RESEARCH ARTICLE

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Effectiveness of a Nurse-Led, WhatsApp-Based, Interactive Educational Intervention on Skin Cancer Knowledge and Sun Protection Behaviors: A Randomized, Controlled, Solomon Four-Group Study

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Abstract

Objective: This study aimed to examine the effectiveness of an interactive educational intervention delivered via WhatsApp on improving community-dwelling women 's knowledge of skin cancer and sun protection behaviors. The study was conducted using a randomized, controlled experimental design based on the Solomon four-group model. **Methods:** A randomized, controlled trial was conducted with 152 female participants assigned to four groups based on the Solomon design (two experimental, two control). One experimental and one control group were pre-tested, while the others were not. The experimental groups received structured, interactive education via WhatsApp for twelve weeks. Outcomes were measured using validated tools to assess skin cancer knowledge and sun protection behaviors. Data were analyzed with SPSS using descriptive and non-parametric tests. The Kolmogorov–Smirnov test indicated a non-normal distribution; therefore, Wilcoxon and Mann–Whitney U tests were applied. Statistical significance was set at $p < 0.05$. **Results:** Post-test scores showed significant improvements in knowledge and sun protection behaviors in the intervention groups compared to controls ($p<0.05$). No significant pre-test effect was detected, supporting the intervention's internal validity. The findings indicate that WhatsApp-based interactive education effectively enhances health literacy and sun protection behaviors. **Conclusion:** The results demonstrate the efficacy of a randomized, controlled educational intervention using mobile technology to enhance knowledge and health-related behavior. This approach provides a low-cost, scalable method for community-based health promotion.

Keywords: Skin cancer- Sun protection behaviors- WhatsApp-based intervention- Randomized controlled trial

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Introduction

Worldwide, skin cancer rates have increased significantly over the last three decades (Yu et al., 2016). The etiology of skin cancer is strongly associated with skin type and ultraviolet (UV) radiation exposure [1]. In Canada, over 80,000 cases of skin cancer are diagnosed each year, and UV exposure is estimated to be linked to 80–90% of these cases [2]. Similarly, the highest overall incidence rates in Australia and New Zealand are attributed to excessive sun exposure and the predominantly fair-skinned population [3].

Understanding the natural history of skin cancer is fundamental to developing prevention and control strategies aimed at reducing the global burden. These strategies encompass health promotion, primary prevention, secondary prevention, and tertiary prevention approaches [4].

At the primary prevention level, UV radiation exposure represents the most common and modifiable environmental risk factor for skin cancer. As such, it remains the main target of global prevention efforts. Secondary and tertiary prevention strategies emphasize the early detection of skin cancer, disease progression prevention, clinical monitoring, and educational and behavioral interventions [5]. Tertiary prevention in skin cancer focuses on minimizing disease recurrence, managing long-term complications, and enhancing survivors' quality of life through continued surveillance, rehabilitation, and behavioral education. It includes regular dermatological follow-up, psychosocial support, and patient-centered education to promote ongoing sun protection and self-skin examination, thereby preventing secondary lesions and improving functional recovery [6]. Integrating all prevention strategies into public health programs ensures comprehensive cancer prevention and control by addressing not only prevention and treatment, but also survival and long-term behavior maintenance [7, 8].

The literature highlights that although educational

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programs have been shown to reduce sunburn incidence in the general population, such interventions remain limited. Furthermore, the general public's awareness of the harmful effects of UVB exposure is often insufficient, with low levels of knowledge and attitudes toward skin cancer prevention [9]. For educational interventions to be effective in changing knowledge and behaviors, they must be designed to respect the values, preferences, and expressed needs of participants. Programs should be coordinated, integrated, and offer physical comfort, emotional support, and fear and anxiety reduction, with easily accessible and continuous content [10].

For many years, healthcare professionals have utilized online platforms available on social media for patient education, health promotion, public relations, and crisis communication [11]. Social media platforms include blogs, microblogging (e.g., Twitter), social networks (e.g., Facebook, WhatsApp, YouTube), and more. The key challenge for academics is to assess both the benefits and limitations of social media's impact on health outcomes [12].

Despite the growing use of social media in health education, there remains a gap in evidence regarding the effectiveness of mobile-based and nurse-led interventions in improving knowledge and preventive behaviors related to skin cancer. Previous studies have primarily focused on traditional, face-to-face education or mass media campaigns, with limited evaluation of interactive, digitally delivered programs [13, 14]. Considering the increasing global prevalence of skin cancer and the accessibility of mobile platforms, there is a critical need to investigate whether nurse-led, WhatsApp-based interventions can effectively promote sun-safe behaviors and enhance health literacy [15, 16].

