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Mobile Health Intervention to Improve Uptake and 12-Month Continuation of Long-Acting Reversible Contraception Among Urban Female Adolescents: A Multicenter Randomized Controlled Trial

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A B S T R A C T

Introduction: Adolescent pregnancy remains a major source of obstetric and psychosocial morbidity in densely populated Indonesian cities. Long-acting reversible contraception (LARC) offers first-line efficacy, yet adolescent uptake and continuation are constrained by misinformation and stigma. Mobile health (mHealth) may bridge this gap discreetly. We evaluated whether an interactive, encrypted mHealth platform improves LARC uptake and 12-month continuation versus standard care.

Methods: We conducted a parallel, two-arm (1:1), open-label multicenter randomized controlled trial with blinded outcome assessment at two tertiary reproductive-health centers in Jakarta and Palembang, Indonesia. Sexually active women aged 15–21 years not desiring pregnancy within 12 months were block-randomized (stratified by center and parity). The platform delivered interactive education, private counselor chat, and automated reminders. Primary outcomes were LARC uptake at 1 month (intention-to-treat) and time-to-discontinuation over 12 months, analyzed with risk ratios (RR), Kaplan–Meier survival, Cox regression, and number needed to treat (NNT).

Results: Of 390 adolescents screened, 364 were randomized (182 per arm). LARC uptake was 36.8% with mHealth versus 16.5% with standard care (RR 2.23, 95% CI 1.53–3.26; adjusted odds ratio 2.95, 95% CI 1.80–4.84; p<0.001). Absolute risk reduction was 20.3% (NNT 5). The 12-month continuation rate was 82.1% versus 56.7% (log-rank p=0.014), and Cox regression showed a 62% lower discontinuation hazard (adjusted hazard ratio 0.38, 95% CI 0.17–0.85; p=0.018).

Conclusion: An encrypted, interactive mHealth intervention more than doubled LARC uptake and improved 12-month continuation among urban Indonesian adolescents, supporting integration of scalable, stigma-sensitive digital platforms into adolescent family-planning services.

1. Introduction

Adolescent pregnancy is a persistent global public-health challenge with disproportionate biomedical and psychosocial consequences in rapidly urbanizing low- and middle-income settings. Pregnancy at the extremes of maternal age, including adolescence, is consistently associated with preterm birth, low birth weight, anemia, and hypertensive disorders, as well as substantial perinatal mental-health morbidity and interrupted education[1–4]. In Indonesia, where adolescents

constitute a large share of the population and internal migration concentrates youth in metropolitan and secondary cities, unmet contraceptive need among young women remains substantial despite expanding family-planning infrastructure[5,6]. Cities such as Jakarta and Palembang exemplify the dual epidemiology of an established metropolis and an emerging provincial city, in which adolescents simultaneously face information overload from unregulated digital sources and information scarcity from trustworthy clinical channels.

Long-acting reversible contraception (LARC) — subdermal implants and intrauterine devices (IUDs) — delivers the highest real-world contraceptive effectiveness available, with typical-use failure rates below 1% because efficacy is independent of daily adherence[7,8]. Professional bodies recommend LARC as a first-line option for adolescents, who derive particular benefit from forgettable, highly effective methods that decouple contraceptive protection from the behavioral demands of pill-taking or condom negotiation[9]. The advantage of LARC is mechanistic: implants provide sustained progestin-mediated ovulation suppression and cervical-mucus thickening over three to five years, while copper and levonorgestrel IUDs create a spermicidal and anti-implantation endometrial environment, eliminating the adherence gap that undermines short-acting methods[7,8].

Despite this evidence, LARC uptake and continuation among adolescents are limited by modifiable barriers operating at the individual, provider, and system levels. Misconceptions about future infertility, insertion pain, and bleeding changes, together with provider bias and the social stigma of seeking contraception at conventional facilities, suppress demand among adolescents[10]. Structured contraceptive counseling improves informed method choice and uptake, but conventional face-to-face approaches are resource-intensive, vary in quality, and may expose adolescents to judgmental encounters that deter return visits[11]. Early discontinuation, frequently driven by unmanaged bleeding changes and inadequate anticipatory guidance, further erodes the effectiveness advantage of LARC[12]. There is therefore a strong rationale for low-stigma, scalable channels that supplement clinical counseling with accurate, private, continuously available information.

Mobile health (mHealth) interventions—delivered through the smartphones that most urban adolescents already own—offer a confidential, scalable channel for accurate information, behavioral reminders, and remote counseling. Systematic reviews and meta-analyses indicate that mHealth and telehealth interventions can improve sexual and reproductive-health knowledge and contraceptive use among young people[13,14]. Cluster-randomized trials have shown that interactive mobile interventions increase the adoption of modern contraception in the postpartum period[15], and on-demand mobile platforms can deliver tailored reproductive-health information directly to adolescents[16]. Importantly, digital reminder and adherence-support systems specifically improve method continuation and daily medication use in adolescent and young-adult populations[17,18], suggesting that multi-component platforms may act on both initiation and persistence.

