and skin type and found clusters that were related to differences in usual sun protection behavior (23). The other clustered farmers in Georgia based on use of purchasing and using sun protection items (24). Whereas those examples and the present study have very different populations, it seems that all populations were heterogeneous with regard to sun protection and related beliefs and attitudes. Silk and Parrot (24) provided examples of how targeted messages might be constructed for subgroups and suggested that future segmentation studies involve both behaviors and psychosocial and social determinants. The sex differences we found suggest that the level of readiness to adopt sun protection habits differs by sex and would be improved by knowing more about tanning motivation and activity-related sun habits. For the present study, we considered the possibility that distinct patterns of sun protection might emerge. For example, the LCA technique could have identified a subgroup that used clothing, shade, and limiting exposure and avoided sunscreen use. However, the results suggested more of a continuum of all sun protection habits for females and a continuum of sunscreen use for males. It may be that as the public becomes more aware of a need for protection and the range of effective strategies such as shade, shirt, and hat use, they may develop distinct patterns for protection.

There are a number of limitations for this study. First, the sample size for males was small, thus limiting power to detect class differences and, ultimately, generalizability of the findings. The question about sunburns last summer is worded differently than questions used for national surveys, which often ask about blistering, and may have contributed to the higher sunburn rates reported by this sample. However, the differences observed between latent classes are considered reliable. Another limitation was that all measures relied on self-report, which has the potential for inaccuracy due to poor recall, difficulty estimating the frequency of routine behaviors, and social demand biases (25). There are, however, ongoing and recent studies that validate self-report measures using objective techniques such as observation and sunscreen swabbing (25-27). Finally, there were limitations to some of our measures such as not asking about tanning intentions and having daily midday exposure that did not measure any exposure of <1 h.

In conclusion, we found the LCA method effective for finding relevant and valid subgroups within a heterogeneous at-risk population for skin cancer. It would also be interesting to test LCA in a setting where all participants are not at high risk for skin cancer, such as in multiethnic populations, where increased UVB exposure may have benefits by providing vitamin D. With the recent controversy about vitamin D levels (28-31), there is concern that some individuals are at risk for vitamin D insufficiency, which has been related to incidence and mortality of other cancers (32). LCA could also be useful to determine if an intervention can move persons from one class to another over time, especially in the sun protection field where patterns of behavior may be relevant (e.g., some habits may be exchangeable; refs. 11, 13). LCA could identify subgroups for targeted intervention strategies as part of intervention development when individually tailored materials are inefficient or not feasible (33).

