

# The Impact of Intensive Nurse Home Visiting on Pregnancy and Postpartum Mental Health for Low-Income First-Time Mothers \*

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**Abstract**

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# 1 Introduction

Depression during pregnancy or the postpartum period affects many women - 17% of mothers experience antenatal depression and 13% of mothers experience postpartum depression (Dagher et al., 2021). Maternal depression rates are higher among disadvantaged groups; postpartum depression affects approximately one in four low-income women (Kozhimannil and Kim, 2014). Maternal depression can have potentially severe consequences for the mother and infant. Maternal depression left untreated can increase the risk of suicide, substance abuse, and missed prenatal or postnatal health care appointments for the mother and for the child increases the risk of adverse health outcomes (Casey et al., 2004), (Perry, 2008), child development issues (Deave et al., 2008), and child behavioural problems (Frank and Meara, 2009). Moreover, the consequences of maternal depression are increasingly recognised by policymakers (Kim, 2024) as potential drivers of racial and economic inequalities in maternal and infant health (Kennedy-Moulton et al., 2022), (Case et al., 2002).

Many low-income parents experiencing depression never receive a diagnosis, so the systematic screening during pregnancy and postpartum that occurs during intensive nurse home visiting programmes is a way to identify undiagnosed mothers. The U.S. Preventive Services Task Force (USPSTF) recommends screening for depression for all adults, including pregnant and postpartum women, as well as having systems in place such that individuals can receive sufficient follow-up and treatment if needed (O'Connor et al., 2019). Specifically for mothers, the USPSTF recommends counseling intervention for mothers who are at increased risk of perinatal depression (USPSTF, 2019). Even when perinatal depression is identified during pregnancy or postpartum, many who are diagnosed never receive any treatment (Huang et al., 2007). Further, racial disparities exist. Black women are less likely to be screened relative to White women (Sidebottom et al., 2021), have lower health care utilisation (Song et al., 2004), and are less likely to receive treatment (Kozhimannil et al., 2011).

Policymakers have invested in interventions targeting low-income mothers to try to address health inequalities. Pregnancy and early childhood interventions, in particular, have been shown to have positive effects on health, education, and earnings throughout the life course (e.g. Conti et al. (2016), Campbell et al. (2014)). This paper explores the effects of one such intervention: intensive home visiting. We look at the impact of intensive home visiting on perinatal mental health outcomes for a low-income, Medicaid eligible population. Intensive home visiting programs are designed to develop a long-term relationship between a home visitor and a pregnant

person during the transition to parenthood. They have the potential to reduce anxiety and stress in the perinatal period by providing mothers with support, advice, and reassurance. Intensive nurse home visiting programs may also increase the identification and treatment of depression and anxiety during pregnancy and postpartum. For example, these programs often feature regular mental health screens. Evidence on the impacts of intensive nurse home visiting on diagnosis, treatment, and occurrence of mental health conditions is somewhat mixed. There is some evidence that nurse home visiting can have a positive effect on reducing depressive symptoms and use of psycholeptics (Sandner et al., 2018) (Michalopoulos et al., 2019), but most studies have found no significant effects of nurse home visiting on maternal depression outcomes (Jacobs et al., 2015), (Olds et al., 2004). There are challenges, however, in implementing home visiting programmes to best serve people with mental health conditions. Mothers suffering from depression and anxiety may struggle to engage with the programme, and delivery of the programme relies on nurses gaining access to mothers in their homes. In addition, those delivering intensive home visiting programmes may reinforce racial disparities in treatment by failing to identify depression in Black mothers due to bias, or differences in symptoms and reporting for Black and White mothers.

In this paper, we evaluate the effects of an intensive nurse home visiting programme on maternal mental health diagnoses and treatment, leveraging a large-scale randomised controlled trial of the Nurse-Family Partnership (NFP) in South Carolina that enrolled between 2016 and 2020, following outcomes through 2022. We look at outcomes during pregnancy and up to sixty days postpartum using a set of administrative datasets: survey data on mothers, NFP programme data, vital records data, Medicaid claims and hospital discharge data, and South Carolina Department of Mental Health data. We find that NFP has no statistically significant impact on mental health diagnoses and treatment, nor on substance use. However, heterogeneity analysis reveals racial differences in the impact of the programme on depression medication. Non-Hispanic Black mothers assigned to NFP were less likely to receive medication than their counterparts in the control group. In contrast, non-Hispanic White mothers assigned to NFP were more likely to receive medication than control mothers. We explore potential drivers of this finding with descriptive analyses. We examine heterogeneity in baseline anxiety and depression characteristics, NFP visit duration and frequency, and mental health screening and referrals across Black and White mothers. Our sample of Black mothers were more likely to present with de-

pressive symptoms at intake, so pre-existing prevalence of mental health conditions cannot explain our findings. Black mothers had slightly fewer NFP visits than White mothers, consist with the prior literature (O'Brien et al., 2012). We conclude that participation in NFP, in terms of the number of visits and length of visits is unlikely to explain the disparities though. We find some evidence of racial disparities in mental health screening, which could be a contributor. Black mothers participating in NFP were less likely to be screened at 36 weeks of pregnancy. Finally, referrals may be an important factor; Black mothers were less likely to be referred to mental health services by NFP nurses than White mothers.

## 2 Nurse-Family Partnership

NFP is an established home-visiting programme for low-income, first-time mothers and their families. The original trials evaluating NFP took place between the 1970s and 1990s (Olds, 2006), with families enrolled in these trials being followed across many decades (Eckenrode et al., 2017), (Conti et al., 2024), (Olds et al., 2019). Evidence from these early trials motivated the scale-up of NFP to forty US states and eight countries with millions of dollars in U.S. federal funding through the Maternal, Infant, and Early Childhood Home Visiting (MIECHV) programme.

As part of the NFP programme, registered nurses visit families in their homes throughout pregnancy and up to two years following birth. NFP nurses use methods such as motivational interviewing, goal-setting, and educational tools to provide the most value to the mothers they see. The nurses routinely assess physical and mental health, and can make referrals to health and social services. The NFP nurses tailor their visits and visit content to the clients' needs and preferences, but have some programme requirements. For example, nurses must screen mothers for depression and anxiety at pre-specified intervals, and follow protocols for referral and care co-ordination for mothers who screen positive. The pre-specified interval are: 36 weeks pregnant, 1-8 weeks postpartum, 4-6 months postpartum, and 12 months postpartum. Screening is also recommended at intake, or within the first few visits. Additional screening is encouraged, as needed. The recommended screening tools are the Patient Health Questionnaire-9 (PHQ-9) for depression, and the Generalised Anxiety Disorder (GAD-7) form for anxiety. The results of these screens are recorded in the programme's database, along with any referrals made. Nurses can make referrals for mental health services by calling a community provider and requesting services, or can

support mothers in connecting to providers themselves. Note that screening provided by NFP nurses that suggests depression or anxiety is not considered a clinical diagnosis of depression, and is not a substitute for a complete mental health assessment and clinical judgement. Visits last between sixty to ninety minutes, and take place weekly for the first four weeks after enrolment and then fortnightly until the birth. This totals up to 40 home visits - up to 15 visits during the prenatal period, up to 8 visits in the postpartum period through to 60 days post delivery, and up to 9 visits in the remaining period until the child is 24 months. The visit cadence can be adjusted depending on mothers' needs, and families can choose to exit the programme if they so wish. The nurses spoke English or Spanish, and translation services are available for mothers who speak another language.

Table 1 shows descriptive statistics on participation in the South Carolina NFP trial across the prenatal and postpartum period. 98% of mothers received at least one nurse visit in the prenatal period, and this figure is 76% in the the postpartum period. Telehealth visits were less common - around a quarter of mothers received at least one telehealth visit. Visits lasted about an hour, and in-person visits were over double the length of telehealth visits. The mean number of visits in the prenatal period was 9.34, and 3.64 in the postpartum period up to 60 days after birth.

