DISCUSSION PAPER

The Current Understanding of Gestational Weight Gain Among Women with Obesity and the Need for Future Research

Anna Maria Siega-Riz, PhD, University of Massachusetts Amherst;
Lisa M. Bodnar, PhD, MPH, RD, University of Pittsburgh Graduate School of Public Health; **Naomi E. Stotland, MD,** University of California, San Francisco; and
Jamie Stang, PhD, MPH, RDN, University of Minnesota School of Public Health

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ABSTRACT | *Obesity affects many women of reproductive age in the United States. In 2009, the Institute of Medicine and the National Research Council published the report* Weight Gain During Pregnancy: Reexamining the Guidelines, *which recommends gestational weight gain guidelines based on pre-pregnancy body mass index (BMI) and considers multiple maternal and child health outcomes in an effort to balance the risk and benefits of the amount of gestational weight gain for these outcomes in the short and long term. Since the publication of that report, more evidence has emerged about weight gain in pregnancy among women with class II obesity (BMI of 35–39.9) and class III obesity (BMI of 40 or greater). New evidence includes trends in weight gains and associated health outcomes, as well as promising interventions, including digital health tools and group prenatal care. Despite this emerging evidence, there are still many limitations and research gaps that need to be filled in order to properly care for pregnant women with obesity and their fetus/child. Interventions should be developed with the involvement and engagement of the communities they will serve.*

Introduction

In June 2018, the Roundtable on Obesity Solutions of the National Academies of Sciences, Engineering, and Medicine (the National Academies) held a webinar titled "The Current Understanding of Pre-Pregnancy Weight, Gestational Weight Gain, and the Impacts on Maternal and Child Health Among Women with Obesity" with the objective of focusing on women with class II and class III obesity and exploring new evidence that has emerged since the 2009 Institute of Medicine (IOM) and National Research Council (NRC) gestational weight gain (GWG) recommendations were released (as of March 2016, the National Academies' Health and Medicine Division continues the consensus studies and convening activities previously undertaken by the IOM) [1]. Since the publication of that report, much has been published in the literature in regard to GWG patterns for women with overweight and obesity as well as interventions designed specifically to help women gain only within targeted ranges. In this paper, the authors, all speakers from that webinar, will present a summary of the how the 2009 IOM/NRC GWG recommendations were made and the major data gap that existed at that time, describe new GWG trends for women entering pregnancy with class II and class III obesity (body mass index [BMI] at or above 35), briefly summarize the most promising interventions for women with overweight and obesity, and provide a discussion of the research gaps that will need to be addressed before new recommendations can be made for these groups of women.

Background

Overweight and obesity affect many women of reproductive age in the United States, 27 and 41 percent respectively in 2015 and 2016 [2]. The 2009 IOM/NRC gestational weight gain recommendations, which were based on pre-pregnancy BMI and considered multiple maternal and child outcomes, also took into consideration this high prevalence of overweight and obesity [1]. This work was a paradigm shift in many ways. First, the committee that authored the report considered the risks and benefits of weight gain for the baby beyond that of low birth weight to include preterm birth,

large-for-gestational age (LGA), childhood obesity, and infant mortality. The 2009 committee also considered the health of the mother, including pregnancy complications, mode of delivery, and postpartum weight retention.

As noted in the report, the committee was guided by the basic principle that each product of conception represented the following amount of weight gain at term: fetus = 3.40 kg/7.50 lbs (2.5–5.0 kg [[5.51–11.02 lbs]); placenta = 0.65 kg/1.43 lbs; amniotic fluid = 0.80 kg/1.76 lbs; maternal tissue, such as uterus, mammary glands, etc. = 1.38 kg/3.04 lbs; blood, such as plasma and red cell volume = 1.45 kg/3.20 lbs; maternal fat stores = 3.35 kg/7.39 lbs; and extracellular/extravascular fluid = 1.48 kg/3.26 lbs, and if edema is present, up to 4.7 kg/10.36 lbs, all equaling 12.5 kg/27.56 lbs [1]. Of note, these are the basic figures first compiled by Hytten and Leitch decades ago and updated by Hytten and Chamberlain in 1991—referring to normal-weight women (BMI of 18.5–24.9), eating to appetite, who delivered optimal-weight babies (in countries where few had obesity)—whose total gain was 12.5 kg (or 27.56 lbs) [1, 3, 4]. These data are important because they allude to the minimum amount most women need to gain for a healthy pregnancy and it gives the sense that the products of conception might be differentially related to outcomes (e.g., greater fluid retention indicative of pregnancy-induced hypertension/pre-eclampsia and greater placenta weight being indicative of small-for-gestational age [SGA]).

The evidence included in the 2009 IOM/NRC report demonstrated a rather straightforward relationship between fat gain and fat retention postpartum (i.e., more weight gained during pregnancy resulted in more weight women had to lose in the postpartum period) [1]. In contrast, the relationship between GWG and fetal size was more complex [5]. Furthermore, the 2009 report suggested that gaining within the IOM guidelines was associated with reasonable changes in body composition in the postpartum period such that gaining within the targeted weight was associated with less maternal fat deposition [6]. Thus, given the obesogenic environment in which we live, maternal fat stores was the one component that allowed for variation in weight gain for women of different weight status entering pregnancy [7]. In other words, the 2009 committee noted that it was hard to justify issuing a recommendation that pregnant mothers should gain anything substantially lower than 9kg, while doing no harm to mother or baby, given the scientific evidence at that time [1].

Table 1 provides the recommendations from the 2009 IOM/NRC report, which illustrate that recommended weight gain varies by pre-pregnancy BMI category, with women with a BMI ≥ 30 being asked to gain the least amount of weight, ranging from 5–9 kg (11–20 lbs). At the time when the report was released, it was emphasized that there were limitations associated with these recommendations. The greatest limitation was the lack of data in the published literature for women with BMIs ≥ 35 [8].