Although previous research has acknowledged the educational potential of mobile technologies, there remains a paucity of studies employing interactive, WhatsApp-based interventions within preventive nursing. Addressing this gap, the present study contributes to the growing field of digital health by integrating an accessible, community-oriented, and nurse-led model into preventive education. This approach not only advances the evidence base for mobile health interventions but also highlights the role of nurses as key facilitators in promoting behavioral change through digital platforms.

The Solomon four-group design was selected to control for potential pretest sensitization effects and to strengthen both internal and external validity. Recent studies have demonstrated that this design effectively isolates pretest effects and enhances generalizability by allowing comparisons across groups with and without pretests and controls [13, 17 , 18].

The aim of this study was to examine the effect of an interactive education program delivered via the WhatsApp platform on community-dwelling women's skin cancer knowledge and sun protection behaviors using a Solomon four-group randomized controlled experimental design.

Materials and Methods

Study Design and Period

This study was conducted as a randomized controlled trial (RCT) based on the Solomon four-group design, between August 1 and November 1, 2024. The Solomon design was used to evaluate the effects of pretest sensitization and intervention interaction, allowing the comparison of both pre-tested and non-pre-tested groups [19-21].

Setting

The study was conducted on the island of Cyprus, located in the Mediterranean region. The island is characterized by frequent sun exposure throughout the year due to its climate, tourism, and agricultural activities, making it a relevant context for investigating sun protection behaviors.

Population and Sample

The population of the study consisted of women who met the inclusion criteria and volunteered to participate (N = 187). The sample size was determined using G*Power analysis with the following parameters: effect size (f) = 0.40, power (1-β) = 0.80, and α = 0.05. Based on these values, a minimum sample of 111 participants was required. Considering a potential attrition rate of 10% due to reasons such as withdrawal, relocation, or communication issues, the final sample included 152 community-dwelling women, equally distributed across four groups (n = 38 per group).

Sampling Procedure

Recruitment announcements were shared with the target population, and a total of 187 community-dwelling women registered for the study. However, 35 women were excluded due to issues such as incorrect WhatsApp numbers or being unavailable during the study period. The remaining 152 eligible participants were randomly assigned into four groups using a simple random sampling method via lottery:

- Group 1 (Experimental – Pretest/Posttest, n = 38)
- Group 2 (Control – Pretest/Posttest, n = 38)
- Group 3 (Experimental – Posttest only, n = 38)
- Group 4 (Control – Posttest only, n = 38)

Group equivalence was ensured based on demographic variables such as age, gender, skin type, and length of residence on the island.

Implementation of the Study
Data Collection Process

The data collection tools were transferred to Google Forms. The scales used in the study were administered as a pre-test to Group 1 and Group 2, and as a post-test to all groups at the end of the intervention. Completion of the form took approximately 15 minutes per participant.

Educational Intervention (12 Weeks – WhatsApp Group)

The training program titled "I Know Skin Cancer – I Protect Myself from the Sun" was delivered to Group 1 (pre-tested, n=38) and Group 3 (non-pre-tested, n=38) female participants via WhatsApp. To ensure data confidentiality, researchers obtained participants' phone numbers with explicit consent and created a closed WhatsApp group through the control panel. Communication was limited to the researcher and each participant individually, preventing participants from accessing or contacting one another. All digital data were stored securely and used solely for research purposes.To protect participants' privacy, avatars were used instead of real profile photos. Participants interacted using various emojis (such as like, surprise, congratulations, fear, etc.) and clarified unclear topics through question–answer exchanges with the researcher. Weekly progress was monitored through short quizzes and QuoAD games.

Development of the Educational Program

The program was structured based on primary, secondary, and tertiary prevention levels. Its content was evaluated by an expert panel consisting of two public health nurses, one internal medicine nurse, a Turkish language teacher, and an online content specialist. The panel reviewed the conceptual framework and structural coherence of the messages. Consensus was achieved regarding visual materials, color harmony, font type and size, message order, word count, and attention-grabbing quality. In addition, the content was pilot-tested with 10 women with similar sociodemographic characteristics to the target population. Minor revisions were made based on their feedback to improve clarity.

Implementation of the Educational Program

The researcher sent two messages per day one in the morning and one in the evening every day of the week, totaling 180 messages over 12 weeks. Morning messages included daily weather forecasts (temperature, humidity, sea temperature) and UV index levels, accompanied by motivational slogans. Evening messages were designed to promote knowledge acquisition and behavior change (e.g., sun protection behaviors, early detection and treatment of skin cancer).

Control Groups (Group 2 – Pre-tested, Group 4 – Non-pre-tested)

No direct intervention was applied to the control groups. These participants were passively exposed to information through national and local media (TV, internet, etc.), including content related to weather, heat, and the harms of UV rays. Group 2 received both pre- and post-tests, while Group 4 received only a post-test.

