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Skin Protective Measures Taken during the 2017 North American Solar Eclipse in Georgia

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Abstract: A total solar eclipse occurred over North America on 21 August 2017 and was a much-publicized astronomical event whose observance depended upon favorable weather. The eclipse also was a biometeorological event because people needed to both protect their both eyes and skin from the sun's ultraviolet radiation. Although much attention was devoted in the media to the visual experience of the eclipse and to eye protection, skin protection received almost no emphasis. Thus, the authors surveyed 1014 university students in Athens, Georgia shortly after the eclipse event about their skin protective behaviors. Overall, people observed the eclipse outside for approximately one hour. The time spent outside differed significantly according to peoples' self-reported skin response to the sun. The respondents also indicated that that they observed the eclipse for significantly longer periods of time than would be needed for them to receive a sunburn. Other than wearing sunglasses and using eclipse glasses, the most frequent skin protective measures were to seek shade and to wear short-sleeve shirts. Wearing additional clothing, hats, or any type of sunscreen were comparatively infrequent. We discussed the need for safeguarding the skin because every sunburn event at younger ages can increase the likelihood of skin cancers.

Keywords: biometeorology; skin protective measures; solar eclipse; sun exposure; ultraviolet radiation (UVR)

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1. Introduction

The total solar eclipse of 21 August 2017 that occurred over North America represented an interesting intersection of: 1. an astronomical event, 2. the meteorological conditions (clear skies) necessary for people to experience the event, and 3. biometeorological considerations (ambient weather conditions for being outside and the potential effects of ultraviolet radiation (UVR) on the skin and eyes). Because numerous viewing events were organized along the eclipse transect, the 2017 eclipse provided a unique opportunity to study the self-reported skin protective measures that people followed.

A search of the Newspapers Source Plus database in the United States revealed that while nearly 50 news media articles in August emphasized ways to experience the eclipse to protect the eyes—using either approved eclipse glasses or using pin-hole projection—no articles appeared in the database discussing the necessity or methods for protecting the skin. One possible misconception was that because the sun's disk was being eclipsed and its UV radiation was decreasing, the sun's ability to harm anything but the eyes (if one looked directly at the sun without protection) was minimized. Although this assumption may be valid during the time of near total occlusion, many people spent more time in the full UVR field both before and after the eclipse. This eclipse-related UVR exposure and the possibility for sunburn (erythema) is noteworthy because only a few such over-exposures are necessary to dramatically increase one's risks for skin-related cancers [1,2]. In addition, people with fair skin (that burn, then peel) require as little as 15 to 20 min of summer UVR exposure to experience a mild sunburn (a minimal erythemal dose or MED) [3–5].

Given the potential for extended UVR exposure during the eclipse, the authors conducted a survey of people who were outside while observing the 2017 eclipse in Athens, Georgia. Athens is located in the northeastern portion of the state, approximately 120 km (km) from Atlanta. The survey inquired about eclipse observation behaviors and safety precautions taken. The subsequent section describes the 2017 total eclipse event in meteorological and biometeorological terms and culminates with the principal research questions about nature and degree of UV exposure experienced and the types of skin protective measures taken during the eclipse. The survey method and results then follow.

1.1. Ultraviolent Radiation (UVR) Overexposure and Melanoma Risk

Although people of all skin pigment types require some exposure to the UV radiation so that the skin can produce needed vitamin D to supplement what is consumed dietarily, UV over-exposures—especially on multiple occasions—can increase the likelihood of skin cancers [1,2,5–7]. Cancer of the skin make up the most prevalent forms of all cancers [8,9]. Basal cell carcinoma (BCC) and squamous cell carcinoma (SCC) are more common skin cancers than melanoma (1% of cancers). Malignant melanoma, however, is the most lethal of skin cancers. The incidence rates of BCC and SCC have increased due to better detection, longer lifespans, and greater exposure to UV radiation. Once believed to be a rare disease, within the last 50 years the incidence of melanoma has increased more rapidly than any other cancer [10]. The incidence of melanoma has declined somewhat since 2014 because of better detection and medical treatments [8].

There are three primary risk factors for all skin cancers, the first of which is lighter colored skin. White people have the highest risks for skin cancer, with Hispanic-Latino people have incidence rates that are 3 times lower [8]. People who are Black or Asian/Pacific have the lowest level of risks (approximately 30-fold lower than Whites). Although they experience lower risk levels, Black and Hispanic people still are susceptible to skin cancer because of later diagnoses and lower perceived risks [9,11]. The second risk factor is sun exposure. Significantly, experiencing five or more blistering sunburns between the ages of 15–20 years was associated with relative risks of 1.68 for BCC and SCC and 1.90 for malignant melanoma [1,2]. A third risk factor is a family history of skin cancers. Of these three risk factors, taking skin protective measures and avoiding sunburn is a behavioral choice that can be under a person's control [8].

