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Enhancing reproductive health among adolescent girls in India: results of an individualized RCT to study the efficacy of the go Nisha go mobile game

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Abstract

Background Adolescent girls in India face significant barriers to accessing sexual and reproductive health (SRH) information and services. Digital interventions, particularly mobile-based ones, promise to deliver SRH education in a fun and engaging manner. These can be offered privately directly to the adolescent, allowing players to 'experience' the outcomes of their choices, receive tailored feedback, and the option to 'try again'.

Methods This study evaluated the efficacy of "Go Nisha Go®" (GNG), a low-end smartphone-based digital game for adolescent girls in India, using a two-armed, encouragement-led, randomized controlled trial (RCT). The study involved 1950 participants from Patna, Jaipur, and Delhi NCR. The intervention group received encouragement to play GNG, while the control group did not. Key constructs measured included menstrual health management (MHM), contraception knowledge, and agency. Data were collected at baseline and a ten-week follow-up.

Results The intervention group showed significant improvements in various MHM parameters, contraception knowledge, and agency outcomes compared to the control group. Overall, 1697 out of 1993 participants completed the study after ten weeks (85%). The intervention group's awareness of menstrual hygiene products increased from 33 to 92%, while comprehensive knowledge of oral contraceptive pills (OCPs) rose from 2 to 17% ($p < 0.0001$). Confidence in negotiating contraception use increased from 60 to 85% ($p < 0.0001$), and the attitude of refusing sex when not ready improved from 61 to 85% ($p < 0.0001$).The subjects in the game group showed high levels of satisfaction with the app, with 74% discussing the game with others and 66% recommending it. The belief in negotiating marriage decisions with parents also improved more in the intervention group than in the control group.

Conclusion The findings of the first-ever RCT outcome evaluation for a digital mobile game app for enhancing SRH education among adolescent girls in low-resource settings support the efficacy of digital games for health like GNG. The game's engaging and interactive format effectively communicated complex and sensitive SRH information, empowered participants, and encouraged ($p < 0.0001$) critical health behaviors through informed decision-making. Future studies could explore the long-term sustainability of behavior changes induced by such interventions and their effectiveness across different settings and populations.

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Introduction

India is home to 253 million adolescents [1], and faces significant demographic challenges and opportunities. The burden of gendered expectations on adolescent girls undermines their health, educational attainment, and participation in the workforce, perpetuating inequality. Notably, nearly 3 in 10 girls (27%) are married before the age of 18, and 8% of adolescent girls (15–19 years old) have already started having children [2] which can derail their educational and career aspirations. Chandramouli and Patel (2017) [3] emphasize that informed decisions regarding sexual and reproductive health (SRH) empower\girls, enabling choices like pursuing higher education, achieving financial independence, and building household savings, thus contributing to poverty reduction and socio-economic development.

Despite advancements in SRH and gender equity, adolescent girls in India continue to encounter barriers to accessing menstrual health and hygiene management (MHM) and SRH information and services. Health system programs often target older adolescents [4]. Alarmingly, 50% of girls aged 15–19 do not use menstrual hygiene products [5]. Studies highlight limited knowledge of menstrual health, contraception, and self-care among adolescent girls, increasing their risk of adverse outcomes such as low educational attainment, lack of career aspirations, early marriage, unintended pregnancies, and gender-based violence [6]. Addressing these barriers is crucial for empowering girls and promoting their well being and socio-economic contributions.

Adolescents' development in SRH can be significantly influenced by constructing healthy relationships and gaining appropriate knowledge during adolescence [7]. However, issues related to confidentiality, stigma, and limited access to services further hinder adolescents from seeking SRH information and care [8–10]. Digital interventions, particularly mobile-based ones, have shown promise in delivering SRH education. They offer privacy, accessibility, and the ability to tailor messages to specific populations, making them suitable for adolescents [11–13]. With its burgeoning adolescent population and increasing mobile phone usage, India presents a significant opportunity to leverage mobile technology for SRH education [14].

Data from the UDAYA study in India highlighted that unmarried Indian adolescents demand the appropriate knowledge to promote safer sexual behaviour and lead a responsible and healthy lifestyle [15]. However, adolescents' SRH outcomes are influenced by a complex interplay of factors operating at various levels. These young individuals make decisions about their behaviours based on their knowledge, beliefs, and abilities, all within the context of their relationships, families, communities, and economic circumstances [16].

Evidence shows that such interventions of 'serious games'[1] could increase motivation, engagement, and overall sustainability of health behaviours [17–19] including adolescent health [20]. Closer to India, in Nepal, a pilot for a set of four mobile games called "*Nari Paila*" (Women First), was adapted from Nepalese community games called Pragati, to integrate information on menstrual health, fertility, and family planning into a free Android app [21].

