

**Intervention strategies to improve nutrition and health behaviours before conception**

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## Abstract

The nutritional status of women and men before conception has profound implications for the growth, development and long-term health of their offspring. Evidence of the effectiveness of preconception interventions in improving outcomes for mothers or babies is scarce, though given the large potential health return, relatively low costs and risk of harm, intervention is still warranted. We identify three promising strategies for intervention that are likely to be scalable and to have positive effects on a range of health outcomes: supplementation and fortification; cash transfers; and behaviour change interventions. Based on this, we suggest a model specifying pathways to effect. Pathways are incorporated into a lifecourse framework using individual motivation and receptiveness at different 'preconception action phases' to guide design and targeting of preconception interventions. Interventions with those not planning immediate pregnancy take advantage of settings and implementation platforms outside the maternal and child health arena, since this group is unlikely to be engaged with maternal health services. Interventions to improve women's nutritional status and health behaviours at all preconception action phases need to take account of social and environmental determinants to avoid exacerbating health and gender inequalities, and should be underpinned by a social movement that touches the whole population. A dual strategy that targets specific groups actively planning a pregnancy, while improving the health of the population more broadly, is proposed. The engagement of modern marketing techniques points to a social movement based on an emotional and symbolic connection between improved maternal nutrition and health prior to conception and offspring health. We suggest that speedy and scalable public health benefit might be achieved through strategic engagement with the private sector. Political theory supports the development of an advocacy coalition of groups interested in preconception health, to harness the political will and leadership necessary to turn high-level policy into effective co-ordinated action.

## Introduction

In 2016 the United Nations declared a ‘Decade of Action on Nutrition’ and committed to ‘end all forms of malnutrition, including internationally agreed targets on stunting and wasting in children under 5 years, and addressing the nutritional needs of adolescent girls, pregnant and lactating women’(p. 1).(1) There is increasing evidence from epidemiological and developmental biology research that these growth and development targets for children and the consequent reduction in their risk of non-communicable disease in adulthood could be achieved through improving women’s nutritional status and health behaviour before conception. (Reference Stephenson et al; Fleming et al; (2)) Two previous Lancet series have called for innovation in the design and delivery of affordable, scalable nutrition interventions to improve maternal and child health.(3, 4) In this paper, we review what is known about the effectiveness of nutrition and behavioural interventions before conception, and propose a strategy of aligning interventions to individual motivation and receptiveness at different ‘preconception action phases’ during the lifecourse. We propose a dual strategy targeting health improvement in both men and women planning a pregnancy and in the general population. This is on the basis that improvements in preconception health require a supportive environment, underpinned by a ‘social movement’ and policy initiatives, and of necessity engaging big business.

## Method

We conducted a quasi-systematic review of trials of preconception nutrition and health behaviour interventions to identify effective interventions and specify pathways to effect. All search details are in a web appendix. (Provide link to web appendix.) We included interventions assessing nutritional status and body composition outcomes only, excluding other clinical outcomes such as improved glycaemic control. Pathways to effect were then incorporated into a lifecourse framework to aid targeting of interventions. Current preconception interventions were reviewed using the REAIM framework to assess, where possible, their reach, efficacy/effectiveness, adoption, implementation

and maintenance.(5) Finally, we applied a consumer marketing approach to the challenge of creating a social movement to strengthen political resolve for wide-scale intervention

### **Current strategies for preconception nutrition intervention**

We identified 14 controlled primary studies evaluating three strategies: supplementation/fortification, cash transfers or incentives, and behaviour change intervention. Too few good quality studies conducted in the preconception period were identified to enable firm conclusions about effectiveness or meta-analysis. Current epidemiological and biological evidence points, however, to the value of intervening prior to conception. Intervention strategies were therefore selected for review on the basis of scalability, likely benefit to a nutritional outcomes in the preconception period and being low risk. Using these strategies, we developed a model identifying the key pathways to be quantified once more high quality data from randomised trials are available (Figure 1).

#### *Supplementation and food fortification*

The majority of evidence for the benefit of improving preconception nutrition and health comes from ‘supplementation trials’. These trials examine the effects of micronutrient and energy supplementation. The Bacon Chow study in Taiwan found that supplementing undernourished women’s diets with 800kcal and 40g protein per day after their first baby increased birthweight in the second baby when compared to a control group given just 80kcal per day.(6) A similar study in the USA also found increased birthweight of subsequent babies among women given supplements for five to seven months following first birth, compared with those given supplements for up to two months.(7) The Mumbai Maternal Nutrition Project showed that a locally-sourced micronutrient-rich snack, given daily before conception and during pregnancy, reduced the likelihood of gestational diabetes, and increased birthweight in a high-risk Indian population but only among mothers who were not underweight.(8, 9) These studies currently represent the best available evidence for preconception nutritional supplementation. Efficient and effective strategies to improve access to

additional calories before conception still need to be identified in contexts where maternal undernutrition is common.

Supplementation interventions are acceptable to women but uptake is often hampered by poor adherence. Several solutions have been proposed, including a contraceptive pill containing folic acid currently available in the USA.(10, 11) The impact of this ingenious solution depends, however, on contraceptive pill use which varies widely between countries. Fortifying foods such as flour or rice has wide potential reach and is currently mandated in 87 countries.(12) The WHO has also issued a guideline for the fortification of salt with iodine, which can prevent irreversible mental impairment of the fetus.(13) Reductions in the prevalence of neural tube defects have been observed following mandatory folic acid fortification in the USA, Canada, Chile, Costa Rica and South Africa.(14, 15) However folic acid fortification is not mandatory in Europe. In the UK, there are concerns about increasing cancer risk in older populations, potential masking of vitamin B12 deficiency anaemia, and removing individual choice.(14) Despite these concerns, is little evidence of negative consequences from the implementation of folic acid fortification .(16) The UK's Scientific Advisory Committee on Nutrition continues to recommend mandatory folic acid fortification to improve the folate status of women most at risk of neural tube defect-affected pregnancies.

#### *Cash transfers/incentives*

None of the studies we found explicitly investigated the effects of preconception cash transfers on birth or nutritional outcomes. This strategy was included in the model, however, because in low income settings, cash transfers are effective in improving i) school enrolment and attendance among girls, ii) access to preventive healthcare and iii) household food consumption.(17-19) As these are all risk factors for poor birth and nutritional outcomes, preconception cash transfers may be useful.(20, 21) Further work is needed to demonstrate effectiveness and acceptability of combatting overweight and obesity through incentivising the purchase of healthy foods in high income settings.

#### *Behaviour change interventions*

Two systematic reviews examining 12 preconception trials identified possible improvements in i) health behaviours including reducing alcohol consumption and smoking, and ii) psychological mediators of intervention effects, such as maternal self-efficacy and perceived control.(22, 23). Neither review reported on maternal nutritional status as an outcome. Two studies tested the effect of preconception nutritional and/or behavioural interventions on birth outcomes: a study in the Netherlands found no effect on pregnancy outcomes when general practitioners counselled couples on health behaviours (24); and a study in Australia found a negative effect on birthweight of counselling on risk factors including diet, timing of next pregnancy, and specialist referrals.(25) The authors speculate that improved preconception health meant that previously unsustainable pregnancies were sustained for longer, resulting in more pre-term births and lower birth weights. If true, this would be an unexpected and adverse effect of preconception intervention.

The challenges of addressing preconception under-nutrition in low income settings may require broader behavioural strategies than those tackling over-nutrition in high income settings. Low resource households cannot simply change their behaviour if food is unavailable and so strategies must combine behaviour change with food access in the way that the CARING Trial has recently evaluated in eastern India.(26, 27) This trial also used a healthcare approach that has successfully engaged women and reduced maternal and neonatal mortality in rural, low-resource settings: participatory learning and action through women's groups.(28) This facilitated group-based problem-solving approach involves women of all ages and tackles a variety of maternal and newborn problems including nutrition. Although the original trials of this approach do not report on nutritional outcomes, the CARING trial has found that although the approach was not able to significantly increase child length, it did improve key secondary outcomes including dietary diversity and handwashing. The LBWSAT trial is due to report soon.(29) *(See Panel 2 for details of ongoing trials.)* Interventions in high resource contexts can focus on individual choice but evidence suggests that multi-level interventions may be more effective.(30) The recently-announced intervention trials developed as part of the Canadian governments Healthy Life Trajectory Initiative are good examples

of such multi-level interventions that aim to address preconception nutrition and health behaviour but also wider health and social determinants (<http://www.cihr-irsc.gc.ca/e/49511.html>). These trials will provide gold standard evidence of the effectiveness and cost-effectiveness of multicomponent preconception interventions in improving outcomes for children.

Preconception interventions often require engagement from individuals who are not thinking about becoming pregnant in the near future and are unlikely to be using maternal health services.