The South Carolina NFP trial was delivered through the South Carolina Department of Health and Human Services (SCDHHS) with initial funding via a Medicaid 1915(b) waiver and philanthropists. The programme is financed through a Pay for Success model, so that later funding is delivered by SCDHHS if evaluation of the trial finds impact estimates that exceed pre-specified thresholds.<sup>1</sup> NFP is well-established in South Carolina, as it has operated in the state since 2009. This means that referral pathways were already embedded prior to the trial. The trial was implemented by nine agencies, each serving their own catchment area, within the state. Both rural and urban areas were covered by the programme during the trial. Prior to the RCT, NFP served 500 to 600 mothers annually in South Carolina. The trial increased this number to 1200 mothers annually, with a respective increase in staffing. Prior work from the South Carolina trial found that NFP had no significant effects on birth or neonatal outcomes (McConnell et al., 2022), or prenatal care (Gourevitch et al., 2023). While this paper explores mental health outcomes, other outcomes including postpartum care utilisation, contraception and birth spacing, and child health

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<sup>1</sup>More detail on the Pay for Success model can be found in the study protocol. (McConnell et al., 2020).

outcomes are being explored in other forthcoming manuscripts.

Table 1. Participation in NFP

	Prenatal %/Num.	60 days postpartum %/Num.
<b>Programme encounters</b>		
Received at least one visit	98.27	75.51
Received at least one in-person visit	98.24	66.43
Received at least one telehealth visit	28.01	25.25
Received visits to within 14 days of delivery	78.26	70.83
Number of visits	9.34	3.64
Number of in-person visits	8.29	2.89
Number of telehealth visits	1.05	0.75
<b>Visit duration</b>		
Avg. duration of visits	66.82	62.97
Avg. duration of in-person visits	70.46	70.10
Avg. duration of telehealth visits	28.16	28.91

Notes: N=3,794. Data only available for participants who matched to programme data. “Duration” variables available for participants with at least one in-person visit. “Number” and “Duration” variables are means. “Received” variables are percentages. “Duration” variables are in minutes.

## 3 Methods

### 3.1 Study design

We conducted an individually randomised clinical trial of NFP in South Carolina. Trained NFP staff members ran trial enrolment. Potential study participants were identified by the South Carolina Department of Health and Human Services based on the Medicaid eligibility database. Others were recommended via referring partners (e.g. local health care providers, schools, WIC agencies), or by a family member or friend. Individuals could also self-refer. Following referral, eligibility had to be determined. Individuals were eligible if they were currently pregnant (with gestation period of less than 28 weeks), had no previous live births, were income-eligible for Medicaid during pregnancy, were at least 15 years old, lived in the NFP catchment area, were not incarcerated or living in a lockdown facility, and had sufficient language fluency to benefit from the programme. Study participants then completed a baseline survey. Following this, study participants were randomised into the treatment group, with access to the NFP programme, or the control group. Two-thirds of mothers were randomised to the treatment group, and a third to the control group. The control group had access to regular care available in South Carolina, including community and medical services. Mothers enrolled in Medicaid have access to two postpartum

home visits up to six weeks after delivery. These home visits includes a medical assessment of the mother and infant, an assessment of barriers to health, counseling on postpartum recovery, family planning, information on the needs of a newborn, and assistance with establishing a primary source of care for the mother and infant. Only 11% of control group participants received at least one of these visits. 6% of NFP intervention participants received at least one of these visits. All participants were given a list of available community resources for first time, low-income mothers. Most home visits took place in the client’s home, but there were disruptions caused by the COVID-19 pandemic. South Carolina restricted public gatherings on March 23rd 2020, and following this date, 93% of home visits were via tele-health. More details on the trial are available in the published study protocol ([McConnell et al., 2020](#)).

### **3.2 Data**

We combine several rich administrative datasets to evaluate the effects of the NFP on maternal mental health. First, we use data from a baseline survey that collected information on participants’ demographic and health information, such as age, race and ethnicity, body mass index, education, receipt of social service programmes, substance use, and mental health status. Next, we use NFP programme data including information on visits conducted by the nurses, mental health screening, and referrals to mental health and substance use providers. Third, we use vital records data to identify live births and fetal deaths and for linkage to other datasets. Fourth, we use Medicaid claims and hospital discharge data including pharmacy records to observe diagnoses of depression, anxiety and substance use. We also see receipt of treatment (medication or therapy). Finally, we use data from the South Carolina Department of Mental Health to observe therapy visits. Participants are matched to administrative data via a probabilistic match based on name, race, Social Security number, birth date, and Medicaid ID in collaboration with South Carolina’s data repository.

### **3.3 Sample**

The sample is made up of study participants with a live birth or fetal death in the vital records data within 120 days of the expected delivery date reported on the baseline survey. We call these “index births”. We include all mothers in our index birth sample, regardless of whether they match to all of the relevant data sources. As a robustness check, we repeat the programme analysis on a sample of mothers who

have at least one day of Medicaid coverage in the postpartum period and on a sample of mothers who have continuous Medicaid coverage up to 60 days postpartum.

Table 2 evidences that there are no statistically significant differences in baseline characteristics between the treatment and control groups. We can also see that the sample is racially diverse: 55% of mothers self-identified as Black, 35% as White, and 10% as Hispanic. 18% of the sample are teenagers between the ages of 15 and 17, and just over half (54%) are 19 to 24 years old. Considering highest level of education, a little less than 60% of the sample have at most a high school diploma. Nearly 20% of the sample report depressive symptoms at baseline, and 66% report high levels of stress. 14% of mothers report receiving mental health treatment in the past year. Half of mothers (51%) drank alcohol in the 3 months prior to their pregnancy, and a quarter (26%) of mothers smoked cigarettes in the same time period. 66% of the sample received at least one social service programme such as Temporary Assistance for Needy Families or the Supplemental Nutrition Assistance Programme.



Table 2. Balance table

Variables	Treatment Mean	Control Mean	Difference P-val
Age (%)			
- 15-18	18.21	17.53	0.56
- 19-24	54.81	54.98	0.91
- 25-34	24.16	25.47	0.31
- 35+	2.82	2.02	0.09
Race/ethnicity (%)			
- Hispanic	5.52	6.25	0.32
- Non-Hispanic Black	55.04	55.62	0.71
- Non-Hispanic White	34.89	34.39	0.73
- Asian, Indigenous, Native Hawaiian/Pacific Islander, 2+ race, Non-Hispanic	4.55	3.75	0.21
BMI (%)			
- <18.5	5.73	5.34	0.58
- 18.5-24.9	37.18	39.52	0.12
- 25-29.9	22.22	21.66	0.66
- >30.0	34.87	33.48	0.34
Highest education level (%)			
- Less than high school diploma	22.62	21.70	0.47
- High school diploma or equivalent	36.00	34.27	0.23
- Some college, less than bachelor's degree	33.89	36.05	0.13
- Bachelor's degree or higher	7.47	7.97	0.53
Mental health/substance use (%)			
- Depressive symptoms	19.27	18.70	0.63
- High stress	66.06	66.01	0.97
- Received mental health treatment in last year	13.79	13.54	0.81
- Reported drinking alcohol in 3 months before pregnancy	50.72	51.32	0.69
- Reported smoking cigarettes in 3 months before pregnancy	25.05	27.03	0.14
Other health indicators (%)			
- Used ED in 6 months before enrolment	51.11	52.26	0.44
- Reported health as fair/poor	12.79	11.04	0.08
Family planning indicators (%)			
- Has access to family planning or birth control	55.88	55.42	0.76
- Reported desire for mother children in future	67.62	67.73	0.94
Pregnancy indicators at baseline			
- Gestational age at enrolment (weeks)	14.867	14.52	0.07
- Received $\geq 1$ prenatal visit before enrolment (%)	85.08	84.04	0.34
Socioeconomic indicators (%)			
- Received $\geq 1$ social service programs	65.46	66.81	0.35
- Worked for pay at time	52.94	52.63	0.83
- Lived with parents	43.30	44.34	0.49
- Experienced housing insecurity	16.50	17.51	0.37
Observations	3295	1637	4932

Notes: Survey data collected after enrolment and before randomization between 2016 and 2020. "BMI" is body mass index. "ED" is emergency department. "High stress" is a Perceived Stress Scale 4 score of  $\geq 4$ . "Depressive symptoms" is a Patient Health Questionnaire 2 score of  $\geq 3$ . Social service programs include Temporary Assistance for Needy Families; Supplemental Nutrition Assistance Program; Supplemental Security Income; Special Supplemental Nutrition Program for Women, Infants, and Children; and unemployment benefits. "Housing insecure" is whether the mother moved at least twice in the previous 12 months.

