

Effects of the First 1,000 Days Systems-Change Intervention on Obesity Risk Factors During Pregnancy

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Abstract

Background: First 1,000 Days is a systems-oriented program starting in early pregnancy lasting through the first 24 months of infancy focused on preventing obesity and related risk factors among low income, mother-infant pairs. The program was developed in partnership with stakeholders to create an infrastructure for system-wide change. It includes screening for adverse health behaviors and socio-contextual factors, patient navigation and educational materials to support behavior change and social needs, and individualized health coaching for women at highest risk of obesity and has been shown to reduce excess gestational weight gain for women who were overweight at the start of their pregnancy.

Methods: We collected information through self-administered questionnaires during the first and third trimester of gestation and from electronic health records relating to obesity risk factors. Measures collected included behavior (i.e., diet, physical activity and screen time) and psychosocial outcomes, as well as enrollment in Women, Infant, and Children (WIC) program. We examined the extent to which participation in the program was associated with changes in behaviors and psychosocial outcomes among women during pregnancy.

Results: Women completed surveys at their initial and third trimester prenatal visits (n=264). Mean age (SD) was 30.2 (5.51) years and 75% had an annual household income of <\$50,000. Mean pre-pregnancy body mass index (BMI) was 27.7 kg/m² and 64% started pregnancy with a BMI \geq 25 kg/m². In multivariable adjusted models, we observed decreases in intake of sugary-drinks (-0.96 servings/day; 95% CI: -1.86, -0.06) and in screen time (-0.21 hours/day; 95% CI: -0.40, -0.02), and an increase in physical activity (0.87 days/week; 95% CI: 0.56, 1.17) from the first to third trimester. We also observed a decrease in pregnancy-related anxiety score (-1.06 units; 95% CI: -1.32, -0.79) and higher odds of enrollment in Women, Infant, and Children (WIC) program (OR: 2.58; 95% CI: 1.96, 3.41).

Conclusions: Our findings suggest that a systems-oriented prenatal intervention is associated with improvements in behaviors and psychosocial outcomes during pregnancy among low-income mothers.

Trial registration: ClinicalTrials.gov (NCT03191591; Retrospectively registered on June 19, 2017)

Background

Obesity remains highly prevalent and is a major contributor to chronic disease and other adverse consequences.^{1,2} Socioeconomic and racial/ ethnic disparities continue to persist despite national prevention efforts.^{3,4} Some of the origins of maternal and childhood obesity are linked to the first 1,000 days, a period from conception through the first two years of life and have life course impacts.⁵⁻⁷ During pregnancy, behaviors, such as maternal diet and physical activity, maternal anxiety, and connection to resources affect excessive weight gain and postpartum weight retention.^{8,9} As highlighted by the World Health Organization,¹⁰ this period represents a critical time for health-promotion interventions to prevent maternal and childhood obesity.

Intervention efforts focused on the first 1000 days have shown improvement in behaviors, psychosocial outcomes, and utilization of the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) resulting in improved outcomes for women and their children.¹¹ These studies have predominately targeted individual-level of change,¹²⁻¹⁴ while few interventions have focused on a broader context of change using a systems-level approach. In addition, few studies have been designed to support women and infant from low-income households as they may be more vulnerable than their peers to socio-contextual factors that influence behaviors, psychosocial status, and connection to resources. The First 1000 Days program was developed in conjunction with stakeholders to build an infrastructure for system-wide change for obesity prevention during the antenatal and postpartum periods.^{15,16} The program addresses clinical, behavior, and socio-contextual factors contributing to excess weight gain during pregnancy and during the first two years of life and has been shown to reduce excess gestational weight gain for women who were overweight at the start of their pregnancy.¹⁶

The purpose of this study is to examine behavior (i.e, diet, screen time, physical activity), psychosocial (i.e., anxiety), and WIC program enrollment changes from the first to third trimester for low-income women at high risk for obesity participating in the systems-oriented First 1,000 Days program in the greater Boston area. We hypothesized that program participation would lead to improvements in behavioral and psychosocial risk factors and promote the use of social support services during pregnancy.

