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Home visiting for first-time mothers and subsequent pregnancy spacing

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Abstract

Objective—Determine association of home visiting with subsequent pregnancy outcomes

Study Design—Retrospective study of Ohio mothers delivering their first infant from 2007–2009. First, we compared mothers enrolled in home visiting to a matched eligible group. Second, we compared outcomes within home visiting based on program participation (low < 25% of recommended home visits, moderate 25–75%, high 75–100% and very high >100%). Time to subsequent pregnancy within 18 months was evaluated using Cox proportional hazards regression; logistic regression tested the likelihood of subsequent preterm birth.

Result—Of 1,516 participants, 1,460 were matched 1:1 to a comparison mother (n=2,920). After multivariable adjustment, enrollment was associated with no difference in pregnancy spacing or subsequent preterm birth. Among those enrolled, moderate vs. low participants had reduced risk of repeat pregnancy over 18 months (hazard ratio 0.68, p=0.003).

Conclusion—Increased pregnancy spacing is observed among women with at least moderate home visiting participation.

INTRODUCTION

Preterm birth (< 37 weeks gestation) affects roughly 500,000 infants annually in the U.S. and is a leading causes of infant mortality[1]. As one strategy to address disparities, home visiting programs have received federal investments to provide education, social support, and interventions in a home-based setting[2]. Based on social determinants of health theory[3], these programs seek to mitigate 1) barriers to healthcare, (2) behavioral risk factors, and (3)

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CONFLICT OF INTEREST
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psychosocial stressors[4]. Despite several promising studies[5–9], a recent meta-analysis suggests that on average, home visiting is not effective in changing birth outcomes[10]. A key limitation is that most pregnant women who enroll in home visiting do so relatively late in pregnancy, minimizing the opportunity to address modifiable risk factors[11–14]. For home visiting programs, the greatest opportunity is likely in addressing risk factors for future pregnancy.

A growing body of literature has demonstrated the importance of adequate pregnancy spacing to reduce risk of preterm birth, particularly among high-risk women[15–17]. Pregnancy spacing may also have important consequences for maternal educational attainment and economic self-sufficiency[18], underscoring the long-range impact of this outcome for the maternal life course. Home visitors have an opportunity to impact pregnancy spacing through emphasis on self-efficacy and connection with family planning services. Prior literature describing home visiting effects on pregnancy spacing has been inconsistent[19–22]. With recent and ongoing expansion of home visiting programs across the U.S., evaluation of subsequent pregnancies is critical to assessing long-term programmatic benefits.

The goal of this study was to evaluate the association of pregnancy spacing with home visiting enrollment among high-risk first-time mothers. We hypothesized that participants would be more likely to delay subsequent pregnancy compared with eligible, non-enrolled women. We also sought to determine the effects of varying participation in this voluntary program by enrolled women. For home visiting programs, which often struggle to engage families in consistent visit schedules and to retain families in services over time, the issue of attrition and loss to follow up has important implications for interpretation and evaluation of program outcomes. We hypothesized that among enrolled participants, greater program participation after birth of the first infant would be associated with improved pregnancy spacing.

METHODS

This retrospective cohort study evaluated a population of high-risk, first time mothers enrolled from 2007–2009 in a well-established, regional home visiting program serving 7 counties throughout Greater Cincinnati. This program contracts with 10 home visiting agencies in Ohio which adhere to program, training and evaluation standards established by Cincinnati Children's Hospital Medical Center (CCHMC), employing a core curriculum based on one of two national model of Healthy Families America[23] (HFA, 9 sites) and Nurse-Family Partnership[24] (NFP, 1 site). Overall program goals are to: 1) provide pregnancy education and care coordination, 2) promote a nurturing home environment, 3) optimize child development, 4) link families to health services, and 5) promote economic self-sufficiency. Eligible participants must be first-time mothers with at least 1 of 4 characteristics: unmarried, low income (up to 300% of poverty level, receipt of Medicaid, or reported financial concerns), < 18 years of age, or suboptimal prenatal care (broadly defined with no specific gestational age cutoff). Of these 4 criteria, suboptimal prenatal care is the least commonly used with <5% of participants enrolled based on this alone. Participants are enrolled during pregnancy or before their child reaches 3 months of age. Home visitors hold bachelor's degrees with training in child development and related disciplines (HFA), or are

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licensed nurses (NFP). To address pregnancy spacing, the program uses both formal approaches, such as handouts and tools to promote maternal health, life course planning, and connection to postpartum care, as well as informal approaches, e.g. motivation and confidence building for mothers to achieve their goals. The schedule of visits starts with weekly home visits, tapering to fewer visits as the child ages, with completion at 3 years of age.

