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Barriers and facilitators to potential nationwide implementation of fertility health awareness strategies in young married couples in Singapore: an implementation study

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Abstract

Background Globally, the total fertility rate has declined over the years, partly attributable to limited public awareness of age-related fertility decline. To address this, we conducted an effectiveness-implementation hybrid type I, three-arm, open-label randomised clinical trial (RCT) to evaluate the effects of fertility health screening (FHS) and fertility awareness tools (FAT) on knowledge, attitudes, and practices related to childbearing. This study reports the implementation outcomes, barriers, and facilitators to potential nationwide implementation of these two interventions.

Method The study comprised a three-arm RCT and a qualitative component involving individual semi-structured interviews conducted from January 2021 to March 2024. Eligible participants were married, childless heterosexual couples with a female partner aged between 25 and 34 years. Healthcare professionals (HCPs) who implemented the interventions, along with purposively selected couples, participated in the interviews. The interview guide was based on the Consolidated Framework for Implementation Research. Interviews were audio-recorded, transcribed, and analysed using thematic analysis. Completion of each FHS component was verified against medical records, and data used to inform cost was collected via a productivity loss survey and Time Driven Activity Based Costing.

Results A total of 778 heterosexual couples were randomised in this three-arm RCT. Of these, 29 couples and 20 HCPs took part in the interviews. FHS was perceived as valuable for family planning, while views on FAT were mixed. Both interventions demonstrated high fidelity. HCPs spent a median of 219 min delivering FHS, which costs on average \$83.36 per couple. Each couple also incurred a median total cost of productivity loss and transportation of \$663.55 over all FHS visits. Key facilitators of FHS were the use of evidence-based testing and professional guidance,

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whereas resource and time constraints were notable barriers. Key barriers for FAT included the lack of content novelty and access to health screening though its structured design was a facilitator.

Conclusion Both FHS and FAT were deemed acceptable and feasible by couples and HCPs. Cost and staffing emerged as significant barriers to broader implementation and scalability. These findings offer insights into translating educational and fertility awareness interventions into practice and guiding future nationwide and international implementation efforts.

Keywords Fertility screening, Education, Age related fertility decline, Intervention, Implementation science

Text box 1. Contributions to the literature

- This was an effectiveness-implementation hybrid study evaluating various implementation outcomes, barriers, and facilitators of two interventions: fertility health screening (FHS) and fertility awareness tools (FAT).
- We found valuable insights from recipients of the interventions and providers that can inform the adaptation and scaling of a fertility education intervention.
- There is a paucity of implementation studies in fertility medicine and the results help build an evidence base for implementing suitable interventions to improve more informed fertility decision-making in Singapore and beyond.

Introduction

Many developed countries have witnessed declining birth rates over the years, with people marrying and having children later [1]. The average age at first birth in Singapore increased from 27.5 years in 1990 to 31.6 years in 2023 [2]. While these trends continue, the limited biological fertility window remains a reality, resulting in unintended subfertility and pregnancy complications [3, 4]. In Singapore, medically assisted reproduction services are available in private fertility centres and 3 public healthcare institutions [5]. The Government co-funds up to 75% of costs at the public institutions for up to 3 fresh and 3 frozen cycles for couples with at least 1 Singapore Citizen where the woman is below 40 years of age [6].

Fertility awareness education significantly improves women's knowledge about fertility [7–12]. There is also evidence that counselling tailored to areas of misunderstanding is more effective than generic educational materials at increasing fertility awareness in women donating eggs [13]. However, evidence for fertility education alone in modifying childbearing intentions and behaviours is limited [10, 14]. The addition of a behavioural change component is therefore warranted to address relevant psychological determinants to modify the downstream conception efforts, given the multitude of factors affecting childbearing decisions.

We therefore designed two theory-guided, evidence-based personalised fertility interventions, namely fertility health screening (FHS) and fertility awareness tools (FAT), to deliver fertility education and target psychological determinants to influence childbearing intention

[15]. These two interventions were evaluated in an effectiveness-implementation hybrid type I randomised controlled trial (RCT) [15], which showed an increase in fertility knowledge but not a change in intended age of first birth or conception efforts six months post randomisation in Singaporean couples [16]. The hybrid trial design also enables the concurrent understanding of barriers and facilitators to the potential nationwide implementation of these interventions and to explain the RCT results, offering practical insights and actionable guidance for decision-makers, and facilitating the translation to effective real-world applications [17].

In this study, we report the implementation outcomes within the RCT and barriers and facilitators to potential nationwide implementation of the interventions. The outcomes follow Proctor's Implementation Outcomes Framework [18], and exploration of potential barriers and facilitators was guided by the Consolidated Framework for Implementation Research (CFIR), a comprehensive framework to identify factors at multiple levels that can affect implementation success [19].

