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Trajectories of Breastfeeding-Related Thoughts and Attitudes Among Low-Income Smoke-Exposed Pregnant Women: A Latent Class Growth Analysis

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Abstract

Background: Psychosocial predictors of breastfeeding and changes in those factors during pregnancy, along with the relationship of those changes with both breastfeeding and smoke use and exposure, are not well explored.

Research Aim: The aim of this study was to identify distinct trajectories of psychosocial determinants of breastfeeding and smoking in pregnant women.

Methods: We used a longitudinal study design and data from a randomized controlled trial conducted among smoke-exposed pregnant women and their infants. Participants were recruited early in pregnancy and were surveyed at ≤ 16 and 32 weeks gestation, delivery, 3 and 6 months postpartum for breastfeeding intentions, initiation, continuation, and smoke use and exposure. Psychosocial variables associated with breastfeeding were measured at baseline and 32 weeks gestation using the Mitra index, a structured questionnaire that assesses barriers and facilitators of breastfeeding intentions. Latent class growth analysis was performed using Mitra scores to identify distinct subgroups of participants with different trajectories. Sociodemographic characteristics, breastfeeding, and tobacco smoke use and exposure were compared across classes.

Results: Three or four trajectories were identified for each of the six Mitra scores. Trajectories for all Mitra scores were associated with breastfeeding intention and initiation. Overall, Mitra, knowledge, self-efficacy, social support, and time barrier classes all differed by tobacco smoke use or exposure.

Conclusion: Trajectories of breastfeeding knowledge, self-efficacy, social support, and time to breastfeed/social barriers are associated with tobacco smoke use and exposure during pregnancy. Encouragement to breastfeed and to cease and avoid tobacco smoke should start early in pregnancy, focusing on these determinants to improve health outcomes.

Keywords

breastfeeding, breastfeeding promotion, lactation, Latent Class Growth Modeling, psychosocial determinants, smoking cessation

Background

Breastfeeding, the healthiest form of infant feeding, is a protective factor against child and adult cardiovascular diseases and cancers (Meek & Noble, 2022). Infant feeding decisions may be made early in pregnancy. Still, many women are unsure about their choice until late in the third trimester and even change their decision before delivery (Risica & McCausland, 2017). Previous studies have identified various sociodemographic factors that influence breastfeeding initiation and duration. For instance, past research has shown that younger mothers are less likely to initiate and maintain exclusive breastfeeding (Asimaki et al., 2022). Additionally, while non-Hispanic Black and American Indian/Alaska Native people are the least likely racial groups to initiate breastfeeding, it has been shown that non-Hispanic Black and Hispanic/Latino adults are less likely to breastfeed beyond 6 months postpartum (Quintero et al., 2023).

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Additional factors influencing breastfeeding decisions include maternal education and income level (Tang et al., 2019).

Aside from demographics, breastfeeding intention and initiation are also associated with many psychosocial factors, including knowledge, self-efficacy, thoughts and attitudes, and social and institutional support (Barbosa et al., 2017; Johnson et al., 2015; Oniwon et al., 2016; Park et al., 2018; Schindler-Ruwisch et al., 2019; Thomas et al., 2017). Tobacco smokers, recent quitters, and environmental tobacco smoke (ETS)-exposed pregnant people are also less likely to intend to (Lee et al., 2005; McLnnes et al., 2001) and initiate breastfeeding (Drehmer et al., 2020; Schindler-Ruwisch et al., 2021). Developed and validated in a sample of low-income pregnant women, the Mitra index is a structured questionnaire that assesses psychosocial facilitators and barriers of breastfeeding intentions (Mitra et al., 2004). Using the Mitra index, research from our group has previously shown that smoke-exposed women are more likely to consider or initiate breastfeeding with an increase in self-efficacy, social support, and improvement in time to breastfeed and social barriers (Risica & McCausland, 2017). It has not yet been examined, however, whether pregnant individuals experience heterogeneous patterns of change in psychosocial determinants of breastfeeding and smoking. Understanding how these determinants change during pregnancy among specific subgroups can help providers tailor and adapt breastfeeding education and smoking cessation efforts throughout pregnancy.

