



Results of a social media campaign to prevent indoor tanning by teens: A randomized controlled trial

David B. Buller^{a,*}, Sherry Pagoto^b, Katie Baker^c, Barbara J. Walkosz^a, Joel Hillhouse^c, Kimberly L. Henry^d, Julia Berteletti^a, Jessica Bibeau^b

^a Klein Buendel, Inc., 1667 Cole Boulevard, Suite 225, Golden, CO 80401, United States

^b Department of Allied Health Sciences, Koons Hall, University of Connecticut, Storrs, CT 06269, United States

^c Department of Community and Behavioral Health, College of Public Health, Lamb Hall, Suite 300, East Tennessee State University, Johnson City, TN 37614, United States

^d Department of Psychology, Colorado State University, Ft. Collins, CO 80523, United States

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ABSTRACT

Indoor tanning (IT) increases risk of developing skin cancer. A social media campaign to reduce mother's permissiveness toward their teenage daughters IT was evaluated. Mothers (N = 869) of daughters aged 14–17 in 34 states without bans on IT by minors were enrolled in a randomized trial with assessments at baseline and 12-months follow-up in 2017–19. A year-long adolescent health campaign was delivered to all mothers. The intervention group received posts on preventing IT and the control group, posts about preventing prescription drug misuse. Daughters (n = 469; 54.0%) completed the assessments at baseline and 12 months. At 12-month follow-up, intervention-group mothers were less permissive of IT by daughters (unadjusted means = 1.70 [95% CI: 1.59, 1.80] v. 1.85 [1.73, 1.97] [5-point Likert scale], b = -0.152), reported more communication about avoiding IT with daughters (4.09 [3.84, 4.35] v. 3.42 [3.16, 3.68] [sum of 7 yes/no items], b = 0.213), and had lower intentions to indoor tan (1.41 [1.28, 1.55] v. 1.60 [1.43, 1.76] [7-point likelihood scale], b = -0.221) than control-group mothers. Daughters confirmed intervention-group mothers communicated about IT (3.81 [3.49, 4.14] v. 3.20 [2.87, 3.53] [sum of 7 yes/no items], b = 0.237) and shared IT posts (unadjusted percentages = 52.4% v. 36.4%, b = 0.438) more than control-group mothers. No differences were found in IT behavior, self-efficacy to refuse permission, and negative attitudes toward IT. A social media campaign may be an effective strategy to convince mothers to withhold permission for IT, which may help increase the effectiveness of state laws designed to reduce IT by minors by requiring parental permission.

1. Introduction

Indoor tanning (IT) increases risk of developing melanoma, the most common cancer in women aged 25–29 (Little and Eide, 2012), and keratinocyte carcinomas (Burgard et al., 2018; Gandini et al., 2019; O'Sullivan et al., 2019), and remains popular with some US teen girls (Centers for Disease Control and Prevention, 2020; Niu et al., 2018; Turrisi et al., 2012; Holman et al., 2013; Hillhouse et al., 2017). IT interventions directed at tanners via print materials, websites, and UV photography have been effective, especially appearance-focused interventions (Turrisi et al., 2012; Persson et al., 2018). However, they may be less effective in practice because indoor tanners may have low motivation to access and read them and UV photography equipment is

not widely available. Social media can reach many Americans, allow users to share experiences, seek advice, and support each other (Sutton, 2018; Majority of Adults Look Online for Health Information, 2013), and disseminate IT prevention widely. Social media interventions on weight loss, condom use, physical activity, and HIV testing have been effective (Cavallo et al., 2012; Napolitano et al., 2013; Young et al., 2013; Bull et al., 2012).

Mothers may be important factors in teen daughters' tanning initiation and tanning norms (Stryker et al., 2004; Baker et al., 2010). Discussions of IT among mothers and daughters vary and sometimes minimize risk, especially if the mother tans (Gordon et al., 2016; Magee et al., 2007). Activating mothers to disapprove of and resist IT could provoke communication with daughters that reduces perceived benefits,

* Corresponding author.

E-mail address: dbuller@kleinbuendel.com (D.B. Buller).

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increases perceived harms and norms to avoid IT, and encourages compliance with public controls on IT (e.g., parental permission requirements). Only two previous studies have tested interventions that reduced mothers permissiveness for IT, one conveying IT health risks, misconceptions, parental influence, industry tactics, and communication skills (Lazovich et al., 2013) and another addressing IT attitudes, appearance beliefs, alternatives, appearance damage, health effects, and normative beliefs, maternal modeling of IT, and IT-specific communication. (Baker, 2013) We evaluated the first social media campaign aimed at mothers' permissiveness for IT to prevent IT by daughters, testing these hypotheses:

H1: The social media campaign on IT will statistically significantly reduce (a) mother's permissiveness regarding their daughter's IT, (b) their daughter's perception of maternal permissiveness toward IT, and (c) both mother's and daughter's IT relative to the control condition.

H2: A statistically significantly greater number of mothers will support a ban on IT for minors in the intervention group compared to the control condition.

2. Method

All study protocols were approved by the Western Institutional Review Board (IRB) and the IRBs at East Tennessee State University and University of Connecticut.