1.2. The August 2017 Eclipse Event

The "Great American Eclipse" occurred on 21 August 2017 and was a nationally publicized event in the United States because the last major eclipse that was visible to the lower 48 states (coast-to-coast) occurred in 1918 [12]. The path of totality (full occlusion of the sun by the moon) traversed the United States beginning in Oregon at approximately 17:15 Universal Time Coordinated (UTC) and moved towards the southeast, reaching the coast of South Carolina at approximately 18:48 (UTC) or 2:48 p.m. Eastern Daylight Time (EDT) [13]. The survey research location, Athens, Georgia (33.9519° N, 83.3576° W), was just outside of the path of totality. The maximal occlusion of the sun was 99% and occurred at 18:38 UTC or 2:38 p.m. EDT. A number of viewing events were organized for people to experience the eclipse and these were publicized in the Athens area [14].

Meteorologically, although some occasional passing, isolated clouds were noted at 12:00 and again at 13:00 local time, 21 August was mostly clear with respect to cloud cover. Figure 1 shows a Visible Infrared Imaging Radiometer Suite (VIIRS) image of the southeastern United States at 18:30 UTC as the area of totality was approaching Georgia.

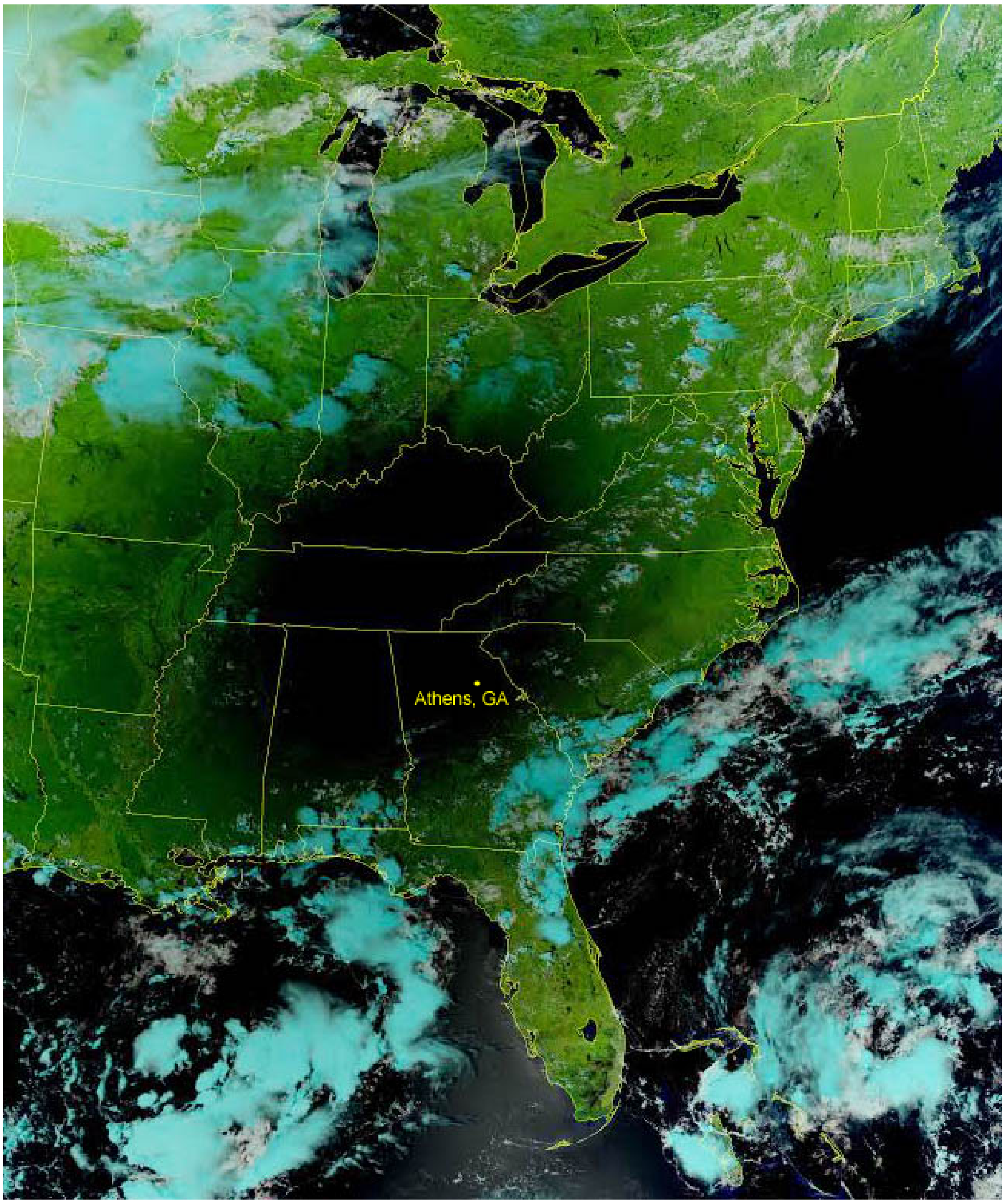

