Teenage Obese Pregnancy: The "Double Burden" of Age and Excessive Weight on the Mother-Offspring Pair's Health

Cristiana Berti[1], Zulfiqar A Bhutta[2,3], Patrick Catalano[4], Shirin Elahi[5], Mark Hanson[6], Michael B Krawinkel[7], Valeria Savasi[1] and Irene Cetin[1,*]

[1]*Department of Biomedical and Clinical Sciences, University of Milan, Milan, Italy*

[2]*Centre for Global Child Health, The Hospital for Sick Children, Toronto, Canada*

[3]*Center of Excellence in Women and Child Health, The Aga Khan University, Karachi, Pakistan*

[4]*Department of Reproductive Biology, Center for Reproductive Health, Case Western Reserve University at Metro Health Medical Center, Cleveland, Ohio, USA*

[5]*Normann Partners, Stockholm and London*

[6]*Institute of Developmental Sciences and NIHR Biomedical Research Centre, University of Southampton and University Hospital Southampton, UK*

[7]*Institute of Nutritional Sciences – International Nutrition, Justus-Liebig-University, Giessen, Germany*

Abstract: Obesity and pregnancy are a combination that may create unique interconnected challenges for the health of the next generation. Although pregnant obese adolescents are of concern worldwide, yet it is an issue that is currently unattended to. Here, we provide an overview of the implications for the mother-offspring pair's health associated to teenage-pregnancy, with a focus on obesity and 'what works' to prevent the obesity-risk during pregnancy. Interrelated health-issues are highlighted, which include: increased negative consequences related to childbearing at young age; associations of maternal pre-gravid excessive-weight with maternal and fetal complications; and limited evidence addressing obese pregnancy in adolescents. Targeting adolescents appears the most effective approach to reduce the obesity-risk trajectory of the prospective parents early-in-life, thus breaking the intergenerational cycle of non-communicable diseases. Specifically-focused educational programs with clear and motivational messages about nutrition, physical activity and sexual health, are perceived as key-components of preventive campaigns with digital web-based technology and specialized health-services being the most promising platforms to deliver knowledge. Successful education has a double advantage: to establish healthy behaviors among adolescents at an early-stage of life, thereby preventing both obesity and early pregnancy. Lastly, realistic solutions require also political understanding and commitment.

Keywords: Adolescents, Pregnancy complications, Non-communicable diseases, Dietary-lifestyle interventions, Education, Food environment, Physical activity.

INTRODUCTION

"A transitional period between childhood and adulthood, adolescence provides an opportunity to prepare for a healthy productive and reproductive life, and to prevent the onset of nutrition-related chronic diseases in adult life, while addressing adolescence-specific nutrition issues and possibly also correcting some nutritional problems originating in the past" [1].

According to the Developmental Origins of Health and Disease (DOHaD), early life environmental exposures impact later-life risk of non-communicable diseases (NCDs) [2]. Proper nutrition early in life is crucial for the overall health of the next generations [3], and nutrition status has a broad range of multifaceted determinants [4, 5].

It is becoming increasingly evident that adolescent girls should be addressed in nutrition intervention programs as an "*entry-point*" to improve the health of women and children and to break the intergenerational cycle of malnutrition and NCDs [6, 7]. Investing in adolescents can accelerate the fight against deprivation, inequity and gender-discrimination in light of major epidemiologic evidence. In particular, adolescent population is going to increase so that the figure of 1.2 billion adolescents [aged 10–19 years), who accounted for approximately one fifth of the world's population in 2010, is predicted to increase until 2050 [8].

In this context, each year, an estimated 16 million of births worldwide occur in girls aged 15–19. Pregnancy- and childbirth-related complications account for nearly

*Address correspondence to this author at the Department of Biomedical and Clinical Sciences, University of Milan, via Castelvetro, 32, 20154 Milan, Italy; Tel: +39 02503 19618; Fax: +39 02 5031 9806; E-mail: irene.cetin@unimi.it

E-ISSN: 2311-8687/19

50,000 deaths of adolescent girls [8]. Pregnancy in adolescents carries a higher risk of complications and mortality in mothers and children, and poorer birth outcomes than in adult women [9, 10]

Overweight/obesity in female 10–24 year olds has increased between 1990 and 2013, with a prevalence of nearly one out of five young people in NCDs-predominant countries [7]. This burden poses serious threat to health from childhood to adulthood, including the spreading of NCDs in young people [7]. Indeed, overweight and obesity have pervasively increased in all age-groups due to the rapid shifts of contemporary food patterns towards diets dominated by higher intake of energy-dense/nutrient-poor foods and sugar-sweetened beverages along with sedentary lifestyles [11, 12]. Of alarm, the co-existence of under- and over-nutrition leads to the so-called "dual burden of malnutrition" [13, 14]. Individuals experiencing a dual burden of malnutrition may suffer of overweight/obesity coupled with micronutrient deficiencies, or stunting co-occurring with high levels of central adiposity [13].

Accessibility may represent an opportunity because adolescents are usually in education systems, and are therefore a captive audience for education on broader lifestyle and nutrition issues, should educators manage to harness their potential.

The potential of these data on adolescents' health and wellbeing is of great concern. The health of pregnant adolescents may contribute to the health of the next generation by affecting developing fetus and child [6]. Hence, we explore and discuss the state of knowledge regarding the risks and challenges related to adolescent pregnancy, with a specific focus on obesity, in the attempt to provide policy-makers, practitioners and academics with suggestions for preventive nutrition-based strategies to break the intergenerational cycle of malnutrition and NCDs. The issues were addressed according to the following framing: what is known about the challenges of childbearing at young age in the mother-offspring pair's health; what is known about the consequences of excessive weight on maternal metabolic- and obstetric-complications as well as fetal overweight; and what are the opportunities and challenges for progress in establishing healthy behaviors of parents-to-be to prevent both obesity and pregnancy during adolescence.

GAPS IN THE CURRENT STATE OF KNOWLEDGE

Shortcomings exist in the available evidence concerning risks and challenges related to adolescent pregnancy owing to the paucity of available studies addressing the impact of obesity as it relates to teenage pregnancy, and the lack of information on biological mechanisms behind relationships between teenage pregnancy and outcomes. Furthermore, multiple lifestyle interventions for weight control initiated during pregnancy have not yet shown substantial effects on adverse perinatal outcomes. In contrast, there is a robust body of relevant research about how to prevent adolescents in general from engaging in risky behaviors (*i.e*., sedentary habits, smoking, alcohol consumption, unsafe sex, etc.). Distilling information from this literature appears to be an efficient approach about how best to achieve the objective of reducing the risk of both obesity in women of childbearing age, and adverse pregnancy and fetal obesity-related conditions. Learning through analyses of existing experiences is worldwide promoted as a prompt way to gather key-combinations of political commitment, strategic programming, and resources, and to determine key-success factors and barriers in scaling-up nutrition interventions [15-18].

THE BURDEN OF ADOLESCENCE IN PREGNANCY

Pregnant women are considered a 'vulnerable group', as their nutritional requirements increase to sustain fetal/infant growth and development as well as maternal metabolism and tissue accretion [19]. When occurring in adolescence, pregnancy poses extra burdens due to the concomitant rise in nutritional needs to maintain the adolescent's growth, leading to the incomplete attainment of the physical, reproductive (*i.e*., genital tract and the musculoskeletal system), cognitive, or psychosocial maturity, associated with the hardness to be reached by the health-care radar [7, 10, 20].

Adolescence is a sensitive time of rapid growth and development [1], during which normative and maladaptive patterns shape future trajectories [7]. Poor nutrition may have repercussion on both the final adult body size, resulting in stunting or thinness, and the nutritional status of the offspring with thin or stunted women more likely to have small-for-gestational-age (SGA) and preterm babies creating a negative inter-generational cycle [21, 22]. Not being fully grown themselves at the time of the first childbearing, teenage mothers likely compete with the developing fetus for nutrients even when their pre-pregnant nutritional status is relatively good [23, 24]. Indeed, many adolescent girls enter pregnancy widely malnourished, anemic and short stature, which greatly increases the risk of adverse pregnancy-outcome and the likelihood

of stunting in childhood [21, 25]. In addition, adolescents are highly vulnerable to psychosocial models and social media that are critically relevant to their dietary practices and lifestyles such as dieting, drinking alcohol and smoking that may be detrimental for both the maternal nutritional status and the overall pregnancy outcome [26, 27].

