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Erythema and ultraviolet indoor tanning: findings from a diary study

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ABSTRACT

The use of artificial ultraviolet (UV) indoor tanning (IT) beds increases the risk of skin cancer. The IT industry claims IT devices provide users with control over the amount of UV radiation exposure and thus reduces risks of sunburn (i.e., skin erythema) when tanning. This study aims to establish the prevalence and predictors of IT-related erythema using diary data. Six bimonthly diary surveys were administered to 198 female college IT users. Diaries assessed IT use and IT-related erythema. Among participants who used IT, 66 % experienced at least one episode of erythema and nearly one in five IT sessions resulted in skin erythema. Those who reported the most frequent IT use prior to the study were less likely to experience an IT-related erythema on a given IT session compared to the least experienced IT users. Perceived susceptibility to burns from IT use was positively associated with risk of erythema. Erythema was a frequently reported experience among IT users. Implications for policy makers and behavioral medicine practitioners are discussed.

KEYWORDS

Indoor tanning, Tanning beds, Melanoma, Erythema, Prevention, Intervention

Implications

Practice: Behavioral medicine providers need to address the importance of preventing indoor tanning-induced skin erythema to indoor tanning users, particularly among users with higher perceived susceptibility to sunburns.

Policy: Policy makers should be critical of claims from the indoor tanning industry that the use of indoor tanning provides protection from sunburn as erythema is frequently reported among indoor tanning users.

Research: Indoor tanning interventions should contain content designed to encourage users to consider the appearance and health implications of erythema from indoor tanning as well as include erythema as an outcome measure of intervention efficacy in reducing future skin cancer risk.

The incidence of melanoma continues to rise among young women in the United States [1]. Melanoma is now the most common cancer in 25- to 29-year-old women and represents 12 % of all cancers in 20- to 40-year-old women [2]. Intentional exposure to intense and intermittent ultraviolet (UV) radiation, both natural and artificial, may explain this trend [3]. The use of artificial UV indoor tanning (IT) beds has been increasing among women since the late 1980s [2, 4]. Several studies have shown a positive association between IT use and melanoma and other skin cancers [5–7]. For example, a recent case–control study found that 76 % of melanomas in 18–29-year-old individuals who used IT at least once were attributable to IT [7]. IT has been classified as a carcinogen to humans by the World Health Organization's International Agency for Research on Cancer [8, 9].

As a result of the mounting evidence of the risks of IT, legislators and policy makers have begun to consider increasing regulation of IT. In 2011, California became the first US state to ban individuals under the age of 18 from using IT [10]. Currently, more than 30 US states regulate the use of IT among minors [11]. The American Academy of Dermatology Association opposes the use of IT for nonmedical purposes and supports the recommendation by the World Health Organization that IT be banned among minors [9, 12]. Internationally, cosmetic IT is prohibited for minors in some Canadian provinces and in multiple European countries and is completely prohibited in Brazil [13].

In contrast to the policy statements and recommendations of numerous national and international health organizations, there are a number of organizations and groups that advocate for the use of IT for nonmedical purposes. For example, the Indoor Tanning Association (ITA), which represents IT manufacturers, distributors, and facility owners in the United

States, opposes restrictions on IT and claims that the risks of UV exposure from IT have been overstated [14]. The ITA and other IT proponents suggest that the use of IT devices for tanning represents a healthy alternative to sun exposure as users have greater control over the duration and amount of UV exposure [14–16], which reduces the risk of sunburn (referred to generally as erythema). For example, in a March 2010 United States Federal Drug Administration public hearing regarding a possible medical device reclassification of IT [17], a scientist who acknowledged funding from the IT industry stated in a presentation that: "Sunbed use in the United States does not result in sunburning. Therefore, sunbed use is likely akin to chronic sun exposure and should not increase the risk of melanoma." [18]. However, evidence from multiple population-based studies indicates that 17–59 % of IT users report having erythema related to IT [19–23].

