



Periconception mHealth platform for prevention of placental-related outcomes and non-communicable diseases



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ABSTRACT

Most placental-related pregnancy complications originate during the first trimester of pregnancy where gene-environmental interactions play a role. The environmental factors also include parental behaviors that can be positive, such as folic acid supplement use, or negative, e.g. poor lifestyle choices like smoking, and nutritional choices that contribute to obesity or micronutrient deficits. The overlapping risk factors associated with non-communicable disease are poor nutrition, smoking, and obesity. These modifiable factors differ between individuals, populations and high, middle and low income countries, but have in common that they are extremely difficult to change. Parents-to-be however are most motivated to change poor behaviors when they are aware of short-term health benefits of having a healthy baby. Therefore, these couples should be empowered to use evidence-based and personalized effective tools to improve poor behaviors. Moreover, these tools should be implemented to support healthcare professionals in delivering 'nutrition and lifestyle care' in routine patient care. From this background the usability and effectiveness of the mHealth coaching program www.SmarterPregnancy.co.uk (Dutch version www.SlimmerZwanger.nl) is presented as an opportunity to further customize this tool for specific target groups, healthcare professionals and low resource settings with the potential to prevent placental-related and non-communicable disease during the life course.

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1. Introduction

The worldwide epidemic of non-communicable diseases (NCD), including obesity, cardiovascular-metabolic and psychiatric diseases, is a burden to which poor nutrition and lifestyle behaviors with a prevalence up to 80% significantly contribute [1]. Unfortunately, nutrition and lifestyle care is a gap in general patient health care. Research has demonstrated that poor maternal nutrition and obesity during pregnancy is associated with placental-related outcomes, such as low birth weight and preeclampsia, and subsequent increased risks of NCD already in childhood [2]. New knowledge reveals that poor behaviors in the largely ignored periconception period may enhance adverse pregnancy outcomes and susceptibility to NCD with transmission into succeeding generations [3,4]. This may partially explain why preventive interventions and strategies in adulthood are less effective to reduce the burden of these disease risks and therefore should be focused at this early moment in life.

2. Periconception and pregnancy life course and health outcome

The preconception phase is a time span of 14 weeks prior to conception. Together with the following 10 weeks after conception, this is defined the periconception phase [5]. The most prevalent adverse reproductive and placental-related outcomes largely originate in this early phase of life. This is a largely neglected period of life by both the woman and her partner, but also by healthcare professionals. Therefore, it is challenging to target this group in time for preconception interventions and care (primary prevention). In Europe, every year around 8 million couples are in the preconception phase contemplating pregnancy of which approximately 7 million become pregnant from which only 5 million babies are born. Approximately 17% (1 million each year) of these babies suffers from a BIG 3 outcome, i.e., preterm birth (9%), congenital malformation (2%), and low birth weight (6%). These three outcomes determine 83% of the perinatal mortality rate, which varies in Europe between 4.7 per 1000 babies in Finland up to 9.7 per 1000 in the Netherlands [6]. The perinatal mortality rate

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is a measure of health and prosperity and is not limited to the baby. Perinatal mortality and morbidity are the tip of the iceberg when it concerns problems in the growth and development of babies and of health during the life course. The evidence is overwhelming that babies born after a placental-related complication, such as low birth weight, have an increased risk of NCD in later life [7]. Specific risk groups are the offspring of obese, socially deprived, and sub-fertile women [8].

Maternal and paternal (genetic) conditions and environmental influences, such as maternal folic acid supplement use, nutrition and lifestyle, affect the preconception maturation of the gametes and the growth of the embryo in early pregnancy. Poor quality of gametes, containing the genetic material of the future embryo, is associated with subfertility and placental-related outcome [9]. Recent insights demonstrate that embryonic health, estimated by growth and development, is not the same but differs between pregnancies, conditions and environmental influences. In addition, embryonic health is associated with fetal growth and birth weight of the baby. Moreover, being small as an embryo is associated with an increased risk of adverse placental-related outcome [4]. The lasting impact of embryonic growth and development demonstrates the need for the general availability and accessibility of evidence-based preconception care. Preconception and early pregnancy have been largely neglected as phases of the life course. Recent discoveries of their significance for lifelong health and disease suggest that there is an urgent need for the development and implementation of nutrition and lifestyle support that is easily accessible, anonymous, evidence-based, personalized, effective and empowering. mHealth tools offer a cheap and sustainable solution.

