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Original Research

Impact of fruit and vegetable benefits on pregnancy outcomes among WIC participants: a natural experiment

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Abstract

Proper nutrition is critical for maternal and neonatal health. In January 2017, the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) in San Francisco, California, began providing an additional $40 per month in fruit and vegetable (F&V) benefits to pregnant clients with the goal of improving food security and nutrition-related outcomes. We evaluated whether pregnant women on WIC who received this additional F&V benefit exhibited better perinatal and birth outcomes compared with those who received standard WIC benefits. We used 2010–2019 birth certificate data from the National Center for Health Statistics. The intervention group consisted of WIC participants living in San Francisco (SF) County (intervention county) and whose first trimester started after January 2017. We used a quasi-experimental synthetic control method to compare trends between the intervention and control groups (a weighted sample of other California counties that did not distribute additional F&V benefits). Outcomes included low birth weight, preterm birth, small-for-gestational-age, gestational diabetes, and gestational weight gain. No significant differences in maternal and neonatal outcomes among WIC recipients in SF and synthetic control group were observed after the F&V benefits were distributed. Prior studies have shown that additional F&V benefits have positive effects on maternal and infant outcomes, indicating that F&V vouchers are a promising strategy for supporting equitable health outcomes. Our null results suggest that more rigorous research is needed to determine their optimal dose and duration, especially in high-cost-of-living areas, and to examine more upstream and structural interventions.

Lay summary

More than 15% of pregnant women in the USA are estimated to be food insecure. Food insecurity can negatively affect maternal and infant health. In January 2017, the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) in San Francisco, California, began providing an additional $40 per month in fruit and vegetable (F&V) benefits to pregnant clients with the goal of improving food security and nutrition. This study evaluated whether pregnant women who received this additional F&V benefit had better health compared with those who received standard WIC benefits. We found no significant improvement in health among those who received the additional F&V benefits. A few prior studies have demonstrated that F&V benefits may be a promising strategy for improving maternal and infant health among low-income pregnant women. The results of this study suggest that more research is needed to examine larger benefit sizes and other geographical areas.

Keywords Nutrition, Perinatal and birth outcomes, Fruit and vegetable benefits, Special Supplemental Nutrition Program for Women, Infants, and Children program (WIC), Synthetic controls

Implications

Practice: Fruit and vegetable (F&V) supplements during pregnancy are important for maternal and infant outcomes among low-income families, but $40 per month may not be sufficient to alter birth outcomes.
Policy: The Special Supplemental Nutrition Program for Women, Infants, and Children should test F&V benefits of larger dollar value, particularly in areas with high cost of living, or work with local programs that provide additional support to low-income people.
Research: More research is needed to demonstrate whether larger F&V benefit sizes or more upstream interventions (e.g., unconditional cash transfers) are effective at reducing perinatal health inequities, including in geographically diverse areas.

INTRODUCTION

Nutrition during pregnancy plays a major role in shaping fetal growth and development and in ensuring positive maternal health during the perinatal and postpartum periods. Food insecurity, defined as the lack of consistent access to enough food for an active, healthy life, is common among

households that have limited financial and other household resources [1]. About 15%–18.3% of pregnant women in the USA were estimated to be food insecure during 1999–2010 [2]. During pregnancy, food insecurity is associated with stress, iron deficiency, inappropriate gestational weight gain, disordered eating patterns, and gestational diabetes (GDM) [3–5]. Furthermore, maternal food insecurity may contribute to worse birth outcomes, including preterm birth, low birth weight (LBW), and birth defects, which in turn have adverse effects on children's health and well-being later in life [6–8]. Epidemiologic studies indicate that early nutrition plays a key role in developmental programming in utero, which can result in epigenetic modifications that can put infants at risk for poor health outcomes, such as cardiovascular disease, metabolic syndrome, and diabetes, later in life [9]. This literature highlights the need to promote adequate maternal nutrition and food security during pregnancy.

Nutritional assistance during pregnancy can improve maternal and neonatal outcomes [10]. For example, the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) is the nation's third-largest federal food and nutrition assistance program. WIC provides low-income pregnant and postpartum women and children under 5 years old with supplemental food, nutrition and breastfeeding education, and referrals to health care and other social services. In 2020, WIC served over 6 million participants per month, including almost half of all infants born in the USA [11]. In addition to providing participants with vouchers to purchase specific food items like bread and milk, WIC participants also receive additional dollars, known as a cash-value benefit, designated to purchase fruits and vegetables. Receipt of WIC benefits, including changes in 2009 to improve the nutritional content of the food packages, is associated with improvements in perinatal diet quality, maternal health, and child health [12–15].