For each participant, home visiting data were abstracted from a web-based data entry system used to document service provision data and for billing[25]. To derive information for the index pregnancy, program records were linked to Ohio vital statistics and birth-related hospital discharge of both mother and infant. Record linkage was accomplished using LINKS (University of Manitoba), a SAS-based probabilistic and deterministic matching program[26]. Similarly, linkage to subsequent live births for these mothers was conducted using Ohio vital statistics through 2013, such that information on subsequent pregnancies was examined within a three-year time frame from birth of the index infant (i.e. fixed type 1 censoring). The Ohio Department of Health and CCHMC Institutional Review Boards approved this study, including a waiver of consent based on minimal risk to subjects and feasibility..

Analysis

Interpregnancy interval (IPI) was defined as length of time between index birth and date of conception for the second pregnancy, derived by subtracting the second infant's gestational age from her or his birth date and then calculating the interval between the index birth and conception of the second infant. Using this method, only second conceptions resulting in an Ohio live birth were counted as events. IPI was assessed as a continuous variable as well as a binary variable (< or ≥18 months)[15]. As in previous analyses, we also evaluated a secondary outcome of very short IPI (≤ 6 months) to reflect rapid repeat births[22]. Among women with a subsequent pregnancy identified within the study time frame, preterm birth was assessed using the obstetrical estimate of gestational age documented in vital statistics.

This was a two-phased analysis of home visiting participation and pregnancy spacing. First, we examined outcome differences between those enrolled in home visiting and those not enrolled. Our prior research has shown that among women eligible for home visiting in the region, approximately one third are referred and among those referred approximately half enroll[26]. Therefore, using Ohio vital statistics from the same years of 2007–2009, a matched comparison group of first-time mothers was selected based on program eligibility criteria. To minimize the potential for self-selection bias in the enrolled group[27], we excluded from the comparison group any women who were referred to home visiting but declined enrollment. We also excluded women with an index neonatal death, because home visiting requires participants to either be pregnant or parenting and therefore they would no longer be eligible for services. Similarly, women with a previable gestational age at delivery (< 23 weeks) for the index pregnancy were also excluded, as such infants have a low likelihood of survival or eventual discharge by 3 months of age thereby precluding home visiting participation. We then performed a 1:1 matching of potential comparison mothers to home visiting participants using the following matching characteristics: race, maternal age, index year of

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birth, and residence within a ZIP code with either higher or lower penetration of the home visiting program (< or ≥ 25% of eligible women in the area enrolled in home visiting). Exact matching constraints were permitted to vary modestly for maternal age (1 year; approximately 20% standard deviation in age) and birth year (2 years) to prevent unnecessary exclusion of matched comparisons. We also matched by propensity score[28], derived using logistic regression for the individual conditional probability of participating in home visiting based on the following baseline characteristics: maternal age, education level, tobacco use, marital status, race, ethnicity, ZIP code of residence, hypertension before or during the index pregnancy, and diabetes before or during the index pregnancy. These characteristics were selected on the basis of prior research demonstrating their importance in predicting referral and enrollment into home visiting[26]. A 1:1 matching ratio was selected to minimize bias and ensure balance of covariates across enrolled and comparison mothers. Matches were constrained by a caliper of 20% of the propensity score standard deviation[29]. A greedy algorithm with weighted Euclidean distance was used to perform sample matching with SAS[30]. Balance of covariates across controls and the enrolled participants was assessed using absolute standardized differences in means.

For the second phase of the analysis, we evaluated whether level of program participation was associated with outcome differences within the group of women enrolled in home visiting. As above, women with a gestational age < 23 weeks at delivery and those with a neonatal death were excluded. Based on empirical evidence from multiple programs that attrition from home visiting is common in the first year[31], we measured participation as percentage of expected home visits completed over the first year of life for the mother's first infant per the program's curriculum (complete participation would approximate 32 total home visits). We categorized these percentages *a priori* into levels of participation deemed low (0–25% of expected visits), moderate (25–75% of expected visits), high (75–100% of expected visits), and very high (>100%). Our characterization of 75–100% of expected visits as high participation aligns closely with previous research on home visiting engagement[31,32]. Characteristics of participants by participation level were analyzed by the Pearson chi-squared test or Student's t test.

For both phases of analysis, Cox proportional hazards regression models tested differences in timing to subsequent pregnancy. Models were tested for the assumption of proportional hazards using Schoenfeld residuals and adjusted for clinical and demographic covariates. For the analysis of program participation, modelling was also stratified by agency to account for site-level differences in the baseline hazard. Cumulative hazard function curves were used to display results graphically. Finally, for both phases of analysis we used multivariable logistic regression to evaluate the likelihood of preterm birth among those women experiencing a subsequent pregnancy. Analyses were conducted using STATA 11.1.