2.1. Participants

Participants were mothers of teenage daughters, enrolled between May 2017 and June 2018. Inclusion criteria included (1) having a daughter aged 14 to 17, (2) living in one of 34 states without a complete ban on IT by minors (i.e., 6 – no restrictions; 2 – age restrictions; 14 – parental permission; and 12 – age restrictions and parental permission), (3) reading English, (4) having a Facebook account and logging in at least once per week, and 5) willing to “friend” the project's community manager to join a private Facebook group. Ethnic minority mothers were included but not specifically recruited because skin type does not perfectly align with race/ethnicity and public policy requires broad support. Given variable onset of IT among teens, history of IT was not required. Initially, mothers were recruited in Tennessee using community-based methods (through Coordinated School Health coordinators, at community events, and with outcalls). When these methods were insufficient, Qualtrics recruited mothers from its survey panel in 33 other states. All mothers received a social media feed and were blind to treatment, being told they would receive information on adolescent health and mother-daughter communication. Statistical power calculations were revised from a clustered design based on participants within schools to a unclustered recruitment of mothers; a target sample size of 860 would achieve 80% power for small to moderate effects.

Once mothers were recruited, attempts were made to enroll their daughters to complete assessments. Since the intervention was not delivered to daughters, and to avoid a major recruitment barrier, daughters' participation was not required. Mothers provided parental consent and daughters, informed assent. In families with multiple age-eligible daughters, the one with the nearest birthday was selected.

2.2. Trial design

Mothers were enrolled in a randomized controlled trial. Following baseline survey, mothers were randomized into intervention or control conditions by the project biostatistician, using a permuted-block randomization (block size = 2). Mothers “friended” the project community moderator and were added into the assigned Facebook private group. All participants received a feed of messages on health topics,

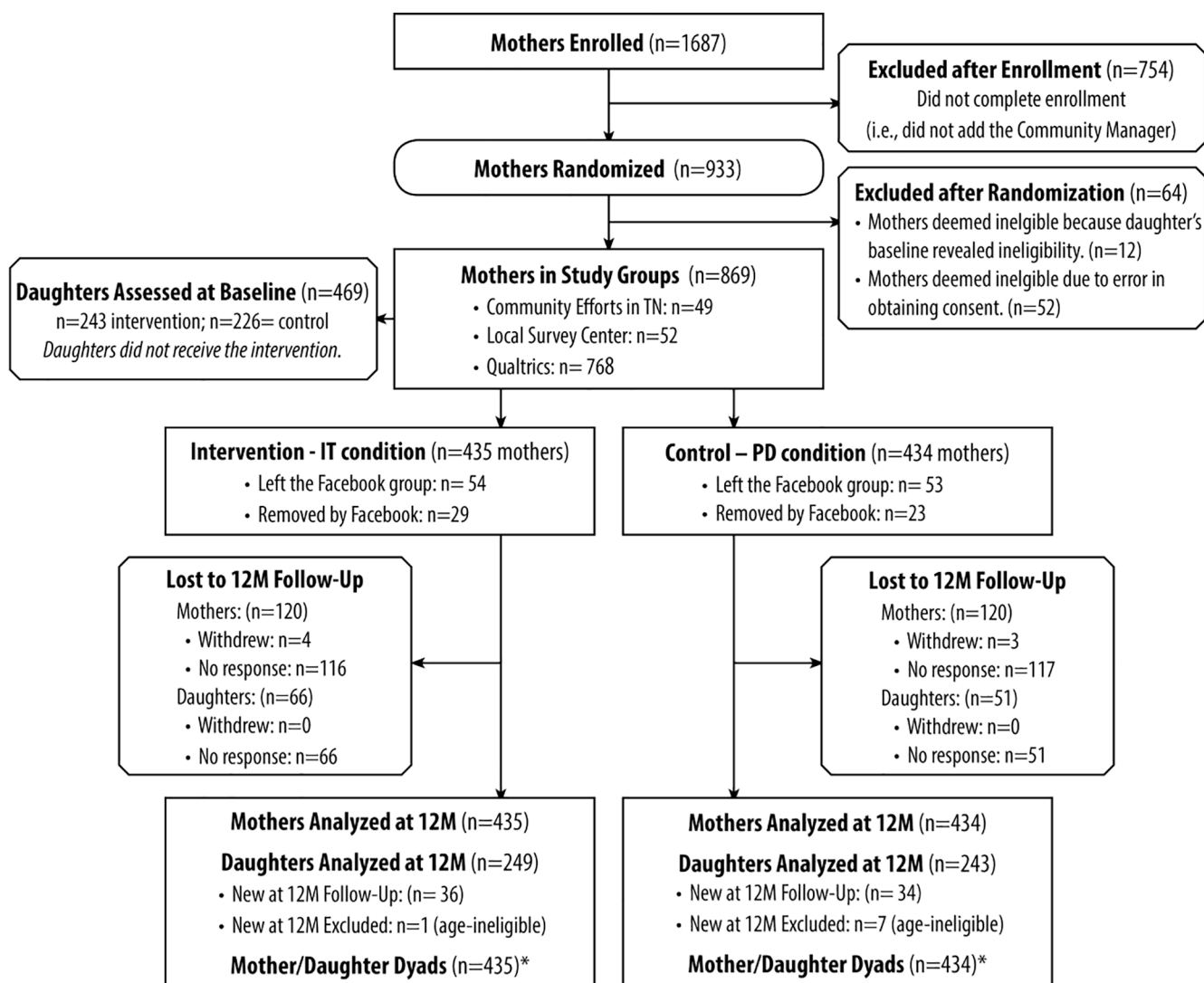
mother-daughter communication, and relevant current events, which included posts on preventing IT (intervention) or prescription drug misuse (control). Study staff, other than the community moderator and program manager, were blinded. Mothers stayed in the group for 12 months and completed posttest surveys at 12-months post-randomization. Retention was achieved by asking mothers who left the private groups to re-join, alerting mothers to upcoming posttest, and compensating mothers for assessments (\$40 for baseline; \$20 for posttest). Daughters were invited to complete the baseline survey and 12-month posttest (compensation=\$20 and \$15, respectively). Daughters did not receive any intervention.

