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Preventive Effects on Birth Outcomes: Buffering Impact of Maternal Stress, Depression, and Anxiety

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Abstract
Objective Although maternal stress, anxiety, and depression have been linked to negative birth outcomes, few studies have investigated preventive interventions targeting maternal mental health as a means of reducing such problems. This randomized controlled study examines whether Family Foundations (FF)—a transition to parenthood program for couples focused on promoting coparenting quality, with previously documented impact on maternal stress, depression, and anxiety—can buffer the negative effects of maternal mental health problems.
Methods To assess the effects of FF, we used a randomized block design with a sample of 259 expectant mothers assigned to FF or a control condition and analyzed using propensity score models. We examine two-way interactions of condition (intervention vs. control) with maternal mental health problems (financial stress, depression, and anxiety) on birth outcomes (birth weight, days in hospital for mothers and infants). For birth weight, we assess whether intervention effects depend on length of gestation by including a third interaction term.
Results FF buffered ($p < 0.05$) the negative impact of maternal mental health problems on birth weight and both mother and infant length of post-partum hospital stay. For birth weight, assignment to FF was associated with higher birth weight for infants born before term.
Conclusions These results demonstrate that a psycho-educational program for couples focused on enhancing mutual coparental support, with preventive effects on maternal mental health, can reduce incidence of birth problems among women at elevated risk. Such improvements in birth outcomes could translate into substantial reductions in public and personal healthcare costs. Future work should assess mediating mechanisms of intervention impact and cost-benefit ratio of the intervention.
Clinical trials registration The Family Foundations follow-up intervention study is currently registered with www.clinicaltrials.gov. The study identifier is NCT01907412.

Keywords Prenatal stress · Depression · Anxiety · Birth weight · Length of hospital stay · Coparenting · Family Foundations

Abbreviations

FF	Family Foundations
ABOs	Adverse birth outcomes

Significance

What is already known about this topic? Maternal prenatal stress, anxiety, and depression have been linked to negative birth outcomes, but few studies have investigated preventive interventions targeting maternal mental health as a means of reducing such problems.

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What does this study add? These results demonstrate that a relatively inexpensive psycho-educational program for couples with preventive effects on maternal mental health can reduce incidence of birth problems such as low birth weight and duration of post-partum hospital stay among women at moderate to high risk.

Background

Rates of maternal or infant problems at birth are high globally and, in relative terms compared to other developed countries, also high in the US [6, 9, 37, 49]. Problems such as low birth weight and medical complications are not only associated with high health care costs, but put children at increased risk for mortality, poor developmental and behavioral outcomes, chronic health problems, low-educational attainment, and psychological disorders into adulthood [5, 9, 11, 12, 24, 28, 29, 42]. Most approaches for improving maternal and neonatal well-being focus on access to prenatal health care, maternal health behaviors, and avoidance of exposure of the fetus to harmful factors via maternal smoking and drug use [1, 3]. However, pregnant women's mental and emotional health represents an emerging prevention target as current research links prenatal anxiety and depression with suboptimal fetal development and birth problems [4, 7, 8, 10, 26, 45]. By inducing maternal stress, a parallel literature also links prenatal exposure to poverty and financial strain with these adverse outcomes [25, 40, 41, 50].

Family Foundations (FF) is a universal, couple-focused psycho-educational program for first-time parents that focuses on enhancing the coparenting relationship, the ways that parents support and collaborate with each other in their roles as parents [20]. The program focus is based on research demonstrating that coparenting relationship quality influences parent mental health and adjustment, parenting quality, and child outcomes [15, 16]. FF consists of a series of classes before and after birth, and has been shown to reduce maternal stress and depression [20]. In a first randomized trial evaluation (N = 169 couples), results from post-test and follow-up data collected from 6 months to 3.5 years after birth indicated that FF successfully enhanced coparenting, reduced parental stress, and lowered maternal depression and anxiety [18]. Results also indicated that the program improved parenting quality, improved children's self-regulation, reduced levels of internalizing and externalizing problems, and enhanced school adaptation when children were 7 years old [19]. The magnitude of effects differed across outcomes, with effect sizes of $d = 0.56$ for maternal depression, and $d = 0.55$ for child internalizing and 0.78 for boys' externalizing at age 7.