Teenage-pregnancy is independently associated with preterm delivery, low birth-weight and neonatal mortality [28-30]. A general tendency for poorer outcomes in younger teenagers, and more benefits to child's survival and health of delaying the first birth beyond the teenage years into the 20s has been observed [29, 31-34]. Existing data highlight that the increased risk is more likely intrinsic to maternal youth, suggesting that the disadvantages of young age might be causally related largely to biological/physiological and/or behavioral-emotional immaturity rather than only to inadequate socio-economical circumstances, ante-natal care or delivery care [28, 30]. Indeed, the still-growing of adolescent mothers and/or other biologic factors (*i.e*., low pre-pregnancy weight and height, parity, contracted pelvis), may be implicated in the poorer pregnancy-outcomes during adolescence [35, 36]. It may be also plausible that teen mothers are less able to attend to their infant's needs than older mothers [30]. Furthermore, by being predisposed to high fertility and poor fertility outcomes (*i.e*., repeated childbirth in less than 24 months, unplanned motherhood and unsafe pregnancy termination) [37, 38], the adolescent's reproductive health may be negatively impacted by pregnancy. Particularly, inter-pregnancy intervals shorter than 18 months were found to be significantly associated with SGA, preterm birth and death in the first year of life, to imply that in populations with high fertility rates, repeated pregnancies may promote under-nutrition and morbidity in the mother-offspring pair [39].

THE BURDEN OF OVERWEIGHT/OBESITY IN PREGNANCY

Obesity during pregnancy constitutes an important health issue, as a major risk factor for obstetric complications, offspring's morbidity and higher health-care costs [40, 41]. Alarmingly, obesity in women of reproductive age is increasing in prevalence with current estimates indicating that by 2025 more than 21% of women worldwide will be obese [42]. Women who are obese during pregnancy and their offspring are much more likely than other women and newborns to experience a range of adverse outcomes [42]. As shown by studies in Table **1** [43-49], there are a number of short- and long-term adverse implications on mothers' and their offspring's health associated with maternal excessive weight before and during pregnancy:

- *Mother*: Pregnancy complications likely relate to pre-gravid weight rather than Gestational Weight Gain (GWG) [43]. Excessive GWG is a major determinant for maternal post-partum weight retention, which may contribute to maternal pre-gravid obesity in a subsequent pregnancy [50], and is related to caesarean delivery and preterm birth, but proportionally less to a risk for pre-eclampsia, Gestational Diabetes Mellitus (GDM) and fetal overgrowth or macrosomia [51] in women who are already obese prior to pregnancy. The strongest determinant for a high birth-weight is likely the high maternal pre-gravid Body Mass Index (BMI) [43, 47, 50]. In other words, pre-pregnancy obesity is a greater risk factor for adverse outcome in women who are obese whereas excessive gestational weight gain is a greater risk factor in women who are normal weight prior to pregnancy. The underlying subclinical metabolic disturbances in obese pregnancy, which become clinically manifest during pregnancy as GDM, hypertensive disorders and fetal macrosomia are under investigation. However, insulin resistance, elevated levels of plasma triglycerides, cholesterol and leptin are supposed to exert adverse effects, along with adipose tissue producing pro-inflammatory factors, complement factors and components of the coagulation/fibrinolytic cascade that appear to mediate the obesity-associated metabolic complications [41, 52]. GDM and obesity are both independent and collectively related to adverse pregnancy outcomes [41, 45]. Actually, both pre-gestational and gestational diabetes have shown high association with adverse maternal and fetal outcomes [47]. In pregnancies complicated by diabetes, altered maternal lipid and amino acid metabolism in addition to hyperglycemia likely constitutes a risk for macrosomia. Furthermore, women with GDM in previous pregnancy have likely at least seven-fold increased risk of developing type-2 diabetes in future compared with normo-glycemic pregnancies [47]

- *Offspring*: The offspring of obese women is at increased risk for both neonatal morbidity and long-term s*equelae* related to the abnormal *in utero* metabolic environment, *i.e*., NCDs [43, 45, 53]. Indeed, obesity is characterized by metabolic and endocrine derangements, with low grade subclinical systemic and tissue specific inflammation being the hallmark causally linked to insulin resistance and associated to fetal, neonatal, and long term outcomes of adiposity in the

Table 1: The Short- and Long-Term Adverse Implications of Maternal Excessive Weight before and during Pregnancy on the Mother's and her Offspring's Health

	Adverse Implication
Mother	
	Early in pregnancy: Increased risk of spontaneous abortion and congenital anomalies [45]
	In later pregnancy: Increased risk of gestational diabetes, hypertensive disorders, cardiac dysfunction, proteinuria, sleep apnea, non-alcoholic fatty liver disease [47, 49]
	At delivery: Increased risk of instrumental and caesarean birth, surgical site infection and venous thrombosis (45)
Offspring	Increased risk for fetal overgrowth, mortality and morbidity [43, 47]
	Increased risk for neonatal morbidity, and later obesity and metabolic syndrome [44, 46, 47]
	Increased risk of premature death in adult offspring [48]

offspring [43]. Fetal overgrowth or macrosomia (the most commonly reported effect of maternal diabetes and/or excessive BMI) is of major concern, mostly in the developed nations where an increase in mean term birth-weight has been reported [43]. Body composition measures in neonates from normal glucose-tolerant pregnancies of pre-gravid overweight/obese *versus* lean/average-weight women, showed that overweight/obese women gave birth to heavier neonates, and the increase in birth-weight was attributable primarily to an increase in adiposity [54, 55]. Obesity in early-pregnancy likely increases significantly the risk of obesity and metabolic syndrome in the offspring, independent of maternal GDM or excessive GWG [44, 46]. The relationship between excessive GWG and offspring overweight seems to be modified by maternal pre-gravid BMI, which has been taken into account in the current recommendations for GWG by the Institute of Medicine, in which ranges for the increase in body mass have been recommended based on the pre-gravid BMI [41]. Nevertheless, the desirable degree of GWG remains a matter of debate, with some claiming that there is an obligatory physiologic weight gain during pregnancy necessary for a healthy pregnancy [4], whilst some authors recommend that less weight gain for obese women may improve some perinatal outcomes [41, 56]. By considering that also intrauterine exposure to diabetes *per se* conveys the risk for developing diabetes and obesity in youth [45, 53], combination of maternal obesity and GDM may have a greater impact on fetal growth than either one alone [45]. GDM and macrosomia induce metabolic abnormalities, altered hypothalamic neuropeptide production degraded antioxidant status, and disrupted immune system, thus promoting potential obesity and metabolic syndrome in the offspring [57]. Actually, the U- or J-shaped relationship between fetal growth and adult metabolic diseases, suggests that exposure to both under-nutrition and over-nutrition in fetal life may lead to postnatal obesity and related NCDs [2]. In fact, low birth-weight (mostly arising from being born preterm or *in utero* growth restriction) when combined with rapid compensatory 'catch-up' growth after birth and/or higher calorie diet in youth, also seems to predispose to obesity *via* a mismatch between fetal and post-natal environments [2].

Pregnant Obese Adolescents

With a 2.6% annual increase from 1990 to 2013 in NCD-predominant countries, pregnant obese adolescents are a pressing perinatal and public-health concern [7]. Whilst the number of studies investigating the effects of overweight and obesity on pregnancy outcomes and offspring' health among adults is fairly extensive, there is a dearth of attention at overweight/obese adolescents. Consistent with adult literature, they show that pregnancy/obstetric complications and adverse neonatal outcomes, such as caesarean delivery, pregnancy-induced hypertension, pre-eclampsia, GDM, incidence of macrosomia, are likely significantly more common in overweight pregnant adolescents than in those of appropriate weight [58-63]. Furthermore, metabolic factors underlying maternal growth during adolescent pregnancy likely inhibit storage oxidation and endorse fat deposition and retention during pregnancy and postpartum, increasing the risk of maternal overweight/obesity from an early age [24].