The cash-value benefit for WIC recipients has historically been only $11 per month. A recent cohort study found that 44% of pregnant women do not meet the recommended vegetable intake during pregnancy or the postpartum period, and that reduced vegetable intake was associated with lower income [16]. Consequently, beginning in 2017, EatSF, a program providing a financial supplement to low-income, food-insecure individuals and families in San Francisco, California, began a partnership with the San Francisco (SF) WIC program. The goal was to help pregnant WIC participants in high cost-of-living areas where WIC benefits are not sufficient to cover the food budgets of many enrollees. The EatSF program provides pregnant WIC participants with an additional $40 in vouchers per month to purchase fresh or frozen fruits and vegetables (F&V) for a duration of 6 months, in addition to the standard WIC package. The program was designed to reduce economic barriers to purchasing F&V by allowing participants to access produce at participating grocery stores and farmers markets. Details of what $40 of F&V vouchers could buy are provided in Supplementary Material. A recent pilot study of the program found that voucher recipients were more food-secure, ate more F&V, and had lower risk of preterm birth, compared with WIC participants who gave birth before the F&V vouchers were implemented, and thus did not receive the vouchers [17].

In this study, we took advantage of this natural experiment whereby pregnant WIC recipients in SF received F&V vouchers while other California counties did not, to examine the impact of this benefit on maternal and infant outcomes. We used a quasi-experimental design to account for secular (i.e., underlying) trends in the outcomes among WIC recipients in other counties that did not implement this benefit. We hypothesized that those who received WIC plus the F&V vouchers would have improved birth outcomes compared with those who received standard WIC benefits.

DATA AND SAMPLE

We used restricted birth certificate data from the National Center for Health Statistics (NCHS), geocoded at the county level. Self-reported WIC participation has been available in the national birth certificate data since 2010 for California. Thus, our sample included data from 2010 to 2019 (7 years preintervention and 3 years postintervention). In California, WIC benefits are distributed by 83 local agencies (health departments, Indian Health Centers, and nonprofit organizations) under contract with the California Department of Public Health. In SF, the County of SF administers the program.

We included all birth records from California that reported WIC participation and a delivery date during the designated time period (see sample selection flowchart, Fig. 1). During the data cleaning process, we identified a data artifact for WIC participation in SF: one major hospital misclassified many non-WIC participants (the majority with private health insurance) as WIC participants between 2013 and 2015. Since NCHS does not allow for identification of birth facility, we dropped all birth records with private health insurance in SF and other California counties to avoid this artifact. While this limits generalizability to those without private insurance, those with private insurance are much less likely to be WIC participants anyway, making the remaining population of non-participants a better control group for women participating in WIC. After dropping records with missing demographic characteristics, our final sample included 1,831,649 records (19,861 records in SF and 1,811,788 records in other California counties).

EXPOSURE

In 2017, all pregnant WIC recipients in SF became eligible to receive the F&V vouchers at participating stores (n = 30). Between 2017 and 2019, approximately 2,200 participants enrolled in this joint program and received the F&V vouchers during regularly scheduled clinic visits. The percentage of pregnant SF WIC recipients who received F&V vouchers varied from 41% to 66% between 2017 and 2019. However, these numbers could be overestimated if pregnant women with private health insurance, which were dropped from the sample, enrolled in the joint program, which may be rare (less than 3%). Of the vouchers distributed to participants, approximately 75% were redeemed at participating stores for F&V.

In our sample, we considered a person to be exposed to the F&V voucher program if they indicated WIC participation, residence in SF (intervention county), and a first trimester after January 2017 when the program started.

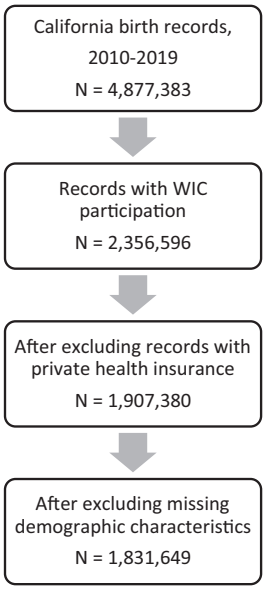

Fig 1 | Sample selection. Note: Sample included restricted birth certificate data from the National Center for Health Statistics (NCHS) for California from 2010 to 2019.