### 3.4 Outcomes

For the main analysis of the effects of NFP on perinatal mental health, we look at outcomes relating to diagnosis and treatment of mental health conditions in the perinatal period. We focus on outcomes that were pre-registered in the clinical trials registry, and set out in the trial protocol and pre-analysis plan (McConnell et al., 2020), (McConnell et al., 2021). These include variables for: any outpatient diagnosis of depression, anxiety or stress-reaction; any medication; any psychotherapy visit; any inpatient or emergency department visit with a diagnosis for depression, anxiety, or stress-reaction; the number of inpatient or emergency department visits with a diagnosis for depression, anxiety, or stress reaction; any substance use; and whether the mother received a second prescription or therapy visit within 120 days of their first. A composite outcome captures any depression, anxiety, or stress-reaction diagnosis; any psychotherapy visit; or any medication. Any medication is defined as a filled prescription for antidepressants or anxiolytics. ICD-10 diagnosis, therapeutic class codes, and Current Procedure Terminology (CPT) codes used to define these outcomes can be found in Appendix Tables A1, A2, A3, and A4. The diagnosis outcome is intended to capture detection of mental health conditions. The variables including prescriptions and therapy measure mental health treatment for mothers. The inpatient or emergency department visit outcome represents a negative scenario, as these hospital visits could indicate inadequate outpatient treatment of perinatal depression. All outcomes are examined throughout the pregnancy period and up to sixty days postpartum. Sixty days postpartum is significant as this is when many women lost Medicaid coverage in South Carolina during the trial (prior to the onset of the COVID-19 pandemic).

Using healthcare claims and discharge data is an imperfect way to assess prevalence of depression and anxiety in the study population. Receiving a depression diagnosis by a Medicaid provider is a function of the patient’s presence at the facility, the information revealed to a doctor by the patient, and the doctor’s propensity to diagnose to that patient. Further, seeing an increase in depression diagnoses could represent either an increase in the prevalence, or an increase in the identification of depression in a population. Participation in NFP could reduce depressive symptoms through easing stress and anxiety via interactions with NFP nurses, or it could increase the detection of perinatal depression if the NFP nurses helped mothers recognise their symptoms and encouraged them to seek care and treatment from a mental health provider. The former would lead to a reduction in depression diagnoses, and

the latter, and increase. We also look at treatment in the form of medication. Medication use is observed for mothers who filled a prescription (although we cannot confirm whether the medication was taken as prescribed). We are not able to observe mothers who received a prescription but did not fill it. Finally, we cannot observe treatment that is not billed to Medicaid.

In order to understand the context of routine depression screening within the Medicaid program in South Carolina, we also conduct descriptive analysis on perinatal mental health screening. We observe screening for mental health, alcohol and substance use, smoking patterns, and domestic violence using the Screening, Brief Intervention and Referral to Treatment (SBIRT). Clinicians are encouraged to deliver SBIRT to all pregnant Medicaid mothers, as early as possible. The first component of the SBIRT is screening, where a doctor asks a set of questions to assess the risks to the mother and infant. This takes five to ten minutes to complete. If needed, a brief intervention is then conducted. This is a short counselling session to highlight potential issues and motivate the mother to acknowledge any problems. The brief intervention can last between five to thirty minutes. Then, there is referral to treatment. As per SBIRT guidelines, if an individual screens positive for any risk factors, providers should make a referral and ideally secure an appointment before the individual leaves. Providers can bill for the screening once per fiscal year, and the brief intervention twice per fiscal year. We also observe specific depression screening. The recommended depression screening tool is a standardised tool such as the Edinburgh Postnatal Depression Scale (EPDS). The EPDS is a screening questionnaire that aims to identify mothers with symptoms of depression and anxiety in the perinatal period. The EPDS is not a diagnostic tool; mothers with scores indicating depressive symptoms should receive follow-up care. Mothers complete the questionnaire themselves, answering ten questions about their emotional experiences over the past week. The ACOG recommends that all women are screened for perinatal mental health conditions, and at the following cadence: at the first obstetric visit to assess mental health before pregnancy, at 24 to 28 weeks of gestation to assess mental health during pregnancy, and at the comprehensive postpartum visit to identify onset in early postpartum ([ACOG, 2024](#)). Screenings can take place during prenatal care appointments. Providers can also bill for a depression screening at well-child visits under South Carolina’s Medicaid policy (twice per date of service). Infants are due a well-child visit at 3-5 days, one month, and two months after birth. Mothers in the treatment group could also be screened and referred for services by NFP nurses. We

look at the prevalence of depression screening, mental health referrals, and substance use referrals by NFP nurses across the pregnancy and postpartum period in the treatment arm. Finally, in order to understand patterns of differential treatment impacts on study outcomes across race, we look at screening prevalence and accordance to timing guidelines by nurses implementing NFP, by race. For the study period we focus on, NFP guidance advised screening at intake, at 36 weeks pregnant, and 1-8 weeks after birth. We examine the rates of depression screening, SBIRT screening, and SBIRT referrals in the sample in the prenatal period, from birth to sixty days postpartum, and a combination of these two periods.

### 3.5 Empirical approach

We use ordinary least squares linear regression models to compare outcomes for participants in the treatment and control group using two-sided hypothesis tests. We estimate raw comparisons in unadjusted models, and then control for pre-specified covariates in adjusted models (McConnell et al., 2021). Covariates include indicators for the implementing NFP agency, age groups, race and ethnicity, gestational age at time of study enrolment, relationship with father of the child, education, employment, receipt of social services, housing stability, health status, psychological state, access and utilisation of health care, alcohol and smoking use, stress, pregnancy risk factors, and family planning metrics. We also use the dummy-variable adjustment approach to account for missing baseline covariates, as described in the pre-analysis plan (McConnell et al., 2021) (Puma MJ, 2009).

To evaluate the effects of NFP on maternal mental health, we use an intent-to-treat (ITT) framework which estimates the average impact of NFP comparing outcomes for all index births assigned to treatment and all index births assigned to control. All mothers who were randomised to receive NFP were in the treatment group, but there is variation in the level of participation in the programme. Furthermore, mothers in the control group may still have received services during pregnancy that mirror some of what NFP offers. For example, the Healthy Families America, Healthy Steps and Parents as Teachers programmes. Most of these programmes enrol after pregnancy, and operate at a much smaller scale than NFP.

We conduct subgroup analyses for non-Hispanic Black mothers, non-Hispanic White mothers, and a pre-specified vulnerable subgroup. The vulnerable subgroup is defined as participants who were at least one of the following: younger than 19 years at baseline, without a high school degree, or who experienced mental health

challenges. Mothers with mental health challenges were identified by either receiving a score of three or higher on the Patient Health Questionnaire 2, or reporting receipt of mental health treatment in the year prior to enrolment. These indicators of vulnerability put the mother at risk of developing postnatal depression (Biaggi et al., 2016), (Goyal et al., 2010), (Kingston et al., 2012). Additionally, this subgroup mimics subgroups in which the original NFP trials found greater impacts. Subgroup analyses by race is important as prior work shows racial differences in treatment for perinatal depression (Kozhimannil et al., 2011).

