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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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**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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1 **Abstract**

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

11 **Method:** The study comprised a three-arm RCT and a qualitative  
12 component involving individual semi-structured interviews conducted  
13 from January 2021 to March 2024. Eligible participants were married,  
14 childless heterosexual couples with a female partner aged between 25 and  
15 34 years. Healthcare professionals (HCPs) who implemented the  
16 interventions, along with purposively selected couples, participated in the  
17 interviews. The interview guide was based on the Consolidated Framework  
18 for Implementation Research. Interviews were audio-recorded,  
19 transcribed, and analysed using thematic analysis. Completion of each  
20 FHS component was verified against medical records, and data used to  
21 inform cost was collected via a productivity loss survey and Time Driven  
22 Activity Based Costing.

23 **Results:** A total of 778 heterosexual couples were randomised in this three-  
24 arm RCT. Of these, 29 couples and 20 HCPs took part in the interviews.  
25 FHS was perceived as valuable for family planning, while views on FAT

26 were mixed. Both interventions demonstrated high fidelity. HCPs spent a  
27 median of 219 minutes delivering FHS, which costs on average \$83.36 per  
28 couple. Each couple also incurred a median total cost of productivity loss  
29 and transportation of \$663.55 over all FHS visits. Key facilitators of FHS  
30 were the use of evidence-based testing and professional guidance,  
31 whereas resource and time constraints were notable barriers. Key barriers  
32 for FAT included the lack of content novelty and access to health screening  
33 though its structured design was a facilitator.

34 **Conclusion:** Both FHS and FAT were deemed acceptable and feasible by  
35 couples and HCPs. Cost and staffing emerged as significant barriers to  
36 broader implementation and scalability. These findings offer insights into  
37 translating educational and fertility awareness interventions into practice  
38 and guiding future nationwide and international implementation efforts.  
39 (350 words)

40

## 41 **Contributions to the literature**

42  This is an effectiveness-implementation hybrid study evaluating various  
43 implementation outcomes, barriers, and facilitators of two interventions:  
44 fertility health screening (FHS) and fertility awareness tools (FAT).  
45  We found valuable insights from recipients of the interventions and  
46 providers that can inform the adaptation and scaling of a fertility education  
47 intervention.  
48  There is a paucity of implementation studies in fertility medicine and the  
49 results help build an evidence base for implementing suitable interventions

50 to improve more informed fertility decision-making in Singapore and  
51 beyond.

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52 **Introduction**

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

63 Fertility awareness education significantly improves women's  
64 knowledge about fertility [7, 8, 9, 10, 11, 12]. There is also evidence that  
65 counselling tailored to areas of misunderstanding is more effective than  
66 generic educational materials at increasing fertility awareness in women  
67 donating eggs [13]. However, evidence for fertility education alone in  
68 modifying childbearing intentions and behaviours is limited [10, 14]. The  
69 addition of a behavioural change component is therefore warranted to  
70 address relevant psychological determinants to modify the downstream  
71 conception efforts, given the multitude of factors affecting childbearing  
72 decisions.

73 We therefore designed two theory-guided, evidence-based personalised  
74 fertility interventions, namely fertility health screening (FHS) and fertility  
75 awareness tools (FAT), to deliver fertility education and target  
76 psychological determinants to influence childbearing intention [15]. These

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

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

93 **Methods**94 **Study setting and study design**

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

112 Couples assigned to the control arm were informed that they would be  
113 receiving standard care during the study, and they were required to  
114 complete a follow-up questionnaire at 6 months. Couples assigned to FHS  
115 underwent a fertility health screening comprising an anti-Mullerian  
116 hormone (AMH) test and semen analysis (SA), followed by a consultation  
117 with a gynecologist and a reproductive planning counselling session with

118 a nurse. In this study, the AMH test was not used as a diagnostic tool to  
119 predict fertility potential, but rather as part of a broader reproductive  
120 health assessment. The purpose of including AMH was to enhance couples'  
121 understanding of their reproductive health status and to facilitate  
122 personalized counselling on fertility planning during the consultation.  
123 Couples assigned to FAT were directed to an online portal where they were  
124 shown a video targeting attitudes toward having children and the timing  
125 of childbearing.