Methods

Study Overview

Women enrolled in this study were participants in The First 1,000 Days program, a systems-level initiative that engages stakeholders across clinical and public health sectors to reduce the prevalence of obesity and obesity risk factors among mother-infant pairs who are low-income by addressing the levels of individual, family, and socio-contextual factors that hinder progress in obesity prevention. The system-wide intervention begins when women initiate prenatal care in their first trimester of pregnancy and offers support for mothers, their partners, and eventually the mother-partner-infant triads, throughout pregnancy and the child's first 24 months. The conceptual framework, intervention design, evaluation methods, and primary results have been described in detail elsewhere.^{15,16} A subset of women completed surveys in their first and third trimesters of prenatal visits to examine individual-level changes in behavior and psychosocial outcomes. For this secondary analysis, a quasi-experimental pre-post design was used to evaluate the changes in the behavior and psychosocial outcomes from the first to third trimester visit among participants.

Eligibility and Recruitment

The First 1,000 Days program was offered to women who initiated prenatal care between August 2016 and September 2017 in three community health centers in Boston, Revere, and Chelsea, Massachusetts that serve predominantly low-income, racially/ethnically diverse populations. Upon completion of the

intake survey and consent, women were considered to be enrolled in the program. The intake survey was administered to women at their first prenatal care visit which for most women was during the first trimester. Of the 366 women who completed a first trimester intake survey, 286 (78%) also completed a third trimester survey, and 264 (72%) women were included in the analyses as 22 women had missing vital demographic data (Fig. 1). The First 1,000 Days study protocol was approved by Partners HealthCare Institutional Review Board and registered at ClinicalTrials.gov (NCT03191591).

Program Components in Pregnancy

The First 1,000 Days program has multiple components that aim to improve primary and secondary prevention of obesity. The program components that have been previously described in detail and include: staff and provider training emphasizing obesity prevention efforts; clinical decision support tools to track gestational weight gain; first prenatal visit universal screening for health behaviors and socio-contextual factors; patient navigation focused on healthy behavior change, social needs, and clinical and public health services; and health coaching for women at high risk of obesity.^{15,16}

During pregnancy, the program focused on five behavior targets including: eating a balanced nutrition plan; drinking predominantly water and avoiding sugary-drinks; being physically active; getting recommended amounts of sleep; and reducing stress through social supports. Information regarding the behavior targets was delivered through printed materials including posters hanging in health centers and public health offices and individual booklets provided to patients. Booklets were available in English, Spanish, Vietnamese, and Arabic and contained customizable sections for gestational weight gain recommendations and behavior changed goal setting (Fig. 2). Women could also enroll in a text-messaging program to provide behavior change support and education and received 2–3 text messages during their pregnancy. Short informational videos (Vidscrips®) were also created in English and Spanish and available to women and their partners. The videos reinforced the behavior targets of the program, answered commonly asked questions, and provided recommendations.

Data Collection and Outcome Measurements

Information was collected through self-administered questionnaires during the first and third trimester of gestation and from electronic health records (EHR). Measures collected included behavior (i.e., diet, physical activity and screen time) and psychosocial outcomes, as well as WIC program enrollment. Surveys were available in English, Spanish, and Arabic.