## 4 Results

### 4.1 Descriptive analysis of mental health screening and referral

Table 3 Panel A shows depression screening in the NFP programme. We see that 99% of mothers in the treatment group received a depression screening at some point from the start of their pregnancy up to sixty days postpartum. A fraction of these led to a mental health referral - only 16% of treatment mothers in total. 12% of treatment mothers received a mental health referral in the prenatal period. There is then a drop in referrals during the postpartum period up to 60 days. A small proportion of NFP mothers received a referral for substance use, 4%, and the majority of these referrals occurred in the prenatal period when there is heightened concern for the health of the infant from maternal substance use. Table 3 Panel B shows screening by the Medicaid programme for the full sample. The rate of depression screening by Medicaid providers is much lower than in the NFP programme, with 24% of all mothers (both treatment and control) being screened across the study period. There is almost no depression screening by Medicaid providers during pregnancy. After birth, in the postpartum period, 24% of mothers receive a depression screening. This figure is low given the guidance to screen in the postpartum period ACOG (2024), and the fact that providers can bill depression screens for mothers during well-child visits. Instead, providers are using the SBIRT screen in the prenatal period. 30% of mothers received a prenatal SBIRT screening. 8% of mothers receive an SBIRT referral. After delivery, the use of SBIRT screens falls close to zero.

Table 3. Prevalence of mental health screening and referral

	Prenatal	60 days pp	Study period
<b>Panel A: NFP</b>			
Any depression screening	97.32 (16.14)	79.91 (40.08)	98.80 (10.90)
Any referral for mental health	12.18 (32.71)	6.40 (24.48)	15.63 (36.32)
Any referral for substance use	3.57 (18.55)	0.47 (6.81)	3.72 (18.94)
<b>Panel B: Medicaid</b>			
Any depression screening	0.53 (7.24)	23.95 (42.68)	24.37 (42.94)
Any SBIRT screening	29.89 (45.78)	0.28 (5.32)	30.11 (45.88)
Any depression or SBIRT screening	30.37 (45.99)	24.15 (42.80)	47.47 (49.94)
Any SBIRT referral	7.91 (26.99)	0.12 (3.49)	7.95 (27.05)

Notes: N=3,925 for NFP programme data. N=4,932 for Medicaid data. “Panel A: NFP” denotes screening and referral conducted by NFP nurses to mothers in the treatment group. “Panel B: Medicaid” denotes screenings and referrals that are observed in Medicaid claims data, for both treatment and control mothers. For all variables the values represent percentages. “Prenatal” denotes that the screening or referral took place during the prenatal period. For “Prenatal”, Panel A statistics are calculated for the sample of mothers who had NFP visits until birth. “60 days pp” denotes that the screening or referral took place after delivery, up to 60 days postpartum. For “60 days pp”, Panel A statistics are calculated for the sample of mothers who had NFP visits until 60 days postpartum. “Study period” denotes the prenatal period and up to 60 days postpartum. For “Study period”, Panel A statistics are calculated for the sample of mothers who had NFP visits until 60 days postpartum. “Medicaid - Any depression screening” is whether the mother received a depression screen (Edinburgh Postnatal Depression Scale) during any well-child visit. “Medicaid - Any SBIRT screening” is whether the mother received the “Screening, Brief Intervention, and Referral to Treatment” screen. “Medicaid - Any SBIRT referral” is whether the mother was referred to a specialist from an SBIRT screen. Standard errors in parentheses.

## 4.2 Analysis of main programme effects

When we look at pre-registered study outcomes, we find that the NFP programme had no statistically significant effect on mental health diagnoses, nor on treatment in the form of medication or therapy. We also find no significant difference in substance use. Table 4 shows the NFP programme effects on our outcomes for all index birth mothers, and for sub-samples of non-Hispanic White and non-Hispanic Black index birth mothers. We do find heterogenous NFP programme effects by race. Non-Hispanic White mothers randomly assigned to NFP were 4% more likely to receive mental health medication treatment than those randomly assigned to the control group. In contrast, non-Hispanic Black mothers were 3% less likely to receive medication if they are in the NFP treatment group rather than the control group. Both of these effects are statistically significant, and the difference between the adjusted treatment effects for non-Hispanic White and Black mothers is also statistically significant. These opposing programme effects are in addition to the large gap in diagnosis and receipt of treatment for non-Hispanic Black and White mothers. For non-Hispanic White control group mothers, 43% received an outpatient mental health diagnosis. This figure is 24% for non-Hispanic Black control group mothers. Further, 21% of non-Hispanic White control group mothers received any medication, in comparison to 10% of non-

Hispanic Black control group mothers. These racial disparities in rates of medication use are similar to those documented in other studies; [Huybrechts et al. \(2013\)](#) found that 3.5% of Black mothers use antidepressants during pregnancy versus 14.4% of White mothers. There is also a racial difference in therapy use: 6% of non-Hispanic White control group mothers received some therapy, relative to 4% of non-Hispanic Black control group mothers. In addition, non-Hispanic White mothers were more likely to have follow up treatment. We find no significant effects of NFP on maternal mental health for the vulnerable subgroup (Appendix Table [A10](#)). Sensitivity analysis on a sample of mothers with any Medicaid coverage in the postpartum period and on a sample of mothers with continuous Medicaid coverage up to 60 days postpartum can be found in Appendix Tables [A11](#) and [A12](#).

Table 4. Treatment effects of NFP

	Treatment Mean	Control Mean	Unadjusted Effect	Adjusted Effect	
<b>Full sample</b>					
Any OP diagnosis/medication/therapy	31.81	33.17	-1.36	-1.34	[-3.80, 1.11]
Any OP diagnosis	28.44	29.99	-1.56	-1.55	[-3.95, 0.84]
Any Medication	13.20	13.19	0.01	0.06	[-1.84, 1.95]
Any Therapy	5.01	4.64	0.36	0.41	[-0.77, 1.59]
Any IP/ED visit	13.93	12.34	1.59	1.47	[-0.37, 3.31]
Num. IP/ED visits	0.24	0.21	0.03	0.03	[-0.02, 0.08]
Treatment follow up	8.86	8.67	0.19	0.14	[-1.39, 1.68]
Any substance use	21.49	22.42	-0.93	-0.47	[-2.57, 1.62]
<b>Non-Hispanic White sample</b>					
Any OP diagnosis/medication/therapy	47.55	47.23	0.32	0.71	[-4.02, 5.44]
Any OP diagnosis	41.07	43.21	-2.14	-1.83	[-6.55, 2.88]
Any Medication	24.24	20.65	3.59	4.35 *	[0.17, 8.53]
Any Therapy	7.77	6.12	1.65	1.89	[-0.53, 4.30]
Any IP/ED visit	19.33	16.25	3.08	3.16 +	[-0.57, 6.88]
Num. IP/ED visits	0.33	0.29	0.04	0.05	[-0.06, 0.16]
Treatment follow up	16.47	14.72	1.74	1.74	[-1.77, 5.25]
Any substance use	29.69	31.55	-1.85	-1.26	[-5.31, 2.80]
<b>Non-Hispanic Black sample</b>					
Any OP diagnosis/medication/therapy	24.87	26.95	-2.08	-1.76	[-5.10, 1.57]
Any OP diagnosis	22.82	23.64	-0.83	-0.58	[-3.78, 2.61]
Any Medication	7.74	10.28	-2.54	-2.69 *	[-5.02, -0.36]
Any Therapy	3.81	3.78	0.03	-0.22	[-1.70, 1.26]
Any IP/ED visit	11.61	10.99	0.62	0.56	[-1.87, 3.00]
Num. IP/ED visits	0.21	0.18	0.03	0.02	[-0.03, 0.08]
Treatment follow up	5.40	5.67	-0.28	-0.43	[-2.19, 1.34]
Any substance use	18.30	18.32	-0.02	0.10	[-2.72, 2.91]

+  $p < 0.1$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Notes: Full sample N = 4,932. Non-Hispanic White sample N = 1604. Non-Hispanic Black sample N = 2551. For all variables, the means and effects are percentages. “OP” stands for outpatient. “L&D” stands for labour and delivery. “IP” stands for inpatient. “ED” stands for emergency department. “Any OP diagnosis/medication/therapy” is any outpatient diagnosis for depression or anxiety, medication, or therapy. “Any IP/ED visit” is an inpatient or emergency department visit with a postpartum depression or anxiety diagnosis, excluding labour and delivery. “Num. IP/ED” is defined the same, but counts the number of visits. “Treatment follow up” is a second prescription or therapy visit within 120 days of first prescription or therapy visit. 95% confidence intervals in brackets.