Gamified apps like the UNICEF-supported OKY app [22] have improved MHM, but lack published outcome evaluations. The field of health games is growing, but many lack validation and have poor designs. Kato (2017) [23] highlighted the need for high-quality efficacy studies that are drawn on digital game-based learning principles and rigorous outcome evaluations grounded in scientific methodologie, and not just game heuristics.

Early formative research [24] undertaken by Howard Delafield International (HDI) with adolescent girls from three Indian cities provided evidence of adolescent girls' aspirations and the need to strengthen services to reach adolescents with SRH information and services rooted in girls' agency. This background supported the development of learning objectives in designing the digital game app, Go Nisha Go® (GNG), which is rooted in theoretical frameworks [25], a design-led Theory of Change, [26] and human-centred design principles [27]. While the GNG game borrows elements from pre-existing theoretical framework such as Social Ecological Model [28], the game was designed primarily using a grounded approach based on formative research [26]. To the best of our knowledge, GNG, a free-to-download Android mobile game app launched in India in June 2022, produced by a women-owned small business (HDI) is the first digital game for adolescents to enhance SRH outcomes that

[1] 'Serious game' is an accepted terminology in social and behavioral change programming context. Such 'serious games' are designed to combine learning strategies, knowledge structures, and game elements to teach specific skills, knowledge, and attitudes.

has been evaluated using an encouragement design-led RCT methodology. This paper describes the findings of the outcome evaluation and addresses the research gap in evaluating digital interventions, especially mobile game apps for improving SRH knowledge and behavioral outcomes, particularly among adolescent girls in low-income settings.

Objectives

The objectives of this study were to examine the effect of GNG, a smartphone-based serious game intervention for adolescent girls in India, on MHM, contraception knowledge, and agency. At follow-up, differences in the intervention group who were encouraged to play the game were compared to the control group who did not receive any encouragement. The study also aimed to investigate user satisfaction and feedback. We hypothesized that the GNG study participants would be more likely to report improved MHM, contraception knowledge, and agency to negotiate the use of contraception and delay of marriage, relative to participants in the control condition.

Methods

Study design

We conducted a two-armed, encouragement-led, RCT evaluating the effects of GNG among adolescent girls on MHM, contraception knowledge, and agency in Patna, Jaipur, and Delhi NCR, India. The complete study protocol is published elsewhere [29]. The data was collected from January through February 2023 for the baseline and June and July 2023 for the follow-up.

Randomization

We randomized participants into treatment and control arms, where the treatment arm received exposure to GNG as part of the encouragement design, while the control arm did not receive any encouragement to download or play the game. Encouragement included weekly WhatsApp messages, scripted phone calls, and reminders highlighting key game benefits to engage participants. A household screening was carried out to prepare an eligible list of participants, who were then individually randomized using a random number generator into intervention or control groups. A random number was generated in STATA to administer a simple random sampling of participants at the individual level. Participants were equally distributed into intervention and control arms without any stratification.

Sampling & recruitment

We determined the recruitment of 1,950 participants from three sites: 650 girls each from Patna, Jaipur, and Delhi NCR for in-person interviews. Trained surveyors carried out household listing and identified eligible participants using eligibility criteria: unmarried, adolescent girls aged 15 to 19 years, able to read 'Hinglish' (Hindi and English hybrid in Latin Script), and who had access to an Android-based smartphone with internet. Eligible participants were then individually randomized into intervention and control groups.

Study procedure

Trained female surveyors administered the interviews with adolescent girls using electronic tablets on the Census and Survey Processing System (CSPro) application. Surveys were administered in a private space in the participant's residence and lasted approximately 60 min. S urveyors underwent a ten-day training program covering hands-on training on survey tools, ethical considerations, interview techniques, interview do's and don'ts, and the use of electronic tablets. Supervisors conducted random checks to ensure adherence to protocols. Field supervisors and senior researchers conducted regular spot-checking and back-checking.

Intervention

The intervention, a mobile game called Go Nisha Go is a role-play, simulation game [8] that follows the life of a young, urban, Delhi-based protagonist, Nisha, as she embarks on a journey of self-discovery and agency. Across five levels, the game uses an aspirational [9] travel theme that has Nisha visiting the Indian cities of Sikkim, Mumbai, Goa, and Hyderabad, while meeting inspirational women (a scientist, an influencer, a nurse, and a police officer), as part of her internship for a web series production. The interaction and communication with the game is made effortless [30]. Each level focuses on specific learning-based objectives (related to MHM, fertility awareness, contraception, consent, and negotiation around marriage and career, scaffolded on outcomes related to negotiation, relationship obligations, health knowledge, and confidence. The game has several strategically placed 'nudges' in gameplay, trade-offs/rewards, minigames, and direct access to resources, such as educational videos and a chatbot [26]. These 'nudges' are meant to increase knowledge incrementally, and in turn, improve the self-efficacy of the gamers to make informed choices. The SRH information is delivered directly to the player allowing them to experience the outcome of their choices, receive tailored feedback, and the option to try again. The game does not collect any Personally Identifiable Data (PID), thus protecting players' privacy.

