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## Effectiveness of the EM 2R3SW Digital Application on Parental Outcomes for Childhood Leukemia Prevention: A Quasi-Experimental Study in Depok, Indonesia

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### Abstract

**Background:** Childhood acute lymphoblastic leukemia (ALL) is a leading cause of cancer-related morbidity and mortality in low- and middle-income countries, including Indonesia. Parental gaps in knowledge, attitudes, preventive behaviors, and healthy lifestyle practices contribute to delayed detection and poor outcomes. Digital health platforms offer scalable strategies to strengthen preventive health literacy in families.

**Objective:** To evaluate the effectiveness of EM-2R3SW, a web-based digital education application, on parental knowledge, attitudes, preventive behaviors, and healthy lifestyle practices related to childhood leukemia prevention.

**Methods:** A quasi-experimental pretest-posttest study was conducted among mothers of children aged 0-18 years in Sukmajaya District, Depok, Indonesia (N = 112). Participants accessed leukemia-prevention multimedia content within EM-2R3SW over two weeks. Validated questionnaires measured outcomes at baseline and post-intervention. Data were analyzed using Wilcoxon signed-rank tests due to non-normal distribution (Kolmogorov-Smirnov  $p < 0.05$ ).

**Results:** Significant improvements were observed across all outcomes. Knowledge scores increased from 16.48 to 27.65, attitudes from 68.15 to 85.95, preventive behaviors from 72.39 to 112.20, and healthy lifestyle practices from 68.39 to 109.27 (all  $p < 0.001$ ). Category transitions demonstrated marked progression from inadequate to good-very good levels, particularly in preventive practices.

**Conclusion:** The EM-2R3SW digital intervention effectively improved parental literacy and behavioral determinants for childhood leukemia prevention. This approach is feasible, low-cost, and scalable for community-based cancer prevention efforts in resource-limited settings. Larger randomized studies with long-term follow-up are recommended.

**Keywords:** Childhood acute lymphoblastic leukemia; parental literacy; preventive behavior; mHealth; digital education; Indonesia

## INTRODUCTION

Acute Lymphoblastic Leukemia (ALL) is the most common malignancy and a major contributor to childhood morbidity and mortality worldwide(1). Globally, approximately 90,000 children die from cancer each year(2). In Indonesia, ALL remains a critical public health burden, with an estimated 14,979 new childhood cases annually, placing the country among the highest in Southeast Asia (3). Despite advances in pediatric cancer treatment, survival rates in low- and middle-income countries remain significantly lower than in high-income settings primarily due to a lack of early detection and community awareness (4).

The etiology of childhood leukemia is multifactorial, involving genetic predisposition, viral infections, environmental exposures (such as benzene and pesticides), and unhealthy lifestyle behaviors(5,6). Lack of parental knowledge is strongly associated with delayed recognition of early signs, late diagnosis, and poor treatment outcomes (7).

In Indonesia, leukemia contributes to one-third of all childhood cancer cases, with ALL consistently ranked among the top ten cancer types(8). In West Java Province, leukemia accounts for 11.12% of the total Disability-Adjusted Life Years (DALYs) burden, significantly affecting families and community well-being(9). Sukmajaya District in Depok has reported rising leukemia cases, exceeding 200 new cases annually, yet parental awareness regarding risk factors and preventive behaviors remains low (10).

Digital health interventions are increasingly recognized as effective strategies for improving health literacy and influencing preventive behaviors among parents and caregivers(11,12). Web-based platforms, in particular, provide accessible, scalable, and interactive education tailored to community needs (13). The EM-2R3SW application was developed to address gaps in parental knowledge related to childhood leukemia prevention by delivering multimedia educational content to foster knowledge gain, positive attitudes, proactive behavioral change, and healthier lifestyles.

Effectiveness of such interventions must be scientifically validated to ensure they contribute measurable improvements in community health outcomes(14). Therefore, this study aims to evaluate the effectiveness of the EM-2R3SW

application in improving parental knowledge, attitudes, preventive behaviors, and healthy lifestyle practices related to childhood leukemia prevention in Sukmajaya, Depok. The findings are expected to support digital health integration in cancer prevention programs across Indonesia.