WHY TO HANDLE OBESITY PRIOR TO PREGNANCY

Finding a means to diminish the dual burden of malnutrition among adolescents, women and couples of reproductive age, is important as interactions

Table 2: **Effect of Weight Loss Interventions Incorporating Nutrition Counseling and/or Physical Activity Initiated during Pregnancy on Pregnancy-Related Outcomes**

Study	Test	Results
Systematic review with meta-analysis of 128 [RCTs + quasi RCTs + observational studies] [47]	To assess the risk factors and interventions for screening, detection, prevention and management of pre-pregnancy obesity, pre-diabetes and diabetes at different levels of care	Dietary intervention Low glycemic index- vs. high glycemic index-diets for pregnant women: fewer LGA infants = 0.09 (0.01 — 0.69); lower fasting glucose values = -0.28 (-0.54 — -0.02) mmol/L
Systematic review with meta-analysis of 13 [RCTs + quasi-RCTs] [71]	Any type of dietary intervention for preventing excessive GWG	Intervention vs. No-intervention: - Decrease of: total GWG [-1.92 kg (-3.65 — -0.19), p = 0.03]; weight retention at 6 months postpartum [-1.90 kg (-2.69 — -1.12), p < 0.0001]; cesarean section incidence [RR = 0.75 (0.60 — 0.94), p = 0.013] - No significant effect on birth-weight, pre-eclampsia, GDM, preterm birth
Systematic review with meta-analysis of 44 relevant RCTs [72]	Any dietary or lifestyle interventions with potential to influence gestational maternal/fetal weight and obstetric outcomes	Intervention vs. No-intervention: Dietary intervention - GWG (kg) = -3.84 (-5.22 — -2.45), p < 0.001 - GDM = 0.39 (0.23 — 0.69), p = 0.001 - Pre-eclampsia = 0.67 (0.53 — 0.85), p < 0.001 - Gestational hypertension = 0.30 (0.10 — 0.88), p = 0.03 - Preterm delivery = 0.68 (0.48 — 0.96), p = 0.03 - Shoulder dystocia = 0.38 (0.21 — 0.69), p = 0.001 Physical Activity - GWG (kg) = -0.72 (-1.20 — -0.25), p = 0.003 - Birth-weight (g) = −60 (-120 — -10), p = 0.02 Mixed approach - GWG (kg) = -1.06 (-1.67 — -0.46), p < 0.001 All interventions - GWG (kg) = -1.42 (-1.89 — -0.95), p < 0.001 - Pre-eclampsia = 0.74 (0.60 — 0.92), p = 0.006 - Shoulder dystocia = 0.39 (0.22 — 0.70), p = 0.002
LiP (Lifestyle in Pregnancy) study: RCT, n = 360 obese women in early pregnancy, Denmark [73]	Comprehensive dietary and lifestyle intervention (IG) vs. controls (CG) on GWG and obstetric outcomes	IG vs. CG: - Lower median GWG [7.0 (4.7 — 10.6) vs. 8.6 kg (5.7 — 11.5), p = 0.01] - Birth-weight (g): higher [3,742 (3,464 — 4,070) vs. 3,593 (3,335 — 3,930), p = 0.039] - Obstetric outcomes: no significant difference
ROLO study: RCT of a LGI diet from early pregnancy in secundigravid women whose first baby was macrosomic, n = 800 pregnant women, Ireland [74]	Recommended eucaloric LGI diet (IG) vs. no dietary intervention (CG) in "recurrence of fetal macrosomia" prevention	IG vs. CG: - Absolute birth-weight, birth-weight centile, or ponderal index: no significant difference - GWG: lower [mean difference = -1.3 (-2.4 — - 0.2), p = 0.01] - Rate of glucose intolerance: lower [21% (67 — 320) vs. 28% (100 — 352), p = 0.02]
PREGGIO (Pregnancy and Glycemic Index Outcomes) study: a 2-arm, parallel-design RCT, n = 691 pregnant women, Australia [75]	LGI dietary advice (IG) vs. Healthy Eating advice (CG) at the 1st antenatal visit on fetal birth-weight, birth percentile, and Ponderal Index	IG vs. CG: - No significant differences in primary outcomes of fetal weight
LIMIT Study: Multicentre RCT, n = 2212 overweight/obese pregnant women, Australia [76]	Comprehensive dietary and lifestyle intervention delivered by research staff (IG) vs. standard care (CG) on health outcomes in overweight/obese pregnant women	IG vs. CG: - Risk of LGA infant not significantly different - Infants less likely to have birth-weight above 4000 g [RR = 0.82 (0.68 — 0.99), p = 0.03] - No differences in maternal pregnancy and birth outcomes

UPBEAT trial (UK Pregnancies Better Eating and Activity Trial): multicentre RCT, n = 1555 obese pregnant women, United Kingdom [77]	Intervention addressing diet and physical activity through eight health trainer-led sessions vs. standard antenatal care on maternal GDs and LGA infants	IG vs. CG: - GD incidence: no difference - LGA incidence: no difference - Incidence of miscarriage, major obstetric hemorrhage, SGA infants: no difference - Dietary glycemic load, GWG, maternal sum-of-skinfold thicknesses: lower - Physical activity: higher
DALI (Vitamin D And Lifestyle Intervention for GDM prevention) pilot: European multicenter RCT, n = 120 obese pregnant women, ten European centers [78]	Three lifestyle interventions, *i.e*., healthy eating (HE) vs. physical activity (PA) vs. (HE plus PA) on GDM risk	- HE vs. PA vs. HE+PA: no difference - HE vs. PA: lower GWG and fasting glucose at 24–28 weeks

RCTs, randomized controlled trials; GWG, gestational weight gain; LGI, low glycemic index; GDs, gestational diabetes; LGA, large-for-gestational age; SGA, small-for-gestational age.

between the pre- and post-natal environmental nutrition may ultimately determine the offspring's health [3]. As the result of a complex system of interrelated social, political and scientific factors, its prevention requires mixed and concerted approaches including education, behavioral and lifestyle changes [64-68]. Most important, delivering evidence-based interventions should be done carefully and after identifying the right channels and tools [7, 69].

The Challenge of the Pre-Conception Period

The physiological state in which the parents enter pregnancy, *i.e*., the diet, body composition and lifestyle, is universally accepted as the very factor in the prevention of pregnancy-related diseases and NCD-risk components [3, 6, 68, 70, 71]. Once pregnancy is underway, it is too late to truly affect fundamental dietary and lifestyle habits. To date, multiple lifestyle interventions for weight control initiated during pregnancy (Table **2**) [47, 72-77] have not shown substantial effects on outcome in pregnant mother. Predominantly, those based on balanced/healthy and/or low glycemic diets were effective for reducing excessive GWG safely, but had less success on fetal weight (*i.e*., fetal overgrowth) and pregnancy-related complications [47, 75, 78, 79]. Recently a randomized clinical trial of exercise in overweight/obese chinese women shows that exercise started early in pregnancy significantly decreased GDM and gestational weight gain before the mid-second trimester (Moreover, despite low-glycemic index diets and physical activity in pregnancy offered some advantages against borderline and gestational diabetes by improving maternal glucose homoeostasis [47, 75, 79], pre-conception diabetic education and dietary advice were likely more effective in reducing the occurrence of congenital malformations, the risk of perinatal mortality and the level of HbA1c in the 1st trimester of pregnancy [47]. Consequently, earlier interventions aiming to optimize pre-gravid BMI and nutrient reserves may be needed to ensure a healthy pregnancy and break the intergenerational cycle of malnutrition and NCDs [40]. The optimum nutrient intake, that is micronutrient status, must be achieved prior to pregnancy to favor the overall reproductive and/or pregnancy cycle [40, 70]. Similarly, women with excessive pre-gravid BMI must improve metabolic conditioning before pregnancy to decrease complications of fetal overgrowth and GDM [51], and those with pre-existing diabetes need to normalize glucose levels to reduce the risk of congenital anomalies [47]. Maternal pre-gravid and early pregnancy metabolic condition in fact programs early placenta function and gene expression [43]. These alterations in maternal/placental function, that is increased expression of lipogenic and low-grade inflammatory genes within white adipose tissue and placenta, occur in the 1st trimester of pregnancy prior to when most intervention trials are initiated. Further, obese women may be less amenable to lifestyle changes improving metabolic function and clinical outcomes [51].

OPPORTUNITIES FOR BREAKING THE INTERGENERATIONAL CYCLE OF NCDS

In a context of high risk of complications and poorer birth outcomes associated with childbearing among teens, worldwide high rate of teenage-pregnancy, association between maternal obesity and morbidities, and epidemic prevalence of overweight/obesity around the world, targeting adolescents is likely to be the most effective means to break the intergenerational-cycle of malnutrition and NCDs.

As depicted in Figure **1**, reaching-out to this population means to:

- Counsel adolescents about the importance of not getting pregnant until they have completed their

own growth, usually around their 20th birthday [33]

- By-pass the difficulty of arriving at pregnant adolescents early enough in pregnancy. This group of population frequently does not access healthcare, that represents a major limitation in ensuring adequate uptake of interventions early in the lifecycle through appropriate strategies, such as enhancing adolescent nutrition and family planning [7, 16]

- Educate the future parents they must look after their own health for the future wellbeing of the next generation, that is to establish basics for future healthy nutrition-related behaviors [6]

- Convey the message that pregnancy is a special time to be healthy and prepared for [6].