126 At 6 months, all couples, including those in the control group, were sent  
127 a follow-up self-administered questionnaire via email to measure post-  
128 intervention fertility knowledge, parenthood intentions, and conception  
129 efforts. Couples who completed follow-up questions received an incentive  
130 of \$80.

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

135

### 136 **Implementation outcomes and data collection**

137 We evaluated seven out of the eight implementation outcomes proposed  
138 by Proctor *et al* (18). As the interventions are still in the pre-  
139 implementation phase, sustainability is less relevant and therefore omitted.  
140 The data sources used to inform each of these outcomes are shown in Table  
141 1. Couple interviews and open-ended questions from the follow-up  
142 questionnaires were analyzed to assess outcomes related to acceptability,

143 appropriateness, feasibility, implementation cost, and coverage/reach. The  
144 6-month follow-up questionnaire included one open-ended question  
145 inviting participants to share their views on the intervention ("Please tell  
146 us what you think about the fertility screening or fertility awareness  
147 tool." ). HCP interviews were analyzed to assess outcomes related to  
148 adoption, appropriateness, feasibility, implementation cost, and  
149 coverage/reach. A fidelity checklist was employed to document the  
150 completion of key steps during each FHS visit, verified against visit logs,  
151 and laboratory and medical records by study clinical research coordinators  
152 (CRCs) (Supplementary file 1). The return of completed FertiSTAT  
153 questionnaires to CRCs served as a proxy indicator for FAT completion, as  
154 the online portal was set up such that couples could only download  
155 FertiSTAT after watching the video. To assess feasibility and cost, couples  
156 in FHS were required to report the time taken, transportation costs, and  
157 number of hours missed at work to attend each session in a 12-item  
158 productivity loss questionnaire designed for this study. Couples in FAT  
159 were also asked to report the time taken to complete the intervention.  
160 Time Driven Activity Based Costing, a micro-costing methodology that  
161 estimates the cost of delivering a service based on process costs [21], was  
162 used to estimate the cost to deliver FHS. We constructed process maps for  
163 each site and recorded the personnel involved and time taken for each step  
164 (Supplementary file 2).

165

166 *Data analysis*

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

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

180

## 181 **Qualitative study**

### 182 *Eligibility criteria*

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

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

195

196 *Study procedures*

197 The interviews were conducted by a research fellow (HZ), who was trained  
198 in qualitative research, and four CRCs who were trained and assessed to  
199 be competent by HZ. To avoid potential bias, HZ and the CRCs interviewed  
200 participants not from their institutions to ensure they had no prior  
201 relationship with participants. The interviews were conducted from June  
202 2021 to December 2023, over Zoom and audio recorded, and lasted  
203 approximately 30 minutes each. The audio files were stored in encrypted  
204 folders accessible only by the study team.

205

206 *Interview guide*

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

211

212 *Data Analysis*

213 The interviews were transcribed using Otter.ai, reviewed, and refined by  
214 the CRCs for accuracy. Coding frameworks and themes were developed  
215 iteratively using Braun and Clarke's (2006) six-step process [23]. This  
216 involved familiarizing ourselves with the data by reading the transcripts in

217 their entirety before generating relevant codes, grouping them into  
218 themes and sub-themes, and defining the themes. Inductive thematic  
219 analysis was used to evaluate the implementation outcomes [23], and a  
220 deductive approach was utilised when applying the findings to pre-  
221 determined implementation outcomes. NVivo 12 software was used to  
222 facilitate coding and categorizing the data. We then reviewed the themes,  
223 identified those deemed relevant to the research questions, and mapped  
224 them to selected CFIR constructs and implementation outcomes. As an  
225 updated CFIR [24] was published in 2022, we used this for the mapping  
226 instead. Finally, we followed O'Brien et al.'s (2014) Standards for  
227 Reporting Qualitative Research (Supplementary file 5) [25] for reporting  
228 the findings. To protect participants' anonymity, we assigned relevant  
229 code identifiers to the participants ("HCP", "H" (husband), and "W"  
230 (wife)).