OUTCOMES

We selected infant and maternal outcomes that are potentially affected by the receipt of additional nutrition support. Infant outcomes included whether the infant had LBW (<2500 g); was preterm (born before 37 weeks' gestation); or was small for gestational age (SGA). Maternal outcomes included whether the mother was diagnosed with GDM; or gained weight that was within, below, or above the recommended gestational weight gain according to guidelines from the Institute of Medicine (now known as the National Academy of Medicine) [18]. Weight gain variables were derived based on a mother's height, pre-pregnancy weight, and delivery weight. For GDM, we excluded the year 2017 because a major hospital in SF temporarily changed its standard for GDM diagnosis in 2017 before reverting to pre-2017 diagnostic procedures. All variables were coded as binary variables.

COVARIATES

Covariates included mother's age at delivery; race and Hispanic origin; education; marital status; foreign-born status; and pre-pregnancy body mass index. Racial/ethnic categories included non-Hispanic White, non-Hispanic Black, Hispanic, and other [19]. Unfortunately, NCHS does not provide more granular details for this last category, which may represent a large minority of women in SF of primarily Asian origin. Meanwhile, marital status was missing for 2017 and later, as NCHS stopped releasing the marital status of mothers who gave birth in California due to state statutory restrictions [20]. We imputed the missing marital status for these years based on women's demographic characteristics using a logistic regression model.

ANALYSIS

We used a synthetic control method to estimate the effect of receipt of additional F&V vouchers on the outcomes of interest. We observed compositional differences between the intervention and control counties on key demographic characteristics (e.g., age, racial/ethnic composition) before and after the intervention, including when we used all California counties as the control group, and when we restricted the control group to SF-adjacent counties only. This precludes our ability to use a standard difference-in-differences (DiD) methodology. The synthetic control method is an analytic technique ideally suited to examining the effects of a policy while accounting for underlying secular trends in the outcomes in a "control" group that did not receive the treatment intervention, an extension of the commonly used DiD analysis. It improves on standard DiD, which uses an unweighted average of control counties selected by the investigator, and which may have contributed to the violations of the model assumptions described above. In essence, the synthetic control method allows us to compare trends in outcomes for SF with trends among a weighted sample of other counties that did not distribute additional F&V vouchers, extrapolating from trends in nontreatment counties before 2017 to generate a counterfactual trend for SF. Significant differences between the postintervention trends of outcomes in SF and in its synthetic control would indicate that additional F&V vouchers had an impact on birth outcomes for WIC participants.

In particular, the synthetic control group for SF County (synthetic SF) was constructed using data from all other California counties. We first aggregated demographic characteristics and health outcomes from the individual level to the county level by taking the mean, as synthetic control analysis occurs at the level of the treatment (i.e., the county) rather than the level of the individual. We then used the health outcomes and demographic characteristics in the preintervention period to generate weights for the control counties such that the weighted combination of control counties mirrors SF County as closely as possible during the preintervention period. This is accomplished by choosing weights for the control counties that minimize the root mean square prediction error (RMSPE) over the preintervention period. All models included covariates mentioned above, averaged over the preintervention time-period, as well as the outcome of interest at 6, 12, and 18 months before the intervention. As described in the Results section, six counties were assigned positive weights and formed the synthetic SF, most of which are Bay Area counties that are similar geographically and demographically to SF.

The fact that women's health outcomes in SF county were consistently worse than in all other California counties made it difficult to construct a weighted combination of control counties that provided a good estimate of the counterfactual trend in outcomes for SF county. To address this problem, we used a demeaned method, a slight modification in the synthetic control method that has been widely used to improve pretreatment fit and generate asymptotically unbiased estimates [21, 22]. Specifically, we subtracted the mean preintervention outcomes from the annual rates in each county. We then ran the synthetic control methods using these adjusted (demeaned) values rather than the original values. This modification provided a smaller RMSPE and hence, an improved estimate of the counterfactual.

Different from the usual hypothesis-testing methods, the synthetic control method relies on placebo tests to infer whether the estimated treatment effects are statistically significant.