Latent class growth analysis is a modeling technique that identifies heterogeneous trajectories in a given sample by grouping individuals with similar patterns of change over time into meaningful clusters that can be used in future analyses (Nagin & Odgers, 2010). With this modeling technique, latent subgroups can be identified that may respond differently to intervention strategies based on a specific pattern of change, which can inform the development of tailored, optimized interventions. Therefore, the aim of this study was to identify distinct trajectories of psychosocial determinants of breastfeeding and smoking in pregnant women.

Key Messages

- Infant feeding decisions are associated with many psychosocial factors. The relationship between change in breastfeeding-related psychosocial factors and breastfeeding intention and behaviors and tobacco smoke use and exposure, however, is not well studied.
- Trajectories of breastfeeding knowledge, self-efficacy, social support, and time/social barriers are associated with tobacco smoke use and exposure during pregnancy.
- Encouragement of breastfeeding and tobacco smoke cessation and avoidance should start early in pregnancy focusing on these determinants to improve health outcomes.

Methods

Research Design

This study used a longitudinal design. The rationale for the longitudinal design was that we were interested in changes in psychosocial determinants of breastfeeding intentions and behaviors. Institutional review boards at Brown University and the recruitment sites approved this study.

Setting and Relevant Context

This study was conducted with data collected for a randomized controlled trial of Baby's Breath, an intervention aimed at reducing smoking and ETS exposure among low-income women in Rhode Island (RI) during and after pregnancy (Risica & McCausland, 2017). National estimates have shown that, between 2016 and 2019, among adults with an annual household income of less than $20,000, 22.5% reported never breastfeeding (Diaz et al., 2023). There is also evidence of a considerable decrease in the percentage of pregnant women in RI who smoked during pregnancy between 2016 and 2021 (7.4% vs. 3.4%; Martin et al., 2023). A report published by the United States Breastfeeding Committee (USBC) in 2023 estimated that rates of breastfeeding initiation among RI women were 67.7% (a decrease from 73.7% in 2012), and rates of infants receiving formula before 2 days of age were estimated to be 23.2% (compared to 25.6% in 2012). These have not changed considerably, highlighting the applicability and relevance of results from the present study (U.S. Centers for Disease Control and Prevention [CDC], 2012; U.S. Breastfeeding Committee, 2023). Breastfeeding is well supported in Rhode Island, which is home to four Baby-Friendly hospitals, including the large hospital that was the site of delivery for most participants in the Baby's Breath study. Breastfeeding support providers are available in all counties, supported by most insurance plans, and the state provides a 24-hour breastfeeding support warm line.

Sample

This study is a secondary analysis of data collected as part of a larger randomized controlled trial—Baby's Breath—a health education intervention that aimed to reduce smoking and environmental tobacco smoke (ETS) exposure among women during and after pregnancy (Risica & McCausland, 2017; Risica et al., 2018). While the intervention group received messages focused on smoking cessation and avoidance of ETS, both study groups received the same minimal

messages regarding infant feeding and breastfeeding behaviors. The study recruited participants who were no later than 16 weeks' gestation with a singleton, were English speaking, 18 years or older, and either current tobacco smokers, recently quit, or were exposed to ETS from someone else in their household. The present analytic sample includes 399 women who had complete data for all variables at baseline (Risica & McCausland, 2017). The current study differs from the primary analysis that focused on changes in breastfeeding intention during pregnancy and breastfeeding initiation as an outcome. This secondary data analysis focuses on changes in a set of psychosocial predictors and their association with smoking and breastfeeding. The present study is sufficiently powered to identify the appropriate number of classes accurately and to detect differences in our outcomes of interest (Sinha et al., 2021).

Measures

The demographic characteristics assessed at baseline, using a structured questionnaire, included age (< 21 years, 21–25 years, and > 25 years old), annual household income (< $10,000/year, $10–30,000, > $30,000/year), education (< high school, high school, some college), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic or other races), nativity (U.S.-born or otherwise), native language (English or other languages), employment status (employed vs. unemployed), parity (primiparous or multiparous), marital status (married or not).

The Mitra Index, which contains 18 items, was used to assess breastfeeding knowledge, attitudes, self-efficacy, and barriers at baseline and 32 weeks' gestation (Khoury et al., 2005; Mitra et al., 2004). Responses ranged from "*agree a lot*" to "*disagree a lot.*" We assigned numerical values ranging from −2 to +2, which were then averaged to create an overall score where higher values represent more favorable breastfeeding-related responses. Five subscales identified by the original author[4] were created and labeled as: "Time and Social barriers," "Social Support," "Embarrassment barriers," "Self-efficacy," and "Knowledge." This tool had a Cronbach's alpha of 0.76 for the scale (Mitra et al., 2004) in the original study, and an average Cronbach's alpha of 0.69 in our study.

