Received: 26 October 2017 | Revised: 23 March 2018 | Accepted: 16 April 2018

DOI: 10.1111/mcn.12622

ORIGINAL ARTICLE

WILEY | Maternal & Child Nutrition

Prospective associations of breastfeeding and smoking cessation among low-income pregnant women

April L. Carswell[1] | Kenneth D. Ward[2] | Mark W. Vander Weg[3] | Isabel C. Scarinci[4] | Laura Girsch[2] | Mary Read[2] | George Relyea[2] | Weiyu Chen[2]

[1] ICF, Atlanta, Georgia, USA

[2] School of Public Health, University of Memphis, Memphis, Tennessee, USA

[3] Iowa City VA Health Care System, University of Iowa, Iowa City, Iowa, USA

[4] University of Alabama, Birmingham, Alabama, USA

Correspondence
Dr. Ken Ward, Division of Social and Behavioral Sciences, 3825 DeSoto Avenue, School of Public Health, University of Memphis, Memphis TN 38152, USA.
Email: kdward@memphis.edu

Funding information
The Urban Child Institute, Grant/Award Number: None

Abstract

Although low-income pregnant women have high rates of smoking and low rates of breastfeeding, few studies have examined prospective associations between these risk factors in community samples. Doing so may help improve breast-feeding support programs in this population. We used a secondary analysis of 247 low-income pregnant smokers in Memphis, Tennessee, who were interviewed up to 4 times (twice during pregnancy and twice through 6 months postpartum). Smoking cessation during prepartum and postpartum was defined as a self-report of not smoking for ≥1 week and an expired carbon monoxide level of <10 ppm. Multivariable logistic regression analyses were used to determine whether intent to breastfeed was associated with smoking cessation and whether smoking cessation was associated with actual breastfeeding. Models were adjusted for sociodemographic, pregnancy-related, and smoking-related confounders. Thirty-nine percent of participants intended to breastfeed, and 38% did so. Women who intended to breastfeed were 2 times more likely to quit smoking prepartum (adjusted OR = 1.99, 95% CI [1.06, 3.74]), but not postpartum (adjusted OR = 1.27, 95% CI [0.57, 2.84]). Quitting smoking at baseline and during pregnancy was associated with subsequent breastfeeding (adjusted OR 2.27, 95% CI [1.05, 4.94] and adjusted OR = 2.49, 95% CI [1.21, 5.11]). Low-income women who intended to breastfeed were more likely to quit smoking during pregnancy and those who quit smoking at baseline and prepartum were more likely to breastfeed. Simultaneously supporting breastfeeding and smoking cessation may be very useful to change these important health behaviours among this high-risk population.

KEYWORDS

breastfeeding, health promotion, low Income, pregnancy, prospective smoking

1 | INTRODUCTION

Despite the many health benefits of breastfeeding (Eidelman et al., 2012; Ip, Chung, Raman, Trikalinos, & Lau, 2009; Quigley, Kelly, & Sacker, 2007), rates in the United States continue to be below Healthy People 2020 goals. Failure to initiate breastfeeding and early discontinuation are associated with several maternal characteristics, including lower educational attainment and income (Kahn, Certain, & Whitaker, 2002; Lauria, Lamberti, & Grandolfo, 2012); younger age (Eidelman et al., 2012); and being African American compared with Caucasian (CDC, 2013; Eidelman et al., 2012; Li, Ogden, Ballew, Gillespie, & Grummer-Strawn, 2002). Breastfeeding initiation rates are lowest (roughly 30%) among women with all these risk factors—African American, impoverished women under 20 years of age (McDowell, Wang, & Kennedy-Stephenson, 2008). Other risk factors include having a greater number of children (Khoury, Moazzem, Jarjoura, Carothers, & Hinton, 2005; Lee et al., 2005); being unmarried (Lee et al., 2005); having inadequate social support (Khoury et al.,

2005; Lee et al., 2005; Mickens, Modeste, Montgomery, & Taylor, 2009); and experiencing prepartum depression (Fairlie, Gillman, & Rich-Edwards, 2009; Insaf et al., 2011).

Another important risk factor for failure to breastfeed is cigarette smoking. Several cross-sectional studies of low-income pregnant women indicate that smokers are less likely than nonsmokers to intend to breastfeed (Khoury et al., 2005; Lee et al., 2005; Ward, Vander Weg, Sell, Scarinci, & Read, 2006). Only 36% of new mothers who smoke initiate breastfeeding and less than 10% breastfeed for the recommended 6 months (Baxter, Cooklin, & Smith, 2009; Horta, Kramer, & Platt, 2001; Li et al., 2002).

Given the consistency of these cross-sectional findings, an important question is whether smoking and breastfeeding are linked prospectively. Documentation of prospective relationships (i.e., intent to breastfeed predicts subsequent cessation, or cessation during pregnancy predicts subsequent breastfeeding) would suggest that encouraging breastfeeding could help motivate pregnant women to quit smoking and new mothers to remain abstinent. Secondary analyses from several recent smoking cessation or relapse prevention trials for pregnant and postpartum women documented prospective associations between breastfeeding and smoking. Among pregnant women in their second and third trimester who were enrolled in a relapse prevention trial, those not intending to breastfeed were more likely to be smoking 1 month postpartum (Simmons, Sutton, Quinn, Meade, & Brandon, 2014). In another relapse prevention trial, women who were breastfeeding at 8 weeks postpartum were more likely to be abstinent from smoking at both 8 and 26 weeks postpartum (Kendzor et al., 2010). In a small (n = 31) uncontrolled prepartum smoking cessation intervention, a strong positive correlation was observed between days to relapse and duration of breastfeeding (r = 0.92). Although very large, the correlation was not statistically significant (p = .08) due to small sample size (DiSantis, Collins, & McCoy, 2010). Finally, a secondary analysis that combined data from three controlled trials of financial incentives to encourage smoking cessation among pregnant women examined whether smoking cessation was causally associated with breastfeeding (Higgins et al., 2010). Incentive-based treatment significantly increased duration of breastfeeding at 8 and 12 weeks postpartum, and these effects were mediated by changes in smoking status. Results were inconsistent, however, with no mediation effects observed earlier (2 and 4 weeks) or later (24 weeks) postpartum. Thus, based on trial data, it appears that breastfeeding is associated with improved cessation outcomes, and vice versa, quitting smoking increases the likelihood of breastfeeding. A limitation of these studies is that volunteers in cessation trials are highly selected and unlikely to be representative of the general population of pregnant and postpartum smokers.