Table 1 | Gestational Weight Recommendations from the 2009 Institute of Medicine and National Research Council Report[a]

Pre-pregnancy BMI Category	Total Weight Gain (lb, kg)	Rate of Weight Gain 2nd and 3rd Trimester (lb/week, kg/week)
Underweight (<18.5 kg/m^2)	28 - 40, 12.5 - 18	1.0 (1.0 - 1.3), 0.51 (0.44 - 0.58)
Normal weight (18.5 - 24.9 kg/m^2)	25 - 35, 11.5 - 16	1.0 (0.8 - 1.0), 0.42 (0.35 - 0.50)
Overweight (25.0 - 29.9 kg/m^2)	15 - 25, 7 - 11.5	0.6 (0.5 - 0.7), 0.28 (0.23 - 0.33)
Obesity[b] (≥30.0 kg/m^2)	11 - 20, 5 - 9	0.5 (0.4 - 0.6), 0.22 (0.17 - 0.27)

[a]Calculations assume a first-trimester weight gain of 1.1 - 4.4 lbs (0.5 - 2.0 kg).
[b]Since the release of the 2009 report, efforts are being made to discontinue the use of language that contributes to bias and stigma associated with weight. In line with people-first language, "obesity" is preferred to "obese." More information on people-first language can be found at https://www.obesityaction.org/action-through-advocacy/weight-bias/people-first-language

SOURCE: Adapted from Institute of Medicine and National Research Council, 2009 [1]

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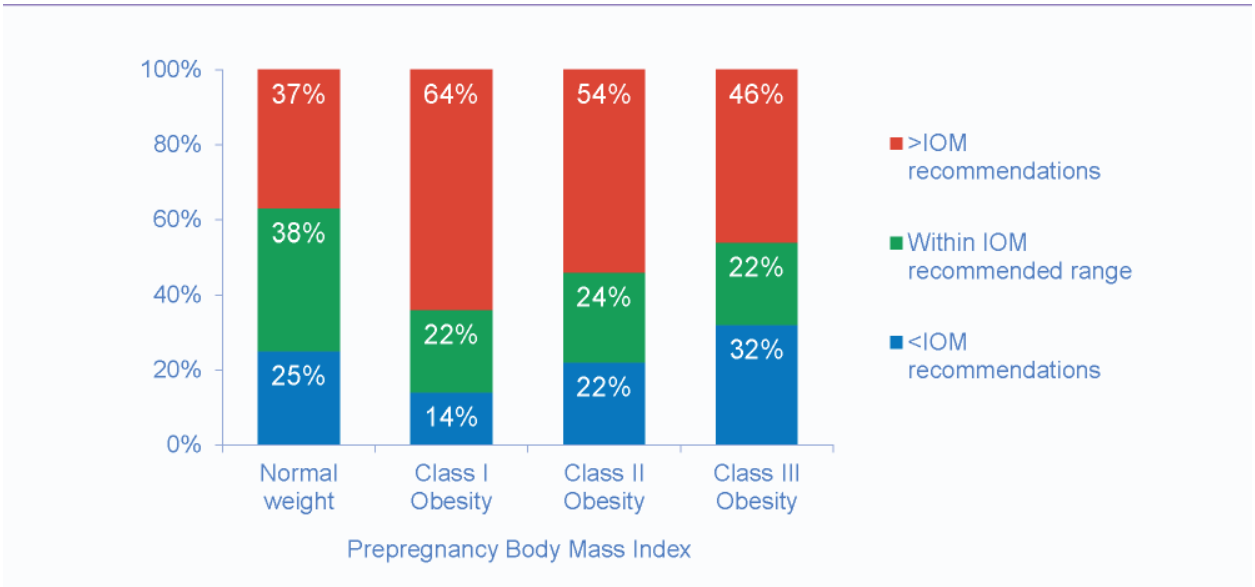
New Evidence on GWG for Women with Class II and Class III Obesity (BMI ≥ 35)

The prevalence of obesity in the United States has reached 41 percent, up from 17 percent in 1976 [2]. More striking, however, is the increase in severe obesity (BMI ≥ 40 kg/m2). Forty years ago, 1 in 50 Americans had a BMI of 40 or more, while in 2019 it is about 1 in 10 [2]. These rates are expected to continue to rise through 2030 [9]. Obesity is also common among pregnant women. At conception, 21 percent of women have a BMI of 30 or more and 9 percent have a BMI of 35 or more [10].

GWG tends to decline as BMI increases, but is higher than the 2009 IOM guidelines. Mean GWG ranges from 12.3–12.7 kg (27.1–28.0 lbs), 10.0–10.8 kg (22.04–23.81 lbs), and 7.5–9.5 kg (16.53–20.94 lbs) among women with class I (BMI 30–34.9), class II (BMI 35–39.9), and class III (BMI ≥ 40) obesity [11–17], respectively, which are generally higher than the recommended range of 5 to 9 kg [2]. As shown in *Figure 1*, only about one in four women with obesity gains within the IOM/NRC recommended range [10]. Contrast this with women with normal weight, who are more than 1.5 times as likely as women with obesity to gain within the guidelines. Most women with obesity gain in excess of the IOM/NRC guidelines, but inadequate weight gain is also common. Weight loss during pregnancy increases as severity of obesity rises; 2–5 percent, 4–9 percent, and 9–16 percent of women with class I, II, or III obesity respectively weigh less at delivery than they did at conception [12–14, 17, 18–20].

The association between GWG and adverse health outcomes differs according to pre-pregnancy BMI [2], with more optimal outcomes observed with lower weight gains for women with higher BMIs, whereas lower weight gains for women with a normal BMI may be less ideal. There is a large volume of research linking GWG and adverse maternal and child health outcomes among women with obesity [2], but few studies have evaluated these associations after stratifying women according to the severity of obesity. To the knowledge of the authors of this paper, gestational diabetes, SGA and LGA, cesarean delivery, preterm birth, and infant death are the only outcomes that have been studied in relation to weight gain by obesity severity. Rigorous evaluation of GWG relative to birth outcomes requires using measures of weight gain that are uncorrelated with length of pregnancy to avoid confounding by gestational duration [21]. Furthermore, because the pathophysiology of preeclampsia or the treatment of gestational diabetes may alter total weight gain, a measure of weight gain before clinical presentation of these conditions is necessary to avoid bias due to reverse causality [21].

Figure 1 | Gestational weight gain adequacy in the United States, 2012 and 2013, according to the 2009 Institute of Medicine and National Research Council guidelines



NOTE: Class I obesity is defined as a BMI of 30 - 34.9, class II obesity is defined as a BMI of 35 - 39.9, and class III obesity is defined as a BMI of 40 or greater.