Breastfeeding intention was assessed at baseline and 32 weeks' gestation. Response categories included "exclusive breastfeeding," "breastfeeding and formula in combination," "exclusive formula," and "undecided." We created a dichotomous breastfeeding intention variable with response categories considering breastfeeding (including those who planned to exclusively breastfeed, breastfeed, and formula-feed, and were undecided) and not considering breastfeeding (i.e., those who planned to exclusively formula-feed).

Breastfeeding initiation was assessed after delivery, defined as women who breastfed for at least 1 day and initiated formula or another type of supplementation later. Women were asked, "Which of the following best describes how you are currently feeding your baby?" with response options of breast-feeding only," "breast-feeding and formula," and "formula only." For formula-feeding participants, the following question was asked, "Did you ever breastfeed the baby?" with response options of "Yes" and "No," and "For how long?" with an open-ended response option. We also asked all participants who were not exclusively breastfeeding at the time of the survey, "How old was your baby when you started feeding formula or other food?" with an open-ended response option. Those who never attempted to breastfeed or breastfed for less than 1 day and initiated formula or other food supplementation were classified as "exclusive formula-feeding."

Participants self-reported their tobacco smoke status at baseline and 32 weeks' gestation. Smokers currently smoke cigarettes or had smoked a cigarette in the last 7 days. Quitters had smoked over 100 cigarettes in their lifetime, did not currently smoke cigarettes, and had stopped smoking during pregnancy or less than 3 months before pregnancy, and planned to continue cigarette cessation after delivery. Pausers reported the same as quitters but planned to smoke again after delivery. ETS-exposed participants did not currently smoke cigarettes and had not smoked over 100 cigarettes ever, but were exposed to someone else's tobacco smoke on a daily basis (Risica et al., 2018).

Data Collection

Recruitment occurred between February of 2006 to June of 2009, and the final 6-month evaluation occurred in June of 2010. Surveys were conducted at baseline (< 16 weeks) and 32 weeks gestation, after delivery, and 3 and 6 months postpartum, using computer-assisted telephone interviews. As part of recruitment, research staff obtained oral consent from participants during the baseline telephone interview.

Data Analysis

Characteristics of participants at baseline were examined using frequency procedures in SPSS (Version 29.0.1.0). We performed latent class growth analysis (LCGA) to identify distinct subgroups of participants with different trajectories in the overall Mitra score and each of the five subscales (Jung & Wickrama, 2008; Nylund et al., 2007). For each subscale, model fit was assessed through a combination of fit indices: (a) the lowest Akaike information criterion (AIC; Akaike, 1974); (b) the lowest Bayesian information criterion (BIC; Schwartz, 1978); (c) the lowest Vuong–Lo–Mendell–Rubin likelihood ratio test (VLMR); (d) Lo–Mendell–Rubin Adjusted (LMRA); and (e) entropy to be 0.70 or greater (see Table 1 for fit indices).

We assessed relationships of class membership with sociodemographic characteristics (e.g., age, race, marital status, income, parity), breastfeeding, and smoking behaviors using the Bolck, Croon, and Hagenaars (BCH) approach

Table 1. Fit Indices for Latent Class Growth Solutions Across the Overall Mitra Scale and Sub-Scores.