For the outcome evaluation study, a ten-week encouragement activity was designed for participants

to download and play GNG with continuous nudges through phone calls and WhatsApp messages, and follow-up scripted phone calls from the program facilitators. While the intervention arm received this encouragement, the control arm did not receive any encouragement to play the game. Adolescent girls in the control arm had access to the standard of care available. These included health and nutrition initiatives such as the Sabala program (Rajiv Gandhi Scheme for Empowerment of Adolescent Girls) [31] for 10 to 18-year-old rural adolescent girls, services provided by Anganwadi centres, and any functional adolescent friendly health clinics. These services were equivalently available across the treatment and control conditions. Both arms also had free access to GNG via Google Play Store.

Measures

We measured three key constructs in our study including MHM, contraception, and agency. MHM was measured using outcomes of fertility awareness, awareness of menstrual hygiene products (three or more), use of menstrual hygiene products, tracking their menstruation, and attitude towards MHM. Contraception was measured using comprehensive knowledge of modern contraceptive methods (OCP, ECP, and condoms) and confidence in negotiating contraception. Agency was measured using outcomes such as belief in negotiating with whom and when to marry, and feeling confident to say no to a sexual act. Table -1 gives the definitions for each outcome (Table 1).

Covariates included girls' age, current studying status, household Below Poverty Line (BPL) card ownership [32], vocational training, number of siblings, caste, religion, and mobile ownership.

Data analysis

The results were analyzed and reported following the CONSORT guidelines. A Consort diagram was used to summarize the process of selecting and tracking adolescents throughout the study (Fig. 1). The interviewer was unfamiliar with the girl in the study group. The analysis results of adolescent girls' demographics and baseline outcome variables were presented using descriptive summary measures, such as mean for continuous variables and percentage for categorical variables. Intervention effects were reported using unadjusted models. The details of the analytical methods have been described in a previous publication [29].

Ethics

The Population Council Institutional Review Board (IRB) and Sigma IRB in India approved the research protocol design, consent forms, and conduct of the

Table 1 Definition of study outcomes

Construct	Outcome	Definition
Menstrual health management (MHM)	Fertility awareness	Correct knowledge of the fertile period during the menstrual cycle
	Awareness of 3 or more menstrual hygiene products	Knowledge of 3 or more menstrual hygiene management products from the following (tampons, menstrual cups, pads, reusable pads, etc.)
	Use of sanitary menstrual hygiene products	Use of commonly available MHM products such as pads, menstrual cups, and tampons
	Practised tracking their menstrual cycle	Actively keeping track of the menstrual cycle using a mobile app, calendar, or notebook
	Attitude towards MHM	Cumulative score of belief on the following statements: · Getting your period is just part of being a woman · Getting your period is healthy · Your period blood is not dirty · You can attend school when you have your period · You can play sports when you have your period · A girl with her period can enter the kitchen strongly agree = 5, agree = 4, neutral = 3, disagree = 2, strongly disagree = 1
Contraception	Comprehensive knowledge of OCP	Knowledge of the method, frequency of use, and where to get it
	Comprehensive knowledge of condom	Awareness of the method, the knowledge that a condom can only be used once, and where to get them
	Comprehensive knowledge of ECP	Awareness of the method, knowing that it can be used in a 72-h window after sex, and where to get them
	Confident in negotiating contraception	Intent to negotiate for contraception use in future sexual acts
Agency	Intent to negotiate when and whom to marry	Intent to negotiate with parents timing and choice of partner for marriage
	Attitude of refusing sex when not ready	Believe that a girl can refuse sex if she is not ready for it