Inclusion and Exclusion Criteria

Community-dwelling women omen who volunteered to participate, could read and understand Turkish, self-assessed their skin type as Fitzpatrick scale type 4 or below, and were able to use the WhatsApp application on their smartphones were included in the study. Women who had lived on the island for less than one year or who were present on the island for vacation purposes were excluded.

Data Collection Instruments

Skin Cancer Sociodemographic Data Form

A 25-item questionnaire developed by the researchers based on the literature [22-24] was used to determine participants' age, education level, marital status, skin color, skin cancer risk factors, sun exposure, and sun protection behaviors.

Skin Cancer and Sun Knowledge Scale (SCSKS)

This 25-item scale was developed by Day et al. [25] and the Turkish validity and reliability study was conducted by Haney et al. [26]. The SCSKS measures knowledge of sun protection (items 1, 16-22), tanning (items 2-12), skin cancer risk factors (items 13-14, 23), prevention of skin cancer (items 15, 24), and symptoms of skin cancer (item 25). It consists of 15 true/false questions and 10 open-ended questions. Scores range from 0 to 25.

Sun Protection Behavior Scale (SPBS)

Originally developed by Rossie et al. [27] and adapted to Turkish by Aygün and Ergün (2015), this scale includes eight items with three subscales: Sun Avoidance (items 1, 2, 3), Use of Sunscreen Products (items 4, 5, 6), and Hat Wearing (items 7, 8). Scores range from 8 to 40 [27, 28].

Fitzpatrick Skin Type Scale

Developed by Dr. Thomas B. Fitzpatrick (1988), this scale classifies skin types into six categories (very fair, fair, medium, normal, dark, brown, very dark, etc.) based on skin reaction to sun exposure.

Data Analysis

The data were analyzed using the SPSS statistical software. Descriptive statistics, including frequency, percentage, mean, median, and standard deviation, were calculated. The distribution of the data was examined using the Kolmogorov–Smirnov test, which indicated that the data were not normally distributed. Therefore, non-parametric tests were applied. The Wilcoxon Signed-Rank Test was used for within-group (pre–post) comparisons, while the Mann–Whitney U Test was employed for between-group comparisons. The Solomon four-group design further enabled a separate assessment of pretest and intervention effects. All analyses were conducted with a 95% confidence interval, and statistical significance was set at $p < 0.05$.

Ethical considerations

Research approval was obtained from the Scientific Research Evaluation Ethics Committee of Eastern Mediterranean University University under the number ETK00-2024-016. Scale permissions and participant consent were obtained in writing.

Limitation

The study is limited to community-dwelling women living on an island in the Mediterranean region, and therefore the findings may not be generalizable. Moreover, the sample included only Turkish-speaking women residing in the island context, which may restrict the cultural and linguistic representativeness of the results. In addition, the data were collected through self-reporting, which may be subject to social desirability bias. The lack of long-term follow-up does not provide information about the sustainability of the training.

Results

Among the participants in Group 1 (intervention applied, pre-post test), 63.2% had been living on the island for more than 10 years, with a mean age of 24.26±5.77. Of these, 89.5% had university-level education or higher, 86.8% were single, and none reported a family history of skin cancer.

In Group 3 (intervention applied, post-test only), 65.8% had been living on the island for 10 years or more, the mean age was 27.44±11.21, 52.6% had completed university or higher education, and 3.6% reported a distant family history of skin cancer.

In Group 2 (no intervention, pre-post test), 47.4% had lived in Cyprus for 1 to 4 years, the mean age was 22.05±3.92, all had university-level education, 94.7% were single, and 5.3% reported a family history of skin cancer.

Among participants in Group 4 (no intervention, post-test only), 73.7% had been living on the island for 10 years or more, the mean age was 29.26±10.07, 71.1% had university-level education, 60.5% were single, and 3.6% reported a family history of skin cancer (Table 1).

As shown in Table 2, among participants in Group 1, 60.5% reported not being exposed to the sun, and 50.0% always used sunglasses. Among those who used sunglasses, 60.5% stated their glasses had UV protection. Additionally, 36.8% reported sun exposure due to work-related reasons. A significant majority (89.5%) did not perform regular skin checks, and 71.1% stated they would not notice changes in their moles. About 65.8% reported sun exposure for 1–2 hours, and 70.3% had experienced sunburn due to sun exposure. Among those who had sunburn, 20.2% reported the burn occurred on their face. Moreover, 55.3% reported no sunburn incidents in a typical year. Regarding the severity of sunburns, 68.4% identified first-degree burns as the most severe type they had experienced, and 19.0% reported managing sunburn with cold water or cold compresses (Table 2).

To examine the interaction between measurement and intervention based on the Solomon four-group experimental design, a 2x2 factorial model was constructed and analyzed using the Kruskal-Wallis H test (Figure 1).