Figure 1. Natural color image (day, land, cloud) of the southeastern United States taken at 18:30 UTC by the Visible Infrared Imaging Radiometer Suite (VIIRS) aboard the NOAA/NASA Suomi NPP satellite. Vegetation appears green, liquid clouds appear white, and higher ice clouds appear as cyan. The image depicts the moon's shadow just before the maxima in Athens, Georgia. Used with permission, courtesy of the NOAA/NASA Suomi NPP satellite.

Figure 2 shows the total incoming solar irradiance at an agricultural research site in Watkinsville (33.8869° N, 83.41941° W) that is located approximately 13 km to the south/southwest of Athens, Georgia. This radiometer, a Licor LI 200X pyranometer recorded the sun's global horizontal irradiance (400 to 1100 nanometers) every 15 min. Figure 2 shows that the incoming solar radiation decreases steadily from 17:00 UTC (13:00 EDT) to reach a minimum value of 23.6 W/m^2 at 18:45 UTC (14:45 EDT) The irradiance values then increased steadily until 20:00 UTC (16:00 EDT). The eclipse event itself spanned just slightly under three hours.

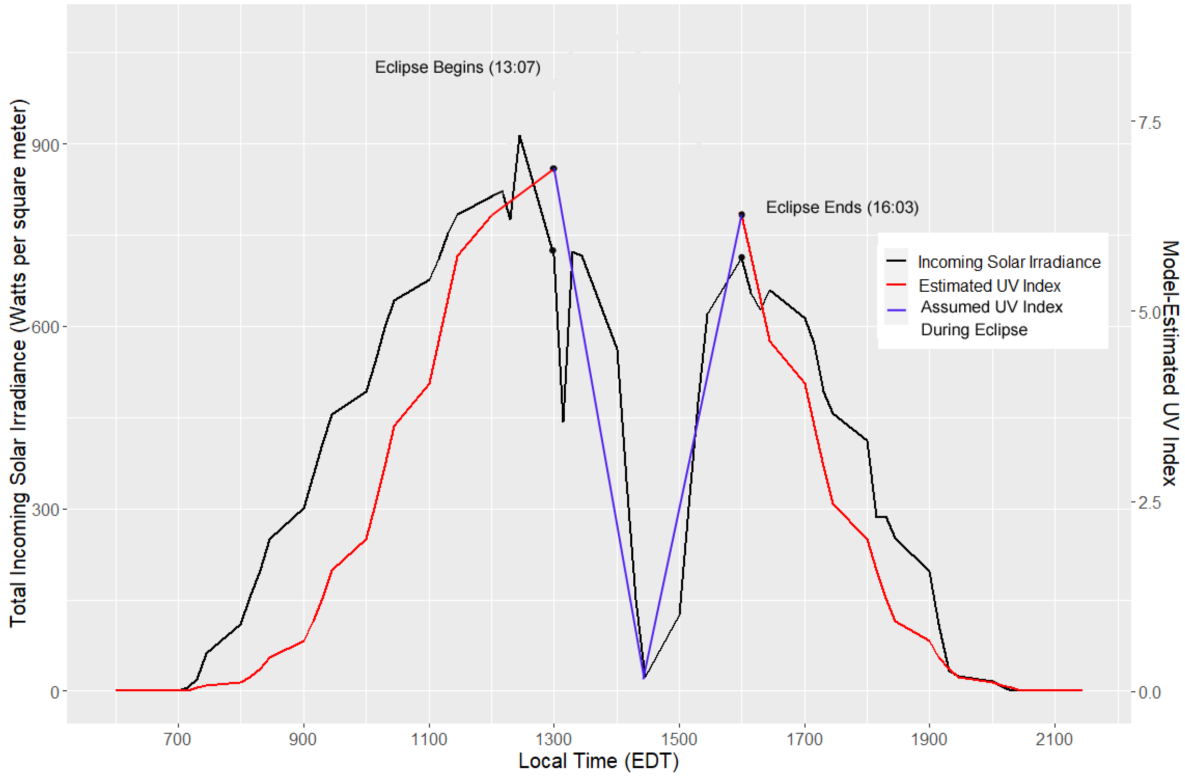

Figure 2. Total incoming solar irradiance and model-estimated UV index near the research site on 21 August 2017. Note that dots on each graph mark the beginning and end of the eclipse.