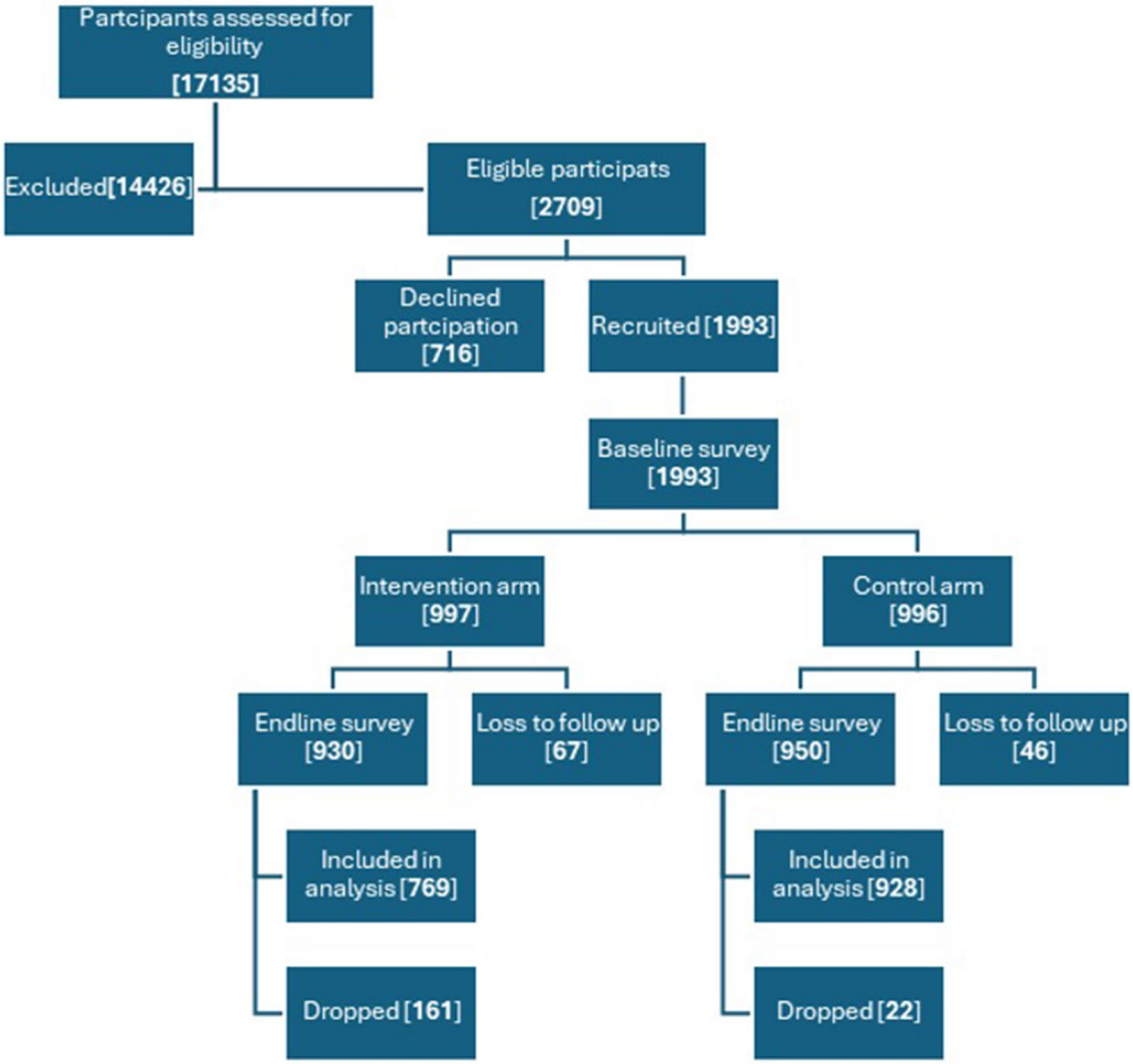

Fig. 1 Consort diagram. *Of the 6% lost to follow-up, primary reasons included change of home address (71%) and limited engagement interest (29%)

study. All participants provided consent or assent before enrollment in the study. Assent was sought from the game players below 18 years age.

Results

The baseline study involved recruiting and surveying 1,993 participants (see details in Fig. 1). The participants were randomized into two groups: intervention and control, comprising 997 and 996 individuals. The intervention group was encouraged to engage with GNG. A follow-up survey was conducted after ten weeks, revealing a 6% loss to follow-up, with 7% in the intervention arm and 5% in the control arm.

The analysis employed the per-protocol method, excluding 161 participants from the intervention arm who did not engage with GNG, and 22 participants from the control arm who did. Consequently, the final descriptive and regression analysis sample comprised 769 individuals in the intervention group and 928 in the control group.

Baseline characteristics

The average age of participants was around 16.7 years, both in the intervention and control groups. Most of the participants (81% overall) attended school at the time of the research. About 20% of the participants were BPL as evidenced by their family's BPL card with a significant

proportion (62%) belonging to socially marginalized communities, specifically Scheduled Caste (SC) and Scheduled Tribe (ST), 85% of the girls identified as Hindu. Even though mobile ownership of their phone was limited (77% used borrowed phones), there were no differences between the control and intervention groups for the variable of ownership of phones. Notably, the educational qualification of the head of household (HoH) was slightly higher among the girls in the intervention group (72%) compared to the control group (68%). Table 2 details all baseline characteristics.