Breastfeeding attitudes	Class	AIC	BIC	Entropy	VLMR	*p*	LMRA	*p*
Mitra Index	2	1319.37	1347.30	0.77	−777.15	< 0.001	235.80	< 0.001
	3[a]	1272.99	1312.88	0.72	−652.69	0.0032	49.62	0.0042
	4 (did not converge)	—	—	—	—		—	
Knowledge	2	1825.63	1853.55	0.64	−979.03	< 0.001	138.71	< 0.001
	3	1779.50	1819.39	0.80	−905.82	0.030	49.38	0.035
	4[a]	1750.49	1802.34	0.86	−879.75	0.0023	33.17	0.0030
	5 (did not converge)	—	—	—	—		—	
Self-Efficacy	2	2097.62	2125.55	0.79	−1152.32	< 0.001	209.37	< 0.001
	3	2038.69	2078.58	0.85	−1041.81	< 0.001	61.51	0.0011
	4[a]	1986.47	2038.33	0.91	−1009.34	< 0.001	55.15	< 0.001
	5 (did not converge)	—	—	—	—		—	
Time	2	1781.43	1809.36	0.75	−967.76	< 0.001	159.23	< 0.001
	3[a]	1751.19	1791.08	0.73	−883.72	0.031	34.33	0.036
	4	—	—	—	—		—	
Support	2	1904.01	1931.94	0.69	−1014.61	0.0011	131.86	0.0015
	3	1851.29	1891.18	0.82	−945.01	0.0093	55.62	0.011
	4a	1810.77	1862.63	0.86	−915.65	0.150	44.07	0.160
Embarrassment	2	2308.55	2336.48	0.72	−1239.32	< 0.001	174.38	< 0.001
	3[a]	2275.17	2315.06	0.76	−1147.28	<0.001	37.31	0.0011
	4 (did not converge)	—	—	—	—		—	

Note. AIC = Akaike information criterion; BIC = Bayesian information criterion; VLMR = Vuong–Lo–Mendell–Rubin likelihood ratio test; LMR = Lo-Mendell-Rubin Adjusted.
[a]Selected model based on fit indices.

(Bakk et al., 2013) for continuous variables, and the DCAT approach for categorical variables (Lanza, 2013). All analyses were conducted in Mplus (Version 8.1; Muthén & Muthén, 2017).

Results

Characteristics of the Sample

The sample included a diverse group of women, two-thirds of whom ($n = 263$) were 25 years or younger (Table 1). A considerable proportion of participants self-identified as non-Hispanic White ($n = 160$, 40%), and most of the sample ($n = 294$, 73%) reported an annual household income of $30,000 USD or less. A significant proportion of participants reported initiating breastfeeding after hospital discharge ($n = 209$, 52%) but, by 6 months postpartum, only 8% ($n = 33$) of participants reported any type of breastfeeding. At 16 weeks gestation, 38% ($n = 152$) of the participants were smoking, 5% ($n = 22$) had recently quit, 18% ($n = 70$) paused during pregnancy, and 39% ($n = 154$) were ETS-exposed non-smokers (Table 2).

Composition of Classes for the Overall Mitra Index and Each Subscale

Overall Mitra Index. A three-class model, with balanced classes, provided the best fit for the overall Mitra score. Participants in the first class (*Low Stable;* $n = 118$, 30%) reported a low average Mitra score at 16 weeks gestation ($\alpha = 0.02$) and did not experience significant change by 32 weeks (ß = 0.01). The second class (*Moderate Increasing;* $n = 148$, 37% of the sample) had a relatively moderate 16-weeks Mitra score ($\alpha = 0.60$) and showed a significant increase in the overall Mitra index score over the two-time points (ß = 0.17). Class 3 participants (*High Increasing;* $n = 133$, 33%) scored relatively high at baseline ($\alpha = 1.28$) and experienced a significant increase over time (ß = 0.15)

Knowledge. A four-class model provided the best fit for the knowledge subscale. Participants in the first class (*Low Decreasing,* $n = 21$, 5%) scored relatively low breastfeeding knowledge at 16 weeks ($\alpha = -0.28$) and were scored with a significant decrease by 32 weeks (ß = −0.61). The second class (*Moderate Stable*, $n = 67$, 17%) reported a moderate knowledge score at 16 weeks ($\alpha = 0.13$) but did not experience significant changes over time (ß = −0.14). Class 3 participants (*Moderate Increasing,* $n = 159$, 40%) reported a moderate knowledge score at 16 weeks ($\alpha = 0.66$) and a significant increase in knowledge over time (ß = 0.13). Lastly, Class 4 participants (*High Increasing,* $n = 152$, 38%) had high knowledge scores at 16 weeks ($\alpha = 1.31$) and showed significantly increased knowledge over time (ß = 0.45)

Self-efficacy. A four-class model was chosen for the breastfeeding self-efficacy subscale. Participants in the

Table 2. Socio-Demographic Characteristics of Low-Income Smoke-Exposed Women ($N = 399$) Recruited for Baby's Breath.

