Evidence-Based Communication to Increase Melanoma Knowledge and Skin Checks

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Rates of melanoma—the deadliest form of skin cancer—have increased. Early detection can save lives, and patients have a critical role to play in checking their skin. We aim to identify health communication messages that best educate the public and increase intentions toward skin checks. After viewing messages intended to increase melanoma knowledge, participants correctly identified a greater proportion (74.6 vs 70.4%) of moles (mean number = 17.9, 95% confidence interval [CI] = 17.5–18.3 vs 16.9, 95% CI = 16.6–17.3; $P < .001$, partial eta-squared = 0.03) and had knowledge of more melanoma warning signs (mean number = 5.8, 95% CI = 5.7–5.8 vs 5.6, 95% CI = 5.5–5.7, $P = .01$, partial eta-squared = 0.02). After viewing messages intended to increase self-confidence in checking their skin accurately, they were also more likely to report greater intentions to do a skin check on a scale of 1–5 (mean number = 3.8, 95% CI = 3.7–3.9 vs 3.6, 95% CI = 3.4–3.7, $P = .005$, partial eta-squared = 0.02). Online melanoma messages aimed at increasing both melanoma knowledge and skin-check confidence may be most effective in improving the accuracy of skin self-examinations and intentions to do them.

Keywords: Health communication, Knowledge, Melanoma, Self-efficacy, Social media

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INTRODUCTION

According to the United States (US) Surveillance, Epidemiology, and End Results program, overall melanoma incidence is on the rise. From 1975 to 2020, age-adjusted incidence rates increased from 8.78 to 23.52 per 100,000 in the US (National Cancer Institute, 2023). When broken down by age, incidence rates decreased among younger adults (aged <30 years) from 2006 to 2015 but increased among older adults (aged ≥40 years) (Paulson et al, 2020; Thrift and Gudenkauf, 2020). Melanoma is currently the fifth most common cancer in the US and United Kingdom (National Cancer Institute, 2023). However, unlike many other cancers, melanoma can be visually detected by both patients and healthcare professionals. In fact, 57% of diagnosed patients with melanoma detected their own melanomas, followed by physicians (16%) and then spouses (11%) (Brady et al, 2000).

Early detection of melanoma is vital in improving prognoses. Tumor thickness is an important prognostic factor (Balch et al, 2009) that correlates with metastasis rate (Breslow, 1979). Thus, early diagnosis while the tumor is still thin has the potential to increase survival (Friedman et al, 1985; Kaufman and Mehnert, 2016; Weinstock et al, 1999).

Visual examination of the skin (by oneself, a partner, or a health provider) is an essential tool to aid in early detection, although support for routine screenings is not universal. For example, the US Preventative Services Task Force and the National Cancer Institute Physician Data Query information do not have a statement for or against routine screening by providers with total body skin examination, citing a lack of evidence (US Preventive Services Task Force, 2023). However, the American Academy of Dermatology and the American Cancer Society encourage regular provider-based skin examinations and self-examination (Johnson et al, 2017). Nonetheless, some studies support the link between skin self-examination and early detection of melanomas (Berwick et al, 1996; Carli et al, 2003; Kaufman and Mehnert, 2016; Paddock et al, 2016; Pollitt et al, 2009; Swetter et al, 2012) as well as the need for further investigation of strategies to increase the frequency and accuracy of skin self-examination (Berwick et al, 1996; Geller et al, 2007; Hamidi et al, 2010; Leachman et al, 2023; Terushkin and Halpern, 2009; Torrecilla-Martínez et al, 2021).

Effective public health communication and campaigns can increase informed decisions and healthier behaviors among patients (Bauer et al, 2014; Noar, 2006; Rimal et al, 1999; Snyder, 2007; Snyder and Hamilton, 2002), and previous public health campaigns aimed specifically at early diagnosis of melanoma have shown promising results (Meyer et al, 2021; Robinson et al, 2021). For example, a 3-part public health campaign targeting dermatologist training; informing

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Abbreviations: CI, confidence interval; MTurk, Mechanical Turk; η_p^2, partial eta squared; US, United States