Within the Indonesian and broader low- and middle-income context, however, adolescent-tailored digital reproductive-health services remain scarce and are rarely evaluated with rigorous trial designs[19,20]. Existing national counseling relies heavily on printed flipcharts and brochures that are neither interactive nor private, and access to telemedicine can itself be inequitable, varying with insurance and connectivity[21]. Two evidence gaps follow. First, most mHealth contraception studies have evaluated short-acting methods or composite self-reported knowledge rather than the clinically decisive endpoints of medical-record-verified LARC insertion and objectively measured continuation[13,17]. Second, few randomized trials have been conducted in Southeast Asian urban adolescent populations with blinded outcome assessment, time-to-event analysis, and multivariable adjustment[14,16].

Indonesia has prioritized digital transformation of health services, and the rapid expansion of mobile connectivity offers an opportunity to reach adolescents who are underserved by facility-based reproductive-health programs. National family-planning strategy increasingly emphasizes demand generation and the reduction of unmet need among young people, yet the evidence base for digitally delivered adolescent contraception services in the country is thin and largely observational[5,6,19]. Rigorous experimental evidence is needed to justify investment in such platforms and to ensure that digital tools narrow rather than widen existing equity gaps.

We therefore conducted a multicenter randomized controlled trial in two Indonesian cities to test whether an encrypted, interactive mHealth platform—combining education modules, private counselor chat, and automated reminders—improves (1) LARC uptake within one month and (2) 12-month LARC continuation among urban female adolescents, compared with standard care. We hypothesized that mHealth would increase uptake by at least 20 percentage points and reduce the hazard of discontinuation by approximately 40%, and that the effect would be consistent across both participating cities.

2. Methods

Study design and setting

This was a parallel, two-arm, individually randomized controlled trial with 1:1 allocation, conducted and reported in accordance with the CONSORT 2010 statement for parallel-group trials[22]. The intervention was open-label because digital content cannot be masked from participants or field educators; however, allocation was concealed from the trial statistician and the medical reviewers who adjudicated clinical outcomes, who saw only neutral group labels ('Group X' and 'Group Y'). The trial was conducted at two urban tertiary reproductive-health centers located in Jakarta and Palembang, Indonesia. The two cities were purposively selected to reflect the demographic spectrum of a major metropolitan area and a developing provincial city, improving the external validity of the findings. To preserve double-blind peer review and participant confidentiality, individual facilities are not named. Each participant was followed for 12 months across four scheduled assessment visits.

Participants

Eligible participants were female adolescents aged 15–21 years residing in the catchment cities who were sexually active, did not intend to become pregnant within the subsequent 12 months, owned and personally used an Android or iOS smartphone, and could read and communicate in Bahasa Indonesia. Participants younger than 18 years provided written informed assent together with parental or guardian consent, whereas those aged 18 years or older provided written informed consent, in accordance with local regulations. Exclusion criteria comprised any absolute medical contraindication to LARC under the World Health Organization Medical Eligibility Criteria for Contraceptive Use (for example, undiagnosed abnormal uterine bleeding, gynecologic malignancy, or active pelvic inflammatory disease); current pregnancy or a postpartum period shorter than six weeks; and a stated plan to relocate from the catchment cities within 12 months. Eligibility was confirmed by a clinician, and pregnancy was excluded by history and, where indicated, by urine human chorionic gonadotropin testing before enrollment.

Sample size

The sample size was calculated for the primary uptake outcome using the formula for comparison of two independent proportions with continuity correction (Fleiss), implemented in G*Power 3.1.9.7. Based on prior literature and program data, the control uptake proportion was estimated at 15% and the mHealth uptake proportion was projected at 30%, a 15 percentage-point difference judged to be the minimal clinically important effect for adolescent LARC programming. With a two-sided alpha of 0.05 and 80% power, the minimum requirement was 134 participants per arm. Anticipating up to 20% attrition over 12

months of follow-up, this was inflated to 168 participants per arm. Recruitment was extended to 182 participants per arm to permit balanced enrollment across the two study centers (91 participants per arm at each center), yielding a total of 364 participants recruited across the two centers (182 in each city, balanced 1:1 between arms).

Randomization, concealment, and blinding

A computer-generated block randomization sequence with variable block sizes (4 and 6) was prepared by an independent statistician and stratified by study center (Jakarta vs Palembang) and parity (nullipara vs multipara) to ensure balance on key prognostic factors. Allocation was concealed using sequentially numbered, opaque, sealed envelopes (SNOSE), which were opened by an independent research coordinator only after the participant had signed informed consent and completed the baseline assessment, thereby preventing selection and allocation bias. Because of the nature of the digital intervention, participants and field educators could not be blinded; however, the principle of blinding was rigorously applied to the data analyst and the medical reviewers who assessed clinical outcomes, who remained unaware of group identity throughout.