SOURCE: Presented by Lisa Bodnar, June 13, 2018. Adapted from Deputy et al., 2015 [10]

A recent systematic review reported a clear, positive dose–response association between GWG and risk of LGA and cesarean delivery among women with class II and III obesity [22]. Although the relation is slightly less consistent, the review generally found that higher GWG was related to a lower risk of SGA in women with severe obesity [22].

There is only one study with an adequate sample size that reported on risk of gestational diabetes according to weight gain up to 24–28 weeks (the time of gestational diabetes screening) among women by obesity severity [23]. The authors of said study examined first and second trimester weight gain trajectories in relation to gestational diabetes and found that only first trimester weight gain trajectory was positively associated with diabetes in women with class I or II obesity. Furthermore, among women with class III obesity, there was no relation to risk of gestational diabetes with GWG in either trimester.

Unlike the U-shaped relations between GWG and the risk of preterm birth that have been reported in leaner women, two studies have reported that the risk of preterm birth is relatively flat and became meaningfully elevated only at very high GWGs [12, 24]. The risk of infant death has been elevated at both extremes of GWG for women with class II obesity. There were 1 to 2 excess infant deaths per 1,000 liveborn infants at weight gains of 5.5 kg or less, and very high weight gains of 35–42 kg (77.16–95.59 lbs) were associated with 2 excess deaths per 1,000 live-born infants. However, among women with class III obesity, GWG was not associated with infant death [12].

Overall, some evidence suggests that for women with severe obesity, low weight gain may increase the risk of SGA birth and infant death, and high weight gain may increase the risk of LGA birth, cesarean delivery, preterm birth, and infant death. Thus, for now, gaining within the targeted range is best.

Interventions Designed for Women with Overweight or Obesity: What Works?

While many intervention studies focus on GWG among patients with obesity, there is a lack of data and clinical studies that specifically target class II and III obesity. Most studies combine people of all obesity classes, so it is not possible to specifically identify which interventions are most effective in this subgroup. Below, studies grouped into three intervention domains are summarized: traditional diet and exercise, digital health, and other.

Traditional Diet and Exercise Interventions

Overall, diet, exercise, and diet plus exercise interventions in pregnancy show a modest but significant effect on reducing GWG [25]. However, many U.S.-based studies show that these interventions are less effective among women with obesity. The interventions studied are often not well described and are heterogeneous from study to study, so it is difficult to make recommendations for specific regimens. Not surprisingly, more intensive (and expensive) interventions with more frequent human interaction seem to be more effective than brief (once or twice) interventions or brochure-based advice. The type of diet (e.g., low glycemic, low fat) seems to be less important than overall caloric restriction, similar to the findings of studies involving non-pregnant individuals, but little is known about the long-term impact of such diets on infant health. Three recent review studies showed that exercise-alone interventions, while effective in some Asian and European studies, have generally not been shown to be effective at preventing excessive GWG in U.S.-based trials [26–28]. This finding held when the systematic review authors looked at the subgroup of women with obesity, although unfortunately the class of obesity (class I, II, or III) was not specified. However, exercise in pregnancy appears safe and may provide other benefits besides weight control [28].

Digital Health Interventions

There have been some promising findings from digital health interventions such as smartphone weight management apps and Web-based programs. Programs that engage with social media and create networks can provide peer support, and smartphone interventions allow 24/7 engagement with weight management resources. A review article found that among women with overweight or obesity, digital health interventions for weight gain in pregnancy were effective, especially if used in conjunction with a human element (e.g., phone calls, in-person visits, group visits) [29]. More research is needed on the use of various tracking devices in pregnancy, including activity/exercise monitors (e.g., pedometers, accelerometers). It is also unknown how many providers are recommending smartphone apps for weight management in pregnancy, and what barriers exist to their use, especially among lower-income patients, patients of color, and non-English-speaking patients in the United States. There are ongoing studies of digital GWG interventions, including one focusing on black patients with obesity [30].

Other Non-Traditional Weight Gain Interventions

A randomized trial of a meal replacement (prepared shakes/drinks) program among pregnant patients with overweight and obesity showed reduced GWG in the intervention group [31]. More studies are needed to examine the acceptability and safety of meal replacement in pregnancy, but these findings are promising and could be accessible to many patients in the United States. In addition, group prenatal care was associated with a small but statistically significant reduction in GWG and postpartum weight retention in one randomized controlled trial [32]. However, a recent systematic review and meta-analysis reported inconsistent impact of group prenatal care on GWG [33]. Given that group prenatal care has been linked to a number of improved perinatal outcomes (including fewer preterm births) as well as patient satisfaction, access to this model of care should be expanded.

Obesity Stigma, Bias, and Patient-Centered Care

Pregnant patients with a higher BMI report high rates of negative experience in the health care system, and these negative experiences lead some patients to avoid or delay care [34]. The first step to improving outcomes among patients with higher BMIs is to work on providing non-judgmental, comfortable, and patient-centered care. *Table 2* provides some resources for health care workers to use in guiding the care of pregnant women with overweight and obesity. Studies have shown that physicians hold strong negative biases against patients who weigh more, so efforts to increase awareness and anti-bias training of both new and senior clinicians may be necessary to reduce the negative impact on patients. As noted in Table 2, members of the Strategies to Overcome and Prevent (STOP) Obesity Alliance have created a toolkit in which providers are given several helpful tips and recommendations on how to have these conversations about weight. For example, it is suggested to avoid words such as "fat," "obese," "diet," and "exercise" and instead use terms such as "increased BMI," "unhealthy weight," and "eating habits." Similar to other medical topics, sometimes it is best to listen first, be empathic, and ask the patient if it would be acceptable to discuss their weight. The STOP Obesity Alliance tool kit has many other examples of how to begin and continue these necessary conversations [35].

Providers and researchers also need to be cautious to avoid "mommy blaming," especially among patients of color, who have been inappropriately blamed for high rates of perinatal morbidity and mortality [36]. While obesity is associated with adverse perinatal outcomes, black patients have higher rates of perinatal morbidity and mortality even when controlling for BMI, income, and other factors [37]. Research on racial inequity in perinatal outcomes indicates that structural racism, not "lifestyle," is a primary factor in racial health disparities [38, 39]. Therefore, it is all the more important to start conversations about obesity and weight gain with a patient-centered focus by listening to patients first and identifying their weight gain and pregnancy-related goals before providing advice. It is also essential to involve and engage with the communities of patients when developing interventions rather than imposing interventions that may not serve the needs and cultural characteristics of those communities [40].