Given the program's effects on maternal mental health, we hypothesized preventive impact for women at risk of poor birth outcomes due to mental health problems. In the prior study, we used cortisol to identify women at risk of Adverse Birth Outcomes (ABOs), as higher levels of cortisol during pregnancy are linked to preterm birth and low birth weight [2, 14, 31, 52]. Results indicated that random assignment to FF was associated with reduced ABO's for pregnant mothers who had moderate to high levels of the stress-related hormone cortisol, which was sampled once late in the afternoon or early evening [22].

In this extension, we utilize a larger sample and we replace cortisol as a risk indicator with women's self-reported financial stress, anxiety, and depression. Our rationale was that these risk indicators should yield similar results as in our prior work with cortisol as these indicators are linked to cortisol levels through the functioning of the Hypothalamic–Pituitary–Adrenal axis, which modulates the body's response to stress. However, these psychological indicators are easily obtained through brief and reliable questionnaires and thus provide a potentially less burdensome and more rapid means of identifying women at risk in health care settings. Accordingly, in this study we test the impact of FF as a protective factor, buffering the negative impact of stress, depression, and anxiety on birth outcomes. Given our reliance on participant recall, rather than medical records, we utilize indicators that are easily reported by parents and subject to limited recall bias: birth weight and duration of mother and infant hospital stays after birth. In examining birth weight, we explore whether program impact operates differently on birth weight depending on number of weeks gestation.

Patients and Methods

Study Design

This randomized trial included a sample of 399 heterosexual couples residing in three mid-Atlantic and one southwestern US states (see Fig. 1). To participate, couples had to be expecting a first baby, cohabiting or married, and each parent over 18 years of age. Couples were primarily recruited through childbirth education programs and Ob/Gyn clinics, but also through media advertisements and fliers. Couples were randomly assigned to intervention or control conditions after pretest data collection using a randomized block design. Intervention status was blinded to participants throughout the duration of the study. The FF preventive intervention program consisted of nine classes, with five held on a weekly basis during mid-pregnancy, and four held on a weekly basis several months after birth. Program content fostered positive coparenting by incorporating material on parental emotional self-management, conflict resolution skills, cognitive attributions, problem