Interventions

Participants allocated to standard care received conventional face-to-face family-planning counseling from a midwife or general practitioner using the national flipchart, supplemented by printed brochures describing contraceptive options and routine visit schedules. Participants allocated to the intervention arm received the same standard counseling plus access to a dedicated, encrypted mHealth platform comprising three integrated components. First, an interactive education module delivered infographics and short videos on LARC effectiveness, the insertion procedure, and self-management of anticipated side effects, designed to correct common misconceptions. Second, a private live-chat consultation feature connected participants directly with reproductive-health counselors and midwives, lowering the access barrier to expert advice without a stigmatizing clinic visit. Third, automated push reminders were delivered three times weekly during the first month and weekly thereafter through month 12, covering follow-up scheduling, motivational messaging, and early detection of clinical complaints. Platform engagement metrics were logged to monitor exposure.

Outcomes and assessments

Data were collected at four time points—baseline (T0), 1 month (T1), 6 months (T2), and 12 months (T3)—using a secure electronic data capture (EDC) system to minimize missing data. The primary uptake outcome was the proportion of participants with medical-record-verified LARC insertion (implant or IUD) within 30 days of randomization. The primary continuation outcome was time to LARC discontinuation, defined as device removal or expulsion, over 12 months and ascertained at T2 and T3. Secondary outcomes included a validated knowledge-and-attitude questionnaire addressing LARC myths, effectiveness, and side effects (5-point Likert scale; Cronbach's alpha >0.82) administered at T0, T1, and T3, and side-effect and satisfaction profiles—spotting, amenorrhea, pelvic pain, and expulsion, with satisfaction measured by the eight-item Client Satisfaction Questionnaire (CSQ-8)—at T2 and T3.

Data management and platform security

All data were captured through a secure, password-protected EDC system with role-based access and full audit trails, minimizing transcription error and missing data. The mHealth platform employed end-to-end encryption, secure authentication, and local data protection consistent with national regulations; identifiable information was segregated from clinical research data, and analytic datasets were fully de-identified. Platform engagement metrics—module completion, chat utilization, and reminder acknowledgement—were logged automatically to characterize intervention exposure and to support per-protocol sensitivity analyses. Data quality was

monitored by an independent coordinator through scheduled range and consistency checks, and source-document verification was performed against medical records for the primary insertion and discontinuation outcomes.

Statistical analysis

Analyses followed the intention-to-treat principle for the primary uptake outcome. Categorical variables were compared with the Pearson chi-square test and continuous variables with the independent t-test. Proportions are reported with Wilson 95% confidence intervals (CI). The intervention effect on uptake is expressed as risk ratio (RR), odds ratio (OR), absolute risk reduction (ARR), and number needed to treat (NNT), with effect size quantified by Cramér's V. Continuation was analyzed using Kaplan–Meier survival curves compared by the log-rank test, and multivariable Cox proportional-hazards regression adjusted for age, parity, and study center, reporting adjusted hazard ratios (aHR) with 95% CI and a Nagelkerke pseudo-R^2. The proportional-hazards assumption was assessed using Schoenfeld residuals. Pre-specified subgroup analyses examined the effect by study center, age band, and parity. A two-sided $p<0.05$ was considered statistically significant, and p values are reported to three decimal places.

Ethics

The study protocol was approved by the institutional research ethics committee (approval number CMHC/EC/2024/0417). All participants provided written informed consent, or assent with parental consent as appropriate for minors. The trial adhered to the principles of the Declaration of Helsinki. Data were de-identified and stored on encrypted servers with restricted access, and no institutional identifiers are reported in order to preserve confidentiality and the integrity of double-blind review.

3. Results and Discussion

Between recruitment and the close of follow-up, 390 adolescents were screened, of whom 26 were ineligible or declined, leaving 364 who met eligibility criteria and were randomized at two tertiary reproductive-health centers in Jakarta and Palembang, Indonesia, with 182 allocated to the mHealth arm and 182 to standard care. Allocation was balanced 1:1 across the two cities (50.0% Jakarta in each arm). Retention through 12 months exceeded the planned 80%, and the primary uptake analysis included all randomized participants under the intention-to-treat principle. Baseline demographic and clinical characteristics did not differ significantly between groups, indicating successful randomization and minimal residual confounding, as detailed in Table 1.