Supplying pre-conception care means managing existing risks before pregnancy [67]. By dealing with prevention of teenage pregnancy, birth spacing, promotion of contraceptive use, optimization of weight, it appears to be the very chance to prevent harmful exposures from affecting both the parents-to-be and their future offspring [80-83]. Achieving the engagement of adolescents requires access to information systems and quality youth-friendly services provided by health care personnel trained to work with youth [80, 83-87].

Education about "Early-in-Life" Nutrition Among Adolescents

There is an increasing recognition that the most promising strategy to improve the prospective parents' body-composition and lifestyle/behavior is the promotion of health literacy among adolescents [6, 14, 69]. There is a wealth of evidence about how to avert unhealthy behaviors among adolescents [67, 88-90], several lessons can be drawn from, which may be applicable for reducing adverse pregnancy and fetal conditions. Existing data highlight that to be successful

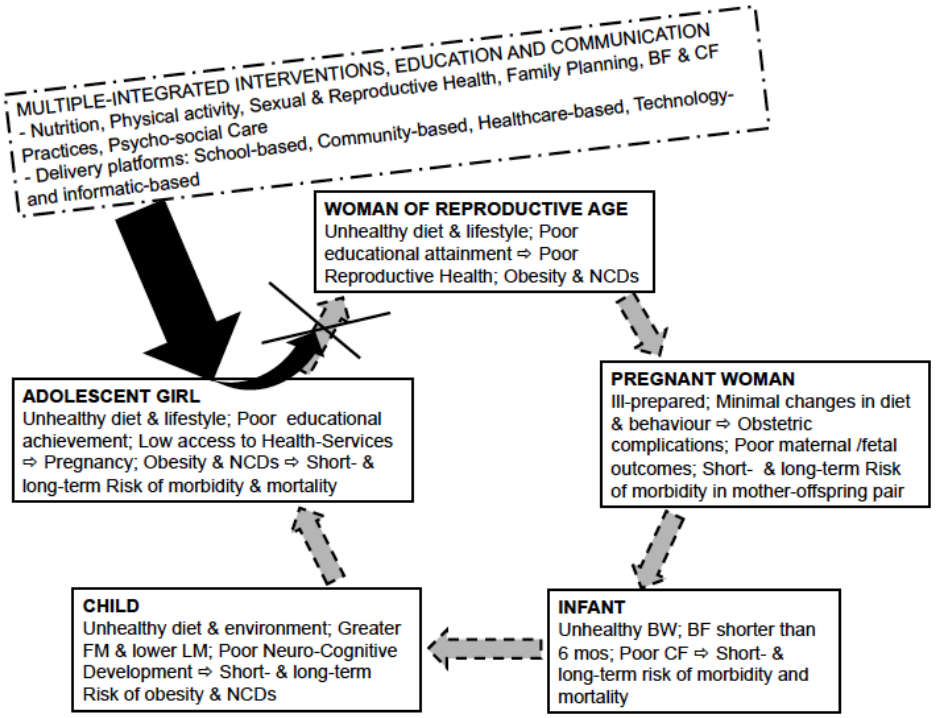

Figure 1: Adolescent girls as the *"entry-point"* to break the intergenerational cycle of obesity and NCDs.

Malnourished and poor educated teen-girls are at higher risk of poor nutritional status, reproductive health and adverse fetal growth, with long-lasting negative consequences on the mother-infant pair's development. Multiple-integrated nutrition and lifestyle programs, including health literacy, aimed at today adolescents may have transformative impact on nutritional status, health and well-being of the current and succeeding generations. Better nourished and educated teen-girls may be more healthier and attentive mothers and have healthier children. School, community, communication and information digital technology, specialized health-services are the most effective platforms to deliver interventions on nutrition, physical activity, sexual- and reproductive-health education, healthy lifestyle.

NCDs, Non-communicable diseases; BF, Breastfeeding; mos, months; CF, complementary feeding; FM, fat mass; LM, lean mass; BW, body weight.

these interventions must be embedded within the social-economic context where adolescents live; include multi-component interventions focusing on nutrition, physical activity, family planning, breastfeeding and infant feeding practices; and be linked with existing public-health programs in sexual and reproductive health and/or maternal/child health-initiatives, that is using as platforms school- and community-based delivery, communication and information technology, specialized health-services and youth organizations [26, 64, 69, 84, 85, 91-93]. In particular, text messaging, mobile technology, digital web-based platforms, including comprehensive eHealth websites and interactive web-based systems, appear to be a promising strategy to promote health-related topics [94-96]. Interestingly, the use of computer-, web game- and mobile Apps-based nutrition education interventions targeting adolescent overweight and obesity evidenced the potential of the multimedia technology to persuade young people to improve overall dietary habits and healthy lifestyle thus restraining the expansion of overweight/obesity [97-99].

IMPLICATIONS AND FUTURE DIRECTIONS

Teenage mothers are a high-risk and vulnerable population. Pregnancy may compromise their own physiological and nutritional status alongside that of their fetus, with lifelong health consequences on the mother-infant pair. Obesity may exacerbate such risks.

Enhancing environmental exposures during early life offer important potential for primary prevention of DOHaD-related NCDs [3, 6]. A growing body of research suggests that improving body composition, diet and lifestyle of adolescents, who are the prospective parents, is crucial for their own health and that of their future child. Lifestyle interventions during adolescence have the potential to modify adult unhealthy risks by switching at-risk individuals from a high to lower risk trajectory [2]. There is a substantial amount of evidence on obesity's health effects during pregnancy, little of this evidence is specific to adolescents. Similarly, there is not yet much of a conclusive evidence regarding the potential effects of strategies for addressing the phenomenon of obesity during pregnancy. However, most of the available data likely indicate that initiating programs of dietary and lifestyle counseling before conception may offer effective solutions.

By considering that the behaviors leading to obesity take root early in life, it is very reasonable that the most sensible approach of addressing this problem is to target adolescents in general, as "*entry point*", *i.e.*, before they are even old enough to enter a state of pregnancy risk, by encouraging healthy eating habits, which in turn is likely to lead to more favorable pregnancy-related outcomes later in life [6, 14, 69]. Several lessons may be drawn from existing experience on *"what works"* for reducing adolescents' harmful behaviors which can be transferable for preventing the risk of teenage obese pregnancy and adverse-related conditions. Taken together, the findings of this review suggest that successful programs for improving lifestyle behaviors among adolescents should be designed to maximize impact on lifestyle and behavior change, rather than weight as an outcome, by comprising different sectors and disciplines. In particular, there is a need for promotion of health literacy during adolescence to be robustly addressed and implemented in multiple-integrated interventions, including programs in sexual health and contraception [83]. Discouraging adolescents from becoming pregnant in the first place perhaps represents the best way of reducing the extent of adolescent obesity during pregnancy. To this regard, youth engagement is essential. Thus, access for all adolescent to quality youth-friendly services provided by clinicians trained to work with youth should be ensured [80, 84, 85, 87].

Modifying lifestyle and dietary behaviors is not an easy task. More rigorous efforts for improving communication interventions should be considered in future programs to counteract the information avalanche: too much information, countless competing messages coming from too many stakeholders (*i.e.*, health profession, mass media, fast food, alcohol and cigarette manufacturers etc), much of it incorrect [100, 101]. Indeed, in today's world we are all inundated with information overload. To improve knowledge and responsiveness to healthy guideline/information to be attained for achieving an optimal health, nutrition education must communicate clear, accurate and actionable messages with a specific goal for target groups [100-104]. To become the most effective, education strategies have necessarily to accustom to the preferred communication channels between adolescents and their peers, by using motivational messages specifically tailored to this group, in a dynamic and interactive mode [103-105]. Media, information- and mobile-technology, and text messaging may offer new possibilities for engagement and service delivery [97-99]. Finally, being this age-group very sensitive to outside influences (parents, media, and peers), strategies based on environment

changes to reduce the exposure of young people to negative influences should be particularly attractive for governmental policy-makers [12, 86, 106]. It is unlikely that such a change may succeed without strong visible signals of commitment from the highest levels in government [68, 106]. This may be of critical importance by considering that ultra-processed foods (*i.e.*, burgers, frozen pizza and pasta dishes, nuggets and sticks, crisps, biscuits, confectionery, cereal bars, carbonated and other sugared drinks, various snack products) which are characteristically energy-dense, fatty, sugary or salty as well as attractive, hyper-palatable, cheap and ready-to-eat, have become increasingly dominant in food supplies [107]. Despite transnational food manufacturing, retailing and fast food service corporations have been recognized as the main driving-force in shaping the global food system, so far the full impact of industrialized food processing on health has likely remained overlooked and underestimated [107]. National governments, along with non-governmental organizations, academics, and civil society should severely appraise the responsibility of the private sector in NCDs prevention and control to prevent harm caused by unhealthy commodity industries in public regulation and market intervention [68, 108, 109]. Indeed, alcohol, tobacco, ultra-processed food and drinks industries should not have any role in creating national or international policy for NCDs policy [108].