Prior studies of the prevalence of IT-related erythema have used long recall latencies regarding the occurrence of erythema. In the current study, we sought to better understand the prevalence and correlates of IT-related erythema by utilizing diary data. Diary data are valuable for understanding temporal relationships, establishing evidence for causal relationships, and determining the IT session-specific and IT user characteristics that influence whether erythema is experienced. This is an important public health issue as erythema is a marker of skin cell DNA mutations that cause programmed cell deaths and can, over a course of years, progress into skin cancer [24]. Epidemiological studies show that UV-induced erythema significantly increases the risk of melanoma and nonmelanoma skin cancers [25–27].

There were three primary aims of this study. The first aim was to establish the prevalence of IT-induced erythema across all individuals during the study period. The second aim was to examine the frequency of IT and IT-related erythema within individual participants across the study period. These two aims provide a sense of the overall frequency of IT-related erythema at the level of both the individual and the sample. The final aim was to determine the IT user-specific and IT session-specific predictors of IT-related erythema for any given individual IT session. Identifying such predictors provides valuable information that clinicians and health educators can use to identify those individuals and IT practices that are most strongly linked to IT-related erythema. We hypothesized that IT users who report more sensitive skin types (i.e., are more likely to burn as a result of UV exposure) and a history of fewer IT sessions would be at an increased risk of erythema. In addition, we expected that increased perceived susceptibility to burns from IT use would be associated with a lower likelihood of erythema as users with high perceived risk would be motivated to take precautions to prevent burns.

METHODS

Sample

Participants were 198 female freshman and sophomore students from two universities in the Northeastern and Southeastern United States (mean age=18.95 years, SD=1.93). Participants served as the randomly assigned, nonintervention control group in an IT intervention efficacy study [28]. Participants were eligible for the study if they reported IT at least once in the previous year (mean IT sessions in the previous 12 months=27.01). The sample was split nearly evenly between the universities (48.2 % of the participants were from the Southeastern University). Students from the two universities did not differ significantly with regard to their skin type, number of IT sessions prior to the diaries, mean number of IT sessions during the diaries, or mean number of erythemas during the diaries. Additional sample demographics and study design information are available elsewhere [28].

Procedure

Participants were recruited by emails sent to a randomly generated list of 1,690 students. Of the 1,690 invited students, 853 participated in a baseline screening survey. Approximately half of those students met eligibility requirements and agreed to participate in the intervention efficacy study (n=455). The final sample size for the current analysis consisted of the 198 control group participants who completed study assessments during the second wave of data collection (the first wave did not contain all of the daily diary measures). Participants completed a study screening survey in October, a pre-diary survey in November, and an email diary every other Sunday starting from January 13th to March 25th (a total of six diaries). The purpose of the screening survey was to identify IT users for entry into the study. The pre-diary survey was used to collect detailed information about participant demographics and cognitions related to IT. The diaries asked participants to recall their IT experiences and erythema for the previous 14 days. The measurement period was chosen to reflect the months of peak IT use for many users [28]. There were minimal rates of diary noncompletion (average of 4.3 % across all diaries). All assessments were administered online and participants were offered monetary incentives for each assessment ($15 for the screening survey, $20 for the pre-diary survey, and $10 for each diary). All participants gave informed consent and all procedures were approved by the Institutional Review Board at each site.

Measures

Screening and pre-diary surveys

Participants estimated how many times they used IT in the past 12 months (screening survey) and past 1 month (pre-diary survey) [29]. Responses were summed to create a measure of IT use in the past 13 months. Response options were coded into

dummy variables based on a quartile split of the response distribution. Perceived susceptibility to burns from IT use was assessed with three items (If I indoor UV tan I am likely to get burned; Indoor UV tanning could leave my skin red; and Indoor UV tanning could leave my skin painful) measured on five-point Likert-type scales (anchored from "strongly disagree" to "strongly agree"). Responses to the three items were averaged and standardized to create a composite measure (α=0.86). Fitzpatrick's skin type [30] measures the tendency for sunburn following sun exposure with lower numbers representing skin that is more susceptible to burning. Specifically, participants were asked whether their skin would burn or tan "if you were to lie in the sun for one hour unprotected in the early summer when you had NO tan." Response options were: "always burn, never turning tan in the week following" (type I), "usually burn, tan (with difficulty) less than average" (type II), "sometimes mildly burn, tan about average" (type II), "rarely burn, tan (with ease) more than average" (type IV), "rarely or never burn, my skin is brown" (type V), and "rarely or never burn, my skin is black" (type VI). Skin type was distributed as follows: I=8 %, II=20 %, III=42 %, IV=27 %, V=4 %, VI=0 %.