Methods

Study setting and study design

This was a prospective, multicenter, three-arm parallel group open-label RCT conducted at one general hospital and one specialist hospital from January 2021 to March 2024, coupled with a qualitative component, the protocol of which has been described elsewhere [13]. Briefly, the RCT was designed to evaluate the effectiveness of two interventions, FHS and FAT, on fertility intentions, fertility knowledge, and conception efforts. Young, married, Singaporean or permanent resident couples with the female partner between 25 and 34 years of age were recruited through direct approaches at polyclinics, email broadcasts to SingHealth staff, postings on our internal institutional website, promotion materials (posters and brochures) displayed at healthcare institutions and selected public venues, and on SingHealth institutions' Facebook and Instagram accounts. There were no restrictions with regard to childbearing intention or attempts, as long as they fulfilled the inclusion and exclusion criteria. Couples who returned the baseline questionnaires received a reimbursement of \$20 and were randomised

into one of three arms: (i) FHS, (ii) FAT, and (iii) no intervention (Control).

Couples assigned to the control arm were informed that they would be receiving standard care during the study, and they were required to complete a follow-up questionnaire at 6 months. Couples assigned to FHS underwent a fertility health screening comprising an anti-Mullerian hormone (AMH) test and semen analysis (SA), followed by a consultation with a gynecologist and a reproductive planning counselling session with a nurse. In this study, the AMH test was not used as a diagnostic tool to predict fertility potential, but rather as part of a broader reproductive health assessment. The purpose of including AMH was to enhance couples' understanding of their reproductive health status and to facilitate personalized counselling on fertility planning during the consultation. Couples assigned to FAT were directed to an online portal where they were shown a video targeting attitudes toward having children and the timing of childbearing.

At 6 months, all couples, including those in the control group, were sent a follow-up self-administered questionnaire via email to measure post-intervention fertility knowledge, parenthood intentions, and conception

efforts. Couples who completed follow-up questions received an incentive of \$80.

The study was reviewed and approved by the Centralized Institutional Review Board of SingHealth (Ref No. 2019/2095). The reporting of this implementation study follows the Standards for Reporting Implementation Studies (StaRI) guidelines [20].

Implementation outcomes and data collection

We evaluated seven out of the eight implementation outcomes proposed by Proctor et al. (18). As the interventions are still in the pre-implementation phase, sustainability is less relevant and therefore omitted. The data sources used to inform each of these outcomes are shown in Table 1. Couple interviews and open-ended questions from the follow-up questionnaires were analyzed to assess outcomes related to acceptability, appropriateness, feasibility, implementation cost, and coverage/reach. The 6-month follow-up questionnaire included one open-ended question inviting participants to share their views on the intervention ("Please tell us what you think about the fertility screening or fertility awareness tool."). HCP interviews were analyzed to assess outcomes related to adoption, appropriateness, feasibility, implementation cost, and coverage/reach. A fidelity checklist

Table 1 Implementation science outcomes included

Implementation science outcomes included	Working definition	Variables/data source
Acceptability	The perception among stakeholders that an intervention is agreeable	<ul style="list-style-type: none"> • IDIs (couple) • FUQ Q56[†] & Q57[†]
Adoption	The intention, initial decision, or action to try to employ a new intervention	<ul style="list-style-type: none"> • No. of doctors/nurses in FHS • IDIs (HCPs)
Appropriateness	The perceived fit or relevance of the intervention in a particular setting or for a particular target audience or problem	<ul style="list-style-type: none"> • IDIs (couple, HCPs) • FUQ Q56[†] & Q57[†]
Feasibility	The extent to which an intervention can be carried out in a particular setting or organization	<ul style="list-style-type: none"> • IDIs (couples, HCPs) • FUQ Q56[†] & Q57[†] • TDABC (time taken) • PLQ (couple time taken) • Meeting minutes (issues)
Fidelity	The degree to which an intervention was implemented as it was designed	<ul style="list-style-type: none"> • Fidelity checklist (FHS) • % returning FertiSTAT (FAT) • % couples sent reminder email
Implementation cost	Incremental or total (including intervention cost) cost of implementation strategy	<ul style="list-style-type: none"> • TDABC + test + publicity cost • IDIs (couples, HCPs) • FUQ Q56[†]
Coverage/reach	The degree to which the population that is eligible to benefit from an intervention actually receives it	<ul style="list-style-type: none"> • Response rate • No. rejected due to quota (none) • Dropout rate • Dropout reasons • Characteristics of couples who dropped out vs. completed • IDIs (couples, HCPs)

[†]Please tell us what you think about the fertility screening or fertility awareness tool. It can be positive or negative, there are no correct or wrong answers

[†]How likely would you recommend it to other young couples? [Not at all, slightly, moderately, very, extremely]

FUQ: follow-up questionnaire; HCPs: healthcare professionals; IDIs: in-depth interviews; PLQ: productivity loss questionnaire, TDABC: Time Driven Activity Based Costing

FUQ and PLQ were completed by both the husbands and wives separately

was employed to document the completion of key steps during each FHS visit, verified against visit logs, and laboratory and medical records by study clinical research coordinators (CRCs) (Supplementary file 1). The return of completed FertiSTAT questionnaires to CRCs served as a proxy indicator for FAT completion, as the online portal was set up such that couples could only download FertiSTAT after watching the video. To assess feasibility and cost, couples in FHS were required to report the time taken, transportation costs, and number of hours missed at work to attend each session in a 12-item productivity loss questionnaire designed for this study. Couples in FAT were also asked to report the time taken to complete the intervention. Time Driven Activity Based Costing, a micro-costing methodology that estimates the cost of delivering a service based on process costs [21], was used to estimate the cost to deliver FHS. We constructed process maps for each site and recorded the personnel involved and time taken for each step (Supplementary file 2).