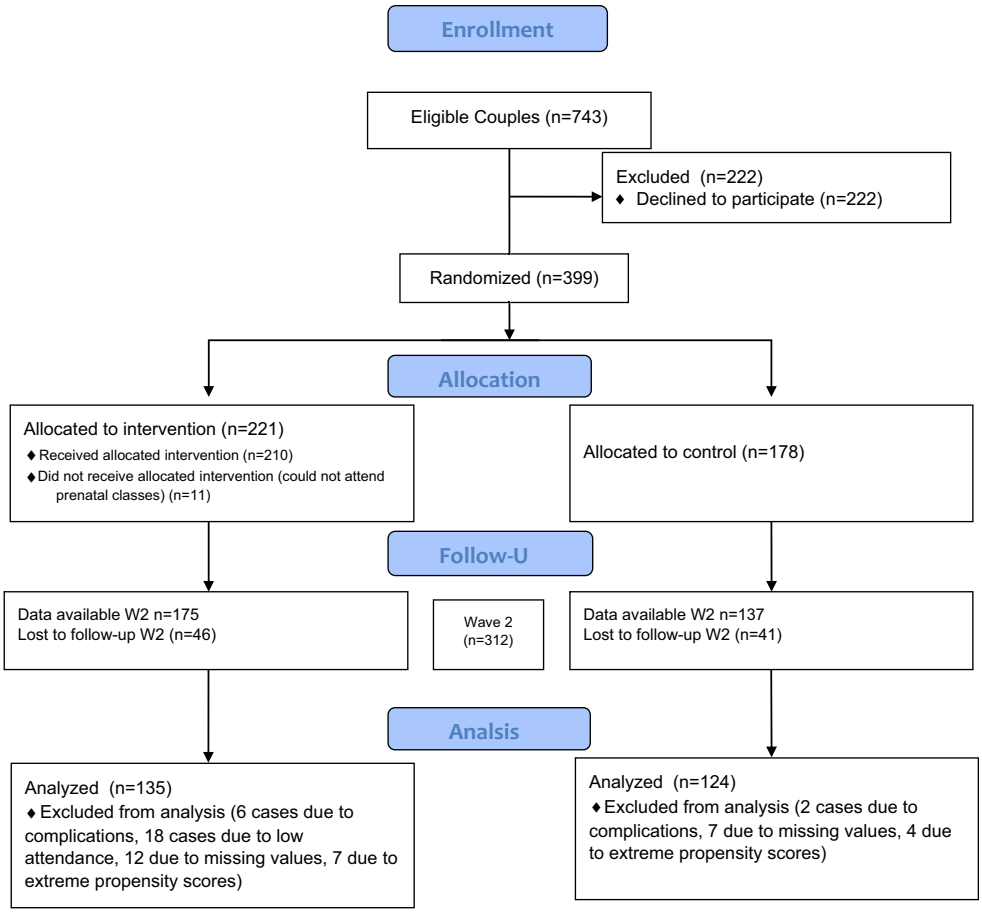

Fig. 1 Family Foundations consort flow diagram

solving, communication skills, and mutual support strategies. Classes included brief didactic presentations, video vignettes, couple skills training exercises, and group discussions. Control group families were mailed literature on selecting quality child care and stages of child development.

Recruitment and pretest interviews were conducted between 2008 and 2012. Pretest data collection consisted of a research assistant visit to the home to administer questionnaires to expectant mothers and fathers, and videotaped couple interaction protocols, at 22.8 weeks (SD 5.5) gestation on average. At pretest, mothers had a mean age of 28.4 years (SD 2.91), mean education of 15.7 years (SD 1.5), and median household income of $87,500. Of these respondents, 84.7 % were non-Hispanic white, and 86.6 % were married.

The average attendance rate at the five prenatal classes among intervention participants was 87.9 %, corresponding to average of 4.3 classes attended. (This rate is based on at least one parent attending, although it was rare for only one parent to attend alone). The first author estimates that attending three of the five prenatal classes would represent minimally adequate dosage. Among intervention condition mothers, 8.2 % did not attend at least three of the five prenatal classes. As we describe below, we utilized propensity score analysis to address this issue of adequate dosage in evaluating intervention effects.

Data on birth weight and birth date were collected by mailed postcards or phone calls shortly after delivery, with additional data collected through a posttest home visit at roughly 10 months postpartum. Mothers answered questions about birth outcomes. The number of mothers completing interviews at posttest was 312 ($N = 137/178$ control; $n = 175/221$, intervention). We excluded eight families (six intervention and two control) from analyses because of severe parent or infant medical problems (e.g., severe congenital defect, chronic illness) or multiple births. Fifteen additional cases were not included due to missing pretest control variables.

Our attrition analysis examined whether several background variables representing socioeconomic, mental health and other demographic information) predicted the likelihood to drop out before posttest. From this we found no significant condition differences in likelihood to drop out of the study before posttest. Analyses involved logistic regressions to model likelihood for attrition.

Measures

Demographics

At pretest, respondents provided demographic information including age, number of years in school, self-rated general health (ranging from 1 to 4, with '1' being poor and '4' being excellent), height and pre-pregnancy weight.

