

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

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Accepted refereed manuscript of: Barker M, Dombrowski SU, Colbourn T, Fall CHD, Kriznik NM, Lawrence W, Norris SA, Ngaiza G, Patel D, Skordis-Worrall J, Sniehotta FF, Steegers-Theunissen R, Vogel C, Woods-Townsend K & Stephenson J (2018) Intervention strategies to improve nutrition and health behaviours before conception. *Lancet*, 391 (10132), pp. 1853-1864. DOI: <https://doi.org/10.1016/S0140-6736%2818%2930313-1>

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32 **Abstract**

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

56

57 **Introduction**

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

73 **Method**

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

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

83 **Current strategies for preconception nutrition intervention**

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

93 *Supplementation and food fortification*

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

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

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

122 *Cash transfers/incentives*

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

130 *Behaviour change interventions*

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

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

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

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

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

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

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

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

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

- 180 3. The goal to become a parent is nested within other facilitating and conflicting
181 developmental lifecourse goals, which are pursued as opportunities evolve over time.
- 182 4. Motivation to become a parent is the driver that translates that goal into relevant
183 preconception behaviours.
- 184 5. Translating the goal to become a parent into conception and pregnancy outcomes is
185 imperfect.

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

197 *Intervening with children and adolescents*

198 In the first phase of Preconception Action, motivation to become a parent, forms without any
199 physical capability for childbearing, which changes as children develop into adolescents. Laying
200 foundations for a healthy life is essential at this time for reasons independent of any preconception
201 health agenda, but given the general low level of awareness of healthy preparation for pregnancy as
202 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

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

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

298 *Interventions with adults intending to become pregnant*

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

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

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

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

325 *Interventions with adults intending to become pregnant again*

326 In the fourth phase, the goal to become a parent is re-activated. Preparation for this pregnancy is
327 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-

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

356 Many post-partum randomised studies report low recruitment or retention rates however; post-
357 partum mothers report multiple barriers to participation, including little spare time, stress and sleep
358 deprivation. Interventions may need to take a supportive approach involving home visits, provision
359 of foods and/or childcare, and/or self-monitoring facilities such as weighing scales.(85) One solution
360 may be to integrate in-person support for inter-partum behaviour change with a digital service.

361 Postpartum weight retention is associated with lifetime obesity risk and adverse outcomes in the
362 next pregnancy. A recent, cluster randomised trial of an internet-based weight loss programme
363 coupled with face-to-face support (Fit Moms/Mamás Activas) in low-income women in California,
364 USA, found that women in the intervention group maintained significantly greater weight loss at 12
365 months than women who were not randomised to the intervention (3.2kg versus 0.9kg; difference
366 2.3 kg (95% CI, 1.1 to 3.5). (86)

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

368 A social movement to optimise preconception health, nutritional status and health behaviours needs
369 to involve the whole population and harness political will and leadership. A social movement in
370 Brazil led to significant improvements in preconception nutrition for women and virtual eradication
371 of undernutrition and wasting among children under-five between 1994 and 2006.(87, 88) The
372 movement involved i) a 'National Campaign against Hunger' that raised public awareness of the
373 need to tackle malnutrition and ii) development of an advocacy coalition with political affinities that
374 created a critical mass of activists and monitored government's progress in reducing malnutrition.
375 Eradicating malnutrition became a high-profile social responsibility, prompting strong leadership
376 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

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

452 **Conclusions**

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

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

470

471 **Contributors**

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

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

481

482 **Declaration of interests**

483 We declare no competing interests.

484 **Acknowledgments**

485 The idea for this series was conceived by Judith Stephenson and developed during a four day
486 symposium, led by Mary Barker and Judith Stephenson and funded by The Rank Prize Funds, on
487 'Preconception Nutrition and Lifelong Health' in Grasmere, UK, February 2016. We thank a number
488 of individuals who have contributed their thoughts and time to this paper: Nicola Heslehurst for her
489 contribution to an early draft of this paper; Zulfi Bhutta for his perspectives on interventions in
490 LMICs; Chandni Jacob and Mark Hanson for their contribution to the review; Jayne Hutchinson and
491 Janet Cade for advice on fortification; Matthijs van Dijk for data from Smarter Pregnancy; Julius
492 Cheah and the Ministry of Health Malaysia for data from the Jom Mama Project; Mike Kelly for
493 discussions on the value of social practices; and Andy Last for his insights into how a social
494 movement might be created around preconception health.