Interventions to improve health behaviours of adolescents and young adults may therefore have to be placed outside maternal and child health services and appeal to motivations unrelated to health, such as attractiveness.(31-33)

#### **Motivation for, and engagement in, preconception nutrition and behavioural interventions**

The complexities involved in changing individual and population health behaviours are well recognised. It is usually not enough to simply educate or give advice. Knowing something is ‘good for you’ is rarely sufficient to change behaviour. Successful behaviour change requires the target population to i) engage with the need to change, ii) sustain the motivation to maintain the change, and iii) be supported by contexts (service providers, society, social networks, environments) that facilitate change.(34)

Figure 2 displays a model of Preconception Action Phases adapted from the Rubicon Model of Action Phases and the Action Phase Model of Developmental Regulation, and applied to preconception motivations and interventions.(35, 36) It is based on five assumptions:

1. Most young adults intend to become parents at some point and this goal begins to form in childhood.
2. Young adults have the adaptive capacity to pursue this goal amongst their other developmental lifecourse goals and to translate it into action.

3. The goal to become a parent is nested within other facilitating and conflicting developmental lifecourse goals, which are pursued as opportunities evolve over time.

4. Motivation to become a parent is the driver that translates that goal into relevant preconception behaviours.

5. Translating the goal to become a parent into conception and pregnancy outcomes is imperfect.

The model distinguishes four phases characterised by overarching biological or psychological agendas and motives in relation to the goal to become a parent. From left to right across the figure interventions become less general and more targeted towards specific populations, in keeping with the dual strategy for promoting preconception health proposed in this paper. Intervention reach will be greater in the earlier phases of the model though effect sizes are likely to be smaller due to lower intensity. Benefits of interventions in these early phases will be general; healthier diets will benefit both the individual and society and enhance motivation in those not planning imminent pregnancy. Creating a social movement would raise awareness of the significance of preconception nutrition and generate a supportive social environment for preconception health. It would help build engagement at each phase and facilitate preparation for pregnancy as a normal part of 'having a baby', and standard healthcare practice.(37)

#### *Intervening with children and adolescents*

In the first phase of Preconception Action, motivation to become a parent, forms without any physical capability for childbearing, which changes as children develop into adolescents. Laying foundations for a healthy life is essential at this time for reasons independent of any preconception health agenda, but given the general low level of awareness of healthy preparation for pregnancy as a concept, awareness-raising is needed from an early age.

203 Recent recognition of the ‘triple benefit’ from investment in adolescent health – their health now,  
204 their health in the future and the health of the next generation – has focused attention on this  
205 lifecourse phase.(38-40) Ninety percent of the world’s 1.8 billion adolescents live in low- and middle-  
206 income countries (LMICs); up to half are stunted and pregnancy is common.(39) For this group, a key  
207 intervention in improving outcomes for mothers and babies is to delay first pregnancy beyond 18  
208 years, when nutrients are no longer needed to support maternal growth.(41) In high income  
209 countries (HICs), adolescents have the poorest diets of any age group.(42) Both physiological  
210 responses and health behaviours established during adolescence are known to track into adulthood,  
211 and neurological and epigenetic changes in adolescence suggest it as a critical period for establishing  
212 long-term health risk.(43, 44) Adolescents typically disengage with traditional health messages,  
213 prioritising the immediate over the long-term; having a strong desire for autonomy causes them to  
214 reject instructive health education.(45, 46) Effective interventions with adolescents need to  
215 empower and encourage by giving rather than taking away responsibility.

216 The LifeLab programme (*see web appendix for details*) is an example of a school-based intervention  
217 aimed at developing adolescents’ motivations for improving their diets and physical activity levels  
218 through engagement with science, with an emphasis on their health but with reference to benefits  
219 for their future children.(47, 48) The students report that being good parents in the future is  
220 important to them. Learning about preconception health motivates them to improve their diets and  
221 physical activity. LifeLab has potential to help children and adolescents develop a concept of  
222 preconception and parenthood, but this may not motivate change because it is not an immediate  
223 imperative. Motivation is a necessary but not sufficient condition for behaviour change.(49) The  
224 addition of an in-person intervention to LifeLab would support students’ capabilities (ie. ‘you can do  
225 this!’, ‘I believe in you!’) and opportunities for behaviour change (ie. ‘how are you going to exercise  
226 more?’, ‘what is your plan for eating healthily?’). In settings where female participation in formal  
227 schooling is low, alternative approaches are needed to ensure engagement of adolescent boys and  
228 girls.

229 In rural South Africa, where there are high rates of overweight and obesity amongst adolescents, the  
230 'Ntshembo' ('Hope') intervention aims to achieve a healthy body mass index in 14-19 year olds  
231 through a two-year programme of behaviour change support. Working with adolescents, their carers  
232 and village leaders, Ntshembo is explicitly designed to address individual and community  
233 motivations and capabilities and to restructure opportunities for adolescents to eat well and  
234 exercise more.(50) It harnesses the power of social influence on adolescent behaviour through peer  
235 support, and employs community health workers trained to support problem-solving and capitalise  
236 on adolescents' need for autonomy; the development of an adolescent-friendly health service to  
237 deliver gender and context-specific interventions is widely supported.(51) As in LifeLab, the  
238 preconception agenda in Ntshembo is largely that of the intervention developers, who will need to  
239 engage with adolescent's own imperatives for the intervention to succeed. The results of the current  
240 pilot trial are eagerly awaited.

#### 241 *Interventions with adults not immediately intending to become pregnant*

242 In this second phase, the goal to become a parent is refined and shaped by the individuals'  
243 psychological, social, economic and biological status.(52-54) As young adults mature, developmental  
244 goals such as completing education, obtaining employment and forming intimate relationships  
245 generally take priority over becoming a parent. Consequently, preconception health will have little  
246 'motivational currency' during this phase. Effective methods of engagement at this stage will be  
247 highly context specific.

248 In some cultures, marriage offers an opportunity to engage couples in thinking about their nutrition  
249 and health before conception, particularly in countries where pre-marital testing aimed at reducing  
250 transmission of inherited disorders is mandatory. The Jom Mama project, supported by the  
251 Malaysian government, uses an existing pre-marital HIV screening and wellness programme to  
252 provide preconception nutrition support to couples, using a combination of a web-based platform  
253 and in-person behaviour change support. (55) *(See web appendix for more details.)* Newly-married

254 Malaysian women said that having a healthy baby in the future was a major motivation for  
255 improving their diets and physical activity. *(See Panel 3 for details of these conversations.)* Other  
256 lifecourse goals however, such as work, were a barrier to eating well and being active. The  
257 effectiveness of this intervention is not yet known but may be constrained by its focus on individual  
258 responsibility and the fact that it does not directly address the challenge of social influences or an  
259 obesogenic environment.

260 The absence of dedicated preconception healthcare in many countries means interventions to  
261 improve preconception nutritional status need to take advantage of routine contact between young  
262 adults and healthcare providers.(56) Offering support in reproductive health clinics, for example, has  
263 the potential to improve the preconception nutritional status of women who may or may not be  
264 actively planning pregnancies. This requires healthcare professionals to be aware of its significance,  
265 have skills to intervene and see it as part of their job; none of which is currently the case. To help  
266 raise awareness, the USA's Centre for Disease Control promotes a 'Reproductive Life Plan' intended  
267 to encourage people of child-bearing age to prepare for pregnancy and maximise the preconception  
268 benefit of interactions with healthcare professionals.(57)

269 Training for healthcare professionals of all types in skills to support behaviour change is available in  
270 the form of Healthy Conversation Skills. This set of easily-acquired, theory-based skills for  
271 practitioners is designed to engage and motivate patients and clients during brief consultations.  
272 Unlike giving information and advice, Healthy Conversation Skills training promotes use of open  
273 discovery questions, listening, reflecting and goal-setting to enable a woman or couple to prepare  
274 for pregnancy and support them in finding their own solutions to challenges. The skills have been  
275 used in maternal and child health contexts around the world and their use is both acceptable and  
276 feasible.(58-60)

277 Armed with such skills, practice and community nurses, sexual and reproductive health clinic staff,  
278 those working in Early Pregnancy Units who see women who have miscarried, and staff providing

weight management services are all potential agents for delivering appropriate, timely, and culturally-sensitive support to improve preconception nutritional status at scale. Extending training in skills to support behaviour change to community health workers has potential for widespread impact on preconception health; evidence from other contexts suggests this can improve health outcomes in a range of public health and primary care settings.(61, 62) Local and national policies would be helpful to support the implementation of such training for community health workers. An approach such as Healthy Conversation Skills enables healthcare professionals to provide care that is responsive to women's personal, social and cultural milieux.(56)

In contexts outside healthcare, supermarkets represent an unexploited opportunity for promoting preconception nutrition. Supermarkets have an unparalleled reach into communities and expertise in customer engagement. Women do the majority of family food shopping and in HICs these choices are made in supermarkets.(63) Recent research indicates that the food choices of disadvantaged women are particularly susceptible to the supermarket environment, suggesting that modifications which encourage the purchasing of healthier foods might have greatest impact on women with the poorest diets.(64) In LMICs, the role of supermarkets as food purveyors is rapidly increasing although this is less the case in remote and rural areas where increasing the accessibility of nutrient-dense food remains a priority.(65, 66) A model whereby supermarkets offer preconception nutritional support organised around sales of folic acid and other supplements is one that could be developed in HICs and, if successful, translated to LMICs as supermarkets become more widespread.