As shown in Table 3, the mean scores of the Skin Cancer and Sun Knowledge Scale were similar in Intervention Group 1 (21.89±2.22) and Intervention Group 2 (21.71±1.16), while the scores were also similar between Control Group 1 (11.10±1.97) and Control Group 2 (12.00±1.97) ($\chi^2 = 114.50$, $p < .001$). A significant difference was also found in the total scores of the Sun Protection Behavior Scale ($\chi^2 = 85.75$, $p < .001$), with mean scores of 35.94±2.53 for Intervention Group 1, 35.63±1.60 for Intervention Group 2, 27.97±4.53 for Control Group 1, and 27.31±5.72 for Control Group 2

Table 1. Socio-Demographic Characteristics of Participants

Variables	Experimental Group-1		Experimental Group -2		Control-1		Control-2	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Age: Mean±Sd, min,max								
Group 1 (Experimental + Pretest): 24.26 ± 5.77 — Median: 22.00 — Min: 20.00 — Max: 47.00								
Group 2 (Control + Pretest): 22.05 ± 3.92 — Median: 21.00 — Min: 19.00 — Max: 38.00								
Group 3 (Experimental): 27.44 ± 11.21 — Median: 22.00 — Min: 16.00 — Max: 56.00								
Group 4 (Control): 29.26 ± 10.07 — Median: 25.00 — Min: 16.00 — Max: 53.00								
Time spent living on the island								
<1 year less	---	---	---	---	3	7.9	2	5.3
1-4 years	13	34.2	9	23.7	18	47.4	6	15.8
5-9 years	1	2.6	4	10.5	2	5.3	2	5.3
<10 years more	24	63.2	25	65.8	15	39.5	28	73.7
Education Status								
Primary School	---	---	3	7.9	---	---	5	13.2
High School	4	10.5	15	39.5	---	---	6	15.8
Universty	34	89.5	20	52.6	38	100	27	71.1
Marital Status								
Maried	4	10.5	9	23.7	1	2.6	15	39.5
Single	33	86.8	28	73.7	36	94.7	23	60.5
I don't want to say	1	2.6	1	2.6	1	2.6	---	---
Family Skin Cancer History								
Yes	---	---	1	2.6	2	5.3	1	2.6
No	38	100	37	97.4	36	94.7	37	97.4

Table 2. Distribution of Participants' Practices Regarding Sun Protection Behaviors

Variables	Experimental-1		Experimental -2		Control--1		Control--2	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Sun Exposure								
Yes	15	39.5	13	34.2	19	50	15	39.5
No	23	60.5	25	65.8	19	50	23	60.5
UV-protected sunglasses								
Yes	23	60.5	21	55.3	24	63.2	21	55.3
No	12	31.6	8	21.1	7	18.4	6	15.8
I dont use	3	7.9	9	23.7	7	18.4	11	28.9
Sun Exposure Due to Work								
Yes	14	26.8	11	28.9	26	68.5	9	23.7
No	24	63.2	27	71.1	12	31.6	29	76.3
Self-Regular Skin Examination								
Yes	4	10.5	5	13.2	6	15.8	5	13.2
No	34	89.5	33	86.8	32	84.2	33	86.8
Noticing Changes in Moles								
Yes	27	71.1	26	68.4	19	50	17	44.7
No	8	21.1	7	18.4	13	34.2	10	26.3
I haven't	3	7.9	5	13.2	6	15.8	11	28.9
Sun Exposure Period								
1-2 hours	25	65.8	21	55.3	20	52.6	27	71.1
3-4 hours	10	26.3	12	31.6	14	36.8	10	26.3
<5 hours	3	7.9	5	13.2	4	10.5	1	2.6
Sun Exposure and Sunburn								
Yes	26	70.3	23	60.5	22	57.9	22	57.9
No	11	29.7	15	39.5	16	42.1	16	42.1
Sunburned Body Part (n:94/78/77/83)*								
Back	14	14.9	13	16.7	10	13	12	14.5
Shoulders	17	18.1	17	21.8	13	16.9	11	13.3
Arms	18	19.1	13	16.7	15	19.5	23	27.7
Hands	6	6.4	3	3.8	6	7.8	4	4.8
Neck	6	6.4	6	7.7	6	7.8	6	7.2
Feet	4	4.3	2	2.6	2	2.6	4	4.8
Face	19	20.2	13	16.7	16	20.8	15	18.1
Skin Color								
Very Light	1	2.6	6	15.8	2	5.3	2	5.3
Light	9	23	7	18.4	10	26.3	4	10.5
Normal	24	63.2	21	55.3	22	57.9	29	76.3
Light Brown	4	10.5	4	10.5	4	10.5	3	7.9

Statistic Test: The Kruskal–Wallis test (non-parametric ANOVA) was used to assess the 2×2 factorial model in the Solomon four-group design. No significant difference was found among posttest scores (p > 0.05).

(Table 3).