RESULTS

Matched analysis of enrolled and non-enrolled

To derive the sample for the first phase of the analysis, we identified 1,516 women with an Ohio birth certificate between 2007 and 2009 and who were enrolled in home visiting either prenatally or after birth of the infant. After applying matching algorithm constraints, 1,460

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participants were matched 1:1 to comparison women who were neither referred to nor enrolled (total sample 2,920 women). Based on this sample size we had >80% power (at alpha=0.05) to detect a 25% reduction in repeat pregnancy by 18 months among enrolled participants using a two-sided test, which is similar to effect sizes shown in prior research[10,19]. As shown in Table 1, characteristics were balanced across the two matched groups. Across this total sample, 485 (16.6%) had an IPI < 18 months (17.4% among enrolled vs. 15.8% among comparisons), and 4.6% had an IPI < 6 months (4.8% among enrolled vs. 4.3% among comparisons).

As shown in Table 2 and Figure 1 (Panel A), after multivariable adjustment enrollment was not associated with a significant difference in timing to repeat pregnancy over an 18 month timeframe (HR 1.13, 95% CI 0.94, 1.37). Tests for interaction with key covariates (race, maternal age, and education level) were not statistically significant. Covariates that were associated with significant risk differences were obesity (HR 1.26, 95% CI 1.01, 1.57), college education (HR 0.68, 95% CI 0.50, 0.92), Hispanic ethnicity (HR 0.46, 95% CI 0.24, 0.89) and index Cesarean delivery (HR 0.59, 95% CI 0.47, 0.75).

Among this sample of enrolled and non-enrolled women, 854 (29.3%) had a repeat pregnancy over a 3 year timeframe; the preterm birth rate for these second pregnancies was 12.3% (12.1% among enrolled vs. 12.5% among comparisons). In multivariable logistic regression shown in Table 2, enrollment was not associated with a significant reduction in odds of preterm birth for the subsequent pregnancy (adjusted odds ratio (AOR) 0.78, 95% CI 0.49, 1.24). However, prior preterm birth and IPI < 6 months were both significant predictors of subsequent preterm birth.

Analysis of participation within home visiting

The second phase of our analysis included only those women enrolled in home visiting. Approximately 37% were classified as low participation, 50% as medium participation, and 10% as high participants. Finally, a small number (3%) received > 100% of the expected intervention. Because we observed significant differences in risk characteristics of participants with this very high level of home visiting service, these were categorized separately (see Table 3). Among all enrolled participants, 19% had a repeat pregnancy within 18 months of first birth, and 5% had a repeat pregnancy within 6 months.

Compared to low program participation, moderate participation was associated with reduced risk of repeat pregnancy over 18 months (HR 0.67, 95% CI 0.52, 0.87). High participation was also associated with a reduced risk (HR 0.55, 95% CI 0.33, 0.91). However, those with the highest number of visits did not demonstrate a significant difference in repeat pregnancies compared with low participants (HR 1.39, 95% CI 0.78, 2.50) (see Figure 1, Panel B). Tests for interaction effects with key covariates (race, maternal age, and education level) were not statistically significant. We did not observe significant differences in timing to repeat based on home visiting model (approximately 5% served by an NFP agency) or on prenatal vs. postnatal enrollment (after birth of the index child). However, covariates that were associated with significant risk differences were maternal smoking (HR 1.19, 95% CI 0.91, 1.57), obesity (HR 1.44, 95% CI 1.08, 1.91), college education (HR 0.63, 95% CI 0.44, 0.91), and index Cesarean delivery (HR 0.64, 95% CI 0.48, 0.86). As a sensitivity analysis,

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we omitted 87 participants who based on program records were discharged from home visiting due to a move outside of the service area; results for all predictors were substantially unchanged.

For the 498 enrolled in home visiting with a repeat pregnancy over 3 years, the preterm birth rate for the second pregnancy was 12.3%. We evaluated for possible mediation by modeling the analysis of preterm birth with and without IPI as a covariate. In multivariable logistic regression, high home visiting participation demonstrated a trend towards reduced odds of subsequent preterm birth, but the effect was not statistically significant (AOR 0.45, 95% CI 0.10, 2.06). When IPI < 6 months was added to the model of preterm birth (Table 4), the effect of high home visiting participation was not substantially different, while IPI itself was a significant predictor of preterm birth (AOR 4.30, 95% CI 2.21, 8.38).