#### *Interventions with adults intending to become pregnant*

In the third phase, the goal to become a parent has been activated through a combination of social (e.g. subjective norms), situational (e.g. marriage) and biological (e.g. age) factors and is now actively pursued. This phase is characterised by an increased investment of thought, time and effort into becoming pregnant. Willingness to engage in interventions increases and can range from passive (e.g. reduced investment in contraception) to active behaviours. Preconception interventions are

likely to be attended to and, with support, translated into behaviour change. Interventions need to allow for swift and discrete implementation, given the sensitive nature of couples' plans for conception, and active promotion through channels such as contraception counselling.

Since this group is likely to be engaged and seeking information, preconception health services in primary care, with a focus on nutrition, may be appropriate. There is evidence that interventions offered in this setting can improve preconception health behaviours in women who are planning to become pregnant.(23, 67, 68) Screening for pregnancy intention (ref Stephenson et al paper 1 in this series) would enable practitioners in sexual and reproductive health clinics to offer preconception support to women attending for removal of implants and IUDs, for example.

Digital interventions, web or smartphone-based, offer privacy and easy access for disadvantaged or disenfranchised groups less likely to engage with more formal services. 'Smarter Pregnancy', or Slimmer Zwanger in Dutch, is a rare example of a digital intervention designed specifically to support improvements in preconception nutrition and health behaviours. It has had some success with couples who are actively preparing for pregnancy.(69, 70) (See web appendix for details.) Mobile phone interventions to improve maternal and child health in LMICs have delivered tailored information and supported improved infant feeding outcomes.(71) Evidence is accumulating that combining digital interventions with motivational human interaction increases engagement with, and effectiveness of, behaviour change interventions.(72) An accessible, population-wide preconception healthcare service could be offered to women via a digital intervention combined with face-to-face or telephone contact with healthcare staff trained in a motivational approach such as Healthy Conversation Skills.

#### *Interventions with adults intending to become pregnant again*

In the fourth phase, the goal to become a parent is re-activated. Preparation for this pregnancy is likely to be influenced by couples' previous preconception experiences. Previously uncomplicated

328 pregnancies might decrease receptiveness for preconception input; if their first baby was healthy  
329 why would couples change their preparations?

330 Women and their families have intensive contact with health services and health professionals  
331 during pregnancy and are motivated to make dietary changes. Evidence shows that interventions  
332 can support maternal dietary behaviour change (*ref Stephenson et al paper 1 in this series*), and  
333 reduce postnatal weight gain. (73-77)

334 In LMICs, interest has focussed mainly on maternal underweight and micronutrient deficiencies.  
335 Numerous supplementation studies have shown women's willingness to take nutritional  
336 supplements during pregnancy, with consequent reductions in low birth weight. Few have addressed  
337 under-nutrition during pregnancy by supporting change in habitual dietary behaviour, probably  
338 because choices tend to be limited in undernourished settings. Qualitative studies have suggested  
339 modifiable dietary behaviours in LMIC populations however, and this is ripe for more  
340 research.(78)Young rural Indian women report avoiding specific nutritious foods because of fears  
341 they could harm a pregnancy, 'eat down' in the belief that this will make delivery easier, eat the  
342 least nutritious foods after other family members have eaten because of household hierarchies, and  
343 observe women's cultural fasting days, eating predominantly low nutrient foods.(79, 80) These data  
344 provide further support for embedding preconception nutritional interventions in those that support  
345 wider social and cultural change.

346 Maternal and child healthcare systems offer some post- or inter-partum opportunities for working  
347 with women to support dietary behaviour change. Women interviewed following an inter-partum  
348 intervention at a health visitor clinic in London, UK, had a new awareness that their nutritional status  
349 during and between pregnancies had an impact on the baby (*see Panel 3*). In HICs, post-partum  
350 studies have focussed mainly on limiting weight retention among normal or overweight women  
351 and/or improving glucose tolerance among women with a history of gestational diabetes.(81, 82)  
352 Reviews suggest that interventions to address both diet and physical activity which include self-

monitoring of progress may be more effective than others.(83, 84) Some studies have successfully used education programmes or financial incentives to improve dietary quality by reducing energy intake and increasing fruit, vegetable and whole grain intake.

Many post-partum randomised studies report low recruitment or retention rates however; post-partum mothers report multiple barriers to participation, including little spare time, stress and sleep deprivation. Interventions may need to take a supportive approach involving home visits, provision of foods and/or childcare, and/or self-monitoring facilities such as weighing scales.(85) One solution may be to integrate in-person support for inter-partum behaviour change with a digital service. Postpartum weight retention is associated with lifetime obesity risk and adverse outcomes in the next pregnancy. A recent, cluster randomised trial of an internet-based weight loss programme coupled with face-to-face support (Fit Moms/Mamás Activas) in low-income women in California, USA, found that women in the intervention group maintained significantly greater weight loss at 12 months than women who were not randomised to the intervention (3.2kg versus 0.9kg; difference 2.3 kg (95% CI, 1.1 to 3.5). (86)

### **Creating a social movement for preconception nutrition**

A social movement to optimise preconception health, nutritional status and health behaviours needs to involve the whole population and harness political will and leadership. A social movement in Brazil led to significant improvements in preconception nutrition for women and virtual eradication of undernutrition and wasting among children under-five between 1994 and 2006.(87, 88) The movement involved i) a 'National Campaign against Hunger' that raised public awareness of the need to tackle malnutrition and ii) development of an advocacy coalition with political affinities that created a critical mass of activists and monitored government's progress in reducing malnutrition. Eradicating malnutrition became a high-profile social responsibility, prompting strong leadership from central government in addressing food security. Underpinning Brazil's approach was an

377 appreciation that how women feed themselves and their children is not solely an individual  
378 responsibility but involves wider determinants.

379 Social movements are distinct from social marketing campaigns. The latter would classically attempt  
380 to improve nutrition and health behaviour through providing information and recommending  
381 behaviour change, but may fail to reach the neediest groups and inadvertently widen  
382 inequalities.(89, 90) The UK's 'Change4Life' intervention adopted this approach, with little evidence  
383 of effectiveness.(91) Social practice theory provides some insight as to why such campaigns are  
384 insufficient; individuals and communities require not only knowledge but also resources to enact  
385 change, and a purpose or meaning to provide motivation.(92) A social movement which would  
386 provide these might best be founded in socially-constructed ideas of human action and allied  
387 therefore to the field of consumer marketing and brand creation.

388 Consumer marketing recognises that individual behaviour and choices are a function of self-image,  
389 and brands must develop an emotional and symbolic connection with consumers, making the brand  
390 a form of self-expression.(93) A campaign using current brand development practice would target  
391 emotions that are central to an individual's identity. This approach is epitomised in such campaigns  
392 as the 'handwashing with soap' social movement, which applied brand marketing practices and an  
393 advocacy campaign to address infant mortality under the tag-line "Help a Child Reach 5". The media  
394 campaign follows the principles of being personally relevant, emotionally engaging and easy to  
395 understand.(94) The evidence-based rationale for handwashing is given only after the other appeals  
396 have been made. The campaign was driven by a multi-national company (Unilever), supported by an  
397 alliance of public health activists and academics. It has received strong endorsement by the  
398 inclusion of handwashing with soap as an indicator in the Sustainable Development Goals, and  
399 government policy initiatives to improve washing facilities.

400 The handwashing movement is an example of mutual benefit for public health and for private sector  
401 profit that can come from a joint social purpose. Companies are much more likely to 'do the right  
402 thing' and to do it sustainably if public health benefit is accompanied by commercial gain.(94)

403 Black and colleagues in the Lancet in 2013 declare that 'the private sector is an important force in  
404 shaping nutrition outcomes and has the potential to do more' to improve maternal and child  
405 nutrition (p.374).(3) There is a growing recognition of the importance of engaging with the food  
406 industry in recognition of their reach and power to shape consumer behaviour. A major difficulty  
407 with applying the 'mutual benefit' approach to improving preconception nutrition and lifestyle  
408 through a relationship with the food industry is their history of malpractice in respect of infant  
409 feeding and their role in generating and sustaining an obesogenic environment. Whether  
410 commercial and public health interests can be aligned in the way they have been for handwashing  
411 remains to be seen. One attempt is Unilever's campaign to market stock cubes fortified to reduce  
412 iron-deficiency anaemia amongst women in Nigeria.(95) Current lobbying by industry against sugar-  
413 sweetened beverage taxes does suggest, however, that caution is required to ensure the legitimacy  
414 of health actions and lobbying by food industry. Independent monitoring of food industry activities  
415 by academia and the public is crucial to building societal support that will catalyse government and  
416 industry actions in respect of preconception health.(96)

417 Applying marketing principles to generating a preconception social movement suggests that it  
418 should be emotionally engaging and positively framed. The voice of a child not yet born, speaking  
419 from the future, thanking parents, grandparents, aunts, etc. for looking after her health from before  
420 conception is the kind of emotional appeal applicable to a preconception campaign. The call to  
421 action would target the whole population and would ask people to, for example, support young  
422 women or couples to achieve an optimal pre-pregnancy weight or eat a variety of fruit and  
423 vegetables. The challenge is to identify simple actions around which the campaign could be built.