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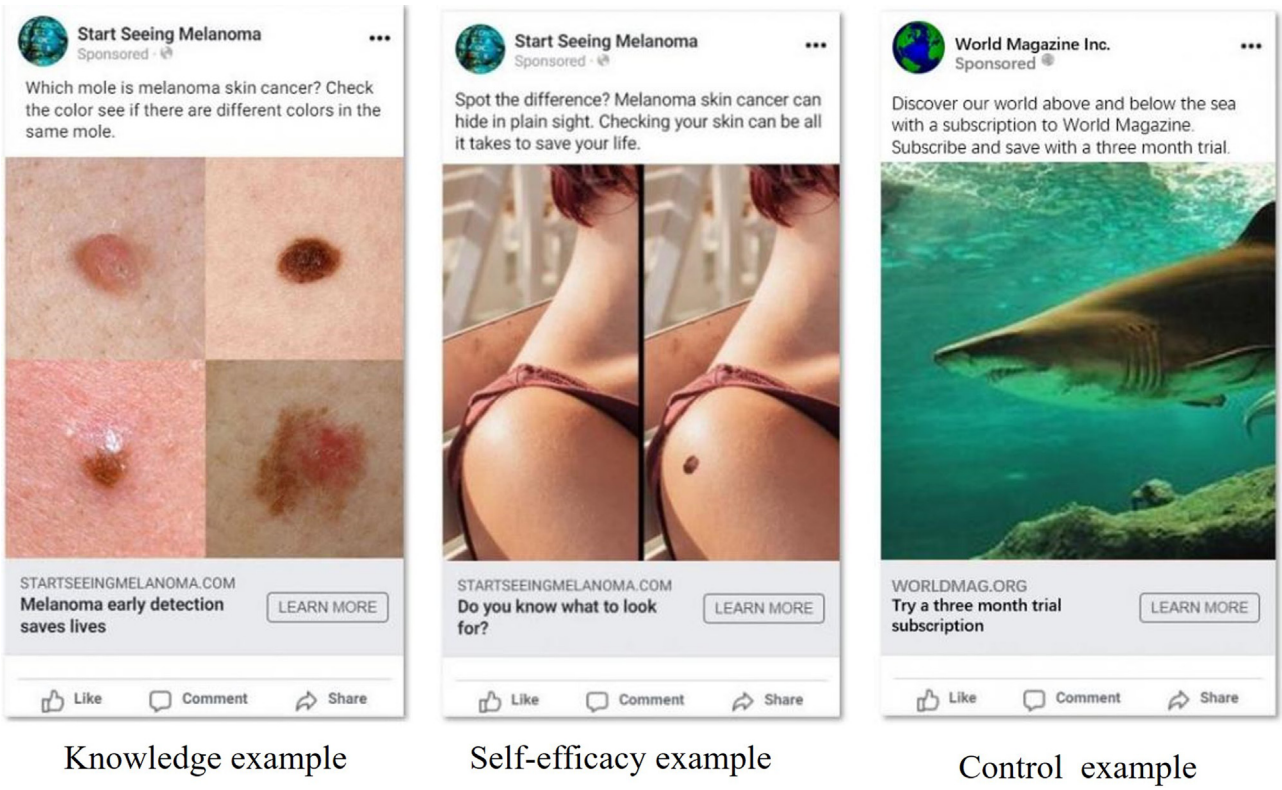

Figure 1. Examples of knowledge, self-efficacy, and control messages.

general practitioners; and distribution of skin self-examination information through leaflets, conferences, radio announcements, and television programs was conducted to increase early diagnosis of cutaneous melanoma in Trentino, Italy. The campaign was effective at saving lives and money (Cristofolini et al, 1993). Another study carried out over the last 10 years in South West England found that the number of thinner melanoma diagnoses (<1 mm) has increased, whereas the number of medium-thickness melanomas (1–4 mm) decreased. Although unable to establish causation, these authors suggested that various skin cancer awareness campaigns conducted for healthcare providers/services and produced online for the public may have produced this effect (Armstrong et al, 2014). Another public health campaign aimed at early referral and treatment of melanoma through booklets provided to healthcare providers and informational leaflets/posters provided to the public also increased the proportion of thin melanoma diagnoses, reduced the rate of thick tumors, and decreased melanoma-related mortality in women (MacKie and Hole, 1992). However, not all public health campaigns have been completely successful (Boniol et al, 2015; Katalinic et al, 2015; Stang and Jöckel, 2016; Stang et al, 2016). However, to the best of our knowledge, none of these campaigns has evaluated in a scientifically rigorous way which types of messages are effective in producing increased melanoma knowledge, the desired prevention behaviors, or the intention to comply with prevention recommendations.

Similar to some of the United Kingdom's online campaigns, we planned to use social media as a relatively inexpensive means to reach a larger audience. However, we first needed to optimize the type of messages used, which is the focus of this paper. The public health communication messages tested in this study (Figure 1) were designed specifically for platforms such as Facebook and Instagram and focused on increasing melanoma knowledge and self-efficacy because both have been shown to predict other healthy behaviors such as exercise (Faghri and Buden, 2015; Rimal, 2001, 2000). Thus, we reasoned that to conduct effective, regular skin checks, people may need to know how to check their skin for melanoma (knowledge) and to have confidence that they can do it successfully (self-efficacy). The aim of this study was to conduct an online randomized clinical study of health communication messages to identify health communication strategies that increase correct visual identification of moles, knowledge of melanoma warning signs, skin self-examination intentions, and positive attitudes toward checking their skin.

RESULTS

A total of 401 participants remained after data cleaning was complete. The mean (SD) age was 40.32 (12.17) years, with an age range of 19–74 years; 183 (46%) participants were female, and 215 (54%) were male. Table 1 presents the general participant characteristics. Supplementary Table S1 shows the full breakdown of all demographics. The 4 target outcomes were selected a priori, and the preregistered hypotheses for this study can be found at https://osf.io/26bpw/. We controlled for self-reported gender in all analyses summarized below (Figure 2).

Participants who were exposed to the knowledge messages correctly identified significantly more (74.6 vs 70.4%) moles