In the subdimensions: Sun Avoidance: Intervention Group 1 (13.21±1.25), Intervention Group 2 (12.94±0.83), Control Group 1 (12.00±1.97), Control Group 2 (11.44±2.18) – significant difference ($\chi^2 = 21.26$, $p < .001$). Use of Sunscreen: Intervention Group 1 (13.71±1.20), Intervention Group 2 (13.36±1.05), Control Group 1 (12.07±3.19), Control Group 2 (11.42±2.94) – significant difference ($\chi^2 = 18.46$, $p < .001$). Use of Hat and Sunglasses: Intervention Group 1 (13.71±1.20), Intervention Group 2 (13.36±1.05), Control Group 1 (12.07±3.19), Control Group 2 (11.42±2.94) – significant difference ($\chi^2 = 30.91$, $p < .001$).These findings indicate that both Intervention Groups (with and without pretest) achieved similar scores in knowledge and behavior, suggesting that the pretest did not influence the outcomes. Additionally, both control groups also showed similar, significantly lower scores compared to the intervention groups. Thus, the effectiveness of the training intervention is confirmed, while the pretest effect appears to be negligible ($p > .05$).

Table 3. Analysis of Posttest Scale Scores According to the Solomon Four-Group Design

Scales	Groups (Post Test)	n	Ort.	Ss	Med	S.O.	Test
Skin Cancer and Sun Information Scale	Experimental-1	38	21.89	2.22	22.5	117.17	X^2: 114.50
	Control-1	38	11.1	2.49	11	41.32	p: .000
	Experimental 2	38	21.71	1.16	22	111.75	p<0.05
	Control-2	38	10.63	2.29	11	35.76	
Sun Protection Behavior Scale (Total)	Experimental-1	38	35.94	2.53	35	109.67	X^2: 85.75
	Control-1	38	27.97	4.69	29	43.61	p:0.000
	Experimental- 2	38	35.63	1.6	36	109.28	p<0.05
	Control- 2	38	27.31	5.72	26.5	43.45	
Sun Avoidance Subscale	Experimental-1	38	13.21	1.25	13	93.88	X^2: 21.26
	Control- 1	38	12	1.97	12	66.26	p: 0.000
	Experimental-2	38	12.94	0.83	13	90.09	p<0.05
	Control- 2	38	11.44	2.18	12	55.76	
Sunscreen Use	Experimental-1	38	13.71	1.2	14	94.92	X^2: 18.46
Sub Scale	Control-1	38	12.07	3.19	12.5	71.13	p:0.000
	Experimental- 2	38	13.36	1.05	13	85.03	p<0.05
	Control-2	38	11.42	2.94	12	54.92	
Hat Usage Subscale	Experimental-1	38	9.02	0.94	9v00	106.28	X^2: 92.51
	Control-1	38	3.89	2.07	4	38.84	p: 0.000
	Experimental-2	38	9.31	0.96	10	113.7	p<0.05
	Control-2	38	4.44	2.74	3	47.18	

Statistic Test: The Kruskal–Wallis test (non-parametric ANOVA) was used to assess the 2×2 factorial model in the Solomon four-group design. No significant difference was found among posttest scores (p > 0.05).

Significant increases were observed across all scales and subscales following the intervention in Experimental Group 1. The mean score on the Skin Cancer and Sun Knowledge Scale increased from 10.13 (±2.17) to 21.89 (±2.22), indicating a statistically significant improvement (Z = 5.358; p < .001). Similarly, the total score on the Sun Protection Behavior Scale rose from 28.00 (±4.15) to 35.94 (±2.53) (Z = 5.115; p < .001). Subscale improvements were also significant: Sun Avoidance (Z = 2.838; p = .005), Sunscreen Use (Z = 3.070; p = .002), and Hat Use (Z = 3.158; p = .002). These results demonstrate that the intervention effectively enhanced both knowledge and protective behaviors.

Post-test comparisons between Experimental Group 1 (pre-test + intervention) and Control Group 1 (pre-test only) revealed significant differences across all measures: Knowledge (U = 2.50; p < 0.001), Behavior (U = 57.5; p < 0.001), Sun Avoidance (U = 46.5; p < 0.001), Sunscreen Use (U = 51.75; p = 0.029), and Hat Use (U = 37.5; p = 0.006). These findings confirm the effectiveness of the intervention over the control condition.

To assess the potential influence of pretesting, scores were compared between Experimental Group 1 and Control Group 2 (post-test only). Experimental Group 1 demonstrated significantly higher scores across all dimensions: Knowledge (Z = 5.835; p < .001), Behavior (Z = 5.630; p < .001), Sun Avoidance (Z = 2.60; p < .05), Sunscreen Use (Z = 2.02; p < .05), and Hat Use (Z = 5.630; p < .001). These results suggest that the pretest did not confound the intervention's effects.