231 **Results**

232 A total of 778 heterosexual couples were randomised into the three RCT  
 233 arms (226 in FHS, 238 in FAT, and 314 in the control group). Among them,  
 234 216, 216, and 314 couples completed the study, respectively. A total of 53  
 235 couples were invited to participate in the interviews, and among them, 29  
 236 couples (16 from FHS and 13 from FAT, comprising 29 husbands and 29  
 237 wives) agreed and completed the joint interviews. A total of 66 HCPs and  
 238 managers were invited, out of which 20 responded (10 doctors, 8  
 239 laboratory staff, 1 nurse, and 1 manager). Their demographics are shown  
 240 in Table 2. Additionally, 124 wives and 131 husbands completed the open-  
 241 ended question in the follow-up questionnaire, which contributed to the  
 242 data on implementation outcomes.

243

244 **Implementation outcomes**

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

247

248 **Acceptability**

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

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

255 *I think the fertility screening is very useful, especially for the  
 256 last session where the doctor explains to us thoroughly our  
 257 results and assures us that we have no issues in having a child.*

258 *This gives us peace of mind and less pressure. - SGH175-H*

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

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

270 W

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

273 W

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

277

278 **Adoption**

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

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

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

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

302

303 **Appropriateness**

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

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

316 SGH8-W

317 *It provided a sense of relief to know that both of us had no  
318 issues with our fertility based on the screening results. -*

319 SGH293-H

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

324 *I felt there were things I already knew, and the awareness just  
325 helped to reinforce certain facts or misconceptions I may have  
326 had about fertility and family planning, etc. Overall, although  
327 I was not in the clinic group to undergo tests for my fertility,*

328 *I'm better aware of the process through the videos that were  
 329 shared with me. - SGH288-H*

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

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

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

337 The HCPs noted that the interventions would be beneficial to some extent,  
 338 particularly for individuals who already desire to have children but have  
 339 not yet taken steps to achieve their goals. They highlighted the importance  
 340 of nurses and doctors providing counselling in layman's terms to ensure  
 341 participant comprehension.

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

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

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

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

353

354 **Feasibility**

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

360 *In Singapore, we do not have much time to talk to the patient.*

361 *In our daily counselling sessions in the public sector, the  
 362 allocated time is usually 10 to 15 minutes. So, to address  
 363 patients' concerns effectively, we need to allocate longer  
 364 consultation times. - HCP4*

365 *The AMH would be a lot more resource-intensive due to the  
 366 need to find the time and manpower to attend to the couples.*

367 *The workload for those healthcare professionals administering  
 368 it would also be quite intense. - HCP9*

369 *If this intervention were to be upscaled, I think manpower  
 370 would be an issue because we would need to cope with the  
 371 increased demand for this service. - HCP17*

372 There were several issues during participant recruitment and  
 373 implementation of FHS within the RCT that could point to similar  
 374 challenges if these were to be implemented in routine practice. First, only  
 375 a total of four nurses were involved in the study, as there were very few  
 376 nurses with specific seniority and experience to conduct reproductive  
 377 counselling. Second, multiple visits were needed to complete the FHS, as

378 AMH and SA had to be done before the consultations. Some couples ended  
379 up taking a few months to complete the whole intervention due to  
380 difficulties in scheduling appointments, as the visits were offered only  
381 during office hours.