CONCLUSIONS

Addressing issues related to adolescent pregnancy and obesity, concurrently, by establishing healthy behaviors among today-adolescents may reduce adverse pregnancy-conditions with the potential of improving the future generations' health. However, it still represents a very public health challenge to be solved as it goes beyond biology, that is beyond being pregnant obese teenagers. Physical (nutritional, ecological) and psychological environments are indeed powerfully involved. In particular, persistent obesogenic environments oppose efforts to facilitate weight loss and prevent weight regain. It must be very clear that to achieve sustainable permanent solutions in the real world, strong efforts of healthcare providers, the community, and public health endeavors must be oriented mostly towards guaranteeing healthy environments. This implies that for changes in adolescents' behavior to become effective, politics and food marketing industries are required to be retained in the overall attempt to face these challenges.

FUNDING

None

CONFLICT OF INTEREST

None

REFERENCES

[1] World Health Organization. Nutrition in adolescence - Issues and challenges for the health sector: Issues in adolescent health and development (WHO discussion papers on adolescence). Geneva (Switzerland): WHO; 2005. [cited 2017 March 28]. Available from: http://apps.who.int/iris/bitstream/10665/43342/1/9241593660_eng.pdf

[2] Hanson MA, Gluckman PD. Early developmental conditioning of later health and disease: Physiology or pathophysiology? Physiol Rev 2014; 94: 1027-76. https://doi.org/10.1152/physrev.00029.2013

[3] Berti C, Agostoni C, Davanzo R, Hyppönen E, Isolauri E, Meltzer HM, Steegers-Theunissen RP, Cetin I. Early life nutritional exposures and lifelong health: An insight on immediate and long-lasting impacts of probiotics, vitamin D and breastfeeding. Nutr Rev 2017; pii: nuw056. https://doi.org/10.1093/nutrit/nuw056

[4] Ruel MT, Alderman H, Maternal and Child Nutrition Study Group. Nutrition-sensitive interventions and programmes: How can they help to accelerate progress in improving maternal and child nutrition? Lancet 2013; 382: 536-51. https://doi.org/10.1016/S0140-6736(13)60843-0

[5] Darnton-Hill I, Samman S. Challenges and opportunities in scaling-up nutrition in healthcare. Healthcare 2015; 3: 3-19. https://doi.org/10.3390/healthcare3010003

[6] Hanson MA, Gluckman PD, Ma RC, Matzen P, Biesma RG. Early life opportunities for prevention of diabetes in low and middle income countries. BMC Public Health 2012; 12: 1025. https://doi.org/10.1186/1471-2458-12-1025

[7] Patton GC, Sawyer SM, Santelli JS, Ross DA, Afifi R, Allen NB, Arora M, Azzopardi P, Baldwin W, Bonell C, et al. Our future: A Lancet commission on adolescent health and wellbeing. Lancet 2016; 387: 2423-78. https://doi.org/10.1016/S0140-6736(16)00579-1

[8] United Nations Children's Fund. Progress for Children. A report card on adolescents. USA: UNICEF; 2012; [cited 2017 March 28]. Available from: http://www.unicef.org/publications/index_62280.html.

[9] Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, Ezzati M, Grantham-McGregor S, Katz J, Martorell R, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet 2013; 382: 427-51. https://doi.org/10.1016/S0140-6736(13)60937-X

[10] Fleming N, O'Driscoll T, Becker G, Spitzer RF; CANPAGO Committee, Allen L, Millar D, Brain P, Dalziel N, Dubuc E, et al. Adolescent Pregnancy Guidelines. J Obstet Gynaecol Can 2015; 37: 740-59. https://doi.org/10.1016/S1701-2163(15)30180-8

[11] Malik VS, Willett WC, Hu FB. Global obesity: Trends, risk factors and policy implications. Nat Rev Endocrinol 2013; 9: 13-27. https://doi.org/10.1038/nrendo.2012.199

[12] Lobstein T, Jackson-Leach R, Moodie ML, Hall KD, Gortmaker SL, Swinburn BA, James WP, Wang Y, McPherson K. Child and adolescent obesity: part of a bigger picture. Lancet 2015; 385: 2510-20. https://doi.org/10.1016/S0140-6736(14)61746-3

[13] Tzioumis E, Adair LS. Childhood dual burden of under- and overnutrition in low- and middle-income countries: A critical review. Food Nutr Bull 2014; 35: 230-43. https://doi.org/10.1177/156482651403500210

[14] Lassi ZS, Salam RA, Das JK, Wazny K, Bhutta ZA. An unfinished agenda on adolescent health: Opportunities for interventions. Semin Perinatol 2015; 39: 353-60. https://doi.org/10.1053/j.semperi.2015.06.005

[15] Bryce J, Coitinho D, Darnton-Hill, I Pelletier D, Pinstrup-Andersen P; Maternal and Child Undernutrition Study Group. Maternal and child undernutrition: Effective action at national level. Lancet 2008; 371: 510-26. https://doi.org/10.1016/S0140-6736(07)61694-8

[16] Bhutta ZA, Das JK, Rizvi A, Gaffey MF, Walker N, Horton S, Webb P, Lartey A, Black RE; Lancet Nutrition Interventions Review Group, et al. Evidence-based interventions for improvement of maternal and child nutrition: What can be done and at what cost? Lancet 2013; 382: 452-77. https://doi.org/10.1016/S0140-6736(13)60996-4

[17] Gillespie S, Haddad L, Mannar V, Menon P, Nisbett N; Maternal and Child Nutrition Study Group. The politics of reducing malnutrition: Building commitment and accelerating progress. Lancet 2013; 382: 552-69. https://doi.org/10.1016/S0140-6736(13)60842-9

[18] Pelletier DL, Porter CM, Aarons GA, Wuehler SE, Neufeld LM. Expanding the frontiers of population nutrition research: new questions, new methods, and new approaches. Adv Nutr 2013; 4, 92-114. https://doi.org/10.3945/an.112.003160

[19] Berti C, Decsi T, Dykes F, Hermoso M, Koletzko B, Massari M, Moreno LA, Serra-Majem L, Cetin I. Critical issues in setting micronutrient recommendations for pregnant women: An insight. Matern Child Nutr 2010; 6: S5-S22. https://doi.org/10.1111/j.1740-8709.2010.00269.x

[20] Pérez-López FR, Chedraui P, Kravitz AS, Salazar-Pousada D, Hidalgo L. Present problems and controversies concerning pregnant adolescents. J Contraception 2011; 2: 85-94. https://doi.org/10.2147/OAJC.S13398

[21] Christian P, Mullany LC, Hurley KM, Katz J, Black RE. Nutrition and maternal, neonatal, and child health. Semin Perinatol 2015; 39: 361-72. https://doi.org/10.1053/j.semperi.2015.06.009

[22] Kozuki N, Katz J, Lee AC, Vogel JP, Silveira MF, Sania A, Stevens GA, Cousens S, Caulfield LE, Christian P, et al. Short maternal stature increases risk of small-for-gestational-age and preterm births in low- and middle-income countries: Individual participant data meta-analysis and population attributable fraction. J Nutr 2015; 145: 2542-50. https://doi.org/10.3945/jn.115.216374

[23] Moran VK. A systematic review of dietary assessments of pregnant adolescents in industrialised countries. Br J Nutr 2007; 97: 411-25. https://doi.org/10.1017/S0007114507381373

[24] Scholl TO. Adolescent pregnancy: An overview in developed and developing nations. Perinatol Reprod Hum 2007; 21: 93-200.

[25] Restrepo Mesa SL, Parra Sosa BE. Implicaciones del estado nutricional materno en el peso al nacer del neonato. Perspect Nutr Humana 2009; 11: 179-86.