Data analysis

Descriptive statistics were used to summarise quantitative indicators: counts and percentages for categorical variables, and means and standard deviations or medians and interquartile ranges for continuous variables. We performed a chi-square test or t-test, as appropriate, to compare demographic characteristics between participants who completed the study and those who did not. P-values < 0.05 were considered statistically significant. All analyses were performed using R v4.4.0.

The cost of productivity loss was estimated using the Human Capital Approach, in which one hour of productivity loss is valued as one hour of an employee's compensation [22]. The total cost of productivity loss was calculated by multiplying the number of work hours missed by the estimated hourly wage, based on a 44-hour workweek. All costs were reported in 2024 Singapore Dollars.

Qualitative study

Eligibility criteria

Healthcare professionals (HCPs) from both participating hospitals and couples randomised to FHS or FAT were invited for in-depth interviews by the study team CRCs via email. HCPs were invited for in-depth interviews soon after recruitment started in Jan 2021 until the target number was reached. Couples in both intervention arms were invited for in-depth interviews after they had completed the 6-month follow-up questionnaire. For maximum variation, purposive sampling was used to recruit HCPs, including doctors, nurses, administrative staff, laboratory personnel, and middle and senior management. These HCPs were selected based on their potential

involvement in implementing the interventions, clinical expertise, and experience. The couples were also purposively recruited based on their treatment arm, age group, and responses to the primary outcome.

Study procedures

The interviews were conducted by a research fellow (HZ), who was trained in qualitative research, and four CRCs who were trained and assessed to be competent by HZ. To avoid potential bias, HZ and the CRCs interviewed participants not from their institutions to ensure they had no prior relationship with participants. The interviews were conducted from June 2021 to December 2023, over Zoom and audio recorded, and lasted approximately 30 min each. The audio files were stored in encrypted folders accessible only by the study team.

Interview guide

The interview guide was developed based on Damschroder et al.'s (2009) CFIR [19]. Constructs deemed to be relevant to the implementation of either intervention were selected and agreed on by consensus within the study team (Supplementary files 3 & 4).

Data analysis

The interviews were transcribed using Otter.ai, reviewed, and refined by the CRCs for accuracy. Coding frameworks and themes were developed iteratively using Braun and Clarke's (2006) six-step process [23]. This involved familiarizing ourselves with the data by reading the transcripts in their entirety before generating relevant codes, grouping them into themes and sub-themes, and defining the themes. Inductive thematic analysis was used to evaluate the implementation outcomes [23], and a deductive approach was utilised when applying the findings to pre-determined implementation outcomes. NVivo 12 software was used to facilitate coding and categorizing the data. We then reviewed the themes, identified those deemed relevant to the research questions, and mapped them to selected CFIR constructs and implementation outcomes. As an updated CFIR [24] was published in 2022, we used this for the mapping instead. Finally, we followed O'Brien et al.'s (2014) Standards for Reporting Qualitative Research (Supplementary file 5) [25] for reporting the findings. To protect participants' anonymity, we assigned relevant code identifiers to the participants ("HCP", "H" (husband), and "W" (wife)).

Results

A total of 778 heterosexual couples were randomised into the three RCT arms (226 in FHS, 238 in FAT, and 314 in the control group). Among them, 216, 216, and 314 couples completed the study, respectively. A total of 53 couples were invited to participate in the interviews,

and among them, 29 couples (16 from FHS and 13 from FAT, comprising 29 husbands and 29 wives) agreed and completed the joint interviews. A total of 66 HCPs and managers were invited, out of which 20 responded (10 doctors, 8 laboratory staff, 1 nurse, and 1 manager). Their demographics are shown in Table 2. Additionally, 124 wives and 131 husbands completed the open-ended question in the follow-up questionnaire, which contributed to the data on implementation outcomes.

Implementation outcomes

Sample illustrative quotes according to implementation outcomes are given below and in Supplementary file 6.

Acceptability

Many couples in FHS expressed that undergoing FHS was a positive and useful experience, aiding them in family planning. In addition to insights into their health and fertility potential, FHS also alleviated participants' fear of infertility and raised their awareness about fertility.

It gave me good insights into my current sperm status and how to improve it. – SGH134-H

I think the fertility screening is very useful, especially for the last session where the doctor explains to us thoroughly our results and assures us that we have no issues in having a child. This gives us peace of mind and less pressure. – SGH175-H

However, participants in FAT had mixed opinions about the intervention. Some of them found the brochure and video informative and educational, which served as a good reminder. Other participants were disappointed with the video's limited information, adding that it did not change their views on fertility or provide clear guidance on what actions to take or where to seek help.