424 **Building advocacy coalitions for preconception nutrition**

425 Political science suggests that we need to develop a strong advocacy coalition within international,  
426 national and local policy subsystems to place preconception nutrition firmly on government agendas  
427 to incite global policy action.(97) International organisations are already engaged in advocacy to  
428 promote improved preconception healthcare. In 2012, WHO coordinated a global consensus on  
429 'Preconception Care to Reduce Maternal and Childhood Mortality and Morbidity' and provided a  
430 package of evidence-based interventions, including nutritional interventions.(98) Following this,  
431 preconception nutrition was integrated into a number of transnational organisation initiatives. With  
432 the notable exception of the Netherlands, only LMICs provide examples of political support for the  
433 adoption of strategies to address social, environmental and economic determinants of maternal and  
434 child malnutrition and grass roots demand for action.(87, 99) Political debate in the Netherlands was  
435 sparked by academics drawing attention to high national perinatal mortality rates, especially among  
436 poor immigrant communities. The promotion of preconception health to reach the poorest has since  
437 become a Dutch priority and includes addressing social deprivation and broad determinants of  
438 maternal ill-health.

439 Policy change is more likely if advocacy coalitions are developed to focus on a specific policy  
440 subsystem and engage multiple participants (i.e. government agencies, research institutions, non-  
441 government organisations, the media, commercial interests and influential individuals) to build  
442 critical mass.(97) Strong leadership, adequate resources, and coordinated infrastructure are  
443 required to ensure advocacy coalitions sustain engagement over the potentially lengthy period of  
444 time necessary to achieve high-level, coordinated policy action particularly in competitive policy  
445 subsystems with opposing advocacy coalitions. Initiatives such as sugar taxes or marketing  
446 restrictions to curb sugar intake have recently gained policy traction in some countries following  
447 decades of increasing evidence, advocacy and public awareness and in spite of strong opposition  
448 from food companies.(100) One major advantage of campaigning for better preconception nutrition  
449 is that the focus is building stronger mothers and babies and reducing non-communicable disease in

the next generation. These are uncontroversial messages, easy for the public to engage with emotionally.

## **Conclusions**

A dual strategy of simultaneously targeting women and couples most likely to be planning a pregnancy, while promoting the health of all women of child-bearing age may be the most effective approach to improving preconception health. Sparse evidence from robust and context-relevant trials of preconception nutrition and health behaviour interventions makes it hard to draw firm conclusions about their effectiveness in improving outcomes for mothers and babies on a large scale. Trials of preconception interventions are far fewer than those conducted during pregnancy, because recruitment is more difficult and outcomes can be assessed only in women who subsequently become pregnant. Fortunately several such trials are underway. Meanwhile, public health strategies to improve nutritional status in children and those of reproductive age should be strengthened without delay.

Best evidence suggests that interventions will be more effective for longer if they use existing delivery platforms within a systems approach. System-wide changes to accommodate preconception healthcare will need support from a social movement that establishes its importance for the health of the next generation, stresses societal responsibility and requires strong local, national and international leadership. The strength of this social movement and the capacity to deliver effective nutrition and behavioural interventions may be enhanced through carefully negotiated engagement with commercial interests.

## **Contributors**

MB conceptualised the review in consultation with all authors and wrote the first draft of the paper with substantial inputs from TC, JSW, GN, SUD, FFS, CHDF, SN, CV, NMK, WL and JS. TC, JSW and GN

carried out the review and produced the pathways model of intervention effects. The analysis of preconception action phases was developed by SUD and FFS. SN, RST, DP, KWT provided data and wrote descriptions of exemplar intervention studies. CHDF wrote the first draft of the section on interventions with adults intending to become pregnant again. Sections on the creation of a social movement and advocacy coalitions were produced by CV and NMK. JS oversaw and advised on all aspects of producing and editing this paper. All authors saw successive drafts of the paper and provided input. MB finalized the paper and is the overall guarantor.

#### **Declaration of interests**

We declare no competing interests.

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#### **References**

1. World Health Organisation. Work Programme of the UN Decade of Action on Nutrition, 2016-2025 Geneva: WHO; 2017 [Available from: <http://www.who.int/nutrition/decade-of-action/workprogramme-2016to2025/en/>].

2. Godfrey KM, Gluckman PD, Hanson MA. Developmental origins of metabolic disease: life course and intergenerational perspectives. *Trends in endocrinology and metabolism: TEM*. 2010;21(4):199-205.
3. Black RE, Alderman H, Bhutta ZA, Gillespie S, Haddad L, Horton S, et al. Maternal and child nutrition: building momentum for impact. *The Lancet*. 2013;382(9890):372-5.
4. Ceschia A, Horton R. Maternal health: time for a radical reappraisal. *The Lancet*. 2016;388(10056):2064-6.
5. Gaglio B, Shoup JA, Glasgow RE. The RE-AIM Framework: A Systematic Review of Use Over Time. *American Journal of Public Health*. 2013;103(6):e38-e46.
6. McDonald EC, Pollitt E, Mueller W, Hsueh AM, Sherwin R. The Bacon Chow study: maternal nutrition supplementation and birth weight of offspring. *Am J Clin Nutr*. 1981;34(10):2133-44.
7. Caan B, Horgen DM, Margen S, King JC, Jewell NP. Benefits associated with WIC supplemental feeding during the interpregnancy interval. *Am J Clin Nutr*. 1987;45(1):29-41.
8. Potdar RD, Sahariah SA, Gandhi M, Kehoe SH, Brown N, Sane H, et al. Improving women's diet quality preconceptionally and during gestation: effects on birth weight and prevalence of low birth weight--a randomized controlled efficacy trial in India (Mumbai Maternal Nutrition Project). *Am J Clin Nutr*. 2014;100(5):1257-68.
9. Sahariah SA, Potdar RD, Gandhi M, Kehoe SH, Brown N, Sane H, et al. A Daily Snack Containing Leafy Green Vegetables, Fruit, and Milk before and during Pregnancy Prevents Gestational Diabetes in a Randomized, Controlled Trial in Mumbai, India. *The Journal of Nutrition*. 2016;146(7):1453S-60S.
10. Pena-Rosas JP, De-Regil LM, Dowswell T, Viteri FE. Daily oral iron supplementation during pregnancy. *The Cochrane database of systematic reviews*. 2012;12:CD004736.
11. Lassi ZS, Bhutta ZA. Clinical utility of folate-containing oral contraceptives. *International Journal of Women's Health*. 2012;4:185-90.
12. Food Fortification Initiative. Say Hello to a Fortified Future: 2016 YEAR IN REVIEW 2016 [Available from: [http://ffinetwork.org/about/stay\\_informed/publications/documents/FFI2016Review.pdf](http://ffinetwork.org/about/stay_informed/publications/documents/FFI2016Review.pdf).
13. World Health Organisation. Fortification of food-grade salt with iodine for the prevention and control of iodine deficiency disorders: Guideline. Geneva, Switzerland: World Health Organisation; 2014.
14. Crider KS, Bailey LB, Berry RJ. Folic Acid Food Fortification—Its History, Effect, Concerns, and Future Directions. *Nutrients*. 2011;3(3):370-84.
15. Mastroiacovo P, Leoncini E. More folic acid, the five questions: why, who, when, how much, and how. *BioFactors (Oxford, England)*. 2011;37(4):272-9.
16. Scientific Advisory Committee on Nutrition. Update on folic acid. 2017 July 2017.
17. Manley J, Gitter S, Slavchevska V. How Effective are Cash Transfers at Improving Nutritional Status? A Rapid Evidence Assessment of Programmes' Effects on Anthropometric Outcomes. . London: EPPI Centre, Social Sciences Research Unit, Institute of Education, University of London; 2012.
18. Fenn B, Colbourn T, Dolan C, Pietzsch S, Sangrasi M, Shoham J. Impact evaluation of different cash-based intervention modalities on child and maternal nutritional status in Sindh Province, Pakistan, at 6 mo and at 1 y: A cluster randomised controlled trial. *PLOS Medicine*. 2017;14(5):e1002305.
19. Fenn B, Pietzsch S, Morel J, Ait-Aissa M, Calo M, Grootenhuis F, et al. Research on Food Assistance for Nutritional Impact (REFANI): Literature Review. New York, USA: Action Against Hunger; 2015.
20. Ruel MT, Alderman H. Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition? *Lancet*. 2013;382(9891):536-51.
21. Rawlings LB, Rubio GM. Evaluating the Impact of Conditional Cash Transfer Programs. *The World Bank Research Observer*. 2005;20(1):29-55.