Key outcomes

Table 3 presents the percentage of participants at baseline and endline grouped by control and intervention. Table 4 outlines the results of the regression analysis and captures shifts in various outcome variables from baseline to endline, comparing the control and intervention arms. The data is stratified into three main categories: Menstrual Health Management, Contraception, and Agency, each with specific metrics. The p-values indicate the statistical significance ($p < 0.05$) of these changes.

Menstrual health management

The outcomes of the chi-square test and regression analysis suggest statistically significant improvements in multiple parameters of MHM. In the control arm fertility awareness rose from 3 to 10% (p-value < 0.0001), while in the intervention arm, it increased more substantially from 4 to 23% (p-value < 0.0001). The odds ratio (OR) for fertility awareness in the intervention arm at endline compared to the control arm at baseline was 2.31 (95% CI 1.90–2.73, $p < 0.0001$), indicating that participants in the intervention group were more than twice as likely to have improved fertility awareness compared to the control group. Possession of a BPL card by the household was a predictor of fertility awareness, and those who had a BPL card were more likely to have higher fertility awareness (correct knowledge of the fertile period during the menstrual cycle).

Awareness of menstrual hygiene products for the control arm increased from 32 to 39% (p-value = 0.0031). In contrast, the intervention group exhibited a dramatic increase from 33 to 92% (p-value < 0.0001), showcasing the effectiveness of the intervention in raising awareness about menstrual hygiene products. The OR of 3.19 (95% CI 2.90–3.48, $p < 0.0001$), suggests that treatment arm participants at the endline were over three times as likely to be aware of three or more types of MHM products compared to the control arm at baseline. Those who were in school were more likely to know about MHM products. The use of MHM products was already high at baseline (94% in control, 95% in intervention) and remained the same by the endline. However, menstrual tracking practices showed a significant change in the treatment arm (24–40%; $p < 0.0001$ with a crude OR of 2.57 (95% CI 2.07–3.19, $p < 0.0001$). Those who were in school were more likely to know about MHM products. Education of Head of Household (HoH) was also positively associated with fertility awareness.

Table 2 Characteristics of participants at baseline in control and intervention arms

Background characteristic		Overall mean/frequency (%) (95% Confidence Interval)	Control mean/frequency (%) (95% Confidence Interval)	Intervention mean/frequency (%) (95% Confidence Interval)	p-value*
N		1697	928	769	0.5433
Girls age (years)		16.7 (16.61–16.74)	16.7 (16.56–16.75)	16.7 (16.60–16.77)	0.9728
Currently studying	Yes	81% (80–83%)	81% (78–83%)	82% (79–85%)	0.5609
	No	19% (17–21%)	19% (17–22%)	18% (15–21%)	
BPL	Yes	20% (18–22%)	19% (17–22%)	21% (18–23%)	0.5551
	No	80% (78–82%)	81% (78–83%)	79% (77–82%)	
HoH education	Literate	70% (68–72%)	68% (64–70%)	72% (69–76%)	0.0265
	Illiterate	30% (28–32%)	32% (30–36%)	28% (24–31%)	
Caste	Marginalized	62% (60–64%)	63% (60–66%)	61% (57–64%)	0.3076
	Non-marginalized	38% (36–40%)	37% (34–40%)	39% (36–43%)	
Religion	Hindu	85% (83–86%)	85% (83–87%)	84% (82–87%)	0.9119
	Non-Hindu	15% (14–17%)	15% (13–18%)	16% (13–18%)	
Mobile ownership	Yes	23% (21–25%)	23% (20–25%)	23% (20–26%)	0.9990
	No	77% (75–79%)	77% (75–80%)	77% (74–80%)	

As participants did not differ statistically in most of these variables, they were not included as covariates in future analyses