I think it's a good reminder for me to remember how valuable it is of youth in terms of fertility, and we have to start thinking about family planning and trying to conceive while we're still young and have the energy. So, I think that's a good reminder and refresh of all the knowledge that we should have. – KKH17-W

Neutral - might be more beneficial to go for fertility screening to get advice rather than self-study using the tool. – SGH157-W

We were hoping we were getting into the first group; we could get some check-ups or whatever, that is more useful to us because all we already knew. – KKH19-H

Adoption

Four doctors and four nurses from both study sites were actively involved in providing consultation and counseling to participants in FHS. The interviewed HCPs highlighted that FHS was effective in gauging reproductive potential and raising awareness of the impact of time and age on women's fertility.

While tests such as AMH and SA provided a useful snapshot of current fertility, their predictive value was limited, especially SA, which might not accurately correlate with pregnancy outcomes and could change with a man's health. These tests offered only insights at one point in time, making it important for couples to understand the limitations. Adoption of such programs may be influenced by how well doctors think couples can grasp these nuances.

It's useful for giving couples an idea of their reproductive potential, but semen analysis doesn't always correlate with pregnancy outcomes and can vary with a man's health, so it's not very predictive. – HCP3

I think FertStart is great for young couples as it raises awareness and gives them a snapshot of their reproductive health, helping them decide when to start a family. However, tests like AMH or semen analysis only reflect their current state. Just because results are good now 'doesn't mean they'll stay that way in a year or two, as reproductive health can change with age. It's really just a one-time screening. – HCP19

Appropriateness

Couples in FHS reported that they benefited from FHS tests and consultations with the consultant obstetrician and the nurse. These services provided a better understanding of their fertility prospects, clear instructions on the next steps, and information about available options and factors affecting infertility. Participants also noted that FHS was beneficial for early identification of potential issues if conception does not occur, helping couples decide if they need to adjust their family planning timeline. Additionally, normal results can provide a sense of relief and boost confidence:

The fertility screening was helpful in informing us about our current physical health /fertility status and whether there is an urgent need to bring forward our family planning timeline. –SGH8-W

It provided a sense of relief to know that both of us

Table 2 Demographics of interviewed participants

Characteristics	Specific characteristics	Number of participants	
HCP	Designation of HCP		
	Doctor	10 • 4 senior residents • 4 consultants • 1 associate consultant • 1 doctor from senior management	
	Laboratory staff	8 • 4 embryologists • 3 medical laboratory technologists • 1 senior medical laboratory clinical scientist	
	Nurse	1 assistant nurse clinician	
	Manager	1 deputy director, Women's SOC including IVF centres and subfertility clinics	
	Gender		
	Male	4	
	Female	16	
	Institution HCP was from		
	KKH	15 HCPs	
	SGH	5 HCPs	
	Couples	Institution couples underwent the intervention	
		KKH	14 couples
SGH		15 couples	
Type of intervention couples underwent			
FHS		16 couples	
FAT		13 couples	
Age			
25–30		15 (13 W, 2 H)	
31–35		36 (16 W, 20 H)	
36–40		6 (H)	
41–45		1 (H)	
Educational level			
University degree or above		52 (27 W, 25 H)	
Polytechnic diploma		3 (2 W, 1 H)	
Professional qualification or above		2 (H)	
'O'/'N' level or equivalent		1 (H)	
Ethnicity			
Chinese	56 (28 W, 28 H)		
Indian	1 (W)		
Korean	1 (H)		

Table 2 (continued)

Characteristics	Specific characteristics	Number of participants
	Religion	
	No religion	23 (10 W, 13 H)
	Buddhism	15 (8 W, 7 H)
	Christianity	13 (8 W, 5 H)
	Taoism	5 (1 W, 4 H)
	Catholicism	1 (W)
	Hindusim	1 (W)
	Monthly income range of individual participants	
	<\$999	2 (W)
	\$1,000-\$1,999	1 (H)
	\$2,000-\$2,999	5 (2 W, 3 H)
	\$3,000-\$3,999	13 (8 W, 5 H)
	\$4,000-\$4,999	12 (7 W, 5 H)
	\$5,000-\$6,999	16 (7 W, 9 H)
	\$7,000-\$8,999	4 (2 W, 2 H)
	\$9,000-\$10,999	5 (1 W, 4 H)

FAT: fertility awareness tools, FHS: fertility health screening, HCP: healthcare professionals, IVF: in vitro fertilization, KKH: KK Women's and Children's Hospital, SGH: Singapore General Hospital, SOC: specialist outpatient clinic; 'O'/'N' Level = General Certificate of Education Ordinary / Normal level

had no issues with our fertility based on the screening results. – SGH293-H

Couples in FAT had a neutral attitude towards it. While some acknowledged that the FAT helped raise awareness about fertility, others felt that it was not very helpful and did not provide information beyond what was already available on the internet:

I felt there were things I already knew, and the awareness just helped to reinforce certain facts or misconceptions I may have had about fertility and family planning, etc. Overall, although I was not in the clinic group to undergo tests for my fertility, I'm better aware of the process through the videos that were shared with me. – SGH288-H

The tool doesn't really help or add to the information we can already find on the internet. – SGH323-H

One participant also mentioned that the intervention was not very helpful for couples who weren't planning to have kids (yet):

No, because we're both under 35. We are not really trying for a baby. So, if have, have, don't have, don't have. So it doesn't make a difference to us. - KKH19-W

The HCPs noted that the interventions would be beneficial to some extent, particularly for individuals who already desire to have children but have not yet taken steps to achieve their goals. They highlighted the

importance of nurses and doctors providing counselling in layman's terms to ensure participant comprehension.