We used Diffey's [15] solar spectral irradiance model to estimate the ultraviolet index (UVI) for 21 August 2017 in Athens, Georgia. This model takes as inputs the month and day, the latitude of the site, and the local solar time. Diffey's model accounts for airmass and ozone thickness. We felt justified in using this model because the day was clear, except for some brief passing clouds at 12:00 and again at 13:00. The model-estimated UVI is depicted as a solid red line in Figure 2. Figure 2 shows that the UVI was in the range of 6 to 7 (classified as high by the WHO [16]) regarding exposure risk for sunburn in the late morning and midday hours (11:00 to 13:00) leading up to the eclipse.

To calculate the approximate UVI-hour dose that a person may have received if they watched the eclipse from start to end, we assumed a uniform decline in the UVI from a value of 7 at 13:07 to a value of 0 at 14:38 (EDT, maxima). Similarly, we assumed a uniform increase in UVI from 0 at 14:38 to 6.26 at 16:03. This is depicted by a blue line in Figure 2. The area under the blue portion of UVI graph from 13:07 to 16:03 EDT corresponds to the UVI-hour dose according to Kiedron et al. [17]. We calculated that being outside to observe the eclipse from beginning to end would result in a dose of 9.7 UVI-hours (the equivalent of one hour's exposure to a UVI value of 9.7), which is characterized as Very High by the WHO [16]. Alternatively, we calculated the UVI dose that would be received if a person were to watch the eclipse for two hours, starting at the first occlusion of the sun to the maxima (taking approximately one and a half hours) to 30 min after the maxima. This calculation resulted in an estimated dose of 6.6 UVI-hours. Observing the eclipse for one hour centered around the maxima resulted in a dose of 3.3 UVI-hours (Moderate risk).

Climatologicallly, August is the second warmest month of the year on average and, for 2017, it was the month with the highest observed percentage of possible recorded sunshine (75%, considering cloud cover) and was the month with the highest mean value of relative humidity (76%) [18]. Figure 3 depicts the temperature, heat index (HI), and wet-bulb globe temperature (WBGT) at 15-min intervals from 10:00 to 19:00 local time. This meteorological data, also from the research station at Watkinsville, shows that 21 August was a hot and somewhat humid day. In the time approaching the eclipse interval, the ambient air temperatures were in the upper 80's °F, the HI's were in the mid 90's °F and the WBGT's were in the low 80's °F. According to the National Weather Service, heat indices in the mid 90's warrant "Extreme Caution" because heat cramps, heat stroke, heat exhaustion are possible with physical activity or prolonged exposure to the heat conditions [19]. The WBGT values during the eclipse (for the southeastern United States) posed a "Moderate Threat" according to the National Weather Service [20,21]. Such a moderate threat means that working or exercising in direct sunlight for more than 30 min will stress the body.

Figure 3. Profile of temperature, heat index (HI) and wet-bulb global temperature (WBGT) near the research site on 21 August 2017.

1.3. Research Questions

The weather of the eclipse day brought conditions that were both conducive to viewing as well as seasonably warm and humid. Given this combination of possible sun exposure around the eclipse and the warm thermal environment, we wanted to investigate three questions through a survey of people who observed the eclipse in Athens, Georgia:

1. What types of skin protective precautions did people take during the eclipse?
2. How long did people report they were exposed to the sun during the eclipse event?
3. Where people exposed to the sun radiation longer than they estimated it would take for them to receive a sunburn?

We investigated these research questions through a self-report survey of people who observed the eclipse while outside.

2. Materials and Methods

2.1. Participants & Procedures

Participation in the study was voluntary. The incentive for the study (for participants and non-participants) was entry in a randomized drawing to receive one of five $50 Amazon gift cards. The participants were sent an email that briefly described the study and that solicited their participation. The survey items were implemented via the Qualtrics platform.

The data collection began shortly after the eclipse and continued for approximately one month. By 27 September 2017, 95% of the data had been collected. The survey, consent and debriefing forms, and procedures were reviewed and approved by the University of Georgia Institutional Review Board (Approval: STUDY00005042).