Table 1. Subset of Participant Demographics

Demographics	Total (N = 401)	Self-Efficacy (n = 100)	Knowledge (n = 98)	Knowledge + Self-Efficacy (n = 98)	Control Only (n = 105)
Age, y, mean (SD) (range)	40.32 (12.17) (19–74)	41.81 (12.87) (20–73)	41.04 (12.64) (19–74)	39.66 (11.68) (20–72)	38.86 (11.43) (22–72)
Age, y					
18–29	81	19	19	21	22
30–39	134	31	32	33	38
40–49	98	22	22	26	28
50–59	51	16	14	12	9
60–69	32	11	10	4	7
70–79	5	1	1	2	1
Gender					
Male	215 (54%)	44 (44%)	63 (64%)	52 (53%)	56 (53%)
Female	183 (46%)	55 (55%)	35 (36%)	45 (46%)	48 (46%)
Nonbinary	2 (0%)	1 (1%)	0 (0%)	0 (0%)	1 (1%)
Prefer not to answer	1 (0%)	0 (0%)	0 (0%)	1 (1%)	0 (0%)
Education					
Less than HS	1 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (1%)
HS/GED/equivalent	52 (13%)	14 (14%)	14 (14%)	13 (13%)	11 (10%)
Some college	85 (21%)	19 (19%)	21 (21%)	22 (22%)	23 (22%)
Vocational or 2-year degree	43 (11%)	15 (15%)	6 (6%)	14 (14%)	8 (8%)
4-year degree or more	218 (54%)	52 (52%)	57 (58%)	48 (49%)	61 (58%)
Prefer not to answer	2 (0%)	0 (0%)	0 (0%)	1 (1%)	1 (1%)
Race[1]					
American Indian or Alaska Native	5 (1%)	3 (3%)	0 (0%)	1 (1%)	1 (1%)
Asian	29 (7%)	6 (6%)	6 (6%)	10 (10%)	7 (7%)
Black or African-American	41 (10%)	9 (9%)	9 (9%)	11 (11%)	12 (11%)
Hispanic or Latino/a/x	34 (8%)	10 (10%)	7 (7%)	10 (10%)	7 (7%)
Native Hawaiian or Pacific Islander	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
White	315 (79%)	81 (81%)	80 (82%)	70 (71%)	84 (80%)
Other	2 (0%)	0 (0%)	0 (0%)	1 (1%)	1 (1%)
Prefer not to answer	1 (0%)	0 (0%)	0 (0%)	1 (1%)	0 (0%)
Melanoma history (self)					
No	386 (96%)	92 (92%)	97 (99%)	95 (97%)	102 (97%)
Yes	12 (3%)	7 (7%)	1 (1%)	2 (2%)	2 (2%)
I don't know	3 (1%)	1 (1%)	0 (0%)	1 (1%)	1 (1%)
Sunburn					
Get a severe sunburn with blisters	16 (4%)	7 (7%)	4 (4%)	1 (1%)	4 (4%)
Have a moderate sunburn with peeling	129 (32%)	35 (35%)	29 (30%)	34 (35%)	31 (30%)
Burn mildly with little darkening or tanning	148 (37%)	26 (26%)	41 (42%)	41 (42%)	40 (38%)
Turn darker without sunburn	84 (21%)	26 (26%)	19 (19%)	17 (17%)	22 (21%)
Nothing would happen to my skin	24 (6%)	6 (6%)	5 (5%)	5 (5%)	8 (8%)

Abbreviations: GED, General Education Development; HS, high school.
[1]Race percentages may add up to >100% owing to allowing participants to select >1 race.

(mean = 17.9, 95% confidence interval [CI] = 17.5–18.3 vs 16.9, 95% CI = 16.6–17.3; $P < .001$, partial eta squared [η_p^2] = 0.04) than those only exposed to the self-efficacy and/or control messages, indicating that they were better able to identify which moles were melanomas and which ones were benign. They also scored significantly higher on warning sign knowledge by correctly selecting more warning signs (mean = 5.8, 95% CI = 5.7–5.8 vs 5.6, 95% CI = 5.5–5.7; $P = .006$, $\eta_p^2 = 0.02$). Exploratory analyses revealed that the knowledge messages also led to fewer false positives (mean = 4.4, 95% CI = 4.0–4.8 vs 5.4, 95% CI = 5.0–5.8; $P < .001$, $\eta_p^2 = 0.03$); in other words, fewer benign moles were thought to be melanomas. No effect of gender emerged in any of these analyses.

When controlling for gender, the effect of self-efficacy messages on melanoma-related self-efficacy approached