Two prospective observational studies examined the association of breastfeeding and smoking cessation among community samples of pregnant women. In a study from Australia, 587 pregnant women recruited from two public maternity clinics were followed for 12 months (Giglia, Binns, & Alfonso, 2006). Women who quit smoking during pregnancy were significantly more likely than nonquitters to breastfeed for at least 6 months (OR = 3.70; 95% CI [1.55, 8.83]). Another study recruited 3,534 new mothers, within a few days of giving birth, from 25 local health units in Italy (Lauria et al., 2012). Among women who quit smoking during pregnancy, those who breastfed were less likely to relapse than women who did not breastfeed at 3 month (8.4% vs. 29.3%, respectively); 6 month (14.3% vs. 47.0%); and 12 month (19.6% vs. 35.2%) follow-ups.

Key messages

- Despite national focus in the United States on reducing maternal smoking and increasing breastfeeding, lower-income women continue to smoke at disproportionate rates and are less likely to breastfeed than higher income women.
- This prospective study indicates that intending to breastfeed increases the likelihood of quitting smoking during pregnancy, and vice versa, that quitting smoking during pregnancy increases the likelihood of breastfeeding.
- These results suggest that simultaneously supporting breastfeeding and smoking cessation may help motivate change in both of these important health behaviours among this high-risk population.

Because no prospective studies have examined the associations of breastfeeding and smoking cessation among community samples in the United States, we examined these associations in a cohort of 255 low-income smokers, recruited in a southern U.S. city (Memphis, Tennessee). Examining these associations in the Southern United States is particularly important because many southern states, including Tennessee, have a higher prevalence of smoking during pregnancy (Tong, Dietz, Farr, D'Angelo, & England, 2013) and a lower prevalence of breastfeeding (Control & Prevention, 2010) than states in other regions. We hypothesized that intent to breastfeed would be associated with smoking quit attempts both prepartum and postpartum; quitting smoking during pregnancy would be associated with initiation and duration of breastfeeding; and that these associations would be independent of potential confounders such as sociodemographic and pregnancy-related factors, and nicotine dependence.

2 | METHODS

2.1 | Sample

This study is a secondary analysis from a prospective cohort study of low-income pregnant women conducted from 2000 to 2002. Participants were recruited from the obstetrics service of an inner-city public hospital and Women, Infant, and Children (WIC) clinics in the greater Memphis, Tennessee, metropolitan area. To be eligible for the study, women had to (a) be currently pregnant, (b) report having smoked cigarettes regularly during the month prior to finding out they were pregnant, (c) plan to live in the Memphis area until the infant was at least 6 months old, and (d) be willing to participate in up to four interviews through 6 months postpartum.

A total of 382 women who were screened met eligibility criteria. Of those, 255 (66.8%) agreed to participate in the project. The other 127 women (33.2%) did not participate due to not responding to attempts to interview them (n = 121), moving out of the area (n = 4), or giving birth before the interview could be conducted (n = 2). For the current set of analyses, eight participants were excluded due to missing data on variables of interest, providing an analytic sample of 247.

The protocol and informed consent document were approved by the Institutional Review Boards of The University of Memphis and University of Tennessee Health Science Center. Baseline characteristics of the sample have been reported previously (Ward et al., 2006).

2.2 | Procedures

Patients were screened by clinic staff during scheduled appointments, as well as by survey interviewers who approached patients in clinic waiting rooms. Participants who met the inclusion criteria were given a description of the study. Women who agreed to participate provided written informed consent.

Questionnaires were administered in an interview format, to allow women with limited literacy skills to participate. The baseline interview (Interview 1) was conducted at the time the participant was recruited into the study; women were invited to participate regardless of gestational age to obtain a broad cross section of pregnancy-related experiences at baseline. Subsequent interviews were conducted at a clinic or WIC office visit occurring during the 24th–40th weeks of pregnancy (Interview 2), 1 to 3 months postpartum (Interview 3), and 4 to 6 months postpartum (Interview 4). If a participant completed Interview 1 during week 24 of pregnancy or later, Interview 2 was conducted at least 2 weeks after Interview 1. If a participant missed her scheduled clinic appointment, the interview was conducted during a rescheduled appointment or by telephone. Participants provided a breath sample to assess expired-air carbon monoxide (CO) level, using a Vitalograph Breath CO monitor (Vitalograph Inc., Lenexa, Kansas). The completion of these questionnaires and breath test took approximately 60 min. Subjects were financially compensated for their participation ($15 for Interviews 1, 2, and 3; $25 for Interview 4).