22. Whitworth MK, Dowswell T. Routine pre-pregnancy health promotion for improving pregnancy outcomes. *Cochrane Database of Systematic Reviews* 2009( Issue 4):Art. No.: CD007536. DOI: 10.1002/14651858.CD007536.pub2.
23. Hussein N, Kai J, Qureshi N. The effects of preconception interventions on improving reproductive health and pregnancy outcomes in primary care: A systematic review. *The European journal of general practice*. 2016;22(1):42-52.
24. Elsinga J, de Jong-Potjer LC, van der Pal-de Bruin KM, le Cessie S, Assendelft WJ, Buitendijk SE. The effect of preconception counselling on lifestyle and other behaviour before and during pregnancy. *Womens Health Issues*. 2008;18(6 Suppl):S117-25.
25. Lumley J, Donohue L. Aiming to increase birth weight: a randomised trial of pre-pregnancy information, advice and counselling in inner-urban Melbourne. *BMC Public Health*. 2006;6:299.
26. Nair N, Tripathy P, Sachdev HS, Bhattacharyya S, Gope R, Gagrai S, et al. Participatory women's groups and counselling through home visits to improve child growth in rural eastern India: protocol for a cluster randomised controlled trial. *BMC Public Health*. 2015;15(1):384.
27. Nair N, Tripathy P, Sachdev HS, Pradhan H, Bhattacharyya S, Gope R, et al. Effect of participatory women's groups and counselling through home visits on children's linear growth in rural eastern India (CARING trial): a cluster-randomised controlled trial. *The Lancet Global health*. 2017;5(10):e1004-e16.
28. Prost A, Colbourn T, Seward N, Azad K, Coomarasamy A, Copas A, et al. Women's groups practising participatory learning and action to improve maternal and newborn health in low-resource settings: a systematic review and meta-analysis. *Lancet*. 2013;381(9879):1736-46.
29. Saville NM, Shrestha BP, Style S, Harris-Fry H, Beard BJ, Sengupta A, et al. Protocol of the Low Birth Weight South Asia Trial (LBWSAT), a cluster-randomised controlled trial testing impact on birth weight and infant nutrition of Participatory Learning and Action through women's groups, with and without unconditional transfers of fortified food or cash during pregnancy in Nepal. *BMC pregnancy and childbirth*. 2016;16:320.
30. Compernelle S, De Cocker K, Lakerveld J, Mackenbach JD, Nijpels G, Oppert J-M, et al. A RE-AIM evaluation of evidence-based multi-level interventions to improve obesity-related behaviours in adults: a systematic review (the SPOTLIGHT project). *International Journal of Behavioral Nutrition and Physical Activity*. 2014;11(1):147.
31. Santos I, Sniehotta FF, Marques MM, Carraça EV, Teixeira PJ. Prevalence of personal weight control attempts in adults: a systematic review and meta-analysis. *Obesity Reviews*. 2017;18(1):32-50.
32. Bhutta Z, Das J, Rizvi A, Gaffey M, Walker N, Horton S, et al. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *Lancet*. 2013;382(9890):452 - 77.
33. De-Regil LM, Harding KB, Roche ML. Preconceptional Nutrition Interventions for Adolescent Girls and Adult Women: Global Guidelines and Gaps in Evidence and Policy with Emphasis on Micronutrients. *The Journal of Nutrition*. 2016;146(7):1461S-70S.
34. Kwasnicka D, Dombrowski SU, White M, Sniehotta F. Theoretical explanations for maintenance of behaviour change: a systematic review of behaviour theories. *Health Psychol Rev*. 2016;10(3):277-96.
35. Heckhausen H. *Motivation and Action*. Berlin: Springer-Verlag; 1991.
36. Heckhausen J. *Developmental regulation in adulthood: Age-normative and sociostructural constraints as adaptive challenges*. Cambridge: Cambridge University Press; 2006.
37. Steegers EA, Barker ME, Steegers-Theunissen RP, Williams MA. *Societal Valorization of New Knowledge to Improve Perinatal Health: Time to Act*. *Paediatric and Perinatal Epidemiology*. 2016;30:201-4.
38. United Nations Secretary-General. *Global Strategy for Women's, Children's and Adolescent's Health (2016-2030)*. New York; 2015.

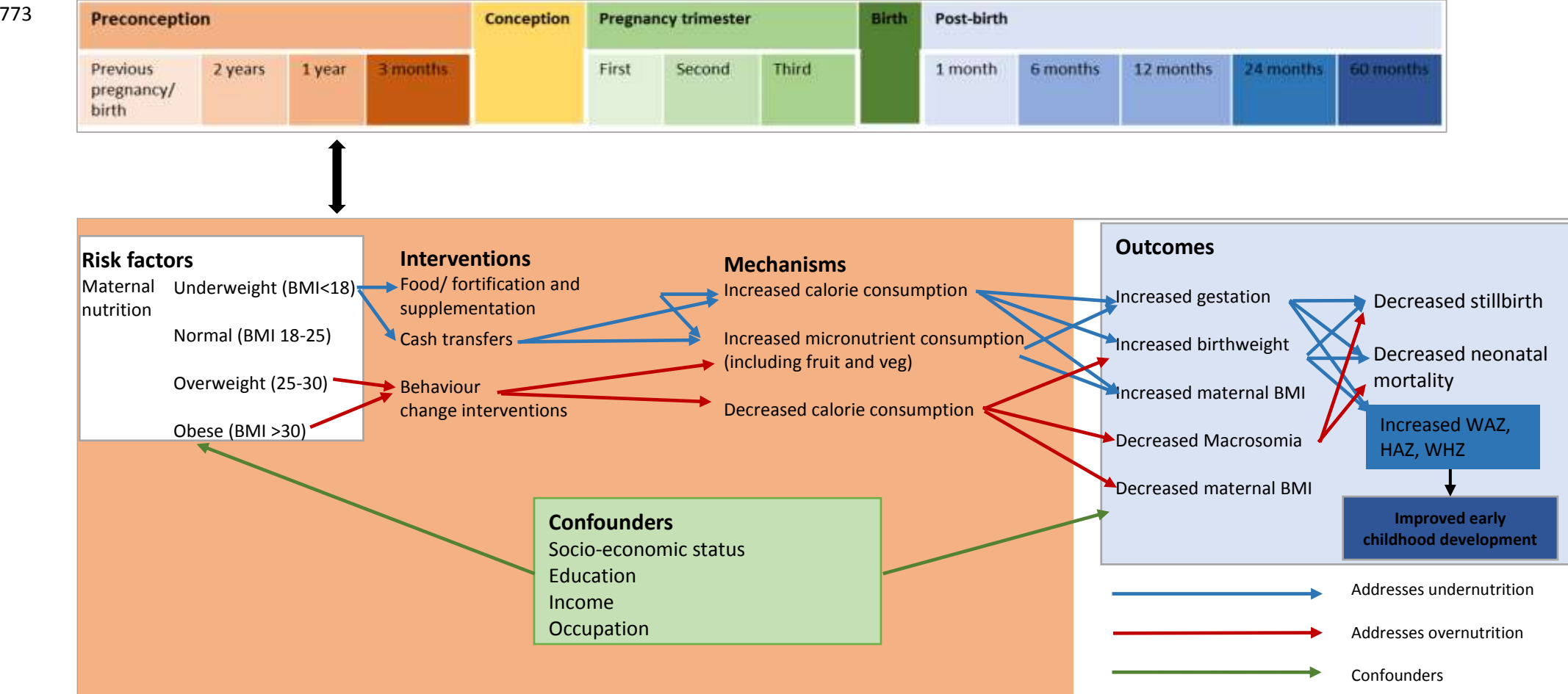
39. World Health Organisation. Global Accelerated Action for the Health of Adolescents (AA-HA!): guidance to support country implementation. Geneva: World Health Organisation; 2017. Contract No.: WHO/FWC/MCA/17.05.
40. Patton GC, Sawyer SM, Santelli JS, Ross DA, Afifi R, Allen NB, et al. Our future: a Lancet commission on adolescent health and wellbeing. *The Lancet*. 2016;387(10036):2423-78.
41. King JC. A Summary of Pathways or Mechanisms Linking Preconception Maternal Nutrition with Birth Outcomes. *The Journal of Nutrition*. 2016.
42. Bates B, Lennox A, Prentice A, Bates C, Page P, Nicholson S, et al. National Diet and Nutrition Survey: Results from Years 1-4 (combined) of the Rolling Programme (2008/2009 – 2011/12). London: Public Health England and Food Standards Agency; 2014.
43. Craigie AM, Lake AA, Kelly SA, Adamson AJ, Mathers JC. Tracking of obesity-related behaviours from childhood to adulthood: a systematic review. *Maturitas*. 2011;70.
44. Viner RM, Ross D, Hardy R, Kuh D, Power C, Johnson A, et al. Life course epidemiology: recognising the importance of adolescence. *Journal of epidemiology and community health*. 2015.
45. Vansteenkiste M, Simons J, Lens W, Sheldon KM, Deci EL. Motivating learning, performance, and persistence: the synergistic effects of intrinsic goal contents and autonomy-supportive contexts. *J Pers Soc Psychol*. 2004;87(2):246-60.
46. Blakemore SJ, Mills KL. Is adolescence a sensitive period for sociocultural processing? *Annu Rev Psychol*. 2014;65:187-207.
47. Grace M, Woods-Townsend K, Griffiths J, Godfrey K, Hanson MA, Galloway I, et al. A science-based approach to developing teenagers' views on their health and the health of their future children. *Heath Education*. 2012;112(6):543-59.
48. Woods-Townsend K, Bagust L, Barker M, Christodoulou A, Davey H, Godfrey K, et al. Engaging teenagers in improving their health behaviours and increasing their interest in science (Evaluation of LifeLab Southampton): study protocol for a cluster randomized controlled trial. *Trials*. 2015;16(1):372.
49. Michie S, West R. Behaviour change theory and evidence: a presentation to Government. *Health Psychology Review*. 2013;7(1):1-22.
50. Draper CE, Micklesfield LK, Kahn K, Tollman SM, Pettifor JM, Dunger DB, et al. Application of Intervention Mapping to develop a community-based health promotion pre-pregnancy intervention for adolescent girls in rural South Africa: Project Ntshembo (Hope). *BMC Public Health*. 2014;14 Suppl 2:S5.
51. Bhutta ZA, Lassi ZS, Bergeron G, Koletzko B, Salam R, Diaz A, et al. Delivering an action agenda for nutrition interventions addressing adolescent girls and young women: priorities for implementation and research. *Annals of the New York Academy of Sciences*. 2017;1393(1):61-71.
52. Bachrach CA, Morgan SP. A Cognitive-Social Model of Fertility Intentions. *Population and development review*. 2013;39(3):459-85.
53. Miller WB. Childbearing motivations, desires, and intentions: a theoretical framework. *Genetic, Social, and General Psychology Monographs*. 1994.
54. Nettle D. Flexibility in reproductive timing in human females: integrating ultimate and proximate explanations. *Philosophical Transactions of the Royal Society B: Biological Sciences*. 2011;366(1563):357-65.
55. Norris SA, Ho JCC, Rashed AA, Vinding V, Skau JKH, Biesma R, et al. Pre-pregnancy community-based intervention for couples in Malaysia: application of intervention mapping. *BMC Public Health*. 2016;16:1167.
56. Tuomainen H, Cross-Bardell L, Bhoday M, Qureshi N, Kai J. Opportunities and challenges for enhancing preconception health in primary care: qualitative study with women from ethnically diverse communities. *BMJ Open*. 2013;3(7).
57. Centre for Disease Control. My Reproductive Life Plan Atlanta, GA2014 [Available from: <https://www.cdc.gov/preconception/reproductiveplan.html>].