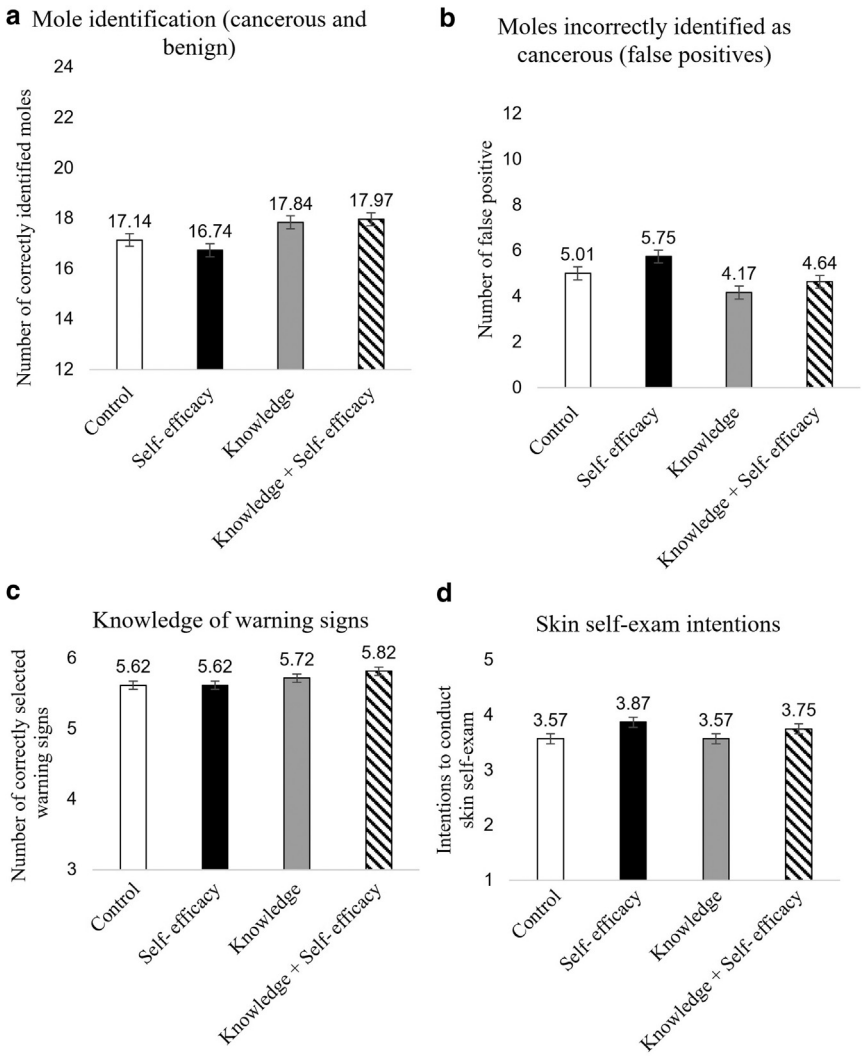

Figure 2. Description of findings on select measures and questions. (**a**) Number of correctly identified moles, both cancerous and benign, by condition represented by estimated marginal mean ± SE (scale range = 0−24). (**b**) Number of false positives by condition represented by estimated marginal mean ± SE (scale range = 0−13). (**c**) Number of correctly selected melanoma warning signs by condition represented by estimated marginal mean ± SE (scale range = 0−6). (**d**) Skin self-examination intentions by condition represented by estimated marginal mean ± SE (scale range = 1−5).

significance ($P = .052$), and women reported greater confidence that they could check their skin successfully than men on this scale of 1−5 (mean = 3.6, 95% CI = 3.5−3.7 vs 3.4, 95% CI = 3.3−3.5; $P = .03$, $\eta_p^2 = 0.01$). Critically, however, those exposed to self-efficacy messages reported greater intentions to do a skin check on a scale of 1−5 (mean = 3.8, 95% CI = 3.7−3.9 vs 3.6, 95% CI = 3.5−3.7; $P = .01$, $\eta_p^2 = 0.02$) than those exposed only to the knowledge and/or control messages. Women also reported greater intentions to do a skin check than men (mean = 3.9, 95% CI = 3.7−4.0 vs 3.6, 95% CI = 3.4−3.7; $P < .001$, $\eta_p^2 = 0.03$). Moreover, the effect of the self-efficacy messages was marginally significant ($P = .07$) for positive attitudes toward checking their skin, with women reporting more positive attitudes toward checking their skin than men on a scale of 1−5 (mean = 4.2, 95% CI = 4.1−4.3 vs 4.0, 95% CI = 3.9−4.1; $P = .004$, $\eta_p^2 = 0.02$). Exploratory analyses revealed that when considering cancerous moles, women correctly identified more melanomas than men (mean = 9.5, 95% CI = 9.2−9.8 vs 9.1, 95% CI = 8.8−9.4; $P = .046$, $\eta_p^2 = 0.01$); the effect of the self-efficacy messages in correctly identifying cancerous moles was marginally significant ($P = .06$). When considering benign moles, self-efficacy messages led to more false positives (mean = 5.2, 95% CI = 4.8−5.6 vs 4.6, 95% CI = 4.2−5.0; $P = .04$, $\eta_p^2 = 0.01$).

There were no interactions of knowledge and self-efficacy on any outcomes. Although self-efficacy and knowledge message effects did not depend on one another, the combined knowledge and self-efficacy messages provided the greatest benefit because participants received the benefits of both message types, and no unintended repercussions emerged in combining the messages (Figure 2 presents the comparisons between conditions on select measures and items).

DISCUSSION

This study suggests that online messages designed for use on platforms such as Facebook and Instagram are potentially useful tools for health communication about melanoma. Specifically, messages targeting knowledge were effective at improving the correct visual identification of moles (correctly identifying both melanoma and benign moles) and knowledge of melanoma warning signs, whereas those targeting self-efficacy effectively increased skin self-examination intentions. The combination of both messages did not further enhance each other, but participants reaped the benefits of

both types of messages without any noticeable significant drawbacks, suggesting that combining interventions is a potentially beneficial avenue for future research. An additional effect of gender emerged; women scored higher on melanoma-related self-efficacy, intentions to do a skin check, and positive attitudes toward checking one's skin.

To our knowledge, this study in dermatology rigorously evaluates previously unreported messages that effectively increase knowledge, healthy behaviors, and the intention to comply with early detection recommendations. It is also among the studies to consider previously unreported social media strategies that have the potential for widespread dissemination of information in a format that people casually consume on a regular basis. In fact, a larger public health campaign based on these experimental results and targeting knowledge and self-efficacy was launched several months after the conclusion of this study. Other research teams could similarly conduct studies as we did here to inform strategies used in larger-scale public health campaigns.

However, the present results also highlighted some limitations and areas that would benefit from further exploration. Because the study was not longitudinal, we were unable to ascertain whether participants actually conducted a successful skin examination or correctly identified a cancerous or noncancerous mole on their own or someone else's body. Future research could also benefit from a pretest–post-test design to control for any baseline differences persisting despite random assignment to conditions. In addition, although we did share correct mole identifications at the end of the study, we could not determine whether this added education had any additional impact on their confidence or ability to identify moles correctly. Both questions represent interesting and promising areas for further study. We also do not have the complete mole or medical/dermatology history for participants, although we did request the melanoma history of the participants, their family, and their friends (Table 1 and Supplementary Table S1). Further studies may benefit from collecting a more complete health history from participants to examine any potential relationships and control for possible confounders. Furthermore, although we generally obtained statistically significant findings in this study, these small interventions created comparatively small effects. With 4 target outcomes, conservative corrections for multiple testing indicate an adjusted alpha level of 0.0125 (0.05/4 for the 4 outcomes). However, even with this conservative alpha level, 2 of the 4 target outcomes remained significant (correct identification of moles and knowledge of warning signs). Stronger manipulations with more substantial impacts on knowledge and behavior would be beneficial.