To improve the accuracy of self-report and minimize responding based on perceived social desirability, the research study was separated from the participant's medical care. For example, information collected was not shared with clinical staff or health care providers. Research assistants who conducted interviews were university employees rather than hospital/clinic employees and were carefully trained not to express any judgement or opinion about the participant's smoking status during the data collection process. We emphasized to participants that the goal was to better understand the factors that make it easier or more difficult for them to quit smoking, regardless of whether they quit or not.

2.3 | Measures

2.3.1 | Smoking status

We examined smoking status at three time periods: *baseline* (quit ≥1 week at Interview 1), *prepartum* (quit ≥1 week at either Interviews 1 or 2), and *postpartum* (quit ≥1 week at either Interviews 3 or 4). Being quit was defined as a self-report of not having smoked a cigarette for at least the past week, and an expired-air CO level of <10 ppm. One week abstinence, based on self-report and expired CO, was used as a conservative definition of cessation due to (a) limitations in biochemically verifying smoking status for extended time intervals (SRNT Subcommittee on Biochemical Verification, 2002); (b) the high rates of falsely reporting not smoking among pregnant women (Ford, Taqppin, Schluter, & Wild, 1997; Russell, Crawford, & Woodby, 2003; Windsor, Woodby, Miller, & Hardin, 2011); and (c) the fact that 47% of participants did not complete all four interviews, which would have caused excessive error in estimating prolonged abstinence based on the first two considerations.

2.3.2 | Breastfeeding

Intent to breastfeed was assessed at Interview 1 with the question, "Do you plan to breastfeed?" Response choices were "Yes," "No," and "Undecided." For the present analyses, participants who responded "No" or "Undecided" were classified as not intending to breastfeed. Participants who responded "Yes" were classified as intending to breastfeed. Initiation of breastfeeding was assessed at Interview 4 (4–6 months postpartum) with the question, "Have you breastfed your new baby at all?" Among women who initiated breastfeeding, we also queried whether the participant had breastfed recently ("Have you breastfeed your new baby during the last two weeks?") and the total duration of breastfeeding ("For approximately how many weeks total have/did you breastfeed your new baby?")

2.3.3 | Sociodemographic and pregnancy-related characteristics

Sociodemographic characteristics, assessed by self-report at Interview 1, included age, marital status, race, and education level. Primigravida status was coded as the current pregnancy being the first for which the woman would give birth versus having previously given birth, and number of weeks of pregnancy at the baseline interview was calculated as the number of weeks since the participant's last period.

2.3.4 | Smoking history and dependence

At Interview 1, participants self-reported their age when they started smoking regularly (at least one cigarette per day), total number of years as a regular smoker, the number of times before the current pregnancy when they quit smoking for at least 24 hr, and their prepregnancy smoking rate (number of cigarettes smoked per day). Dependence was measured using a modified version of the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991). The FTND is a widely used and well-validated six-item instrument that has adequate internal consistency and test–retest reliability, is significantly related to biochemical measures of smoking exposure (Heatherton et al., 1991), and predicts cessation (Aubin et al., 2004). The questionnaire was modified to reflect the 3-month period prior to when participants found out they were pregnant.

2.4 | Approach to statistical analysis

To test the association of intent to breastfeed with smoking cessation, we conducted multivariable logistic regression analyses, regressing

smoking status in three separate analyzes (quit vs. not quit at baseline, prepartum, or postpartum) on intent to breastfeed. For each outcome variable, two models were run: Model 1 was unadjusted for covariates, and Model 2 adjusted for several confounders, including education (≤12 years of education vs. > 12 years), race (White vs. non-White), number of weeks pregnant, and gravid status. We selected potential confounders based on established predictors of prenatal smoking and breastfeeding from the literature and compared odds ratios from logistic models with and without the variable. If the odds ratio changed by at least 10% when the variable was included, it was kept in adjusted models (Maldonado & Greenland, 1993). The final set of confounders included education, race, number of weeks pregnant at baseline, and gravid status. Because prenatal smoking and breastfeeding rates differ by race (Anstey, Chen, Elam-Evans, & Perrine, 2017; Curtin & Mathews, 2016), we evaluated whether race modified breastfeeding and smoking associations as a first step in our adjusted models. Interaction terms included race by breastfeeding intent, race by education, education by breastfeeding intent, and race by education by breastfeeding intent. Because none of these interactions were statistically significant (all p values > .16), they were excluded from final models.

We used a similar statistical approach to assess whether quitting smoking was associated with ever breastfeeding. In three separate analyses, we regressed whether the participant had breastfed (yes or no) on smoking status (quit vs. not quit at baseline, prepartum, or postpartum). Analyses were conducted both unadjusted and adjusted for the same set of confounders as in the previous models. As a first step in in the adjusted model, we also included four interaction terms: race by smoking status, race by education, education by smoking status, and race by education by smoking status. Because none of these interactions were statistically significant (all p values > .21), they were excluded from final models. Data were analysed using the SAS statistical software package windows version 9.4.

3 | RESULTS

3.1 | Sample characteristics

Of the 247 participants included in these analyses, 142 (57%) were Caucasian, 98 (40%) were African American, and 7 were "Other," including 1 Hispanic, 1 Asian, and 4 biracial/multiracial. At Interview 1, participants averaged 24 years of age (range 18 to 43 years), and on average were 19 weeks pregnant. Fifty-six percent of participants were single, 68% were unemployed, and 79% had 12 years of education or less. More than half of the participants (53%) reported an annual household income of $15,000 or below, and 95% reported an income of below $40,000/year. Of the 247 participants, 134 (53%) completed all four interviews, and 227 (89%) completed at least one prepartum and one postpartum interview. Failure to complete interviews in most other cases was due to participants not keeping scheduled appointments and not responding to telephone calls to reschedule them within the appropriate time window.