3. Dietary habits and lifestyle

During the periconception and pregnancy period the most prevalent nutritional risk factor is the adherence to a Western dietary pattern, characterized by an inadequate intake of vegetables and fruits and excessive intakes of carbohydrates, saturated fats and animal proteins [10]. The strongest and most prevalent lifestyle risk factors are smoking (>10%) and social alcohol use (>14 alcoholic drinks each week) [11]. It is well known that in particular these modifiable behaviors all contribute to NCD, but unfortunately not many citizens, health care professionals, stakeholders and politicians are aware that the same poor dietary habits and lifestyle are associated with a 1.3–1.9 fold increased risk of subfertility and 1.6–4.8 fold increased risk of BIG3 outcome [12,13]. This means that only in Europe each year 1 million couples experience subfertility and nearly 1 million babies are born with preterm birth, low birth weight or congenital malformation all with lifelong increased risks of NCD.

The nutrition of women and men during the periconception and pregnancy life course is increasingly important for the nourishment of the female and male gametes. During this early phase reproductive tissues of especially the woman also have to be replenished with essential nutrients to cover the nutritional needs of the embryo as well as the placenta during the first trimester. Indeed, the evidence addressing the detrimental influences of a qualitative poor diet in the preconception and pregnancy life course is overwhelming [5]. Moreover, obesity, a resulting phenotype of a qualitative poor diet and a more sedentary lifestyle, and social deprivation are in a similar manner associated with increased risks of subfertility and adverse placental-related outcomes. Beneficial effects have been observed from strong adherence to the Mediterranean diet, a dietary pattern rich in olive oil, vegetables and fish, such as a 40% increased chance of pregnancy after fertility treatment, a 70% reduced risk of spina bifida, a nearly 3-fold increased risk of low birth weight and growth restriction, and a

twofold increased risk of a baby with cleft lip and or palate [5,14]. Moreover, in man strong adherence to the traditional Dutch dietary pattern comprising of large amounts of vegetables, potatoes, meat and gravy, or Western diet, a dietary pattern rich in saturated fats, animal proteins and refined sugars, increased and decreased sperm count with 50% and 40%, respectively [15]. Some of these data have already been confirmed by others.

Natural folate is an important substrate of the one-carbon metabolism, in which one-carbon groups are provided for essential cellular processes such as the synthesis of proteins, lipids, DNA, RNA, and methylation of chromatin. As the preconception and pregnancy life course is a period of rapid growth and numerous cell divisions, folate requirements are increased. In addition, preconception use of synthetic folic acid supplements has been proven to prevent neural tube defects by more than 70%, which has led the World Health Organization to recommend folic acid supplement use from the preconception period up to 12 weeks of pregnancy. Despite public health campaigns only 10–50% of women uses a folic acid supplement in the periconception period [16]. Due to the high stability and bioavailability of the synthetic folic acid form, maternal folate status is strongly determined by folic acid supplement use. However, folate-rich dietary intakes of vegetables and fruits, metabolism, the use of medication, smoking, alcohol use and health conditions, and genetic variations in folate genes also affect folate status. Evidence is accumulating that folic acid supplement use during the first trimester also increases birth weight. Epigenetic effects of periconception folic acid supplement use are demonstrated in association with birth weight in an opposite direction as has been shown 60 years after prenatal exposure to the Dutch Hunger winter [17,18]. This might be one of the molecular biologic mechanisms underlying the association between poor dietary habits and lifestyle, and low birth weight and fetal growth restriction and the increased risk of NCD. Smoking and alcohol use are also associated with increased risk of NCD. Smoking has been recognized as one of the strongest risk factor for subfertility and fetal growth restriction [19]. Women who smoke have a higher risk of subfertility and of having a baby with low birth weight and growth restriction or stillborn. Epidemiological data also point to a detrimental effect of smoking on semen parameters. Smoking in man is associated with a poor sperm quality and sperm damage [20]. Excessive alcohol consumption decreases fertility of both women and men. The amount of safe alcohol consumption associated with adverse reproductive and pregnancy outcome is not clear. However, social alcohol use reduces the chance of pregnancy with 40–70% [21]. Alcohol use during pregnancy is also associated with increased risks of BIG3 outcome [22].