As detailed in Table 1, the mean age was 18.4 ± 1.6 years in the mHealth arm and 18.6 ± 1.5 years in the standard-care arm (p=0.214). The proportion who were married was 22.5% versus 20.8% (p=0.693), and nulliparity was common in both arms (79.6% vs 81.8%; p=0.592), reflecting a predominantly young, low-parity urban population. Baseline health-literacy scores were comparable (62.4 ± 8.1 vs 61.8 ± 7.9; p=0.467), confirming that subsequent differences in outcomes were unlikely to be explained by pre-existing differences in knowledge or educational attainment.

Table 1. Baseline maternal characteristics.

Characteristic	mHealth (n=182)	Standard care (n=182)	p-value*
Age, years (mean ± SD)	18.4 ± 1.6	18.6 ± 1.5	0.214
Married, n (%)	41 (22.5)	38 (20.8)	0.693
Nulliparous, n (%)	145 (79.6)	149 (81.8)	0.592
Health-literacy score (0–100)	62.4 ± 8.1	61.8 ± 7.9	0.467
Study center: Jakarta, n (%)	91 (50.0)	91 (50.0)	1.000

*Notes: *Independent t-test (continuous); Pearson chi-square (categorical). Values are mean ± SD or n (%).*

Table 2. Clinical outcomes and bivariate analysis of LARC uptake.

Outcome	mHealth	Standard care	RR (95% CI)	p-value
LARC uptake, overall	67 (36.8)	30 (16.5)	2.23 (1.53–3.26)	<0.001
Subdermal implant	45 (24.7)	18 (9.9)	2.50 (1.51–4.15)	<0.001
IUD	22 (12.1)	12 (6.6)	1.83 (0.94–3.59)	0.071
Adjusted OR (overall)	2.95 (1.80–4.84)	Reference	ARR 20.3%	NNT 5 (4–9)

Notes: RR, risk ratio; OR, odds ratio; ARR, absolute risk reduction; NNT, number needed to treat; CI, confidence interval.

The primary uptake outcome strongly favored the intervention, as summarized in Table 2 and illustrated in Figure 1. At one month, LARC was inserted in 67 of 182 participants (36.8%, 95% CI 30.1–44.0) in the mHealth arm versus 30 of 182 (16.5%, 95% CI 11.8–22.6) in the standard-care arm. The mHealth intervention more than doubled the likelihood of LARC uptake (RR 2.23, 95% CI 1.53–3.26; OR 2.95, 95% CI 1.80–4.84; chi-square=18.21, p<0.001), corresponding to a moderate association by Cramér's V (0.224). The absolute risk reduction was 20.3% (95% CI 11.5–29.2), translating into a number needed to treat of 5 (95% CI 4–9): only five adolescents need to receive the mHealth intervention to generate one additional LARC user.

Method-specific analysis, also shown in Table 2, indicated that the effect was driven principally by subdermal implants. Implant uptake was 24.7% (45/182) with mHealth versus 9.9% (18/182) with standard care (RR 2.50, 95% CI 1.51–4.15; p<0.001). IUD uptake was higher with mHealth (12.1% vs 6.6%) but the difference did not reach statistical significance (RR 1.83, 95% CI 0.94–3.59; p=0.071), consistent with the greater procedural threshold, pelvic-examination requirement, and counseling intensity associated with IUD initiation in adolescents. The differential pattern in Figure 1 suggests that digital reassurance most readily shifts behavior toward the method perceived as least invasive.