## METHODS

### Study design

This study employed a quasi-experimental approach using a one-group pretest-posttest design to evaluate the effectiveness of the EM-2R3SW digital application in improving parental determinants associated with childhood leukemia prevention. The research was conducted over a two-month period in Sukmajaya District, Depok, Indonesia, an urban region characterized by dense residential areas and a limited availability of structured health education programs for cancer prevention.

### Sample

The target population consisted of mothers who had at least one child aged 0–18 years residing in the area. A total of 112 mothers were recruited to participate through purposive sampling, based on eligibility criteria that included willingness to participate voluntarily, ability to read and operate a smartphone device, and access to an Android phone to support digital intervention. Individuals were excluded if they demonstrated cognitive or communication impairments or if they were unable to complete the intervention and posttest assessment due to withdrawal or loss to follow-up.

Sample adequacy was determined using an a priori power analysis conducted with G\*Power software. Assuming a moderate effect size of 0.50, significance level of 0.05, and power of 0.80, the minimum recommended sample size was 102 participants. Therefore, enrolling 112 participants ensured sufficient statistical power to detect meaningful changes in the measured outcomes.

### Intervention

The intervention consisted of exposure to the EM-2R3SW digital application over a 14-day period. The application was specifically developed as a web-based platform tailored for Indonesian parents, integrating multimedia content such as instructional videos, animated infographics, digital posters, and interactive quizzes designed to enhance parental knowledge

and promote healthy behavioral change. The educational materials covered essential domains related to childhood leukemia prevention, including recognition of risk factors, understanding early warning signs, adoption of a healthy lifestyle, environmental exposure reduction, and strengthening of preventive health behaviors within the household context. The content was developed in collaboration with pediatric nursing educators and reviewed for cultural relevance and literacy appropriateness for diverse parental backgrounds. Participants were encouraged to explore the educational modules independently during the two-week period, with optional technical support provided by the research team when needed.

### Data collection

Data were collected at two time points—prior to intervention initiation and immediately following completion of the two-week access period. Four outcome variables were assessed using standardized structured questionnaires.

### Instrument

Parental knowledge was measured using a 20-item true/false instrument, while attitudes toward leukemia prevention were assessed through a 20-item five-point Likert scale, ranging from strongly disagree to strongly agree. Preventive behaviors were evaluated through a 28-item behavioral frequency scale, and healthy lifestyle practices were measured using a 25-item self-reported lifestyle assessment. These instruments were adapted from previously validated tools used in cancer-prevention behavioral studies and underwent linguistic and contextual adaptation procedures for Indonesian use. Prior psychometric testing demonstrated satisfactory reliability coefficients, with Cronbach's alpha values ranging from .81 to .90 in the current sample.

### Data analysis

All data were analyzed using SPSS version 26. Descriptive statistics were employed to characterize participant demographics and summarize outcome score distributions at both assessment points. The Kolmogorov-Smirnov test was used to assess the normality of outcome data, and the results indicated non-normal distribution across all variables. Consequently, the Wilcoxon signed-rank test was chosen as the appropriate non-parametric method to evaluate pre- and post-intervention changes, with a significance threshold set at  $p < 0.05$ . Additional effect size interpretation supported the magnitude of intervention impact.

### Ethical consideration

Ethical approval for the study was granted by the Health Research Ethics Committee (No. 3144/UN25.8/BAA/DL/2025). All participants received a clear explanation of the study aims and procedures, provided written informed consent electronically, and were assured confidentiality and the freedom to discontinue participation at any stage without consequence. At the conclusion of the study, participants were given the opportunity to provide feedback on application usability and acceptability to inform further development and refinement of the EM-2R3SW platform.

## RESULTS

Table 1 shows that the majority of respondents were adults in the productive age category (24–34 years), predominantly with secondary education (senior/junior high school) and mostly unemployed. These characteristics suggest a population with potential gaps in health literacy and limited access to information, reinforcing the need for accessible digital health education interventions such as EM-2R3SW.