Generalizability of the findings is another area of concern. Mechanical Turk (MTurk) is used in health research studies because it is cost-effective and produces high-quality and highly reliable data; however, it is not representative of the US population (for a review, see Mortensen and Hughes [2018]). Demographically, MTurk workers tend to be more educated, younger, and male; they also tend to have lower income and are more liberal than the general population (Levay et al, 2016; McCredie and Morey, 2019; Qureshi et al, 2022). They also tend to have lower vaccination rates, lower smoking rates, lower self-reported assessments of general health, and higher reports of depression (Walters et al, 2018), further supporting the need to test these interventions in a natural setting. However, it is unclear how these baseline differences would be related to the current research. If anything, these interventions may be expected to work better in a more representative sample that would be older and more female than typical MTurk samples.

Finally, it is important to address an ongoing debate over the potential benefits versus drawbacks of skin examinations. Commonly listed downsides to skin self-examinations and regular screening of non–high-risk patients include pre/postscreening anxiety, unnecessary excisions, costs associated with excess physician visits and biopsies, false positives, and overdiagnoses (Kaufman and Mehnert, 2016). Overdiagnoses are a particular concern, especially given the relatively stable mortality rate even while the incidence rate of melanoma has increased (Rubin, 2020). In particular, melanoma overdiagnosis rates were estimated as high as 59% and 60%, respectively, among White women and men (Adamson et al, 2022). Some argue that dermatologists should be more conservative in their diagnosis and biopsy thresholds and that population-wide screening should stop (Welch et al, 2021). However, others argue that overdiagnoses of thin lesions, although still a substantial problem, cannot account for the increasing incidence rate. Incidence rates for invasive melanomas across all thickness groups have increased, and the thickness of T3/T4 lesions has increased, even when controlling for sociodemographic factors that may limit access to early detection efforts (Shaikh et al, 2016). Specifically regarding the rising rate in older adults, an increase has occurred in both local and metastatic melanomas (Paulson et al, 2020). Recently (2010–2018), the incidence rate of thin melanomas seems to have stabilized, whereas the rate of thick melanomas continues to rise (Chen et al, 2022).

Given these trends, it is important to highlight that our exploratory analyses indicated that self-efficacy messages indeed may increase the rate at which patients suspect benign moles of being malignant; however, the knowledge messages helped to decrease this false-positive rate and increase overall accuracy, which could address the issue of overdiagnosis. Self-referral is an important factor for bringing a suspicious mole to a provider who can then provide a more accurate diagnosis. Lesion-directed screening where patients self-selected into a physician skin check on the basis of a list of criteria had similar detection rates and cost less time and money than a blanket invite for a total body examination (Hoorens et al, 2016).

Previous studies have emphasized the importance of improving the accuracy of skin checks and have explored various strategies such as using mole mapping (with both drawn and digital images), using skin self-examination guides with picture aids, and encouraging partner involvement (Friedman et al, 1985; Phelan et al, 2005; Pollitt et al, 2009; Robinson et al, 2010; Weinstock et al, 2004). Despite the low rate of skin examinations among patients and healthcare providers (Berwick et al, 1996; Johnson et al, 2017; Weinstock et al, 1999), total body skin examinations remain a low-risk, noninvasive method that has the potential to decrease overall treatment costs through early detection of melanoma (Cristofolini et al, 1993; Johnson et al, 2017;

Kaufman and Mehnert, 2016). The role of skin self-examinations and education to increase screening accuracy would clearly benefit from further study, especially with randomized trials that could empirically test the value of promoting these in public health.

The results of this study suggest that online messages focused on improving knowledge and self-efficacy are effective at increasing correct visual identification of moles, knowledge of melanoma warning signs, and skin self-examination intentions. These findings suggest that online social media interventions may increase early detection of melanoma, which future research should investigate.

MATERIALS AND METHODS

Survey design

Participants were exposed to 6 Facebook-/Instagram-style melanoma messages and then responded to questions assessing their ability to correctly identify moles, knowledge of melanoma warning signs, skin self-examination intentions, and attitudes toward checking their skin. Other theory-based messages and measures that did not relate to the focus of this study were also used and collected; information about them can be found in Figure 3 and Table 2.

Demographic data for age, gender, education, race/ethnicity, income, rural/urban residence status, city and state of residence, Facebook use, political ideology, melanoma history, and personal melanoma risk factors was assessed through self-report at the survey end. These demographic data were collected for exploratory analyses to assess any potential differences in behavior or knowledge.

Correct visual identification of moles was calculated by totaling the number of correct responses to 24 pictures of moles (known a priori to be melanomas or benign); thus, the number correct equaled the number of melanomas correctly identified as melanomas plus the number of benign moles correctly identified as benign. Knowledge of melanoma warning signs was assessed by summing the number of correct verbal melanoma descriptions in 6 pairs of verbal descriptions. For example, "Which of the following is more likely to be a warning sign of melanoma? A mole that you were born with vs a new mole." Skin self-examination intentions were measured using the averaged response to 7 questions on a 5-point Likert scale. For example, "How likely is it that you will check your skin for cancer in the next month or two? Definitely won't – definitely will." Attitudes toward skin self-examinations were measured using the averaged response to 4 questions on a 5-point Likert scale. For example, "It is important to check my skin for skin cancer even if I have no symptoms. Strongly disagree – strongly agree."