495

496

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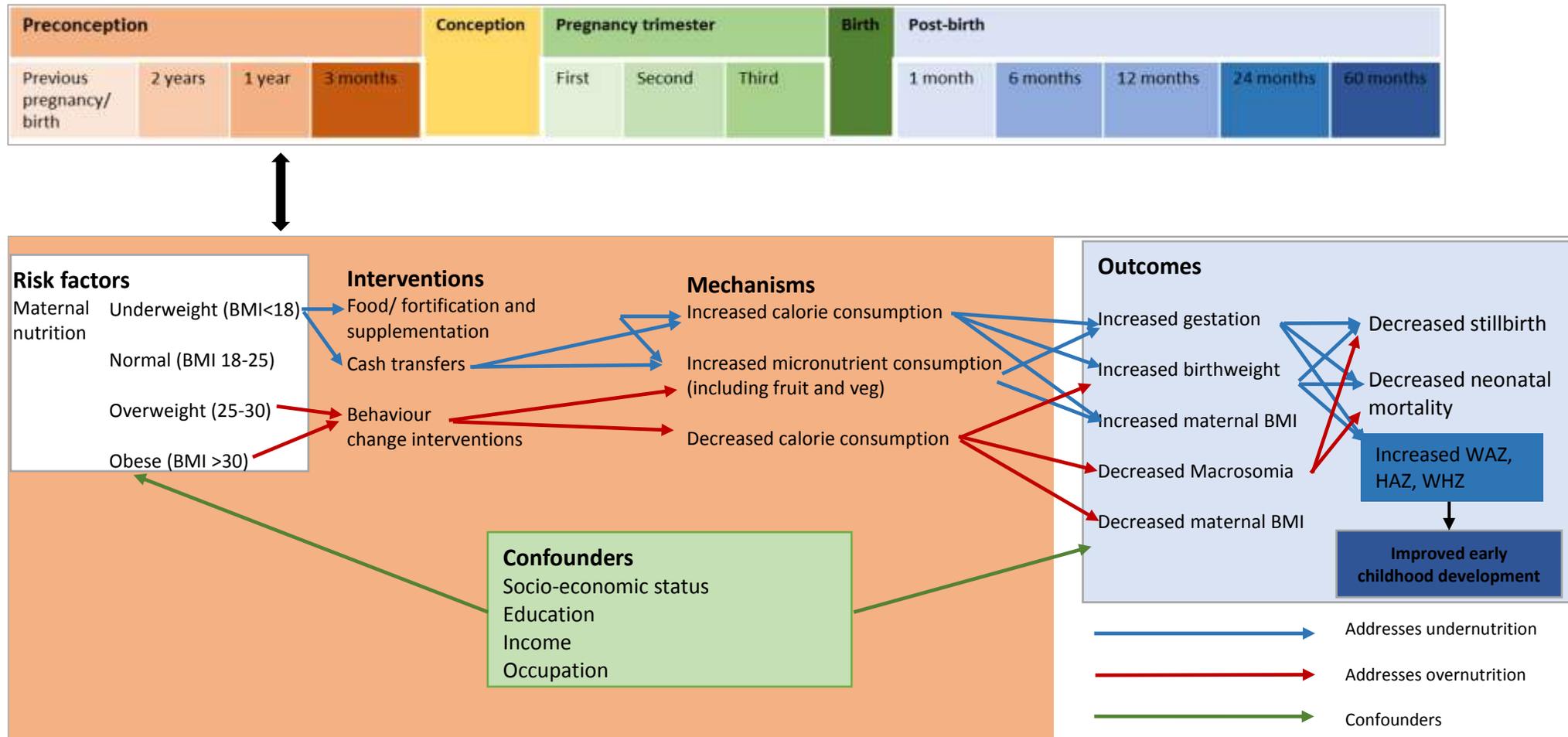
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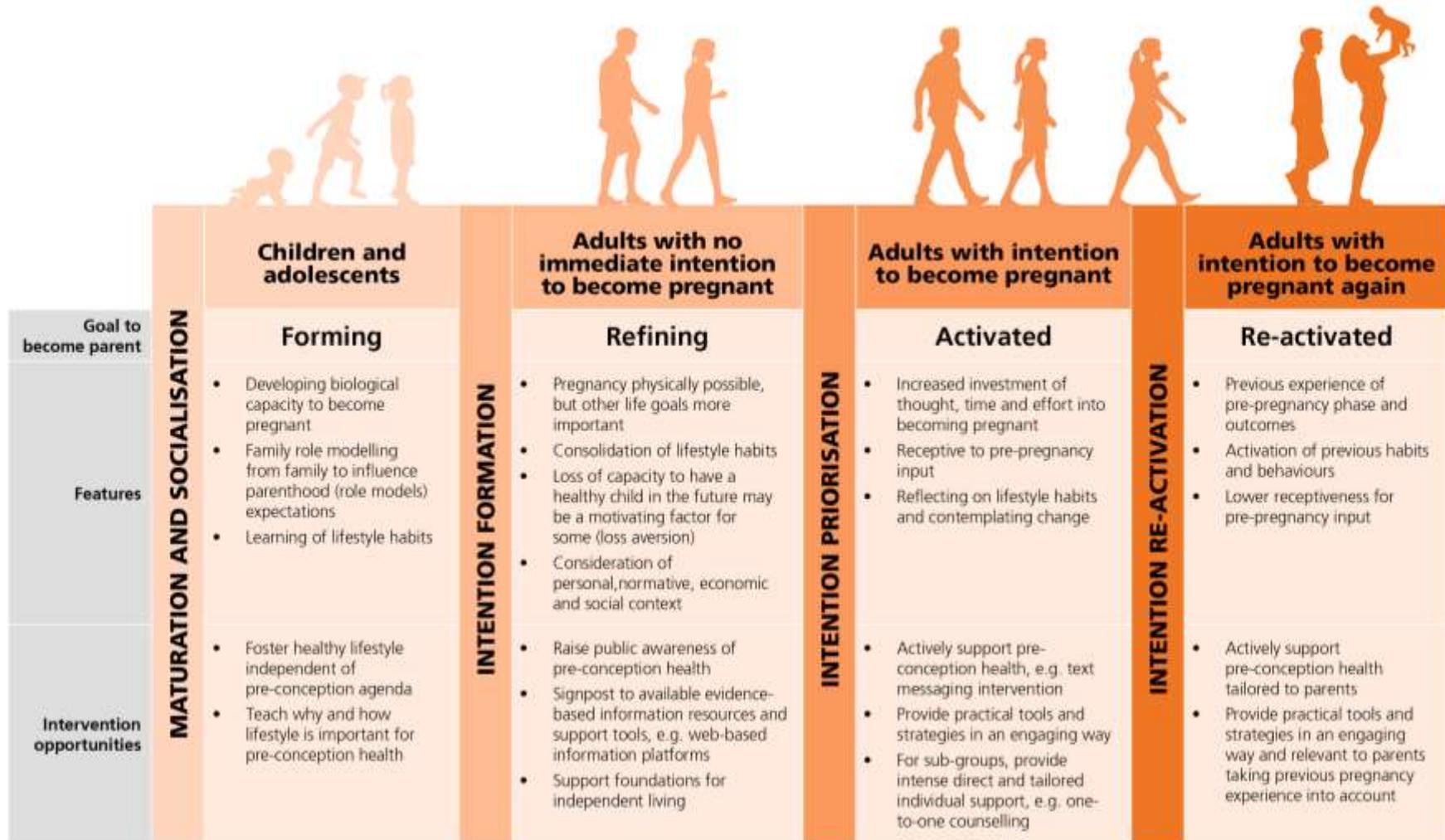
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771 **Figure 1: Conceptual model of pathways between interventions to improve maternal nutritional status and maternal and infant outcomes** (Figure is
 772 colour coded such that brown box containing pathways relates to the preconception period and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