58. Black C, Lawrence W, Cradock S, Ntani G, Tinati T, Jarman M, et al. Healthy Conversation Skills: increasing competence and confidence in front-line staff. *Pub Health Nutr.* 2014;17(3):700-7.
59. Baird J, Jarman M, Lawrence W, Black C, Davies J, Tinati T, et al. The effect of a behaviour change intervention on the diets and physical activity levels of women attending Sure Start Children's Centres: results from a complex public health intervention. *BMJ Open.* 2014;4(7):e005290.
60. Lawrence W, Black C, Tinati T, Cradock S, Begum R, Jarman M, et al. 'Making every contact count': longitudinal evaluation of the impact of training in behaviour change on the work of health and social care practitioners. *Journal of health psychology.* 2016;21(2):138-51.
61. Gaziano TA, Abrahams-Gessel S, Denman CA, Montano CM, Khanam M, Puoane T, et al. An assessment of community health workers' ability to screen for cardiovascular disease risk with a simple, non-invasive risk assessment instrument in Bangladesh, Guatemala, Mexico, and South Africa: an observational study. *The Lancet Global health.* 2015;3(9):e556-63.
62. Patel V, Weobong B, Weiss HA, Anand A, Bhat B, Katti B, et al. The Healthy Activity Program (HAP), a lay counsellor-delivered brief psychological treatment for severe depression, in primary care in India: a randomised controlled trial. *The Lancet.* 2016.
63. Pechey R, Monsivais P. Supermarket Choice, Shopping Behavior, Socioeconomic Status, and Food Purchases. *American journal of preventive medicine.* 2015;49(6):868-77.
64. Vogel C, Ntani G, Inskip H, Barker M, Cummins S, Cooper C, et al. Education and the Relationship Between Supermarket Environment and Diet. *American journal of preventive medicine.* 2016;51(2):e27-34.
65. Development Initiatives. *Global Nutrition Report 2017: Nourishing the SDGs.* Bristol, UK: Development Initiatives.; 2017.
66. Hawkes C. Dietary Implications of Supermarket Development: A Global Perspective. *Development Policy Review.* 2008;26(6):657-92.
67. Hammiche F, Laven JS, van Mil N, de Cock M, de Vries JH, Lindemans J, et al. Tailored preconceptional dietary and lifestyle counselling in a tertiary outpatient clinic in The Netherlands. *Human reproduction (Oxford, England).* 2011;26(9):2432-41.
68. Twigt JM, Bolhuis ME, Steegers EA, Hammiche F, van Inzen WG, Laven JS, et al. The preconception diet is associated with the chance of ongoing pregnancy in women undergoing IVF/ICSI treatment. *Human reproduction (Oxford, England).* 2012;27(8):2526-31.
69. van Dijk MR, Koster MPH, Willemsen SP, Huijgen NA, Laven JSE, Steegers-Theunissen RPM. Healthy preconception nutrition and lifestyle using personalized mobile health coaching is associated with enhanced pregnancy chance. *Reproductive biomedicine online.* 2017;35(4):453-60.
70. Van Dijk MR, Huijgen NA, Willemsen SP, Laven JSE, Steegers EAP, Steegers-Theunissen RPM. Impact of an mHealth Platform for Pregnancy on Nutrition and Lifestyle of the Reproductive Population: A Survey. *JMIR mHealth and uHealth.* 2016;4(2):e53.
71. Lee SH, Nurmatov UB, Nwaru BI, Mukherjee M, Grant L, Pagliari C. Effectiveness of mHealth interventions for maternal, newborn and child health in low- and middle-income countries: Systematic review and meta-analysis. *Journal of Global Health.* 2016;6(1):010401.
72. Dennison L, Morrison L, Lloyd S, Phillips D, Stuart B, Williams S, et al. Does brief telephone support improve engagement with a web-based weight management intervention? Randomized controlled trial. *Journal of medical Internet research.* 2014;16(3):e95.
73. Muktabhant B, Lawrie TA, Lumbiganon P, Laopaiboon M. Diet or exercise, or both, for preventing excessive weight gain in pregnancy. *The Cochrane Database Of Systematic Reviews.* 2015;6:CD007145.
74. Tanentsapf I, Heitmann BL, Adegboye ARA. Systematic review of clinical trials on dietary interventions to prevent excessive weight gain during pregnancy among normal weight, overweight and obese women. *BMC Pregnancy and Childbirth.* 2011;11(1):81.
75. Gardner B, Wardle J, Poston L, Croker H. Changing diet and physical activity to reduce gestational weight gain: a meta-analysis. *Obesity Reviews.* 2011;12:e602-e20.