Characteristic	*n* (%)
Age	
< 21 years	112 (28)
21–25 years	151 (38)
> 25 years	136 (34)
Race/Ethnicity	
White	160 (40)
Black	53 (13)
Hispanic	109 (27)
Non-Hispanic	289 (72)
Other	77 (19)
Education	
Less than high school	144 (36)
High school graduate/GED	143 (36)
Some college or more	109 (27)
Employment	
Employed	179 (45)
Not employed	219 (55)
Annual Household Income	
< $US 10,000	165 (41)
$US 10,000–30,000	129 (32)
> $US 30,000	51 (13)
Don't know	50 (13)
Partner Status	
Not married	184 (46)
Married	212 (53)
Nativity	
Born in the United States	335 (84)
Born outside of the United States	64 (16)
First Language	
English	315 (79)
Not English	84 (21)
Previous Live Births (Multiparous)	
Yes	184 (46)
No	185 (46)
Breastfeeding Intentions (16 weeks)	
Any BF or undecided	277 (69)

first class (*Low Increasing*, $n = 15$, 4%) reported low breastfeeding self-efficacy at 16 weeks ($\alpha = -1.52$) but experienced a significant increase over time (ß = 0.51). The second class (*Low/Moderate Increasing,* $n = 101$, 26%) reported relatively lower baseline self-efficacy scores ($\alpha = -0.29$) but showed a significant increase by 32 weeks (ß = 0.51). Participants in Class 3 (*Moderate Stable*, $n = 101$ 26%) had relatively moderate scores for self-efficacy at 16 weeks ($\alpha = 0.73$) and did not show significant changes by 32 weeks (ß = 0.03). Lastly, Class 4 participants (*High Decreasing,* $n = 182$, 44%) reported higher 16-weeks self-efficacy scores ($\alpha = 1.81$) but a significant decrease in self-efficacy over time (ß = −0.31).

Time barriers. A three-class solution provided the best fit for the time subscale. Participants in the first class (*Low Stable,* $n = 58$, 15%) had lower scores (more time barriers) at 16 weeks ($\alpha = -0.35$) and remained stable over time (ß = 0.36). The second class (*Moderate Increasing,* $n = 141$, *35*%) had moderate scores at baseline ($\alpha = 0.56$) but experienced a significant increase (lower time barriers) over time (ß = 0.39). Those in the third class (*High Decreasing*, $n = 200$, 50%) reported relatively high scores (low time barriers) at baseline ($\alpha = 1.61$) but experienced a significant decrease over time (ß = −0.13).

Social support. A four-class solution was chosen as the best fit for the support subscale. Participants in the first class (*Low Decreasing*, $n = 29$, 7%) reported low levels of support at 16 weeks ($\alpha = -0.08$) and experienced a significant decrease by 32 weeks (ß = −0.75). The second class (*Moderate Decreasing,* $n = 112$, 28%) had moderate scores at baseline ($\alpha = 0.50$) and experienced a significant decrease in support over time (ß = −0.25). Class 3 participants (*Moderate Stable*, $n = 111$, 28%) had moderate scores for support at baseline ($\alpha = 0.86$) and remained stable over time (ß = 0.19). Those in Class 4 (*High Increasing,* $n = 147$, 37%) reported high scores at 16 weeks ($\alpha = 1.43$) and experienced even higher support by 32 weeks (ß = 0.47).

Embarrassment barriers. The fit indices showed that a three-class solution provided the best fit for the embarrassment subscale. The first class (*Low Decreasing*, $n = 121$, 30%) reported low embarrassment barriers scores (high embarrassment) at 16 weeks ($\alpha = -1.01$) and experienced a significant decrease (worsening embarrassment) over time (ß = −0.27 ± 0.10). The second class (*Moderate Stable,* $n = 166$, 42%) reported moderate scores at 16 weeks ($\alpha = -0.16$) and showed no significant change by 32 weeks (ß = 0.19). Class 3 participants (*High increasing*, $n = 112$, 28%) had higher scores (lower embarrassment barriers) at 16 weeks ($\alpha = 0.90$) and experienced a significant increase (less embarrassment) by 32 weeks (ß = 0.58; Supplemental Figures 1 to 6 in the online supplemental material illustrate the trajectories).

Socio-Demographic Characteristics by Classes

Overall Mitra Index. Participants in the *Low Stable* class (i.e., lowest scores for psychosocial support for breastfeeding) were significantly older ($p = 0.01$) and more likely to have had a previous live birth ($p < 0.001$) compared to those in the *Moderate Increasing* class.