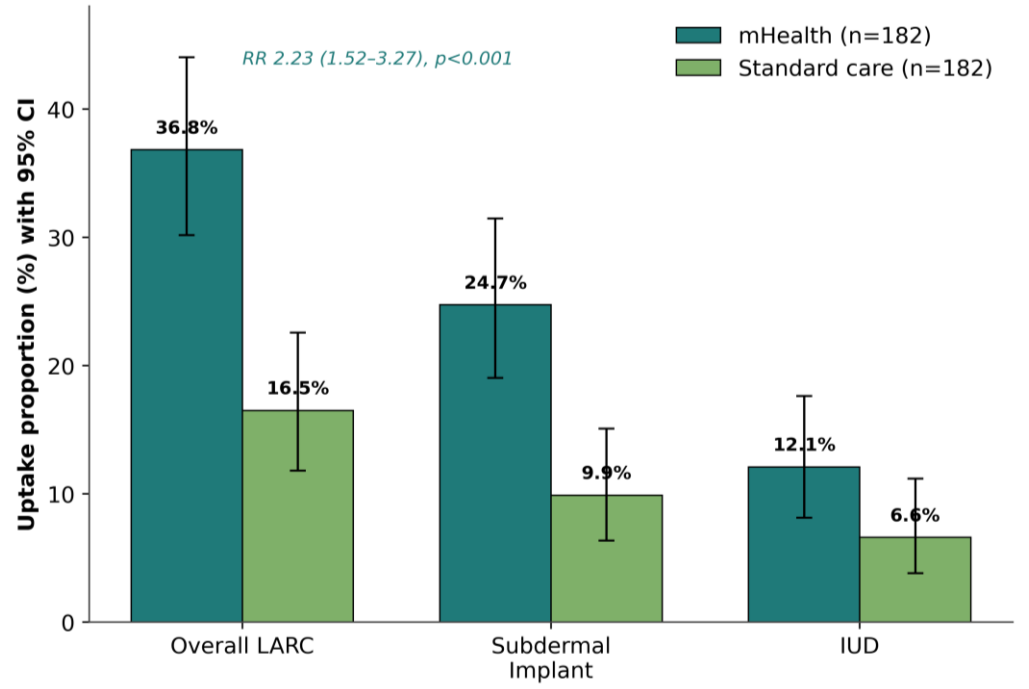

Figure 1. LARC uptake at 1 month by study arm with 95% confidence intervals (intention-to-treat).

Among the 97 participants who initiated LARC, continuation was monitored to 12 months. As shown by the Kaplan–Meier curves in Figure 2, time to discontinuation (device removal or expulsion) was significantly longer in the intervention arm (log-rank p=0.014). The 12-month continuation rate was 82.1% (55/67, 95% CI 71.3–89.4) with mHealth versus 56.7% (17/30, 95% CI 39.2–72.6) with standard care. Most discontinuations in the control arm clustered within the first six months, the period of greatest bleeding-related dissatisfaction, whereas events in the intervention arm were fewer and more evenly distributed. Expressed as avoided early discontinuation, the number needed to treat to prevent one discontinuation over 12 months was approximately 4 (95% CI 2–18).

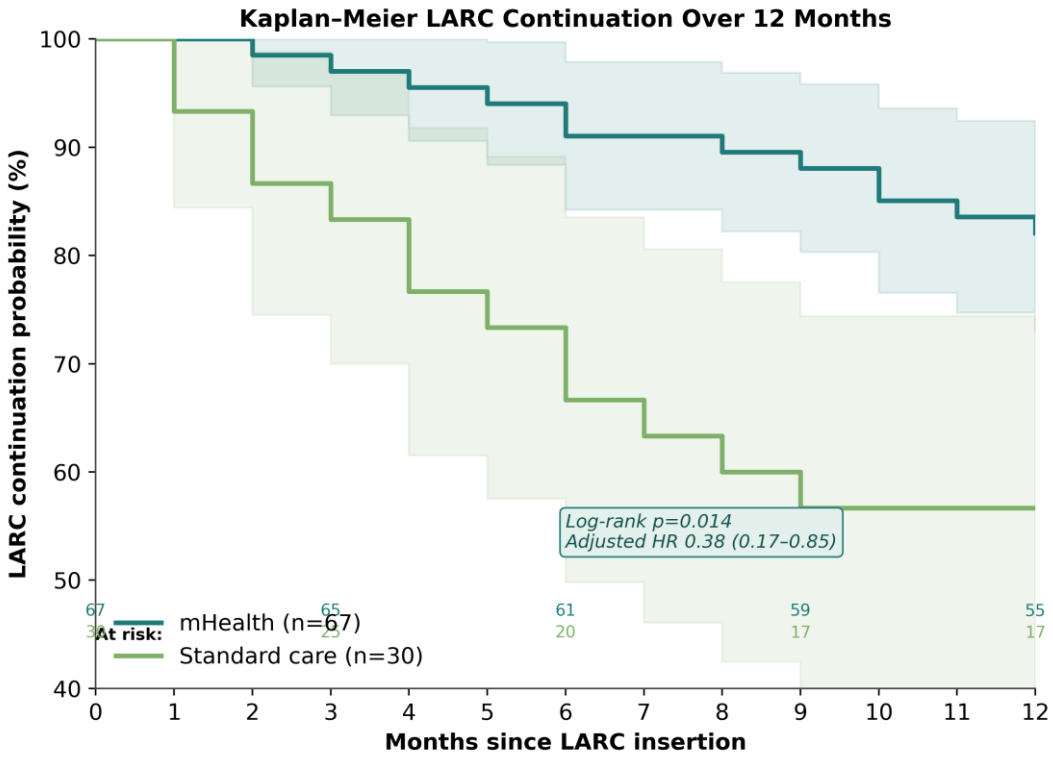

Figure 2. Kaplan–Meier curves for 12-month LARC continuation by study arm (log-rank p=0.014).

Table 3. Multivariable Cox regression and 12-month continuation outcomes.