Diary IT assessment

Each diary survey asked participants to recall their IT behavior over the previous 14 days and indicate which day(s) they used IT. For each day IT was used, participants were asked the following item: "Did you experience any of the following skin problems related to this tanning session?" Response options included "burned" and "red skin." For the purpose of analyses, an item reflecting IT erythema was created and coded as follows: a 0 if no burn or redness was reported and a 1 if either burn or redness was reported. Participants indicated the number of minutes spent in each IT tanning session and this variable was used to examine the relationship between IT session length and likelihood of erythema. Participants also indicated whether they wore goggles or clothing (bikini tops or bottoms) during the IT session.

A potential concern in the present study is that the erythema measure may be confounded by outside sun exposure. However, several aspects of the study serve to alleviate this concern. First, the data were collected during winter months, making prolonged outdoor sun exposure sufficient to cause sunburn unlikely. Second, the item used to assess erythema asked participants about burns and redness that were specific to IT. Finally, we examined the association between time (i.e., date of reported IT session) and erythema using regression analysis and did not find an association. This suggests that reported erythema were not more common later in the measurement period which represented the beginning of spring and likely increased outdoor sun exposure. There is also a possibility that vacation sun exposure could confound results. However, the erythema questions were specific to those experienced during IT use and we have little reason to believe the use of IT while on vacation is a common occurrence.

Statistical analysis

There were three primary aims of the statistical analysis. The first aim was to determine how often an IT session resulted in erythema in our sample. Descriptive statistics are reported at the IT session-level to describe IT and the prevalence of skin erythema as well as to examine the typical session duration and the use of clothing and goggles. The second aim was to determine the frequency of erythemas considered across all individuals during the entire study period. Individual-level descriptive statistics are presented in order to examine prevalence of erythema across all of the IT users as well as to establish the number of IT sessions and typical use of clothing and goggles during the study period. The final aim was to determine the predictors of IT-related erythema for any given individual IT session. We used hierarchical linear modeling (HLM) with HLM 6.04 software (SSI, Lincolnwood, IL) to analyze the multilevel data consisting of session-level IT variables (level 1) nested within individual-level variables (level 2). The outcome of interest for this analysis was whether or not an individual experienced an erythema during IT sessions. The level 1 variable of interest was the duration of the IT session. The modeling of the level 2 variables of prior IT experience, skin type, and perceived susceptibility to burns from IT represent between-individual differences in the likelihood of experiencing erythema. The erythema outcome variable was binary (0 = no erythema reported, 1 = erythema reported). Accordingly, we utilized the Bernoulli option in HLM 6.04 and specified a binary sampling model and a logit link function was utilized [31]. This analysis produced odds ratios of experiencing erythema conditioned on the model predictors.

RESULTS

Descriptive statistics

Session-level data

A total of 1,429 IT sessions were reported by the 198 participants (Table 1) during the 12-week study period. The sessions lasted an average of 13.95 min (SD=5.57). Around half of the sessions lasted less than 15 min and more than a quarter lasted 20 min or more. Users did not wear any clothing in three-quarters of the sessions and bikini bottoms were the only clothing used in 17.0 % of sessions. Goggles were used in 61.4 % of sessions. Approximately one in five IT sessions resulted in erythema.

Table 1 | Duration, use of clothing and goggles, and skin problems from diary reports of 1,429 indoor tanning sessions

Variable	% of sessions
Duration of indoor tanning session (min)	
Mean=13.95 (SD=5.57)	
Less than 10 min	22.1
10 min	16.2
11 to 14 min	12.7
15 min	15.4
16 to 19 min	4.6
20 min	26.5
More than 20 min	2.4
Use of clothing	
Nothing (indoor tan in the nude)	77.3
Bikini bottoms only	17.0
Bikini top only	1.7
Bikini bottoms and top	3.9
Use of goggles	
Yes	61.4
No	38.6
Erythema from session	
Yes	18.8
No	81.2