This allows us to calculate the treatment effects for each untreated unit assuming it had received treatment. If there was a real treatment effect, we should expect that the estimated treatment effect for the unit that was actually treated is in the tails of the distribution of all estimated treatment effects [23]. In this study, we conducted placebo tests by calculating the effect size for each California county assuming the F&V vouchers had been distributed there since 2017. We then overlaid SF with all the placebos to make inferences.

RESULTS

Sample characteristics

Table 1 presents women's demographic characteristics and infant and maternal health outcomes in the intervention county and control counties before and after 2017. Women in SF were more likely to be foreign born and had a different racial/ethnic composition compared to other California counties. For example, more than 30% of women in SF reported being a race/ethnicity other than White, Black, or Hispanic, while this was true for less than 10% on average in other California counties. Health outcomes for women in SF were generally worse than those in other California counties. For example, the prevalence of GDM was approximately 11%–12% in SF, while it was only 5%–7% in other California counties. This difference in observed characteristics highlights the importance of the synthetic control method to produce a control group of California counties that more closely matches trends in SF.

County weights in the synthetic SF

As mentioned above, the synthetic control method constructs a synthetic control as a weighted average of the control counties based on the best match to preintervention covariates and outcomes in SF County. Table 2 shows the weights assigned to control counties and the resulting RMSPEs. Six counties (Alameda, Humboldt, Inyo, Napa, San Mateo, and Santa Clara), most of which are Bay Area counties that are similar geographically and demographically to SF, were assigned positive weights and formed the synthetic SF. The remaining California counties all received zero weights. The RMSPEs were very small in all models (i.e., less than 0.03), indicating a good fit [24].

Effects of F&V vouchers on infant and maternal health

We first examined the trends for each outcome in SF and synthetic SF over time graphically (Fig. 2). The preintervention trend for the adjusted outcomes of interest in SF

Table 1 | WIC participants' characteristics in San Francisco and other California counties

	SF County		Other California Counties	
	Preintervention	Postintervention	Preintervention	Postintervention
Women's characteristics				
Age (years)	28.6 (6.1)	29.4 (5.9)	26.7 (6.1)	27.7 (6.1)
Race				
Non-Hispanic White	7.6	5.8	12.6	11.6
Non-Hispanic Black	10.4	9.0	7.1	6.6
Hispanic	49.3	51.9	73.4	74.0
Other non-Hispanics	32.7	33.4	7.0	7.9
Education				
Less than high school	34.3	29.0	37.2	29.0
High school	32.9	35.1	35.4	38.5
Some college	23.2	22.6	23.0	26.6
College	8.0	11.3	3.7	4.9
Graduate degree	1.6	2.0	0.8	1.0
Married	43.3	40.8	37.7	28.0
Foreign born	71.1	74.2	46.7	42.3
Prepregnancy body mass index	25.9 (6.1)	26.5 (6.5)	27.2 (6.4)	28.1 (6.7)
Health outcomes				
Low birth weight	8.8	9.5	6.6	7.0
Preterm birth	10.5	11.4	9.2	8.9
Small for gestational age	11.2	10.7	10.2	9.8
Gestational diabetes	10.8	12.2	4.9	7.1
Gestational weight gain (within)	35.0	33.7	31.9	31.7
Gestational weight gain (below)	22.1	24.3	23.9	25.2
Gestational weight gain (above)	41.8	41.0	42.9	41.7
Number of Observations	15503	4358	1374512	437276

Note: All values are % or mean (SD). Sample included restricted birth certificate data from the National Center for Health Statistics for California from 2010 to 2019. Respondents with private health insurance were excluded and year 2017 dropped for gestational diabetes. Gestational weight gain that is within, below, or above the recommended level was defined following guidelines from the Institute of Medicine (now known as the National Academy of Medicine).