DISCUSSION

Several aspects of real world programmatic implementation likely contribute to the inconsistency of published findings on home visiting and birth outcomes, including referral bias towards women with more complicated pregnancies[27], as well as an inability of home visiting programs to reach most participants until they are late in pregnancy[13]. Given these limitations, the question of whether home visiting influences subsequent birth outcomes has significant public health implications. In this study of high-risk first-time mothers, we observed no difference in pregnancy spacing or subsequent preterm birth between those enrolled and not enrolled in home visiting, which suggests limited overall impact of this intervention. These findings may be related to lack of sustained engagement among participants in this intensive, voluntary program, of whom roughly one quarter had fewer than 5 home visits after delivery of their first infant. Importantly, we observed that among enrolled participants, those with at least moderate program participation did have increased time to subsequent pregnancy compared with those who had very few home visits. While we observed no significant effect of participation level on subsequent preterm birth, our ability to detect differences in preterm birth was likely affected by the limited number of subsequent pregnancies, particularly among those women with moderate and high program participation. Shorter IPI was a significant risk factor for preterm birth within this cohort, indicating that pregnancy spacing is important for home visiting programs to achieve long term benefits for participants.

Prior studies on home visiting and pregnancy spacing have yielded mixed results[21]. A recent cohort study comparing women enrolled and not enrolled in NFP home visiting in Pennsylvania demonstrated positive effects on pregnancy spacing, particularly for young women and those living in rural locations[20]. Conversely, evaluation of HFA home visiting in Hawaii has demonstrated no improvement in pregnancy spacing among enrolled participants compared with those not enrolled[19]. We do not suspect our null findings are due to insufficient power to detect small but meaningful differences, as the trend for enrolled women actually appeared slightly worse than comparisons. Lack of effect has previously been attributed to several factors, including program attrition and lack of program specificity with regards to family planning interventions. Across home visiting programs nationally, heterogeneity of services is well documented, with most participants not receiving the

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recommended number of visits[31]. Our current findings provide further insight into the impact of variable dose of the intended intervention on this important outcome. Results suggest not only the need for specific content on pregnancy spacing, but also to maximize delivery of this content to all participants, including those only enrolled briefly.

Finally, we found that very high program utilization was associated with increased maternal risk, including hypertension, diabetes, obesity, and smoking. For this subgroup, pregnancy outcomes were not statistically different from those of very low program utilizers (and suggestive of a trend towards worse outcomes). This is consistent with prior findings that very high prenatal care utilization is associated with greater maternal pregnancy risk[33], as well as recent findings from Holland et al. that increasing use of home visiting over time is predictive of poor outcomes[34]. This non-linear association between maternal risk and dosage of preventive services likely reflects the dynamic process of evaluation by both providers and participants, such that higher needs can be a driver of more frequent visits. Within home visiting, recommended visit schedules are not empirically based but rather derived *a priori*; although general wisdom suggests “more is better,” our findings suggest that the extent of a home visiting dose-effect relationship may depend on maternal characteristics and on the outcome being evaluated. Further research is needed not only on approaches to strengthen maternal motivation to participate and adhere to recommended visits, but also to optimize program dose based on their risk characteristics and outcomes[35].

Strengths include a large regional cohort with 3 years of follow up data and details of service use for this community-based program. We have attempted to minimize selection bias associated with referral and decision to enroll, which may be considerable among the eligible population[27]. However, selection bias remains a significant limitation of this study design. There may be unmeasured, systematic differences between women who received high and low levels of service. Bias toward overstating the results would occur if, for example, women with subsequent pregnancies were less able to adhere to the home visiting schedule, or if those with adequate participation were especially motivated with regards to family planning. Alternatively, prior data from our program suggests there may be bias in retention such that participants with higher acute needs are more likely to remain engaged in home visiting[36].

Furthermore, given limitations of the data we could not quantify either time spent on pregnancy spacing counselling, the quality of such information, or the percentage of women who initiated postpartum contraception. Ascertainment bias should also be considered, because miscarriages, therapeutic abortions, and births outside of Ohio were not counted as events. We have no reason to believe that miscarriages and abortion might be systematically different between women with lower and higher program participation. However, it is possible that women exiting the program earlier were also more likely to move out of the state and therefore be less likely to have a record of subsequent pregnancy, biasing our estimates towards the null. Finally, generalizability may also be concern, given our analysis was confined to one regional program. However, rates of subsequent pregnancy for women in our sample were consistent with rates among an eligible, at-risk population in Ohio.

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CONCLUSIONS

Among women enrolled in home visiting, short IPI is a risk factor for preterm birth. Greater program specificity with regards to pregnancy spacing may promote long term benefits. Programmatic effects on pregnancy spacing are demonstrated among those with at least moderate program participation. Although findings suggest that increasing delivery of recommended home visits may increase observable program benefits, future efforts to develop and implement empirically-based visit schedules should take into account maternal risk characteristics as well as outcomes of interest.

