

Additional File 5: Design of Behavioural Change Component

The addition of a behavioural change component is necessary to maximise the chance of the intervention having a strong and sustained effect on childbearing decisions. We designed the behavioural change component using Intervention Mapping, a protocol for systematic theory and evidence-based behavioural change planning, described in Figure S1 [1,2].

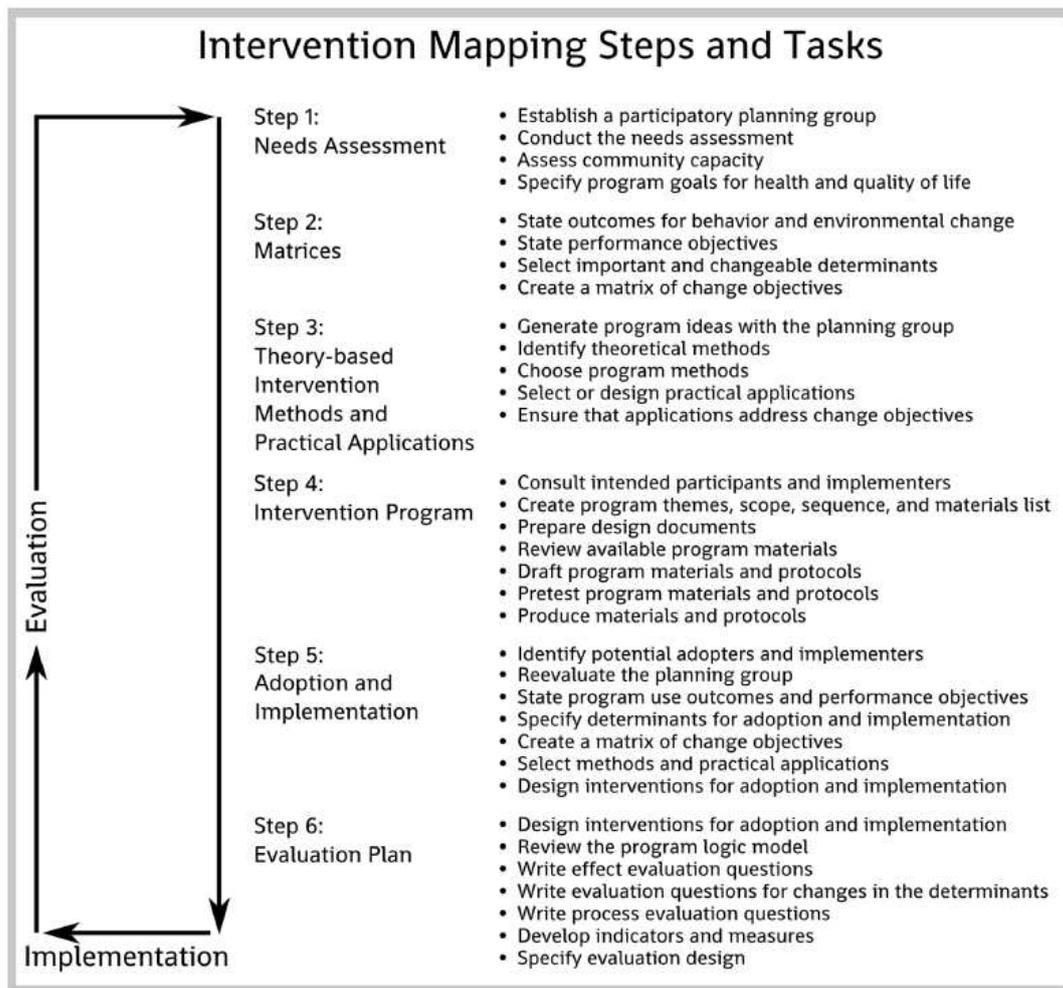


Figure S1 Intervention mapping steps and tasks [2]

For step 1, the overall goal and its rationale has been laid out in the introduction in the main article. In step 2, the overall goal is broken down into target behaviours, with specific change

objectives of the relevant determinants defined in a matrix. For a behaviour change method to be effective, it must i) target a determinant that predicts behaviour, ii) it must be able to change that determinant and iii) it must be translated into a practical application in a way that preserves the parameters (conditions) of effectiveness and fits the target population, culture and context [3].

To target intentions to have a child at an earlier age (primary outcome), we consolidated factors associated with childbearing intentions from the literature, determinants from the TPB and HBM (Figures S2 & S3) and constructs shown to affect fertility intentions in experimental studies (relationship with partner, cost of children, cultural norms, religiosity and mortality risk) (Table S1) [4–10].