382

### 383 **Fidelity**

384 Majority of couples in both intervention arms completed the study (95.6%  
385 for FHS and 90.8% for FAT). Reminder emails were sent to a total of 442  
386 (95.3%) of the couples. The doctor's notes and reproductive counselling  
387 records showed that all couples in the FHS adhered to the plan,  
388 demonstrating high fidelity to the intervention. For couples randomised to  
389 FAT, 89 out of 102 (87.3%) couples returned the FertiSTAT, a proxy that  
390 they had completed the intervention.

391

### 392 **Implementation cost**

393 Each participant took a median of two half-days off from work for the  
394 consultations. The median individual monthly salary in this group of  
395 participants was reported as \$4,500 (3,500, 6,000). Based on a 44-hour  
396 workweek, the estimated hourly wage rate was \$25.57 (19.89, 34.09).  
397 Consequently, the study visits resulted in a median productivity loss of  
398 \$272.73 (181.82, 409.09) per person.

399 In addition, they spent a median of \$20.00 (6.00, 60.00) on  
400 transportation for all the visits. The median total cost of productivity loss  
401 and transportation for each couple was \$663.55 (453.75, 907.05) (Table  
402 3).

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

406 Some couples mentioned that cost was a barrier, particularly for young  
 407 couples who had just started working, as screening could lead to  
 408 subsequent expensive interventions if problems were uncovered.  
 409 Participants in FAT also commented that the government should provide  
 410 increased subsidies and free medical consultations. Most couples  
 411 expressed reluctance to pay for fertility screening, believing it  
 412 unnecessary if they were young and healthy unless the test was free or  
 413 heavily subsidised. However, one participant mentioned that facing  
 414 difficulties conceiving would make them more willing to pay for the test  
 415 upfront:

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

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

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

425 *I think the cost would be higher for the screening and may not  
 426 be widely acceptable by clinicians because a lot of resources  
 427 would be involved. We also don't really know how well it*

428       *reflects the ability to conceive for the patient. However, I think*  
429       *it is easier to implement the video; much fewer resources are*  
430       *required and so, would be more widely acceptable.* - HCP8

431

432       **Reach**

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

437       A total of 137 (17.6%) couples dropped out of the RCT. Common reasons  
438       for nonparticipation included being pregnant (n=5, 3.6%), lack of interest  
439       (2, 1.5%), lack of time (4, 2.9%), found to be ineligible (3, 2.2%),  
440       inconvenience (2, 1.5%), inability to complete the intervention (5, 3.6%),  
441       personal reasons (1, 0.7%), and being uncontactable (115, 48.5%). There  
442       were significant differences in ethnicity, educational level, and income (for  
443       males) between those who completed the study and those who dropped  
444       out. Among nonparticipants, both male and female, there were fewer  
445       Chinese and Buddhists, and more Malays and Muslims, compared to  
446       participants. Those who completed the study were more likely to have  
447       attained a university degree or higher, while those who dropped out were  
448       more likely to hold a diploma ([a qualification between GCE A-Levels or](#)  
449       [college and below an undergraduate degree](#)) as their highest level of  
450       education (Supplementary file 8). This suggests that the interventions, if  
451       implemented nationwide, may not reach all demographic segments of the  
452       population equally.

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

456        *It is important to engage the young audience, who are mostly  
 457        on social media since the target audience is those in their 20s  
 458        and early 30s. They may no longer prefer to watch long videos.*

459        *Therefore, we may have to use social media like TikTok to raise  
 460        awareness of the issues and interventions.* - HCP20

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

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

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

475

476        **Barriers and facilitators to the potential nationwide  
 477        implementation of interventions**

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

483

#### 484 **FHS**

##### 485 **CFIR Domain: Innovation**

486 *FHS Barrier 1: Lack of comprehensiveness (Construct: Innovation  
487 evidence-based)*

488 One of the perceived barriers to FHS was the lack of comprehensiveness.  
489 Many HCPs interviewed expressed concerns that AMH and SA alone did  
490 not offer comprehensive evidence to accurately assess a couple's fertility  
491 potential, as they did not account for other critical factors like hormonal  
492 balance, genetic history, and physical or anatomical issues.