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References

1. Institute of Medicine (U.S.) Committee on Understanding Premature Birth and Assuring Healthy Outcomes. Preterm birth: causes, consequences, and prevention. Washington D.C.: National Academies Press; 2006.
2. Health Resources and Services Administration. [Cited September 1, 2011] Maternal, Infant, and Early Childhood Home Visiting Program. 2010. Available from: http://mchb.hrsa.gov/programs/homevisiting
3. Larson K, Russ SA, Crall JJ, Halfon N. Influence of multiple social risks on children's health. Pediatrics. 2008 Feb; 121(2):337–344. [PubMed: 18245425]
4. U.S. Department of Health and Human Services. [Cited January 31, 2013] Home Visiting Evidence of Effectiveness. Available from: http://homvee.acf.hhs.gov/
5. Donovan EF, Ammerman RT, Besl J, Atherton H, Khoury JC, Altaye M, et al. Intensive home visiting is associated with decreased risk of infant death. Pediatrics. 2007 Jun; 119(6):1145–1151. [PubMed: 17545382]
6. Kitzman H, Olds DL, Henderson CR Jr, Hanks C, Cole R, Tatelbaum R, et al. Effect of prenatal and infancy home visitation by nurses on pregnancy outcomes, childhood injuries, and repeated childbearing. A randomized controlled trial. JAMA. 1997 Aug 27; 278(8):644–652. [PubMed: 9272896]
7. Lee E, Mitchell-Herzfeld SD, Lowenfels AA, Greene R, Dorabawila V, DuMont KA. Reducing low birth weight through home visitation: a randomized controlled trial. Am J Prev Med. 2009 Feb; 36(2):154–160. [PubMed: 19135906]
8. Reece EA, Leguizamon G, Silva J, Whiteman V, Smith D. Intensive interventional maternity care reduces infant morbidity and hospital costs. J Matern Fetal Neonatal Med. 2002 Mar; 11(3):204–210. [PubMed: 12380679]
9. Wells N, Sbrocco T, Hsiao CW, Hill LD, Vaughn NA, Lockley B. The impact of nurse case management home visitation on birth outcomes in African-American women. J Natl Med Assoc. 2008 May; 100(5):547–552. [PubMed: 18507207]
10. Filene JH, Kaminski JW, Valle LA, Cachat P. Components associated with home visiting program outcomes: a meta-analysis. Pediatrics. 2013 Nov; 132(Suppl 2):S100–S109. [PubMed: 24187111]

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11. Slaughter JC, Issel LM. Developing a measure of prenatal case management dosage. Matern Child Health J. 2012 Jul; 16(5):1120–1130. [PubMed: 21706295]

12. Roman L, Raffo JE, Zhu Q, Meghea CI. A statewide medicaid enhanced prenatal care program: impact on birth outcomes. JAMA Pediatr. 2014 Mar; 168(3):220–227. [PubMed: 24394980]

13. Goyal NK, Hall ES, Meinzen-Derr JK, Kahn RS, Short JA, Van Ginkel JB, et al. Dosage effect of prenatal home visiting on pregnancy outcomes in at-risk, first-time mothers. Pediatrics. 2013 Nov; 132(Suppl 2):S118–S125. [PubMed: 24187113]

14. Goyal NK, Folger AT, Hall ES, Teeters A, Van Ginkel JB, Ammerman RT. Multilevel assessment of prenatal engagement in home visiting. J Epidemiol Community Health. 2016 Sep; 70(9):888–894. [PubMed: 26912773]

15. DeFranco EA, Ehrlich S, Muglia LJ. Influence of interpregnancy interval on birth timing. BJOG. 2014 Dec; 121(13):1633–1640. [PubMed: 24893887]

16. Nabukera SK, Wingate MS, Owen J, Salihu HM, Swaminathan S, Alexander GR, et al. Racial disparities in perinatal outcomes and pregnancy spacing among women delaying initiation of childbearing. Matern Child Health J. 2009 Jan; 13(1):81–89. [PubMed: 18317891]

17. Smith GC, Pell JP, Dobbie R. Interpregnancy interval and risk of preterm birth and neonatal death: retrospective cohort study. BMJ. 2003 Aug 9.327(7410):313. [PubMed: 12907483]

18. Polit DF, Kahn JR. Early subsequent pregnancy among economically disadvantaged teenage mothers. Am J Public Health. 1986 Feb; 76(2):167–171. [PubMed: 3946698]