Table 2 | Weights assigned to counties for synthetic SF

	SF County						
	Low birth weight	Preterm birth	Small for gestational age	Gestational diabetes	Gestational weight gain (within)	Gestational weight gain (below)	Gestational weight gain (above)
Alameda	0.87	0.764	0.606	0.483	0.99	0.584	0.698
Humboldt	—	—	0.091	—	—	—	—
Inyo	—	—	0.026	0.429	—	0.144	0.207
Napa	—	0.163	—	—	—	—	—
San Mateo	—	0.073	0.277	0.088	0.01	0.272	0.095
Santa Clara	0.13	—	—	—	—	—	—
RMSPE	0.0052	0.0056	0.012	0.013	0.019	0.018	0.026

Note: Sample included restricted birth certificate data from the National Center for Health Statistics for California from 2010 to 2019. Respondents with private health insurance were excluded and year 2017 dropped for gestational diabetes. Gestational weight gain that is within, below, or above the recommended level was defined following guidelines from the Institute of Medicine (now known as the National Academy of Medicine). Results from the demeaned analysis are presented. To create the demeaned value, we subtracted the mean preintervention rate of outcomes from the annual rates in each county and used these data to generate a synthetic SF comparison group. Other California counties not listed above all received zero weight. RMSPE: root mean square prediction error.

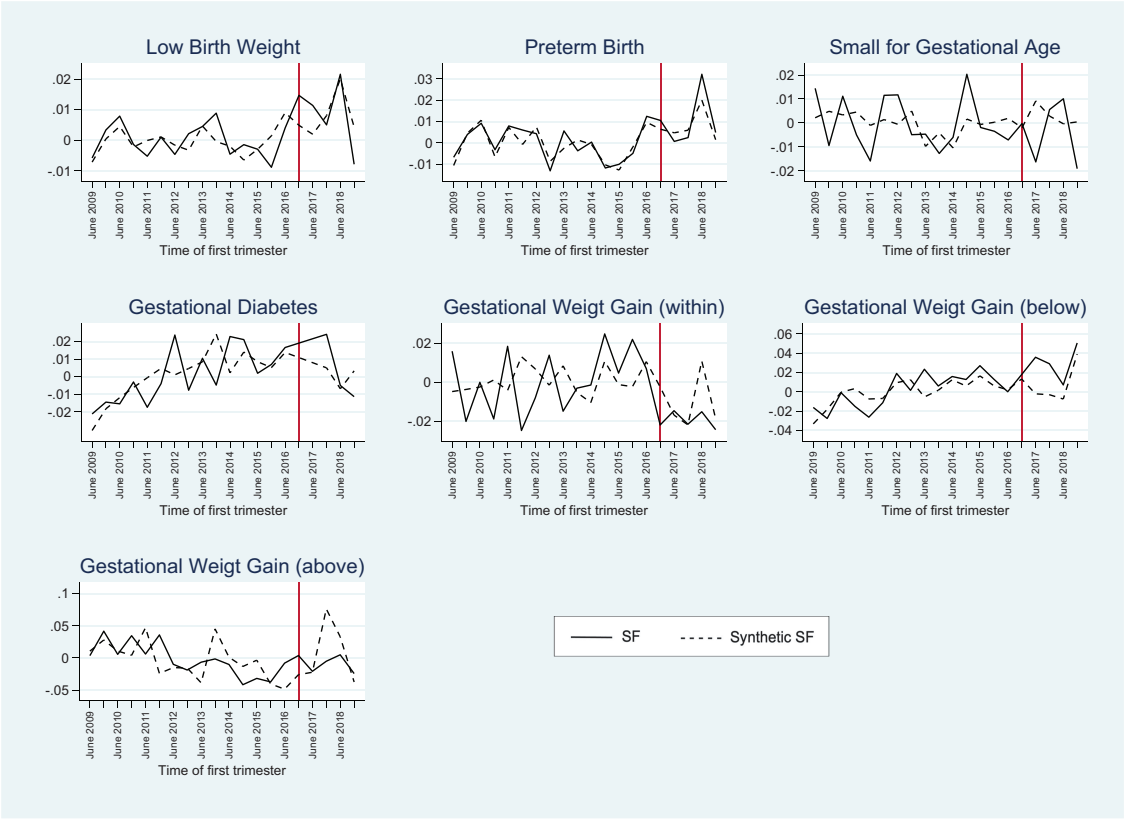

Fig 2 | Health outcomes for SF and synthetic SF over time. Note: Sample included restricted birth certificate data from the National Center for Health Statistics for California from 2010 to 2019. Respondents with private health insurance were excluded and year 2017 dropped for gestational diabetes. Gestational weight gain that is within, below, or above the recommended level was defined following guidelines from the Institute of Medicine (now known as the National Academy of Medicine). The y-axis represents the demeaned rate of outcomes. The difference between the postintervention trends of outcomes in SF and in synthetic SF represents the effect of additional F&V vouchers on maternal and birth outcomes.

and synthetic SF were very similar, indicating that the synthetic control group provided an appropriate match to SF, as confirmed by the low RMSPE described above. There was no obvious divergence in the postintervention period, however.