3.2 | Rates and Correlates of Intent to Breastfeed and Actual Breastfeeding

At baseline, 97 participants (39%) intended to breastfeed. As shown in Table 1, participants who intended to breastfeed were more likely to be Caucasian, have more than 12 years of education, and be primigravida. Breastfeeding intenders and nonintenders did not differ

TABLE 1 Correlates of intent to breastfeed at baseline (n = 247)

	Intend to breastfeed (n = 97)	Did not intend to breastfeed (n = 150)	p value
Sociodemographics			
Race (Caucasian)	67 (69%)	75 (50%)	.003
Age in years	23.7 (5.5)	24.4 (5.0)	.302
>12 years education	32 (33%)	20 (13%)	<.001
Total household income			
<$10,000	22 (23%)	57 (39%)	.034
$10,000–15,000	44 (45%)	52 (35%)	
>20,000	31 (32%)	39 (26%)	
Married or cohabitating	47 (48%)	61 (41%)	.228
Employed full-time	31 (31%)	49 (31%)	.987
Primigravida	38 (39%)	30 (20%)	<.001
Number of weeks pregnant	18.7 (8.4)	19.8 (8.8)	.362
Smoking history and dependence			
Age started smoking regularly	15.4 (3.4)	15.9 (3.6)	.291
Total years smoking at least one cigarette per day	7.4 (5.7)	7.9 (5.3)	.550
Quit attempts prior to current pregnancy	2.6 (4.9)	2.6 (8.6)	.993
Longest period without smoking prior to current pregnancy	120.5 (341.6)	80.9 (161.9)	.222
Prepregnancy smoking rate	20.0 (13.6)	17.5 (11.3)	.124
Expired-air CO level	10.1 (8.9)	10.9 (9.5)	.511
Fagerstrom test for nicotine dependence	4.4 (2.7)	4.5 (2.2)	.689

Note. Numbers are mean (SD) if not otherwise noted.

significantly on any of the smoking history and dependence variables, including age when regular smoking began, total years of regular smoking, prepregnancy smoking rate, number of prior quit attempts, and FTND score.

At the final postpartum follow-up (Interview 4), 38% of participants (79 of 210) reported having initiated breastfeeding their new baby. Intent to breastfeed was correlated with ever breastfeeding (r = .57; p = <.001). Seventy percent of participants who intended to breastfeed did so, compared with 14% who did not intend to breastfeed.

3.3 | Smoking cessation rates

At baseline (Interview 1), 48 (19%) of the sample were quit (i.e., a self-report of no smoking for at least the past 7 days and an expired CO of <10 ppm). Roughly 25% of participants (n = 61) were prepartum quitters (quit for at least 1 week at Interviews 1 and/or 2), and approximately 13% were postpartum quitters (quit for at least 1 week at postpartum Interviews 3 and/or 4). Only 5.4% of prepartum nonquitters were postpartum quitters, compared with 34.4% of prepartum quitters (p < .001). Quit rates at baseline, prepartum, and postpartum did not significantly differ by race (all p values > .19).

3.4 | Association of intent to breastfeed with subsequent smoking cessation

As shown in Table 2, women who intended to breastfeed had a two-fold increased odds of having quit smoking at the time of the baseline interview (unadjusted OR = 2.13, 95% CI [1.13, 4.03]). This association, however, was not statistically significant after adjusting for confounders (OR = 1.64; 95% CI [0.83, 3.24]). Women who intended to breastfeed had higher odds of quitting smoking during prepartum (unadjusted OR = 2.46; 95% CI [1.36, 4.43]), and this association remained statistically significant after adjusting for confounding variables (OR = 1.99; 95% CI [1.06, 3.74]). Because the association of intent to breastfed with baseline quit status is entirely cross-sectional (i.e., both intent to breastfeed and quit status were assessed at Interview 1), and the association of intent to breastfeed with prepartum quit status mixed cross-sectional and prospective associations (i.e., participants were quit at Interviews 1 and/or 2), we conducted an additional analysis that was entirely prospective to test this association. Restricting the analysis to participants who had not quit smoking at Interview 1, we examined whether intent to breastfeed was associated with having quit smoking at Interview 2. As in the previous analyses, the odds ratio was positive (2.56), but the association was not statistically significant (95% CI [0.76, 8.66], p = .131), which may reflect low statistical power to the small number of participants who smoked at Interview 1 but quit at Interview 2 (n = 13). Intent to breastfeed was not significantly associated with postpartum quitting in either unadjusted or adjusted models (p values > .27).

3.5 | Associations of smoking cessation with subsequent breastfeeding

As shown in Table 3, participants who had quit smoking by the time of the baseline interval, or who subsequently quit during either the prepartum or postpartum periods, were more likely to have initiated breastfeeding. In unadjusted models, the odds of ever breastfeeding ranged from 2.30 for women who quit during postpartum to 2.93 for those who quit at baseline, compared with women who did not quit smoking during the same time interval. The magnitudes of the baseline, prepartum, and postpartum associations were attenuated by adjustment for confounders, such that the baseline and prepartum associations decreased (OR 2.27, 95% CI [1.05, 4.94] and OR 2.49, 95% CI [1.21, 5.11], prospectively), and the postpartum association was no longer statistically significant (OR 2.01, 95% CI [0.84, 4.80]).