Randomized conditions

In 4 experimental conditions, participants viewed 6 control messages or messages designed to increase self-efficacy (3 control and 3 self-efficacy), knowledge (3 control and 3 knowledge), or both self-efficacy and knowledge (3 self-efficacy and 3 knowledge). Figure 1

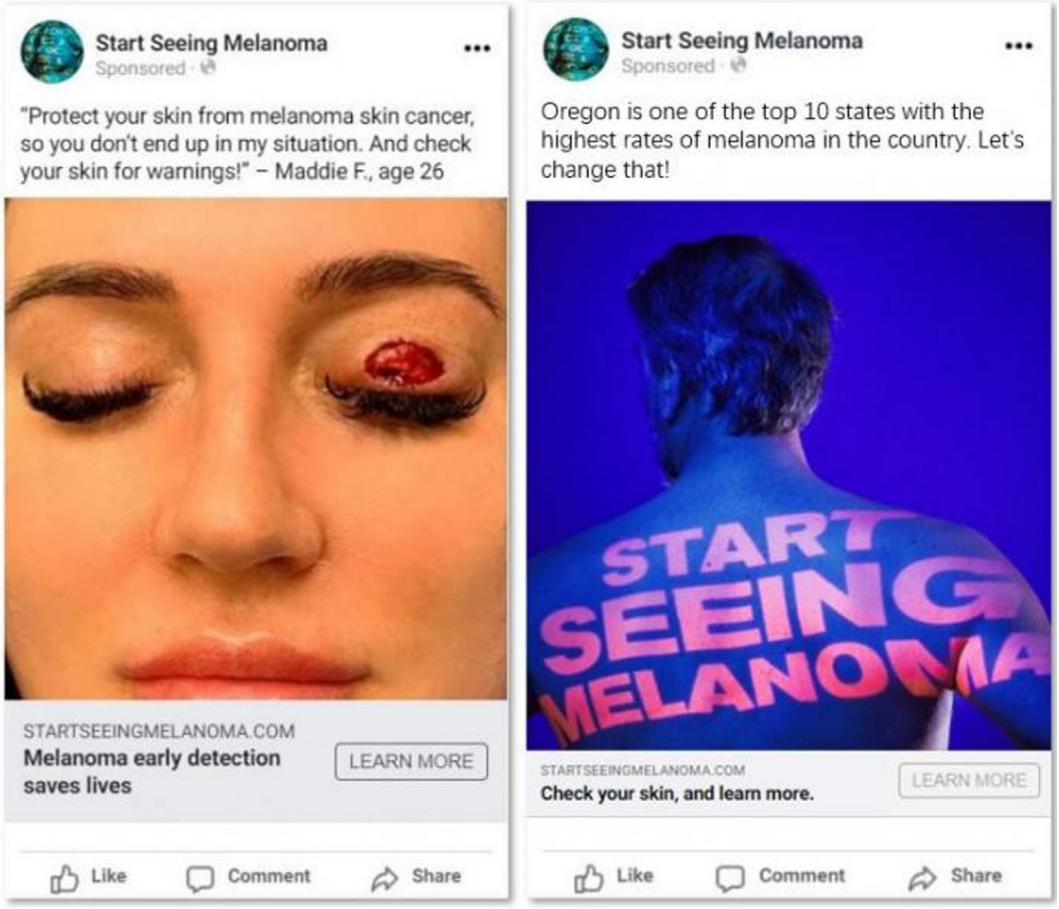

Figure 3. Examples of theory-based messages shown to other independent participant groups but not used in the main study. Shown are theory-based fear messages (left) and atheoretical messages (right) designed by a professional advertising agency to promote the Start Seeing Melanoma Campaign.

Table 2. Descriptions and Descriptive Statistics on Additional Measures Collected but Not Used in the Main Study

Measure	Description	Scale Direction	Mean (SE)
Prestudy mood	Current mood of participants at the beginning of the study	1–5; bad mood to good mood	2.3 (0.0)
Prestudy skin check experience	Participant's experience with checking their skin for cancer at the beginning of the study	1–7; already check their skin often to do not want to check their skin	4.2 (0.1)
Threat severity of melanoma	Perceived severity of melanoma	1–5; low to high severity	3.1 (0.0)
Threat susceptibility for melanoma	Perceived susceptibility for melanoma	1–5; low to high susceptibility	4.3 (0.0)
Emotion toward melanoma	How strongly participants feel a variety of different negative emotions toward melanoma	1–4; low to high strength of emotion	2.3 (0.0)
Information seeking intentions	Would the participant like to learn more about 3 sources of additional information about melanoma?	0–3; would like to see none of to all 3 of the sources provided	1.2 (0.0)
Barriers for self-check	What barriers prevent the participant from checking their skin?	0–13; number of barriers selected	2.6 (0.1)
Barriers for provider	What barriers prevent the participant from having a provider check their skin?	0–13; number of barriers selected	1.7 (0.1)
Reactance	Participants' negative reaction to the messages	1–5; low to high reactance	1.9 (0.0)
General self-efficacy	Scale to measure participant's general self-efficacy	1–5; low to high general self-efficacy	4.0 (0.0)
Behavioral inhibition scale	Scale to measure motivation to avoid adverse outcomes	1–4; high to low motivation	2.2 (0.0)
Need for cognition	Scale to measure participant's inclination to engage in and enjoyment of effortful cognitive activities	1–5; low to high inclination	3.5 (0.0)

Abbreviation: SE, standard error.

shows an example of each message type, and Figure 4 presents a study design visualization.

Knowledge messages were intended to improve melanoma warning sign knowledge and correct identification of moles. These messages showed real examples of what is and is not melanoma along with text that explicitly informed participants about what to look for to identify melanoma (ie, color variations, asymmetry, or uneven borders). After 2 seconds, a bright red arrow appeared to identify which mole was melanoma.

Self-efficacy messages were aimed at increasing the viewer's confidence in checking their skin for melanoma as a preventive measure. Self-efficacy messages showed a side-by-side comparison of the same body photo but with 1 photo containing an easy-to-spot melanoma. The difference was designed to be quite easy to improve participants' belief (their confidence) that they could spot melanoma. To ensure that these self-efficacy messages successfully manipulated self-efficacy, a melanoma-specific self-efficacy index was compiled using the averaged response to 3 questions on a 5-point Likert scale from strongly disagree to strongly agree. For example, "I am confident that I am able to check my skin for signs of skin cancer."