2.3. Intervention

The intervention, named *Health Chat*, was designed by the research team based on social cognitive theory (SCT) (Bandura, 2004), transportation theory (TT) (Green, 2006), and diffusion of innovations theory (DIT) (Rogers, 2003). From SCT, posts addressed the social situation (social norms not to indoor tan or give permission for daughter to tan), behavioral capability (knowledge of risks of IT and skills to refuse IT requests), expectations (beliefs that IT increases risk for melanoma), observational learning (stories about dangers of IT), self-efficacy to avoid IT (how to have daughter refuse IT invitations), and alternatives to IT (e.g., sunless tanners). Posts provided mothers with skills for communicating with teens (e.g., active listening, self-disclosure, empathy, and conflict management). From TT, a number of posts linked to narratives from mothers and daughters about IT risks, not giving permission, and avoiding IT, to capitalize on transportation and identification effects of stories (Green, 2006; Slater et al., 2003). To increase mothers' engagement, posts referenced current events and public figures and encouraged mothers to react to (e.g., like) and comment on posts to capitalize on social comparison processes that can build norms (Suls and Miller, 1977; Turner and Killian, 1992). Posts included social norms-based, appearance-based, and health-risk messaging. Messages were created by investigators and reviewed by the entire team for acceptability and readability. Revised messages were pretested in a pilot feed with mothers (n = 90) not in the trial and refined to enhance aesthetics, clarity, and engagement. Messages were also developed during the intervention period, to incorporate current events.

Approximately 84% of posts addressed mother-daughter communication and adolescent health topics that mothers indicated were of interest in formative research, they engaged with during pilot testing, or emerged in mothers' own comments on posts. Topics included mental health (e.g., stress and bullying), vaccinations (e.g., influenza and human papillomavirus), substance use (e.g., alcohol, cannabis, and tobacco), healthy lifestyles (e.g., physical activity and nutrition), media literacy, and general parenting (e.g., college preparation).

For the experimental manipulation, about 16% of posts focused on preventing IT (intervention group) or prescription drug misuse (control group). Initially, these topics constituted 25% of posts but the rate was reduced when mothers indicated topic fatigue and engagement declined. IT posts were intended to: (1) increase awareness of state IT policy and teen interest in IT, (2) elevate knowledge of IT risks, (3) improve mothers' self-efficacy for resisting daughters' IT requests (e.g., addressing sensitive topics and managing conflict), (4) call for modeling tanning avoidance, (5) convey reasons adolescent girls indoor tan (e.g., stress reduction; peer pressure), (6) promote behavioral alternatives (e.g., appearance-enhancing activities and stress coping) (Pagoto et al., 2010) and (7) increase tanning avoidance and sun safety. Posts were based on literature on risk factors, evidence-based IT interventions (Hillhouse et al., 2017; Mays and Zhao, 2016; Pagoto et al., 2010; Baker, 2013), government and non-profit organizations' messages (e.g., Centers for Disease Control and Prevention), and investigator-developed video interviews with mothers and professionals about IT risks, skin cancer, and mother-daughter communication. Posts on prescription drug misuse were created for the control group, with the same objectives



*Structural Equation Models were fit at the level of the dyad.

Fig. 1. CONSORT diagram for randomized trial.

as the IT posts and consulting East Tennessee State University's Addiction Science Center and relevant websites. Prescription drug misuse was selected because, (a) it was unrelated to tanning and (b) it was an emerging issue of interest.

Health Chat was delivered in two private Facebook groups. Posts, comments, reactions, and membership were not viewable to or sharable with Facebook users outside the group, which prevented contamination. Messages were posted twice a day to each group (~710 total posts) over 12 months, with 2–3 posts per week on preventing IT (intervention) or prescription drug misuse (control) (~113 posts each), a rate sufficient to influence but which avoided message fatigue. A community manager scheduled posts, monitored reactions/comments, and replied to misinformation. Participants received a bi-weekly email newsletter highlighting the most popular recent posts.

2.4. Measures

Primary Outcomes. The primary outcomes were changes in mothers' permissiveness toward IT by daughters, IT behavior, and support for stricter bans on IT by minors. Mothers' permissiveness was measured using 4 Likert-type items (1 = strongly disagree, 5 = strongly agree) on permitting (I would allow my daughter to use a tanning bed; I think it's

OK for my daughter to use a tanning bed; $\alpha = 0.92$) and facilitating daughter's IT (I would pay for my daughter to tan at a tanning salon; I would take my daughter to a tanning salon to use a tanning bed; $\alpha = 0.93$) (Hillhouse et al., 2016). Daughters rated their mothers on these measures (permit $\alpha = 0.87$; facilitate $\alpha = 0.91$) (Baker, 2013). Mothers reported if they had provided written permission for the daughter to indoor tan in the past year. IT behavior was recorded by asking the number of times mothers and daughters used a tanning bed or booth between December to March prior to the survey, the "season" of highest IT behavior (Hillhouse et al., 2005). Due to low incidence, these variables were dichotomized as any use vs. no use. Similar measures had strong associations with diary measures (Visser et al., 2008). Mothers and daughters reported IT intention in the next 3, 6, and 12 months ($\alpha = 0.97$ for mothers; $\alpha = 0.97$ for daughters). Intention measures had continuous distributions so they were not dichotomized.