Substance Use

To represent potential effects of alcohol abuse, we used lifetime report of the number of alcohol-related problems. Given that maternal tobacco consumption and second-hand smoke exposure may lead to ABOs [32, 38, 39], we also included a measure of level of cigarette smoking, averaged across parents. No mothers reported drug use within the past 30 days and thus we included no measure of drug use.

Stress and Mental Health

To represent stress from financial concerns, we included a scale derived from three survey items assessing hardship due to a lack of resources, recent need to reduce standard of living, and reported difficulty living on current income [33, 36]. Alpha (α) at pretest was 0.71. To represent depression at pretest we used a 14-item version of the Center for Epidemiological Studies Depression Scale (CES-D) [44] ($\alpha = 0.81$). To represent general levels of anxiety, we used a subscale of the State-Trait Anxiety Inventory [48] ($\alpha = 0.88$). This scale consists of ten items covering topics such as tendency to be nervous or restless, satisfaction with self, and likelihood to get into a state of turmoil or tension while thinking of recent concerns and interests.

Birth Outcomes

Data on birth weight and gestational age (computed on the basis of due date and date of birth) were self-reported by the mother. Five deliveries that occurred at less than 34 completed weeks were recoded to be 34 weeks in order to reduce the influence of outliers [43]. Length of hospital stay (LOS) was determined from the number of mother-reported days that the newborn and mother spent in the hospital after birth, recorded as separate variables. Because delivery method was highly predictive of LOS, we included an indicator of cesarean delivery (1 = C-section, 0 = no C-section) in models for LOS outcomes. In order to reduce influence of outliers in our analysis, the number of days for the length of stay of the child in the hospital was capped at 17, using box-plots to guide this adjustment. Overall, distributions of birth outcomes were relatively symmetric with extreme values in some cases. Standard linear regression was deemed appropriate based on examined distributional characteristics with specification of robust standard errors to correct for slight non-normality.

Analysis

We used separate regression models for each outcome to examine (a) main effects of the intervention on outcomes for the full sample; and (b) whether the intervention moderated associations between measures of prenatal distress and pregnancy outcomes. As noted above, moderated effects were considered in terms of pre-intervention self-report of stress (financial concerns) or mental health (depression and anxiety). Study site was included in regression models as three yes/no indicators. For assessing moderation, we considered the possibility that associations may take a non-linear form (e.g., where the link between pre-intervention stress and birth outcome is not constant across levels of stress). To test for this, we included a quadratic term for the moderator in initial statistical models. To further assess if moderated effects on birth weight differed based on gestational age at birth, we examined significance of three-way interactions (intervention status $\times$ moderator $\times$ gestational age). This test would enable assessment of whether the intervention buffers the link between pre-intervention stress or poor mental health and birth weight differentially dependent on gestational age. We did not retain three-way interactions or quadratic terms if coefficients were not at least marginally significant ($p < 0.10$) in order to assess intervention effects within best fitting models. To aid in interpretation of moderation effects, we mean-centered the three moderators in analytic models; this leads to the negative values reported in Fig. 2.

As noted, a relatively small number of intervention group mothers attended fewer than three of the five prenatal classes (eight intervention-group mothers attended zero classes, while 10 attended 1–2 classes). This level of program participation was deemed insufficient for engendering program impact on birth outcomes, and thus these cases were excluded from the analysis. Excluding certain intervention group participants can introduce bias if similar control group participants are not also excluded. To address this potential bias, we employed propensity score techniques to achieve balance between groups [27]. Per standard procedure for generating propensity scores with a two-group comparison, we used logistic regression to determine the predicted probability for group status among the remaining sample (i.e., modeling likelihood to be in the intervention group and participate in three or more classes). These values were then used to create inverse probability weights to adjust model estimates for appropriate sample representation within both groups [13, 34]. Thirty-one baseline measures representing participant background