We then examined the quantitative results of the synthetic control analysis. Table 3 presents the mean of adjusted outcomes in SF and synthetic SF in the postintervention period. The difference in mean adjusted outcomes was 0.001 for LBW, 0.003 for preterm birth, −0.008 for SGA, 0.007 for GDM, −0.006 for weight gain within IOM recommendations, 0.03 for weight gain below IOM recommendations, and −0.02 for weight gain above the recommendations. These numbers indicate the percentage-point change in the

Table 3 | Effect of the EatSF program on birth outcomes

	SF	Synthetic SF	Difference
Low birth weight	0.009	0.010	−0.001
Preterm birth	0.010	0.013	−0.003
Small gestational age	−0.004	0.004	−0.008
Gestational diabetes	0.003	−0.004	0.007
Gestational weight gain (within)	−0.019	−0.013	−0.006
Gestational weight gain (below)	0.028	−0.001	0.029
Gestational weight gain (above)	−0.008	0.012	−0.020

Note: Sample included restricted birth certificate data from the National Center for Health Statistics for California from 2010 to 2019. Respondents with private health insurance were excluded and year 2017 dropped for gestational diabetes. Gestational weight gain that is within, below, or above the recommended level was defined following guidelines from the Institute of Medicine (now known as the National Academy of Medicine).

outcomes after receiving F&V voucher, adjusting for confounders. For instance, receiving F&V was associated with a 0.1 percentage-point increase in the probability of LBW, or a 0.8 percentage-point reduction in the probability of SGA.

Placebo tests shown in Fig. 3 indicated whether the above differences were statistically significant. In the figure, outcomes for all other county placebos are laid over outcomes from SF County. For all outcomes of interest, SF is not in the tails of the distribution of the estimated effects, indicating that trends in SF were not significantly different from those in the control group.

DISCUSSION

This study examined the impact of a 6-month supplemental F&V voucher among pregnant WIC participants in San Francisco, California. Using a rigorous quasi-experimental design, we found no significant changes in a range of infant and maternal outcomes. While this contradicts findings from a pilot observational study of this program, which found that pregnant women who received the vouchers had a 37% lower odds of preterm delivery when compared to historical controls [17], there are several reasons why we may not have observed our hypothesized effects.

First, compared to the pilot study of 592 pregnant WIC participants enrolled in the EatSF program, the results of this study may be subject to measurement error, as we were not able to match birth records with administrative WIC records, limiting our ability to determine the actual percentage of WIC recipients that participated in the EatSF program. Second, the prior study compared the preterm birth outcome between pregnant WIC participants who got F&V vouchers and gave birth between February 2017 and February 2018 and a historical comparison group (i.e., WIC participants who gave birth between January 2016 and January 2017 and thus did not get F&V vouchers). The observed reduction in preterm birth rate in the intervention group may also be attributed to other government efforts over the year, rather than the F&V voucher alone. In this study, we compared birth outcomes for pregnant WIC women eligible for F&V vouchers with pregnant WIC women ineligible for F&V vouchers who gave birth at the same time. The smaller estimated effects may be the result of eliminating other confounders. Third, the dose and/or reach of the intervention may not have been sufficient to have a meaningful impact on health outcomes, particular in SF which has a very high cost-of-living relative to other areas of California and the U.S. While $40 per month may be adequate to reduce food insecurity, it may not be enough to have a clinically meaningful effect on health outcomes at the population level among this high-risk marginalized population. Although evidence has shown positive effects of F&V prescription programs on several nutrition and health outcomes across different populations, there is still no consensus on the optimal dose and duration of such programs. Fourth, the effect size may have been small, and the sample not adequately powered, to observe a significant impact. Since we are using all possible births in SF during this time, there is no way to increase the sample size; using more recent years of data would include pandemic-era data which may bias study results.

