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Research Article

# Development of a Decision-Making System for Promoting Marriage Age Maturity among Adolescents in East Java

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***ABSTRACT***

*Marriage is a physical and spiritual bond between a man and a woman as husband and wife, with the aim of forming a happy and lasting family based on belief in God Almighty. Premature marriage can have adverse effects, not only for the husband and wife, but also for future generations. The utilization of machine learning is needed to analyze the potential risk of early marriage. To date, programmatic and research approaches to marriage age maturity have primarily relied on inferential statistics, with limited application of machine learning methods.This study aims to develop a decision support system for promoting marriage age maturity among adolescents in East Java. This is a non-reactive study utilizing secondary data from the 2018 SKAP (Survey on Family Planning Performance and Accountability), obtained from the East Java Representative Office of BKKBN. The unit of analysis is all adolescent respondents in East Java who met the criteria for participation in the 2018 SKAP. Data analysis was conducted using univariate, bivariate, and Decision Tree methods. Knowledge was found to be a complex factor influencing adolescents' decisions regarding marriage planning, while economic status emerged as an additional supporting factor. The results of the machine learning analysis, presented in the form of an algorithm, are expected to serve as a foundation for decision-making related to the promotion of marriage age maturity among adolescents in East Java.*

***Keywords:*** *Adolescents, decision tree, marriage*

## INTRODUCTION

Marriage is a social institution aimed at forming a household between partners, ideally grounded in physical, mental, and social maturity. In the context of population development and family health, Indonesia's National Population and Family Planning Board (BKKBN) recommends the ideal marriage age as 25 for men and 20 for women, as part of a strategy to delay age at first marriage (BKKBN, 2024). However, child marriage remains a serious issue in various regions of Indonesia, including East Java Province.

According to data from the National Socioeconomic Survey (Susenas), the national prevalence of early marriage reaches 11.9%, with higher rates in rural areas. A study by Fitria , et al., (2024) reveals that women with low educational attainment are up to 448 times more likely to experience child marriage compared to those with higher education. This situation is exacerbated by socio-cultural and economic factors influencing marriage decisions, particularly among poor and undereducated communities (Fitria , et al., 2024).

In East Java, Suyanto, et al., (2023) found that early marriage not only leads to school dropouts but also results in unintended pregnancies, domestic violence, and intergenerational poverty. They identified cultural norms, parental pressure, and lack of access to reproductive health education as key drivers of child marriage, particularly in districts like Sumenep, Bondowoso, and Probolinggo. Similar findings were reported by Imron, et al., (2020), highlighting that age at first marriage is influenced by education level, socioeconomic status, media exposure, and reproductive health knowledge.

Various government interventions have been implemented, including the Generation Planning (GenRe) program, peer education activities, and the enactment of Law No. 16 of 2019 which raised the minimum marriage age to 19 for both males and females. However, the impact remains uneven, as many programs fail to address the root causes of early marriage at the individual and community levels (UNFPA, 2016; BKKBN, 2024).

Traditional statistical approaches are often insufficient to capture the complexity of early marriage determinants. Therefore, technology- and data-driven models capable of providing predictive and adaptive analyses are needed. The use of machine learning algorithms, such as decision trees, enables decision modeling based on multiple variables simultaneously. Fitria , et al., (2024) demonstrated that machine learning models can identify high-risk groups more accurately and efficiently, allowing for more targeted interventions.

Patriarchal cultural norms, gender role perceptions, and social pressures on girls to marry young remain major challenges in rural communities. In many cases, families view early marriage as a solution to preserve family honor or reduce financial burdens, particularly in resource-constrained settings (Suyanto, et al., 2023; Wijayati, et al., 2017). Low reproductive health literacy further increases adolescents' vulnerability, as many lack awareness of the biological and mental consequences of early marriage (Fitria , et al., 2024).

A shift from generalized programming to personalized, context-specific approaches is crucial. Imron, et al., (2020) emphasized the importance of multidimensional frameworks that incorporate national surveys such as Susenas, IDHS, and local administrative data. Integrating data-driven methods is believed to produce policy interventions that are more responsive to local characteristics.