These melanoma messages were presented as sponsored posts from Start Seeing Melanoma and encouraged viewers to visit the startseeingmelanoma.com website. Control messages were presented as sponsored posts from World Magazine and typically had nature images unrelated to melanoma.

Informed consent

Because the study involved viewing health-related communications that pose minimal risks to participants, written informed consent was

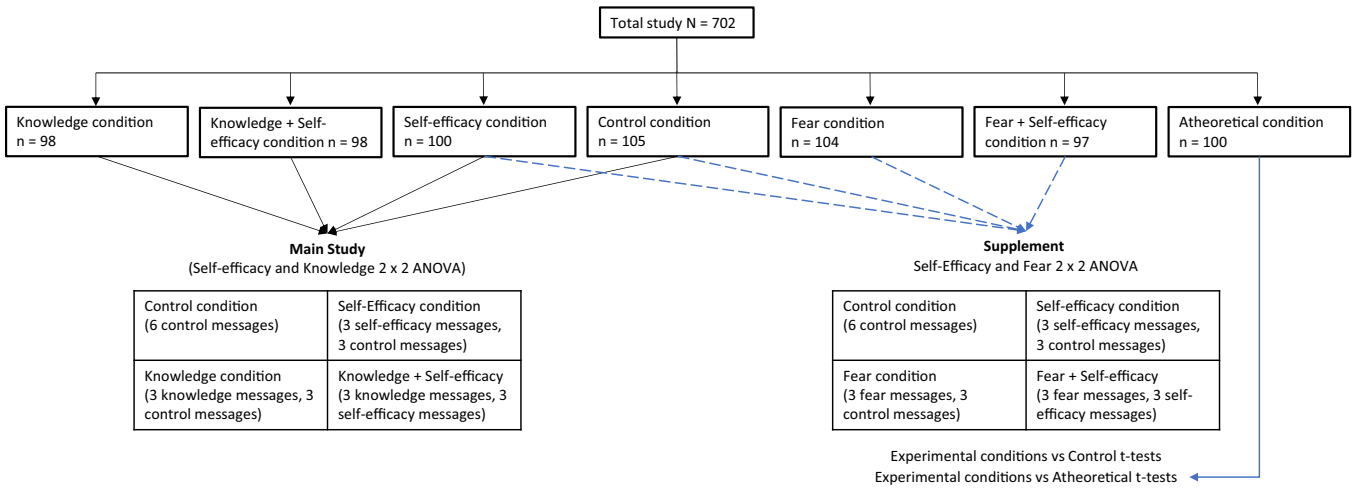

Figure 4. Study design visualization to show subject selection and analysis plan.

Table 3. Results (Estimated Marginal Means, 95% CIs, and Significance) for Fear and Self-Efficacy Conditions and their Interaction Based on a 2 × 2 ANOVA

Measure	Self-Efficacy = 0 (Estimated Marginal Mean, 95% CI)	Self-Efficacy = 1 (Estimated Marginal Mean, 95% CI)	*P*-Value	Fear = 0 (Estimated Marginal Mean, 95% CI)	Fear = 1 (Estimated Marginal Mean, 95% CI)	*P*-Value	Interaction *P*-Value
Visual identification of moles	17.2 (16.8–17.5)	17.0 (16.6–17.3)	.4	16.9 (16.6–17.3)	17.2 (16.8–17.6)	.3	.5
Knowledge of warning signs	5.7 (5.6–5.8)	5.6 (5.5–5.7)	.5	5.6 (5.5–5.7)	5.7 (5.6–5.8)	.3	.5
Attitudes toward checking their skin	4.0 (4.0–4.1)	4.1 (4.0–4.2)	.2	4.1 (4.0–4.2)	4.1 (4.0–4.2)	.5	1.0
Intention to do a skin check skin	3.6 (3.5–3.7)	3.8 (3.7–3.9)	.04	3.7 (3.6–3.8)	3.7 (3.6–3.8)	.6	.1

Abbreviation: CI, confidence interval.

not required. Participants were presented with information about the study and were given a choice between consenting or not. Only participants who provided consent proceeded to the study.

Randomization procedure

Participants were randomized to conditions. Within conditions, the order of messages within each type (ie, knowledge, control, or self-efficacy) was randomized, and each participant saw 6 messages. Participants in the control condition saw 6 control messages. Participants in the self-efficacy condition saw 3 control messages (randomly selected from the 6 control messages) and then 3 self-efficacy messages. Participants in the knowledge condition similarly saw 3 (randomly selected) control messages and then 3 knowledge messages. Finally, participants in the knowledge + self-efficacy condition saw all 3 knowledge messages and then all 3 self-efficacy messages.

After viewing the messages, participants first responded to the measure directly related to their assigned condition; then they were asked to respond to the remaining measures in random order. For example, in the knowledge condition, correct identification of moles was measured first, and then the rest of the measures were collected in random order; all measures were randomized for the control group. The order of items within each measure also was randomized.

Participants

Collection of survey data for human participants was approved by Oregon Health and Science University's Institutional Review Board. Participants were presented with informed consent information at the beginning of the survey, after which they either consented and continued the survey or exited the survey.