To determine whether quitting smoking was associated with duration of breastfeeding, we repeated the adjusted models in Table 3 for the 79 women who had initiated breastfeeding, assessing the association between quit status at baseline, prepartum, and postpartum with recent (past 2 weeks) breastfeeding in one set of models, and total

TABLE 2 Associations of intent to breastfeed with subsequent smoking cessation (n = 247)

Cessation interval	Quit (%)		Model 1			Model 2[a]		
	Intend to breastfeed	Does not intend to breastfeed	Odds ratio	95% CI	p value	Odds ratio	95% CI	p value
Baseline	26 (26.3)	22 (14.7)	2.13	1.13, 4.03	.020*	1.64	0.83, 3.24	.154
Prepartum	34 (35.1)	27 (18.0)	2.46	1.36, 4.43	.003*	1.99	1.06, 3.74	.033*
Postpartum	16 (15.5)	16 (10.7)	1.53	0.72, 3.26	.269	1.27	0.57, 2.85	.556

[a]Model adjusted for education, race, no. weeks pregnant and gravid status.

*Significant at p = .05.

TABLE 3 Associations of smoking cessation with subsequent breastfeeding (n = 210)

Cessation interval	Quit (%)		Model 1			Model 2[a]		
	Breastfed	Did not breastfeed	Odds ratio	95% CI	p value	Odds ratio	95% CI	p value
Baseline	24 (30.4)	17 (13.9)	2.93	1.45, 5.89	.003*	2.27	1.05, 4.94	.038*
Prepartum	30 (38.0)	23 (17.6)	2.88	1.52, 5.45	.001*	2.49	1.21, 5.11	.013*
Postpartum	16 (21.3)	13 (10.0)	2.30	1.04, 5.10	.039*	2.01	0.84, 4.80	.115

[a]Model adjusted for education, race, number of weeks pregnant, and gravid status.

*Significant at p = .05.

number of weeks of breastfeeding in a second set of models. Recent breastfeeding was not significantly associated with having quit smoking at either baseline or during prepartum, although trends were in the expected positive direction in this restricted dataset (OR = 2.14, 95% CI [0.63, 7.31] for baseline quitting, and OR = 2.75, 95% CI [0.81, 9.33] for prepartum quitting). Having breastfed in the past 2 weeks was associated with greater odds of quitting smoking during postpartum (OR = 4.15, 95% CI [1.14, 15.80]).

On average, the 79 women who breastfed did so for 8.5 weeks (*SD* = 6.3). Total number of weeks of breastfeeding was not significantly associated with either being quit at baseline (β = −1.38, *SE* = 1.60, *p* = .39) or prepartum (β = −0.28, *SE* = 1.57, *p* = .8574) but was associated with postpartum quitting. Participants who were quit for at least 1 week during postpartum breastfed an average of 3.7 weeks longer than women who did not quit during postpartum (β = 3.74, *SE* = 1.81, *p* = .0428).

3.6 | Additional analyses

The models in Tables 2 and 3 were rerun, substituting other indices of tobacco dependence (age when began smoking, total number of years smoking, prepregnancy number of cigarettes smoked each day, number of quit attempts prior to current pregnancy, expired-air CO level, and longest period without smoking prior to current pregnancy) for FTND. Each indicator was entered in a separate model (i.e., FTND was removed, and one indicator was entered) along with sociodemographic and pregnancy-related covariates, as indicated in Table 2. In none of the models did the smoking history or dependence variable appreciably affect the magnitude or direction of the association between intent to breastfeed and cessation at baseline, prepartum, or postpartum. Race did not modify the association of breastfeeding intent with subsequent quit status at baseline, prepartum, or postpartum (all *p* values for race interactions included in the adjusted models listed in Table 2 were >.219), or the associations of quit status at baseline, prepartum, or postpartum with ever breastfeeding (all *p* values for race interactions included in the adjusted models listed in Table 3 were >.512).

4 | DISCUSSION

To our knowledge, this is the first study in the United States to prospectively examine the associations between breastfeeding and smoking cessation in a community-recruited sample. We focused on low-income women, who are at especially high risk of smoking during pregnancy and not breastfeeding (CDC, 2013; Eidelman et al., 2012; Li et al., 2002). Women who intended to breastfeed were more likely to quit smoking during pregnancy compared with those who did not intend to breastfeed. Similarly, women who quit smoking during pregnancy were more likely to initiate breastfeeding. Among women who initiated breastfeeding, quitting smoking during postpartum was positively associated with both recent (last 2 weeks) breastfeeding and the total number of weeks of breastfeeding. Our findings support previous prospective findings in clinical trials and non-U.S. community samples (DiSantis et al., 2010; Higgins et al., 2010; Kendzor et al., 2010; Lauria et al., 2012; Simmons et al., 2014), indicating important relationships between smoking and breastfeeding—two major causes of perinatal complications among low-income women.

Only 39% of women in our study intended to breastfeed, and 38% actually initiated breastfeeding. These rates are very low, but consistent with other data collected around the same time period (2000–2002). For example, only 53% and 50% of low-income pregnant women in Philadelphia (Lee et al., 2005) and Mississippi (Mitra, Khoury, Hinton, & Carothers, 2004), respectively, reported intending to breastfeed. Likewise, only 40% of African American pregnant women in the United States initiated breastfeeding in 2001 (Li, Zhao, Mokdad, Barker, & Grummer-Strawn, 2003). Although breastfeeding rates have improved over time, current rates of initiating breastfeeding are still much too low. For example, the Healthy People 2020 goal for initiation of breastfeeding is 81.9% (CDC, 2018), but in Tennessee, where our study was conducted, rates from 2011 to 2015 were 70.7% for White women and 55.5% for Black women (Anstey et al., 2017).