**Table 1. Sociodemographic Characteristics of Respondents (n = 112)**

Characteristics	Category	n	%
<b>Age (years)</b>	24–34	62	55.4
	35–55	50	44.6
<b>Education Level</b>	Elementary School	15	13.4
	Junior High School	40	35.7
	Senior/Vocational High School	50	44.6
<b>Employment Status</b>	Bachelor's Degree	7	6.3
	Unemployed	85	75.9
	Employed	27	24.1

**Note.** Percentages are rounded to one decimal point.

**Table 2. Respondents' Pre-Post Intervention Outcomes (n = 112)**

Variable	Category	Pre-test n (%)	Post-test n (%)
Knowledge	Good	20 (17.9)	80 (67.9)
	Satisfactory	67 (59.8)	26 (23.2)
	Unsatisfactory	25 (22.3)	6 (5.4)
Attitude	Positive	52 (46.4)	112 (100)
	Negative	60 (53.6)	0 (0)
Preventive Behavior	Very Low	10 (8.9)	0 (0)
	Low	45 (40.2)	0 (0)
	High	53 (47.3)	15 (13.4)
	Very High	4 (3.6)	97 (86.6)
Healthy Lifestyle	Very Low	5 (4.5)	0 (0)
	Low	33 (29.5)	0 (0)
	High	66 (58.9)	10 (8.9)
	Very High	8 (7.1)	102 (91.1)

**Table 3. Bivariate Analysis of Pre-Post Outcomes (n = 112)**

Variable	Normality (K-S Test) p-value	Pre-test Mean	Post-test Mean	Wilcoxon p-value	Conclusion
Knowledge	<0.05	16.48	27.65	<0.001*	Significant improvement
Attitude	<0.05	68.15	85.95	<0.001*	Significant improvement
Preventive Behavior	<0.05	72.39	112.20	<0.001*	Significant improvement
Healthy Lifestyle	<0.05	68.39	109.27	<0.001*	Significant improvement

\*Significant at  $\alpha = .05$ .

Non-parametric Wilcoxon Signed-Rank Test was applied due to non-normal data distribution.

Table 2 demonstrates a substantial transition from low and moderate levels to high and very high categories in knowledge, attitudes, preventive behaviors, and healthy lifestyle practices after using the EM-2R3SW web-based application. Negative attitudes and low behavioral and lifestyle categories were eliminated entirely in the post-intervention assessment. These results indicate the intervention's strong influence on improving parental awareness and proactive actions toward preventing childhood leukemia.

Table 3 shows that all pre-post variables violated normality assumptions, requiring the use of the Wilcoxon signed-rank test. The significant p-values ( $<.001$ ) for all variables confirm that the EM-2R3SW intervention effectively enhanced parental knowledge, attitudes, preventive behaviors, and healthy lifestyle practices. These findings support the effectiveness of digital health education in promoting behavioral change related to childhood leukemia prevention.

## DISCUSSION

This study demonstrated that the EM-2R3SW digital application significantly improved parental knowledge, attitudes, preventive behaviors, and healthy lifestyle practices related to childhood leukemia prevention. These findings highlight that digitally delivered health education can effectively strengthen parental health literacy and encourage protective behaviors in resource-limited communities.

A significant increase in knowledge scores suggests that parents benefitted from easily accessible, multimedia-based content, consistent with prior work showing that digital media enhances comprehension and retention of cancer-related information among parents and caregivers (15). Knowledge improvement is also recognized as the first step toward empowering families to engage in early cancer detection and risk-reduction strategies(16). Prior studies indicate that parents with greater leukemia-related knowledge are more likely to seek timely care when early symptoms arise, which has a strong influence on treatment outcomes (17).

The intervention also improved parental attitudes toward cancer prevention, suggesting positive shifts in perception, motivation, and readiness to adopt preventive behaviors. According to behavioral theory frameworks, attitude change is a determinant of health-seeking behavior and essential for sustaining lifestyle modifications (18). Similar digital interventions have been shown to foster more proactive attitudes among parents regarding childhood cancer risk management and symptom recognition(19,20).