2.2. Survey

The survey consisted of 20 items that solicited information about the participants' eclipse viewing location (Athens versus other locations) and the time spent outdoors during the eclipse event. The survey also inquired about sun exposure safety precautions, typical skin response to one hour of sun exposure at the beginning of the summer without the use of sunscreen (3 levels: burn, then peel; burn, then tan, and tan only), typical tan level after summer exposure (4 levels: dark tan; medium tan; light tan; and practically no tan at all). The last section of the survey inquired about demographic characteristics (age, gender, race). Items that solicited information about time estimates of being outside in the sun during the eclipse or time spent looking through eclipse glasses were operationalized through a visual analog scale in which people could click on and then move a slider to indicate their response. Skin response to the sun and similar categorical items were implemented with clickable radio buttons. There were eight sun protective behaviors which we incorporated from Melanoma Research Foundation [22] web page on prevention. For each of the eight items, respondents were asked to indicate "yes" or "no" if they took the precaution while observing the eclipse. The demographic items were placed at the end of the survey, just before the completion and debriefing message. The survey required approximately five minutes for completion.

2.3. Data Analysis

We primarily used descriptive statistics given the exploratory nature of the research. This means that for categorical variables (e. g., typical skin response to sun exposure, sun protective measures undertaken), we calculated totals and percentages. For quantitative variables (time spent outside in the sun observing the eclipse, time at which people usual sunburn) we calculated descriptive statistics. Because the distributions for quantitative variables were quite skewed and deviated from normality, we used non-parametric methods to check for possible statistically significant differences among the quantitative variables having to do with time estimations. We conducted the analyses with the R Statistics Package and the nparLD library [23,24].

3. Results

3.1. Sample Characteristics

The research participants were 1014 students who viewed the eclipse at or near the University of Georgia campus in Athens, Georgia. The sample was 18% men and included 82% White, 9% Asian, 5% Black, 2% Hispanic and 2% Other. We were deliberate about including non-White people because they also experience risks (although somewhat lower) for sun-related cancer [9,11]. The participants' ages ranged from 18 to 64 years (M = 23.3 years, Mdn = 21 years, SD = 5.7 years). Because the sample consisted of university students, the participants generally were young in age; only 2.7% of the participants were aged 40 years or greater. Because the eclipse occurred at the end of the summer, we asked the respondents to indicate the level of tan that they usually have at the end of summer. People reported their tan using four levels: 1. Dark tan (15.0%); 2. Medium tan (37.3%); 3. Light tan (34.6%); and 4. Practically no tan (13.1%). A chi-square test of independence revealed that level of tan depended upon gender, X^2 (N = 1014, df = 3) = 10.97, p = 0.01. Proportionately more women indicated they would possess a dark tan at the end of summer than was the case for men. Similarly, comparatively more men possessed a light tan at the end of summer than women did.

We asked the participants to indicate the response of their skin if it were exposed without any protection to one hour of midday summer sun. There were three response options: 1. Burn then peel (27% of respondent); 2. Burn then tan (42%); and 3. Tan only (31%). Inquiring about the skin's responsiveness to the sun in this manner is a more effective way to gauge the potentially hazardous effects of UVR than inquiring about skin color or tone [25]. We observed that the level of tan at the end of the summer was statistically dependent upon the type of skin response to UVR, X^2 (N = 1014, df = 6) = 232.31, $p < 0.0001$. People who reported that their skin typically burns and then peels indicated that they would have either a light tan or no tan at all (80%). Conversely, those who either burned then tanned (59.9%) or who tanned only (70.6%) reported higher proportions of medium or dark tan levels at the end of the summer. The response of the participants skin and their gender were not statistically dependent upon each other, $p = 0.58$.

3.2. UVR Exposure and Skin Protective Behaviors during the Eclipse

Table 1 provides the descriptive statistics for peoples' sun exposure while observing the eclipse. We organized Table 1 according to the response of unprotected skin to one hour of midday summer sun exposure. We asked the participants to provide an estimate of the amount of time in minutes that would be required for them to receive a sunburn without using any UVR protection. This survey item had two functions, the first of which was as a check for peoples' replies about the response of their skin to one hour of sun exposure. We expected that people who indicated that they would burn and then peel would require briefer sun exposure before sunburn occurred compared to people who would tan only. Second, we wanted to compare this time-to-sunburn to the amount of time people reported being outside in the sun to observe the eclipse.

Table 1. UVR Exposure During the Eclipse.