[26] Todd AS, Street SJ, Ziviani J, Byrne NM, Hills AP. Overweight and obese adolescent girls: The importance of promoting sensible eating and activity behaviors from the start of the adolescent period. Int J Environ Res Public Health 2015; 12: 2306-29. https://doi.org/10.3390/ijerph120202306

[27] American College of Obstetricians and Gynecologists (ACOG) Opinion. Concerns regarding social media and health issues in adolescents and young adults. Committee Opinion No. 653. Obstet Gynecol 2016; 127: e62-e65. https://doi.org/10.1097/AOG.0000000000001313

[28] Chen XK, Wen SW, Fleming N, Demissie K, Rhoads GG, Walker M. Teenage pregnancy and adverse birth outcomes: A large population based retrospective cohort study. Int J Epidemiol 2007; 36: 368-73. https://doi.org/10.1093/ije/dyl284

[29] Santos NL, Costa MC, Amaral MT, Vieira GO, Bacelar EB, de Almeida AH. Teenage pregnancy: Analysis of risk factors for low birth weight, prematurity and cesarean delivery. Cien Saude Colet 2014; 19: 719-26. https://doi.org/10.1590/1413-81232014193.18352013

[30] Fall CHD, Sachdev HS, Osmond C, Restrepo-Mendez MC, Victora C, Martorell R, Stein AD5, Sinha S, Tandon N, Adair L, et al. Association between maternal age at childbirth and child and adult outcomes in the off spring: A prospective study in five low-income and middle-income countries (COHORTS collaboration). Lancet Glob Health 2015; 3: e366-e377. https://doi.org/10.1016/S2214-109X(15)00038-8

[31] Conde-Agudelo A, Belizán JM, Lammers C. Maternal-perinatal morbidity and mortality associated with adolescent pregnancy in Latin America: Cross-sectional study. Am J Obstet Gynecol 2005; 192: 342-9. https://doi.org/10.1016/j.ajog.2004.10.593

[32] Finlay JE, Özaltin E, Canning D. The association of maternal age with infant mortality, child anthropometric failure, diarrhoea and anaemia for first births: evidence from 55 low- and middle-income countries. BMJ Open 2011; 1: e000226. https://doi.org/10.1136/bmjopen-2011-000226

[33] Nasrullah M, Zakar R, Zakar MZ, Krämer A. Girl-child marriage and its association with morbidity and mortality of children under 5 years of age in a nationally-representative sample of Pakistan. J Pediatr 164; 2014: 639-46. https://doi.org/10.1016/j.jpeds.2013.11.017

[34] Althabe F, Moore JL, Gibbons L, Berrueta M, Goudar SS, Chomba E, Derman RJ, Patel A, Saleem S, Pasha O, et al. Adverse maternal and perinatal outcomes in adolescent pregnancies: The Global Network's Maternal Newborn Health Registry study. Reprod Health 2015; 12: S8. https://doi.org/10.1186/1742-4755-12-S2-S8

[35] Gibbs CM, Wendt A, Peters S, Hogue CJ. The impact of early age at first childbirth on maternal and infant health. Paediatr Perinat Epidemiol 2012; 26: 259-84. https://doi.org/10.1111/j.1365-3016.2012.01290.x

[36] Wells JCK. The New "Obstetrical Dilemma": Stunting, obesity and the risk of obstructed labour. Anat Rec 2017; 300: 716-31. https://doi.org/10.1002/ar.23540

[37] Prakash R, Singh A, Pathak PK, Parasuramanet S. Early marriage, poor reproductive health status of mother and child well-being in India. J Fam Plann Reprod Health Care 2011; 37: 136-45. https://doi.org/10.1136/jfprhc-2011-0080

[38] Nasrullah M. Child marriage and its impact on maternal and child health in Pakistan. PhD Thesis; 2015, University of Bielefeld, Germany. [cited 2017 March 28]. Available from: https: //pub.uni-bielefeld.de/publication/2766061.

[39] Kozuki N, Lee AC, Silveira MF, Victora CG, Adair L, Humphrey J, Ntozini R, Black RE, Katz J; Child Health Epidemiology Reference Group Small-for-Gestational-Age-Preterm Birth Working Group. The associations of birth intervals with small-for-gestational-age, preterm, and neonatal and infant mortality: A meta-analysis. BMC Public Health 2013; 13 Suppl 3: S3. https://doi.org/10.1186/1471-2458-13-S3-S3

[40] Dean SV, Lassi ZS, Imam AM, Bhutta ZA. Preconception care: Nutritional risks and interventions. Reprod Health 2014; 11 Suppl 3: S3. https://doi.org/10.1186/1742-4755-11-S3-S3

[41] Berti C, Cetin I, Agostoni C, Desoye G, Devlieger R, Emmett PM, Ensenauer R, Hauner H, Herrera E, Hoesli I, Krauss-Etschmann S, et al. Pregnancy and infants' outcome: Nutritional and metabolic implications. Crit Rev Food Sci Nutr 2016; 56: 82-91. https://doi.org/10.1080/10408398.2012.745477

[42] Poston L, Caleyachetty R, Cnattingius S, Corvalán C, Uauy R, Herring S, Gillman MW. Preconceptional and maternal obesity: Epidemiology and health consequences. Lancet Diabetes Endocrinol 2016; 4: 1025-36. https://doi.org/10.1016/S2213-8587(16)30217-0

[43] Catalano PM, Shankar K. Obesity and pregnancy: Mechanisms of short term and long term adverse consequences for mother and child. BMJ 2017; 360: j1 doi: 10.1136/bmj.j1. https://doi.org/10.1136/bmj.j1

[44] Catalano PM, Farrell K, Thomas A, Huston-Presley L, Mencin P, de Mouzon SH, Amini SB. Perinatal risk factors for childhood obesity and metabolic dysregulation. Am J Clin Nutr 2009; 90: 1303-13. https://doi.org/10.3945/ajcn.2008.27416

[45] Catalano PM. The impact of gestational diabetes and maternal obesity on the mother and her offspring. J Dev Orig Health Dis 2010; 1: 208-15. https://doi.org/10.1017/S2040174410000115

[46] Phillips LH, Santhakumaran S, Gale C, Prior E, Logan KM, Hyde MJ, Modi N. The diabetic pregnancy and offspring BMI in childhood: A systematic review and meta-analysis. Diabetologia 2011; 54: 1957-66. https://doi.org/10.1007/s00125-011-2180-y

[47] Lassi ZS, Bhutta ZA. Risk factors and interventions related to maternal and pre-pregnancy obesity, prediabetes and diabetes for maternal, fetal and neonatal outcomes: A systematic review. Expert Rev Obstet Gynecol 2013; 8: 639-60. https://doi.org/10.1586/17474108.2013.841453

[48] Reynolds RM, Allan KM, Raja EA, Bhattacharya S, McNeill G, Hannaford PC, Sarwar N, Lee AJ, Bhattacharya S, Norman JE. Maternal obesity during pregnancy and premature mortality from cardiovasculalar event in adult offspring: Follow-up of 1 323 275 person years. BMJ 2013; 347: f4539. https://doi.org/10.1136/bmj.f4539

[49] Catalano PM. Obesity in pregnancy. Obstet Gynecol 2015; 126: e112-e126. https://doi.org/10.1097/AOG.0000000000001211

[50] Nohr EA, Vaeth M, Baker JL, Sørensen TIa, Olsen J, Rasmussen KM. Combined associations of prepregnancy body mass index and gestational weight gain with the outcome of pregnancy. Am J Clin Nutr 2008; 87: 1750-9. https://doi.org/10.1093/ajcn/87.6.1750

[51] Catalano P, deMouzon SH. Maternal obesity and metabolic risk to the offspring: Why lifestyle interventions may have not achieved the desired outcomes. Int J Obes (Lond) 2015; 39: 642-9. https://doi.org/10.1038/ijo.2015.15

[52] O'Tierney-Ginn P, Presley L, Myers S, Catalano P. Placental growth response to maternal insulin in early pregnancy. J Clin Endocrinol Metab 2015; 100: 159-65. https://doi.org/10.1210/jc.2014-3281

[53] Debelea D, Crume T. Maternal environment and the transgenerational cycle of obesity and diabetes. Diabetes 2011; 60: 1849-55. https://doi.org/10.2337/db11-0400

[54] Sewell MF, Huston-Presley L, Super DM, Catalano PM. Increased neonatal fat mass, not lean body mass, is associated with maternal obesity. Am J Obstet Gynecol 2006; 195: 1100-3. https://doi.org/10.1016/j.ajog.2006.06.014

[55] Hull HR, Thornton JC, Ji Y, Paley C, Rosenn B, Mathews P, Navder K, Yu A, Dorsey K, Gallagher D. Higher infant body fat with excessive gestational weight gain in overweight women. Am J Obstet Gynecol 2011; 205: 211.e1-e7. https://doi.org/10.1016/j.ajog.2011.04.004