### 4.3 Exploring mechanisms for heterogeneity by race

Next, we investigate potential drivers of the heterogeneous programme effects of NFP by race.

#### 4.3.1 Racial differences in mental health prior to the intervention

Disparities in mental health treatment for Black and White mothers and a lower diagnosis rate for Black mothers could arise from racial differences in mental health status before the NFP intervention. Using data from the baseline survey, we investigate mental health symptoms upon intake, treatment history and prior substance use by race. Non-Hispanic Black mothers were more likely than non-Hispanic White mothers to report depressive symptoms at intake, as exhibited in Table 5. 21% of non-Hispanic Black mothers scored at least three on the Patient Health Questionnaire 2, in comparison to 17% of non-Hispanic White mothers. Despite this difference in depressive symptoms by race, a much lower proportion of Black mothers had received mental health treatment in the year prior to NFP, 8%, relative to 24% of White mothers. Both of these racial differences are statistically significant. These findings hold when controlling for NFP Implementing Agency (IA) and personal characteristics, as shown in Appendix Table A7. Reductions in rates of mental health treatment for Black mothers participating in NFP do not seem to be driven by Black study participants experiencing fewer symptoms or being less in need of mental health treatment.

Table 5. Mental health and substance use prior to intervention, by race

Variables	Black (1) %	White (2) %	(1)-(2) P
Depressive symptoms	21.05	16.83	0.00
High stress	65.50	65.15	0.82
Received mental health treatment in last year	7.92	24.00	0.00
Reported drinking alcohol in 3 months before pregnancy	51.27	53.30	0.20
Reported smoking cigarettes in 3 months before pregnancy	17.17	41.65	0.00
Observations	2551	1604	4155

Notes: Survey data collected after enrolment and before randomization between 2016 and 2020. “Black” refers to non-Hispanic Black mothers. “White” refers to non-Hispanic White mothers. “Depressive Symptoms” is a Patient Health Questionnaire 2 score of at least 3. “High Stress” is a Perceived Stress Scale 4 score of at least 4.

#### 4.3.2 Racial differences in participating in NFP

We may worry that differential NFP programme effects by race were driven by racial differences in exit from the programme. We examine this question in Table 7 Panel A.

Non-Hispanic Black mothers were more likely to remain in NFP until birth, and there is no statistically significant difference in programme retention when we consider the full study period from pregnancy to 60 days postpartum. Controlling for the NFP IA and a rich set of personal characteristics confirms that there is no statistically significant difference in retention in NFP by race (Appendix Table A8).

One potential reason for the different impact of the NFP programme across race is because Black mothers received fewer, or shorter, nurse home visits. We explore whether there are racial differences in visit frequency and length. Table 7 Panel B shows that there is no difference in the average NFP home visit duration for non-Hispanic Black and White mothers. When we control for IA and personal characteristics (Appendix Table A6), there is a small statistically significant reduction in the visit length of Black mothers relative to White mothers of 2 minutes. Across the study period of pregnancy and up to 60 days postpartum, Black mothers had fewer visits than their White counterparts. The same holds for the postpartum period up to 60 days following delivery. This effect remains in the postpartum period when adding in controls, as shown in Table A6. Differences in the number of visits could be nurse or mother driven, or both. Black mothers may not have wanted, or had time for, as many visits.

#### **4.3.3 Racial differences in mental health screening and referral patterns by NFP**

We move on to examine screening and referral rates by race within the NFP programme. Lower rates of mental health diagnoses and treatment amongst Black women could be due to differences in screening and referral for Black participants. Table 6 shows NFP screening adherence by race. NFP nurses should screen mothers at intake, at 36 weeks of pregnancy, and between 1 to 8 weeks following birth. Around 88% of mothers were screened at intake - so around 13% of mothers were not screened. At 36 weeks into pregnancy, non-Hispanic White mothers were 4 percentage points more likely to be screened by NFP nurses. Table 7 Panel C shows additional screening and referral outcomes for non-Hispanic Black and White mothers in the intervention group. Across the prenatal period, the postpartum period up to 60 days after delivery, and the whole study period, there is no statistically significant difference in depression screening by NFP nurses for Black and White mothers. However, White mothers were referred for mental health services at a higher rate than Black mothers. Appendix Table A9 adds in controls for the NFP IA and for a rich set of individ-

ual characteristics. Differences in mental health referrals between Black and White mothers remain.

Table 6. NFP mental health screening and referral, by race

Variables	Black (1) %/Num.	White (2) %/Num.	(1)-(2) P
Screened at intake	87.68	86.12	0.23
Screened at 36 weeks pregnant	58.48	62.81	0.02
Screened 1-8 weeks after birth	65.10	67.35	0.22
Observations	1705	1081	2786

Notes: Survey data collected after enrolment and before randomization between 2016 and 2020. All variables are in % terms. “Black” refers to non-Hispanic Black mothers. “White” refers to non-Hispanic White mothers.

Finally, we consider whether lower rates of screening and referral for Black compared to White mothers observed in the NFP programme data are also observed in screening and referral patterns in the Medicaid program. We revisit the prevalence of mental health screening during pregnancy and the postpartum period (as in Table 3) and break down the Medicaid analysis by race in Table 8. We see that across the whole study period, there is no racial difference in receipt of depression or SBIRT screening. Non-Hispanic White mothers, however, were more likely to receive an SBIRT referral than non-Hispanic Black mothers. Together, these findings suggest that a lack of screening of Black mothers by Medicaid providers is unlikely to explain why they were receiving fewer diagnoses and treatment than White mothers. A lower rate of mental health referrals for Black mothers, however, may be a contributing factor.

Table 7. NFP visits and screening

	Prenatal			60 days pp			Study period		
	Black (1)	White (2)	(1)-(2) P	Black (1)	White (2)	(1)-(2) P	Black (1)	White (2)	(1)-(2) P
<b>Panel A: Retention</b>									
Visits across period	79.34 (40.50)	75.76 (42.87)	0.03	70.54 (45.60)	69.94 (45.88)	0.73	70.54 (45.60)	69.94 (45.88)	0.73
<b>Panel B: Visits</b>									
Avg. visit length	65.96 (22.52)	66.23 (21.05)	0.86	62.11 (36.59)	61.17 (24.78)	0.84	64.90 (22.23)	64.39 (17.99)	0.87
Visit count	11.05 (4.36)	11.98 (4.51)	0.06	5.09 (2.29)	5.44 (2.33)	0.00	16.35 (5.78)	17.56 (5.97)	0.05
<b>Panel C: Screening and referral</b>									
Number of depression screenings	1.71 (0.67)	1.82 (0.60)	0.35	1.05 (0.79)	1.14 (0.92)	0.14	2.79 (1.11)	2.98 (1.17)	0.15
Any depression screening	96.67 (17.94)	98.05 (13.85)	0.11	82.78 (37.77)	84.79 (35.94)	0.67	98.75 (11.11)	99.74 (5.14)	0.06
Any mental health referral	10.36 (30.48)	15.02 (35.75)	0.01	5.49 (22.79)	8.99 (28.63)	0.00	13.89 (34.60)	19.84 (39.91)	0.00

Notes: N=1,705 for sample of non-Hispanic Black mothers. N=1,081 for sample of non-Hispanic White mothers. Survey data collected after enrollment and before randomization between 2016 and 2020. “Prenatal” denotes that the visit took place during the prenatal period. For “Prenatal”, statistics are calculated for the sample of mothers who had NFP visits until birth. “60 days pp” denotes that the visit took place after delivery, up to 60 days postpartum. For “60 days pp”, statistics are calculated for the sample of mothers who had NFP visits until 60 days postpartum. “Study period” denotes the prenatal period and up to 60 days postpartum. For “Study period”, statistics are calculated for the sample of mothers who had NFP visits until 60 days postpartum. The statistics for “Visits across period”, “Any depression screening”, and “Any mental health referral” are percentages. “Avg. visit length” is the average (mean) NFP visit length in minutes for completed visits. “Visit count” is the number of at home NFP completed visits. Standard errors in parentheses.