*Chi-square test

Table 3 Key outcomes for the GNG OE in control and intervention arms

Outcome variable	Overall (%)		Control (%)			Intervention (%)		
	Baseline N = 1697	Endline N = 1697	Baseline	Endline	p-value*	Baseline	Endline	p-value*
Menstrual health management								
Fertility awareness	3% (2–4%)	16% (14–18%)	3% (2–4%)	10% (8–11%)	< 0.0001	4% (3–5%)	23% (20–26%)	< 0.0001
Awareness of 3 or more menstrual hygiene products	33% (31–35%)	63% (61–65%)	32% (29–35%)	39% (36–42%)	0.0031	33% (31–37%)	92% (90–94%)	< 0.0001
Use of sanitary menstrual hygiene products	94% (93–95%)	95% (94–96%)	94% (92–95%)	95% (93–96%)	0.3614	95% (93–96%)	96% (94–97%)	< 0.4012
Practised tracking their menstrual cycle	22% (20–24%)	31% (29–33%)	20% (18–23%)	24% (21–26%)	0.0821	24% (21–27%)	40% (36–43%)	< 0.0001
Attitude towards MHM	19.61 (19.43–19.81)	21.57 (21.40–21.74)	19.56 (19.30–19.83)	21.14 (20.91–21.36)	< 0.0001	19.69 (19.41–19.98)	22.09 (21.83–22.34)	< 0.0001
Contraception								
Comprehensive knowledge of OCP	3% (2–3%)	11% (10–13%)	3% (2–4%)	6% (4–8%)	0.0011	2% (1–3%)	17% (15–20%)	< 0.0001
Comprehensive knowledge of condom	11% (9–12%)	28% (26–31%)	11% (9–13%)	21% (19–24%)	< 0.0001	10% (8–12%)	37% (34–40%)	< 0.0001
Comprehensive knowledge of ECP	1. (0–0.2%)	7% (6–8%)	0.1% (0–0.3%)	3% (2–4%)	< 0.0001	0.1% (0–0.4%)	12% (9–14%)	< 0.0001
Confident in negotiating contraception	61% (59–63%)	75% (73–77%)	62% (59–65%)	70% (67–73%)	0.0002	60% (57–64%)	82% (79–84%)	< 0.0001
Agency								
Intend to negotiate when and whom to marry	69% (66–71%)	76% (73–78%)	69% (66–72%)	70% (67–72%)	0.8800	68% (64–71%)	83% (80–86%)	< 0.0001
Attitude of refusing sex when not ready	62% (60–64%)	78% (76–80%)	63% (60–66%)	73% (70–76%)	< 0.0001	61% (58–65%)	85% (83–88%)	< 0.0001

Table 4 Regression results for the key outcomes (intervention arm at endline compared to control arm at baseline)

Outcome	Unadjusted OR	95% CI	p-value
Fertility awareness	10.12	6.67–15.37	< 0.0001
Awareness about different menstrual hygiene products (3 or more)	24.18	17.99–32.49	< 0.0001
Use of sanitary menstrual products	1.44	0.93–2.24	0.1052
Practised tracking their menstruation	2.57	2.07–3.19	< 0.0001
Attitude towards MHM	2.52	2.16–2.89	0.0018
Comprehensive knowledge of OCP	7.04	4.60–10.78	< 0.0001
Comprehensive knowledge of condom	4.88	3.78–6.28	< 0.0001
Comprehensive knowledge of ECP	121.33	16.86–872.99	< 0.0001
Confident in negotiating contraception	2.76	2.20–3.46	< 0.0001
Intend to negotiate when and whom to marry	2.15	1.70–2.72	< 0.0001
Attitude of refusing sex when not ready	3.40	2.68–4.33	< 0.0001

Contraception

In the control arm, comprehensive knowledge of OCPs rose from 3 to 6% (p-value = 0.0011), whereas in the intervention arm, it increased more significantly from 2 to 17% (p-value < 0.0001). Comprehensive knowledge about condoms in the control group rose from 11 to 21% (p-value < 0.0001), while the intervention group saw an increase from 10 to 37% (p-value < 0.0001). Similarly, knowledge of emergency contraceptive pills (ECPs) in the control arm rose from 0.1% to 3% (p-value < 0.0001), and in the intervention arm it increased from 0.1% to 12% (p-value < 0.0001). Comprehensive knowledge of OCPs, condoms, and ECPs showed significant improvements with crude ORs of 7.04 (95% CI 4.60–10.78, p < 0.0001), 4.88 (95% CI 3.78–6.28, p < 0.0001), and 121.33 (95% CI 16.86–872.99, p < 0.0001) respectively.

The confidence to negotiate contraception use rose slightly (62% to 70%; p-value = 0.0002) in the control arm, while in the intervention group, the shift was more pronounced (60–85%; p-value < 0.0001). Players were seen to be more likely to report this confidence (OR 2.76, 95% CI 2.20–3.46, p < 0.0001).

Agency

The belief in negotiating marriage decisions with parents in the control group remained unchanged at 69% (p = 0.8800) while in the intervention group, it shifted from 68 to 83% (p-value < 0.0001). Regression analysis shows that girls who played the game were 1.5 times more likely to have the intention to negotiate marriage decisions with parents (p < 0.0001) controlling for differences at baseline and time effect.

Attitude to refusing sex with a partner when not ready in the control group, rose from 63 to 73% (p-value < 0.0001), while in the intervention group, it increased from 61 to 85% (p-value < 0.0001). Players of GNG were 2.4 times more likely to have the attitude to turn down sex when not ready (95% CI 2.68–4.33, p < 0.0001).