References

1. Jemal A, Siegel R, Ward E, et al. Cancer statistics, 2006. CA Cancer J Clin 2006;56:106–30.
2. American Cancer Society. Cancer facts and figures 2006. Atlanta: American Cancer Society; 2006.
3. Miller DL, Weinstock MA. Nonmelanoma skin cancer in the United States: incidence. J Am Acad Dermatol 1994;30:774–8.
4. Gallagher RP, Lee TK. Adverse effects of ultraviolet radiation: a brief review. Prog Biophys Mol Biol 2006;92:119–31.
5. Gandini S, Sera F, Cattaruzza MS, et al. Meta-analysis of risk factors for cutaneous melanoma: II. Sun exposure. Eur J Cancer 2005;41:45–60.
6. Kricker A, Armstrong BK, English DR. Sun exposure and non-melanocytic skin cancer. Cancer Causes Control 1994;5:367–92.
7. Nelemans PJ, Rampen FH, Ruiter DJ, Verbeek AL. An addition to the controversy on sunlight exposure and melanoma risk: a meta-analytical approach. J Clin Epidemiol 1995;48:1331–42.
8. Healthy Youth! Health topics, Skin cancer, school health guidelines. Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion. Available from: http://www.cdc.gov/healthyyouth/skincancer/guidelines/summary.htm#How%20to%20Prevent%20Skin%20Cancer.
9. SCF Tips. Skin Cancer Foundation. Available from: http://www.skincancer.org/content/view/66/29/.
10. Agresti A. Categorical data analysis. 2nd ed. Hoboken (NJ): John Wiley & Sons, Inc.; 2002.
11. Muthen BO. Latent variable mixture modeling. In: Marcoulides GA, Schumacker RE, editors. New developments and techniques in structural equation modeling. Mahwah (NJ): Lawrence Erlbaum Associates; 2001. p. 1–33.
12. Bucholz KK, Heath AC, Reich T, et al. Can we subtype alcoholism? A latent class analysis of data from relatives of alcoholics in a multicenter family study of alcoholism. Alcohol Clin Exp Res 1996;20:1462–71.
13. Muthen B, Muthen LK. Integrating person-centered and variable-centered analyses: growth mixture modeling with latent trajectory classes. Alcohol Clin Exp Res 2000;24:882–91.
14. Breslau N, Reboussin BA, Anthony JC, Storr CL. The structure of posttraumatic stress disorder: latent class analysis in 2 community samples. Arch Gen Psychiatry 2005;62:1343–51.
15. Glanz K, Schoenfeld E, Weinstock MA, Layi G, Kidd J, Shigaki DM. Development and reliability of a brief skin cancer risk assessment tool. Cancer Detect Prev 2003;27:311–5.
16. Glanz K, Geller AC, Shigaki D, Maddock JE, Isnec MR. A randomized trial of skin cancer prevention in aquatics settings: the Pool Cool program. Health Psychol 2002;21:579–87.
17. Muthen LK, Muthen BO. Mplus user's guide. 3rd ed. Los Angeles (CA): Muthen & Muthen; 1998-2005.
18. Lo Y, Mendell N, Rubin D. Testing the number of components in a normal mixture. Biometrika 2001;88:767–78.
19. Muthén B. Should substance use disorders be considered as categorical or dimensional? Addiction 2006;101:6–16.
20. Hall HI, Saraiya M, Thompson T, Hartman A, Glanz K, Rimer B. Correlates of sunburn experiences among U.S. adults: results of the 2000 National Health Interview Survey. Public Health Rep 2003;118:540–9.
21. Thieden E, Philipsen PA, Sandby-Moller J, Wulf HC. Sunscreen use related to UV exposure, age, sex, and occupation based on personal dosimeter readings and sun-exposure behavior diaries. Arch Dermatol 2005;141:967–73.
22. Cardinez CJ, Cokkinides VE, Weinstock MA, O'Connell MC. Sun protective behaviors and sunburn experiences in parents of youth ages 11 to 18. Prev Med 2005;41:108–17.
23. Pagoto SL, McChargue DE, Schneider K, Werth Cook J. Sun protection motivational stages and behavior: skin cancer risk profiles. Am J Health Behav 2004;28:531–41.
24. Silk KJ, Parrott RL. All or nothing. or just a hat? Farmers' sun protection behaviors. Health Promot Pract 2006;7:180–5.
25. Glanz K, Mayer JA. Reducing ultraviolet radiation exposure to prevent skin cancer methodology and measurement. Am J Prev Med 2005;29:131–42.
26. Oh SS, Mayer JA, Lewis EC, et al. Validating outdoor workers' self-report of sun protection. Prev Med 2004;39:798–803.
27. O'Riordan DL, Lunde KB, Steffen AD, Maddock JE. Validity of beachgoers' self-report of their sun habits. Arch Dermatol 2006;142:1304–11.
28. Canadian Cancer Society. Key findings released from UV, Vitamin D and Health Conference: national health groups recognize benefits of vitamin D. North American Conference on UV, Vitamin D and Health. Toronto, Canada, 2006.
29. Diffey B. Do we need a revised public health policy on sun exposure? Br J Dermatol 2006;154:1046–51.
30. Lucas RM, Repacholi MH, McMichael AJ. Is the current public health message on UV exposure correct? Bull World Health Organ 2006;84:485–91.
31. Sinclair C. Risks and benefits of sun exposure: implications for public health practice based on the Australian experience. Prog Biophys Mol Biol 2006;92:173–8.
32. Giovannucci E. The epidemiology of vitamin D and cancer incidence and mortality: a review (United States). Cancer Causes Control 2005;16:83–95.
33. Glanz K. Perspectives on using theory: past, present, and future. In: Glanz K, Rimer BK, Lewis FM, editors. Health behavior and health education: theory, research, and practice. 3rd ed. San Francisco (CA): Jossey-Bass, Inc.; 2002. p. 545–58.