Individual-level data

Table 2 provides information about IT sessions averaged across participants. Just over a third of participants did not engage in IT during the diary assessment period (37.1 %). An additional third of the sample used IT one to ten times and 11.9 % reported more than 20 sessions. Among participants who reported IT at least once during the measurement period, nearly half did not use any form of clothing during any IT session. Less than half wore goggles at every IT session and 26.0 % did not use goggles once. The majority of participants (66.1 %) reported at least one episode of IT-related erythema, 50.5 % reported two or more episodes, and 36.3 % reported experiencing erythema three or more times. There was a positive association between the number of IT sessions and number of erythemas (r=.42, p<.001).

Multilevel model

The IT session duration (session-level variable) and the individual-level variables of prior IT experience, skin type, and perceived susceptibility to burns from

Table 2 | Participant-level data on indoor tanning sessions, use of clothing and goggles, and skin problems from diary reports across a 12-week period

Variable	% of sample
Number of indoor tanning sessions	
0	37.1
1–10	34.7
11–20	16.3
≥21	11.9
Use of clothing[a]	
Did not use clothing once	46.8
Used clothing at each session	28.3
Use of goggles[a]	
Did not use goggles at all	26.0
Used goggles at each session	48.1
Number of reported erythema from indoor tanning[a]	
0	33.9
1	15.7
2	14.2
3	13.4
4	4.7
≥5	18.2

[a] Only participants who reported at least one indoor session were included in these descriptive statistics

IT were used to predict IT-related erythema (see Table 3). Holding the individual level factors constant, IT session duration was not significantly associated with erythema. The parameters for the remaining variables represent the main effects of individual-level variables on the likelihood of experiencing erythema across participants. There were no significant differences in the odds of erythema for those who reported ten to 20 or 21–40 pre-diary IT sessions compared to those reporting one to nine sessions. However, participants who reported more than 40 prior IT sessions were less likely to experience erythema compared to those reporting one to nine prior IT sessions. When considered together as a single, ordinal variable, there was a significant trend for the prior IT use category variable (OR=0.74, $p<.05$). Skin type was not significantly associated with reports of IT-related erythema. Greater perceived susceptibility to burns from IT was significantly associated with reports of IT-related erythema. We tested for interactions between the individual-level variables and duration of IT session to assess for evidence of moderating effects on IT erythema. No significant interactions were found.

DISCUSSION

Erythema was a relatively common event, resulting from nearly one in five IT sessions. When considered across individuals, the majority of those who used IT during the study experienced at least one episode of erythema. The erythema rates found in the current study, which involved 12 weeks of assessments, were similar to those reported in several population-based studies that focused on IT-related erythema over a 1-year period [21–23]. The findings of our study contradict assertions from IT proponents that the so-called controlled exposure provided by IT devices results in minimal risk of burn [14–16]. Policy makers need to be aware that despite the claims from the IT industry, erythema is a common experience from IT use. The Federal Trade Commission recently prohibited the ITA from making several claims that the FTC deemed to be false health and safety claims [32]. Policy makers should also consider explicitly limiting the claim that IT does not result in sunburns. Although the current study focused on young adults, these findings support the need to restrict access to IT in minors, as their skin is particularly sensitive to the damaging effect of UV exposure.

Participants who reported using IT at the highest levels prior to the study had a significantly lower risk of experiencing IT-related erythema despite reporting the highest mean number of sessions during the study period. This suggests experienced IT users may learn to adjust their IT exposure pattern to reduce their risk of IT-related erythema compared to those least experienced users. Future work is needed to examine whether experienced users have learned to use IT devices in a way that limits their burn risk. Findings also indicated perceived susceptibility to burns from IT was positively associated with risk of erythema. In an attempt to clarify this finding, we examined the relationship between perceived susceptibility and having a more sensitive skin type and found a significant moderate correlation ($r=.53$, $p<.01$) between the variables. Individuals with more sensitive skin may be accurate in their assessment of their risk for IT-related erythema given their inability to tan but are not able to prevent such burns. Alternatively, they might think erythema is a necessary and worthwhile precursor to gaining a tan rather than a consequence to be avoided. Prevention efforts should target and seek to understand the decision-making of these individuals as their sensitive skin type puts them at increased risk for skin cancer [12]. Sunless tanning options should be promoted as a way to get tanned without putting one's skin at risk for erythema.