The current study demonstrates that associations of breastfeeding and smoking cessation are largely independent of confounding from sociodemographic, pregnancy-related, and smoking-related characteristics. It is important to note, however, that statistically significant associations do not necessarily imply causation, and the mechanisms for these associations remain unknown. Both physiological and motivational factors may be involved. The findings that postpartum quitting was more highly associated than prepartum quitting with recent breastfeeding and duration of breastfeeding suggest that smoking may reduce breast milk production, or affect infants' response to breastfeeding (Napierala, Mazela, Merritt, & Florek, 2016), which would reduce the likelihood of maintaining smoking abstinence. Additional longitudinal studies are needed that evaluate whether quitting and relapse are associated with women's experiences breastfeeding.

Another potential mechanism, related to motivational factors, is women's perceptions that breastfeeding while smoking is harmful to their babies. It has been suggested that young, uneducated mothers who smoke, believing that they should not smoke while breastfeeding, may make the "easier" choice not to breastfeed instead of quitting smoking (Dorea, 2007). A few qualitative studies of pregnant women support this notion, finding that an important disincentive to breastfeed is worry about exposing their children to smoke toxicants (Alexander, Dowling, & Furman, 2010; Goldade et al., 2008; Kaufman, Deenadayalan, & Karpati, 2010). For example, Kaufman et al. (2010) found that low-income pregnant women commonly believed that breastfeeding had the potential to be "dangerous" to infants, especially because of their own poor health practices (i.e., drinking, smoking, and poor eating habits) and thus viewed breast milk as an "unreliable substance" in comparison with infant formula. Thus, an "all or nothing" mindset may result, where the woman will either quit smoking and breastfed, or do neither. The findings that intent to breastfeed is more strongly related to prepartum quitting than postpartum quitting is consistent with pregnant women who want to breastfeed being highly motivated to quit initially, which wanes over time.

Unfortunately, the decision to forego breastfeeding to avoid ingestion of tobacco toxicants is not in the best health interests of the baby. Reproductive experts agree that although smoking during pregnancy is not ideal, it is worse to smoke and not breastfeed (Dorea, 2007; Myr, 2004; Yilmaz, Çaylan, & Karacan, 2013). Dorea (2007)

recommends that "… if public health policies cannot stop addicted mothers from smoking during pregnancy it is fundamental not to miss the chance of encouraging and supporting breastfeeding."

Given the limited success of smoking cessation interventions for pregnant women (Yilmaz et al., 2013), a worthwhile strategy, consistent with recommendations in the literature (Lauria et al., 2012; Yilmaz et al., 2013), is to integrate smoking cessation messaging into breastfeeding support programs, both prepartum and postpartum, while simultaneously encouraging women to breastfeed regardless of whether, or how much, they reduce their smoking (Dorea, 2007; Myr, 2004).

Some important limitations of this study should be noted. First, our sample size was relatively small (n = 247), restricted to low-income women, and recruited from a single city, so results may not generalize to the broader population of pregnant smokers in the United States. Second, our study was a secondary analysis of data collected between 2000 and 2002. Whereas rates of breastfeeding have increased, and rates of smoking have decreased in the United States since then, we are not aware of any evidence that the direction or magnitude of associations between these two risk factors have changed in the interim. In fact, our associations are similar to those collected more recently in several other studies (Giglia et al., 2006; Higgins et al., 2010; Kendzor et al., 2010; Lauria et al., 2012; Simmons et al., 2014). Third, although our findings were independent of race, the small sample size limited our power to detect potentially important race differences in the studied associations. Fourth, because of the limited sample size, imperfect retention, and heterogeneity in smoking status of the cohort over time, we were not able to examine the influence of intent to breastfeed on long-term cessation or relapse patterns. Although being quit for 1 week does not guarantee long-term cessation, it does indicate a serious quit attempt, and more than half of quit attempts fail within the first week (Powell, Dawkins, West, Powell, & Pickering, 2010; Ward, Klesges, Zbikowski, Bliss, & Garvey, 1997). Advantages of using a relatively short quit interval is that it is less reliant on memory of remote quit/relapse events and can be more accurately validated biochemically; this is important in studies of pregnant smokers because falsely reporting being quit is very common (Ford et al., 1997; Russell et al., 2003; Windsor et al., 2011). Future studies should prospectively examine smoking cessation in larger community samples across the United States to have adequate numbers to examine long-term quit patterns. A final limitation is that our study was not designed to evaluate potential mechanisms of smoking/breastfeeding associations. Further work is needed to tease apart motivational, physiological, and other potentially important mechanisms linking smoking cessation to breastfeeding.

In conclusion, among low-income women in the Southern United States, intent to breastfeed predicted quitting smoking during pregnancy and quitting smoking postpartum predicted breastfeeding. These associations were independent of sociodemographic, pregnancy-related, and smoking-related characteristics. These findings suggest that it may be useful to embed smoking cessation efforts into breastfeeding support programs, to improve pregnant women's knowledge of the relative risks and benefits of smoking versus breastfeeding, and to increase motivation to breastfeed by dissociating the decisions to breastfeed and quit smoking.

ACKNOWLEDGMENTS

We thank the women who participated in this study, and the staff of the Department of Obstetrics and Gynecology at Regional One Health and the Shelby County Health Department WIC program.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

CONTRIBUTIONS

ALC analyzed data, wrote the first draft of the manuscript, and revised subsequent drafts. KDW conceptualized the study, obtained funding, and provided input on analysis and interpretation of the data. MWV and ICS helped obtain funding and collect data. LG, GR, and WC assisted in data analysis and interpretation. MR oversaw data collection. All authors provided critical feedback on the manuscript.