[56] Catalano PM, Mele L, Landon MB, Ramin SM, Reddy UM, Casey B, Wapner RJ, Varner MW, Rouse DJ, Thorp JM Jr, et al. Inadequate weight gain in overweight and obese pregnant women: what is the effect on fetal growth? Am J Obstet Gynecol 2014; 211: 137.e1-7. https://doi.org/10.1016/j.ajog.2014.02.004

[57] Yessoufou A, Moutairou K. Maternal diabetes in pregnancy: Early and long-term outcomes on the offspring and the concept of "Metabolic Memory". Exp Diabetes Res 2001; 2011: 218598. https://doi.org/10.1155/2011/218598

[58] Sukalich S, Mingione MJ, Glantz JC. Obstetric outcomes in overweight and obese adolescents. Am J Obstet Gynecol 2006; 195: 851-5. https://doi.org/10.1016/j.ajog.2006.06.070

[59] Haeri S, Guichard I, Baker AM, Saddlemire S, Boggess KA. The effect of teenage maternal obesity on perinatal outcomes. Obstet Gynecol 2009; 113: 300-4. https://doi.org/10.1097/AOG.0b013e3181945b8a

[60] Magriples U, Kershaw TS, Rising SS, Westdahl C, Ickovics JR. The effects of obesity and weight gain in young women on obstetric outcomes. Am J Perinatol 2009; 26: 365-71. https://doi.org/10.1055/s-0028-1110088

[61] Aliyu MH, Luke S, Kristensen S, Alio AP, Salihu HM. Joint effect of obesity and teenage pregnancy on the risk of preeclampsia: A population-based study. J Adolesc Health 2010; 46: 77-82. https://doi.org/10.1016/j.jadohealth.2009.06.006

[62] Halloran DR, Marshall NE, Kunovich RM, Caughey AB. Obesity trends and perinatal outcomes in black and white teenagers. Am J Obstet Gynecol 2012; 207: 492.e1-e7. https://doi.org/10.1016/j.ajog.2012.09.023

[63] Elizondo-Montemayor L, Hernández-Escobar C, Lara-Torre E, Nieblas B, Gómez-Carmona M. Gynecologic and obstetric consequences of obesity in adolescent girls. J Pediatr Adolesc Gynecol 2016; pii: S1083-3188(16)00182-0.

[64] Kumanyika SK, Obarzanek E, Stettler N, Bell R, Field AE, Fortmann SP, Franklin BA, Gillman MW, Lewis CE, Poston WC 2nd, et al. Population-based prevention of obesity: The need for comprehensive promotion of healthful eating, physical activity, and energy balance: A scientific statement from American Heart Association Council on Epidemiology and Prevention, Interdisciplinary Committee for Prevention. Circulation 2008; 118: 428-64. https://doi.org/10.1161/CIRCULATIONAHA.108.189702

[65] Shrimpton R, Rokx C. The double burden of malnutrition: A review of global evidence. Health, Nutrition and Population (HNP) discussion paper; 2012. Washington, USA: The World Bank. [cited 2017 March 28]. Available from: http://documents.worldbank.org/curated/en/905651468339879888/The-double-burden-of-malnutrition-a-review-of-global-evidence. https://doi.org/10.1596/27417

[66] Monasta L, Batty GD, Cattaneo A, Lutje V, Ronfani L, Van Lenthe FJ, Brug J. Early life determinants of overweight and obesity: A review of systematic reviews. Obes Rev 2010; 11: 695-708. https://doi.org/10.1111/j.1467-789X.2010.00735.x

[67] Jackson CA, Henderson M, Frank JW, Haw SJ. An overview of prevention of multiple risk behavior in adolescence and young adulthood. J Public Health (Oxf) 2012; 34: i31-i40. https://doi.org/10.1093/pubmed/fdr113

[68] Hanson M, Barker M, Dodd JM, Kumanyika S, Norris S, Steegers 6, Stephenson J, Thangaratinam S, Yang H. Interventions to prevent maternal obesity before conception, during pregnancy, and post partum. Lancet Diabetes

Endocrinol 2017; 5: 65-76.
https://doi.org/10.1016/S2213-8587(16)30108-5

[69] Bay JL, Morton SM, Vickers MH. Realizing the potential of adolescence to prevent transgenerational conditioning of noncommunicable disease risk: Multi-sectoral design frameworks. Healthcare (Basel) 2016; 4.pii: E39.
https://doi.org/10.3390/healthcare4030039

[70] Cetin I, Berti C, Calabrese S. Role of micronutrients in the periconceptional period. Hum Reprod Update 2010; 16: 80-95.
https://doi.org/10.1093/humupd/dmp025Steegers-

[71] Steegers-Theunissen RPM, Twigt J, Pestinger V, Sinclair KD. The periconceptional period, reproduction and long-term health of offspring: The importance of one-carbon metabolism. Hum Reprod Update 2013; 19: 640-55.
https://doi.org/10.1093/humupd/dmt041

[72] Tanentsapf I, Heitmann BL, Adegboye AR. Systematic review of clinical trials on dietary interventions to prevent excessive weight gain during pregnancy among normal weight, overweight and obese women. BMC Pregnancy Childbirth 2011; 11: 81.
https://doi.org/10.1186/1471-2393-11-81

[73] Thangaratinam S, Rogozinska E, Jolly K, Glinkowski S, Roseboom T, Tomlinson JW, Kunz R, Mol BW, Coomarasamy A, Khan KS. Effects of interventions in pregnancy on maternal weight and obstetric outcomes: Meta-analysis of randomised evidence. BMJ 2012; 344: e2088.
https://doi.org/10.1136/bmj.e2088

[74] Vinter CA, Jensen DM, Ovesen P, Beck-Nielsen H, Jørgensen JS. The LiP (Lifestyle in Pregnancy) study: A randomized controlled trial of lifestyle intervention in 360 obese pregnant women. Diabetes Care 2011; 34: 2502-7.
https://doi.org/10.2337/dc11-1150

[75] Walsh JM, McGowan CA, Mahony R, Foley ME, McAuliffe FM. Low glycaemic index diet in pregnancy to prevent macrosomia (ROLO study): Randomised control trial. BMJ 2012; 345: e5605.
https://doi.org/10.1136/bmj.e5605

[76] Moses RG, Casey SA, Quinn EG, Cleary JM, Tapsell LC, Milosavljevic M, Petocz P, Brand-Miller JC. Pregnancy and Glycemic Index Outcomes study: Effects of low glycemic index compared with conventional dietary advice on selected pregnancy outcomes. Am J Clin Nutr 2014; 99: 517-23.
https://doi.org/10.3945/ajcn.113.074138

[77] Dodd JM, Turnbull D, McPhee AJ, Deussen AR, Grivell RM, Yelland LN, Crowther CA, Wittert G, Owens JA, Robinson JS; et al. Antenatal lifestyle advice for women who are overweight or obese: LIMIT randomised trial. BMJ 2014; 348: g1285.
https://doi.org/10.1136/bmj.g1285

[78] Poston L, Bell R, Croker H, Flynn AC, Godfrey KM, Goff L, Hayes L, Khazaezadeh N, Nelson SM, Oteng-Ntim E, et al. Effect of a behavioural intervention in obese pregnant women (the UPBEAT study): a multicentre, randomised controlled trial. Lancet Diabetes Endocrinol 2015; 3: 767-77.
https://doi.org/10.1016/S2213-8587(15)00227-2

[79] Simmons D, Jelsma JG, Galjaard S, Devlieger R, van Assche A, Jans G, Corcoy R, Adelantado JM, Dunne F, Desoye G, et al. Results from a European multicenter randomized trial of physical activity and/or healthy eating to reduce the risk of gestational diabetes mellitus: The DALI Lifestyle Pilot. Diabetes Care 2015; 38: 1650-6.
https://doi.org/10.2337/dc15-0360

[80] Mbizvo MT, Zaidi S. Addressing critical gaps in achieving universal access to sexual and reproductive health (SRH): The case for improving adolescent SRH, preventing unsafe abortion, and enhancing linkages between SRH and HIV. Int J Gynaecol Obstet 2010; 110 Suppl: S3-6.
https://doi.org/10.1016/j.ijgo.2010.04.001

[81] Lassi ZS, Dean SV, Mallick D, Bhutta ZA. Preconception care: Delivery strategies and packages for care. Reprod Health 2014; 11 Suppl 3: S7.
https://doi.org/10.1186/1742-4755-11-S3-S7

[82] Lindberg L, Santelli J, Desai S. Understanding the decline in adolescent fertility in the United States, 2007-2012. J Adolesc Health 2016; 59: 577-83.
https://doi.org/10.1016/j.jadohealth.2016.06.024

[83] The global strategy for women's, children's and adolescents' health (2016-2030). New York: Every Woman Every Child 2015. [cited 2017 March 28]. Available from: http: //www.who.int/pmnch/media/events/2015/gs_2016_30.pdf.