Machine learning methods—particularly decision tree algorithms—offer high interpretability by generating transparent decision flowcharts for policymakers. These models are suitable for promoting marriage age maturity because they can identify key determinants of early marriage—such as education level, socioeconomic status, cultural norms, and access to health information—while presenting them in a clear and visual format that is easy for stakeholders to understand. By simplifying complex interactions into decision pathways, decision trees allow policymakers to pinpoint high-risk groups and design tailored interventions, such as targeted reproductive health education, economic empowerment programs, or community-based campaigns. This evidence-based approach ensures that interventions are not only predictive but also actionable, supporting more effective strategies to delay marriage age and improve adolescent well-being.

These models facilitate a better understanding of the interplay among various risk factors and enable more evidence-based and contextually grounded interventions (BKKBN, 2024; UNFPA, 2016). Furthermore, region-based models such as those developed by Dietrich, et al., (2022) in South Asia have shown that macroeconomic and climate variables can predict child marriage incidence with up to 77% accuracy. Their findings strengthen the argument for utilizing machine learning in policymaking.

Therefore, this study aims to develop a decision-support system using machine learning, specifically decision tree algorithms, to map the potential for early marriage among adolescents in East Java Province. This approach is expected to contribute to evidence-based, data-personalized interventions that support adolescent marriage delay efforts.

## MATERIAL AND METHODS

This study employed a non-reactive design in which the respondents were unaware that they were being observed or studied. The research utilized a cross-sectional study design and adopted a quantitative approach using secondary data from the 2018 Performance and Accountability Survey of the Population, Family Planning, and Family Development Program (SKAP KKBPK) conducted in East Java Province.

The population analyzed from the 2018 SKAP KKBPK data in this study was adolescents aged 15–24 years. The national target sample consisted of 67,725 households across 34 provinces, 514 districts/cities, and 1,935 villages/urban clusters, proportionally allocated by urban and rural strata. Specifically for East Java Province, the sample included 2,976 households spread over 102 clusters.

After calculating the design weight for each household, a normalized weight was applied to obtain the household normal weight, family normal weight, women of reproductive age (WRA) normal weight, and adolescent normal weight. Required information included the count of complete and incomplete interviews across the family module, WRA module, and adolescent module. Based on the response rate, a total of 1,032 adolescents met the eligibility criteria as respondents, and 1,027 adolescents aged 15–24 years were successfully interviewed.

The data were analyzed using bivariate analysis with the support of R and SPSS software, employing a decision tree framework consisting of several structured stages.

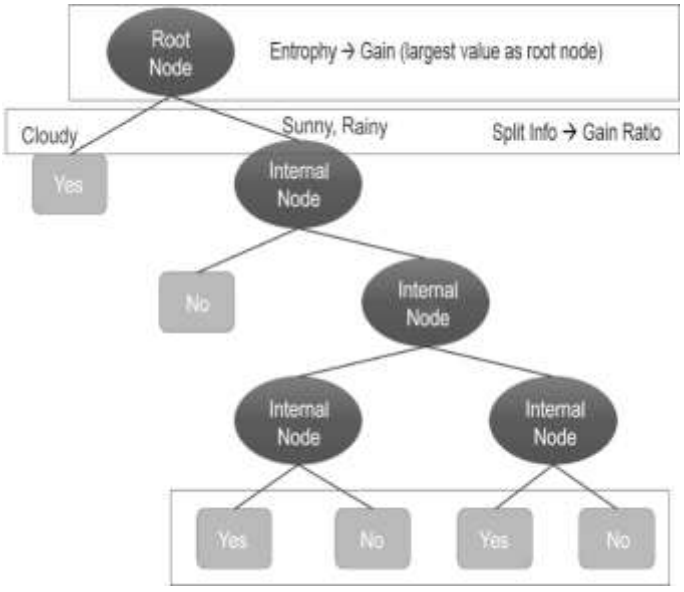


**Figure 1. Decision Tree Development Stages**

Data Analysis Stages:

a. Preparing the training data, which can be obtained from historical data that has occurred previously and has already been classified into specific categories or classes.
b. Determining the root of the decision tree by calculating the highest gain value among all attributes, or alternatively, based on the attribute with the lowest entropy index. Prior to this, the entropy index value is calculated using the following formula:

$$Entrophy(i) = \sum_{j=1}^{m} f(i,j).2\, f[(i,j)]$$

c. Calculate the gain value using the following formula:

$$Gain = -\sum_{i=1}^{p} \frac{ni}{n}.IE(i)$$

d. Calculate the split information:

$$Split\ Information = -\sum_{t=1}^{c} \frac{s_1}{s} log_2 \frac{s_1}{s}$$

e. Calculate the gain ratio using the following method:

$$Gain\ Ratio\ (S,A) = \frac{Gain\ (S,A)}{Split\ Information\ (S,A)}$$

f. The decision tree partitioning process stops if:
   1) All records at node *m* belong to the same class.
   2) There are no more attributes available for further partitioning.
   3) There are no records in any resulting branch that are empty.
g. Continue step (a) using the testing data.