19. El-Kamary SS, Higman SM, Fuddy L, McFarlane E, Sia C, Duggan AK. Hawaii's healthy start home visiting program: determinants and impact of rapid repeat birth. Pediatrics. 2004 Sep; 114(3):e317–e326. [PubMed: 15342892]

20. Rubin DM, O'Reilly AL, Luan X, Dai D, Localio AR, Christian CW. Variation in pregnancy outcomes following statewide implementation of a prenatal home visitation program. Arch Pediatr Adolesc Med. 2011 Mar; 165(3):198–204. [PubMed: 21041588]

21. Sonalkar S, Mody S, Gaffield ME. Outreach and integration programs to promote family planning in the extended postpartum period. Int J Gynaecol Obstet. 2014 Mar; 124(3):193–197. [PubMed: 24434229]

22. Yun K, Chesnokova A, Matone M, Luan X, Localio AR, Rubin DM. Effect of maternal-child home visitation on pregnancy spacing for first-time Latina mothers. Am J Public Health. 2014 Feb; 104(Suppl 1):S152–S158. [PubMed: 24354820]

23. Daro DA, Harding KA. Healthy Families America: using research to enhance practice. Future Child. 1999 Spring-Summer;9(1):152–178. [PubMed: 10414015]

24. Olds DL, Hill PL, O'Brien R, Racine D, Moritz P. Taking preventive intervention to scale: the Nurse-Family Partnership. Cognitive & Behavioral Practice. 2003 Autumn;10(4):278–290.

25. Ammerman RT, Putnam FW, Kopke JE, Gannon TA, Short JA, Van Ginkel JB, et al. Development and implementation of a quality assurance infrastructure in a multisite home visitation program in Ohio and Kentucky. J Prev Interv Community. 2007; 34(1–2):89–107. [PubMed: 17890195]

26. Hall ES, Goyal NK, Ammerman RT, Miller MM, Jones DE, Short JA, et al. Development of a linked perinatal data resource from state administrative and community-based program data. Matern Child Health J. 2014 Jan; 18(1):316–325. [PubMed: 23420307]

27. Goyal NK, Hall ES, Jones DE, Meinzen-Derr JK, Short JA, Ammerman RT, et al. Association of maternal and community factors with enrollment in home visiting among at-risk, first-time mothers. Am J Public Health. 2014 Feb; 104(Suppl 1):S144–S151. [PubMed: 24354835]

28. D'Agostino RB Jr. Propensity score methods for bias reduction in the comparison of a treatment to a non-randomized control group. Stat Med. 1998 Oct 15; 17(19):2265–2281. [PubMed: 9802183]

29. Austin PC. Some methods of propensity-score matching had superior performance to others: results of an empirical investigation and Monte Carlo simulations. Biom J. 2009 Feb; 51(1):171–184. [PubMed: 19197955]

30. Bergstralh E, Kosanke J. GMATCH. 2003 [Cited September 14, 2013] Available from: http://www.mayo.edu/research/departments-divisions/department-health-sciences-research/division-biomedical-statistics-informatics/software/locally-written-sas-macros.

31. Daro, D., Hart, B., Boller, K., Bradley, MC. Children's Bureau, Administration for Children and Families, U.S. Department of Health and Human Services. Princeton, NJ: Mathematica Policy

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Research; 2012 Dec. Replicating home visiting programs with fidelity: baseline data and preliminary findings. Contract No.: GS-10F-0050L/HHSP233200800065W. Available from

32. Duggan A, McFarlane E, Fuddy L, Burrell L, Higman SM, Windham A, et al. Randomized trial of a statewide home visiting program: impact in preventing child abuse and neglect. Child Abuse Negl. 2004 Jun; 28(6):597–622. [PubMed: 15193851]
33. Kotelchuck M. The Adequacy of Prenatal Care Utilization Index: its US distribution and association with low birthweight. Am J Public Health. 1994 Sep; 84(9):1486–1489. [PubMed: 8092377]
34. Holland ML, Xia Y, Kitzman HJ, Dozier AM, Olds DL. Patterns of visit attendance in the nurse-family partnership program. Am J Public Health. 2014 Oct; 104(10):e58–e65. [PubMed: 25122021]
35. mmerman RT. Toward the next generation of home visiting programs: new developments and promising directions. Curr Probl Pediatr Adolesc Health Care. 2016 Apr; 46(4):126–129. [PubMed: 26810691]
36. Ammerman RT, Stevens J, Putnam FW, Altaye M, Hulsmann JE, Lehmkuhl HD, et al. Predictors of early engagement in home visitation. Journal of Family Violence. 2006 Feb; 21(2):105–115.