Table S1 Factors affecting fertility desires and intention

Factors	Evidence type			Interventions		Ref
	surveys/ qualitative studies	Association (correlative studies)	Causative (experimental studies)	Studied	Proven	
Demographic						
Age	✓	✓				[5,11–21]
Gender		✓				[15–17,22–24]
Race/ethnicity		✓				[25–27]
Religiosity		✓				[5,10,13,28]
Educational status		✓				[13,20,25–27,29,30]
Relationship status (not married/ not finding right partner, not being in stable relationship)	✓	✓				[7,13–16,19–21,23,31–35]
Marriage duration		✓				[5,18]
Parity		✓				[13]
Financial/housing						
Financial security / cost of children / income	✓	✓	✓	Baby bonus (Australia)	Baby bonus (Australia)	[5,10,13–16,18–21,26,31–34,36,37]
Housing condition (owning a home / sufficiently large home)	✓					[5,13–16,27,34]
No access to childcare	✓					[13–16]
Not prepared to change lifestyle	✓					[35]
Fertility awareness		✓	✓	<ul style="list-style-type: none"> ▪ Tailored edu (oral) ▪ Life-plan based contraceptive counselling ▪ Online fertility info 	Tailored edu (oral) Brochure (written)	[8,24,38–45]

				<ul style="list-style-type: none"> ▪ Brochures (written or online) ▪ Slide presentation ▪ Video 		
Employment / workplace						
Pursuit of career, personal interests or education	✓	✓				[14–17,31–34]
Not having career stability (permanent position)	✓	✓				[5,13–16,20,33,34]
Not having work that can be combined with having children / workplace support	✓	✓	✓	Federal law of parental allowance and parental leave (Germany)	Federal law of parental allowance and parental leave	[14–16,29,46]
Psychological						
Heritability of need to nurture		✓				[10]
Childhood stress		✓	✓			[10,47]
Father absence		✓				[10]
Personality		✓				
Attachment style (in childhood)		✓	✓			
Reproductive autonomy		✓				
Mortality risk and salience		✓	✓			
Risk tolerance		✓				[48]
Not feeling emotionally ready or mature enough	✓					[14–16,31–34]
Attitudes towards having children (positive and negative)		✓				[4,5,7,18,36,49–51]
Anticipated regret		✓				[4]
Attitudes towards government incentives		✓				[52]

	Gender role attitude		✓				[13]
	Child desire		✓				[13]
	Individualism attitudes		✓				[13]
Health							
	Infertility	✓					[31,32]
	Anticipated fertility/infertility		✓				[7,8,53]
	Physical health		✓				[5,7,13,26]
	Quality of life		✓				[21]
	Depression/psychological health		✓				[13,24]
Social / environment							
	Cooperative breeding and kin support (family support)	✓	✓	✓			[5,10,13,21,35]
	Stressful environment		✓				[10]
	Societal/cultural norms	✓	✓	✓			[4,5,7,10,13,14,24,26,36,51]
	Colleagues giving birth		✓				[54]
	Resource stress & limitation (including materialism)		✓	✓			[10,55]
	Maternal education		✓				[30]
	Maternal expectations and education communication		✓				[56]
	Parental socioeconomic status		✓				[57]
	Spouse's desires		✓				[49,58]
	Partnership satisfaction		✓				[13]
	Family policies (e.g. availability of childcare services)		✓				[13]
	Child value		✓				[13]

Edu: education, info: information

Table updated on 30 August 2021

*Shown to have an effect on fertility desires and intentions in experimental studies

Table S1 lists the factors affecting fertility desires and intention. In Singapore, there are ongoing efforts by the government to address financial cost, housing issues, flexible work arrangements and childcare arrangements, which influence decisions on parenthood. These include shorter waiting time for new Housing Development Board (HDB) flats (public housing in Singapore), housing grants, use of MediSave for antenatal care and ART, Baby Bonus Scheme, expansion of childcare facilities, subsidies for infant care and childcare, parental and childcare leave, and encouraging employers to adopt flexible work arrangements [59]. The current efforts to increase fertility awareness are largely driven by voluntary welfare organisations such as I Love Children (<https://ilovechildren.sg>).

Miller *et al* proposed a framework to model couples' fertility motivation based on the Traits-Desires-Intentions-Behaviour framework [60]. In line with this framework, there is evidence that fertility events can be predicted from fertility motivations [61,62]. This supports the use of antecedents, such as intentions, as intermediate outcomes as well as the importance of collecting desire and motivation data from both partners. We then identified targetable constructs from the Theory of Planned Behavior (TPB) (Figure S2) and Health Belief Model (HBM) (Figure S3), models most commonly applied to childbearing decisions and with empirical support [4–9,51,62,63].