Intervention quality assessment

Table 5 summarises the levels of participant satisfaction with various aspects of GNG, expressed in percentages and mean scores. Regarding categorical measures, 74% (95% CI 71–77%) of girls who played GNG discussed the game with others, and 66% (95% CI 63–70%) recommended it to others. Additionally, 80% (95% CI 77–82%) of participants felt a sense of relatability with the game's protagonist, Nisha, and 92% (95% CI 90–94%) aspired to be like her, indicating strong identification with the character. For continuous measures, the mean score for relatability was 8.4 (95% CI 8.2–8.5) out of 10, suggesting that participants found the content highly relatable. The game was also rated highly enjoyable with a mean score of 8.9 (95% CI 8.7–9.0), and its interactivity received a similar mean score of 8.9 (95% CI 8.7–9.0). Furthermore, the engagement level with GNG was strong, with a mean score of 8.7 (95% CI 8.6–8.8).

Table 5 Participant satisfaction (N = 769)

% (95% CI)	
Discussed GNG	74% (71–77%)
Recommended GNG to others	66% (63–70%)
Relate with Nisha (the protagonist)	80% (77–82%)
Aspire to become like Nisha (the protagonist)	92% (90–94%)
Mean score out of 10	
Relatability	8.4 (8.2–8.5)
Fun	8.9 (8.7–9.0)
Interactivity	8.9 (8.7–9.0)
Engagement	8.7 (8.6–8.8)

Discussion

The findings of this study support the efficacy of digital games like GNG in enhancing SRH education among adolescent girls in India. The improvements in MHM, contraception knowledge, attitude, and efficacy to negotiate crucial decisions like marriage and contraception use highlight the potential of digital games in delivering health information, especially in low-resource settings. Significant improvement in awareness in the intervention group indicates the potential of theory-based principles in enhancing outcomes, such as the application of Prensky's principles of learner engagement [30], including 'goal orientation' and creating decisions and choices for the users. In GNG, players play as Nisha, who confronts relatable complex problems of an adolescent girl's life. Prensky's principle suggests that decisions and choices when confronting specific problems are critical to attaining goals. Decisions, according to Prensky, are at the heart of the 'learning loop" of decision-action-feedback-reflection. In the game-based narrative, Nisha starts her period on the first day of her new internship.

The game used an engaging and immersive experience to convey serious information about contraception and addressed the gaps found in the formative research [24] that boys were a key source of (mis)information about contraception using a boy character in the narrative. The modality of the intervention, GNG, as a choice-based

decision game enabled a simulation of the 'learning loop' [30] by illustrating the decision and the action that follows, and then offering feedback on the consequences (e.g. negotiate condom use or don't negotiate condom use). The storylines, in support of the objectives to increase contraceptive knowledge and confidence to negotiate use, similarly used elements to demonstrate the 'learning loop' that is possible with game.

The increases in efficacy-related outcomes, such as refusing sex when not ready and the increase in confidence in negotiating marriage decisions suggest that GNG effectively empowered participants with greater perceived efficacy to take control of important decisions of their lives. The game's interactive, personalized nature and role-playing elements likely contributed to knowledge, attitude, efficacy, and change by providing a safe environment for practising decision-making. The incremental knowledge gains and reinforcement through challenges within the game and nudges helped build confidence and efficacy. Real-world decisions that emerged in the formative research [24] were illustrated through narratives and compelling storylines where the choices weren't 'right or wrong' but had trade-offs which are more aligned with real world situations. For instance, the player may choose to turn down an internship opportunity to travel to appease her parents, thereby gaining 'obligation points' but will lose 'confidence points'. Through the 5 levels, these trade-offs come with wins and losses in the form of health, confidence, and relationships which are more reflective of decisions in real life. The 'one-way' modalities of most communication interventions often only offer one 'right' choice or message, whereas the interactivity of games can factor in individual desires, as well as social or family norms, thus increasing agency to decide what is best for one's self and circumstances.

High ratings from players demonstrated strong product acceptance. Prensky [25] states that elements of game-based learning (GBL) such as sights, sounds, visuals, challenges, conflict, discovery, decisions, feedback, and reflection—can foster an emotional connection that facilitates learning. These elements, crafted from co-design sessions, reflected realistic renderings of the game user interface. Customized music and sound effects helped to create the necessary tension or excitement for an emotional connection. The conflicts in each level were derived directly from formative research [24]. These were corroborated by ratings for GNG on the Google Store that ranged from 4.3 to 4.7 of a maximum score of 5, which are determined through back-end algorithms for variables such as search engine results, number of downloads, and number of instant user feedback.

With the increase of MHM indicators, contraception knowledge and negotiation, and increased agency to refuse sex and marriage, GNG can communicate complex health information in a simple and accessible manner. Traditional educational methods often struggle to achieve such outcomes due to barriers such as limited resources and sociocultural stigma. By contrast, GNG provides a private and engaging platform for learning, enabling adolescent girls to gain critical health knowledge without fear of judgment or stigma. Moreover, it is personalized based on players choices through precision messaging [33].