Preventive behaviors and healthy lifestyle practices improved significantly after the intervention. These findings align with global literature showing that even without definitive prevention, leukemia risk can be influenced by environmental exposure reduction, hygiene, nutrition, and immunologic strengthening behaviors at home (21). The present results are consistent with cancer-prevention research demonstrating the effectiveness of digital education in promoting behavior change and adherence to early detection recommendations(15,22). In Indonesia, where knowledge gaps often contribute to delayed diagnosis (8), empowering parents to adopt healthier routines could contribute to earlier healthcare engagement and better prognosis.

This study also supports the growing importance of digital health tools for community-based cancer control. mHealth and web-based applications offer high scalability, cost-effectiveness, and accessibility — especially valuable in underserved populations where health communication infrastructure is limited (23,24). As demonstrated in prior research, interactive and visually rich learning environments optimize caregiver engagement and motivation far better than traditional pamphlets alone (25)

Overall, the results reinforce the theoretical pathway whereby improved knowledge and attitudes lead to behavioral intentions and sustained action. This aligns with health behavior models such as the Health Belief Model and Pender's Health Promotion Model, emphasizing perceived benefits, cues to action, and environmental support as triggers for preventive behavior (18,26). The improvements observed across all outcome domains indicate that EM-2R3SW successfully addressed multiple behavioral determinants required to support cancer-prevention efforts within families.

## Limitation

However, several considerations should be noted. This study used a quasi-experimental single-group design, lacking a randomized control arm, which may limit causal inference. Additionally, outcomes were measured immediately post-intervention, preventing assessment of long-term sustainability. Self-report questionnaires may also introduce social desirability bias. External factors such as social support or prior exposure to cancer information were not controlled for, which could influence outcomes. Future studies should integrate a controlled design, include longer follow-up periods, and explore objective behavioral indicators such as clinic visits for screening or environmental risk-reduction practices in the home.

Despite these limitations, this study provides valuable empirical evidence supporting digital parental education as a feasible and impactful public health strategy for childhood leukemia prevention in Indonesia. Integrating EM-2R3SW into routine health-promotion activities led by community health workers or school health programs may help strengthen early cancer detection and prevention at a population level.

## CONCLUSION

This study demonstrated that the EM-2R3SW digital application was effective in improving parental knowledge, attitudes, preventive behaviors, and healthy lifestyle practices related to childhood leukemia prevention among mothers in Sukmajaya, Depok. Significant improvements observed across all outcome variables following the two-week intervention indicate that web-based health education provides an accessible, practical, and engaging platform for strengthening parental health literacy and enabling more proactive prevention efforts. These findings suggest that digital technology can be strategically integrated into community-based health promotion programs to reduce gaps in early detection and to empower parents as the primary gatekeepers of child health. The results of this study provide initial evidence that the EM-2R3SW application can serve as a valuable preventive tool in regions with limited access to pediatric oncology resources. Strengthening public awareness and encouraging early recognition of symptoms are critical components in improving childhood cancer outcomes in Indonesia, where delays in

diagnosis remain a continuing challenge. Incorporating such digital solutions into existing health systems—particularly through collaboration with schools, primary care providers, and community health centers—may increase reach, sustainability, and long-term public health benefits.

Future studies using randomized controlled designs and extended follow-up periods are recommended to determine the durability of behavioral change and to assess clinical outcomes, such as earlier presentation to health services. Additionally, evaluating the feasibility of wider implementation, including different sociodemographic settings and caregiver populations, will be important to support broader policy adoption. Overall, the findings support continued development and scale-up of digital innovations such as EM-2R3SW as part of national strategies for childhood cancer prevention and health promotion.

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### Author Contributions

RRP: Conceptualization, study design, intervention development, data collection, data analysis, manuscript drafting.

RHF: Methodology development, statistical analysis, interpretation of findings, manuscript review and editing.

RDW: Instrument development, data collection supervision, data validation, manuscript revision.

RR: Educational content development, intervention implementation support, qualitative

feedback analysis, manuscript editing.

RDP: Study supervision, ethical compliance, validation of instruments, critical review and final approval of the manuscript.

### Conflict of Interest

The authors declare that there are no conflicts of interest related to this study.

### Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request, subject to ethical approval and the protection of participant confidentiality.

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