ORCID

Kenneth D. Ward http://orcid.org/0000-0001-8972-538X

REFERENCES

Alexander, A., Dowling, D., & Furman, L. (2010). What do pregnant low-income women say about breastfeeding? *Breastfeeding Medicine*, *5*(1), 17–23. https://doi.org/10.1089/bfm.2009.0034

Anstey, E. H., Chen, J., Elam-Evans, L. D., & Perrine, C. G. (2017). Racial and geographic differences in breatfeeding—United States, 2011–2015. *Morbidity and Mortality Weekly Report*, *66*, 723–727.

Aubin, H. J., Lebargy, F., Berlin, I., Bidaut-Mazel, C., Chemali-Hudry, J., & Lagrue, G. (2004). Efficacy of bupropion and predictors of successful outcome in a sample of French smokers: a randomized placebo-controlled trial. *Addiction*, *99*(9), 1206–1218. https://doi.org/10.1111/j.1360-0443.2004.00814.x

Baxter, J., Cooklin, A. R., & Smith, J. (2009). Which mothers wean their babies prematurely from full breastfeeding? An Australian cohort study. *Acta Paediatrica*, *98*(8), 1274–1277. https://doi.org/10.1111/j.1651-2227.2009.01335.x

Centers for Disease Control and Prevention (2010). Racial and ethnic differences in breastfeeding initiation and duration, by state-National Immunization Survey, United States, 2004–2008. *MMWR. Morbidity and Mortality Weekly Report*, *59*(11), 327.

Centers for Disease Control and Prevention (2013). Progress in increasing breastfeeding and reducing racial/ethnic differences—United States, 2000–2008 births. *MMWR. Morbidity and Mortality Weekly Report*, *62*(5), 77.

Centers for Disease Control and Prevention. (2018). Office of Disease Prevention and Health Promotion. HealthyPeople.gov-Maternal, Infant, and Child Health. Retrieved from https://www.healthypeople.gov/2020/topics-objectives/topic/maternal-infant-and-child-health/objectives

Curtin, S. C., & Mathews, T. J. (2016). Smoking prevalence and cessateion before and during pregnancy: Data from the birth certificate, 2014. *Naetional Vital Statistics Reports*, *65*, 1–13.

DiSantis, K. I., Collins, B. N., & McCoy, A. C. (2010). Associations among breastfeeding, smoking relapse, and prenatal factors in a brief postpartum smoking intervention. *Acta Obstetricia et Gynecologica Scandinavica*, *89*(4), 582–586. https://doi.org/10.3109/00016341003678435

Dorea, J. G. (2007). Maternal smoking and infant feeding: Breastfeeding is better and safer. *Maternal and Child Health Journal*, *11*(3), 287–291. https://doi.org/10.1007/s10995-006-0172-1

Eidelman, A. I., Schanler, R. J., Johnston, M., Landers, S., Noble, L., Szucs, K., & Viehmann, L. (2012). Breastfeeding and the use of human milk. *Pediatrics*, *129*(3), e827–e841.

Fairlie, T. G., Gillman, M. W., & Rich-Edwards, J. (2009). High pregnancy-related anxiety and prenatal depressive symptoms as predictors of intention to breastfeed and breastfeeding initiation. *Journal of Women's Health*, *18*(7), 945–953.

Ford, R. P., Taqppin, D. M., Schluter, P. J., & Wild, C. J. (1997). Smoking during pregnancy: How reliable are maternal self reports in New Zealand? [electronic version]. *Journal of Epidemiology & Community Health*, *51*(3), 246–251.

Giglia, R., Binns, C. W., & Alfonso, H. (2006). Maternal cigarette smoking and breastfeeding duration. *Acta Paediatrica*, *95*(11), 1370–1374. https://doi.org/10.1080/08035250600771474

Goldade, K., Nichter, M., Nichter, M., Adrian, S., Tesler, L., & Muramoto, M. (2008). Breastfeeding and smoking among low-income women: Results of a longitudinal qualitative study. *Birth*, *35*(3), 230–240. https://doi.org/10.1111/j.1523-536X.2008.00244.x

Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., & Fagerstrom, K. O. (1991). The Fagerstrom test for nicotine dependence: A revision of the Fagerstrom tolerance questionnaire. *British Journal of Addiction*, *86*(9), 1119–1127.

Higgins, T. M., Higgins, S. T., Heil, S. H., Badger, G. J., Skelly, J. M., Bernstein, I. M., … Preston, A. M. (2010). Effects of cigarette smoking cessation on breastfeeding duration. *Nicotine & Tobacco Research*, *12*(5), 483–488. https://doi.org/10.1093/ntr/ntq031

Horta, B. L., Kramer, M. S., & Platt, R. W. (2001). Maternal smoking and the risk of early weaning: A meta-analysis. *American Journal of Public Health*, *91*(2), 304–307.

Insaf, T. Z., Fortner, R. T., Pekow, P., Dole, N., Markenson, G., & Chasan-Taber, L. (2011). Prenatal stress, anxiety, and depressive symptoms as predictors of intention to breastfeed among Hispanic women. *Journal of Women's Health*, *20*(8), 1183–1192.

Ip, S., Chung, M., Raman, G., Trikalinos, T. A., & Lau, J. (2009). A summary of the Agency for Healthcare Research and Quality's evidence report on breastfeeding in developed countries. *Breastfeeding Medicine*, *4*(S1), S–17-S-30.

Kahn, R. S., Certain, L., & Whitaker, R. C. (2002). A reexamination of smoking before, during, and after pregnancy. *American Journal of Public Health*, *92*(11), 1801–1808.

Kaufman, L., Deenadayalan, S., & Karpati, A. (2010). Breastfeeding ambivalence among low-income African American and Puerto Rican women in North and Central Brooklyn. *Maternal and Child Health Journal*, *14*, 696–704.