Dietary behaviors, including fruit and vegetable, sugary-drinks, and fast food consumption were evaluated by asking women, “During the past 7 days, on average, how often did you eat ...?”. Women responded by selecting: never; once per week, 2–4 times per week, nearly daily, 2–4 times per day, or 5 or more times per day. The fruit and vegetable consumption question included fresh, cooked, canned, or frozen fruits or vegetables and excluded juices or dried fruits; mean consumption was measured in times per day. The sugary-drink question included fruit-flavored drinks, juice from concentrate, punch, Kool-Aid,

soda, sports drinks, sweet tea or coffee drinks, and sweetened milks; mean consumption was measured in beverages consumed weekly. The fast-food question asked about eating from a fast food restaurant; mean consumption was measured in weekly consumption. The items are from a validated food frequency questionnaire and have been previously used during pregnancy.^{17,18}

To evaluate physical activity, women answered, “During the past 7 days, on how many days were you physically active for a total of at least 30 minutes per day? Add up all the time you spent in any kind of physical activity that increased your heart rate and made you breathe hard some of the time.” Responses to this question ranged from 0–7 days per week. This question was adapted from the Youth Risk Behavior Survey.¹⁹

To measure screen time, women were asked, “During the past 7 days, on average, how many hours per day did you usually spend watching TV or videos. Include time spent watching on a television, computer, phone or tablet.” Women selected: never, < 1 hour per day, 1, 2, 3, 4 or 5 hours per day, and 6 or more hours per day. This question was adapted from the Nurses’ Health study.²⁰

We assessed pregnancy-related anxiety using the Pregnancy Anxiety Score, which focused on 5 topics: the extent of worry or concern about their health during pregnancy, about their baby’s health normal growth and developing, about losing the baby, about having a hard labor or difficult delivery, and about taking care of a new baby^{21,22} Possible responses to these questions were: never concerned, sometimes, most of the time, and almost all of the time concerned. A score was calculated by summing each of the five questions with a possible range from 0–20. Higher scores indicate a greater extent of worry or concern. If more than two questions were missing, a score was not calculated.

WIC program enrollment was offered to participants during pregnancy who reported they were not enrolled and met the income level criteria. To evaluate the number of women receiving WIC program support, we asked women, “Do you currently receive benefits from WIC?”. Women responded by answering: yes, no, or unsure.

Confounding Factors

Based on the previous literature, we used covariates for adjusted analyses.^{7,23,24} Socio-demographic variables collected in the first and third trimester survey were used and they included maternal age and race/ ethnicity. Pre-pregnancy body mass index (BMI) was collected from the EHR.

Statistical Analysis

Data from the EHR and survey results were merged to allow for analyses. We compared participants’ responses at baseline (first trimester of gestation) with results from third trimester surveys; each participant was measured twice, resulting in pairs of observations. We used repeated measures design, including the paired t-tests for quantitative variables and the McNemar’s test for qualitative variables in unadjusted models. We also used multivariable regression models to adjust for possible confounders,

including maternal age, race/ethnicity and pre-pregnancy BMI. Mixed-effect linear models were applied for continuous outcomes, with a time predictor to indicate the time points of first and third trimesters. The models accounted for clustering of observations within individuals. The adjusted mean differences between first and third trimester and 95% confidence intervals (CI) were calculated. For the dichotomous outcome, WIC enrollment, we applied logistic regression using generalized model, fitted with generalized estimating equation to address the repeated measurements. The adjusted odds ratio (OR) and 95% CI were generated for the WIC enrollment outcome. We performed analyses on complete cases and excluded participants with missing values in predictor, outcome, or covariates. A 2-sided alpha level of 0.05 was used to test for statistical significance in all analyses. Analyses were performed in RStudio 3.5.1 and SAS 9.4 (SAS institute, Cary, NC).

Results

Of the 286 women who completed a survey at their initial and third trimester prenatal visit, 264 were included in final analyses. Baseline demographic characteristics of participants, summarized in Table 1. Women were a mean (SD) age of 30.8 (5.51) years and initiated their first prenatal care visit at a mean (SD) gestational age of 10.4 (4.65) weeks. Women had a mean (SD) pre-pregnancy BMI of 27.7 (6.43) kg/m² and 64% started pregnancy with a BMI \geq 25 kg/m². At the first trimester visit, 33% of women were enrolled in WIC. 220 (83%) women received patient navigation and/or health coach phone-calls and booklets, 41 (16%) received booklets only, and 3 (1%) did not receive a phone-call or booklet.