## RESULTS AND DISCUSSION

This study analyzed both the dependent and independent variables. The dependent variable examined was the planned age of marriage among male and female adolescents aged 15–24 years. The independent variables included age, education, residence (urban/rural), gender, economic status, adolescent knowledge related to pregnancy, ideal age of marriage for males and females, ideal age for giving birth, youngest ideal age for childbirth, oldest ideal age for childbirth, knowledge of the consequences of early marriage, and exposure to information regarding *Generasi Berencana* (GenRe) Program, *Bina Keluarga Remaja* (BKR), and *Pusat Informasi dan Konseling Remaja* (PIK-R).

Several interesting findings emerged from the analysis using the decision tree method, as illustrated below.

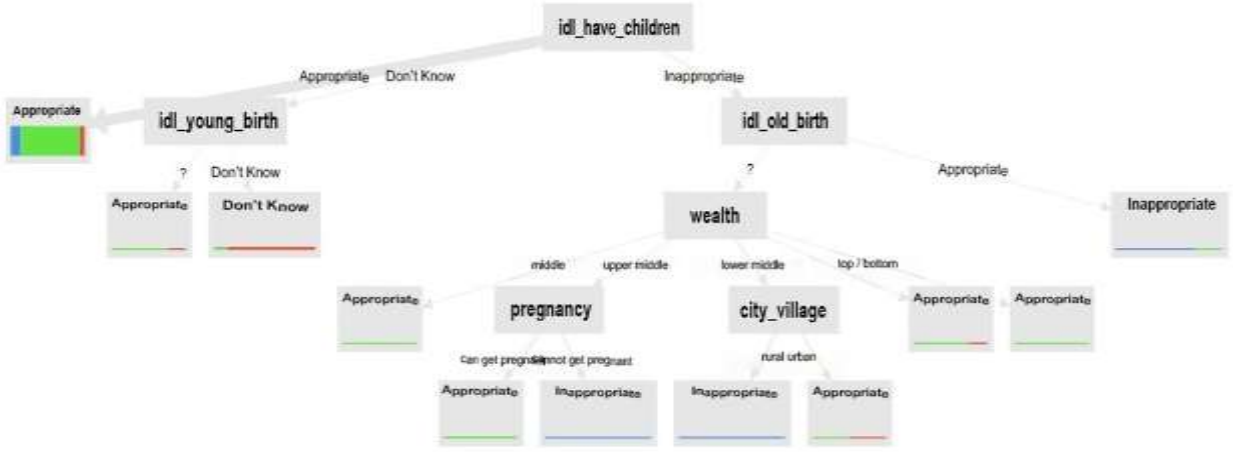


**Figure 1. Results of Decision Tree Analysis**

The findings presented above provide an overview of how adolescents in East Java plan and decide on marriage, as analyzed using a decision tree approach. The accuracy of the marriage age maturity model developed in this study reached 72%. This indicates that the 2018 SKAP KKBPK dataset for East Java Province used in this study has strong predictive capability (above 50%) in determining adolescent marriage planning in the region. Such a level of accuracy reflects sufficient predictive power for applications in social policy, particularly those related to adolescent marriage planning behavior. A study by Agustin, et al., (2021). using a similar method produced a test accuracy of 70.5%, which is highly comparable to the present model's performance and further supports the validity of the model as a policy support tool (Agustin, et al., 2021).

The model's validity is further reinforced through the use of a confusion matrix and gain ratio analysis, which revealed that classification errors were evenly distributed and not biased toward any particular class. The balanced distribution of predictions between adolescents with on-time and early marriage planning suggests that the model is both fair and reliable. This aligns with best practices for evaluating classification models that aim for fairness and impartiality in their predictions (Agustin, et al., 2021).

The model's reliability is also strengthened by a systematic variable selection process. Variables such as reproductive knowledge, awareness of the ideal marriage age, and exposure to government programs emerged as key nodes in the visual representation of the decision tree. This outcome demonstrates that the model is not only accurate but also consistent with sociocultural trends relevant to adolescent behaviour.