Online survey data were collected on August 10–11, 2021. Eligible participants were recruited through the CloudResearch interface for Amazon MTurk with an advertisement to which any MTurk worker could respond so long as they were aged >18 years and located in the US. To ensure data quality, additional requirements included having a 99–100% Human Intelligence Task approval and completion of at least 1000 Human Intelligence Tasks as well as using the following CloudResearch's data quality features: duplicate IP block, suspicious geocode block, verify worker country location, and block low-quality participants (Hauser et al, 2023; Peer et al, 2022, 2014). Participants were paid $3 to complete this 15-minute survey. No participants were entirely excluded from the dataset and analyses. However, as preregistered, 7 participants had extremely low performance on the correct visual identification task, and 1 participant had extremely low performance on the knowledge of warning signs task; these participants were removed from those respective analyses only (which represents 1.7 and 0.2% of the remaining data, respectively).

Statistical analysis

To determine our sample size, we first conducted a small pilot test of efficacy, threat, and knowledge messages with 83–92 participants per condition and found that the effect sizes varied (Cohen's ANOVA effect size [*f*] = 0.14–0.21) and required sample sizes from 47 to 100. With planned analyses using separate 2 × 2 ANOVAs, it was determined that at 80% power with an alpha of 0.05, 100 participants per condition would be needed to detect such effects, including the interaction. Therefore, the target number for the main study was 400 participants.

A 2-way ANOVA was conducted to analyze the effects of the messages on each of the 4 target outcome measures: correct identification of moles, knowledge of melanoma warning signs, skin self-examination intentions, and attitudes toward checking their skin. Data cleaning and analyses were conducted using R, version 4.2.1, with packages psych, dplyr, emmeans, stringr, heplots, and car. A $P < .05$ was considered significant in a 2-tailed test.

Means reported in the results section, with the exception of demographics, are the estimated marginal means derived from the model.

Analyses and results concerning the other messages and outcome measures not included in this paper can be found in Tables 3 and 4.

Ethics statement

Informed consent was obtained from all participants following guidelines approved by the University of Oregon institutional review board in protocol STUDY00000396. Because the study involved viewing health-related communications that pose minimal risks to participants, written informed consent was not required. Participants were presented with information about the study and were given a choice between consenting or not. Only participants who provided consent proceeded to the study.

DATA AVAILABILITY STATEMENT

Datasets related to this article can be found at https://osf.io/nkh75/, hosted at Open Science Framework (Nadratowski and Peters, 2023).

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Table 4. Results from *t*-Tests (Means and SEs) between Control and Experimental Messages and Atheoretical (Designed by an Advertisement Agency) and Experimental Messages

	Experimental Conditions						
Measures	**Self-Efficacy, Mean (SE)**	**Fear, Mean (SE)**	**Knowledge, Mean (SE)**	**Fear + Self-Efficacy, Mean (SE)**	**Knowledge + Self-Efficacy, Mean (SE)**	**Control Only, Mean (SE)**	**Atheoretical, Mean (SE)**
Visual identification of moles	16.7 (0.3)[1]	17.2 (0.2)	17.8 (0.3)	17.2 (0.3)	18.0 (0.2)[2]	17.1 (0.3)	17.5 (0.2)
False positives	5.8 (0.3)	5.2 (0.3)	4.2 (0.2)[1,2]	5.5 (0.3)	4.6 (0.3)	5.0 (0.3)	5.2 (0.3)
Knowledge of warning signs	5.6 (0.1)[1]	5.7 (0.1)	5.7 (0.1)	5.6 (0.1)[1]	5.8 (0)[2]	5.6 (0.1)[1]	5.8 (0)[2]
Attitudes toward checking their skin	4.1 (0.1)	4.1 (0.1)	4.0 (0.1)	4.1 (0.1)	4.2 (0.1)	4.0 (0.1)	4.1 (0.1)
Intention to do a skin check skin	3.9 (0.1)[2]	3.7 (0.1)	3.6 (0.1)	3.7 (0.1)	3.8 (0.1)	3.6 (0.1)	3.8 (0.1)
Self-efficacy	3.6 (0.1)	3.3 (0.1)	3.4 (0.1)	3.5 (0.1)	3.6 (0.1)[2]	3.3 (0.1)	3.4 (0.1)
Response Efficacy	4.3 (0)[2]	4.2 (0)	4.2 (0.1)	4.2 (0.1)	4.3 (0)[2]	4.2 (0)	4.3 (0)
Threat Severity	4.3 (0.1)	4.3 (0.1)	4.2 (0.1)[1]	4.4 (0)[2]	4.2 (0.1)	4.2 (0.1)	4.3 (0.1)
Threat Susceptibility	3.2 (0.1)	3.0 (0.1)[1]	3.2 (0.1)	3.1 (0.1)	3.1 (0.1)	3.1 (0.1)	3.3 (0.1)

Abbreviation: SE, standard error.
[1]$P < .05$ compared with standard-of-care messages.
[2]$P < .05$ compared with control messages.

CONFLICT OF INTEREST
The authors state no conflict of interest.

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AUTHOR CONTRIBUTIONS
Conceptualization: AN, BS-R, AS, JD-B, BD-B, SL, EP; Data Curation: AN, BS-R, AS, JD-B, BD-B, SL, EP; Formal Analysis: AN, BS-R, AS, JD-B, BD-B, SL, EP; Funding Acquisition: SL; Investigation: AN, BS-R, AS, JD-B, BD-B, SL, EP; Methodology: AN, BS-R, AS, JD-B, BD-B, SL, EP; Project Administration: EP; Resources: AN, BS-R, AS, JD-B, BD-B, SL, EP; Software: AN, BS-R, AS, JD-B, BD-B, SL, EP; Supervision: EP; Visualization: AN, BS-R, AS, JD-B, BD-B, SL, EP; Writing — Original Draft: AN; Writing — Review & Editing: AN, BS-R, AS, JD-B, BD-B, SL, EP

Disclaimer
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SUPPLEMENTARY MATERIAL
Supplementary material is linked to the online version of the paper at www.jidonline.org, and at https://doi.org/10.1016/j.xjidi.2023.100253.

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