Mothers' support for bans on IT by minors was evaluated at posttest by measures created by the investigators. Mothers were asked what is the youngest age their state should prohibit minors to indoor tan, coded for those at age 18 versus an age under 18. They reported whether they would take seven actions to support a ban: voting for a state representative who supports a ban, signing a petition, creating and sharing an online petition, writing a letter to, calling, or speaking with elected state

representative to support a ban, and testifying to a state legislative committee in support of a ban (Cronbach coefficient $\alpha = 0.87$).

Secondary Outcomes. Secondary outcomes included theoretical mediators among mothers and daughters, chief among them mother-daughter communication on IT and self-efficacy to resist IT. They reported at pretest and posttest whether they communicated about avoiding IT (i.e., not being pressured to go to the tanning bed to fit in, how UV radiation from tanning beds can damage a person's appearance [e.g., cause wrinkles], etc.; $\alpha = 0.84$ for mothers; $\alpha = 0.86$ for daughters). At posttest, daughters indicated if mothers shared information from the social media campaign ($\alpha = 0.76$). Mothers' self-efficacy to resist IT requests from daughters (single item) and daughter' self-efficacy to say no to IT with peers (3-items, $\alpha = 0.69$) were measured. Positive and negative attitudes toward IT were measured by three 5-point Likert-type items each (e.g., I feel favorable about IT; If I were to indoor tan regularly, my skin is likely to wrinkle; mothers: positive attitudes $\alpha = 0.92$, negative attitudes $\alpha = 0.87$; daughters: positive attitudes $\alpha = 0.94$, negative attitudes $\alpha = 0.91$) and mothers' monitoring of daughters IT, by two items (how much does your mother try to know/really know about your indoor tanning, treated as single items).

Covariates. Measures of potential covariates included mother and daughter age, skin phenotype (i.e., eye color, hair color, and skin tannability) (Berwick et al., 2005) and satisfaction with mother-daughter communication (Overall, I am satisfied with the way my daughter and I communicate; 5-point Likert item). Mothers provided personal and family history of skin cancer and political ideology (Local government has a responsibility to protect community health by educating people about how to stay healthy and avoid disease; 5-point Likert item). Recruitment source and state laws on IT were recorded. Finally, 17 questions assessed other health behaviors in the campaign.

2.5. Statistical analysis

In an intent-to-treat approach, effects of the intervention on each outcome was tested using a series of structural equation models (SEM). Where the variable of interest was measured for both the mother and daughter, a single model was fit, allowing mother and daughter responses to correlate. All multi-item constructs were specified as latent variables. Within each SEM, the outcome(s) were regressed on the binary treatment indicator (0 = control, 1 = intervention), baseline version of the outcome(s),¹ mother and daughter intention to IT in the next 12 months, and a set of covariates (mother and daughter ages, satisfaction with communication, and skin phenotype, family skin cancer history, mothers' political ideology, state law on parental consent for IT by minors, and recruitment source). SEMs were fit using Mplus, Version 8.4, employing a full-information robust maximum likelihood (MLR) estimator for continuous outcomes or a weighted least square mean and variance adjusted (WLSMV) estimator with a probit link for categorical outcomes (see Table 2). Unstandardized effect of treatment (difference between intervention and control groups) and corresponding 95% confidence interval (two-tailed) were calculated for each outcome, as well as the standardized effect of treatment for continuous outcomes. Mplus handles missing data on the endogenous variables using principled missing data techniques (Dong and Peng, 2013) (i.e., multiple imputation and full information maximum likelihood) so all mothers and daughters were analyzed regardless of whether they completed assessments. To account for missing data on the exogenous control variables, predictive means matching was used in the R package mice (van Buuren and Groothuis-Oudshoorn, 2011) to impute 25 datasets; all models were fit using these 25 imputed datasets; and results were combined using Rubin's rules (Rubin, 1987). No sensitivity tests were

¹ To incorporate baseline differences, an analysis of covariance approach was employed that included the baseline measure of the outcome as a control variable in the regression model testing treatment effects.

needed as best practices for missing data were employed and no cases were excluded. We used R, version 3.5.3, and the tidyverse (Hallquist and Wiley, 2018; Wickham et al., 2019) for all data management and table creation, and MplusAutomation, an R package, to collate results (Hallquist and Wiley, 2018).

3. Results

3.1. Profile of samples

A total of 869 mothers were enrolled (see Fig. 1). Also, 469 daughters completed the baseline survey. Number of mothers invited could not be estimated to calculate enrollment rate. Table 1 describes these samples. As planned, mothers were predominately White, non-Hispanic. Also, 57.8% had a college education, and 51.1% had household incomes exceeding \$80,000. Over a third had a family history of skin cancer and a quarter, a skin type at high risk for melanoma. Three quarters of daughters were non-Hispanic white and a quarter had a high-risk skin type. Mothers' political beliefs were diverse, with half saying they were middle-of-the-road but they tended to believe local government has a responsibility to protect community health through health education. Compared to mothers, daughters had lower use of controlled substances, less obesity, and better health status, but similar diet, physical activity, and mental health. Randomization balanced treatment conditions on nearly all characteristics, except that control-group daughters reported more days of vigorous physical activity than intervention-group daughters.