[84] Bearinger LH, Sieving RE, Ferguson J, Sharma V. Global perspectives on the sexual and reproductive health of adolescents: Patterns, prevention, and potential. Lancet 2007; 369: 1220-31.
https://doi.org/10.1016/S0140-6736(07)60367-5

[85] Hopkins C. Supplying emergency contraception to adolescents: The nurse's role. Nurs Stand 2014; 29: 37-43.
https://doi.org/10.7748/ns.29.13.37.e9193

[86] Hadley A, Chandra-Mouli V, Ingham R. Implementing the United Kingdom Government's 10-Year Teenage Pregnancy Strategy for England (1999-2010): Applicable lessons for other Countries. J Adolesc Health 2016; 59: 68-74.
https://doi.org/10.1016/j.jadohealth.2016.03.023

[87] Pritt NM, Norris AH, Berlan E. Barriers and facilitators to adolescents' use of Long-Acting Reversible Contraceptives. J Pediatr Adolesc Gynecol 2016; pii: S1083-3188(16)30095-X.

[88] Doak CM, Visscher TL, Renders CM, Seidell JC. The prevention of overweight and obesity in children and adolescents: A review of interventions and programmes. Obes Rev 2006; 7: 111-36.
https://doi.org/10.1111/j.1467-789X.2006.00234.x

[89] Das JK, Salam RA, Arshad A, Finkelstein Y, Bhutta ZA. Interventions for adolescent substance abuse: An overview of systematic reviews. J Adolesc Health 2016; 59: S61-S75.
https://doi.org/10.1016/j.jadohealth.2016.06.021

[90] Oringanje C, Meremikwu MM, Eko H, Esu E, Meremikwu A, Ehiri JE. Interventions for preventing unintended pregnancies among adolescents. Cochrane Database of Syst Rev 2016; 2: CD005215.
https://doi.org/10.1002/14651858.CD005215.pub3

[91] Vivancos R, Abubakar I, Phillips-Howard P, Hunter PR. School-based sex education is associated with reduced risky sexual behaviour and sexually transmitted infections in young adults. Public Health 2013; 127: 53-7.
https://doi.org/10.1016/j.puhe.2012.09.016

[92] Wang Y, Wu Y, Wilson RF, S Bleich, L Cheskin, C Weston, Bleich S, Cheskin L, Weston C, Showell N, Fawole O, Lau B, Segal J. Childhood obesity prevention programs: Comparative effectiveness review and meta-analysis. Comparative Effectiveness Review No. 115. AHRQ Publication No. 13-EHC081-EF. Rockville, MD: Agency for Healthcare Research and Quality; 2013. [cited 2017 March 28]. Available from: www.effectivehealthcare.ahrq.gov/-reports/final.cfm.

[93] Nishtar S, Gluckman P, Armstrong T. Ending childhood obesity: A time for action. Lancet 2016; 387: 825-7.
https://doi.org/10.1016/S0140-6736(16)00140-9

[94] O'Malley G, Dowdall G, Burls A, Perry IJ, Curran N. Exploring the usability of a mobile App for adolescent obesity management. JMIR Mhealth Uhealth 2014; 2: e29.
https://doi.org/10.2196/mhealth.3262

[95] Marks J, de la Haye K, Barnett LM, Allender S. Friendship Network characteristics are associated with physical activity and sedentary behavior in early adolescence. PLoS One 2015; 10: e0145344.
https://doi.org/10.1371/journal.pone.0145344

[96] Hammersley ML, Jones RA, Okely AD. Parent-focused childhood and adolescent overweight and obesity eHealth interventions: A systematic review and meta-analysis. J Med Internet Res 2016; 18: e203.

https://doi.org/10.2196/jmir.5893

[97] Ajie WN, Chapman-Novakofski KM Impact of computer-mediated, obesity-related nutrition education interventions for adolescents: A systematic review. J Adolesc Health 2014; 54: 631-45. https://doi.org/10.1016/j.jadohealth.2013.12.019

[98] Dute DJ, Bemelmans WJ, Breda J. Using mobile Apps to promote a healthy lifestyle among adolescents and students: A Review of the theoretical basis and lessons learned. JMIR Mhealth Uhealth 2016; 4: e39. https://doi.org/10.2196/mhealth.3559

[99] Fraticelli F, Marchetti D, Polcini F, Mohn AA, Chiarelli F, Fulcheri M, Vitacolonna E. Technology-based intervention for healthy lifestyle promotion in Italian adolescents. Ann Ist Super Sanita 2016; 52: 123-7.

[100] Goldberg JP, Sliwa SA. Session 4: Getting balanced nutrition messages across Communicating actionable nutrition messages: challenges and opportunities. Symposium on 'Nutrition: getting the balance right in 2010'. Proc Nutr Soc 2011; 70: 26-37. https://doi.org/10.1017/S0029665110004714

[101] Elahi S. Communicating Nutrition: A strategic approach. In: AmaNutriCresci Conference Journal. Does the communication about nutrition before, during, after pregnancy work? Who, How, When should communicate it. SIGO Congress: Milano; 19 October 2015: p. 14. [cited 2017 March 28]. Available from: http: //amanutricresci.com/wp-content/uploads/2015/10/FGP-conference-journal-low.pdf.

[102] Finzi C, Finzi E, Frassà SM. Effectiveness of nutrition communication before, during and after pregnancy: The Italian case. In: AmaNutriCresci Conference Journal. Does the communication about nutrition before, during, after pregnancy work? Who, How, When should communicate it. SIGO Congress: Milano; 19 October 2015: p. 10-13. [cited 2017 March 28]. Available from: http: //amanutricresci.com/wp-content/uploads/2015/10/FGP-conference-journal-low.pdf.

[103] Lamstein S, Stillman T, Koniz-Booher P, Aakesson A, Collaiezzi B, Williams T, Beall K, Anson M. Evidence of effective approaches to social and behavior change communication for preventing and reducing stunting and anemia: Report from a Systematic Literature Review. Arlington, VA: USAID/ Strengthening Partnerships, Results, and Innovations in Nutrition Globally (SPRING) Project; 2014. [cited 2017 March 28]. Available from: https: //www.spring-nutrition.org/sites/default/files/publications/reports/spring_sbcc_lit_review.pdf.

[104] McNulty J. Challenges and issues in nutrition education. Rome: Nutrition Education and Consumer Awareness Group, Food and Agriculture Organization of the United Nations; 2013. [cited 2017 March 28]. Available from: www.fao.org/ag/humannutrition/nutritioneducation/en/.

[105] Suggs LS, McIntyre C, Warburton W, Henderson S, Howitt P. Communicating health messages. A framework to increase the effectiveness of health communication globally. Report of the WISH Communicating Complex Health Messages Forum; 2015. [cited 2017 March 28]. Available from: http: //wish-qatar.org/research/reports/communicating-complex-health-messages-en.

[106] Mikkelsen BE, Engesveen K, Afflerbach T, Barnekow V. The human rights framework, the school and healthier eating among young people: A European perspective. Public Health Nutr 2016; 19: 15-25. https://doi.org/10.1017/S1368980015001627

[107] Monteiro CA, Moubarac J-C, Cannon G, Ng SW, Popkin B. Ultra-processed products are becoming dominant in the global food system. Obes Rev 2013; 14 Suppl. 2: 21-8. https://doi.org/10.1111/obr.12107

[108] Moodie R, Stuckler D, Monteiro C, Sheron N, Neal B, Thamarangsi T, Lincoln P, Casswell S; Lancet NCD Action Group. Profits and pandemics: Prevention of harmful effects of tobacco, alcohol, and ultra-processed food and drink industries. Lancet 2013; 381: 670-79. https://doi.org/10.1016/S0140-6736(12)62089-3

[109] Kuruvilla S, Bustreo F, Kuo T, Mishra CK, Taylor K, Fogstad H, Gupta GR, Gilmore K, Temmerman M, Thomas J, et al. The Global strategy for women's, children's and adolescents' health (2016-2030): A roadmap based on evidence and country experience. Bull World Health Organ. 2016; 94: 398-400. https://doi.org/10.2471/BLT.16.170431

Received on 25-7-2019 Accepted on 3-8-2019 Published on 15-8-2019

DOI: https://doi.org/10.12974/2311-8687.2019.07.1