493

494 *FHS Barrier 2: Limited cost-effectiveness (Construct: Innovation cost)*

495 Some HCPs commented that SA and AMH tests were not cost-effective,  
496 especially since SA results might not correlate with fertility outcomes  
497 unless complemented by a more detailed history screening.

498

499 *FHS Facilitator 1: Evidence-based testing (Construct: Innovation  
500 evidence-based)*

501 Participants felt the evidence-based fertility screening and professional  
 502 advice provided greater confidence in the results and outcomes than  
 503 anecdotes or culturally rooted beliefs about fertility.

504

505 **CFIR Domain: Outer setting**

506 *FHS Barrier 3: Cultural sensitivities and discomfort around fertility testing*  
 507 *(Construct: Local attitudes)*

508 The participants shared that their health-seeking behaviour related to  
 509 fertility was shaped by deeply ingrained societal norms and traditional  
 510 values. They noted growing awareness and interest in preconception  
 511 health, particularly in fertility screening among married couples in their  
 512 community. However, they emphasised that cultural barriers continued to  
 513 play a significant role in influencing their decisions and actions. In  
 514 particular, men's discomfort with SA due to masculinity and societal  
 515 expectations created a reluctance to fully engage in testing. These may  
 516 lead to challenges in the adoption of fertility interventions even as  
 517 awareness increases.

518

519 **CFIR Domain: Inner setting**

520 *FHS Barrier 4: Discomfort when producing samples for SA (Construct:*  
 521 *Culture: Recipient-Centredness)*

522 One participant expressed discomfort with the sperm extraction process,  
 523 rooted in personal beliefs about masturbation. Similarly, there was a  
 524 critique of posters featuring scantily clad women in the room revealed a  
 525 conflict with cultural and gender norms geared towards gender respect.

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

528

529 *FHS Barrier 5: Resource constraints in meeting increased demand for*  
530 *fertility services (Construct: Available resources)*

531 Another challenge was the possible shortage of human resources due to a  
532 potential increase in service demand, which has been illustrated under the  
533 section Feasibility. This underscores how resource limitations, particularly  
534 in terms of staffing and clinic capacity, could hinder the effective  
535 implementation of fertility interventions.

536

### 537 **CFIR Domain: Individuals**

538 *FHS Barrier 6: Perceived assertiveness of HCPs during counselling session*  
539 *(Construct: Innovation deliverers - capability)*

540 Some couples perceived the assertiveness of HCPs during the counselling  
541 session somewhat negatively. Therefore, the way counselling was  
542 conducted could either facilitate or hinder the success of FHS. A neutral,  
543 supportive counselling approach that respected the personal choices and  
544 concerns of participants was key to creating a positive environment for  
545 decision-making. However, when participants perceived the approach as  
546 too pronatalist, it could generate resistance and negative feelings,  
547 ultimately reducing the effectiveness of the intervention.

548

549 *FHS Barrier 7: Lack of time for appointments (Construct: Innovation*  
550 *recipients - Opportunity)*

551 Couples expressed how time constraints and work commitments acted as  
552 barriers to accessing fertility interventions, which has been discussed  
553 under the section Feasibility. In a context like Singapore, where  
554 maintaining employment is a priority, individuals might struggle to attend  
555 appointments, frequently rescheduling due to the inability to take time off  
556 work. These factors limited opportunities for individuals to engage with  
557 fertility interventions, even if they were otherwise motivated to seek care.

558

559 *FHS Barrier 8: Fertility tests may be counter-productive if results are  
560 normal (Construct: Innovation recipients - Motivation)*

561 Another barrier was that FHS may be counter-productive if the results  
562 turned out to be normal, as illustrated under the section Appropriateness.