Existing Gaps and Next Steps

While the current body of published literature provides insight with regard to appropriate GWG for women with obesity, significant gaps still exist in the literature. In fact, the existing body of literature suffers from several methodological issues, which limit the strength of the evidence and reduce the ability to generalize findings to an increasingly diverse U.S. population.

Study Design Considerations

Publications that report GWG outcomes are all too often secondary analyses of broader studies, which are not appropriately designed or adequately powered to examine GWG as an outcome. Few studies adequately stratify subjects by class of obesity prior to pregnancy when examining GWG patterns, while too many use a single category of "obesity" for all women with a BMI of 30 or greater [16, 18, 41]. Even fewer studies examine weight loss among women with obesity during pregnancy [19]. In failing to stratify by degree of obesity or to examine weight loss, studies are unable to identify potentially critical differences that could inform clinical interventions for pregnant women. In addition, studies often report only total GWG rather than patterns of weight gain across pregnancy (i.e., by trimester or in the first half of pregnancy), and fail to account for correlations between GWG and fetal growth. The authors of this paper believe that it is vital that future studies examine adequate numbers of participants to permit concurrent deliberation of appropriate categories of pre-pregnancy weight status, GWG patterns, and maternal-fetal outcomes. In sum, to inform optimal weight gain ranges, more research is needed on a wide range of short- and long-term outcomes in women with class II and III obesity, including maternal postpartum weight

Table 2 | Examples of Resources on Weight and Weight Gain Before and During Pregnancy

Topic	Resource
Motivational Interviewing[a]	Dr. Auguste Fortin, a specialist in health care communication, explains his opinions and experiences with motivational interviewing (applicable to weight, diet, and physical activity). *"Motivational interviewing involves four pillars in its practice: compassion, acceptance, partnership, and evocation." –A. Fortin, VI, MD, MPH, Yale University*
Why Weight?[b]	Starting the conversation about weight can be challenging. This resource guides providers on how and why to have these conversations with patients. *"Assessing patients' stage of change can help determine how to assist them moving forward" – Why Weight?*
Weight Bias and Stigma[c]	Another resource on starting conversations about weight. The Rudd Center for Food Policy & Obesity at the University of Connecticut provides links and information about weight bias and discrimination.
Managing Overweight and Obesity in Adults[d]	Systematic review from the Obesity Expert Panel.
Calculating BMI[e]	Resources from the American Heart Association on calculating body mass index, including subcategories such as pregnancy and breastfeeding.
Toolkit: Pregnancy Weight Gain Guidelines Dissemination Webinar[f]	This 88-minute webinar has information for healthy pregnancy and weight gain from the National Academies of Sciences, Engineering, and Medicine.
Referrals[g,h]	This resource shows how to have a referral system in place to easily make suggestions and recommendations for local resources and prenatal programs.
A Guide for Developing Tools Addressing Environmental Factors to Improve Diet and Physical Activity[i]	A guide with community member feedback that assists providers and organizations alike on tools and resources for implementing health promotion programs.
5A Model[j]	The 5A model (assess, advise, agree, assist, and arrange) provides a framework for counseling in clinical practice.

SOURCES: [a] Firth, S. 2016. What is motivational interviewing? *Medpage Today.* Available at http://www.medpagetoday.com/PublicHealthPolicy/GeneralProfessionalIssues/57850. Accessed July 1, 2019.
[b]STOP Obesity Alliance. Why weight? *STOP Obesity Alliance.* Available at http://whyweightguide.org/index.php. Accessed July 1, 2019.
[c]Rudd Center for Food Policy & Obesity, University of Connecticut. *Weight bias and stigma.* Available at http://uconnruddcenter.org/weight-bias-stigma. Accessed October 3, 2019.
[d]National Institutes of Health, National Heart, Lung, and Blood Institute, and North American Association for the Study of Obesity. 2000. *The practical guide: Identification, evaluation, and treatment of overweight and obesity in adults.* NIH Publication Number 00-4084. Available at https://www.nhlbi.nih.gov/files/docs/guidelines/prctgd_c.pdf. Accessed July 1, 2019.
[e]American Heart Association. 2018. *Body mass index in adults.* Available at http://www.heart.org/HEARTORG/HealthyLiving/WeightManagement/BodyMassIndex/Body-Mass-Index-In-Adults-BMI-Calculator-for-Adults_UCM_307849_Article.jsp?gclid=CLmY0Pyd6NMCFU5YDQod590Ixg#bmiswf. Accessed July 1, 2019.
[f]National Academies of Sciences, Engineering, and Medicine. 2018. *Toolkit: Pregnancy weight gain guidelines dissemination webinar.* Available at http://www.nationalacademies.org/hmd/Activities/Children/PregnancyWeightDisseminati on/2013-SEP-09/ToolKit.aspx. Accessed July 1, 2019.
[g]May, L. E., R. R. Suminski, E. R. Linklater, S. Jahnke, and A. G. Glaros. 2013. Exercise during pregnancy: The role of obstetric providers. *Journal of American Osteopathic Association* 113(8):612–619.
[h]Eakin, E. G., W. J. Brown, A. L. Marshall, K. Mummery, and E. Larsen. 2004. Physical activity promotion in primary care: Bridging the gap between research and practice. *American Journal of Preventive Medicine* 27(4):297–303.
[i]Jilcott, S. B., B. A. Laraia, K. R. Evenson, L. M. Lowenstein, and A. S. Ammerman. 2007. A guide for developing intervention tools addressing environmental factors to improve diet and physical activity. *Health Promotion Practice* 8(2):192–204.
[j]Vallis, M., H. Piccinini–Vallis, A. M. Sharma, and Y. Freedhoff. 2013. Modified 5 as minimal intervention for obesity counseling in primary care. *Canadian Family Physician* 59:27–31.

retention, childhood obesity, childhood neurocognitive outcomes, and chronic diseases.

Another gap in the GWG literature is the lack of implementation science to inform clinical practice guidelines. This type of research incorporates a transdisciplinary policy and systems approach, utilizing methods to enhance and ensure the systematic application of research findings and evidence-informed practices that enable broad adoption of interventions that will improve the effectiveness of health care services. This type of research must include effective methods for overcoming implementation challenges in diverse, under-resourced communities and should be made available to practitioners and professional organizations through the adoption of effective communication and dissemination strategies.