Comparison between Experimental Group 1 (pre-test + intervention) and Experimental Group 2 (intervention only) showed no statistically significant differences in post-test scores: Knowledge (U = 1.50; p < 0.001), Behavior (U = 14.25; p < 0.001), Sun Avoidance (U = 37.85), Sunscreen Use (U = 34.85), and Hat Use (U = 14.20; all p < 0.001). These findings support the conclusion that the pretest did not influence outcomes and that the intervention itself was the key factor in the observed improvements.

Significant differences favoring the intervention group were found when comparing Experimental Group 2 and Control Group 2, both of which did not receive pretesting: Knowledge (Z = 1.02; p < 0.001), Behavior (U = 13.70; p < 0.001), Sun Avoidance (U = 38.0), Sunscreen Use (U = 39.7), and Hat Use (U = 12.66; all p < 0.001). These findings clearly show that the intervention was effective even in the absence of a pretest.

When comparing Experimental Group 2 (intervention only) with Control Group 1 (pretest only), significant differences were found in favor of the experimental group for Knowledge (Z = -5.38; p < 0.001), Behavior (Z = -5.30; p < 0.001), Sun Avoidance (Z = -2.00; p = 0.045), Sunscreen Use (Z = -2.02; p = 0.043), and Hat Use (Z = -5.30; p < 0.001), indicating the intervention's effectiveness was not influenced by pretest exposure.

To evaluate the standalone effect of the pretest, Control Group 1 (with pretest) was compared to Control Group 2 (no pretest). No statistically significant differences were found in Knowledge and Sun Protection Behavior scores or subscales (p > 0.05), suggesting that the pretest did not independently affect post-test outcomes.

The pre- and post-test comparison within Control Group 1 yielded no significant changes, further indicating