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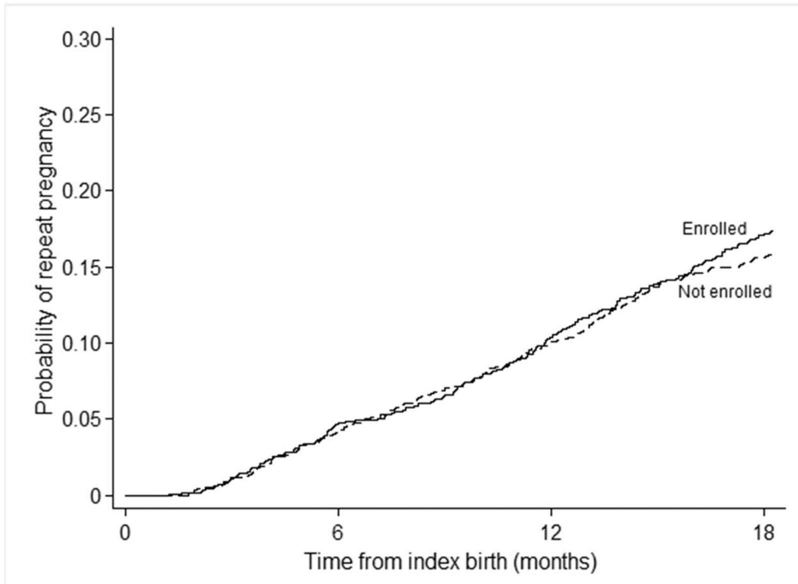
A. Stratification by enrollment in home visiting



B. Stratification by percentage of recommended home visits completed

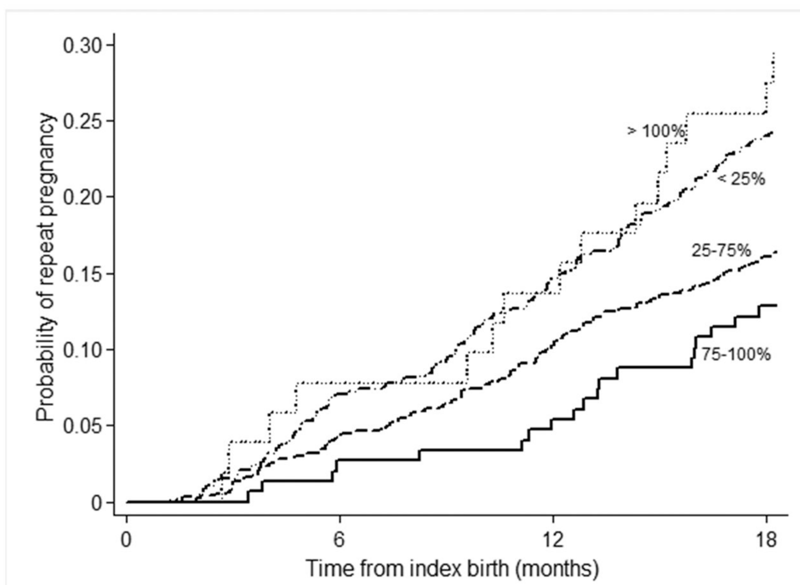


Figure 1. Cumulative hazard function curves for subsequent pregnancy over 18 months

X axis represents time from index birth. Y axis represents probability of subsequent pregnancy. In Panel A, women in home visiting (solid line) are compared to matched, non-enrolled women (dashed line). In Panel B, participants are represented by separate lines based on percentage of recommended home visits received.

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Table 1

Balance of characteristics by home visiting enrollment status, matched cohort (N=2,920)

	Enrolled (n=1,460)	Not enrolled (n=1,460)	Standardized difference in means[a]
Race			
White	34.5	34.5	0.00
African American	64.5	64.5	0.00
Multiracial or other	0.9	0.9	0.00
Hispanic ethnicity	6.7	5.6	0.46
Education level			
< High school degree	45.8	46.2	0.01
High school degree	30.3	29.8	0.01
>High school degree	23.9	24.1	0.01
Insurance			
Medicaid	77.3	76.9	0.01
Private	14.1	16.9	0.08
Self-pay	5.8	4.9	0.03
Other	2.9	1.3	0.13
Age < 18 years	24.3	21.3	0.07
Unmarried	95.6	96.2	0.03
Index preterm birth	13.1	11.1	0.06
Index vaginal delivery	72.7	72.9	0.004
Hypertension	5.7	5.6	0.01
Obesity	28.2	25.4	0.06
Diabetes	3.9	3.4	0.02
Smoker during pregnancy	26.7	26.2	0.01
Sexually transmitted infection	14.2	13.4	0.02

[a]Calculated as the quotient of the maximum of the means minus the minimum of the means, and the pooled standard deviation across the two group.