Participant Characteristics and Generalizability

The inclusion of participants who reflect the diversity of the U.S. population represents another gap in the literature. As the United States continues to develop into a more racially and ethnically diverse population, addressing this research gap becomes particularly relevant. It is estimated that by 2044 the majority of the U.S. population will be non-white [42]. The percentage of foreign-born individuals is expected to increase from 14 percent (2016) to 19 percent by 2060. Immigration from Latin America and Asia is expected to account for most of this change [43]. Currently, 50 percent of children younger than 5 years of age identify as a racial/ethnic minority, and this percentage is likely permanent, as the majority of babies born in the United States between 2010 and 2015 were born to non-white mothers [44]. A recent review of published literature related to GWG found that 72 percent of studies included white women, 66 percent included black women, 45 percent included Hispanic women, and only 20 percent included Asian women [45]. This is concerning given that populations that are expected to experience the most growth are among those least represented in the published literature. Notably, there is also a dearth of studies examining GWG among Native American, Alaskan Native, or Pacific Islander women, who are likely to experience significant disparities in maternal-fetal outcomes.

Social Determinants of Health and Weight Status

Gaps in the literature are also found with respect to the examination of GWG across structural and social determinants of health, such as race, ethnicity, nativity status, degree of acculturation, geography, and measures of socioeconomic status (SES) (e.g., education, household income, marital status, family size). The majority of the literature accounts for social and structural constructs by adjusting for rather than examining and explaining how variances in these factors impact GWG [46, 47]. These factors may affect GWG by altering patterns of food and beverage consumption and physical activity and may affect utilization of health care services, thus warranting more attention in future studies. Also, women from racial and ethnic minority populations have higher rates of living in poverty compared to white women [48]. Failing to adequately account for SES and other structural and social factors may result in the overestimation of associations between race or ethnicity and GWG. Data suggest that differences in health outcomes attributed to race or ethnicity may be attenuated when SES and other structural determinant factors are adequately accounted for in regression analysis [46, 47].

Current literature also often fails to account for nativity and cultural variation within racial and ethnic groups or acculturation among first- and second-generation U.S.-born women [49]. This is problematic as GWG and maternal and fetal outcomes such as preterm birth and low birthweight can be significantly different within racial and ethnic groups. For instance, rates of poor fetal outcomes vary significantly among black women born in the United States, in the Caribbean, or in Africa; however, the role of GWG in these disparities is largely unknown [50]. Similarly, rates of preterm birth are significantly different among Hispanic women with different countries of birth and cultural backgrounds [51], so Hispanic women should not be considered as a homogeneous group. Research suggests that pre-pregnancy BMI and GWG may be lower among Hispanic women, and may vary by cultural background, nativity status, and levels of acculturation [52–54]. Failing to account for nativity status and inter-ethnic origin may mask the impact of cultural practices and beliefs that affect GWG and may prevent the development of culturally tailored interventions for pregnant women.

Lastly, there are substantial gaps in the literature regarding other economic, social, and psychosocial attributes that are thought to disparately impact weight status among populations of pregnant and postpartum women, including food insecurity, nativity status, geography of residence, clinician recommendations regarding GWG, prenatal and postpartum depression, and social support [49–63]. For example, food insecurity is more common among female-headed households

and households of color and has been associated with higher pre-pregnancy BMI and higher GWG, yet is often ignored in research [45, 48, 54]. Material hardship (which includes food insecurity) during childhood has also been found to increase the risk of excessive GWG during pregnancy and later in life [62]. Pregnant women who lack access to health care may be at increased risk for altered GWG due to inadequate access to prenatal interventions. For instance, rural women are more likely to experience obstetric care provider shortages or transportation barriers, resulting in later entry to prenatal care [63, 64]. Notably, immigrant women may not seek health care, including prenatal care, out of distrust or fear of deportation [64, 65]. Therefore, it is important that health care professionals gain the trust of diverse populations, particularly among communities who have experienced historical trauma, and understand the barriers to research recruitment and participation to further develop tailored recruitment and intervention methods that overcome barriers to participation.

Summary and Conclusions

It seems clear that future research needs to employ stronger study designs, include diverse participants, collect more frequent and detailed data, examine differences in GWG by class of obesity, and assess both physiological and socio-economic constructs of health that may impact weight status before and during pregnancy. These types of studies will be required to examine the complex associations between race, ethnicity, SES, culture, residency status, and stressors and weight status among women of reproductive age.

Digital health and meal replacement interventions show promise for modest reduction in GWG for women with obesity, but more research is needed, especially for women with class II and III obesity. Based on available evidence, the best diet to reduce GWG is any reasonably healthful diet that reduces calories and is acceptable to the woman. It is important to listen to patients and communities about their priorities for health when developing interventions for gestational weight gain. Such interventions will be most effective when they are wanted and valued by patients and when their development is informed by communities.

It has been well established that a successful pregnancy starts in the preconceptional period [66]. Thus, for women with obesity in all of the classes, how health care professionals address women's current weight status is complicated due to the comorbidities associated with this condition both before and during pregnancy. Ideally, a reduction in weight prior to pregnancy would be recommended, but this may not be feasible or desired by the woman. Thus, gaining within the target weight gain recommendations may be one way to help optimize the health of the mother and child. While the authors of this paper do not expect GWG to totally mitigate the effects of these complications during pregnancy, it can contribute to improved outcomes for the mother, such as reduced postpartum weight retention, and for the child, outcomes related to development of childhood obesity and other epigenetic changes that may be related to the future development of chronic diseases [67]. Until these research gaps are filled, suggesting a new target GWG for women with obesity is premature. The authors of this paper encourage the scientific community to conduct well-designed studies to help address these gaps and the National Institutes of Health and other agencies to fund such studies.