3.2. Comparison of treatment conditions among mothers

All SEMs demonstrated adequate fit (Table 2). Analysis of mothers' primary and secondary outcomes partially supported Hypothesis 1 (Table 3). Compared to control-group mothers, mothers in the IT social media group were less permissive toward daughters IT at posttest and reported more communication with daughters about avoiding IT. Contrary to Hypothesis 1, treatment groups did not differ on mothers' IT behavior, but mothers in the intervention group expressed lower IT intentions than in the control group, and less positive attitudes toward IT. There were no treatment group differences in mothers' facilitation of IT by daughters, giving permission for daughter's IT, negative beliefs about IT, IT behavior of daughters, and self-efficacy to refuse daughter's requests for IT.

The social media campaign increased mothers' support for bans on IT by minors (Table 3). Mothers in the intervention group were more willing to advocate for a complete ban on IT by minors than control group mothers (the 95% CI is close to, but does not cross zero).

3.3. Comparison of conditions among daughters

Analysis of daughters' data provided mixed support for Hypothesis 1 (Table 4). Intervention-group daughters reported that their mothers communicated more with them about avoiding IT and shared more posts about avoiding IT than control-group daughters. Both should be direct expressions to daughters that mothers were less permissive of daughter's IT. The remaining outcomes assessed with daughters showed no treatment-group differences (Table 4).

4. Discussion

The social media campaign appeared to reduce mothers' permissiveness toward IT by teen daughters and motivate them to communicate with daughters about and share posts on IT prevention, supporting Hypothesis 1a. This should have reinforced harms, expressed a family norm to avoid IT, and encouraged compliance with states controls on IT. This study was the first to explore a social media campaign on IT; other interventions have used printed and web-based materials and UV

Table 1
Profile of the samples of mothers and daughters at baseline.

	Mother Sample			Daughter Sample		
	Indoor Tanning Posts (Intervention)	Prescription Drug Misuse Posts (Control)	Overall	Indoor Tanning Posts (Intervention)	Prescription Drug Misuse Posts (Control)	Overall
	n = 435	n = 434	n = 869	n = 243	n = 226	n = 469
Demographics:						
Age [95% confidence interval]	42.88 [42.25, 43.51]	43.38 [42.76, 44.01]	43.13 [42.69, 43.58]	15.36 [15.23, 15.50]	15.33 [15.19, 15.48]	15.35 [15.25, 15.45]
Ethnicity/race						
White, non-Hispanic	82.1%	82.6%	82.4%	77.8%	71.4%	74.7%
Hispanic	5.8%	6.7%	6.2%	8.1%	10.0%	9.0%
Other	12.1%	10.7%	11.4%	14.1%	18.6%	16.3%
Education¹						
High school or less	8.0%	10.1%	9.0%	NA	NA	NA
Some education beyond high school	34.9%	31.5%	33.2%			
4-year college graduate	29.8%	29.2%	29.5%			
Postgraduate education	27.3%	29.2%	28.3%			
Total annual household income¹						
\$20,000 or less	3.5%	7.6%	5.5%	NA	NA	NA
\$20,001 to \$40,000	14.2%	11.3%	12.8%			
\$40,001 to \$60,000	15.6%	13.1%	14.4%			
\$60,001 to \$80,000	18.8%	13.7%	16.2%			
\$80,001 to \$100,000	14.2%	18.2%	16.2%			
More than \$100,000	33.7%	36.1%	34.9%			
Family history of skin cancer						
Yes	31.4%	26.8%	29.1%	NA	NA	NA
No/Don't know	68.6%	73.2%	70.9%			
Skin type						
Higher risk for melanoma (types 4–5)	26.6%	26.4%	26.5%	26.3%	23.3%	24.8%
Lower risk for melanoma (types 1–3)	73.4%	73.6%	73.5%	73.7%	76.7%	75.2%
Political Ideology:						
Political leaning						
Conservative	22.9%	26.2%	24.5%	NA	NA	NA
Middle-of-the-road	51.2%	52.1%	51.7%			
Liberal	25.9%	21.7%	23.8%			
Local government has a responsibility to protect community health by educating people about how to stay healthy and avoid disease (mean agreement [95% confidence interval])	3.97 [3.88, 4.06]	4.03 [3.94, 4.12]	4.00 [3.94, 4.06]	NA	NA	NA
Government should not interfere in matters of private business and private property (mean agreement [95% confidence interval])	3.32 [3.22, 3.42]	3.32 [3.23, 3.42]	3.32 [3.25, 3.39]	NA	NA	NA
General health status						
Excellent	14.0%	13.8%	13.9%	28.7%	31.0%	29.8%
Very good	44.4%	40.1%	42.2%	39.6%	39.4%	39.5%
Good	30.1%	33.9%	32.0%	23.8%	19.5%	21.7%
Fair	9.9%	10.1%	10.0%	7.5%	8.8%	8.1%
Poor	1.6%	2.1%	1.9%	0.4%	1.3%	0.9%
Health Behaviors:						
Prescription drug misuse	37.6%	37.3%	37.5%	7.4%	5.8%	6.6%
Cigarette smoking (every day or some days)	17.8%	20.5%	19.1%	3.3%	3.6%	3.4%
Alcoholic beverage intake in past 30 days (mean number of days had at least 1 drink [95% confidence interval])	4.60 [3.99, 5.21]	4.64 [3.98, 5.29]	4.62 [4.17, 5.06]	0.36 [0.18, 0.54]	0.50 [0.23, 0.77]	0.43 [0.27, 0.59]
Binge drink alcohol in past two weeks	22.2%	21.8%	22.0%	3.7%	7.6%	5.6%
Used marijuana currently	13.4%	12.4%	12.9%	10.1%	8.6%	9.4%
Daughter vaccinated for human papillomavirus (at least 1 dose)	62.4%	64.4%	63.4%	50.4%	52.9%	51.6%
Fruit intake (mean servings per day [95% confidence interval])	2.34 [2.19, 2.49]	2.18 [2.04, 2.32]	2.26 [2.16, 2.36]	2.38 [2.18, 2.58]	2.54 [2.31, 2.76]	2.46 [2.31, 2.61]
Vegetable intake (mean servings per week [95% confidence interval])	2.64 [2.48, 2.79]	2.55 [2.42, 2.69]	2.59 [2.49, 2.70]	2.28 [2.08, 2.47]	2.36 [2.13, 2.58]	2.31 [2.16, 2.46]
Sugar-sweetened beverage intake (mean times per month [95% confidence interval]) ¹						
Regular soda or pop containing sugar	8.81 [6.92, 10.70]	8.27 [6.97, 9.57]	8.54 [7.40, 9.69]	7.82 [6.19, 9.46]	9.05 [6.03, 12.07]	8.41 [6.73, 10.09]
Sugar-sweetened fruit drinks, sweet tea, and sports/energy drinks	6.01 [5.13, 6.90]	6.71 [5.53, 7.90]	6.36 [5.62, 7.10]	8.02 [6.94, 9.10]	9.46 [7.83, 11.09]	8.71 [7.75, 9.67]
Physical activity (mean time per week of 10 min or more [95% confidence interval])						
Vigorous activity	2.81 [2.58, 3.05]	2.61 [2.35, 2.86]		2.82 [2.52, 3.11]	3.35 [2.94, 3.76]	