The current study highlights the importance of considering erythema as an important aspect of patient education and prevention programs regarding IT. Clinicians and those developing interventions should encourage IT users to refrain from all IT as a primary goal. However, among individuals

Table 3 | Multilevel multivariate predictors of indoor tanning-related erythema

Variable	Odds ratio	95 % CI	p
Minutes of indoor tanning session[a]	1.00	(0.94, 1.03)	0.932
Prior indoor tanning experience (ref.: 1–9 sessions)			
10–20 sessions	0.59	(0.23, 1.51)	0.272
21–40 sessions	0.51	(0.22, 1.20)	0.119
>40 sessions	0.38	(0.16, 0.91)	0.029
Skin type (ref: type I)			
Type II	0.86	(0.20, 3.76)	0.837
Type III	1.04	(0.25, 4.35)	0.960
Types IV and V	0.46	(0.10, 2.18)	0.326
Perceived susceptibility to sunburns from indoor tanning[b]	1.33	(1.01, 1.78)	0.046

Erythema outcome was coded 0 = no sunburn or skin redness and 1 = either sunburn or skin redness

[a] Session-specific variable

[b] The perceived susceptibility to sunburn variable was standardized

who are reluctant to abstain from IT, it may be appropriate to adopt a harm reduction approach of emphasizing the importance of avoiding erythema from IT. IT users should be encouraged to consider the appearance and health implications of experiencing a dose of UV radiation that is sufficiently high to produce erythema. In general, interventions designed to reduce IT behaviors have not focused on erythema as an outcome [28, 33–35]. This shortcoming should be addressed in future studies. We also note that although erythema is a marker for excessive and skin cell-damaging UV exposure, erythema is not necessary for the harmful DNA damage that can lead to skin carcinogenesis. Any tanning resulting from UV exposure is a sign of DNA damage. There is no such thing as a safe tan and the priority of any skin cancer prevention public health message should be to encourage young people to eliminate all intentional UV exposure for the purpose of tanning [36].

The duration of IT sessions was not significantly associated with the risk of erythema. It is possible that differences in type of IT device used could account for this result. For example, 20 min in an IT device with relatively low intensity UV light bulbs may lead to less total UV exposure compared to 15 min in a high intensity device. Further, people may be knowingly limiting their exposure time when using high UV intensity devices. These findings also suggest even short IT sessions can lead to erythema. Information about type of IT device was not collected from participants and future studies should consider collecting such information. It is of concern that goggles were not used in a large portion of IT sessions and one in four IT users did not use goggles for any of their sessions. These rates of goggle usage are similar to those found in a survey of Minnesota high school students [20]. The use of goggles during IT is critical as UV radiation can cause significant acute and chronic eye damage.

Limitations

The limitations of the current study include the focus on a female college sample, although research indicates this group has among the highest rates of IT use [35, 37]. Information was not collected about the type of IT devices used, which limits the inferences that can be made about the relationship between the duration of IT sessions and erythema. The data on IT-related erythema were collected via self-report measures. However, erythema is a memorable and distinct event, which reduces the likelihood of misreporting [38]. The use of self-report measures of behaviors and outcomes remains the standard approach in the skin cancer prevention field [39]. Diary data collection is a preferred method for studying the within-person processes addressed in the current paper but these methods are not without limitations. Diaries do not eliminate the potential for inaccuracies in reporting behavior and require a high level of participant commitment [40]. There is also the potential for participants to alter their behavior as a function of participating in the study but there is little evidence for such effects [40].

CONCLUSIONS

Erythema was a frequently reported experience among IT users. Experienced IT users had a significantly reduced risk of erythema compared to those who reported less use. Higher rates of perceived susceptibility to burn from IT were positively associated with IT-related erythema. These findings contradict the IT industry's claim that risks of sunburn are minimal with IT. Clinicians and researchers designing IT intervention programs should address the importance of avoiding erythema among IT users.

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