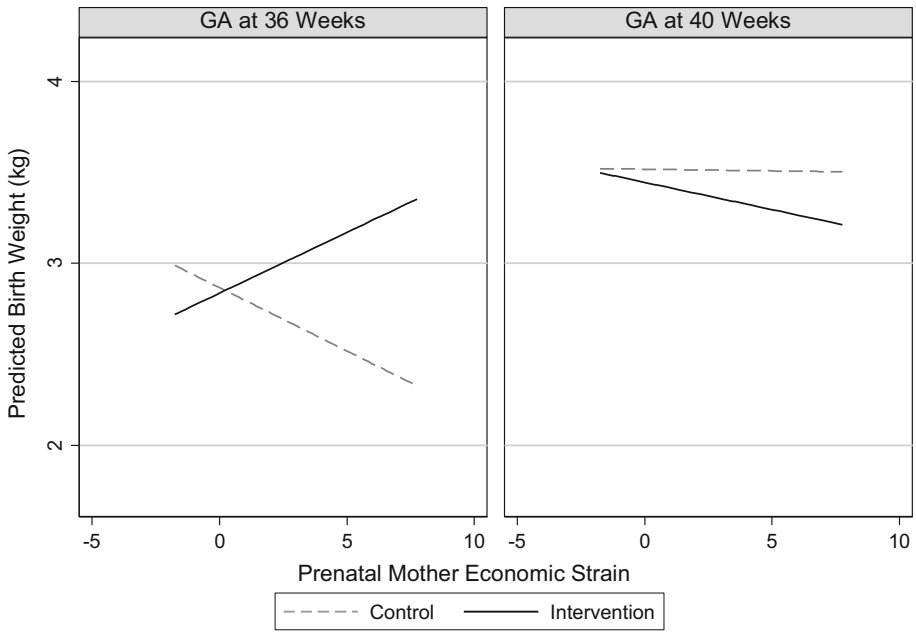

Fig. 2 Model-predicted birth weight by intervention status across levels of economic strain at 36 and 40 weeks gestational age at birth

were predictors in these models, including the following: annual income, education, marital status, age, social support and stress, social desirability, mental health (depression, anxiety, general stress, propensity to worry, stress from financial problems, degree of past antisocial behavior), and relationship characteristics (hostility and conflict in interactions, degree of marital love, couple aggression, argument style, relationship satisfaction). Prior to running regressions on birth outcomes, 11 cases (N = 7 control, N = 4 intervention) were removed because their propensity scores did not fall within the range of scores for the opposite group. The final analytic sample for the study was 259 respondents (N = 124 control, N = 135 intervention). Weighted regression was then used to generate parameter estimates for all outcomes. Weights generated through propensity scores may increase random error and downwardly bias the standard errors for coefficients [23]; use of robust standard errors in all regression models are appropriate to correct for such issues.

Results

Table 1 contains descriptive statistics for model predictors and outcomes for the participants in the study. Results from regression models are presented in Table 2. Overall, we observed no significant main effects of the intervention ($p < 0.05$) although we found significant moderation effects based on pretest levels of all three moderators included in the study. We also found significant three-way interactions indicating moderated intervention effects on birth weight dependent on gestational age and variables representing stress/mental health.

Birth Weight

We found significant moderation of intervention effect on birth weight by economic strain and maternal depression. Given the covariance of birth weight with gestational age, we examined three way interaction terms with gestational age to assess whether moderation effects varied by gestational age. Figure 2 illustrates the relations between intervention status and prenatal economic strain at 36 and 40 weeks gestation (results for depression take the same form). As indicated by Fig. 2, program participation appears to buffer against declining birth weight at 36 weeks associated with high levels of economic strain. However, as shown in the figure, birth weight did not differ across conditions at gestational age of 40 weeks. Post-hoc tests based on these fixed points in the model confirmed a significant group difference for the sample pre-term. A similar pattern was observed for prenatal depression, with post hoc interaction probes indicating the same significance results.