563

564 *FHS Facilitator 2: Professional advice from trained HCPs (Construct:  
565 Innovation deliverers: Capability)*

566 Many couples expressed that effective communication was key to  
567 successfully adopting innovations, as it helped them feel understood and  
568 built trust with HCPs. They noted that receiving clear and professional  
569 explanations made them feel reassured, even if they didn't fully  
570 understand the technical details. Several participants highlighted how  
571 having experts who could offer detailed guidance alongside personalised  
572 recommendations significantly enhanced their overall experience.

573

574 **FAT**

575 **CFIR Domain: Innovation**

576 *FAT Barrier 1: Lack of novelty in educational materials (Construct:*

577 *Innovation design)*

578 A barrier identified by the participants was the lack of novelty in the  
579 materials provided, as discussed under the section Appropriateness. This  
580 suggests that the materials and resources offered might not be adequately  
581 tailored to meet the needs of more informed or experienced individuals,  
582 limiting their effectiveness in enhancing understanding or guiding the next  
583 steps.

584

585 *FAT Facilitator 1: Effective design of educational tools (Construct:*

586 *Innovation design)*

587 Participants shared that the clarity and accessibility of information played  
588 a crucial role in helping them adopt innovations, especially healthcare-  
589 related ones. They appreciated well-organised, visually appealing  
590 materials, mentioning how attractive brochures, engaging video messages,  
591 and clearly designed questionnaires made a difference in their  
592 engagement and decision-making. Some participants found that  
593 infographics and videos helped simplify complex concepts, making them  
594 easier to understand and remember.

595

## 596 **CFIR Domain: Innovation**

597 *FAT Barrier 2: Lack of personalization and access to resources*

598 *(Construct: Available resources)*

599 A key barrier identified was the perceived lack of personalization and  
600 access to health screening. To address this, offering free consultations or

601 teleconsultations to encourage more people to seek help was suggested.  
602 Uncertainty about finding the right doctor and the associated cost were  
603 also significant deterrents, often causing couples to delay seeking care.  
604 Reducing financial burdens and providing clearer guidance would improve  
605 accessibility and uptake.

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606 **Discussion**

607 This is, to our knowledge, the first effectiveness-implementation hybrid  
608 trial integrating both qualitative and quantitative methods. The results  
609 demonstrate that it is possible to implement education programs that are  
610 acceptable and valued by patients and HCPs. Participants were fully  
611 engaged with their group assignment and undertook activities as planned  
612 in the study. However, it might not be possible to scale up these  
613 interventions as they were. The FHS was perceived as too expensive given  
614 the limited value of screening, which addresses changing fertility  
615 parameters. Couples valued professional counselling from trained HCPs,  
616 as they were able to respond effectively to enquiries and guide necessary  
617 actions or behavioral changes. This is in keeping with a systematic review  
618 of nine RCTs, which found that counselling has a significant positive  
619 impact on pregnancy rates and represents an appealing treatment option,  
620 especially for subfertile patients not undergoing medical treatment [26].  
621 Another study also indicated that HCPs were regarded as the most  
622 trustworthy source of information for family planning decision-making [27].

623 The FAT was less costly but was perceived as too simplistic and did not  
624 provide sufficient novel personal information. Similarly, a European RCT  
625 [14] evaluating the effectiveness of video-based education on fertility  
626 awareness found no significant differences in participants' intentions to  
627 adopt fertility-protective behaviours. This suggests that video-based  
628 knowledge alone may not create a strong enough perception of infertility  
629 risk or motivate early childbearing in an unselected population; as it could  
630 add increased perception of risk for, for example, couples who are already

631 trying to conceive or definitely planning to have a family. However, studies  
632 [9, 10, 11] have shown that exposure to fertility information through low-  
633 cost brochures can improve fertility knowledge in the short term, although  
634 the effect typically lasts less than six months. Although our video was  
635 designed to target psychological constructs in the Theory of Planned  
636 Behaviour to promote a more positive attitude towards having children,  
637 emphasise the subjective norm of the desirability of children, induce  
638 anticipated regret of not trying to conceive early, and increase perceived  
639 control of conditions relevant to having children, the effect may not have  
640 been strong enough.