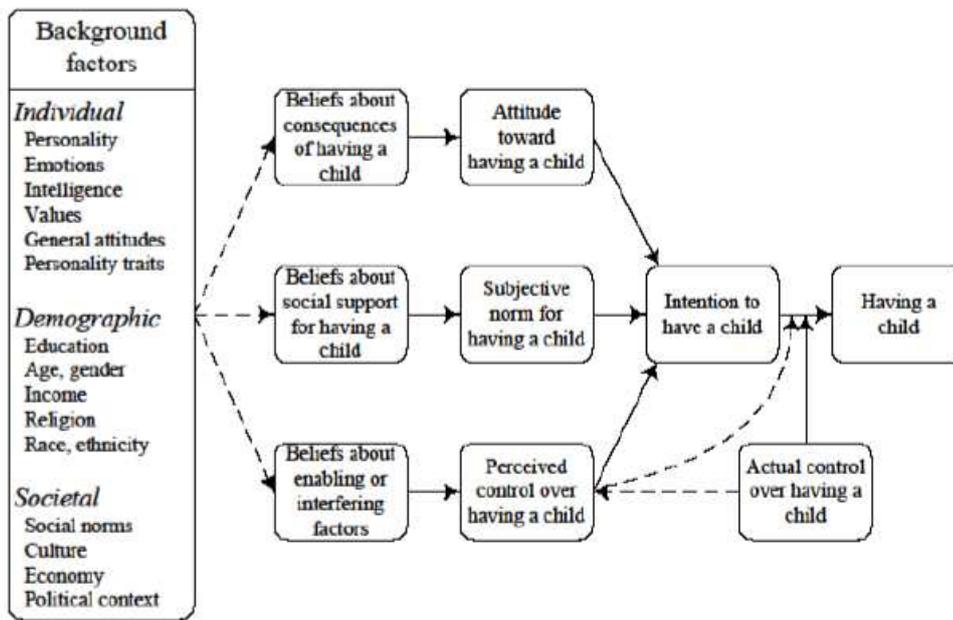


Figure S2 Theory of planned behaviour applied to fertility decisions [9]

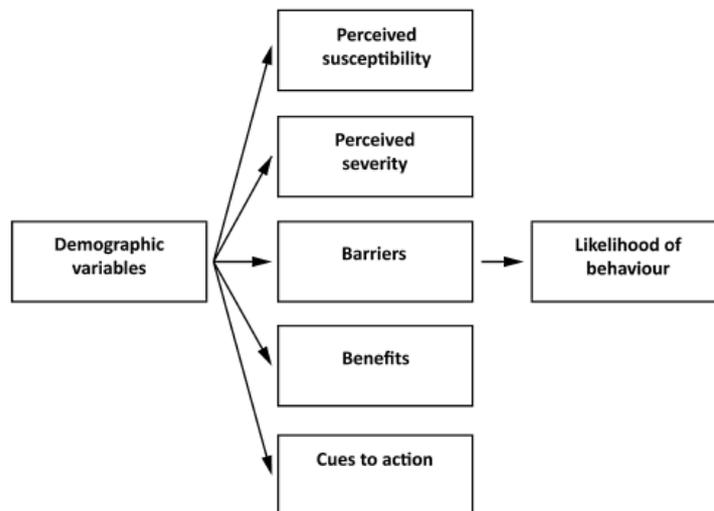


Figure S3 The Health Belief Model [6]

In addition, recent research in areas such as school achievement and marital relationships have found that brief, theory-based social-psychological interventions can cause large, enduring outcomes, and the proposed explanation is a ‘field-theory model’ that categorises interventions into ‘nudges’ (designed to change a specific decision or behaviour in a specific setting in a ‘snapshot’ in time) and ‘movie’ interventions (designed to change core beliefs or other aspects of the self, which interact with social contexts to produce sustained or amplified effects over time) [64]. To change fertility behaviours, the latter type of intervention is clearly more appropriate. Our interventions will therefore aim to change core beliefs from within, rather than provide external cues.

To target our primary outcome of intention to have a child at an earlier age, we consolidated factors associated with childbearing intentions from the literature, determinants from the TPB and HBM (Figures S2 & S3) and constructs shown to affect fertility intentions in experimental studies (relationship with partner, cost of children, cultural norms, religiosity and mortality risk) and targeted mainly fertility awareness and determinants of childbearing intentions (i.e. attitudes towards having children, anticipated regret, social norms and perceived control of the practical barriers) (Table S1) [4–10].

Mortality risk is one of these psychological factors but there is evidence that the effect of mortality risk cues on fertility intentions is modified by childhood socioeconomic status and gender differences [10]. We will therefore not target mortality risk to avoid producing a counterproductive effect. We will therefore target fertility awareness and determinants of childbearing intentions, which incorporates some of the psychological and social factors in Table S1 (i.e. attitudes towards having children, anticipated regret, social norms and perceived control of the practical barriers) in this study.

Since there are overlaps between constructs from different theories and studies, we used the Theoretical Domains Framework (TDF) to guide the grouping of relevant and modifiable determinants of into domains [65]. The primary target behaviour is to reduce the wife’s self-

reported intended age at first birth and the matrix of change objectives for this objective is shown in Table S2.