Table 1
Baseline characteristics of 264 women participating in the First 1,000 Days Program.

Maternal Characteristics at First Trimester Visit	N (%) or Mean (SD)
Gestational age at intake, weeks, mean (SD)	10.4 (4.65)
Maternal age at intake, years, mean (SD)	30.8 (5.51)
Parity, mean (SD)	1.98 (0.92)
Pre-pregnancy BMI, kg/m ² , mean (SD)	27.7 (6.43)
Maternal pre-pregnancy weight status, n (%)	
Underweight	6 (2.3)
Healthy Weight	90 (34.1)
Overweight	94 (35.6)
Obese	74 (28.0)
Race/Ethnicity, n (%)	
White, Non-Hispanic	118 (44.7)
Hispanic or Latino	82 (31.1)
Black, Non-Hispanic	12 (4.5)
Other	52 (19.7)
Preferred language, n (%)	
English	141 (53.6)
Arabic	54 (20.5)
Spanish	46 (17.5)
Other	22 (8.4)
Annual household income, n (%)	
Less Than \$20,000	78 (31.6)
\$20,000 – \$50,000	108 (43.7)
Greater Than \$50,000	61 (24.7)
Employment status, n (%)	
Employed Full-Time	104 (40.0)
Employed Part-Time	72 (27.7)

Maternal Characteristics at First Trimester Visit	N (%) or Mean (SD)
Not Employed, Not Looking For Work	48 (18.5)
Not Employed, Looking For Work	22 (8.5)
Student	14 (5.4)
Married, n (%)	107 (41.0)
Publicly insured or uninsured, n (%)	133 (50.4)
Born outside the United States, n (%)	114 (43.2)

The results of the multivariable models adjusted for confounders for the behavior, psychosocial, and WIC enrollment outcomes are shown in Table 2. In multivariable adjusted models, we observed statistically significant decreases in intake of sugary-drinks (-0.96 servings/week; 95% CI: -1.86, -0.05) and in screen time (-0.21 hours/day; 95% CI: -0.40, -0.02), and an increase in physical activity (0.87 days/week; 95% CI: 0.56, 1.17) from the first to third trimester. We did not observe statistically significant changes between the first and third trimester for fruit and vegetable or fast-food intake. We also observed a decrease in pregnancy-related anxiety score (-1.06 units; 95% CI: -1.32, -0.79) and higher odds of enrollment in WIC (OR: 2.58; 95% CI: 1.96, 3.41).

Table 2
Changes from first to third trimester prenatal visit among women participating in the First 1,000 Days Program, N = 264

Outcomes	Mean (SD) First Trimester Visit	Mean (SD) Third Trimester Visit	Adjusted Mean Differences ^a (95% CI)	p- value
Behavioral Outcomes				
Fruit and vegetables (daily intake)	1.55 (1.29)	1.63 (1.31)	0.08 (-0.09, 0.24)	0.38
Sugary-drinks (weekly intake)	5.19 (6.20)	4.23 (5.62)	-0.96 (-1.87, -0.05)	0.04
Fast food (weekly intake)	0.94 (2.10)	0.81 (1.69)	-0.13 (-0.43, 0.18)	0.42
Physical activity (days per week) ^b	2.57 (2.28)	3.44 (2.29)	0.87 (0.56, 1.17)	< 0.001
Screen time (hours per day)	2.47 (1.59)	2.26 (1.51)	-0.21 (-0.40, -0.02)	0.03
Psychosocial Outcomes				
Pregnancy anxiety total score ^c	9.30 (2.93)	8.22 (2.67)	-1.06 (-1.32, -0.79)	< 0.0001
	First Trimester Visit n(%)	Third Trimester Visit n(%)	Adjusted OR ^a (95% CI)	p- value
The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) enrollment ^d	86 (33.3%)	141 (55.1%)	2.58 (1.96, 3.41)	< 0.001
CI = Confidence interval; OR = Odds ratio				
^a Adjusted estimates from longitudinal model. Adjusted for maternal age at intake, race/ethnicity, and pre-pregnancy BMI.				
^b N=260				
^c N=261; Range from 0 to 20 with higher scores indicating greater extent of worry or concern.				
^d N=250				