References

1. Institute of Medicine and National Research Council (IOM and NRC). 2009. *Weight Gain During Pregnancy: Reexamining the Guidelines.* Washington, DC: The National Academies Press. https://doi.org/10.17226/12584.
2. Fryar, C., M. Carroll, and C. Ogden. 2016. *Prevalence of overweight, obesity, and extreme obesity among adults aged 20 and over: United States, 1960–1962 through 2013–2014.* National Center for Health Statistics, Health E-Stats. Available at https://www.cdc.gov/nchs/data/hestat/obesity_adult_15_16/obesity_adult_15_16.pdf.
3. Hytten, F. E., and I. Leitch. 1971. *The Physiology of Human Pregnancy, 2nd ed.* Oxford, UK: Blackwell Scientific Publications.
4. Hytten, F. E., and G. Chamberlain. 1991. *Clinical Physiology in Obstetrics.* Oxford, UK: Blackwell Scientific Publications.
5. Siega-Riz, A. M., M. Viswanathan, M. K. Moos, A. Deierlein, S. Mumford, J. Knaack, P. Thieda, L. J. Lux, and K. N. Lohr. 2009. A systematic review of outcomes of maternal weight gain according to the Institute of Medicine recommendations: Birthweight, fetal growth, and postpartum weight retention. *American Journal of Obstetrics Gynecology* 201(4):339 e1–e14.
6. Lederman, S. A. 1993. The effect of pregnancy weight gain on later obesity. *Obstetrics and Gynecology* 82(1):148–155.

7. Mackenbach, J. D., H. Rutter, S. Compernolle, K. Glonti, J-M. Oppert, H. Charreire, I. De Bourdeaudhuij, J. Brug, G. Nijpels, and J. Jeroen. 2014. Obesogenic environments: A systematic review of the association between the physical environment and adult weight status, the SPOTLIGHT project. *BMC Public Health* 14(1):233.
8. Rasmussen, K. M., P. M. Catalano, and A. L. Yaktine. 2009. New guidelines for weight gain during pregnancy: What obstetrician/gynecologists should know. *Current Opinions in Obstetrics and Gynecology* 21(6):521–526.
9. Finkelstein, E. A., O. A. Khavjou, H. Thompson, J. G. Trogdon, L. Pan, B. Sherry, and W. Dietz. 2012. Obesity and severe obesity forecasts through 2030. *American Journal of Preventive Medicine* 42(6):563–570.
10. Deputy, N. P., A. J. Sharma, and S. Y. Kim. 2015. Gestational Weight Gain—United States, 2012 and 2013. *Morbidity and Mortality Weekly Report* 64(43):1215–1220.
11. Johnson, J. L., S. L. Farr, P. M. Dietz, A. J. Sharma, W. D. Barfield, and C. L. Robbins. 2015. Trends in gestational weight gain: The Pregnancy Risk Assessment Monitoring System, 2000–2009. *American Journal of Obstetrics and Gynecology* 212(6):806.e1–806.e8.
12. Bodnar, L. M., A. M. Siega-Riz, H. N. Simhan, K. P. Himes, and B. Abrams. 2010. Severe obesity, gestational weight gain, and adverse birth outcomes. *American Journal of Clinical Nutrition* 91(6):1642–1648.
13. Durie, D. E., L. L. Thornburg, and J. C. Glantz. 2011. Effect of second-trimester and third-trimester rate of gestational weight gain on maternal and neonatal outcomes. *Obstetrics and Gynecology* 118(3):569–575.
14. Hinkle, S. N., A. J. Sharma, and P. M. Dietz. 2010. Gestational weight gain in obese mothers and associations with fetal growth. *American Journal of Clinical Nutrition* 92(3):644–651.
15. Park, S., W. M. Sappenfield, C. Bish, H. Salihu, D. Goodman, and D. M. Bensyl. 2011. Assessment of the Institute of Medicine recommendations for weight gain during pregnancy: Florida, 2004–2007. *Maternal and Child Health Journal* 15(3):289–301.
16. Kominiarek, M. A., N. S. Seligman, C. Dolin, W. Gao, V. Berghella, M. Hoffman, and J. U. Hibbard. 2013. Gestational weight gain and obesity: Is 20 pounds too much? *American Journal of Obstetrics and Gynecology* 209(3):214.e1–214.e11.
17. Bodnar, L. M., S. J. Pugh, T. L. Lash, J. A. Hutcheon, K. P. Himes, S. M. Parisi, and B. Abrams. 2016. Low gestational weight gain and risk of adverse perinatal outcomes in obese and severely obese women. *Epidemiology* 27(6):894–902.
18. Blomberg, M. 2011. Maternal and neonatal outcomes among obese women with weight gain below the new Institute of Medicine recommendations. *Obstetrics and Gynecology* 117(5):1065–1070.
19. Bogaerts, A., L. Ameye, E. Martens, and R. Devliegger. 2015. Weight loss in obese pregnant women and risk for adverse perinatal outcomes. *Obstetrics and Gynecology* 125(3):566–575.
20. Beyerlein, A., B. Schiessl, N. Lack, and R. von Kries. 2011. Associations of gestational weight loss with birth-related outcome: A retrospective cohort study. *British Journal of Obstetrics and Gynaecology* 118(1):55–61.
21. Hutcheon, J. A., and L. M. Bodnar. 2018. Good practices for observational studies of maternal weight and weight gain in pregnancy. *Paediatric and Perinatal Epidemiology* 32(2):152–160.
22. Faucher, M. A., and M. K. Barger. 2015. Gestational weight gain in obese women by class of obesity and select maternal/newborn outcomes: A systematic review. *Women and Birth* 28(3):e70–e79.
23. MacDonald, S. C., L. M. Bodnar, K. P. Himes, and J. A. Hutcheon. 2017. Patterns of gestational weight gain in early pregnancy and risk of gestational diabetes mellitus. *Epidemiology* 28(3):419–427.
24. Leonard, S. A., J. A. Hutcheon, L. M. Bodnar, L. C. Petito, and B. Abrams. 2018. Gestational weight gain-for-gestational age Z-score charts applied across U.S. populations. *Paediatrics and Perinatal Epidemiology* 32(2):161–171.
25. Muktabhant, B., T. A. Lawrie, P. Lumbiganon, and M. Laopaiboon. 2015. Diet or exercise, or both, for preventing excessive weight gain in pregnancy. *Cochrane Database of Systematic Reviews* 6:CD007145.
26. Wang, J., D. Wen, X. Liu, and Y. Liu. 2019. Impact of exercise on maternal gestational weight gain. *Medicine (Baltimore)* 98(27):e16199.
27. Craemer, K. A., E. Sampene, N. Safdar, K. M. Antony, and C. K. Wautlet. 2019. Nutrition and exercise strategies to prevent excessive pregnancy weight gain: A meta-analysis. *AJP Reports* 9(1):e92–e120.
28. Beetham, K. S, C. Giles, M. Noetel, V. Clifton, J. C. Jones, and G. Naughton. 2019. The effects of vigorous intensity exercise in the third trimester of pregnancy: A systematic review and meta-analysis. *BMC Pregnancy and Childbirth* 19(1):281.