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Table 2

Multivariable proportional hazards regression and logistic regressions for repeat pregnancy over 18 months, home visiting vs. comparison group

	Adjusted hazard ratio[a], time to subsequent pregnancy (n=2,920)	**Adjusted odds ratio[b], subsequent preterm birth (n=854[c])**
Enrolled in home visiting	1.13 (0.94, 1.37)	0.78 (0.49, 1.24)
Prior preterm birth	1.09 (0.88, 1.33)	**2.23 (1.47, 3.38)**
Interpregnancy interval ≤ 6 months	(not included)	**2.15 (1.22, 3.80)**

[a]Model includes adjustment for race, ethnicity, education level, insurance status, maternal age, breastfeeding status, marital status, hypertension, diabetes, obesity, index delivery method, smoking status during index pregnancy, sexually transmitted infection, and year of index birth. Robust variance estimation was used to account for clustering by matched pairs.

[b]Same covariates as above, with values updated to reflect status during second pregnancy.

[c]Sample reflects those with a repeat pregnancy within 3 years of index birth. Bolded values indicate p-values <0.05.

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Table 3

Baseline characteristics of program enrollees by participation level[a] (N=1,516)

	Low (n=521)	Moderate (n=796)	High (n=148)	Very high (n=51)	p-value
Mean postnatal home visits	3.6	16.0	27.9	37.9	<0.001
Race					< 0.001
White	26.9	29.3	48.0	51.0	
African American	67.8	66.9	44.6	31.4	
Multiracial or other	5.4	3.9	7.4	17.7	
Hispanic ethnicity	4.2	7.7	15.5	13.7	<0.001
Education level					0.22
< High school	54.3	49.8	53.4	51	
High school	25.5	26.8	33.1	33.3	
>High school	20.3	23.4	13.5	15.7	
Insurance					0.53
Medicaid	80.4	77.7	76.9	72.6	
Private	15.6	16.9	15.7	17.7	
Self-pay	3.8	5.2	6.8	7.8	
Other	0.2	0.2	0.7	2.0	
Age < 18 years	29.4	26.4	22.3	21.6	0.14
Prenatal vs. postnatal enrollment	41.1	45.9	60.1	45.1	0.002
Index preterm birth	14.4	14.4	12.2	15.7	0.87
Index vaginal delivery	73.5	70.4	75.0	78.4	0.36
Hypertension	8.5	7.9	8.1	11.8	0.57
Obesity	18.4	23.6	18.2	27.5	0.20
Diabetes	4.2	5.2	2.7	9.8	0.12
Smoker	31.1	31.6	35.1	43.1	0.03
Mental health diagnosis	9.2	9.0	9.5	13.7	0.62
Other substance use	13.1	11.8	11.5	17.7	0.43
Sexually transmitted infection	19.4	18.9	13.5	9.8	0.06
Lives with partner	15.2	15.0	16.2	25.5	0.15

[a]Low participation defined as 0–25% of expected visits, moderate defined as 25–75% of expected visits, high defined as 75–100% of expected visits, and very high defined as >100% of expected visits.

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Table 4

Multivariable proportional hazards regression and logistic regressions for repeat pregnancy over 18 months, by home visiting participation level

	Adjusted hazard ratio[a], time to subsequent pregnancy (n=1,516)	**Adjusted odds ratio[b], subsequent preterm birth (n=498[c])**
Participation level		
Low (< 25% recommended visits)	Reference	Reference
Moderate (25–75% visits)	**0.68 (0.52, 0.87)**	1.07 (0.57, 2.02)
High (75–100% visits)	**0.55 (0.33, 0.92)**	0.58 (0.13, 2.71)
Very high (>100% visits)	1.36 (0.76, 2.43)	2.96 (0.75, 11.77)
Prior preterm birth	1.06 (0.76, 1.49)	**3.70 (1.89, 7.26)**
Interpregnancy interval ≤ 6 months	(not included)	**4.30 (2.21, 8.38)**

[a]Model includes adjustment for race, ethnicity, education level, insurance status, maternal age, breastfeeding status, marital status, hypertension, diabetes, obesity, smoking status during index pregnancy, sexually transmitted infection, delivery method, prenatal vs. postnatal enrollment status and year of index birth. Model is also adjusted for clustering by agency. Bolded values indicate p-values <0.05.

[b]Same covariates as above, with values updated to reflect status during second pregnancy.

[c]Sample reflects those with repeat pregnancy within 3 years of index birth. Bolded values indicate p-values <0.05.