(continued on next page)

Table 1 (continued)

	Mother Sample			Daughter Sample		
	Indoor Tanning Posts (Intervention)	Prescription Drug Misuse Posts (Control)	Overall	Indoor Tanning Posts (Intervention)	Prescription Drug Misuse Posts (Control)	Overall
			2.71 [2.54, 2.88]			3.08 [2.82, 3.33]*
Light or moderate activity	4.23 [3.91, 4.55]	4.15 [3.80, 4.50]	4.19 [3.95, 4.43]	4.13 [3.78, 4.49]	4.38 [3.94, 4.82]	4.25 [3.97, 4.54]
Obesity (BMI >=30)	38.3%	42.5%	40.4%	11.0%	13.6%	12.3%
Mental health in past 30 days (mean number of days was "not good" [95% confidence interval])	5.12 [4.49, 5.75]	5.52 [4.86, 6.19]	5.32 [4.86, 5.78]	5.81 [4.81, 6.80]	4.70 [3.79, 5.60]	5.27 [4.59, 5.94]
Poor physical or mental health kept from doing usual activities in past 30 days (mean number of days [95% confidence interval])	2.87 [2.37, 3.38]	2.48 [2.04, 2.92]	2.68 [2.34, 3.01]	2.81 [2.01, 3.61]	1.91 [1.37, 2.44]	2.37 [1.89, 2.86]

*p < 0.05 for comparison between conditions: Chi-square test or Fisher's Exact test were conducted to compare conditions on categorical characteristics and two-sample t-test was used for continuous characteristics.

¹ Assessed at 12-month follow-up.

Table 2

Fit statistics for structural equation models.¹

Model	Estimator ²	CFI	TLI	RMSEA
Mother's indoor tanning permissiveness scale (permits and facilitates indoor tanning) ³	MLR	0.973	0.946	0.040
Mother provided written permission for daughter to indoor tan ^{3,*}	WLSMV	1	1	0
Indoor tanning behavior (self-report) ^{3,*}	WLSMV	1	1	0
Indoor tanning behavior (partner-report) ^{3,*}	WLSMV	1	1	0
Indoor tanning intentions ^{3,4}	MLR	0.986	0.980	0.025
Mother's supports for indoor tanning ban for minors (<18 years old)*	WLSMV	1	1	0
Mother's willingness to take advocacy actions for complete ban of indoor tanning by minors	WLSMV	0.983	0.975	0.041
Mother-daughter communication about indoor tanning ³	WLSMV	0.965	0.960	0.033
Daughter's report that mother shared messages on IT*	WLSMV	1	1	0
Mother's self-efficacy to refuse daughter's request to indoor tan*	MLR	1	1	0
Daughter's self-efficacy to refuse friends request to indoor tan	MLR	0.964	0.928	0.031
Beliefs about positive and negative aspects of indoor tanning ³	MLR	0.976	0.966	0.026
Daughter's perception of mother's monitoring of their indoor tanning (mother tries to know and really knows)*	MLR	1	1	0
Daughter's report that mother shared messages on prescription drug misuse*	WLSMV	1	1	0

*Just identified models (no latent variables) fit the data perfectly.

¹ Fit statistics included Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA).

² MLR = full-information robust maximum likelihood estimator for continuous outcomes; WLSMV = Weighted Least Square Mean and Variance Adjusted (WLSMV) estimator with a probit link for categorical outcomes.

³ Analysis of mother and daughter reports at the level of the mother-daughter dyad.