Discussion

The First 1000 Days program was created to build an infrastructure for system-wide change, and our findings reveal that the program is effective in improving maternal outcomes that aid in obesity prevention during antenatal and postpartum periods. In this study, we examined behavior, psychosocial, and community resource connection changes in women from low-income households who participated in the First 1000 Days program. We found participation in the program was associated with a decrease in intake of sugary-drinks, screen time, and pregnancy-related anxiety score; and an increase in physical activity from the first to third trimester. Women also had higher odds of enrollment in WIC after program participation.

Similar to other interventions during pregnancy, the First 1000 Days program showed improvement in dietary behaviors illustrating that a systems-level approach can be an effective method for promoting behavior change. Previous interventions have found improvements in overall dietary intake as measured via Healthy Eating Index and the Semi Quantitative Food Frequency Questionnaire,²⁵⁻²⁷ decreased consumption of processed foods,²⁸ and increased consumption of fruits and vegetables.²⁹ We found a decrease in consumption of sugary-drinks that has been shown to be critical in reducing post-partum weight retention,³⁰ but we did not see changes in fruit, vegetables, and junk food intake. Other reasons, such as neighborhood characteristics and food environment, despite our systems-level approach, may have continued to make changes in these dietary areas more challenging for women.³¹

We found a positive program effect on physical activity and screen time, though findings from previous interventions that have targeted physical activity are equivocal and few interventions have targeted screen time.^{13,26,27,29,32} A meta-analysis of 13 studies that examined the effectiveness of physical activity interventions during pregnancy found increases in metabolic equivalents and physical fitness.³³ Ainscough and colleagues²⁶ found a mean difference of 141.1 minutes per week of physical activity between the intervention and control groups in their trial that targeted individual-level change. Although measured differently and in different units, we also found an increase of physical activity of 0.87 days per week. By improving physical activity levels and sedentary behaviors, such as screen time, programs can help improve pregnancy and infant outcomes including gestational diabetes mellitus, excess gestational weight gain, maternal mental health, and infants born large-for-gestational-age.^{13,26}

In addition to behavior changes, we also found that women decreased their anxiety levels, consistent with what has been demonstrated in the literature.^{14,34} A meta-analysis revealed that interventions during pregnancy from four randomized control trials were shown to decrease anxiety scores resulting in a pooled estimate of -1.74 units, similar to our findings of -1.06 units and thereby improving women's mental health during the antenatal period. Another key component of the First 1000 Days program was connecting women to community resources including WIC program, food banks, and social services. By connecting women to community resources and engaging those organizations as stakeholders, the program was able to influence organizational and community factors that impact maternal health.

As previously reported, the First 1000 Days program has been shown to reduce excess gestational weight gain for low-income women who were overweight at the start of their pregnancy.¹⁶ In addition, women who participated in the program were also satisfied with the program, believed it improved their health and well-being, and that it provided an appropriate amount of services.¹⁶ The changes in behavior and mental health likely contributed to the reduction in excess gestational weight gain. Although several programs have demonstrated improvements in behaviors, mental health, and gestational weight gain, many of these studies have focused on the individual level,^{12,35-37} whereas the First 1000 Days program focused on system-wide change. The results of this current study demonstrate that a system-wide approach can be effective in supporting women during pregnancy and advantages of this approach are the connections between clinical and public health programs that target individual-level behaviors and socio-contextual risk factors simultaneously.^{16,38}

This study presents with several limitations. Because the First 1000 Days program utilized a system-wide change approach, i.e., the program had multiple components, we were unable to discern which component impacted the most change. The pre-post quasi-experimental design without a comparison group is susceptible to temporal confounders, but this needs to be balanced with a pragmatic approach to real-world implementation.