29. Lau, Y., P. Klainin-Yobas, T. P. Htun, S. N. Wong, K .L. Tan, S. T. Ho-Lim, C. Chi, C. Tsai, K. W. Ong, S. Shorey, and W. S. W. Tam. 2017. Electronic-based lifestyle interventions in overweight or obese perinatal women: A systematic review and meta-analysis. *Obesity Reviews* 18(9):1071–1087.
30. Herring, S. J., J. J. Albert, N. Darden, B. Bailer, J. Cruice, S. Hassan, G. G. Bennett, L. Goetzl, D. Yu, L. M. Kilby, and G. D. Foster. 2019. Targeting pregnancy-related weight gain to reduce disparities in obesity: Baseline results from the Healthy Babies trial. Contemporary Clinical Trials. *Contemporary Clinical Trials* 87(105822).
31. Phelan, S., R. R. Wing, A. Brannen, A. McHugh, T. A. Hagobian, A. Schaffner, E. Jelalian, C. N. Hart, T. O. Scholl, K. Munoz-Christian, E. Yin, M. G. Phipps, S. Keadle, and B. Abrams. 2018. Randomized controlled clinical trial of behavioral lifestyle intervention with partial meal replacement to reduce excessive gestational weight gain. *American Journal of Clinical Nutrition* 107(2):183–194.
32. Magriples, U., M. H. Boynton, T. S. Kershaw, J. Lewis, S. S. Rising, J. N. Tobin, E. Epel, and J. R. Ickovics. 2015. The impact of group prenatal care on pregnancy and postpartum weight trajectories. *American Journal of Obstetrics and Gynecology* 213(5):688.e1–688.e9.
33. Kominiarek, M.A., A.K. Lewkowitz, E. Carter, S.A. Fowler, and M. Simon. 2019. Gestational weight gain and group prenatal care: A systematic review and meta-analysis. *BMC Pregnancy and Childbirth* 19(1):18.
34. Phelan, S. M., D. J. Burgess, M. W. Yeazel, W. L. Hellerstedt, J. M. Griffin, and M. van Ryn. 2015. Impact of weight bias and stigma on quality of care and outcomes for patients with obesity. *Obesity Reviews* 16(4):319–326.
35. STOP Obesity Alliance. Why weight? *STOP Obesity Alliance.* Available at http://whyweightguide.org/index.php.
36. McLemore, M. 2019. What blame-the-mother stories get wrong about birth outcomes among black moms. *University of Southern California Annenberg Center for Health Journalism.* Available at https://www.centerforhealthjournalism.org/2018/02/18/what-blame-mother-stories-get-wrong-about-birth-outcomes-among-black-moms.
37. Leonard, S. A., L. C. Petito, O. Stephansson, J. A. Hutcheon, L. M. Bodnar, M. S. Mujahid, Y. Cheng, and B. Abrams. 2017. Weight gain during pregnancy and the black-white disparity in preterm birth. *Annals of Epidemiology* 27(5):323–328.
38. Dominguez, T. P., C. Dunkel-Schetter, L. M. Glynn, C. Hobel, and C. A. Sandman. 2008. Racial differences in birth outcomes: The role of general, pregnancy, and racism stress. *Health Psychology* 27(2):194–203.
39. Chae, D. H., S. Clouston, C. D. Martz, M. L. Hatzenbuehler, H. L. F. Cooper, R. Turpin, S. Stephens-Davidowitz, and M. R. Kramer. 2018. Area racism and birth outcomes among blacks in the United States. *Social Science and Medicine* 199:49–55.
40. Franck, L. S., M. R. McLemore, N. Cooper, B. De Castro, A. Y. Gordon, S. Williams, S. Williams, and L. Rand. 2018. A novel method for involving women of color at high risk for preterm birth in research priority setting. *Journal of Visualized Experiments* 131:56220.
41. Goldstein, R. F., S. K. Abell, S. Ranasinha, M. Misso, J. A. Boyle, M. H. Black, N. Li, G. Hu, F. Corrado, L. Rode, Y. J. Kim, M. Haugen, W. O. Song, M. H. Kim, A. Bogaerts, R. Devlieger, J. H. Chung, and H. J. Teede. 2017. Association of gestational weight gain with maternal and infant outcomes: A systematic review and meta-analysis. *Journal of the American Medical Association* 317(21):2207–2225.
42. U.S. Census Bureau. *Projection of the size and composition of the US population: 2014–2060.* Available at https://www.census.gov/content/dam/Census/library/publications/2015/demo/p25-1143.pdf.
43. Pew Research Center. *10 demographic trends that are shaping the US and the world.* Available at http://www.pewresearch.org/facttank/2016/03/31/10-demographic-trends-that-are-shaping-the-u-s-and-the-world.
44. Pew Research Center. *Minority babies are the majority.* Available at https://www.pewresearch.org/fact-tank/2016/06/23/its-official-minority-babies-are-the-majority-among-the-nations-infants-but-only-just.
45. Denize, K. M., N. Acharya, S. A. Prince, D. F. da Silva, A. L. J. Harvey, Z. M. Ferraro, and K. B. Adamo. 2018. Addressing cultural, racial and ethnic discrepancies in guideline discordant gestational weight gain: A systematic review and meta-analysis. *PeerJ* 6:e5407.
46. Headen, I. E., E. M. Davis, M. S. Mujahid, and B. Abrams. 2012. Racial-ethnic differences in pregnancy-related weight. *Advances in Nutrition* 3(1):83–94.