⁴ The three indicators of intentions to indoor tan in the next 3, 6, and 12 months were treated as three indicators of a latent intentions variable.

photography. Positive effects on mothers' IT permissiveness and mother-daughter communication were similar to earlier studies that relied on printed materials (Lazovich et al., 2013; Baker, 2013). The campaign may have increased the frequency of communication and

focused it on harms, countering norms, and resisting pressure to indoor tan. Past studies showed conversations on IT are infrequent (Magee et al., 2007) and mothers sometimes minimize risks, especially if they tan (Gordon et al., 2016). It should be noted that mothers in the intervention condition received many IT posts they could share; control-condition mothers would have shared posts on IT obtained elsewhere. However, contrary to Hypothesis 1b, daughters' perceptions of mothers' IT permissiveness did not decline as they did in previous studies (Lazovich et al., 2013; Baker, 2013), possibly because daughters did not receive the intervention. It is also possible that perceived permissiveness was already so low that there was little chance of further reductions. Many daughters may not have requested mothers' permission to indoor tan in the past year, providing no opportunity for mothers to refuse.

The social media campaign did not support Hypothesis 1c, having no effect on IT behavior of mothers and daughters. However, it did reduce mothers' (but not daughters') intentions to indoor tan. There was low initial levels of IT by both groups so many daughters may not have attempted to indoor tan, because they were too young or IT was sporadic. Mothers' may have more impact as daughters' desires or opportunities to indoor tan increase in the future, especially if communication about IT establishes a family norm against it. However, it is unknown how long mothers' influence persist.

This is the first study to assess intervention effects on mothers' support for state bans on IT by minors. As predicted in Hypothesis 2, the social media campaign seemed to increase mothers' willingness to take political action to support bans. It may have activated mothers who already favored a ban to do more but did not convert undecided or opposing mothers. Activating supporters of bans could help pass these public policies.

The results should be considered in light of the trial's strengths and weaknesses. The sample was recruited from 34 states, increasing its generalizability, but the campaign was tested with mothers interested in adolescent health and well-being, not a general population. The use of private Facebook groups prevented contamination and posts were theory-based. However, the variety of recruitment methods risked selection effects. Internet panels can have biases due to Internet access and higher socioeconomic status. Panel members may have been recruited by Qualtrics to participate in studies other than the current trial, but research has shown that participating in fewer rather than more surveys produces lower quality responses (Zhang et al., 2020). Just over half of daughters participated in assessments, risking non-response biases. Participants could not use the Facebook "share" feature from the private groups which prevented them from shoring up social support and impacting norms. The outcomes were assessed by self-reports, which can have demand and social desirability biases. However, they had high

Table 3

Unadjusted means/proportions and regression coefficients [95% confidence interval] from fitted models for primary and secondary outcomes among mothers by treatment group at posttest.

	Indoor Tanning Posts (Intervention)	Prescription Drug Misuse Posts (Control)	Overall	b ³	β ³
Mother permits daughter to indoor tan	n = 315 1.70 [1.59, 1.80]	n = 314 1.85 [1.73, 1.97]	n = 629 1.77 [1.69, 1.85]	-0.152* [-0.293, -0.010]	-0.148
Mother facilitates daughter indoor tanning	1.50 [1.40, 1.61]	1.58 [1.48, 1.69]	1.54 [1.47, 1.62]	-0.041 [-0.158, 0.075]	-0.049
Mother provided written permission for daughter to indoor tan	5.1%	5.5%	5.3%	-0.011 [-0.450, 0.427]	NA
Mother's indoor tanning behavior (any use vs. no use)	12.6%	10.3%	11.4%	0.070 [-0.435, 0.576]	NA
Mother's intention to indoor tan in the future	1.41 [1.28, 1.55]	1.60 [1.43, 1.76]	1.51 [1.40, 1.61]	-0.221* [-0.394, -0.047]	-0.171
Mother's report of daughter's indoor tanning behavior	8.6%	8.6%	8.6%	-0.004 [-0.618, 0.610]	NA
Mother's support for indoor tanning ban for minors (<18 years old)	63.9%	60.6%	62.3%	0.075 [-0.136, 0.285]	NA
Mother's willingness to take advocacy actions for complete ban of indoor tanning by minors ²	3.15 [2.87, 3.43]	2.77 [2.50, 3.04]	2.96 [2.77, 3.16]	0.134* [0.006, 0.262]	0.181
Mother's report on mother-daughter communication about indoor tanning ¹	4.09 [3.84, 4.35]	3.42 [3.16, 3.68]	3.76 [3.57, 3.94]	0.213* [0.085, 0.341]	0.277
Mother's self-efficacy to refuse daughter's request to indoor tan	4.49 [4.40, 4.58]	4.45 [4.35, 4.55]	4.47 [4.41, 4.54]	0.017 [-0.099, 0.133]	0.020
Mother's beliefs about positive aspects of indoor tanning	1.73 [1.62, 1.84]	1.87 [1.75, 1.98]	1.80 [1.72, 1.88]	-0.153* [-0.275, -0.030]	-0.155
Mother's beliefs about negative consequences of indoor tanning	4.40 [4.29, 4.50]	4.43 [4.34, 4.53]	4.41 [4.35, 4.48]	-0.024 [-0.158, 0.110]	-0.028

*p < 0.05.

¹ Number of topics mother discussed with daughter (possible range = 0 to 7)

² Number of political actions mothers would take to support a ban on indoor tanning by minors (possible range = 0 to 7); asked at posttest only.

