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Sun protection belief clusters: Analysis of Amazon Mechanical Turk data

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Abstract

This study aimed (i) to determine whether people could be differentiated on the basis of their sun protection belief profiles and individual characteristics; and (ii) explore the use of a crowdsourcing web service for the assessment of sun protection beliefs. A sample of 500 adults completed an online survey of sun protection belief items using Amazon Mechanical Turk. A two-phased cluster analysis (i.e. hierarchical and non-hierarchical-k-means) was utilized to determine clusters of sun protection barriers and facilitators. Results yielded three distinct clusters of sun protection barriers and three distinct clusters of sun protection facilitators. Significant associations between gender, age, sun sensitivity, and cluster membership were identified. Results also showed an association between barrier and facilitator cluster membership. The results of this study provided a potential alternative approach to developing future sun protection promotion initiatives in the population. Findings add to our knowledge regarding individuals who support, oppose, or are ambivalent toward sun protection, and inform intervention research by identifying distinct subtypes that may best benefit from (or have a higher need for) skin cancer prevention efforts.

Keywords

health beliefs; internet; skin cancer prevention; health behaviors

Skin cancer (SC) is the most commonly diagnosed cancer in the United States (US). It is estimated that close to 4 million SC diagnoses (including melanoma and non-melanoma carcinomas) are made every year in the US [1]. Although most SC diagnoses could be prevented by protecting the skin from sun exposure, the rate of sun protection (SP) and SC prevention behaviors in the population is suboptimal [2, 3]. Traditional tailored campaigns and interventions for SC prevention have focused on specific settings or people with similar demographic characteristics [4–8]. Some interventions have been developed based on sun protection beliefs, including perceived risk of developing SC, perceived severity of SC, and tanning beliefs [9–13]. However, no intervention has been based on a cluster analysis of beliefs and individual characteristics in the population. The goal of this study is to identify

SP profiles so that in the future, these profiles can be used to inform tailored interventions for the reduction of SC risk in the general population.

This study aimed (i) to determine whether people could be differentiated in the basis of sun protection belief profiles and participants' characteristics; and (ii) explore the use of a crowdsourcing web service for the assessment of sun protection beliefs. The existence of distinctive, interpretable, and internally consistent subgroup profiles of SP barriers and SP facilitators using data collected online ($N=500$) was examined. Replication was assessed across two subsamples. The clusters were externally validated by assessing the differences by clusters using participants' variables and by assessing the relation between the barrier and facilitator subtypes to identify what groups had beliefs which would likely lead to SC risk behaviors.

Methods

Participants

Participants were volunteers from across the United States enrolled in the Amazon Mechanical Turk (MTurk) service [14]. The Institutional Review Board at the Icahn School of Medicine at Mount Sinai approved the project as exempt. Participation was voluntary, all participants were treated equally, and economically/educationally disadvantaged participants were not preferentially enrolled or excluded. Participant recruitment took place over one day (24 hours) in July 2014. Eligible participants completed an online survey to collect data regarding their endorsement of SP beliefs (barriers and facilitators). Eligibility criteria included being: 1) at least 21 years of age, 2) able to read in English, and 3) located in the United States (used as a filter in MTurk), and 4) being an Amazon Mechanical Turk user.

Materials and Procedure

Data were collected using the MTurk service. MTurk is a crowdsourcing web service that enables participants ("workers") to access and complete a variety of "human intelligence tasks" ("HITS"), such as survey completion [14]. We posted recruitment information for the online survey using MTurk. Participants were given information about the study (research information letter) and a letter of informed consent. After they consented, they were asked to fill out the survey including SP belief statements. The statements were generated through a review of the sun protection literature, and after a series of focus groups were completed (Santiago-Rivas, Wang, & Jandorf, manuscript under review). Items based on these statements were designed to tap previously defined theoretical concepts (SP beliefs), and sub-concepts (barriers and facilitators). A list of 40 items to measure SP beliefs was used to collect the data, with 17 items representing SP barriers (e.g., "I worry I will have a vitamin D deficiency if I avoid exposure to the sun") and 23 items representing sun protection facilitators ("I should use sunscreen any time I am in the sun for a long time"). The items were measured on a 5-point Likert scale (1=strongly disagree to 5=strongly agree). Participants completed demographic items (i.e., age, gender, education level, race, and ethnicity). The survey also included assessment of sun sensitivity [15]. Once participants completed the survey they were given a monetary incentive (40 cents).