Knowledge. Participants in the *Low Decreasing* knowledge class were more likely to have been born in the United States than those in the other three knowledge classes ($p < 0.001$).

Self-efficacy. Participants in the *Low Increasing* class for self-efficacy were significantly older than those in the other three classes ($p = 0.003$). Those in the *Low Increasing* self-efficacy

class were more likely to have had a previous live birth ($p = 0.01$) compared to the *High Decreasing* and the *Moderate Stable* classes.

Time barriers. Participants in the *Low Stable* class (i.e., highest reported time barriers across time) were significantly older ($p = 0.03$) than those in the *High Decreasing* class.

Social support. Those in the *Moderate Stable* social support class were more likely to have had a previous live birth, compared to women in the other three classes ($p = 0.009$). Participants in the *Low Decreasing* social support class were more likely to be born in the United States ($p < 0.001$) compared to those in the other three classes.

Embarrassment barriers. Women in the *Low Decreasing* embarrassment barriers class (i.e., highest reported embarrassment) reported lower levels of education than those in the *Moderate Stable* class ($p = 0.04$).

Breastfeeding intention and initiation by classes. For the overall Mitra scale and all the subscales, participants in the high-score classes were more likely to intend to breastfeed at baseline and more likely to initiate breastfeeding, compared to those in the low-score classes. Of note, in the self-efficacy *Low Increasing* class, a small proportion (< 25%) intended to breastfeed and had no participant-initiated breastfeeding (see Supplemental Figure 7 in the online supplemental materials).

Tobacco Smoke Use and Exposure by Classes

Overall Mitra Index. Participants in the Overall Mitra *Low Stable* class ($n = 207$, 52%) compared to those in the *Moderate Increasing* and *High Increasing* classes were more likely to have smoked early in pregnancy ($p = 0.001$).

Knowledge. Participants in the *Low Decreasing* class were more likely to report smoking early in pregnancy compared to those in the *Moderate Stable*, the *Moderate Increasing*, and the *High Increasing* classes ($p < 0.001$).

Self-efficacy. Women in the *Low Increasing* class were more likely to report being current smokers compared to those in the *Low-Moderate Increasing*, the *Moderate Stable*, and the *High Decreasing* classes ($p < 0.001$).

Time barriers. Participants in the *Low Stable* class (i.e., greater time barriers) were more likely to have smoked early in pregnancy compared to those in the *Moderate Increasing* class ($p = 0.03$).

Social support barriers. Participants in the *Low Decreasing* class (i.e., the least social support) and *Moderate Decreasing* class were more likely to have smoked early in pregnancy (compared to those in the *High Increasing* class (i.e., those with the greatest social support), $p < 0.001$.

Embarrassment barriers. There were no significant differences in reported smoking or smoke exposure status between *Embarrassment Barrier* classes (see Supplemental Figure 8 in the online supplemental materials).

Discussion

To our knowledge, this is the first study that identifies latent patterns of change in breastfeeding attitudes and shows the relationship of those changes with breastfeeding behaviors as well as smoking use and exposure during and after pregnancy. Groups of participants with similar baseline status and construct trajectories share similar breastfeeding intentions and initiation likelihood. Some construct trajectories (knowledge, social support, and embarrassment) diverged over time while others (self-efficacy and time/social barriers) tended to converge or stabilize over time.

Our findings also show that the heterogeneous patterns of change in attitudes and thoughts towards breastfeeding are also associated with tobacco smoke use and exposure. There is evidence that pregnant people who intend to breastfeed are more likely to quit smoking (Carswell et al., 2018; Issany et al., 2022; Lee et al., 2005) and people who smoke during pregnancy are less likely to initiate breastfeeding (Donath et al., 2004). To our knowledge, this is the first study to show that patterns of change in psychosocial determinants of breastfeeding are also associated with smoking status. By showing that increasing levels of social support, knowledge, and self-efficacy—which have been shown to promote breastfeeding initiation—are also associated with smoking, our findings highlight the importance of capitalizing on smoking cessation interventions such as Baby's Breath. Focusing on these psychosocial determinants as mechanisms of change can simultaneously result in smoking cessation and better breastfeeding success (Carswell et al., 2018).