Conclusions

We found that women who participated in the First 1000 Days systems-oriented maternal and infant obesity prevention program decreased their sugary-drink consumption, screen time, and pregnancy-related anxiety score; increased their physical activity; and increased enrollment in WIC from the first to third trimester. The changes in behaviors, psychosocial status, and connections to resources are critical to maternal and child health outcomes. The findings indicate that the system-wide First 1000 Days Program can be an effective approach beyond individual change interventions for obesity prevention during the antenatal and postpartum periods for low-income women.

Abbreviations

WIC = the Special Supplemental Nutrition Program for Women, Infants and Children

BMI = Body mass index

EHR = Electronic health records

OR = Odds ratio

CI = Confidence Interval

Declarations

Ethics Approval and consent to participate: All experimental protocols involving human data were in accordance with institutional guidelines. Women received a fact sheet at their initial prenatal visit and survey completion served as consent for participation. The Partners Healthcare institutional review board approved the study protocol and method for obtaining consent.

Consent for publication: Not applicable

Availability of data and materials: The datasets used during the current study are available from the corresponding author on reasonable request.

Competing Interests: The authors declare that they have no competing interests.

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Authors' contributions: MS and LMG conceptualized and designed the study, analyzed and interpreted the data, and drafted the initial manuscript. ML analyzed the data and critically reviewed the manuscript for important intellectual content. MP, SP, MK, and TLB assisted with interpretation of the data and critically reviewed the manuscript for important intellectual content. ET conceptualized and designed the study, interpreted the data, and critically reviewed the manuscript for important intellectual content. All authors read and approved the final manuscript.