Table S2 Matrix of change objectives

Determinant 1: Beliefs about consequences (attitudes, anticipated regret)	Determinant 2: Social influence (subjective norm)	Determinant 3: Beliefs about capabilities (perceived control)
Express agreement that... 1.1: children bring more joy and satisfaction 1.2: they would have more energy to care for children if they had them earlier 1.3: children would help them grow emotionally 1.4: children would help them grow closer as a couple 1.5: children will not hinder career progression 1.6: they can still find time to enjoy things/ activities that they like 1.7: finances will be manageable after having children 1.8: they can still find time to travel 1.9: they would regret it if they end up childless because they started trying too late 1.10: they would regret it if they cannot achieve their desired number of children because they started trying too late 1.11: they are more likely to have a healthy pregnancy and babies if they had them earlier	2.1: express agreement that their parents and peers would support them giving their parents grandchildren	Perceive a lower deterrence of ... in decision to have a child earlier 3.1: current financial situation 3.2: not having a large enough house 3.3: Difficulty in securing childcare 3.4: Not having parental help 3.5: Not having a stable job 3.6: Difficulty in having flexible work arrangements

In step 3 of intervention mapping, these change objectives are then mapped to interventions methods and then translated in to practical applications (Table S3) [2].

Table S3 Mapping of change objectives to methods

Determinants	Change objective	Method	Parameters (conditions for effectiveness)	Practical application		
Beliefs about consequences	1.1: agree that children bring more joy and satisfaction	Persuasive communication	Messages need to be relevant and not too discrepant from the beliefs of the individual; can be stimulated by surprise and repetition. Will include arguments.	Showcase couples who were hesitant due to these concerns but found them true after having children		
	1.3: agree that children would help them grow emotionally					
	1.4: agree that children would help them grow closer as a couple	Modeling	Attention, remembrance, self-efficacy and skills, reinforcement of model; identification with model, coping model instead of mastery model	1.2: agree that they would have more energy to care for children if they had them earlier		
	1.5: agree that children will not hinder career progression			Showcase couples who had children late and find themselves having less energy than they wished and also the opposite		
	1.6: agree that they can still find time to enjoy things/ activities that they like			Showcase couples who still have fulfilling careers with children		
	1.8: agree that they can still find time to travel even with children			Showcase couples who engage in these activities with children		
	1.7: agree that finances will be manageable even after having children			Showcase how couples with financial considerations still cope well with children + mention of different support available (e.g. Baby Bonus Scheme, MediSave Grant for Newborns, pre-school subsidies) and how it helped		
	1.9: agree that they would regret it if they end up childless because they started trying too late			Anticipated regret	Stimulation of imagery; assumes positive intention to avoid the risky behaviour	Showcase couples who had/ tried having children late and ended up in this situation (highlight the regret)
	1.10: agree that they would regret it if they cannot achieve their desired number					

	of children because they started trying too late			
Societal influences	2.1: express agreement that their parents and peers would support this action	Information about others' approval	Positive expectations are available in the environment	Showcase couples (who had children young) recounting their parents and friends' reactions when pregnancy news broke
Beliefs about capabilities	3.1: lower perceived barrier because of current financial situation	Persuasive communication & modeling	As above	Showcase how couples with financial considerations still cope well with children + mention of different support available (e.g. Baby Bonus Scheme, MediSave Grant for Newborns, pre-school subsidies) and how it helped
	3.2: lower perceived barrier because of not having a large enough house			Showcase couples who manage themselves using other resources (childcare, FDWs, etc) + mention of increase in childcare accessibility, affordability & quality
	3.3: lower perceived barrier because of not having a stable job			Showcase couples with different ways of managing work and family commitments (including colleagues who are supportive of them when using flexible work arrangements, how having a non-permanent job can be an advantage)
	3.4: lower perceived barrier because of difficulty in securing childcare			
	3.5: lower perceived barrier because of not having parental help			
	3.6: lower perceived barrier because of difficulty in having flexible work arrangements			

Step 4 in the Intervention Mapping protocol was the creation of an intervention program from the practical applications laid out in step 3. In FHS, some of these practical applications may be applied during the reproductive counselling as appropriate but the focus is on matching the couples' plan to their stated reproductive goals and the emphasis on the reality of age-related fertility decline. For FAT, this intervention program would consist of i) a video containing information on age-related fertility decline and limitations of ART, curated by an expert panel of obstetricians and vignettes corresponding to the practical applications listed in Table S3 and ii) FertiSTAT [66]. In the making of the video, not all practical applications could be included as there was a need to maintain a good balance of flow, duration and positive feeling such that it is not perceived as pushy.

Steps 5 and 6 are more relevant after effectiveness has been demonstrated.

Nevertheless, we are also exploring some implementation factors.

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