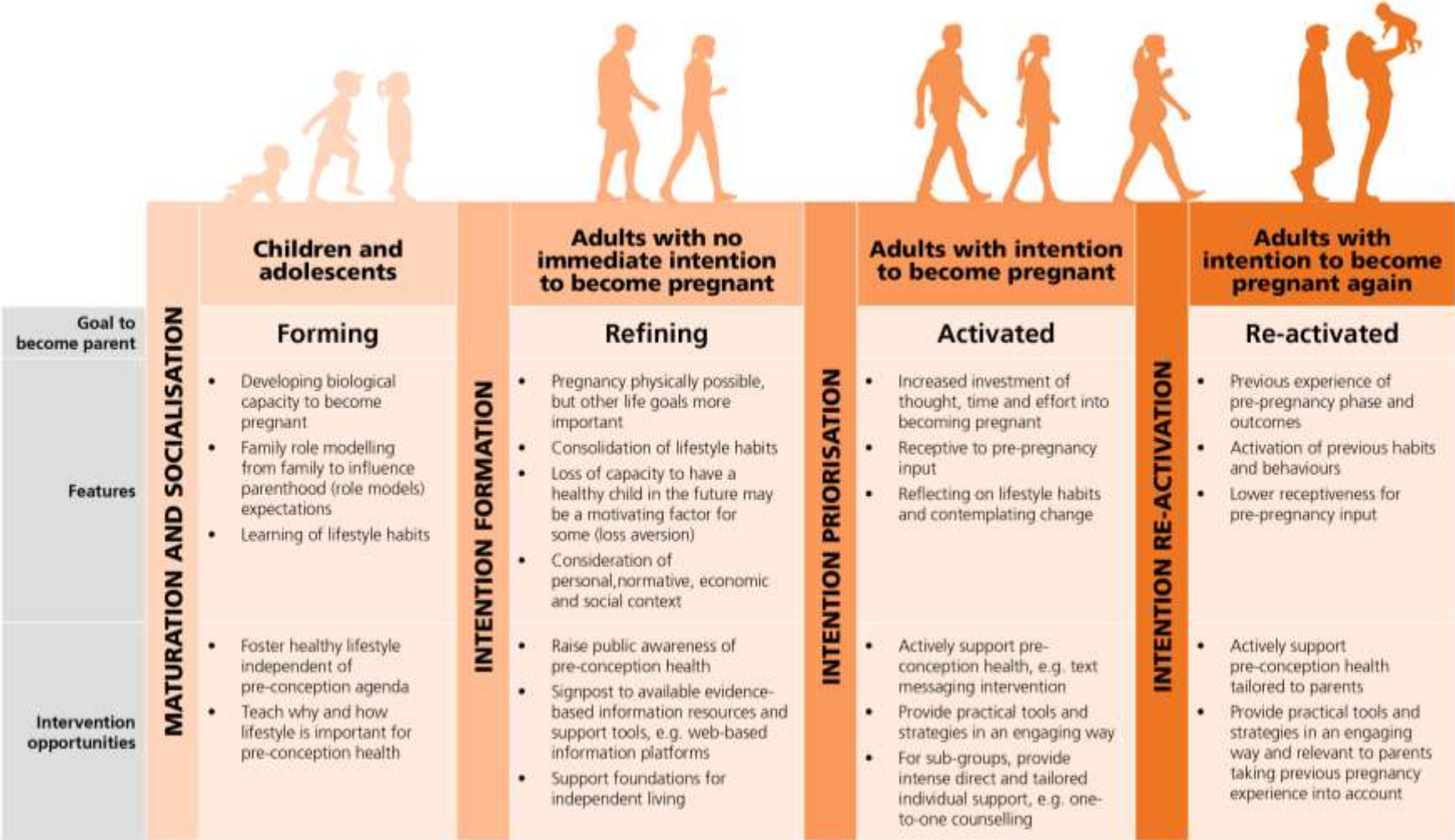
76. Flynn AC, Seed PT, Patel N, Barr S, Bell R, Briley AL, et al. Dietary patterns in obese pregnant women; influence of a behavioral intervention of diet and physical activity in the UPBEAT randomized controlled trial. *Int J Behav Nutr Phys Act*. 2016;13(1):124.
77. Dodd JM, Cramp C, Sui Z, Yelland LN, Deussen AR, Grivell RM, et al. The effects of antenatal dietary and lifestyle advice for women who are overweight or obese on maternal diet and physical activity: the LIMIT randomised trial. *BMC Med*. 2014;12:161.
78. Morrison J, Dulal S, Harris-Fry H, Basnet M, Sharma N, Shrestha B, et al. Formative qualitative research to develop community-based interventions addressing low birth weight in the plains of Nepal. *Public Health Nutr*. 2017:1-8.
79. Chorghade GP, Barker M, Kanade S, Fall CHD. Why are rural Indian women so thin? Findings from a village in Maharashtra. *Public Health Nutrition*. 2006;9(1):9-18.
80. Barker M, Chorghade G, Crozier S, Leary S, Fall C. Gender differences in body mass index in rural India are determined by socio-economic factors and lifestyle. *J Nutr*. 2006;136:3062-8.
81. Huseinovic E, Bertz F, Leu Agelii M, Hellebo Johansson E, Winkvist A, Brekke HK. Effectiveness of a weight loss intervention in postpartum women: results from a randomized controlled trial in primary health care. *Am J Clin Nutr*. 2016;104(2):362-70.
82. Peacock AS, Bogossian FE, Wilkinson SA, Gibbons KS, Kim C, McIntyre HD. A Randomised Controlled Trial to Delay or Prevent Type 2 Diabetes after Gestational Diabetes: Walking for Exercise and Nutrition to Prevent Diabetes for You. *International Journal of Endocrinology*. 2015;2015:8.
83. van der Pligt P, Willcox J, Hesketh KD, Ball K, Wilkinson S, Crawford D, et al. Systematic review of lifestyle interventions to limit postpartum weight retention: implications for future opportunities to prevent maternal overweight and obesity following childbirth. *Obesity reviews : an official journal of the International Association for the Study of Obesity*. 2013;14(10):792-805.
84. Lim S, O'Reilly S, Behrens H, Skinner T, Ellis I, Dunbar JA. Effective strategies for weight loss in post-partum women: a systematic review and meta-analysis. *Obesity reviews : an official journal of the International Association for the Study of Obesity*. 2015;16(11):972-87.
85. Neville CE, McKinley MC, Holmes VA, Spence D, Woodside JV. The effectiveness of weight management interventions in breastfeeding women--a systematic review and critical evaluation. *Birth (Berkeley, Calif)*. 2014;41(3):223-36.
86. Phelan S, Hagobian T, Brannen A, Hatley KE, Schaffner A, Munoz-Christian K, et al. Effect of an Internet-Based Program on Weight Loss for Low-Income Postpartum Women: A Randomized Clinical Trial. *Jama*. 2017;317(23):2381-91.
87. World Health Organization. Global Nutrition Targets 2025: Stunting policy brief. Geneva: World Health Organisation; 2014. Contract No.: WHO/NMH/NHD/14.3.
88. Monteiro CA, Benicio MH, Conde WL, Konno S, Lovadino AL, Barros AJ, et al. Narrowing socioeconomic inequality in child stunting: the Brazilian experience, 1974-2007. *Bulletin of the World Health Organization*. 2010;88(4):305-11.
89. Adams J, Mytton O, White M, Monsivais P. Why Are Some Population Interventions for Diet and Obesity More Equitable and Effective Than Others? The Role of Individual Agency. *PLOS Medicine*. 2016;13(4):e1001990.
90. Lorenc T, Petticrew M, Welch V, Tugwell P. What types of interventions generate inequalities? Evidence from systematic reviews. *Journal of epidemiology and community health*. 2013;67(2):190-3.
91. Kelly MP, Barker M. Why is changing health-related behaviour so difficult? *Public Health*. 2016.
92. Shove E, Pantzar M, Watson M. *The Dynamics of Social Practice: Everyday Life and how it Changes*. London: Sage; 2012.
93. Birdwell L. A study of the influence of image congruence on consumer choice. *The Journal of Business*. 1968;41(1):76.
94. Last A. *Business on a Mission: How to Build a Sustainable Brand*. Saltire, Bradford UK: Greenleaf Publishing; 2016.

95. Unilever. Knorr's Green Food Steps to improve health and livelihoods 2015 [Available from: <https://www.unilever.com/news/news-and-features/Feature-article/2015/knorrs-green-food-steps-to-improve-health-and-livelihoods.html>].
96. Swinburn B, Kraak V, Rutter H, Vandevijvere S, Lobstein T, Sacks G, et al. Strengthening of accountability systems to create healthy food environments and reduce global obesity. *Lancet*. 2015;385(9986):2534-45.
97. Weible C, Sabatier P. A Guide to the Advocacy Coalition Framework. In: F. F, G. M, M. S, editors. *Handbook of Public Policy Analysis: theory, political and methods* Florida, United States: Taylor and Francis Group; 2007. p. 123-36.
98. World Health Organisation. Meeting to develop a global consensus on preconception care to reduce maternal and childhood mortality and morbidity, 6-7 February 2012. Geneva: World Health Organization 2012.
99. Acosta AM. Examining the political, institutional and governance aspects of delivering a national multi-sectoral response to reduce maternal and child malnutrition. *Analysing nutrition governance: Brazil country report*. Brighton; 2011.
100. Kirkpatrick S, Maynard M, Raffoul A, Stapleton J. Population health interventions to curb intake of sugars: Gaps in the evidence. *The FASEB Journal*. 2017;31(1 Supplement):640.26.

771 **Figure 1: Conceptual model of pathways between interventions to improve maternal nutritional status and maternal and infant outcomes** (Figure is  
 772 colour coded such that brown box containing pathways relates to the preconception period and the blue box refers to the period post-birth.)