Predictor / Outcome	Unadjusted HR (95% CI)	Adjusted HR (95% CI)	p-value
mHealth vs standard care	0.35 (0.16–0.77)	0.38 (0.17–0.85)	0.018
Age <18 vs ≥18 years	1.42 (0.65–3.10)	1.30 (0.58–2.92)	0.524
Nullipara vs multipara	1.85 (0.80–4.27)	2.10 (0.88–5.01)	0.095
12-mo continuation, mHealth	82.1% (55/67)	95% CI 71.3–89.4	—
12-mo continuation, control	56.7% (17/30)	95% CI 39.2–72.6	log-rank 0.014

Notes: HR adjusted for age, parity, and study center; CI, confidence interval; Nagelkerke pseudo-R^2 = 0.19.

Multivariable Cox proportional-hazards regression confirmed the protective effect of the intervention after adjustment for age, parity, and study center, as reported in Table 3 and displayed in the forest plot in Figure 3. The mHealth platform reduced the hazard of discontinuation by 62% (adjusted hazard ratio 0.38, 95% CI 0.17–0.85; p=0.018; Nagelkerke pseudo-R^2 = 0.19). Neither younger age (<18 vs ≥18 years; aHR 1.30, 95% CI 0.58–2.92; p=0.524) nor nulliparity (aHR 2.10, 95% CI 0.88–5.01; p=0.095) was independently associated with discontinuation, although nulliparity showed a non-significant trend toward higher risk that may reflect expulsion susceptibility. Schoenfeld residual testing supported the proportional-hazards assumption (global p=0.41). Pre-specified subgroup analysis by center, also displayed in Figure 3, indicated a consistent direction and magnitude of effect in both Jakarta and Palembang, with overlapping confidence intervals, arguing against site-specific confounding.

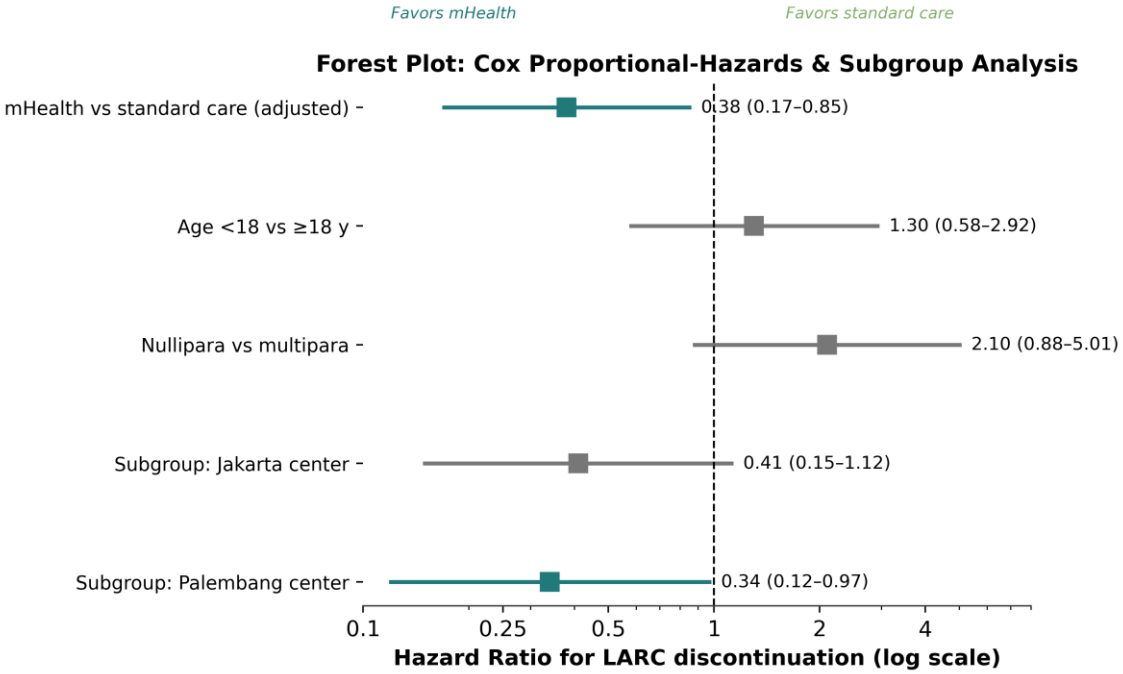

Figure 3. Forest plot of adjusted Cox hazard ratios and subgroup analyses for LARC discontinuation.

Secondary outcomes reinforced the primary findings, as illustrated in Figure 4. Validated knowledge-and-attitude scores, equivalent at baseline (62.4 ± 8.1 vs 61.8 ± 7.9), diverged after the intervention: at one month the mHealth arm scored 78.5 ± 7.2 versus 65.1 ± 7.8 in the standard-care arm (p<0.001), and the advantage persisted at 12 months (81.0 ± 6.9 vs 66.3 ± 7.5; p<0.001), indicating durable correction of LARC misconceptions. Client satisfaction measured by the CSQ-8 was higher in the intervention arm (27.8 ± 3.1 vs 23.4 ± 3.6 out of 32; p<0.001). Method-related side effects were comparable between arms among LARC users, including spotting (38.8% vs 36.7%) and amenorrhea (22.4% vs 20.0%), and device expulsion was numerically lower with mHealth (3.0% vs 6.7%); no serious adverse events attributable to the intervention were recorded. These exploratory results suggest that improved continuation was achieved through better anticipatory guidance and reassurance rather than through any difference in the underlying side-effect burden.