Amazon Mechanical Turk

MTurk is a web service that provides an on-demand, scalable, human workforce to complete tasks, including data categorization, moderation, verification, and tagging (<https://www.mturk.com/mturk/welcome>) [14]. A “Requester” creates tasks on MTurk for “Workers” to work on. A “Worker” is a person who completes assignments, uses the MTurk website (<http://mturk.amazon.com/>) to create/manage their account, find assignments to work on, and submit responses. Anyone can register to work in the MTurk. “Workers” are usually paid small amounts for short tasks (generally less than \$1 for less than 5 minutes of work), and they are from all over the world, with the majority of workers being from either the United States or India. The investigators (“Requesters”) do not receive any personal identification information or IP addresses, and payment to the participants is made by MTurk, avoiding any direct links between investigators and the subjects. Recent research illustrates the use of MTurk to assess health outcomes (e.g., work-asthma interaction, ovarian cancer knowledge, body dissatisfaction) [16–18]. In a study to evaluate parental feeding goals and practices, 171 mothers completed questionnaires via MTurk. Results showed an adequate model fit in which negative feeding practices (e.g., using food as a reward) mediated the relationship between health-related feeding goals (i.e., feeding children with health-oriented goals in mind) and negative eating behaviors (e.g., consumption of candy and snacks). However, negative feeding practices did not mediate the relationship between health-related feeding goals and positive eating behaviors (i.e., fruits and vegetables) [19]. An assessment of high risk sexual behavior conducted in 600 men recruited via MTurk found that men who believe they are less masculine than the typical man (i.e., gender role discrepancy) and experience distress stemming from this discrepancy (i.e., discrepancy stress) engage in high-risk sexual behavior and are subsequently diagnosed with more sexually transmitted diseases [20]. A review of research using MTurk showed that performance of MTurk participants is comparable to that of traditional participants (e.g., cognitive abilities, self-report responses) [21]. These findings illustrate that MTurk is very useful for the collection of quality health-related data.

Data Analysis

The purpose of cluster analysis is to place objects into groups, or clusters, suggested by the data, not defined a priori, such that objects in a given cluster tend to be similar to each other in some sense, and objects in different clusters tend to be dissimilar [22]. The process of taking a heterogeneous sample of entities (usually people in health psychology) and forming relatively homogeneous groups, serves to organize large quantities of multivariate information. Labels can be assigned to the subgroups, making the data more manageable for the individual researcher [23]. In the present study, SAS was used to conduct the cluster analysis. Hierarchical clustering was performed using the squared Euclidean distance metric (a measure of similarity/distance between data points) and Ward’s minimum variance algorithm. Hierarchical agglomerative cluster analysis involves a series of steps, whereby individual cases (people) begin as individual clusters and step-by-step the most similar clusters are joined together, eventually resulting in one cluster containing all cases. Each step is irreversible, so clusters joined at one step cannot be separated later in the clustering process. Ward’s method, a criterion for choosing the clusters to merge at each step, is based on the optimal value of an objective function (in this case, the error sum of squares). Several

methods were used to determine the number of clusters, including the inverse scree test, the cubic clustering criterion (CCC), the pseudo t^2 test, the pseudo F -statistic, and visual inspection of the cluster profiles. These methods are used to follow 'stopping rules' and to determine dissimilarity between clusters as they indicate when the process of clustering from N (number of participants) to one cluster should be stopped. A traditional method of deciding on the number of clusters is to conduct a visual inspection of the dendrogram, which is a tree diagram frequently used to illustrate the arrangement of the clusters produced by hierarchical clustering (part of the cluster analysis output). This analysis was followed by a K-means cluster analysis (an iterative partitioning method that begins with a number of clusters is specified by the researcher before the analysis takes place, and therefore only one cluster solution is given). It has been suggested that performing a hierarchical method first to determine the number of clusters and the cluster centroids, followed by a K-means cluster analysis is a way to optimize results. The stability of the clusters was examined by dividing the sample into two halves, repeating the hierarchical cluster analysis on each, and examining the similarity of the profiles in each subsample when compared to the general sample. If the clusters are stable, a similar cluster structure should be found in each half of the sample. External validity was assessed by comparing the clusters on age, gender, and sun sensitivity. The validation of the clusters must include some evidence of their value to the field of study, for example, by using inferential statistics to compare the groups on variables that were not included in the clustering process. The variables included in cluster identification procedures were standardized within sample and subsamples (halves) to z scores. Cluster analysis has been used in previous research as a tool to assess cancer prevention outcomes [24–27].

Results

Most participants were male (61.1%), white (76.3%), and college-educated (50.8%). Most participants did not report any history of skin cancer (77.1%), and were from the Pacific or South Atlantic regions (23.2% and 19.3%, respectively). The mean age was 30.2 years. Thirty-eight participants were not clustered in the analysis for SP barriers, and thirty-nine participants were not clustered in the analysis for SP facilitators, due to incomplete responses on these sets of items. No outliers were identified.