Table 8. Prevalence of mental health screening and referral, by race

	Prenatal			60 days pp			Study period		
	Black (1)	White (2)	(1)-(2) P	Black (1)	White (2)	(1)-(2) P	Black (1)	White (2)	(1)-(2) P
<b>Medicaid</b>									
Any depression screening	0.35 (0.06)	0.94 (0.10)	0.02	24.30 (0.43)	22.13 (0.42)	0.11	24.58 (0.43)	22.94 (0.42)	0.23
Any SBIRT screening	30.81 (0.46)	30.42 (0.46)	0.79	0.35 (0.06)	0.25 (0.05)	0.56	31.09 (0.46)	30.67 (0.46)	0.78
Any depression or SBIRT screening	31.13 (0.46)	31.36 (0.46)	0.87	24.58 (0.43)	22.32 (0.42)	0.10	48.37 (0.50)	46.57 (0.50)	0.26
Any SBIRT referral	6.82 (0.25)	11.16 (0.31)	0.00	0.04 (0.02)	0.19 (0.04)	0.13	6.82 (0.25)	11.16 (0.31)	0.00

Notes: N=2,551 for sample of non-Hispanic Black mothers. N=1,604 for sample of non-Hispanic White mothers. “Medicaid” denotes screenings and referrals that are observed in Medicaid claims data, for both treatment and control mothers. For all variables the values represent percentages. “Prenatal” denotes that the screening or referral took place during the prenatal period. “60 days pp” denotes that the screening or referral took place after delivery, up to 60 days postpartum. “Study period” denotes the prenatal period and up to 60 days postpartum. “Any depression screening” is whether the mother received a depression screen (Edinburgh Postnatal Depression Scale) during any well-child visit. “Any SBIRT screening” is whether the mother received the “Screening, Brief Intervention, and Referral to Treatment” screen. “Any SBIRT referral” is whether the mother was referred to a specialist from an SBIRT screen. Standard errors in parentheses.

## 5 Discussion and conclusion

This paper makes an important contribution to the literature by providing evidence from a recent randomised control trial of the Nurse Family Partnership in South Carolina on maternal mental health. We observe high rates of depression or anxiety during pregnancy through to 60 days postpartum; 30% of control group mothers had an outpatient diagnosis. This is a higher rate than the 17% of mothers with antenatal depression and 13% of mothers with postpartum depression reported in (Dagher et al., 2021), and the 25% that Kozhimannil and Kim (2014) cite for low-income women. We find that NFP has no statistically significant effects on mental health diagnoses and treatment, and substance use in a sample of first-time mothers who were income-eligible for Medicaid. Prior work evaluating the effects of these programmes on the prevalence and treatment of perinatal mental health is inconclusive, and there is limited evidence of nurse home visiting improving maternal mental health outcomes in the U.S. Evaluating an intensive home visiting programme in Germany, Sandner et al. (2018) find reductions in self-reported depression and prescriptions of psycholeptics. The authors find no change in anti-depressant use or hospitalisations related to mental health disorders. Michalopoulos et al. (2019) find reductions in reports of depressive symptoms in an evaluation of 88 MIEHV programmes across 12 U.S. states. Heckman et al. (2017) re-examine the 1990 Memphis trial of NFP and find improvements in maternal mental health for treated mothers. In contrast Olds et al. (2004) and Jacobs et al. (2015) find no significant effects of nurse home visiting on maternal depression or mental health service use, nor on substance use.

Our key finding is that, overall, non-Hispanic Black mothers were less likely than non-Hispanic White mothers to be diagnosed with a mental health condition and receive treatment in the form of therapy and medication. Further, we find that participation in NFP reinforces racial disparities. Non-Hispanic Black mothers assigned to NFP were less likely to receive medication for a mental health condition relative to control Black mothers, whereas non-Hispanic White mothers randomised to the treatment group were more likely to receive medication relative to White control mothers. We try to examine mechanisms that could explain our findings through analysis of pre-existing mental health conditions, NFP visits, and mental health screening and referrals. Differences in pre-existing symptoms of depression or anxiety cannot explain the diagnoses and treatment disparities. Non-Hispanic Black mothers were more likely to experience depressive symptoms at intake (21%) relative to White mothers (17%). The opposing results on depression medication for Black and White mothers

could be driven by visit duration or frequency - Black mothers received significantly fewer visits in the postpartum period, but the size of the effect is not large. We do not find large racial differences in screening rates, but NFP nurses were more likely to refer White mothers for mental health services than Black mothers (14% of Black mothers referred versus 20% of White mothers). Increased referrals for White mothers could be a factor behind higher treatment levels for White mothers, and the differential NFP programme effects. We need more evidence on the effects of nurse home visiting on maternal health by race. To the best of our knowledge, the only other paper that discusses the effects of nurse home visiting on maternal mental health by race is [Dodge et al. \(2022\)](#). The authors re-examine three nurse home visiting trials to assess whether the interventions reduced racial disparities. In contrast to our findings, they find statistically significant reductions in racial disparities in maternal anxiety and depression from a baseline of worse mental health in Black mothers.

It is hard to detect the underlying mechanisms behind the racial disparities we find. What we observe in our medical claims and survey data is a function of maternal service utilisation, mothers' revelation of information to healthcare providers, physician behaviour and beliefs, depression screening tools, and the accuracy of reporting. There may be racial differences in reporting of information to nurses and doctors, or Black mothers may be purposefully holding information back due to fear of negative repercussions. Black mothers may be worried about being considered a poor mother, or being reported to child welfare services. This is a legitimate fear in the U.S. African American families are more likely to be reported to child welfare services ([Krase, 2013](#)), judged unfit parents, and have their children taken away and placed in foster care relative to White mothers ([Yi et al., 2020](#)). In addition, there may be racial differences in the acknowledgement and acceptance of mental health conditions. Black and White mothers may have different preferences for mental health treatment. Our findings may also be driven by the limitations relating to healthcare providers, nurses, and their tools. Symptoms of depression and anxiety differ by race, so providers may not notice subtle or uncommon presentations of depression and anxiety ([Bailey et al., 2019](#)). Black mothers may use different language to describe depression ([Baker, 2001](#)), and may be more likely to report somatic than affective symptoms ([Lara-Cinisomo et al., 2020](#)). Further, few studies have tested the performance of depression screening tools among racially diverse groups of pregnant and postpartum women in the U.S. ([Ukatu et al., 2018](#)), ([Tandon et al., 2012](#)). Additionally, nurses and medical providers may unconsciously or consciously be treating

Black and White mothers differently, due to implicit bias or prejudice. There is a large literature documenting racial bias in the U.S. (e.g. (Dehon et al., 2017), (Williams and Wyatt, 2015)). Screening, diagnosis, and treatment for depression and anxiety could all be influenced by provider bias. Lastly, we may not observe mental health treatment that mothers are receiving in our data. Services provided at community centres, such as peer support groups, will not appear in medical claims data. Black mothers may be referred to these services at a higher rate than White mothers, for a variety of reasons including those discussed above.