The brochure is good information for them. It's a wake-up call for them if let's say they don't get pregnant after 12 months of trying. – HCP10

However, HCPs expressed concerns including that the fertility test results (AMH, SA) could be counter-productive, and influencing couples' decisions through interventions was difficult:

The couple might think that they have a lot of time and won't start a family anytime soon. – HCP1

It's very hard to convince them to have children, especially in Singapore, where the cost of living and the cost of raising children are high. – HCP15

Feasibility

On average, the HCPs spent a total of 219 min providing services to participants in FHS across the three visits (Table 3). The couples in the FHS group took approximately 0.5 days off from work each to attend each visit (Table 4). Many HCPs expressed concern regarding time and resource constraints due to the potential increase in service demand:

In Singapore, we do not have much time to talk to the patient. In our daily counselling sessions in the public sector, the allocated time is usually 10 to 15 min. So, to address patients' concerns effectively,

Table 3 Time taken to conduct fertility screening by the HCPs

Personnel	Activity	Median (IQR) (minutes)
Clinical Research Coordinator/ Patient Service Associate/Nurse Counsellor	Registration of Visits	10 (9, 12)
	Ordering of tests	5 (1, 5)
	Giving instructions to participants	5 (4, 5)
	Scheduling of appointments	6 (4, 10)
Assistant Nurse Clinician/Nurse Clinician	Blood sampling and transferring samples to the lab	10 (7, 19)
Medical Laboratory Scientist/ Senior Medical Laboratory Scientist	Sample processing for AMH test	90 (90, 90)
	Analysis of SA sample	10 (10, 40)
	Preparation of test report	7 (6, 10)
Senior Resident/Associate Consultant/Consultant/Senior Consultant	Doctor consultation	10 (5, 10)
Assistant Nurse Clinician/Nurse Clinician	Reproductive counselling with nurse	30 (25, 35)
Average time spent on each couple		219.45*

*HCPs spent a total of 44,987 min on 205 couples, averaging 219.45 min per couple

AMH: Anti-Mullerian hormone, HCPs: healthcare professionals, IQR: interquartile range, min: minutes, SA: semen analysis

Table 4 Indirect and direct costs incurred to the couples in FHS

Median (IQR)	Husband	Wife
Time taken off from work to attend Visit 1 (day)	0.5 (0.5, 1.0)	0.5 (0.5, 1.0)
Time taken off from work to attend Visit 2 (day)	0.5 (0.5, 0.5)	0 (0.0, 0.0)
Time taken off from work to attend Visit 3 (day)	0.5 (0.5, 1.0)	0.5 (0.5, 1.0)
Total indirect cost on productivity loss (\$\$)	405.86 (248.50, 516.07)	272.73 (164.84, 408.25)
Transportation expenses for visit 1 (\$\$)	10 (2.5, 18)	2 (0, 5)
Transportation expenses for visit 2 (\$\$)	15 (3.0, 25)	0 (0,0)
Transportation expenses for visit 3 (\$\$)	10 (3.0, 20)	0 (0,4)
Direct cost on transportation (\$\$)	20.00 (6.00, 60.00)	
Total cost on productivity loss and transportation (\$\$)	663.55 (453.75, 907.05)	

FHS: fertility health screening, IQR: interquartile range

we need to allocate longer consultation times. – HCP4

The AMH would be a lot more resource-intensive due to the need to find the time and manpower to attend to the couples. The workload for those healthcare professionals administering it would also be quite intense. – HCP9

If this intervention were to be upscaled, I think manpower would be an issue because we would need to

cope with the increased demand for this service. – HCP17

There were several issues during participant recruitment and implementation of FHS within the RCT that could point to similar challenges if these were to be implemented in routine practice. First, only a total of four nurses were involved in the study, as there were very few nurses with specific seniority and experience to conduct reproductive counselling. Second, multiple visits were needed to complete the FHS, as AMH and SA had to be done before the consultations. Some couples ended up taking a few months to complete the whole intervention due to difficulties in scheduling appointments, as the visits were offered only during office hours.

Fidelity

Majority of couples in both intervention arms completed the study (95.6% for FHS and 90.8% for FAT). Reminder emails were sent to a total of 442 (95.3%) of the couples. The doctor's notes and reproductive counselling records showed that all couples in the FHS adhered to the plan, demonstrating high fidelity to the intervention. For couples randomised to FAT, 89 out of 102 (87.3%) couples returned the FertiSTAT, a proxy that they had completed the intervention.

Implementation cost

Each participant took a median of two half-days off from work for the consultations. The median individual monthly salary in this group of participants was reported as \$4,500 (3,500, 6,000). Based on a 44-hour workweek, the estimated hourly wage rate was \$25.57 (19.89, 34.09). Consequently, the study visits resulted in a median productivity loss of \$272.73 (181.82, 409.09) per person.