47. Bleich, S. N., R. J. Thorpe, Jr., H. Sharif-Harris, R. Fesahazion, and T. A. Laveist. 2010. Social context explains race disparities in obesity among women. *Journal of Epidemiology and Community Health* 64(5):465–469.
48. Semega, J. L., K. R. Fontenot, and M. A. Kollar. 2017. Income and poverty in the United States: 2016. *U.S. Census Bureau Current Population Reports* P60-259.
49. Tabb, K. M., T. Malinga, M. Pineros-Leano, and F. C. D. Andrade. 2017. Impact of pre-pregnancy weight and gestational weight gain on birth outcomes by nativity in the United States: A systematic review. *Healthcare* 5(4):67.
50. Elo, I. T., Z. Vang, and J. F. Culhane. 2014. Variation in birth outcomes by mother's country of birth among non-Hispanic black women in the United States. *Maternal and Child Health Journal* 18(10):2371–2381.
51. March of Dimes. 2007. *Born too soon: Prematurity in the U.S. hispanic population.* White Plains, NY: March of Dimes.
52. Flores, M. E. S., S. E. Simonsen, T. A. Manuck, J. M. Dyer, and K. J. David. 2012. The "Latina epidemiologic paradox": Contrasting patterns of adverse birth outcomes in US-born and foreign-born Latinas. *Women's Health Issues Turok.* 22(5):e501–e507.
53. Chasan-Taber, L., M. D. Schmidt, P. Pekow, B. Sternfeld, C. G. Solomon, and G. Markenson. 2008. Predictors of excessive and inadequate gestational weight gain in Hispanic women. *Obesity (Silver Spring)* 16(7):1657–1666.
54. Pawlak, M. T., B. T. Alvarez, D. M. Jones, and D. C. Lezotte. 2015. The effect of race/ethnicity on gestational weight gain. *Journal of Immigrant and Minority Health* 17(2):325–332.
55. Laraia, B. A., A. M. Siega-Riz, and C. Gundersen. 2010. Household food insecurity is associated with self-reported pregravid weight status, gestational weight gain, and pregnancy complications. *Journal of the American Dietetic Association* 110(5):692–701.
56. Hromi-Fiedler, A., A. Bermudez-Millan, S. Segura-Perez, and R. Perez-Escamilla. 2011. Household food insecurity is associated with depressive symptoms among low-income pregnant Latinas. *Maternal and Child Nutrition* 7(4):421–430.
57. Stotland, N. E., J. S. Haas, P. Brawarsky, R. A. Jackson, E. Fuentes-Afflick, and G. J. Escobar. 2005. Body mass index, provider advice, and target gestational weight gain. *Obstetrics and Gynecology* 105(3):633–638.
58. Herring, S. J., J. W. Rich-Edwards, E. Oken, S. L. Rifas-Shiman, K. P. Kleinman, and M. W. Gillman. 2008. Association of postpartum depression with weight retention 1 year after childbirth. *Obesity (Silver Spring)* 16(6):1296–1301.
59. Laraia, B. A., A. M. Siega-Riz, N. Dole, and E. London. 2009. Pregravid weight is associated with prior dietary restraint and psychosocial factors during pregnancy. *Obesity (Silver Spring)* 17(3):550–558.
60. Thornton, P. L., E. C. Kieffer, Y. Salabarria-Pena, A. Odoms-Young, S. K. Willis, H. Kim, and M. A. Salinas. 2006. Weight, diet, and physical activity-related beliefs and practices among pregnant and postpartum Latino women: The role of social support. *Maternal and Child Health Journal* 10(1):95–104.
61. Fowles, E. R., J. Stang, M. Bryant, and S. Kim. 2012. Stress, depression, social support, and eating habits reduce diet quality in the first trimester in low-income women: A pilot study. *Journal of the Academy of Nutrition and Dietetics* 112(10):1619–1625.
62. Provenzano, A. M., S. L. Rifas-Shiman, S. J. Herring, S. J., J. W. Rich-Edwards, and E. Oken. 2015. Associations of maternal material hardships during childhood and adulthood with prepregnancy weight, gestational weight gain, and postpartum weight retention. *Journal of Women's Health* 24(7):563–571.
63. Committee on Health Care for Underserved Women. 2014. ACOG Committee Opinion No. 586: Health disparities in rural women. *Obstetrics and Gynecology* 123(2 Pt 1):384–388.
64. Baer, R. J., M. R. Altman, S. P. Oltman, K. K. Ryckman, C. D. Chambers, L. Rand, and L. L. Jelliffe-Pawlowski. 2018. Maternal factors influencing late entry into prenatal care: A stratified analysis by race or ethnicity and insurance status. *Journal of Maternal and Fetal Neonatal Medicine* 32(20):3336-3342.
65. Rhodes, S. D., L. Mann, F. M. Siman, E. Song, J. Alonzo, M. Downs, E. Lawlor, O. Martinez, C. J. Sun, M. C. O'Brien, B. A. Reboussin, and M. A. Hall. 2015. The impact of local immigration enforcement policies on the health of immigrant Hispanics/Latinos in the United States. *American Journal of Public Health* 105(2):329–337.
66. Stephenson, J., N. Heslehurst, J. Hall, D. Schoenaker, J. Hutchinson, J. E. Cade, L. Poston, G. Barrett, S. R. Crozier, M. Barker, K. Kumaran, C. S. Yajnik, J. Baird, and G. D. Mishra. 2018. Before the begin-

ning: Nutrition and lifestyle in the preconception period and its importance for future health. *Lancet* 391(10132):1830–1841.

67. Goldstein, R. F., S. K. Abell, S. Ranasinha, M. L. Misso, J. A. Boyle, C. L. Harrison, M. H. Black, N. Li, G. Hu, F. Corrado, H. Hegaard, Y. J. Kim, M. Haugen, W. O. Song, M. H. Kim, A. Bogaerts, R. Devlieger, J. H. Chung, and H. J. Teede. 2018. Gestational weight gain across continents and ethnicity: Systematic review and meta-analysis of maternal and infant outcomes in more than one million women. *BMC Medicine* 16(1):153.

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Author Information

The authors were speakers on the Roundtable on Obesity Solutions webinar "The Current Understanding of Pre-Pregnancy Weight, Gestational Weight Gain, and the Impacts on Maternal and Child Health Among Women with Obesity." **Anna Maria Siega-Riz, PhD,** is Dean and Professor, Departments of Nutrition and Biostatistics and Epidemiology, School of Public Health and Health Sciences, University of Massachusetts Amherst. **Lisa M. Bodnar, PhD, MPH, RD,** is Vice-Chair of Research and Professor of Epidemiology in the Department of Epidemiology at the University of Pittsburgh Graduate School of Public Health. **Naomi E. Stotland, MD,** is Professor of Obstetrics, Gynecology, and Reproductive Sciences at the University of California, San Francisco. **Jamie Stang, PhD, MPH, RDN,** is Associate Professor in the Division of Epidemiology and Community Health at the University of Minnesota School of Public Health.

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Correspondence

Questions or comments should be directed to Anna Maria Siega-Riz at asiegariz@umass.edu.

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