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Figures

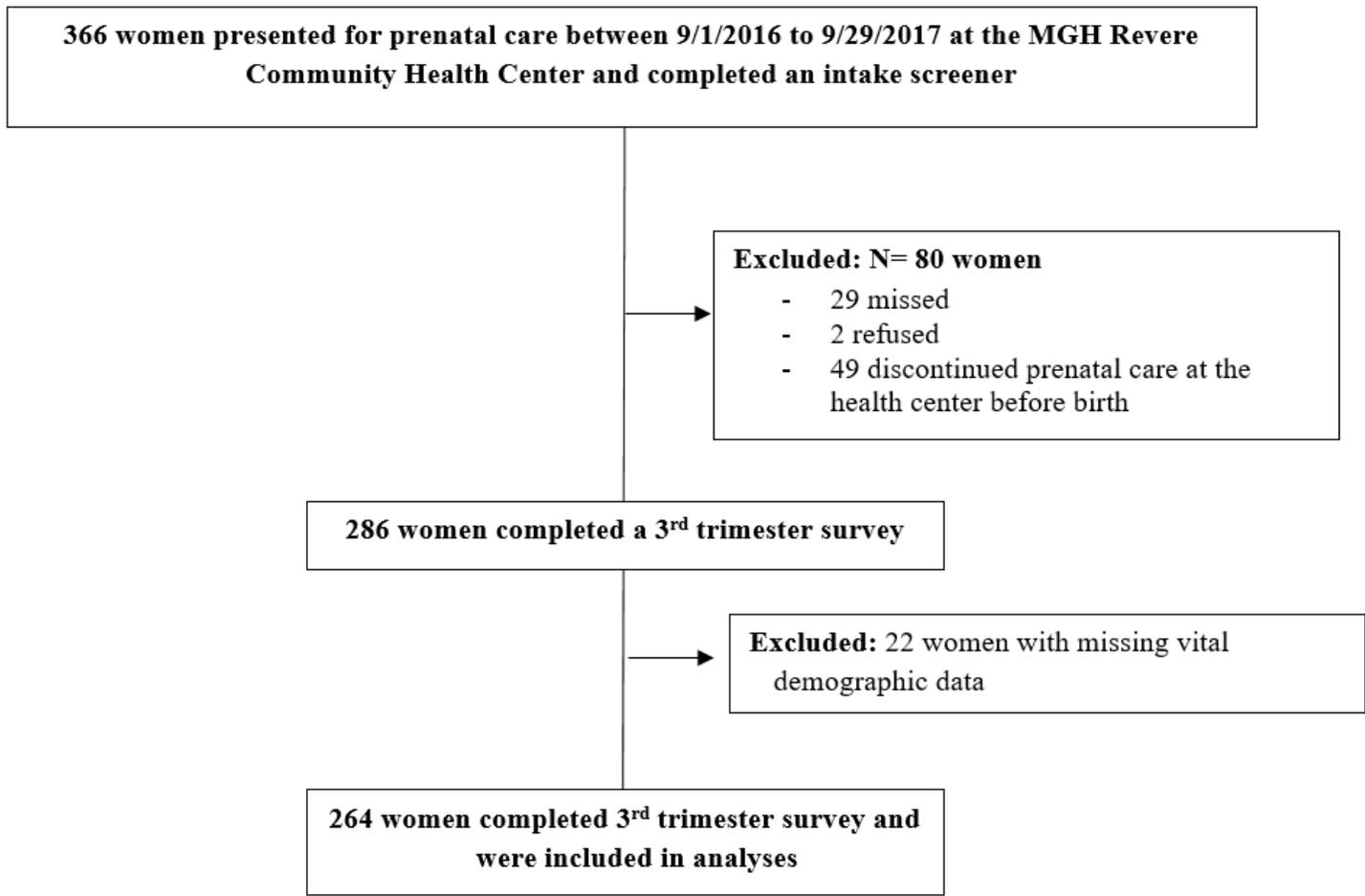


Figure 1

Participant Flow Diagram for Women Participating in The First 1,000 Days Program during pregnancy.

2 Drink mainly water.

Your body is healthier without the sugar and artificial sweeteners that are in many other drinks.

Did you know?

- Drinking water can help prevent swelling, hemorrhoids, and constipation.
- Drinking sugary drinks can lead to too much weight gain.
- Drinking artificially sweetened drinks may cause women to gain extra weight during pregnancy. It may cause their babies to gain weight more quickly as well.

What is a sugary drink?

- * Soda
- * Sports drinks
- * Energy drinks
- * Fruit drinks
- * Sweetened teas
- * Hot or iced coffee with sugar or sweeteners
- * Slushies and other blended drinks
- * Juice (even 100% fruit juice)



TIPS:

- Drink water when you're thirsty, at meals, and during the day.
- Get a reusable water bottle that you like and keep it with you.
- Add lemon, lime, or orange slices to water for flavor.
- Seltzer water is a good choice. It has no sugar or other sweeteners.
- Think of sugary drinks as a treat, not for every day.
- Use less or no sugar in coffee or tea.

3 Be physically active most days.

Get at least 30 minutes per day of moderate-intensity activity, like fast walking.

Did you know?

- Being active and getting exercise during pregnancy is very good for most women.
- Exercise can:
 - * give you more energy!
 - * help relieve stress.
 - * help you not gain too much weight.
 - * make you feel better and happier.
 - * make you stronger for labor and delivery.



Try to be active at least 30 minutes on most days. While active, you should breathe harder, but still be able to talk.

TIPS:

- Go for a brisk walk! It's a great way to get moving, even if you are not active now.
- Find out what activities are offered at your local community center.
- If you are not active now, do what you can and add a little more each week.
- Be active with a friend! Make it fun.
- Walk to the store, or with your kids to school or daycare.
- Check with your doctor or midwife before starting a new exercise routine.



First 1,000 Days®

Figure 2

Examples of First 1,000 Days Pregnancy booklet supporting behavioral changes.