In addition, they spent a median of \$20.00 (6.00, 60.00) on transportation for all the visits. The median total cost of productivity loss and transportation for each couple was \$663.55 (453.75, 907.05) (Table 3).

The FHS involved various HCPs, incurring a total of \$17,088.46 for all the FHS activities for the 226 couples, equivalent to a mean of \$83.36 for each couple (Supplementary file 7).

Some couples mentioned that cost was a barrier, particularly for young couples who had just started working, as screening could lead to subsequent expensive interventions if problems were uncovered. Participants in FAT also commented that the government should provide increased subsidies and free medical consultations. Most couples expressed reluctance to pay for fertility screening, believing it unnecessary if they were young and healthy unless the test was free or heavily subsidised. However, one participant mentioned that facing

difficulties conceiving would make them more willing to pay for the test upfront:

If you experience difficulties, then you will be more inclined and more willing to pay upfront. – SGH-285 H

Most of the HCPs emphasised the importance of keeping the implementation cost low. Some were concerned about the uncertain cost-effectiveness of FHS, and the amount of resources needed if it were to be implemented nationwide.

I am not sure how useful it is to just screen people for semen analysis because what if you get a poor result? The test might have to be repeated and that would increase the cost. – HCP3

I think the cost would be higher for the screening and may not be widely acceptable by clinicians because a lot of resources would be involved. We also don't really know how well it reflects the ability to conceive for the patient. However, I think it is easier to implement the video; much fewer resources are required and so, would be more widely acceptable. – HCP8

Reach

Recruitment for the RCT was challenging, pointing to potential difficulties with reach. However, publicity for a routine service may face fewer challenges compared to recruitment for a research study, especially if coordinated by the government.

A total of 137 (17.6%) couples dropped out of the RCT. Common reasons for nonparticipation included being pregnant ($n=5$, 3.6%), lack of interest (2, 1.5%), lack of time (4, 2.9%), found to be ineligible (3, 2.2%), inconvenience (2, 1.5%), inability to complete the intervention (5, 3.6%), personal reasons (1, 0.7%), and being uncontactable (115, 48.5%). There were significant differences in ethnicity, educational level, and income (for males) between those who completed the study and those who dropped out. Among nonparticipants, both male and female, there were fewer Chinese and Buddhists, and more Malays and Muslims, compared to participants. Those who completed the study were more likely to have attained a university degree or higher, while those who dropped out were more likely to hold a diploma (a qualification between GCE A-Levels or college and below an undergraduate degree) as their highest level of education (Supplementary file 8). This suggests that the interventions, if implemented nationwide, may not reach all demographic segments of the population equally.

Most couples from FHS and FAT suggested increasing awareness of FHS through various social media platforms, such as Instagram, Facebook, and TikTok, as well as traditional media such as radio and brochures.

It is important to engage the young audience, who are mostly on social media since the target audience is those in their 20s and early 30s. They may no longer prefer to watch long videos. Therefore, we may have to use social media like TikTok to raise awareness of the issues and interventions. – HCP20

Another frequently mentioned approach was to partner with the Registry of Marriages to introduce the screening program to newlyweds or the Housing & Development Board when married couples collect keys to their flats. Rather than advertising in public health institutions, where young people rarely visit, participants recommended posting information about fertility checks on public transportation or conducting a roadshow at community centers.

Some participants were also concerned that if the intervention were to be implemented nationwide, individuals who truly required help might not receive the assistance they needed in a timely manner due to capacity constraints:

If more people were to come forward, we might have a bottleneck. Whoever comes first, we serve first, but the people who are in dire need of help might not receive it. – HCP8

Barriers and facilitators to the potential nationwide implementation of interventions

We identified eight barriers and two facilitators for FHS, and two barriers and one facilitator for FAT. These barriers and facilitators were mapped onto four of the five CFIR domains (Fig. 1). FAT, with fewer barriers, appears easier to implement compared to FHS. Sample illustrative quotes are given in Supplementary file 9.

FHS

CFIR domain: innovation

FHS barrier 1: lack of comprehensiveness (construct: innovation evidence-base) One of the perceived barriers to FHS was the lack of comprehensiveness. Many HCPs interviewed expressed concerns that AMH and SA alone did not offer comprehensive evidence to accurately assess a couple's fertility potential, as they did not account

Barriers		CFIR	Facilitators	
FAT	FHS		FHS	FAT
		Innovation		
Lack of comprehensiveness		Innovation evidence base	Evidence-based testing	
Limited cost-effectiveness		Innovation cost		
Lack of novelty in education materials		Innovation design	Effective design of education tools	
		Outer setting		
Cultural sensitivities and discomfort around fertility testing		Local attitudes		
		Inner setting		
Discomfort when producing samples for SA		Culture: Recipient-Centeredness		
Lack of personalization and access to resources	Resource constraints in meeting increased demand for fertility services	Available resources		
		Individuals		
Perceived assertiveness of HCPs during counselling session		Innovation deliverers - Capability	Professional advice from trained HCPs	
Lack of time for appointments		Innovation recipients - Opportunity		
Fertility tests may be counter-productive if results were normal		Innovation recipients - Motivation		

Fig. 1 Barriers and facilitators are mapped onto the CFIR domains. CFIR: consolidated framework for implementation research, FAT: fertility awareness tools, FHS: fertility health screening, HCPs: healthcare professionals, SA: semen analysis

for other critical factors like hormonal balance, genetic history, and physical or anatomical issues.