Interventions aimed at improving dietary intake and reducing food insecurity are promising and need continued evaluation using rigorous study designs to determine their impact, particularly among pregnant women. The previous observational pilot study of the EatSF program documented improvements in food security and diet quality among pregnant WIC recipients but concluded that this was likely not solely attributable to the intervention, but rather the combined effect of multiple coordinated efforts designed to improve birth outcomes. Another study in Massachusetts that connected pregnant women to food resources found an association between program participation and improvements in blood pressure [25]. Recent evaluations of the 2009 revisions to the WIC package—which included additional dollars to purchase F&V and improved nutritional content—showed improvements in diet quality and nutrient intake during pregnancy and improvements in maternal and neonatal health outcomes [12–15]. Furthermore, the revised WIC package was associated with reductions in preeclampsia, appropriate gestational weight gain, longer gestational age, an increased likelihood of birth weight appropriate for gestational age, and a corresponding decrease in small-for-gestational-age and large-for-gestational-age infants [12, 13]. Those studies were conducted in much larger samples and therefore may have been better powered to detect small effects, and they also occurred in different historical and geographic contexts than the present study. Research has also shown that pregnant women receiving Supplemental Nutrition Assistance Program (i.e., SNAP) benefits—especially Black women and women living in high-poverty areas—have improved birth outcomes, including lower risk of having a low-birth-weight infant [26].

There may be opportunities to further study such interventions in future research in larger samples. For example, in March 2021, the federal American Rescue Plan approved a temporary increase to the WIC dollar amount for F&V from $11 to $35 per child and adult per month nationwide. Initially set to expire in September 2021, Congress extended these benefits and increased amounts to $24 for children and $43 or $47 for adults through September 2022. This represents one important policy solution for addressing food and nutrition insecurity, and evaluations should examine its impacts on reducing maternal and infant health disparities. It may also be that nutritional interventions during pregnancy are not as impactful as interventions targeting more upstream and structural risk factors for adverse birth