³ b = unstandardized regression coefficient; β=standardized regression coefficient (not provided for binary outcomes) for outcome on treatment indicator adjusting for baseline control variables.

reliability (necessary for validity) and were appropriate for measuring internal cognitions which can be difficult to assess through observation (and observations can be infeasible in a large, geographically-dispersed sample). Participants were blind to experimental condition and online assessments limited direct contact with experimenters, which may reduce biases (Kreuter et al., 2009; Mummolo and Peterson, 2018).

5. Conclusions

Social media occupies a dominant position in today's media landscape. It is essential for distributing public health information and may influence family health decisions. It may be effective to deliver prevention messages through social media feeds on general parenting and child health topics. Their large numbers of followers could allow messages on low-interest topics such as IT to reach and influence families more than if advocated in a single-issue social media group on skin cancer prevention. Future research should explore how to communicate effectively on social media by testing which post formats, in what context, and at what frequency work best with which user groups.

Parents may play a key role in achieving the effectiveness of state laws designed to reduce IT and prevent skin cancer. Government oversight is limited for these policies. IT facility operators may flout the laws for profit or out of negligence. Social media messaging may convince parents to withhold permission for IT and counter market pressures than undermine state IT laws.

CRedit authorship contribution statement

David B. Buller: Conceptualization, Methodology, Investigation, Writing - original draft, Visualization, Supervision, Project administration, Funding acquisition. **Sherry Pagoto:** Conceptualization, Methodology, Investigation, Resources, Writing - review & editing, Supervision, Project administration, Funding acquisition. **Katie Baker:** Conceptualization, Methodology, Investigation, Writing - review & editing, Supervision, Project administration, Funding acquisition. **Barbara J. Walkosz:** Conceptualization, Methodology, Investigation, Writing - review & editing, Resources, Funding acquisition. **Joel Hillhouse:** Conceptualization, Methodology, Investigation, Writing - review & editing, Funding acquisition. **Kimberly L. Henry:** Conceptualization, Methodology, Formal analysis, Writing - review & editing, Funding acquisition. **Julia Berteletti:** Validation, Investigation, Resources, Data curation, Writing - review & editing, Supervision. **Jessica Bibeau:** Validation, Investigation, Resources, Data curation, Writing - review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Table 4

Unadjusted means/proportions and regression coefficients [95% confidence interval] from fitted models for primary and secondary outcomes among daughters by treatment group at posttest.

	Indoor Tanning Posts (Intervention) n = 213	Prescription Drug Misuse Posts (Control) n = 209	Overall n = 422	b ³	β ³
Daughter's perception that mother permits daughter to indoor tan	2.00 [1.85, 2.16]	2.00 [1.85, 2.15]	2.00 [1.90, 2.11]	0.008 [−0.160, 0.175]	0.007
Daughter's perception that mother facilitate daughter indoor tanning	1.71 [1.56, 1.86]	1.79 [1.64, 1.95]	1.75 [1.64, 1.86]	−0.002 [−0.157, 0.154]	−0.002
Daughter's report that mother provided written permission for daughter to indoor tan	7.1%	4.3%	5.7%	0.256 [−0.322, 0.835]	NA
Daughter's indoor tanning behavior (any use vs. no use)	14.8%	10.2%	12.6%	0.624 [−0.395, 1.642]	NA
Daughter's intention to indoor tan in the future	1.69 [1.48, 1.90]	1.67 [1.47, 1.88]	1.68 [1.53, 1.83]	−0.007 [−0.205, 0.191]	−0.005
Daughter's perception of mother's indoor tanning behavior	11.0%	8.2%	9.6%	0.312 [−0.414, 1.037]	NA
Daughter's report of mother-daughter communication about indoor tanning ¹	3.81 [3.49, 4.14]	3.20 [2.87, 3.53]	3.51 [3.28, 3.74]	0.237* [0.063, 0.411]	0.259
Daughter's report that mother shared messages about IT harms	52.4%	36.4%	44.5%	0.438* [0.186, 0.691]	NA
Daughter's self-efficacy to refuse friends request to indoor tan	5.24 [5.02, 5.47]	5.12 [4.88, 5.36]	5.18 [5.02, 5.35]	0.098 [−0.066, 0.261]	0.103
Daughter's beliefs about positive aspects of indoor tanning	2.06 [1.90, 2.21]	2.10 [1.95, 2.25]	2.08 [1.97, 2.19]	0.003 [−0.160, 0.167]	0.003
Daughter's beliefs about negative consequences of indoor tanning	4.23 [4.10, 4.35]	4.09 [3.96, 4.21]	4.16 [4.07, 4.25]	0.098 [−0.074, 0.270]	0.105
Daughter's perception of mother's monitoring of their indoor tanning (mother tries to know)	2.09 [1.96, 2.22]	2.00 [1.87, 2.13]	2.05 [1.96, 2.14]	0.001 [−0.161, 0.162]	0.001
Daughter's perception of mother's monitoring of their indoor tanning (mother really knows)	2.61 [2.52, 2.71]	2.57 [2.46, 2.67]	2.59 [2.52, 2.66]	−0.002 [−0.135, 0.130]	−0.004
Daughter's report that mother shared messages about prescription drug misuse	48.6%	40.3%	44.5%	0.235 [−0.017, 0.487]	NA

*p < 0.05.

²Number of political actions mothers would take to support a ban on indoor tanning by minors (possible range = 0 to 7); asked at posttest only.

¹ Number of topics mother discussed with daughter (possible range = 0 to 7).

³ b = unstandardized regression coefficient; β=standardized regression coefficient (not provided for binary outcomes) for outcome on treatment indicator adjusting for baseline control variables.

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Appendix A. Supplementary data

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