Congruent with our current findings, prior breastfeeding literature has shown that psychosocial factors such as social support, favorable attitudes toward breastfeeding, and breastfeeding knowledge are also associated with intention to breastfeed (Kloeblen et al., 1999; Kloeblen-Tarver et al., 2002; Shaker et al., 2004), specifically in samples of economically disadvantaged women (Alexander et al., 2010). Social support, a critical factor in successful breastfeeding, can take many forms. For instance, clinicians should support initial breastfeeding decisions and help negotiate barriers, although many are not prepared with adequate skills or time to be supportive (Feldman-Winter et al., 2017; Sriraman & Kellams, 2016). Culturally sensitive counseling is also needed, especially when addressing the unique barriers of women of color (Perez-Escamilla, 2022).

Our findings of differences in breastfeeding intentions, behaviors, and smoking by trajectories of psychosocial

factors map seamlessly onto the stages of change of the transtheoretical model of change (Humphreys et al., 1998). Past research has shown that attitudes towards breastfeeding can be helpful in differentiating between women planning to breastfeed and those who intend to exclusively formula feed (Humphreys et al., 1998; Stuebe & Bonuck, 2011). Additionally, women in the later stages of the transtheoretical model, who are already contemplating breastfeeding, tend to have more positive and less negative attitudes towards breastfeeding than those in the earlier stages (Kloeblen et al., 1999). In line with those findings, our results show that even when they experienced negative changes in their attitudes, women who had positive attitudes towards breastfeeding at the beginning of pregnancy were still more likely to intend to breastfeed and initiate breastfeeding compared to those who had more negative attitudes at baseline, regardless of the direction of change over time.

Our results indicate that, instead of providing universal breastfeeding education to all pregnant individuals, interventions to promote breastfeeding initiation may benefit from a theoretical and tailored approach that facilitates movement across the stages of change of the Transtheoretical Model. For instance, participants with low knowledge and self-efficacy, high social support barriers, embarrassment, and time barriers early in pregnancy could be targeted as pre-contemplators. Interventions for this subgroup should focus on addressing the specifics of times barriers, social support barriers, and knowledge, with images of other women in their perceived community successfully and happily initiating and exclusively breastfeeding.

Limitations

We identify some limitations of the present study as we consider these findings. Results from our smoke-exposed sample recruited for a larger study from clinics serving primarily low-income women in Rhode Island may not be generalizable to non-smoke exposed pregnant people or those elsewhere. The time points at which breastfeeding measures were assessed were not chosen for breastfeeding-related study objectives. Inclusion of participants who breastfed for less than 1 day with those who exclusively formula fed may have introduced bias. Self-reported smoking and breastfeeding variables are subject to social desirability bias. Recruitment without stratification resulted in uneven smoke use and exposure groups with different levels of statistical power, so interpretation among these groups should be conducted with caution. Lastly, some of the classes that emerged had a relatively small sample size. However, congruent with latent class analysis guidelines (O'Donnell et al., 2017) all classes identified in the previous study have at least 5% of the entire sample. Lastly, we acknowledge that the data used in the present study are relatively old. However, there have not been considerable changes in breastfeeding rates in RI between now and when the study was conducted. As such, we believe that our results are still generalizable to the population of interest and there are no significant cohort effects to consider.

Conclusions

Our results shed light on patterns of change in breastfeeding-related psychosocial factors during pregnancy, and their relationships with breastfeeding and smoke exposure. Future intervention research should develop and test interventions addressing these psychosocial barriers. Breastfeeding interventions might target breastfeeding readiness separate from pregnancy, while emphasizing the anticipated barriers and knowledge gaps.

Authors' Note

This manuscript is the first from this cohort to assess patterns of change in breastfeeding determinants in relation to breastfeeding and smoking. The results have been presented in abstract form at the SBM meeting. However, other data from the original randomized controlled trial have been utilized in multiple publications, including: Risica et al. (2018), Gavarkovs et al. (2018), and von Ash et al. (2023).

Author Contributions

Ruth G. St Fleur: Conceptualization, Formal analysis, Methodology, Software, Writing – original draft, Writing – review & editing.
Tayla von Ash: Conceptualization, Investigation, Writing – review & editing.
Anna Alikhani: Conceptualization, Data curation, Investigation, Writing – review & editing.
Shira I. Dunsiger: Conceptualization, Methodology, Writing – review & editing.
Patricia Markham Risica: Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing.