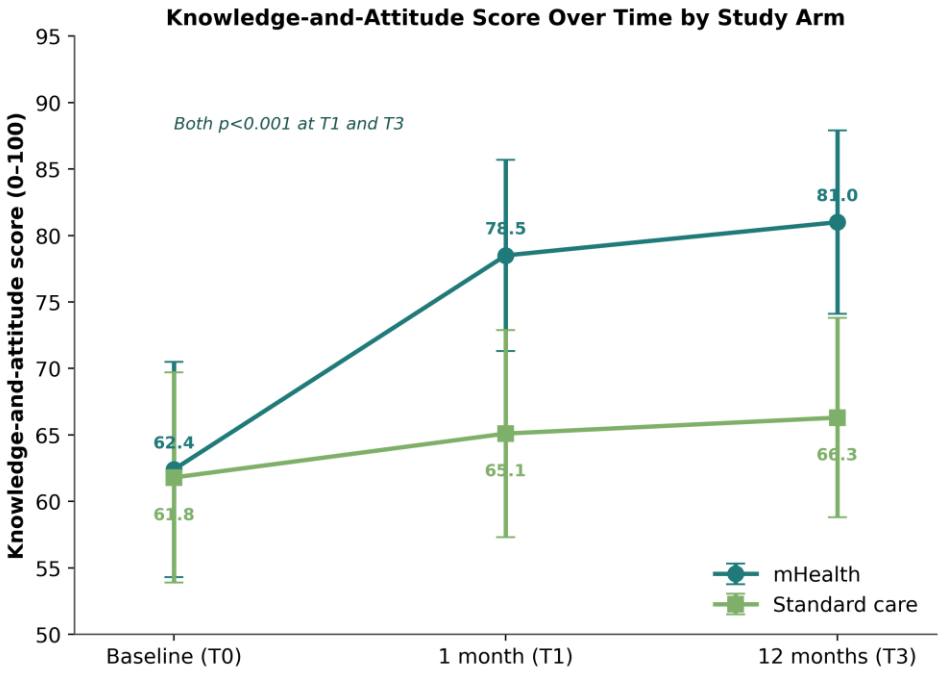

Figure 4. Knowledge-and-attitude score trajectory by study arm (mean and standard deviation).

In this multicenter randomized controlled trial among urban Indonesian female adolescents, an encrypted, interactive mHealth intervention more than doubled one-month LARC uptake and substantially improved 12-month continuation relative to standard care. The intervention produced a clinically meaningful number needed to treat of 5 for uptake and reduced the adjusted hazard of discontinuation by 62%. These effects were robust to multivariable adjustment, consistent across both participating cities, and accompanied by improvements in knowledge and satisfaction, supporting both the internal and external validity of the findings.

The magnitude of the uptake effect is consistent with, and at the upper range of, prior evidence on digital and counseling interventions for contraception. Systematic reviews of mobile-phone and telehealth interventions report improvements in contraceptive knowledge and use, though pooled effect sizes vary with intervention intensity and outcome definition[13,14,17]. Our trial extends this literature by anchoring the primary outcome to medical-record-verified LARC insertion rather than self-reported intention, which strengthens causal inference, and by demonstrating effects on the most effective methods rather than on short-acting contraception alone[15,16].

The continuation findings are particularly salient because early discontinuation undermines the real-world effectiveness advantage of LARC[23,24]. Cohort and program data consistently show that the first year carries the highest discontinuation risk, frequently driven by unmanaged bleeding changes and difficulty accessing reassurance[12,23]. Our intervention's automated reminders and private counselor chat plausibly addressed these mechanisms by normalizing expected side effects and providing timely, low-friction reassurance, echoing evidence that adherence support improves method continuation[17,18]. The 62% reduction in discontinuation hazard is comparable to, or larger than, the protective effects reported for structured support in other settings[24].

The dominant contribution of implants to the uptake effect mirrors findings that implants carry a lower procedural and counseling threshold than IUDs for

adolescents, who often perceive implant insertion as less invasive and less associated with pelvic examination[7,9]. Peer- and education-based interventions similarly shift adolescent attitudes toward LARC by correcting misconceptions[10,25]. The non-significant but directionally positive IUD effect suggests that digital education alone may be insufficient to overcome the higher perceived barriers to IUD initiation, which may require additional in-clinic facilitation; mHealth should therefore complement rather than replace hands-on procedural support for IUD candidates.