There may also be limits to nurses' ability to positively impact maternal mental health outcomes. NFP is broad in its scope. Nurse home visitors have many competing objectives; mental health is only one of the topics covered in the home visits. It may be the case that a more specific intervention targeting maternal mental health would be more effective. One of the attractive features of NFP is the personal relationship that a nurse can build with a mother, but this form of social support during the perinatal period may be insufficient in addressing maternal depression and anxiety. Further, the social support benefits of NFP may not fully reach or benefit Black mothers, given the racial disparities we find. Finally, Black mothers' mental health may not be adequately addressed by NFP if such a patient level intervention cannot surpass the structural factors such as racism and poverty that contribute to poor mental health.

Future work could seek to isolate the role of specific mechanisms discussed in this paper to better understand the mental health diagnosis and treatment gap between Black and White mothers. For example, whether there are racial differences in preferences for depression treatment, and whether healthcare providers exhibit racial biases towards mothers with depression. Research that explores whether Black mothers fear revealing information to providers of intensive home visiting programmes would also be a welcome contribution.



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## A Appendix Tables

Appendix Table A1. Diagnosis codes for depression, anxiety, and stress-reactions

Description	ICD-10 code(s)
Depression	F53; O906; F99; O9934*; F32*; F33*
Anxiety	F41*
Stress-reaction	F43*

Appendix Table A2. Diagnosis codes for substance use

Description	ICD-10 code(s)
Neonatal abstinence disorder	P96.1; P04*
Opioids	F11*
Tobacco	F17.2*; O99.33*; Z72.0
Alcohol	V11.3*; F10.*
Sedative	F13*
Cocaine	F14*
Amphetamines	F15*
Cannabis	F12*

Appendix Table A3. Therapeutic class codes for filled antidepressants or anxiolytics

Description	Therapeutic class codes
Antidepressants	281604
Anxiolytics	2824*

Appendix Table A4. Outpatient psychotherapy codes

Description	CPT codes
Psychotherapy (individual, family, or group)	90804-90815; 90832-90834; 90836- 90840; 90845-90847; 90849; 90853; 90857; 90862; 90875; 90876

Appendix Table A5. Sample definition

Sample measure	Data sources	Definition
Index birth	South Carolina vital records birth certificates and baseline survey	A birth identified by a matched birth certificate in Vital Records with a date of birth within 120 days before or after the estimated delivery date on the baseline survey.

Appendix Table A6. NFP visits, by race

	Visit length Prenatal	Visit length 60 days pp	Visit length Study period	Visit count Prenatal	Visit count 60 days pp	Visit count Study period
Black	-2.441** (0.845)	-2.340 (1.697)	-2.040** (0.789)	-0.180 (0.208)	-0.454*** (0.107)	-0.409 (0.295)
Observations	2733	2105	2734	2742	2144	2743
Adjusted $R^2$	0.111	0.038	0.122	0.083	0.153	0.110
Mean	65.89	62.02	64.83	9.792	4.914	13.63

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Notes: Survey data collected after enrolment and before randomization between 2016 and 2020. “Black” refers to non-Hispanic Black mothers. “60 days pp” denotes that the visit took place after delivery, up to 60 days postpartum. “Study period” includes the prenatal period, delivery, and up to 60 days postpartum. “Avg. visit length” in minutes. “Visit count” is the number of at home NFP completed visits. All models include controls for IA, teen mother, mother aged 28 and over, daily interaction with father, less than high school education, work status, receipt of social service programs, housing insecurity, high risk pregnancy.

Appendix Table A7. Mental health and substance use prior to intervention

	Depressive Symptoms	High Stress	Received MH Treatment	Alcohol	Cigarettes
Black	0.0518*** (0.0133)	0.00877 (0.0160)	-0.150*** (0.0114)	-0.0147 (0.0160)	-0.221*** (0.0141)
Adjusted $R^2$	0.019	0.018	0.067	0.102	0.119
Mean	0.196	0.649	0.137	0.522	0.275

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Notes: N=4,155. Survey data collected after enrolment and before randomization between 2016 and 2020. “Black” refers to non-Hispanic Black mothers. “Depressive Symptoms” is a Patient Health Questionnaire 2 score of at least 3. “High Stress” is a Perceived Stress Scale 4 score of at least 4. All models include controls for IA, teen mother, mother aged 28 and over, daily interaction with father, less than high school education, work status, receipt of social service programs, housing insecurity, high risk pregnancy.

Appendix Table A8. Retention in NFP

	NFP to birth	NFP to 60 days pp	NFP to 1 year pp
Black	0.0284 (0.0168)	-0.00242 (0.0184)	-0.0295 (0.0198)
Adjusted $R^2$	0.025	0.040	0.069
Mean	0.779	0.703	0.523

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Notes: N=2,786. Survey data collected after enrolment and before randomization between 2016 and 2020. “Black” refers to non-Hispanic Black mothers. “NFP to birth” denotes that the mother remained in the NFP programme until birth. “NFP to 60 days pp” denotes that the mother remained in the NFP programme up to 60 days postpartum. “NFP to 1 year pp” denotes that the mother remained in the NFP programme up to 1 year postpartum. All models include controls for IA, teen mother, mother aged 28 and over, daily interaction with father, less than high school education, work status, receipt of social service programs, housing insecurity, high risk pregnancy.

Appendix Table A9. NFP mental health screening and referrals

	Screened at intake			Screened at 36w			Screened 1-8w pp			Num. screenings			Any screening			Any MH referral		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Black	0.02 (0.01)	0.03* (0.01)	0.03* (0.01)	-0.04* (0.02)	-0.02 (0.02)	-0.03 (0.02)	-0.02 (0.02)	0.00 (0.02)	-0.01 (0.02)	-0.08 (0.05)	0.02 (0.05)	-0.02 (0.05)	0.02 (0.01)	0.03* (0.01)	0.02* (0.01)	-0.04** (0.01)	-0.04** (0.01)	-0.04* (0.01)
Adjusted $R^2$	0.000	0.036	0.036	0.002	0.030	0.039	0.000	0.044	0.058	0.004	0.146	0.155	0.001	0.019	0.021	0.003	0.027	0.030
Mean	0.87	0.87	0.87	0.60	0.60	0.60	0.66	0.66	0.66	2.56	2.56	2.56	0.90	0.90	0.90	0.13	0.13	0.13
Controls	No	IA	Full	No	IA	Full	No	IA	Full	No	IA	Full	No	IA	Full	No	IA	Full

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ 

Notes: N=2,786. Survey data collected after enrolment and before randomization between 2016 and 2020. “Black” refers to non-Hispanic Black mothers. “Screened at 36w” is screened at 36 weeks pregnant. “Screened 1-8w pp” is screened at 1-8 weeks after birth. “Any MH referral” is ever referred for mental health treatment. “IA” controls are controls for the NFP implementating agency (IA). “Full” controls include controls for the IA, teen mother, mother aged 28 and over, daily interaction with father, less than high school education, work status, receipt of social service programs, housing insecurity, high risk pregnancy. Standard errors in parentheses.