Kendzor, D. E., Businelle, M. S., Costello, T. J., Castro, Y., Reitzel, L. R., Vidrine, J. I., … Wetter, D. W. (2010). Breast feeding is associated with postpartum smoking abstinence among women who quit smoking due to pregnancy. *Nicotine & Tobacco Research*, *12*(10), 983–988. https://doi.org/10.1093/ntr/ntq132

Khoury, A. J., Moazzem, S. W., Jarjoura, C. M., Carothers, C., & Hinton, A. (2005). Breast-feeding initiation in low-income women: Role of attitudes, support, and perceived control. *Women's Health Issues*, *15*(2), 64–72.

Lauria, L., Lamberti, A., & Grandolfo, M. (2012). Smoking behaviour before, during, and after pregnancy: The effect of breastfeeding. *The Scientific World Journal*, *2012*, 1–9.

Lee, H. J., Rubio, M. R., Elo, I. T., McCollum, K. F., Chung, E. K., & Culhane, J. F. (2005). Factors associated with intention to breastfeed among low-income, inner-city pregnant women. *Maternal and Child Health Journal*, *9*(3), 253–261.

Li, R., Ogden, C., Ballew, C., Gillespie, C., & Grummer-Strawn, L. (2002). Prevalence of exclusive breastfeeding among US infants: The Third National Health and Nutrition Examination Survey (Phase II, 1991-1994). *American Journal of Public Health*, *92*(7), 1107–1110.

Li, R., Zhao, Z., Mokdad, A., Barker, L., & Grummer-Strawn, L. (2003). Prevalence of breastfeeding in the United States: The 2001 National Immunization Survey. *Pediatrics*, *111*, 1198–1201.

Maldonado, G., & Greenland, S. (1993). Simulation study of confounder-selection strategies. *American Journal of Epidemiology*, *138*(11), 923–936.

McDowell, M. M., Wang, C.-Y., & Kennedy-Stephenson, J. (2008). *Breastfeeding in the United States: Findings from the national health and nutrition examination surveys, 1999–2006*. US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics NewYork.

Mickens, A. D., Modeste, N., Montgomery, S., & Taylor, M. (2009). Peer support and breastfeeding intentions among black WIC participants. *Journal of Human Lactation*, *25*(2), 157–162.

Mitra, A. K., Khoury, A. J., Hinton, A. W., & Carothers, C. (2004). Predictors of breastfeeding intention among low-income women. *Maternal and Child Health*, *8*(2), 65–70.

Myr, R. (2004). Promoting, protecting, and supporting breastfeeding in a community with a high rate of tobacco use. *Journal of Human Lactation*, *20*(4), 415–416. https://doi.org/10.1177/0890334404269906

Napierala, M., Mazela, J., Merritt, T. A., & Florek, E. (2016). Tobacco smoking and breastfeeding: Effect on the lactation process, breast milk composition and infant development. A critical review. *Environmental Research*, *151*(2016), 321–338. https://doi.org/10.1016/j.envres.2016.08.002

Powell, J., Dawkins, L., West, R., Powell, J., & Pickering, A. (2010). Relapse to smoking during unaided cessation: Clinical, cognitive and motivational predictors. *Psychopharmacology*, *212*(4), 537–549.

Quigley, M. A., Kelly, Y. J., & Sacker, A. (2007). Breastfeeding and hospitalization for diarrheal and respiratory infection in the United Kingdom Millennium Cohort Study. *Pediatrics*, *119*(4), e837–e842.

Russell, T. V., Crawford, M. A., & Woodby, L. L. (2003). Measurements for active cigarette smoke exposure in prevalence and cessation studies: Why simply asking pregnant women isn't enough. *Nicotine & Tobacco Research*, *6*(2), S141–S151. https://doi.org/10.1080/14622200410001669141

Simmons, V. N., Sutton, S. K., Quinn, G. P., Meade, C. D., & Brandon, T. H. (2014). Prepartum and postpartum predictors of smoking. *Nicotine & Tobacco Research*, *16*(4), 461–468. https://doi.org/10.1093/ntr/ntt177

Tong, V. T., Dietz, P. M., Farr, S. L., D'Angelo, D. V., & England, L. J. (2013). Estimates of smoking before and during pregnancy, and smoking cessation during pregnancy: Comparing two population-based data sources. *Public Health Reports*, *128*(3), 179–188.

Ward, K. D., Klesges, R. C., Zbikowski, S. M., Bliss, R. E., & Garvey, A. J. (1997). Gender differences in the outcome of an unaided smoking cessation attempt. *Addictive Behaviors*, *22*(4), 521–533.

Ward, K. D., Vander Weg, M. W., Sell, M. A., Scarinci, I. C., & Read, M. C. (2006). Characteristics and correlates of quitting among black and white low-income pregnant smokers. *American Journal of Health Behavior*, *30*(6), 651–662.

Windsor, R., Woodby, L., Miller, T., & Hardin, M. (2011). Effectiveness of smoking cessation and reduction in pregnancy treatment (SCRIPT) methods in Medicaid supported prenatal care: SCRIPT Trial III. *Health Education & Behavior*, *38*(4), 412–422. https://doi.org/10.1177/1090198110382503

Yilmaz, G., Çaylan, N. D., & Karacan, C. (2013). Smoking Mothers and Breastfeeding. In *Nutrition in infancy* (pp. 289–305). Springer.

How to cite this article: Carswell AL, Ward KD, Vander Weg MW, et al. Prospective associations of breastfeeding and smoking cessation among low-income pregnant women. *Matern Child Nutr*. 2018;14:e12622. https://doi.org/10.1111/mcn.12622