Our effect sizes are concordant with contemporary randomized trials of structured contraceptive counseling, which have increased LARC uptake in general-practice and post-abortion settings[11,26,27]. Whereas those interventions rely on additional in-person clinician time, the present digital platform achieved comparable gains while augmenting, rather than replacing, the clinical encounter, a configuration that may be more scalable in resource-constrained urban services. Improved knowledge-and-attitude scores in the intervention arm are congruent with the proposed behavioral mechanism and with secondary analyses of counseling trials reporting better contraceptive compliance[28].

Mechanistically, the intervention likely operated through several reinforcing pathways. The interactive education module corrected misconceptions about LARC effectiveness and side effects; the live-chat feature lowered the access barrier to expert reassurance without requiring a potentially stigmatizing clinic visit; and automated reminders sustained engagement through the high-risk early-continuation window. These components align with behavioral models in which knowledge, self-efficacy, and ongoing support jointly drive contraceptive behavior, and with evidence that digital literacy can empower adolescent girls in low- and middle-income settings[18,20].

Comparison with regional and Indonesian evidence reinforces the relevance of these results. National analyses document persistent unmet contraceptive need and the influence of urban context on method use among young Indonesian women[5,6]. Provider-comparison and demand-generation interventions in comparable low- and middle-income settings have likewise improved LARC uptake, underscoring the generalizability of the approach[29]. By delivering tailored, private information through devices adolescents already own, the intervention may specifically counteract stigma and misinformation—barriers repeatedly identified as central to low adolescent LARC uptake in Indonesia and other low- and middle-income regions[2,19,30].

From a clinical and programmatic perspective, the findings suggest that a scalable digital adjunct can be integrated into existing adolescent family-planning services at the city level without displacing in-person care. Because the intervention augments rather than replaces standard counseling, it is compatible with current service models and could be deployed through public reproductive-health platforms with modest incremental cost. The favorable number needed to treat supports likely cost-effectiveness, although formal economic evaluation incorporating averted unintended pregnancies is warranted. Scaling such interventions in Indonesia would require attention to data privacy, equitable smartphone access, and integration of digital records with national family-planning reporting systems[19,21].

The consistency of effects across a metropolitan and a developing provincial city suggests transferability across diverse urban Indonesian settings; however, rural generalizability remains untested, and connectivity and device-ownership gaps could attenuate effectiveness in lower-resource areas[20,21]. Future multicountry and rural trials, longer follow-up, and implementation studies embedded within routine services would clarify the durability and equity of impact.

Strengths of this trial include its multicenter randomized design, blinded outcome assessment and

blinded statistical analysis despite an open-label intervention, allocation concealment using SNOSE, objective medical-record verification of the primary outcome, a clinically meaningful 12-month follow-up, and a comprehensive analytic approach incorporating survival analysis, multivariable adjustment, effect-size reporting, and pre-specified subgroup analyses. Stratified randomization by center and parity minimized confounding, and high retention reduced attrition bias.

Several limitations should be acknowledged. The open-label nature of the intervention could introduce performance bias, only partially mitigated by blinded outcome adjudication. The continuation analysis was restricted to the 97 participants who initiated LARC—a post-randomization subgroup—reducing statistical power and widening confidence intervals, so the continuation estimate should be considered supportive rather than definitive. Self-selected smartphone owners may differ from adolescents without personal devices, limiting generalizability to lower-connectivity populations. Follow-up was limited to 12 months, so longer-term continuation and pregnancy outcomes are unknown, and the trial was conducted in two cities, so rural extrapolation should be cautious. Finally, secondary knowledge and satisfaction outcomes were exploratory and should be interpreted as hypothesis-generating.

4. Conclusion

Among urban Indonesian female adolescents, an encrypted, interactive mHealth intervention combining education, private counseling, and automated reminders more than doubled LARC uptake (RR 2.23; NNT 5) and reduced the 12-month discontinuation hazard by 62% (adjusted HR 0.38) compared with standard care. These findings support integrating scalable, stigma-sensitive digital reproductive-health platforms into adolescent family-planning services and warrant evaluation of longer-term effectiveness, cost-effectiveness, and rural transferability within national programs.

Declarations

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Author Contributions

Conceptualization, methodology, and writing — original draft: R.A. and I.S. Data curation and formal analysis: R.A. and S.U. Supervision and writing — review & editing: I.S. All authors have read and approved the final version of the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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Ethics and Consent

The study was approved by the institutional research ethics committee (approval no. CMHC/EC/2024/0417), in accordance with the Declaration of Helsinki. Written informed consent, or assent with parental consent for minors, was obtained from all participants. No identifiable patient material is included.

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