Appendix Table A10. Treatment effects of NFP, vulnerable subsample

	Treatment Mean	Control Mean	Unadjusted Effect	Adjusted Effect
Any OP diagnosis/medication/therapy	39.09	40.23	-1.14	-1.41 [-5.12, 2.30]
Any OP diagnosis	35.21	37.58	-2.37	-2.73 [-6.41, 0.96]
Any Medication	17.57	16.65	0.93	0.92 [-2.11, 3.95]
Any Therapy	8.25	8.45	-0.20	0.29 [-1.90, 2.48]
Any IP/ED visit	18.41	16.27	2.14	1.58 [-1.42, 4.59]
Num. IP/ED visits	0.34	0.31	0.03	0.03 [-0.07, 0.12]
Treatment follow up	13.51	13.62	-0.11	0.37 [-2.32, 3.05]
Any substance use	24.81	26.61	-1.80	-1.70 [-4.95, 1.54]

<sup>+</sup>  $p < 0.1$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Notes: N=2,616. Vulnerable sample comprises of those younger than 19 years, had not finished high school, or had challenges with mental health (PHQ-2 score of at least 3 at baseline or reported receiving mental health treatment in the year before enrolment). For the “Any” variables, the means and effects are percentages. For the “Num” variable, the mean and effects are numbers. “OP” stands for outpatient. “L&D” stands for labour and delivery. “IP” stands for inpatient. “ED” stands for emergency department. “Any OP diagnosis/medication/therapy” is any outpatient diagnosis for depression or anxiety, medication, or therapy. “Any IP/ED visit” is an inpatient or emergency department visit with a postpartum depression or anxiety diagnosis, excluding labour and delivery. “Num. IP/ED” is defined the same, but counts the number of visits. “Any treatment follow up” is a second prescription or therapy visit within 120 days of first prescription or therapy visit. “Any treatment” is any medication or therapy visit. “Any therapy follow up” is a second therapy visit within 120 days of first therapy visit. “Any medication follow up” is a second medication fill within 120 days of first medication fill.

Appendix Table A11. Treatment effects of NFP, sample of mothers with any Medicaid coverage

	Treatment Mean	Control Mean	Unadjusted Effect	Adjusted Effect
Any OP diagnosis/medication/therapy	32.22	33.71	-1.49	-1.56 [-4.05, 0.92]
Any OP diagnosis	28.80	30.48	-1.67	-1.75 [-4.17, 0.67]
Any Medication	13.37	13.41	-0.04	-0.04 [-1.96, 1.88]
Any Therapy	5.07	4.72	0.35	0.38 [-0.81, 1.57]
Any IP/ED visit	14.02	12.35	1.67	1.49 [-0.36, 3.35]
Num. IP/ED visits	0.25	0.21	0.03	0.03 [-0.02, 0.08]
Treatment follow up	8.98	8.81	0.16	0.07 [-1.49, 1.63]
Any substance use	21.70	22.66	-0.95	-0.51 [-2.63, 1.61]

<sup>+</sup>  $p < 0.1$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Notes: N=4,864. Sensitivity analysis conducted on sample of mothers with any Medicaid coverage up to 60 days postpartum. For the “Any” variables, the means and effects are percentages. For the “Num” variable, the mean and effects are numbers. “OP” stands for outpatient. “L&D” stands for labour and delivery. “IP” stands for inpatient. “ED” stands for emergency department. “Any OP diagnosis/medication/therapy” is any outpatient diagnosis for depression or anxiety, medication, or therapy. “Any IP/ED visit” is an inpatient or emergency department visit with a postpartum depression or anxiety diagnosis, excluding labour and delivery. “Num. IP/ED” is defined the same, but counts the number of visits. “Any treatment follow up” is a second prescription or therapy visit within 120 days of first prescription or therapy visit. “Any treatment” is any medication or therapy visit. “Any therapy follow up” is a second therapy visit within 120 days of first therapy visit. “Any medication follow up” is a second medication fill within 120 days of first medication fill.

Appendix Table A12. Treatment effects of NFP, sample of mothers with continuous Medicaid coverage

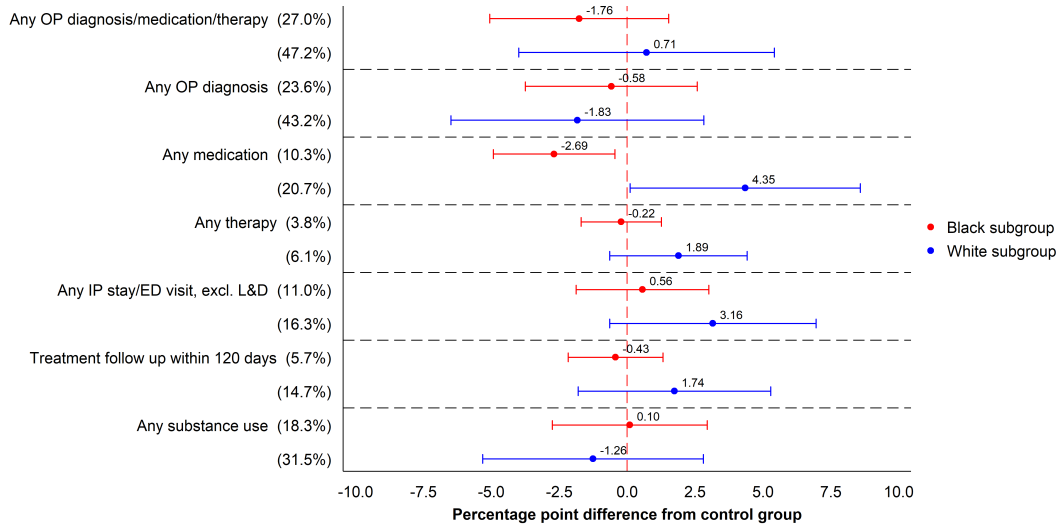
	Treatment Mean	Control Mean	Unadjusted Effect	Adjusted Effect
Any OP diagnosis/medication/therapy	32.41	33.93	-1.51	-1.31 [-3.83, 1.20]
Any OP diagnosis	29.00	30.63	-1.63	-1.45 [-3.91, 1.00]
Any Medication	13.40	13.44	-0.04	0.07 [-1.88, 2.01]
Any Therapy	5.07	4.76	0.32	0.39 [-0.81, 1.59]
Any IP/ED visit	14.16	12.37	1.79	1.78 <sup>+</sup> [-0.10, 3.66]
Num. IP/ED visits	0.25	0.21	0.04	0.04 [-0.01, 0.09]
Treatment follow up	8.96	8.88	0.08	0.08 [-1.49, 1.66]
Any substance use	21.64	22.70	-1.06	-0.39 [-2.53, 1.75]

<sup>+</sup>  $p < 0.1$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Notes: N=4,770. Sensitivity analysis conducted on sample of mothers with continuous Medicaid coverage up to 60 days postpartum. For the “Any” variables, the means and effects are percentages. For the “Num” variable, the mean and effects are numbers. “OP” stands for outpatient. “L&D” stands for labour and delivery. “IP” stands for inpatient. “ED” stands for emergency department. “Any OP diagnosis/medication/therapy” is any outpatient diagnosis for depression or anxiety, medication, or therapy. “Any IP/ED visit” is an inpatient or emergency department visit with a postpartum depression or anxiety diagnosis, excluding labour and delivery. “Num. IP/ED” is defined the same, but counts the number of visits. “Any treatment follow up” is a second prescription or therapy visit within 120 days of first prescription or therapy visit. “Any treatment” is any medication or therapy visit. “Any therapy follow up” is a second therapy visit within 120 days of first therapy visit. “Any medication follow up” is a second medication fill within 120 days of first medication fill.

## B Appendix Figures

Appendix Figure B1. The effect of NFP on mental health outcomes, by race



Notes: Non-Hispanic White sample N = 1604. Non-Hispanic Black sample N = 2551. For all variables, the means and effects are percentages. “OP” stands for outpatient. “L&D” stands for labour and delivery. “IP” stands for inpatient. “ED” stands for emergency department. “Any OP diagnosis/medication/therapy” is any outpatient diagnosis for depression or anxiety, medication, or therapy. “Any IP/ED visit” is an inpatient or emergency department visit with a postpartum depression or anxiety diagnosis, excluding labour and delivery. “Treatment follow up within 120 days” is a second prescription or therapy visit within 120 days of first prescription or therapy visit.