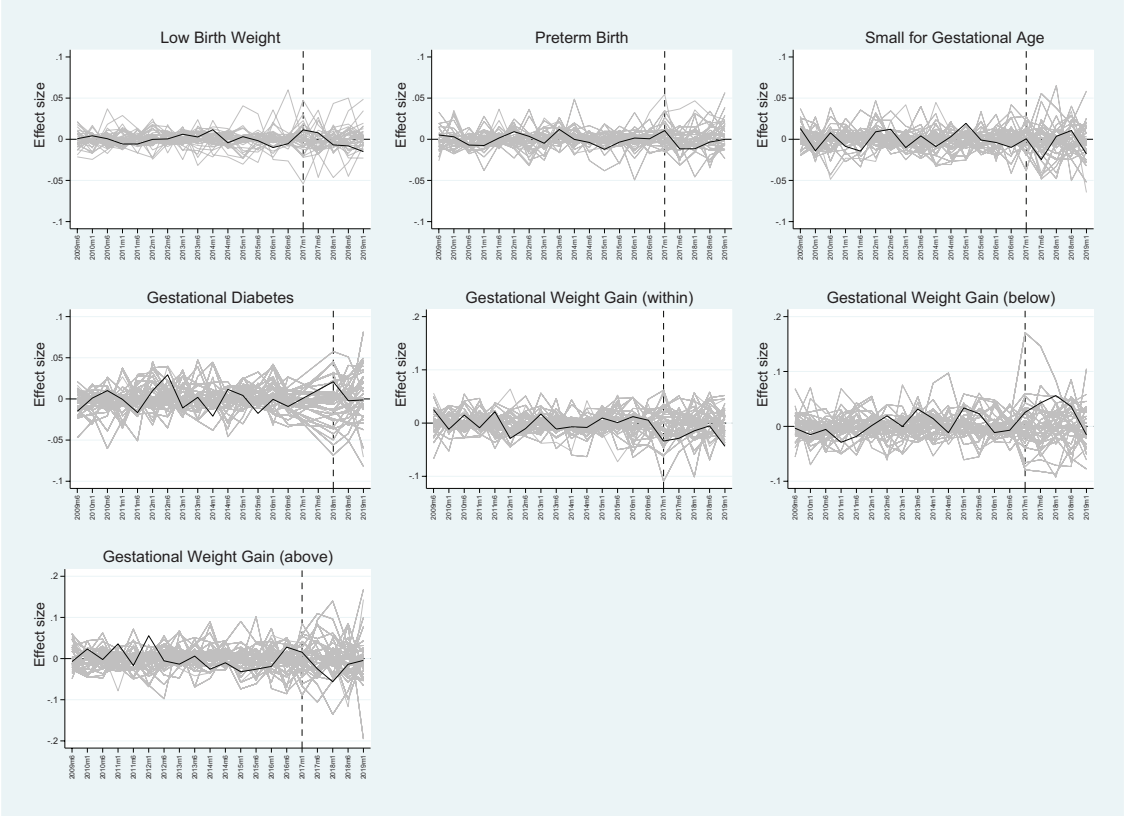

Fig 3 | Placebo tests for difference in outcomes between SF and synthetic SF. Note: Sample included restricted birth certificate data from the National Center for Health Statistics for California from 2010 to 2019. Respondents with private health insurance were excluded and year 2017 dropped for gestational diabetes. Gestational weight gain that is within, below, or above the recommended level was defined following guidelines from the Institute of Medicine (now known as the National Academy of Medicine). These placebo tests were conducted by calculating the effect size for each California county assuming the F&V vouchers had been distributed there since 2017. Outcomes for all other California county placebos are laid over outcomes from SF County. To imply a statistically significant treatment effect would require the estimated treatment effect for SF (actually treated) county to be in the tail of the distribution of all estimated treatment effects.

outcomes, for example, poverty or housing instability; policies targeting these risk factors have been found to be effective in prior work [27, 28].

This study has several strengths, including the use of a rigorous quasi-experimental design and population-level data to assess a contemporary policy. This study also has limitations. As previously stated, we were unable to determine from the birth records who actually participated in the EatSF program. Furthermore, among those who did participate, we were unable to determine how long they were enrolled in the program or their voucher redemption rates. The lack of information on these two aspects introduced measurement error into the exposure variable and hindered our ability to investigate the mechanisms through which the additional F&V vouchers may have affected the outcomes or to suggest solutions in the face of null results. In addition, as suggested by past studies, there may be spillover of WIC benefits to other family members. Our results thus may be underestimated if some of the F&V vouchers were used for other family members, which reduced the quantity of F&V that the pregnant woman consumed [29]. Finally, we only have 3 years of postintervention data at the time that we conducted the analyses and a limited number of voucher recipients, limiting the power of the analyses. Starting in August 2020, all pregnant WIC participants in SF were automatically provided with 9 months of vouchers, although many pandemic-era policies were introduced during this period that differ between SF and other counties; given this possible confounding, later data were therefore not included.

Conclusion

Prior studies have shown that broadly scaled, universal increases in F&V benefit levels for pregnant people enrolled in WIC support better dietary intake and improved birth outcomes. Local programs providing additional support are now common and may be particularly beneficial in high cost-of-living areas where WIC benefits are not sufficient to cover the food budgets of many enrollees. However, the impact of such local programs in conjunction with standard WIC benefits is still unclear, and we were not able to demonstrate their benefit in this study in California. Future research should examine such programs using larger sample sizes and rigorous study designs, a broader range of outcomes, as well as larger benefit sizes in different populations. Successfully addressing profound racial and socioeconomic disparities in prenatal outcomes will require the implementation and scaling of highly impactful, structural, and evidence-based solutions.

Supplementary Material

Supplementary material is available at *Translational Behavioral Medicine* online.

Acknowledgments

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Compliance with Ethical Standards

Conflict of Interest: All authors declare that they have no conflicts of interest.

Ethics approval: Ethics approval for this study was provided by the institutional review board of the senior author's institution (protocol #18-26719).

Informed Consent: This study involved secondary analysis of existing administrative data and informed consent was therefore not required.

Welfare of Animals: This article does not contain any studies with animals performed by any of the authors.

Transparency Statements: This study was not formally registered. The analysis plan was not formally preregistered.

Data Availability: Annual birth data are available online at https://www.cdc.gov/nchs/data_access/vitalstatsonline.htm. Geographic identification (e.g., state, county) is restricted from public use to compromise the confidentiality of survey respondents. Please visit https://www.cdc.gov/rdc/leftbrch/userestricdt.htm for details about accessing restricted data. EatSF program data may be made available to qualified users upon request. Analytic code used to conduct the analyses presented in this study are not available in a public archive. They may be available by emailing the corresponding author. No materials were used in this study.

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