The accuracy achieved by this model offers a promising opportunity to develop a digital decision-support system accessible to institutions such as BKKBN, health departments, and schools. By incorporating up-to-date input data and regularly updating the model, such a system could serve as an early warning tool for high-risk groups. This integration aligns with the recommendations of data-driven national strategies outlined in the National Action Plan for the Prevention of Child Marriage (Bappenas, 2021).

Overall, the 72% accuracy rate represents more than a statistical figure—it reflects the quality of the modelling process and the relevance of the SKAP KKBPK data as a foundation for evidence-based interventions. The model illustrates how machine learning can enhance early marriage prevention strategies by systematically and visually identifying key determinants, thus supporting policy improvements in the fields of population and adolescent health.

**Adolescent Knowledge Factor**

Based on the decision tree analysis, adolescent knowledge emerged as a dominant influencing factor. The decision tree model in this study identified adolescents' knowledge of reproductive health as one of the primary variables affecting the decision on marriage age. Adolescents who possess adequate knowledge regarding the ideal conditions for childbearing—including the ideal age for pregnancy and childbirth, as well as the ideal number of children—tend to plan their marriages more appropriately.

Knowledge is a complex factor in determining whether an adolescent is adequately prepared to plan for marriage. A lack of understanding in even one aspect may lead to poor decision-making. For instance, an adolescent who knows the latest appropriate age to have children but lacks knowledge of the minimum ideal age may still be at risk of planning marriage prematurely and facing the consequences of early childbearing (Fitria , et al., 2024).

Based on this research, adolescents who comprehend the risks of early pregnancy, the importance of marrying at an ideal age, and the biological and social implications of early marriage are more likely to plan for a more mature and healthier union. This type of knowledge goes beyond factual information; it also reflects emotional readiness and critical thinking skills in making long-term life decisions. Therefore, enhancing reproductive health knowledge can encourage adolescents to more thoroughly consider the consequences of marriage-related decisions.

A study conducted in Batam showed a significant relationship between adolescent reproductive knowledge and attitudes toward early marriage ($p < 0.05$) (Sari, et al., 2022). Approximately 67% of adolescents with high levels of knowledge expressed opposition to early marriage. This finding underscores the importance of reproductive health education as an intervention strategy capable of shifting adolescent mindsets and attitudes toward social norms that condone early marriage. Moreover, adolescents who are better informed tend to develop more critical perspectives toward cultural and environmental pressures.

A literature review by Nentika, et al., (2025) highlighted that factors such as age, education level, social environment, cultural norms, and exposure to technology and social media greatly influence adolescents' knowledge of early marriage. The study emphasizes the need for contextual education strategies tailored to the local characteristics and needs of each adolescent community. In the Indonesian context, community- or pesantren-based approaches may serve as alternative strategies to broaden access to accurate and balanced information, especially in areas where access to formal education is limited.

Another study by Dewi, et al., (2021) demonstrated that female adolescents with strong knowledge of the health consequences of early marriage—especially risks of pregnancy complications and low birth weight—were more inclined to delay marriage. This indicates that well-informed adolescents are more capable of considering health aspects as crucial factors in planning for their futures. In addition, such knowledge empowers them to resist social and cultural pressures that often push for early marriage, particularly in rural or traditionally conservative communities.

Exposure to government programs such as "Generasi Berencana" (GenRe), Adolescent Information and Counseling Centers ("Pusat Informasi Konseling-Remaja"/PIK-R), and Adolescent Family Development ("Bina Keluarga Remaja"/BKR) has a significant impact on adolescents' reproductive health knowledge. An evaluation of the GenRe program in Jakarta found that the intervention improved access to information and adolescent awareness about the importance of preparedness for family life. However, its effectiveness was limited to in-school youth (Sari, et al., 2021). This suggests that the impact of such programs is optimal only when adolescents have access to literacy agents—either formally or informally—such as counselors or peer educators.

PIK-R has also proven to be an effective educational medium. A study at SMAN 1 Selong showed that PIK-R activities significantly increased reproductive health knowledge among participating students (Fatmariza, 2019). Although only 8.1% of students participated actively, results showed reductions in negative behaviors such as pornography consumption and vaping. This highlights that even with limited participation, the educational benefits of PIK-R are substantial in helping adolescents process reproductive health information.