Newborn Length of Stay

We found no significant main effect of intervention status on the neonatal hospital stay but found significant moderating effects. Moderation by economic strain ($p < 0.05$) and prenatal maternal depression ($p < 0.05$) was linear, while a significant curvilinear pattern was detected for prenatal maternal anxiety ($p < 0.01$). The linear pattern of the moderation is depicted in Fig. 3a, showing that the intervention reduces the positive association between economic strain and neonatal hospital stay evident among the control group. The pattern was similar for prenatal mother

Table 1 Means for intervention and control group participants

	Control N = 124 Mean/% (SD)	Intervention N = 135 Mean/% (SD)
Pretest variables		
Mother education (years of education)	15.82 (1.35)	15.75 (1.45)
Mother age at pretest	28.93 (4.26)	29.68 (4.56)
Mother's pre-pregnancy body mass index (kg/m^2)	24.71 (5.16)	26.01 (6.24)
Mother's self-rated health	3.43 (0.53)	3.36 (0.53)
Couple pretest smoking (# of tobacco products smoked per day)	1.14 (4.02)	0.65 (2.97)
Mother's history of alcohol problems (# of problems)	1.06 (1.04)	1.08 (1.09)
Mother economic strain	−0.23 (2.18)	−0.21 (2.02)
Mother depression (CESD)	0.46 (0.29)	0.48 (0.37)
Mother anxiety (Stait-Trait anxiety)	18.07 (5.02)	17.81 (4.68)
Birth outcomes		
Gestational age (weeks)	39.37 (1.59)	39.50 (1.55)
Birth weight (kg)	3.42 (0.47)	3.36 (0.47)
Maternity length of stay in hospital after birth (days)	3.04 (2.47)	3.21 (2.68)
Newborn length of stay in hospital after birth (days)	2.53 (1.08)	2.70 (1.03)

depression. Figure 3b shows the non-linear moderated effect for mother prenatal anxiety. The two conditions do not differ at low to moderate anxiety, but the intervention appears to buffer the increased average neonatal hospital stay associated with prenatal anxiety among the control group.

Maternal Length of Stay

We observed significant moderated intervention effects for economic strain ($p < 0.05$) and prenatal anxiety ($p < 0.01$). As with the pattern observed for newborn hospital stay, further examination indicated that the intervention appears to reduce the positive association between economic strain and maternal length of hospital stay found in the control condition.

Discussion

Results of these analyses indicate that FF, a psycho-educational program for couples expecting a first baby, reduces the association of financial stress, depression, or anxiety, with birth weight and LOS in this largely well-educated and low risk sample. Because the rate of adverse pregnancy outcomes is low in absolute terms (even if the rate is high in the United States in relative terms to other developed countries), it is difficult to detect intervention impact without a very large sample. Thus, in the context of this study and sample, we hypothesized that preventive impact would emerge when we considered the program as a protective buffer against risk for low gestational age or hospital stay. This hypothesis required moderation analyses to assess whether the program is effective in reducing problems among women at higher risk associated with psychological stress due to economic strain or mental health problems.

We found that the program reduced the negative influence of financial stress and depression on infant birth weight. In this case, we examined birth weight controlling for number of weeks gestation. We found that for infants born before term, random assignment to the program was associated with higher birth weight.

We also found consistent evidence across all three risk indicators—financial stress, depression, and anxiety—that duration of both mother and infant stay in the hospital was reduced for intervention couples compared to controls at higher levels of risk. We selected duration of hospital stay as an outcome for methodological reasons. Because this report leveraged an existing trial, and was not designed specifically to investigate birth outcomes, we had not collected data from health providers and hospitals regarding pregnancy and birth complications. We selected duration of mother and infant stay in the hospital as salient and summative indicators of complications and problems that could be reported easily and robustly over time. In order to better determine the unique program effect on hospital stay outcomes, we controlled for C-section occurrence.