Survey Item	Response of Unprotected Skin to One Hour of Midday Sun Exposure at Beginning of Summer			All Participants *
	Burn then Peel	Burn then Tan	Tan Only	
Number of Participants (%) *	277 (27%)	421 (42%)	316 (31%)	1014 (100%)
Estimated time (minutes) required for sunburn to occur without protection in midday summer sun without protection. Mean/SD (Mdn)	36.42/21.23 (30)	49.79/26.61 (45)	82.11/33/16 (84)	56.08/32.67 (50)
Minutes spent outside in the sun observing the eclipse. Mean/SD (Mdn)	54.44/38.11 (48)	63.68/39.02 (60)	60.90/39.88 (59)	60.29/39.16 (60)
Minutes spent looking directly at the sun through eclipse glasses. Mean/SD (Mdn)	9.03/8.19 (6)	9.53/9.35 (6)	9.82/8.82 (7)	9.48/8.88 (6)

Note: * Percentage calculations based upon the entire sample of 1014 participants.

There was consistency in peoples' knowledge of their skin responsiveness to UVR exposure and the time that they estimated would be necessary for a sunburn to occur (see Table 1, second row). People who reported that they typically burn then peel estimated a mean of 36.42 min for sunburn to occur compared to progressively longer intervals for burn then tan (47.79 min) and tan only (82.11 min). A Kruskal–Wallis test of the difference in the median values of time-to sunburn was statistically significant, X^2 (N = 1014, df = 2) = 293.25, $p < 0.0001$. Wilcoxon Z tests revealed that all three pairs of medians differed significantly from each other (all $p < 0.0001$).

The third row of Table 1 shows summary statistics for the time people reported spending outside in the sun observing the eclipse. In the three skin response groups, the time spent outside ranged from 1 to 120 min. We checked for statistically significant differences in the median values of peoples' reports of actual time spent in the sun as this may also relate to some awareness of the way that their skin would respond to UVR exposure. Again, the overall Kruskal–Wallis test indicated differences in the median values, X^2 (N = 1014, df = 2) = 9.48, $p = 0.009$. The Wilcoxon Z test indicated that people who burn then peel reported significantly less time observing the eclipse in the sun than did people who burned then tanned, ($p = 0.006$).

We conducted a nonparametric split-plot analysis of variance to examine the differences in the time spent outside observing the eclipse to the estimated time for a sunburn to occur (the repeated/within-subjects factor, 2-levels) as a function of skin response to sun exposure (between subjects factor, 3-levels). This analysis was conducted using the R Statistics Package using the nparLD library [23,24]. The nparLD package offers a Wald-type statistic (WTS) as a test statistic for the interaction and main effects of the within and the between-subjects variables; the WTS has an asymptotic X^2 distribution [24]. We observed that differences in time spent observing the eclipse and estimated time for sunburn to occur depended upon skin response, WTS (2 df) = 135.18, $p < 0.0001$. People who burn then peel and burn then tan spent a significantly longer amount of time outside observing the eclipse that they estimated was necessary for them to receive a sunburn. In contrast, people who tan only observed the eclipse for a shorter interval of time than was necessary for them to receive a sunburn (see Table 1).

There was much more uniformity in the time spent looking at the eclipse with eclipse glasses. People looked at the eclipse, on average, between 9 min to 9 min, 45 s. NASA-related eclipse safety guidelines along with instructions on some eclipse glasses recommended using the glasses continuously for three minutes, intermittently over several hours [for further information please see: https://eclipse2017.nasa.gov/safety (accessed on 12 August 2022) and https://eclipseglasses.com (accessed on 12 August 2022)]. There were no statistically significant differences in the time spent using eclipse glasses according to skin response type, gender, or race.

Table 2 depicts the type of sun protective measures that the respondents performed, organized according to reported skin response type. By a wide margin, the most common protective measure, which was more for the eyes than the skin, was the wearing of sunglasses (see Table 2). The next two most frequent measures involved wearing a short sleeve shirt or cover-up to protect the skin followed by seeking shade under an umbrella, tree, or shelter; slightly under one-half of the participants reported taking these precautions. The proportion of people within all skin response categories who took the remaining measures (wearing sunscreen in the sun or the shade, wearing protective clothing, wearing a hat, or wearing a long sleeve shirt to protect the skin) dropped off precipitously. Only 8.5% of people wore a full brim hat to protect the face and ear regions and 4.5% wore a long sleeve shirt (see Table 2). The frequency of use of these measures was rather uniform within the three skin response groups.

We summed the number of "yes" responses people made for the protective measures within each skin response group. The bottom row of Table 2 presents the descriptive statistics. Somewhat disconcertingly, the respondents reported taking only two or slightly more protective measures on average. We observed that people within the three skin response groups differed with respect to the total number of precautions taken. X^2 (N = 1014, df = 2) = 12.84, $p = 0.002$. People who burn then peel ($p = 0.002$) and those who burn then tan ($p = 0.03$) took more precautions than people who tan only. There were no statistically significant differences in the number of precautions taken during the eclipse according to the participants' gender or race.