From a behavioral standpoint, research in Jombang Regency found that adolescent involvement in PIK-R and PIK-M activities was positively associated with healthy attitudes and actions regarding reproductive health (Faizah, et al., 2023). Peer educator interactions within these centers helped change norms and provided counseling opportunities not typically available within

family settings. As a result, adolescents became more critical in evaluating the risks of early marriage based on factual information they received.

Research by Hasanah & Yuliani (2024) further showed that adolescents living in areas with active PIK-R programs had significantly higher reproductive knowledge scores than those in areas without such programs. This highlights regional disparities in information access and reinforces that the presence and quality of PIK-R and GenRe initiatives are key determinants of reproductive literacy and adolescents' readiness in marriage planning.

Therefore, government programs such as GenRe, PIK-R, and BKR must be expanded in both coverage and quality. Interventions should include peer educator training, context-specific materials, and outreach to out-of-school youth to ensure that reproductive literacy reaches all demographic segments. This strategy will reinforce the findings of the decision tree model, which identifies knowledge as a dominant variable influencing adolescent marriage planning.

The results indicate that adolescent knowledge plays a pivotal role in the decision tree model. Hence, intervention strategies should prioritize early reproductive literacy education through relevant media—such as educational videos, group discussions, school-based outreach, and peer counseling—to reach adolescents across diverse social and educational backgrounds. By increasing adolescent understanding of the physical, psychological, and social consequences of early marriage, they will be better equipped to make informed decisions and avoid being pressured into marriages influenced by environmental or cultural misconceptions.

**Family Economic Factors**

The decision tree analysis indicates that low economic status is one of the determinant factors influencing adolescents' decisions to plan for marriage, although its statistical impact in this model is not highly significant compared to other predictors such as knowledge. Nevertheless, descriptive data from the 2018 SKAP KKBPK survey reveal that adolescents from low-income families are more likely to plan for early marriage. This apparent discrepancy suggests that while economic factors may not emerge as the strongest predictor in the model, they still play an important contextual role in shaping marriage decisions.

Limited household resources often drive families to perceive marriage as a strategy to alleviate financial burdens or reduce social dependency, particularly in communities where cultural norms reinforce early marriage practices. Therefore, the "less significant" finding in the statistical model should not be interpreted as the absence of economic influence, but rather as an indication that economic factors interact with and are often overshadowed by stronger variables such as knowledge and education. This nuance highlights the importance of integrating socioeconomic support with educational and awareness-based interventions to address the multifaceted drivers of early marriage.

According to Rahayu & Wahyuni (2020), while early marriage does not significantly increase monetary poverty, its prevalence remains higher among low-income groups. Although monetary poverty may not be directly affected by early marriage, limited economic conditions tend to restrict access to essential education and reproductive health information. Consequently, adolescents from underprivileged families often face limited choices in shaping their future.

These findings are consistent with a literature review which confirmed that high poverty levels significantly increase the likelihood of girls becoming child brides (Istiqomah, et al., 2023). In communities where cultural norms prioritize early marriage as a socially valued practice, economic factors become a powerful driver behind such decisions. In various local contexts across

Indonesia, cultural and economic pressures often reinforce each other, making early marriage an adaptive choice within these communities.

Research by Khairina & Putra (2023) shows that early marriage is associated with increased vulnerability to poverty in adulthood. Young couples who marry during their productive years but lack financial independence often face economic hardship, which can perpetuate disadvantages across generations. From this perspective, early marriage is not only a consequence of economic pressure but also a mechanism that sustains socioeconomic inequality over time.

The long-term social impacts of early marriage among economically disadvantaged groups include disrupted educational opportunities, low reproductive health literacy, and reduced social mobility. Therefore, effective interventions must include social support measures such as educational scholarships, skills training, and improved access to reproductive health information. These efforts aim to ensure that adolescents have alternative pathways beyond early marriage as the sole perceived solution.

Taken together, the decision tree model illustrates that family economic conditions—though not the most dominant variable—still contribute significantly to the classification of early marriage risk. Accordingly, effective intervention strategies should incorporate measures to address structural poverty through programs such as educational assistance, vocational training, and the economic empowerment of young women. Such interventions offer adolescents and their families tangible alternatives for future planning based on readiness rather than economic desperation.