These effects translate into meaningful differences. For instance, for those at 1.5 standard deviations higher than the mean on the depression scale (roughly 90 % percentile in this sample), the average difference in model-derived

Table 2 Regression coefficients and standard errors for intervention main and moderated effects on adverse birth outcomes

	Birth weight		Neonatal LOS in hospital		Maternal LOS in hospital	
	b	SE	b	SE	b	SE
Model 1: Main effect						
Intervention condition	0.13	0.21	0.03	0.30	0.15	0.10
Model 2a: Moderator = economic strain						
Intervention condition	−0.07	0.05	0.07	0.28	0.17	0.11
Economic strain	−0.01	0.02	0.37**	0.11	0.13**	0.05
Economic strain^2						
Condition × Econ. strain	−0.01	0.02	−0.31*	0.15	−0.11*	0.05
Condition × Econ. strain^2						
Gestational age	0.16**	0.02	–	–	–	–
Condition × GA	−0.01	0.03	–	–	–	–
Econ. strain × GA	0.02$^{\#}$	0.01	–	–	–	–
Condition × Econ. strain × GA	−0.04*	0.02	–	–	–	–
Model 2b: Moderator = prenatal depression						
Intervention condition	−0.05	0.05	0.06	0.28	0.19$^{\#}$	0.11
Prenatal depression	−0.23$^{\#}$	0.12	1.40	0.98	−0.05	0.21
Prenatal depression^2						
Condition × depression	0.26$^{\#}$	0.14	−2.26*	1.13	−0.10	0.30
Condition × depression^2						
Gestational age	0.16**	0.02				
Condition × GA	−0.01	0.03				
Depression × GA	0.07	0.07				
Condition × depression × GA	−0.20*	0.09				
Model 2c: Moderator = prenatal anxiety						
Intervention condition	−0.05	0.06	0.82**	0.30	0.42**	
Prenatal anxiety	−0.22	0.17	1.27	0.84	0.11	
Prenatal anxiety^2			9.51**	3.53	2.38**	
Condition × anxiety	0.13	0.23	−2.21$^{\#}$	1.13	−0.18	
Condition × anxiety^2			−9.78*	3.69	−3.26**	
Gestational age			–	–	–	
Condition × GA			–	–	–	
Anxiety × GA			–	–	–	
Condition × anxiety × GA			–	–	–	

In moderation models, quadratic and three-way-interaction terms are retained if $p < 0.10$. Models retained are best fit among linear, quadratic, and three-way interactions. Controls for all models include site, pretest couple reported smoking levels, pretest mother-reported health, pre-pregnancy BMI, age, history of alcohol problems, and economic strain. An additional control C-section was added for models predicting LOS. *GA* gestational age, *LOS* length of (hospital) stay

$^{\#}$ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$

neonatal length of stay amounted to more than 1 day: 3.64 for control group families versus 2.57 for the intervention group. Similar results were found for both anxiety and economic strain. These results could translate into significant public health savings based on a relatively small proportion of the population, given the high cost to individuals and society of increased hospitalization related to mental health issues and stress in pregnancy. The average cost per hospital inpatient day exceeds $2100 per person (2015 dollars), and this cost does not include potential additional hospital and physician costs due to post-natal complications [51].

The limitations of this study include reliance on participant report and recall for the birth outcomes. Without medical records and provider reports, we utilized robust indicators of outcomes such as birth weight and length of postpartum hospital stay for the mother and neonate. Future research should collect detailed data from parents and