Clusters: Sun Protection Barriers

Using the set of guidelines described above for determining the number of clusters, it was determined that between three and five clusters best represented the data for both the barriers. Comparison of the three, four, and five cluster solutions revealed that the three cluster solution was the most interpretable. For SP barriers, the first cluster ($N=132$; Barrier Endorser) included individuals who tended to agree with statements regarding the disadvantages of SP (barrier scores were above average). The second cluster ($N=178$; Barrier Opponent) indicated little interest in endorsing SP barriers (below and around average scores). The third cluster ($N=152$; Barrier Indecisive) was characterized by a combination of above and below average scores, endorsing both sun exposure and sun protection beliefs.

Clusters: Sun Protection Facilitators

Using the set of guidelines described above for determining the number of clusters, it was determined that between three and five clusters best represented the data for the facilitators. Comparison of the three, four, and five cluster solutions revealed that the three cluster solution was the most interpretable. For SP facilitators, the first cluster ($N=142$; Facilitator Opponent) was characterized by below average scores on most of the facilitator items. This group tended to disagree with most beliefs enabling sun protection. The second cluster ($N=162$; Facilitator Endorser) was characterized by above average level scores, and it supported promotion of sun protection. The third cluster 3 ($N=157$; Facilitator Indecisive) was characterized by above and below average scores, and didn't tend to a consensus regarding skin cancer preventative beliefs.

External Validation

Cluster membership was used as the grouping variable for external validity analyses (Table 1). External validity analyses were conducted for barrier clusters and for facilitator clusters. Chi-square tests of association and one Analysis of Variance with follow-up Tukey's HSD comparisons were performed with gender, sun sensitivity type, and age and each set of SP belief clusters. While most members of the Barrier Endorser cluster were men, younger, and skin type IV (more prone to tan after sun exposure), most of the members of the Facilitator Endorser cluster were female, older, and skin type II (more prone to burn after sun exposure). For gender and sun sensitivity analyses, the columns approximate 100%.

Association Barrier Clusters X Facilitator Clusters

It is well known that endorsement of sun protection beliefs doesn't necessarily predicts sun protection behaviors, or opposition to sun protection risk habits. An assessment of sun protection beliefs and behaviors among state park workers found that while the vast majority of the workers (87.4 %) believed that skin cancer is a serious disease, a minority (35.6 %) believed their risk as outdoor workers was higher than average, and a lower proportion was highly confident they could wear a wide-brimmed hat (21.8 %) and sunscreen (20.7 %) while in the sun [27]. These results highlight the need to identify individuals who endorse health promotion beliefs/condemn risk behaviors (and also individuals who endorse sun exposure/ignore sun protection messages). These individuals/groups might inform future research regarding the identification of mechanism, strategies, and messages needed to develop successful sun protection interventions. The present study allows us to explore the existence of these informative subgroups.

The results of a Chi-square test (not included in the manuscript) for the association between SP barrier profiles and SP facilitator profiles, $\chi^2 (4, N=461) = 137.20, p < .001$, indicated that more than half of the members of the Barrier Endorser cluster were also members of the Facilitator Opponent cluster (57.6%). This subgroup, labeled as Risk-Takes (16.3% of the sample), represents individuals who strongly disagree with sun protection messages. Close to 50% of the members of the Barrier Opponent cluster were also members of the Facilitator Endorsers cluster (49.2%). This subgroup, labeled as Sun Protection Believers (19% of the sample), represents individuals who embrace sun protection and firmly believe in health promotion for the prevention of skin cancer. In addition, 68.3% of members of the Barrier

Indecisive cluster were also members of the Facilitator Indecisive cluster. This subgroup, labeled as Completely Undecided (22.4% of the sample), might represent large proportion of the general population, and a challenge for the effective implementation of strategies to reduce unprotected sun exposure, as they strongly consider the advantages and disadvantages of both sun protection beliefs and skin cancer risk beliefs. A smaller subgroup, labeled as Disengaged, was clustered both in the Barrier Opponent and Facilitator Opponent clusters (10% of the sample). This subgroup represents individuals who are aware of the effects of sun exposure on their skin health, but decided not to endorse practice preventative strategies in a consistent manner.

Discussion

The goal of this study was to identify participants' SP profiles with the potential to be used to develop more broadly tailored intervention materials for the reduction of SC risk in the general population. That is, evidence-based unique messages and interventions would be appropriately developed for subgroups reporting different levels of SC risk beliefs and behaviors. The results provided additional empirical evidence to support the proposition that endorsement of SP beliefs can differ based on individual characteristics.

Cluster analysis revealed that three SP barrier profiles and three SP facilitator profiles existed within this sample of users of MTurk. These results strengthen previous cluster-analytic studies that have examined sun protection beliefs in terms of homogenous subgroups of people [26]. The findings of this study illustrate the relevance of taking into account the association between multivariate population characteristics and SP beliefs.