Table 2. UVR Protective Measures Taken During the Eclipse.

Sun Protective Measures Taken During the Eclipse	Response of Unprotected Skin to One Hour of Midday Sun Exposure at Beginning of Summer **			All Participants *
	Burn then Peel	Burn then Tan	Tan Only	
Wore sunglasses to protect eyes from the sun	196 (70.8%)	303 (72.0%)	216 (68.4%)	70.5%
Wore a short sleeve shirt or cover-up to protect skin from the sun	133 (48.0%)	205 (48.7%)	129 (40.8)	46.0%
Sought shade under an umbrella, tree or other shelter to seek relief from the sun	137 (49.5%)	182 (43.2%)	142 (44.9%)	45.4%
Put on sunscreen with at least 15 SPF when out in the sun	63 (22.7%)	88 (20.9%)	53 (16.8%)	20.1%
Put on sunscreen to protect skin, even when in the shade	62 (22.4%)	75 (17.8%)	35 (11.1%)	17.0%
Wore protective clothing to protect skin from the sun, even when in the shade	45 (16.3%)	69 (16.4%)	35 (11.1%)	14.7%
Wore a hat with a full brim to protect face (nose, ears, neck) from the sun	27 (9.8%)	32 (7.6%)	27 (8.5%)	8.5%
Wore a long sleeve shirt to protect skin from the sun	14 (5.1%)	20 (4.8%)	12 (3.8%)	4.5%
Total Number of Protective Measures Taken. Mean/SD (Mdn)	2.44/1.52 (2)	2.31/1.44 (2)	2.05/1.37 (2)	2.27/1.45 (2)

Note: * Percentage calculations based upon the entire sample of 1014 participants. ** Percentage calculations based upon the totals within each column (277 for Burn then peel, 421 for Burn then tan, and 316 for Tan only).

3.3. Individuals at Higher Risk

Using information presented in Sections 3.1 and 3.2 above, we enumerated the people who may be at especially high risk for sunburn (and what this implies for longer-term skin health). We identified 133 (13.1%) respondents of the 1014 who: 1. reported that they tended to burn then peel in response to one hour of sun exposure in the summer; 2 reported that at the end of summer that they had either a light tan or no tan at all; and 3. reported that they remained outside in the sun observing the eclipse for a period of time that was longer than is required (for them) to get a sunburn. These people reported taking about three of the eight sun protective measures, with the most frequent behaviors being: 1. wearing sunglasses; 2. wearing a short-sleeve shirt; and 3. seeking shade. Of the 133 people we identified in this higher-risk group, there were 88 (66%) or 8.7% of the 1014 who indicated that they did not use any sunscreen at all while either in the sun or the shade. On average, these 88 participants reported spending over an hour in the sun watching the eclipse (M = 69.1 min, SD = 31.86 min, Mdn = 60.5 min). This interval of time, for light or fair-skinned individuals who did not apply any sunscreen, would substantially increase the likelihood of a sunburn given that we estimated the UVI dose for one hour of exposure during the eclipse to be 3.3 UVI-hours (Moderate risk) [16,26].

4. Discussion

4.1. Implications & Recommendations

To our knowledge this is the first empirical study to examine UVR protective measures—with specific emphasis on the skin—taken during a solar eclipse. The results of this study were noteworthy in several ways, the first of which has to do with the recommendations in the media to take eye-related UVR precautions and the use of both sun glasses and eclipse glasses during the eclipse experience. Here, people took more precautions to protect their eyes and vision (by reporting the use of sunglasses and eclipse glasses) than they did to prevent UV overexposure and sunburn. It was of interest also to note that people reported using their eclipse glasses for nearly ten minutes (which may exceed the recommendations for such eclipse eyewear). The high rate of use of eye protection may have been related, at least in part, to the number of newspaper and media mentions about the necessity of using eye protection during the eclipse.

A second noteworthy result was that peoples' knowledge of their skin's response to the sun was related to the times that they estimated would be required for them to receive a sunburn. One implication of this result is that, perhaps on the basis of past experience, people have some workable knowledge about the amount or time of sun exposure that is necessary for them—given the type of skin they have—that results in a sunburn. Although the possession of this self-knowledge is encouraging, the participants apparently did not rely upon it to limit the time of their sun exposure during the eclipse. One possibility is that given the reduction in UVR as the eclipse progressed to totality, some observers may have relaxed their time-exposure limits that they would have otherwise employed during full-sun. As we presented in Section 1.2 above, however, we estimated that with one hour of eclipse observation, people would be exposed to at least 3.3 UVI-hours.