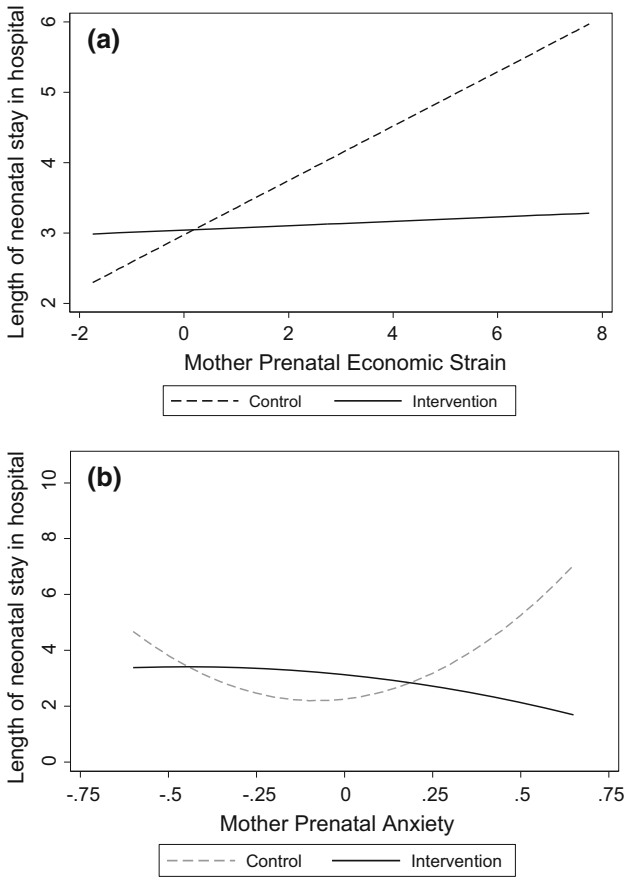

Fig. 3 Neonatal stay in hospital by intervention status across levels of **a** mother prenatal economic strain and **b** mother prenatal anxiety

providers on other pregnancy and birth related problems. Further, a sample with a greater proportion of women at risk due to low income or low education would facilitate greater power and ability to analyze program effects. Finally, we decided to examine program impact for participants who received an adequate dosage of the program before birth (defined as three of the five prenatal classes). Although most participants obtained sufficient dosage, and we utilized appropriate statistical techniques to ensure comparability among conditions, future research may examine this issue by randomly assigning families to varying levels of dosage.

Conclusions

This study replicates and extends our previous analysis of FF's impact on birth outcomes. In that study, we found evidence that the program protected mothers and infants from the negative influence of high levels of cortisol on birth outcomes [30, 46, 53]. In this study, we found evidence that the program protected families from the negative influence of self-reported maternal stress and mental health problems, which may be assessed more quickly and with minimal cost compared to cortisol assay.

Although other methods of reducing risk among women may be developed, an advantage of Family Foundations' psycho-educational approach targeting the coparenting relationship is that it is relatively inexpensive [35] and does not incur adverse side effects as do some medications. Moreover, FF offers additional benefits to parents and children such as enhanced parenting quality, reduced family violence, better infant self-regulation, and better child well-being and adjustment [17–21, 47].

Within the Affordable Care Act (ACA) are a number of provisions designed to improve child health and development, including improved health insurance and funding for early home visiting during pregnancy and early childhood. Our findings suggest that the incorporation of a psycho-educational approach targeting the coparenting relationship into these programs may help buffer the negative impact of stress, depression, and anxiety on birth outcomes. By reducing low birth weight, and length of stay for both mother and infant, these preventive strategies may lead to early savings in health care costs.

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Compliance with Ethical Standards

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Conflict of interest Dr. Mark Feinberg developed the Family Foundations program and is the owner of a private company, Family Gold, which disseminates the program. Dr. Feinberg's conflict of interest has been reviewed by the Institutional Review Board and the Conflict of Interest Committee at The Pennsylvania State University. All other authors, Dr. Deborah Ehrenthal, Dr. Michelle Hostetler, Dr. Damon Jones, Dr. Kari-Lyn Sakuma, Dr. Ian Paul, and Dr. Michael Roettger, declare no potential conflicts of interest from publication of this study.

Integrity of research and reporting All aspects of this study, including design, implementation and analysis, have been approved by the Penn State Institutional Review Board, and have followed the

ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

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