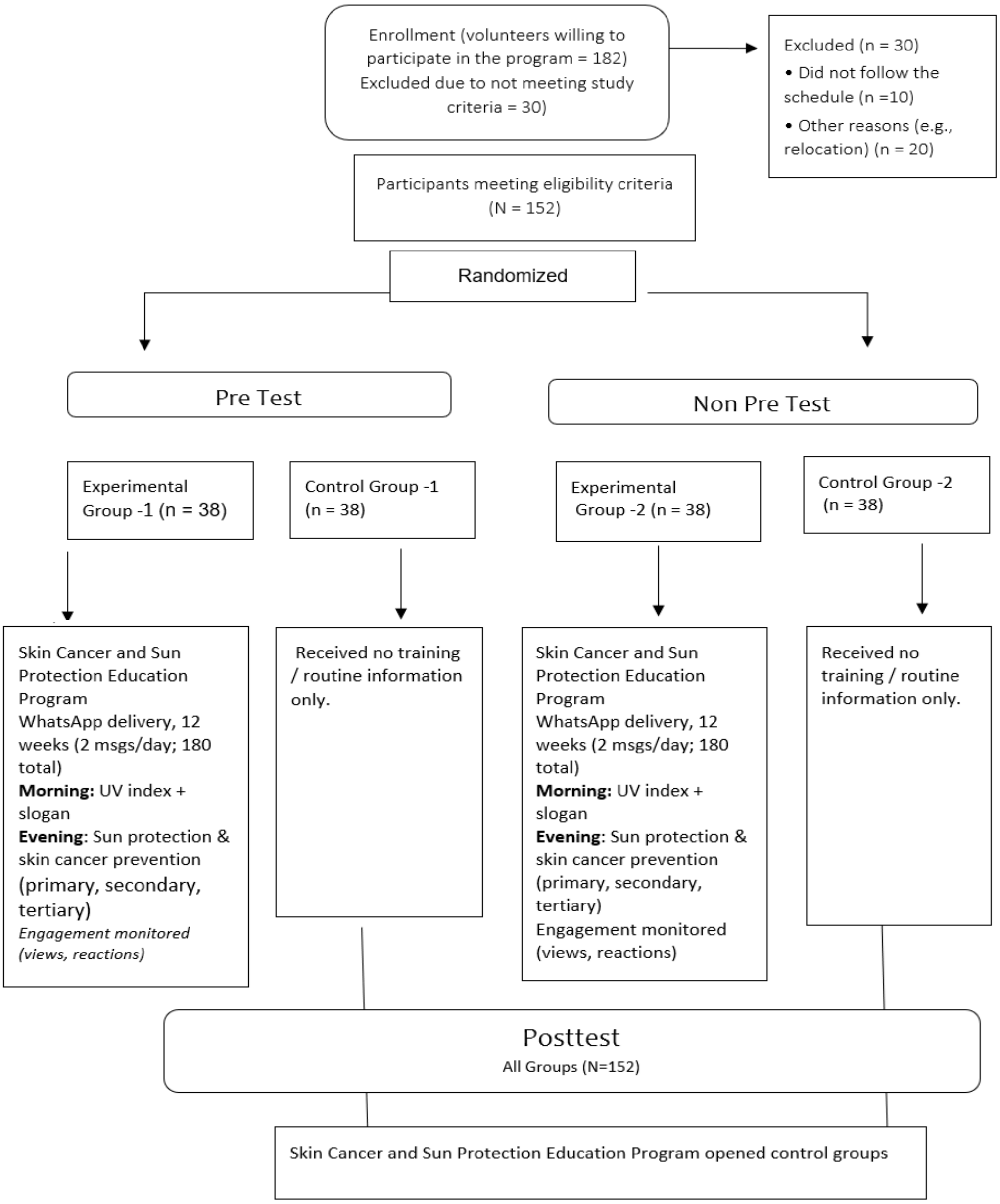

Figure 1. CONSORT Scheme for SOLOMON Four Groups

that the pretest alone did not influence behavior or knowledge scores. Therefore, it can be inferred that observed improvements in the experimental groups are attributable to the intervention rather than to the testing procedure.

Discussion

In this study, the effectiveness of a 12-week interactive educational intervention delivered via WhatsApp on skin cancer knowledge and sun protection behaviors among community-dwelling women was evaluated using the Solomon Four-Group Experimental Design. The primary advantage of the Solomon model is its ability to isolate the effects of the intervention from the effects of pretesting, thereby enabling more precise comparisons [29]. This model is a robust experimental design that enhances both internal and external validity. Overall, the findings indicate that mobile health-based educational interventions can effectively support preventive healthcare practices across primary, secondary, and tertiary levels.

At the end of the intervention, the Skin Cancer and Sun Knowledge Scale (SCSKS) scores in the intervention groups (Experiment-1 and Experiment-2) were approximately twice as high (≈21.7–21.8) as those in the control groups (Control-1 and Control-2; ≈10.6–11.1) ($p < 0.05$). Within-group comparisons revealed a twofold increase in the experimental groups, while no significant change was observed in the controls. The comparison between Experiment Group 2 (post-test only) and Control Group 2 (post-test only) also confirmed that the effect was independent of pretesting ($p < 0.001$). These consistent results demonstrate that the educational content itself significantly improved knowledge, independent of any testing effect. Moreover, no statistically significant difference was observed between Experiment Group 1 and Experiment Group 2 in post-test scores ($p > 0.05$), confirming that the intervention's effect was independent of pretesting. Although some studies suggest that pretesting enhances awareness [30], this was not supported here. These results highlight the effectiveness of interactive WhatsApp education in increasing knowledge, consistent with earlier findings emphasizing the usefulness of digital health platforms [23, 24]. The real-time interaction and contextual relevance of the content (e.g., UV risk alerts during summer months) may have strengthened learning outcomes [10].

This finding aligns with previous studies highlighting the utility of digital platforms in health education [23, 24]. Mobile technologies, particularly messaging applications, eliminate temporal and spatial barriers, making health education more accessible and continuous. The quality of the educational content, its delivery method, and duration must be considered primary factors in its effectiveness. Real-time interaction in WhatsApp groups and contextual relevance during summer months such as incorporating daily temperature and UV risk may have enhanced the program's impact [10].

Findings related to sun protection behaviors support Hypothesis H02, revealing significant improvements in the intervention groups. The Sun Protection Behavior Scale (SPBS) scores were significantly higher in the intervention groups (≈35.6–35.9) compared to the control groups (≈27.3–27.9) ($p < 0.05$). Participants reported more frequent sunscreen use, wearing of hats and sunglasses, and avoidance of peak sun hours. Although photoprotection strategies such as seeking shade and wearing protective clothing were more common in the intervention groups, the island's climate and outdoor lifestyle may have limited full adoption [2].

Participants reported increased use of hats, sunscreen, and avoidance of sun exposure during peak hours. Although photoprotection strategies such as seeking shade and wearing protective clothing were more frequent in the intervention groups, the sunny island setting may have posed limitations on the full implementation of these behaviors in daily routines [2]. While some concerns have been raised regarding the endocrine-disrupting potential of commercial sunscreens [31, 32], the protective benefits of high-SPF sunscreens against melanoma and other skin cancers are well established. The significantly higher sunscreen use in the intervention groups ($p < 0.05$) underscores this. Mechanical protection such as the use of hats, sunglasses, and light-colored clothing to shield high-exposure areas like the head, ears, and nose was approximately twice as common in the experimental groups compared to the controls ($p < .05$), demonstrating the effectiveness of physical protection strategies [9].

These results are consistent with Altun's (2019) findings [22], which also indicated the positive impact of educational interventions on sun protection behaviors. Moreover, the findings are in line with the Health Belief Model (Rosenstock) [33], which posits that individuals are more likely to adopt protective behaviors when they perceive themselves at risk and believe in the efficacy of preventive actions.