773



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



775

776 **Panel 1 - Key messages**

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

796

797

798

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

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

806
807 *NCT02989142 Inter-pregnancy Coaching for a Healthy fuTure (inter-act)*. This intervention
808 targets women with excessive weight gain in their first pregnancy, and attempts to reduce
809 complications in the second pregnancy through an inter-partum programme of coaching
810 combining face-to-face counselling with the use of a mobile App connected to medical
811 devices (scale and pedometer). N=1100, estimated completion Sept 2020. Belgium.

812
813 *NCT01883193 Women First: Preconception Maternal Nutrition (WF)*. Multi-country three-
814 arm, individually randomized, non-masked, controlled trial to ascertain the benefits of
815 ensuring optimal maternal nutrition before conception and providing an evidence base for
816 programmatic priority directed to minimizing the risk of malnutrition in all females of
817 reproductive age. Women required to take a lipid-based micronutrient supplement. Running
818 in Pakistan, India, Guatemala and the Congo. N=7374, Run from University of Colorado,
819 Denver, United States. Completion date October 2019.

820
821 *NCT02617693 Development of Pre-pregnancy Intervention to Reduce the Risk of Diabetes*
822 *and Prediabetes (Jom Mama)*. The aim of this study is to assess the efficacy of a pre-
823 pregnancy intervention to reduce the risk of diabetes and prediabetes. A lifestyle
824 intervention combines behaviour change counselling from community health promoters

825 (CHPs) trained in skills to support behaviour change and utilisation of an e-Health platform
826 providing preconception information and support. N=660, estimated completion November
827 2017. Malaysia.

828

829

830 *NTR4150 Erasmus MC Care Innovation for a healthy pregnancy. Efficacy of "Smarter*
831 *Pregnant", an interactive food and lifestyle coaching program on the mobile phone. To test*
832 *whether use of the "Smarter Pregnant" intervention leads to an improvement in unhealthy*
833 *food habits (vegetables, fruit, folic acid use) after 6 months' intervention, measured as a*
834 *decrease in the Food Risk Score of women and men with a wish to become pregnant. N =*
835 *3000, estimated completion date January 2017. Netherlands.*

836

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

844

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

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

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

858

859

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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