FHS barrier 2: limited cost-effectiveness (construct: innovation cost) Some HCPs commented that SA and AMH tests were not cost-effective, especially since SA results might not correlate with fertility outcomes unless complemented by a more detailed history screening.

FHS facilitator 1: evidence-based testing (construct: innovation evidence-base) Participants felt the evidence-based fertility screening and professional advice provided greater confidence in the results and outcomes than anecdotes or culturally rooted beliefs about fertility.

CFIR domain: outer setting

FHS barrier 3: cultural sensitivities and discomfort around fertility testing (construct: local attitudes) The participants shared that their health-seeking behaviour related to fertility was shaped by deeply ingrained societal norms and traditional values. They noted growing awareness and interest in preconception health, particularly in

fertility screening among married couples in their community. However, they emphasised that cultural barriers continued to play a significant role in influencing their decisions and actions. In particular, men's discomfort with SA due to masculinity and societal expectations created a reluctance to fully engage in testing. These may lead to challenges in the adoption of fertility interventions even as awareness increases.

CFIR domain: inner setting

FHS barrier 4: discomfort when producing samples for SA (construct: culture: recipient-centeredness) One participant expressed discomfort with the sperm extraction process, rooted in personal beliefs about masturbation. Similarly, there was a critique of posters featuring scantily clad women in the room revealed a conflict with cultural and gender norms geared towards gender

respect. These sociocultural values influenced the acceptance of and engagement with the intervention.

FHS barrier 5: resource constraints in meeting increased demand for fertility services (construct: available resources) Another challenge was the possible shortage of human resources due to a potential increase in service demand, which has been illustrated under the section Feasibility. This underscores how resource limitations, particularly in terms of staffing and clinic capacity, could hinder the effective implementation of fertility interventions.

CFIR domain: individuals

FHS barrier 6: perceived assertiveness of HCPs during counselling session (construct: innovation deliverers – capability) Some couples perceived the assertiveness of HCPs during the counselling session somewhat negatively. Therefore, the way counselling was conducted could either facilitate or hinder the success of FHS. A neutral, supportive counselling approach that respected the personal choices and concerns of participants was key to creating a positive environment for decision-making. However, when participants perceived the approach as too pronatalist, it could generate resistance and negative feelings, ultimately reducing the effectiveness of the intervention.

FHS barrier 7: lack of time for appointments (construct: innovation recipients – opportunity) Couples expressed how time constraints and work commitments acted as barriers to accessing fertility interventions, which has been discussed under the section Feasibility. In a context like Singapore, where maintaining employment is a priority, individuals might struggle to attend appointments, frequently rescheduling due to the inability to take time off work. These factors limited opportunities for individuals to engage with fertility interventions, even if they were otherwise motivated to seek care.

FHS barrier 8: fertility tests may be counter-productive if results are normal (construct: innovation recipients – motivation) Another barrier was that FHS may be counter-productive if the results turned out to be normal, as illustrated under the section Appropriateness.

FHS facilitator 2: professional advice from trained HCPs (construct: innovation deliverers - capability) Many couples expressed that effective communication was key to successfully adopting innovations, as it helped them feel understood and built trust with HCPs. They noted that receiving clear and professional explana-

tions made them feel reassured, even if they didn't fully understand the technical details. Several participants highlighted how having experts who could offer detailed guidance alongside personalised recommendations significantly enhanced their overall experience.

FAT

CFIR domain: innovation

FAT barrier 1: lack of novelty in educational materials (construct: innovation design) A barrier identified by the participants was the lack of novelty in the materials provided, as discussed under the section Appropriateness. This suggests that the materials and resources offered might not be adequately tailored to meet the needs of more informed or experienced individuals, limiting their effectiveness in enhancing understanding or guiding the next steps.

FAT facilitator 1: effective design of educational tools (construct: innovation design) Participants shared that the clarity and accessibility of information played a crucial role in helping them adopt innovations, especially healthcare-related ones. They appreciated well-organised, visually appealing materials, mentioning how attractive brochures, engaging video messages, and clearly designed questionnaires made a difference in their engagement and decision-making. Some participants found that infographics and videos helped simplify complex concepts, making them easier to understand and remember.

CFIR domain: innovation

FAT barrier 2: lack of personalization and access to resources (construct: available resources) A key barrier identified was the perceived lack of personalization and access to health screening. To address this, offering free consultations or teleconsultations to encourage more people to seek help was suggested. Uncertainty about finding the right doctor and the associated cost were also significant deterrents, often causing couples to delay seeking care. Reducing financial burdens and providing clearer guidance would improve accessibility and uptake.