Despite the positive results, it is important to note that although WhatsApp-based education offers advantages in terms of accessibility, it may limit personalized feedback typically provided in face-to-face interactions. Future studies could explore the effectiveness of hybrid models that combine mobile education with in-person counseling. Additionally, the sustainability of behavior change over time remains uncertain, as this study focused on short-term outcomes. Long-term follow-up studies are needed to assess the retention of knowledge and behaviors. Variables such as participants' health literacy, digital competence, and prior exposure to health campaigns may have also influenced the outcomes and should be explored in future research.

In line with the first hypothesis, the interactive education provided to the experimental group significantly increased participants' knowledge levels. This finding aligns with existing literature highlighting the effectiveness of educational interventions aimed at enhancing digital health literacy [34, 35]. In particular, structured and interactive training materials have been shown to attract participants' attention and enhance the retention of learning [36].

Regarding the second hypothesis, a significant improvement in sun protection behaviors was observed only in the experimental group, while no such change was detected in the control group. This result indicates that the increase in knowledge translated into behavioral change. Similarly, Erdem et al. [37] reported that programs supported by both face-to-face and online training positively influenced individuals' health behaviors.

The third and fourth hypotheses revealed that the pretest alone did not significantly affect knowledge or behavior. This finding supports the internal validity of the study and suggests that the observed effects can primarily be attributed to the implemented intervention. This strength of the Solomon four-group design lies in its ability to control for potential pretest effects [30].

Previous research has emphasized the effectiveness of widely used communication platforms, such as WhatsApp, in health education [37]. In this study, the interactive training conducted via WhatsApp also offered notable advantages in terms of accessibility, ease of participation, and sustainability. Additionally, it allowed participants to learn at their own pace and at times convenient to them.

The Solomon four-group design employed in this study minimized the potential confounding effect of pretesting, and results indicated that pretests had no significant impact on either knowledge or behavior ($p < .05$). Hypothesis H_{04} compared Experiment Group 1 (pretest + intervention) with Control Group 2 (post-test only) and found significant differences in favor of the experimental group, indicating that the intervention effect was not undermined by pretesting. This suggests the intervention had a robust impact, despite the theoretical risk of pretest-intervention interaction outlined by Campbell and Stanley (1963).

Similarly, Hypothesis H_{03} revealed no significant difference between Experiment Group 1 and Experiment Group 2 (intervention without pretest), confirming that the educational content was the main determinant of change, regardless of pre-existing awareness. These findings align with literature supporting the effectiveness of digital education interventions [38, 39]. In Hypothesis H_{06}, a comparison between Experiment Group 2 and

Control Group 2 (both post-test only) revealed significant differences in favor of the intervention, reinforcing that well-designed educational programs can effectively improve knowledge and behavior even in the absence of pretesting [20]. This enhances the external validity of the study and highlights the direct impact of the intervention.

In Hypothesis H_{05}, the comparison between Experiment Group 2 (intervention only) and Control Group 1 (pretest only) demonstrated significant differences in favor of the intervention. This confirms that pretesting alone is insufficient to elicit change, and active educational engagement is essential. This supports prior studies emphasizing that measuring knowledge is not enough to influence it; structured educational interventions are necessary [40].

Finally, Hypotheses H_{07} and H_{08}, which aimed to assess the effect of pretesting alone, showed no significant within-group or between-group differences between Control Group 1 (pretested) and Control Group 2 (not pretested), suggesting that pretesting did not influence the outcomes. This indicates that pretesting alone was not a cue for increased awareness and did not pose a threat to the study's internal validity [41, 42]. Analyses using the Solomon design confirmed that pretesting had no significant effect on knowledge or behavior, and that the intervention had an independent and strong effect [21]. While some literature proposes that pretests can enhance awareness, this study demonstrates that such an effect is not universally present. The reliability of the Solomon design as an evaluation method is supported by similar findings in other studies [35].

This study demonstrated that a WhatsApp-based, nurse-led educational intervention targeting women over 18 in community settings was effective in enhancing both skin cancer knowledge and sun protection behaviors. The 12-week program, enriched with daily reminders and interactive content during the summer high-risk period, led to significant improvements in participants' awareness and preventive practices. Using the Solomon four-group randomized design, the study provided robust evidence that the intervention itself rather than pretesting accounted for the observed effects, confirming the independent effectiveness of mobile-based preventive education.

Digital health education programs such as this can serve as effective tools for health professionals, especially nurses, in delivering community-based preventive health services across all levels (primary, secondary, tertiary). Even in the absence of pretesting, such interventions have the potential to initiate changes in knowledge and behavior. Therefore, similar digital education programs can be adapted for other health topics and disseminated more widely.

Author Contribution Statement

All authors contributed equally in this study.

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