4. Smarter pregnancy mHealth tool

Nowadays an enormous advantage is that the current reproductive population is used to internet and socio media. Because of the great need of personal and evidence-based nutrition and lifestyle coaching, the online Dutch platform Smarter Pregnancy (www.slimmerzwanger.nl) have been developed and launched in 2011 as online application on the smartphone or mobile phone in combination with internet connection via the computer for use by couples during the periconceptional and pregnancy period (English version www.smarterpregnancy.co.uk).

This mHealth platform consists of a screening module on the website that generates via algorithms, a personal risk profile that is linked to a 6 months individual coaching program with interactions by short message services, email and website containing incentives, tips, tricks, recipes and rewards [23]. This makes the user aware, motivates and empowers them to adopt a healthier lifestyle depending on personal lifestyle risk factors and conditions such as



Fig. 1. Periconception mHealth platform for prevention of placental-related outcomes and non-communicable disease.

gender, medication use, fertility and antenatal treatment, and pregnancy status. The Smarter Pregnancy platform received a CE-1 marking which means that it can be used in medical care because of its compliance to the highest guidelines regarding legislations on safety of medical devices in Europe. In a recent survey of more than 2000 participants, we have shown that nearly 65% completed the 6 months coaching, approximately 30% improved intakes of vegetables, fruit and folic acid, stopped smoking and alcohol use, and a 20–40% increased pregnancy rate was established [23]. This mHealth platform is now being implemented in patient care with support of organizations of health care professionals, patient organizations and one of the largest health care insurance companies in the Netherlands, who reimburse the costs of a subscription. Opportunities to involve multiple stakeholders are explored and will further stimulate the implementation in routine preconception and pregnancy care.

5. Conclusion

The periconception window comprises a time span from 3 months before conception up to 3 months thereafter. Poor nutrition and lifestyles in women during this time span, but also in men, can lead to impaired development of gametes, embryo and placenta. This contributes to short-term adverse reproductive and placental-related outcomes, but also to subsequent sequelae for health and NCD during the life course. Therefore, the responsibility should be taken by parents-to-be as well as health care professionals to prevent these individual and modifiable behaviors already before conception or at least shortly thereafter (Fig. 1). Because it is generally accepted that poor nutrition and lifestyles are extremely difficult to change, the targets groups should be empowered with easily accessible, personalized, individual and evidence based effective tools to accomplish this ambition. Therefore, adopting a life course approach from the periconception period onwards and integrated in patient care may have an important impact on not only the prevention of short-term placental-related outcomes, but also of NCD during the lifecourse.

Currently the Smarter Pregnancy platform has been translated into the English language and is being tested in the UK. Several other universities and hospitals in Europe as well as USA, Canada, Pakistan, India and Africa (LMIC) have shown their interest to customize and implement the Smarter Pregnancy platform into their own (clinical) and low resource settings.

In addition, it is an excellent platform for research (harmonizing study protocols, data collection and sharing), dissemination of new knowledge and societal valorization by multiple stakeholders (food industry, health care insurances, drugstores, pharmaceutical industry etc).

The implementation of personalized and individual evidence-based programs on a mHealth platform will contribute to our ambition to provide as well as improve the quality of preconception and pregnancy care with the ultimate aim to enhance health and prevent NCD of future generations and to reduce related health care and societal costs.

If you are interested in developing your own online mHealth Smarter Pregnancy platform on the smartphone with personalization on language, culture, clinical care and target group, please contact us on slimmerzwanger@erasmusmc.nl or r.steegers@erasmusmc.nl.

Conflict of interest

From 2016 RPMST is CEO of eHealth Care Solutions and CSO of Slimmere Zorg BV.

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