Discussion

This is, to our knowledge, the first effectiveness-implementation hybrid trial integrating both qualitative and quantitative methods. The results demonstrate that it is possible to implement education programs that are acceptable and valued by patients and HCPs. Participants were fully engaged with their group assignment and undertook activities as planned in the study. However, it might not be possible to scale up these interventions as they were. The FHS was perceived as too expensive given

the limited value of screening, which addresses changing fertility parameters. Couples valued professional counselling from trained HCPs, as they were able to respond effectively to enquiries and guide necessary actions or behavioral changes. This is in keeping with a systematic review of nine RCTs, which found that counselling has a significant positive impact on pregnancy rates and represents an appealing treatment option, especially for subfertile patients not undergoing medical treatment [26]. Another study also indicated that HCPs were regarded as the most trustworthy source of information for family planning decision-making [27].

The FAT was less costly but was perceived as too simplistic and did not provide sufficient novel personal information. Similarly, a European RCT [14] evaluating the effectiveness of video-based education on fertility awareness found no significant differences in participants' intentions to adopt fertility-protective behaviours. This suggests that video-based knowledge alone may not create a strong enough perception of infertility risk or motivate early childbearing in an unselected population; as it could add increased perception of risk for, for example, couples who are already trying to conceive or definitely planning to have a family. However, studies [9–11] have shown that exposure to fertility information through low-cost brochures can improve fertility knowledge in the short term, although the effect typically lasts less than six months. Although our video was designed to target psychological constructs in the Theory of Planned Behaviour to promote a more positive attitude towards having children, emphasise the subjective norm of the desirability of children, induce anticipated regret of not trying to conceive early, and increase perceived control of conditions relevant to having children, the effect may not have been strong enough.

Together, the results suggest that couples and HCPs are receptive to fertility awareness interventions, but these would need to be modified to be scaled up nationally. A blended approach incorporating digital health strategies may be preferred for couples with busy schedules to overcome the difficulty of attending physical visits [28]. For example, information could be first provided online, sample collection for fertility testing could be decentralized for convenience, and teleconsultations offered as an option for the doctor consultation and reproductive counselling.

We recognise several limitations to the present study. Firstly, there is likely selection bias in the recruitment, as participants were likely those who wished to have children and/or were open to fertility screening. The findings may also not apply to those who do not wish to have children or have different motivations regarding parenthood, who are likely to require different interventions with different behavioural targets. Second, the HCPs involved in

the study were from only two public hospitals in Singapore. We therefore lack views from HCPs in the private sector, who are likely needed to implement FHS on a nationwide scale. Further engagement with private fertility clinics and other relevant stakeholder groups such as the government would be needed if there is an intention to implement the interventions more broadly. Third, since couple interviews were conducted jointly with both partners, participants' responses may have been shaped by social desirability or partner influence, which could have constrained the disclosure of individual opinions or experiences. Lastly, the cost-effectiveness of FHS was perceived and not formally evaluated. Lastly, this is a formative evaluation, and new barriers and/or facilitators may emerge if these interventions are actually implemented due to changing contexts.

Conclusion

In conclusion, the findings indicate that the two interventions were acceptable and feasible. However, FHS may face implementation challenges due to higher costs and resource demands, while FAT was easier to deliver but limited by less novel educational content. A stepped-care model, starting with FAT and offering FHS to motivated couples, may represent a cost-effective and scalable approach. Future studies should consider a continued evaluation of implementation and contextual factors to inform integration efforts.

Abbreviations

AMH	Anti-Mullerian hormone
CFIR	Consolidated Framework for Implementation Research
CRC	Clinical research coordinator
FAT	Fertility awareness tools
FHS	Fertility health screening
H	Husband
HCPs	Healthcare professionals
RCT	Randomised controlled trial
SA	Semen analysis
W	Wife

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12913-025-13956-3>.

Supplementary Material 1: FHS Fidelity checklist.

Supplementary Material 2: Process map of Fertility Health Screening (FHS) for Time Driven Activity Based Costing (TDABC).

Supplementary Material 3: Interview guide for couples.

Supplementary Material 4: Interview guide for providers and key stakeholders.

Supplementary Material 5: Standards for Reporting Qualitative Research.

Supplementary Material 6: Sample illustrative quotes based on the implementation outcomes.

Supplementary Material 7: Personnel involved in conducting fertility screening and the cost.

Supplementary Material 8: Characteristics of dropouts and completed.

Supplementary Material 9: Consolidated Framework for Implementation Research (CFIR) analysis with example quotes.

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Author contributions

Conceptualization and methodology: SLC, JT, JB, SRY, JKYC, CWK, KHC, SLY; Investigation: HZ; Data curation and validation: SLC, HZ, YX; Formal analysis: HZ, CP, YX, SLC; Supervision: SLC, JT, KHC, SLY; Writing – original draft: HZ, YX; Writing – review & editing: all authors.

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Data availability

The datasets generated and/or analysed during the current study are not publicly available for patient confidentiality but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was reviewed and approved by the Centralized Institutional Review Board of SingHealth (Ref No. 2019/2095). All participants gave their informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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