774     **Figure 2: Model of Pre-conception Action Phases (after Heckhausen)**



775

**Panel 1 - Key messages**

- Epidemiological data and findings from developmental biology suggest that intervening to improve men and women's nutritional status before pregnancy improves longterm outcomes for mothers and babies
- Trials of interventions to improve nutritional status before conception and birth outcomes are scarce, but new trials are underway
- Existing evidence of effectiveness of preconception nutritional interventions endorses the provision of micronutrients, mainly through supplementation or food fortification, particularly folic acid and iodine
- To maximise benefit and achieve health growth trajectories in the next generation, preconception strategies should be broader than supplementation or fortification and address the wider determinants of health
- Motivations to engage with preconception nutrition differ according to age and phase of life stage; understanding and harnessing these motivations is key to successful intervention
- Interventions need also to be context specific and to make best use of existing platforms for delivery
- Preconception interventions need to be supported by a social movement and political will, both of which may of necessity require skilful engagement with powerful commercial interests.

**Panel 2 - Ongoing trials of preconception nutrition interventions**

*NCT02509988 Nutritional Intervention Preconception and During Pregnancy to Maintain Healthy Glucose Metabolism and Offspring Health (NiPPeR study).* The study aims to assess whether a nutritional drink taken before conception and continuing through pregnancy, assists in the maintenance of healthy glucose metabolism in the mother and promotes offspring health. N=1800 women, estimated completion Oct 2018. UK, Singapore and New Zealand sites.

*NCT02989142 Inter-pregnancy Coaching for a Healthy fuTure (inter-act).* This intervention targets women with excessive weight gain in their first pregnancy, and attempts to reduce complications in the second pregnancy through an inter-partum programme of coaching combining face-to-face counselling with the use of a mobile App connected to medical devices (scale and pedometer). N=1100, estimated completion Sept 2020. Belgium.

*NCT01883193 Women First: Preconception Maternal Nutrition (WF).* Multi-country three-arm, individually randomized, non-masked, controlled trial to ascertain the benefits of ensuring optimal maternal nutrition before conception and providing an evidence base for programmatic priority directed to minimizing the risk of malnutrition in all females of reproductive age. Women required to take a lipid-based micronutrient supplement. Running in Pakistan, India, Guatemala and the Congo. N=7374, Run from University of Colorado, Denver, United States. Completion date October 2019.

*NCT02617693 Development of Pre-pregnancy Intervention to Reduce the Risk of Diabetes and Prediabetes (Jom Mama).* The aim of this study is to assess the efficacy of a pre-pregnancy intervention to reduce the risk of diabetes and prediabetes. A lifestyle intervention combines behaviour change counselling from community health promoters

(CHPs) trained in skills to support behaviour change and utilisation of an e-Health platform providing preconception information and support. N=660, estimated completion November 2017. Malaysia.

*NTR4150 Erasmus MC Care Innovation for a healthy pregnancy. Efficacy of "Smarter Pregnant", an interactive food and lifestyle coaching program on the mobile phone.* To test whether use of the "Smarter Pregnant" intervention leads to an improvement in unhealthy food habits (vegetables, fruit, folic acid use) after 6 months' intervention, measured as a decrease in the Food Risk Score of women and men with a wish to become pregnant. N = 3000, estimated completion date January 2017. Netherlands.

Four inter-linked preconception nutrition intervention trials are currently being planned by a consortium of the Canadian Institute for Health Research, the World Health Organisation, the governments of Canada, India, South Africa and China, and academic partners in each country. These randomised controlled trials which are part of *the Healthy Lifestyles Trajectory Initiative (HeLTI)* aim to test the effect of a package of nutritional and lifestyle interventions before conception on body composition of the offspring. They are currently in planning with the aim of beginning in October 2017.

An additional trial below which is not a preconception trial but which will have implications for understanding the value of cash transfers and participatory women's groups in improving the nutritional status of women of childbearing age:

*ISRCTN75964374 The Low Birth Weight in South Asia Trial (LBWSAT)* This cluster randomised controlled trial aims to identify the most cost effective means of increasing birthweight by comparing birthweight in current programme areas with birthweight in areas where one of

three combinations of interventions is conducted:(i) a behaviour change strategy (BCS) involving working with participatory women's groups and other community members to change pregnant women's eating behaviour to increase their intake of nutritious food; (ii) and (iii) combine this BCS with provision of a food supplement or a cash payment respectively. The primary outcome of the trial is birthweight accurate to 10g measured within 72 hours of birth. N = 17,000 pregnant women; 13,000 babies from 80 study areas in southern Nepal. Completion date unknown.

861

862 **Panel 3 - Motivations for engagement in interventions to improve preconception health**

863 In the development of the Jom Mama intervention, 18 couples were interviewed about their  
864 motivations to engage with the intervention programme and to improve their health before  
865 conception. Having a healthy pregnancy and a healthy child were clear motives for improving diet  
866 and lifestyle:

867 *Because I want to conceive as I've never conceived before. So getting pregnant will motivate us.*

868 Respondent 12

869 *I wanted to be healthy for myself and for my child...I think my commitment as a wife and mother is*  
870 *important.* Respondent 10

871 Interviewees suggested a range of incentives including financial and personalised support from  
872 healthcare staff would sustain their engagement in a programme of diet and lifestyle improvement,  
873 as would stories from others at the same stage of life. They also proposed that programme content  
874 should be simple, attractive, and specifically targeted to them and that it should not interfere with  
875 their working hours, suggesting therefore that delivery be on a digital platform, accessible at their  
876 convenience.

877 Participants in Jom Mama described a number of features of their lives as young, working people  
878 that acted as barriers to improving their diets and physical activity levels in preparation for  
879 pregnancy.

880 Working patterns:

881 *I usually don't take breakfast ...and then I start work, rest at 12.30pm, but if I'm too busy I don't rest*  
882 *until the evenings, sometimes at 6pm, sometimes until 8, 9pm only then I go home.* Respondent 8

883 Eating habits:

884 *Sometimes I have lunch at 12 noon...sometimes at 3pm...it's uncertain* Respondent 13

885 Exercise:

886 *Not after marriage...can't make it in the evening. No time* Respondent 01

887 In the UK, women who had recently had a child and were attending routine appointments with  
888 health visitors were approached and asked whether they would be planning another pregnancy in  
889 the following 12 months. Those who indicated they would be interested were invited to participate  
890 in a pilot study of the effectiveness of the *Smarter Pregnancy* intervention and subsequently provide  
891 an in-depth interview. Fifteen women were interviewed and their views of preconception care were  
892 sought.

893 Women felt that just because they had already had a baby did not mean they were aware of what  
894 was required for a healthy conception and pregnancy. Because of their involvement in the inter-  
895 conception study, they accepted that preconception care was important, something they may not  
896 have considered before:

897 *We've not had something like this before and I felt like, at that time when I wanted to get pregnant...*  
898 *you don't know, even though you've had three kids already before. You just forget everything.*  
899 (Woman 31, married with 3 children aged 14, 8 and 4)

900 *I know [now] that our body has to be ready before we get pregnant. You need to be prepared.*  
901 *Everything has to be enough. Since then, I know, I start to understand you have to eat enough*  
902 *vitamins to get pregnant. (Woman 31, married with 2 children - a baby and a 10 year old.)*

903 When they discussed the implications of their new understanding, women highlighted the  
904 importance of improving their health prior to conceiving, with specific focus on improving their diet  
905 and being a healthy weight:

906 *In terms of...sometimes, you lose track of what is healthy. So that is when I had to relook at my diet*  
907 *in terms of having more vegetables and then taking my folic acid and looking at all of these healthy*  
908 *things. (Woman 40, previous still birth, currently pregnant)*

909 Key sources of information for preconception care were the internet and friends and family. There  
910 was a desire for reliable and accredited sources of information to put couples' minds at ease. What  
911 the women said suggests there is an evident gap in current provision of preconception health  
912 information:

913 *I think the problem is if people don't know, they go to Google. And you go to Google, and you get*  
914 *some chat on Mumsnet. And it's a load of women feeding other women garbage... there's so much*  
915 *false information out there. But if you don't know that, you go "This is what it means." Stuff like this*  
916 *[the intervention material] just keeping people on the straight and narrow is quite helpful. (Woman*  
917 *32, one child aged 1 year, recent miscarriage)*

918 There was agreement amongst women that healthier lifestyles can contribute to healthier  
919 pregnancies, a reflection that they had not considered this for their previous pregnancy and an  
920 intention to improve their nutritional status in preparation for the next pregnancy. All of which  
921 suggests that the inter-partum period might be a fruitful time to engage women in preconception  
922 health care.

923 Footnote:

924 In the UK, women are under the care of the community health visiting services from pregnancy up to  
925 5 years of age of the child.

926

927