In addition to identifying SP profiles, the present study aimed to identify which individuals are at risk for insufficient SP, and in turn, likely at risk for SC. A large group of participants (22.4%) were indecisive regarding their endorsement of SP beliefs, that is, they were clustered in both Indecisive groups. This Completely Undecided subgroup may also endorse some SP behaviors, but they may also report low awareness regarding SC risk and the importance of SP. A group that is noteworthy discussing is the Disengaged subcluster. These participants were clustered in both Opponent clusters. This particular group of individuals represents a challenge to SC prevention efforts. Members may not have strong beliefs about SP or sun exposure, and the motivation to make decisions regarding SC prevention might be low. Future research should be done to explore the needs, characteristics, and preferences of this subgroup.

Cluster analysis is an exploratory approach that employs the interpretation of the researcher in the identification of the subgroups. In this study, replication across two samples and external validation using variables not included in the clustering process were implemented to control for the potential influence of researcher bias on the results. The sample obtained was primarily white, male, and of young-adult age. The sample was recruited from an online service, and participants were Internet users. Different patterns of SP beliefs could be expected when using samples with different demographic characteristics, or when using a different method for data collection. These factors are important when assessing the generalizability of the present findings.

Future studies will need to be conducted to assess the predictive ability of the clusters identified by the present study using longitudinal data analysis. An important test of the validity of SP belief clusters is the capacity of the profiles to predict future SP behavior at follow-up assessments. Results from this study could be replicated in an independent sample, with SP behaviors assessed at a later time point, followed by an examination of the association between profiles and behaviors. Another critical aspect of the clusters that require further analysis is their stability. We need to assess whether members of the clusters identified in the present study remain in the same subgroups using longitudinal data. Latent transition analysis could be used to characterize transition over time in SP belief profiles. We found that US Census region of residence was not a predictor of cluster membership, and we are confident that results from the present study and future studies would be generalizable to different regions of the U.S. Similar studies could be conducted in countries where sun protection is more (e.g., Australia) or less integrated in population-based health promotion efforts regarding sun protection. Findings support the notion that the assessment of the endorsement of SP beliefs and characteristics of the population requires a multidimensional perspective, and linking this multidimensional perspective to health promotion efforts for SP promotion could provide an important contribution to SC prevention initiatives.

The *Surgeon General's Call to Action to Prevent Skin Cancer* report stresses the need to develop well-tailored, individual-focused strategies for reaching specific subpopulations [3]. These strategies should create prevention messages targeting clusters of people who share specific characteristics (e.g., outside tanners, inside tanners, sun protection opponents, indecisive individuals). These messages should provide specific information on the most effective methods for sun protection applicable for these specific audiences. Tailored messages about sun protection may be more effective than broad-based messages to the general population. The collection and use of data on clusters of beliefs can help improve the understanding of people's motivations for sun exposure or sun protection, especially subgroups that have been studied less frequently (e.g., sun protection endorsers). We need to increase research efforts to determine population groups most likely to benefit from skin cancer prevention especially for populations at high risk, but we can also increase monitoring those who make informed choices about sun protection, and learn from their experiences.

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Table 1

Frequencies and descriptive results external validity for subtypes of sun protection barriers and facilitators on three variables

Variables	Clusters						
	Barriers			Facilitators			
	Barrier Endorser (N=132)	Barrier Opponent (N=178)	Barrier Indecisive (N=153)	Facilitator Endorser (N=162)	Facilitator Opponent (N=142)	Facilitator Indecisive (N=157)	
Gender	$\chi^2(2, 462) = 24.47^{***}$			$\chi^2(2, 459) = 30.16^{***}$			
Male	74.2%	63.8%	45.1%	42.9%	68.1%	70.1%	
Female	25.8%	36.2%	54.9%	57.1%	31.9%	29.9%	
Skin Type (Sun Sensitivity) *	$\chi^2(8, 460) = 21.09^{**}$			$\chi^2(8, 459) = 36.22^{***}$			
I	3.8%	1.7%	9.9%	10.6%	4.3%	1.9%	
II	19.2%	23.6%	28.9%	31.1%	23.4%	14.6%	
III	30.0%	32.0%	31.6%	28.6%	36.2%	29.9%	
IV	39.2%	35.4%	26.3%	25.5%	32.6%	43.3%	
V	7.7%	7.3%	3.3%	4.3%	3.5%	10.2%	
VI (N/A)							
Age M_{ears} (SD)	$F(2, 460) = 2.82^*$			$F(2, 460) = 2.82^*$			
	28.8 (7.7) ^a	30.3 (9.6) ^b	31.5 (9.8) ^c	32.0 (10.1) ^a	29.9 (9.3) ^b	28.4 (7.7) ^c	
	Tukey's HSD= a<c			Tukey's HSD= a>b, a>c			

Note:

* I=burn, no tan; II=burn, rarely tan; III=medium burn, then tan, IV=tan with ease; V=always tan; VII=no change

** $p < .05$,*** $p < .01$,**** $p < .001$