Perhaps the third and most significant result of this project was the observation that despite knowledge of their skin's responses and the extended exposure to the sun, especially for people that burn then peel or burn then tan, respondents reported a very small number of skin protective measures on average. The modal protective measures were wearing a short sleeve shirt and/or seeking shade. The use of sunscreen, which would have been a significant protective measure, was reported by only 20% of the survey respondents. Perhaps most troubling was the finding that the most vulnerable participants (the 133 individuals discussed above) took minimal protective measures for their skin and did not use sunscreen.

We realize that as a visual astronomical event whose viewing is afforded by fair weather and clear skies, recommendations for eye protections during the eclipse experience is paramount. The eyes can be irreparably damaged to UVR overexposure [9]. We also assert that in addition to being a visual event, eclipses also can be a dermal event if, during clear-sky conditions and in the absence of skin protective behaviors, people experience yet another sunburn that contributes to their lifetime erythemal burden, as Wu and colleagues have described [1,2]. In this regard, many outside events that occur during clear-sky sunny conditions should occasion concern about skin protective measures. Thus, we recommend that those who publicize solar-related events communicate the risks that UVR exposure carries for both the eyes and the skin. We observed that many media reports provided details about eclipse viewing and eye protection, but made no mention about skin protection. The next annular solar eclipse will occur on October 14, 2024 and traverse a path from Oregon southeastward to Texas. Another total solar eclipse will occur on 8 April 2024 in the early afternoon hours and will follows a path from Texas northeastward to Maine, with near-total occlusion occurring near the cities of Dallas, Texas, Cleveland, Ohio, and Buffalo, New York. Hopefully media will highlight the needs to consider skin protection in these future events.

4.2. Limitations

The research in this article possesses several limitations, the first of which pertains to the self-report nature of the survey. Although we contacted people to participate in the suvery immediately after the eclipse, their reports about the amount of time that they spent in the sun may be affected by difficulties in free recall of the eclipse event or in estimating time intervals. This possibility is mitigated somewhat by research comparing free-recall of sun exposure to dosimeter readings that suggests people tend to underestimate the amount of time they were exposed to the sun [27]. Relatedly, although we provided a list of sun-protective measures (which do not require recall, but the somewhat easier task of recollection), it is possible that some people could have inflated the number of precautions that they took in an effort to appear socially desirable. While we did not assess social desirability characteristics in the sample, we suspected that this motive is only minimally operative because of the generally low number of protective measures that people reporting taking. A second limitation of this research stems from the fact that we used a sample of convenience in soliciting participation in the survey. Because of this, it is possible that selection biases could be present (i. e., those interested in natural phenomena or people who are drawn to outdoor social activities) that may not fully reflect the sun-protective behaviors that the general population of adults might follow. A third limitation reflects the geographical location of the study to the southeastern United States, and specfically to within the state of Georgia. With a warmer climate and lower latitude than, for example, Oregon, people in Georgia may have a different relationship with sun protection than people in cooler and less UVR-intense regions. Nonethless, as the first study of its type to examine peoples' observation and sun protective behaviors, we believe the research has value in raising awareness of the need to protect both the eyes and the skin during future eclipse events.

5. Conclusions

We conducted a descriptive and exploratory study of peoples' sun protective behaviors during the 2017 North American eclipse of people within northeast Georgia. As a unique astronomical event, the eclipse was widely publicized and drew many people outside to observe all or some portion of the eclipse. The weather afforded both clear skies and also warm, humid conditions for viewing the mid-afternoon totality. Overall we learned that people took greater precautions to protect their eyes than their skin. The use of sunglasses to protect the eyes from ambient UVR and the use of eclipse glasses were reported with greater frequency than skin protective measures. Probably because the eclipse occurred in mid-August when conditions in Georgia are among the most hot and humid, the most frequent precautions people took were to wear short-sleeved clothing and to seek shade. We also learned that people generally know and are able to report the typical response of their skin to the summer sun and that this knowledge was related to the time people were exposed to sun to observe the eclipse. As both an astronomical and perhaps a social event, people who burn then peel or who burn then tan seem to have been caught up in event and reported being outside in the sun for periods longer than would be necessary for them to receive a sunburn. We identified a subgroup of people who burn then peel who were very susceptible to getting a sunburn given their time exposure to the sun and the relative lack of precautions they took to protect their skin. Our results highlight the need to communicate the dual risks of UVR to both the eyes and the skin in future eclipse events and related outdoor activities.

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