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

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

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

668 **Conclusion**

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

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677 **List of abbreviations**

678 AMH Anti-Mullerian hormone

679 CFIR Consolidated Framework for Implementation Research

680 CRC Clinical research coordinator

681 FAT Fertility awareness tools

682 FHS Fertility health screening

683 H Husband

684 HCPs Healthcare professionals

685 RCT randomised controlled trial

686 SA Semen analysis

687 W Wife

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Barriers		CFIR	Facilitators	
FAT	FHS		FHS	FAT
		<b>Innovation</b>		
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	
		<b>Outer setting</b>		
Cultural sensitivities and discomfort around fertility testing		Local attitudes		
		<b>Inner setting</b>		
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		
		<b>Individuals</b>		
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		

688

689 **Figure 1. Barriers and facilitators are mapped onto the CFIR**  
 690 **domains**

691 CFIR: consolidated framework for implementation research, FAT: fertility  
 692 awareness tools, FHS: fertility health screening, HCPs: healthcare  
 693 professionals, SA: semen analysis

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

\*Q56. 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

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**Table 2 Demographics of Interviewed Participants**

<b>Characteristics</b>	<b>Specific characteristics</b>	<b>Number of participants</b>
HCP	Designation of HCP	
	Doctor	1 0 • 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	
	A	14 couples
	B	15 couples
	Type of intervention couples underwent	
	FHS	16 couples
	FAT	13 couples
	Age	
	25-30	15 (13W, 2H)

31-35	36 (16W, 20H)
36-40	6 (H)
41-45	1 (H)
Educational level	
University degree or above	52 (27W, 25H)
Polytechnic diploma	3 (2W, 1H)
Professional qualification or above	2 (H)
'O'/'N' level or equivalent	1 (H)
Ethnicity	
Chinese	56 (28W, 28H)
Indian	1 (W)
Korean	1 (H)
Religion	
No religion	23 (10W, 13H)
Buddhism	15 (8W, 7H)
Christianity	13 (8W, 5H)
Taoism	5 (1W, 4H)
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 (2W, 3H)
\$3,000-\$3,999	13 (8W, 5H)
\$4,000-\$4,999	12 (7W, 5H)
\$5,000-\$6,999	16 (7W, 9H)
\$7,000-\$8,999	4 (2W, 2H)
\$9,000-\$10,999	5 (1W, 4H)

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

**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)
<b>Average time spent on each couple</b>		<b>219.45*</b>

\*HCPs spent a total of 44,987 minutes on 205 couples, averaging 219.45 minutes 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 (S\$)	405.86 (248.50, 516.07)	272.73 (164.84, 408.25)
Transportation expenses for visit 1 (S\$)	10 (2.5, 18)	2 (0, 5)
Transportation expenses for visit 2 (S\$)	15 (3.0, 25)	0 (0,0)
Transportation expenses for visit 3 (S\$)	10 (3.0, 20)	0 (0,4)
Direct cost on transportation (S\$)	20.00 (6.00, 60.00)	
Total cost on productivity loss and transportation (S\$)		663.55 (453.75, 907.05)

FHS: fertility health screening, IQR: interquartile range

## 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

### Availability of data and materials

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.

### Competing interests

All authors declare no conflict of interest.

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### Authors' 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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**Supplementary Materials**

Supplementary file 1 FHS Fidelity checklist

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

Supplementary file 3 Interview guide for couples

Supplementary file 4 Interview guide for providers and key stakeholders

Supplementary file 5 Standards for Reporting Qualitative Research

Supplementary file 6 Sample illustrative quotes based on the  
implementation outcomes

Supplementary file 7 Personnel involved in conducting fertility  
screening and the cost

Supplementary file 8 Characteristics of dropouts and completed

Supplementary file 9 Consolidated Framework for Implementation  
Research (CFIR) analysis with example quotes

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