The success of GNG demonstrates the feasibility of digital health games to address SRH needs in low-resource settings, which could be adapted for use in other LMICs, addressing universal barriers such as stigma and limited access to care. Our findings also support the integration of digital health interventions like GNG into national adolescent health programs. Policymakers should consider incorporating serious games into school curricula and community health initiatives to enhance SRH education. Given their scalability and cost-effectiveness [34], digital games can be leveraged to address a wide range of health issues beyond SRH, including mental health, nutrition, and chronic disease management. For example, previous studies have demonstrated the effectiveness of game-based interventions in promoting healthy eating behaviours and managing depressive symptoms [35–37]. These applications can be particularly beneficial in resource-limited settings where traditional educational and healthcare resources are scarce.

Limitations

Limitations of the study include the potential for self-report bias in survey responses and the limited generalizability to rural/very poor SES areas where mobile phone access may be lower. The follow-up period in this study was relatively short, which limits the ability to assess the long-term sustainability of the observed behaviour changes. Ensuring that all participants engaged with the game as intended can be challenging. Variations in how participants used the game (e.g., frequency and duration of play) could also have an impact on the study's outcomes. While the current scope of GNG is limited in populations with low smartphone penetration, we plan to incorporate offline components or community-based interventions to extend reach in such areas. Also, given the increasing adoption of smartphones in india and other LMICs, the reach of GNG is likely to increase in future.

This study was focused on key outcomes related to MHM, contraception knowledge, and improving

agency for refusing sex and negotiating contraception use, however, other important aspects of adolescent reproductive health, such as mental health and relationship dynamics were not assessed due to budget and time limitations. Future studies could consider a more comprehensive set of outcome measures.

While the encouragement-led design used in the study may not fully replicate real-world conditions, it is important to note that the encouragement simulated real-world nudges, such as phone/SMS notifications and creative WhatsApp messages serving as digital reminders that encouraged engagement with the health intervention.

Conclusion

The GNG game represents a significant advancement in the use of digital interventions for delivering adolescent health information. The study's findings demonstrate the game's effectiveness in improving SRH knowledge and behaviors among adolescent girls in India. The substantial gains in MHM, fertility awareness, contraception knowledge, and agency underscore the potential of serious games to deliver critical health information in an engaging and accessible manner. The game's design, which includes role-playing elements, incremental knowledge reinforcement, and privacy protection, was instrumental in achieving these outcomes. These features allowed participants to practice decision-making in a safe environment, thereby building their confidence and agency.

Future product development under the Game of Choice, Not Chance Project will explore alternatives to expensive RCTs, such as integrated digital tools, including research bots for assessments that conform to gold standards of product and outcome evaluations. We also plan to conduct longitudinal studies in future to evaluate the sustainability of behavior changes introduced by this game.

Longitudinal research is needed to assess the long-term sustainability of behavior changes induced by such interventions and to explore their effectiveness across different settings and populations. Understanding the mechanisms through which serious games influence behavior change will be crucial for optimizing their design and maximizing their impact.

By leveraging the power of digital technology for improved outcomes where barriers to gendering agency and improving equity include gatekeeping, personal privacy, and data security, GNG has paved the way as a validated proof of concept to improve health outcomes and empower individuals, particularly in resource-limited settings.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12978-025-02005-1.

Additional file 1.

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Author contributions
AR is the Research Lead with Howard Delafield International (HDI) and has contributed to developing the study tools, data analysis, and writing the manuscript. LS is the Regional Director of Asia at HDI and a Co-Investigator on the study and contributed to the study design and management of the study implementation. AD is a Research Advisor and Scientific Writer with HDI and has contributed to the study design, survey development and data analysis. AR, LS and AD drafted this manuscript. AS is a Research Associate with the Population Council Consulting India and a co-PI involved in the implementation and coordination of the study. MB is the Senior Program Officer, and the Population Council is a Co-Investigator in the study and contributed to the implementation of the study. NK is the Country Director, Population Council India and Co-PI on the study and actively engaged in the field implementation, including training in CAPI and quality of data collection. NS is the Country Director, Population Council India and SH is Managing Director, HDI and Project Director of the Game of Choice, Not Chance (GOC) Project and contributed to the study design, manuscript and review. KA was the former India Team Lead at HDI and contributed to the design of the creatives for the encouragement design. NS and SH are the Principal Investigators of the study and provided executive management support to the study. All authors read and approved the final manuscript.

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Data availability
Data is available upon reasonable request from the corresponding author.

Declarations

Competing interests
The authors have no competing interests.

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