**Residential Environment Factor**

The place of residence—whether urban or rural—was also found to influence adolescents' decisions regarding marriage planning, although its impact was relatively modest. This may be attributed to the differing social environments, where urban settings often provide greater support for continuing education, employment, and other opportunities, thereby reducing the emphasis on early marriage. In contrast, early marriage is more commonly accepted in rural areas, where practices such as arranged marriage are still prevalent. Additionally, geographic isolation and limited educational infrastructure in rural settings may further contribute to higher rates of early marriage.

Adolescents residing in rural areas tend to face a higher risk of early marriage compared to their urban counterparts. This disparity is exacerbated by limited access to education, reproductive health services, and uneven program interventions across regions. A study by Idawati, et al., (2024) in Aceh Province revealed that rural women with low economic status were 2.23 times more likely to marry early compared to those from higher-income families. This indicates a strong correlation between economic status and residential location as determinants of early marriage risk. Furthermore, the lack of structural support and educational resources aggravates the situation, making early marriage an adaptive solution for families in remote areas.

National data further highlight that education serves as a significant mediating factor between residential location and early marriage behavior. Research by Fitria, et al., (2024) documented that rural adolescent girls with only primary school education were up to 448 times more likely to marry early compared to those with a university degree (AOR 448.9; $p < 0.001$). This striking finding emphasizes the protective role of education, particularly in regions with limited access to formal schooling.

Cultural norms within rural communities also play a crucial role. Traditional values in many rural settings often perceive early marriage as a social norm and a mechanism to preserve family

honor. These norms exert considerable social pressure on adolescent girls to marry, even when they are not yet emotionally or financially prepared. The interplay of economic hardship, cultural expectations, and lack of education renders this group particularly vulnerable.

Hermambang, et al., (2021) also noted that a greater proportion of women of reproductive age who marry early are found in rural areas. One contributing factor is the stark difference in mindset between rural and urban women. Women with lower educational attainment are more likely to accept early marriage, while those with higher education tend to pursue careers and delay marriage.

Accordingly, government programs such as GenRe, PIK-R, and BKR must be designed to effectively reach rural communities. Strategies such as mobile PIK-R services, engagement of local facilitators, and community-based reproductive health education can enhance both access and relevance of interventions (Siswantara, et al., 2022). Taken together, implementing context-sensitive approaches is key to minimizing disparities and reducing early marriage risk among rural adolescents. Additionally, government involvement in promoting rural economic development and community welfare is essential to address the structural conditions contributing to early marriage.

**Study Limitation**

This study has several limitations that should be acknowledged. First, the use of secondary data from the 2018 SKAP survey restricts the analysis to the variables available in the dataset, which may not fully capture other socio-cultural determinants of early marriage such as religious beliefs, peer influence, or parental expectations. Second, the cross-sectional design limits the ability to establish causal relationships between the identified factors and marriage age maturity. Third, the predictive accuracy of the decision tree model, although relatively high, may be influenced by regional and temporal variations, thereby requiring cautious generalization to other provinces or more recent cohorts. Finally, the model did not incorporate qualitative dimensions that could enrich the interpretation of adolescent decision-making processes. Future research should therefore combine longitudinal and mixed-method approaches with updated datasets to enhance the robustness and contextual relevance of the findings.

## CONCLUSION AND SUGGESTION

This study successfully developed a decision-support system using machine learning, specifically a decision tree algorithm, to map the potential risk of early marriage among adolescents in East Java. The model achieved an accuracy of 72%, demonstrating its predictive capability in identifying key determinants of marriage age planning. The analysis revealed that adolescents' knowledge of reproductive health emerged as the dominant factor influencing early marriage decisions, while family economic conditions and place of residence played lesser but still relevant supporting roles. Adolescents with limited knowledge are more likely to be unaware of the risks associated with early marriage and thus more vulnerable to making such decisions, particularly those living in rural areas and coming from economically disadvantaged families. Therefore, comprehensive interventions are needed to improve adolescent literacy, including the strengthening of programs such as GenRe, BKR, and PIK-R. The government and stakeholders should also expand equitable access to education, especially in remote areas, and ensure that communication strategies are tailored to adolescent characteristics to enhance the effectiveness of educational interventions. In addition, efforts to improve the socioeconomic welfare of communities—particularly in rural settings—should be integrated as part of a sustainable strategy to prevent child marriage.

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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest that could have influenced the outcome of this research. All stages of the study, including data collection, analysis, and reporting, were conducted independently and without any commercial or financial relationships that could be construed as a potential conflict.

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