Disclosures and Conflicts of Interest

The authors declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: At the time of this research, Anna Alikhani was a doctoral student, and Patricia Markham Risica was on her dissertation committee.

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Supplemental Material

Supplementary Material may be found in the "Supplemental material" tab in the online version of this article.

References

Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control*, *19*(6), 716–723. https://doi.org/10.1007/978-1-4612-1694-0_16

Alexander, A., O'Riordan, M. A., & Furman, L. (2010). Do breastfeeding intentions of pregnant inner-city teens and adult women differ? *Breastfeeding Medicine*, *5*(6), 289–296. https://doi.org/10.1089/bfm.2009.0083

Asimaki, E., Dagla, M., Sarantaki, A., & Iliadou, M. (2022). Main biopsychosocial factors influencing breastfeeding: A systematic review. *Maedica (Bucur)*, *17*(4), 955–962. https://doi.org/10.26574/maedica.2022.17.4.955

Bakk, Z., Tekle, F., & Vermunt, J. K. (2013). Estimating the association between latent class membership and external variables using bias-adjusted three-step approaches. *Sociological Methodology*, *43*(1), 272–311. https://doi.org/10.1177/0081175012470644

Barbosa, C. E., Masho, S. W., Carlyle, K. E., & Mosavel, M. (2017). Factors distinguishing positive deviance among low-income African American women: A qualitative study on infant feeding. *Journal of Human Lactation*, *33*(2), 368–378. https://doi.org/10.1177/0890334416673048

Carswell, A. L., Ward, K. D., Vander Weg, M. W., Scarinci, I. C., Girsch, L., Read, M., Relyea, G., & Chen, W. (2018). Prospective associations of breastfeeding and smoking cessation among low-income pregnant women. *Maternal & Child Nutrition*, *14*(4), Article e12622. https://doi.org/10.1111/mcn.12622

Centers for Disease Control and Prevention. (2012). *Breastfeeding report card United States*. https://www.cdc.gov/breastfeeding/pdf/2012breastfeedingreportcard.pdf

Diaz, L. E., Yee, L. M., & Feinglass, J. (2023). Rates of breastfeeding initiation and duration in the United States: Data insights from the 2016–2019 Pregnancy Risk Assessment Monitoring System. *Frontiers in Public Health*, *11*, Article 1256432. https://doi.org/10.3389/fpubh.2023.1256432

Donath, S. M., Amir, L. H., & Team, A. S. (2004). The relationship between maternal smoking and breastfeeding duration after adjustment for maternal infant feeding intention. *Acta Paediatrica*, *93*(11), 1514–1518. https://doi.org/10.1080/08035250410022125

Drehmer, J. E., Ossip, D. J., Nabi-Burza, E., Hipple Walters, B., Gorzkowski, J. A., & Winickoff, J. P. (2020). Pediatric office delivery of smoking cessation assistance for breast-feeding mothers. *Nicotine & Tobacco Research*, *22*(3), 346–353. https://doi.org/10.1093/ntr/nty247

Feldman-Winter, L., Szucs, K., Milano, A., Gottschlich, E., Sisk, B., & Schanler, R. J. (2017). National trends in pediatricians' practices and attitudes about breastfeeding: 1995 to 2014. *Pediatrics*, *140*(4), Article e20171229. https://doi.org/10.1542/peds.2017-1229

Gavarkovs, A. G., Risica, P. M., Parker, D. R., Jennings, E., Mello, J., & Phipps, M. (2018). Self-reported environmental tobacco smoke exposure and avoidance compared with cotinine confirmed tobacco smoke exposure among pregnant women and their infants. *International Journal of Environmental Research and Public Health*, *15*(5), 871. https://doi.org/10.3390/ijerph15050871

Humphreys, A. S., Thompson, N. J., & Miner, K. R. (1998). Assessment of breastfeeding intention using the transtheoretical model and the theory of reasoned action. *Health Education Research*, *13*(3), 331–341. https://doi.org/10.1093/her/13.3.331

Issany, A., Hore, M., Singh, L., Israel, J., Kocher, M. G., & Wen, X. (2022). Reciprocal associations between maternal smoking cessation and breastfeeding. *Breastfeeding Medicine*, *17*(3), 226–232. https://doi.org/10.1089/bfm.2021.0199

Johnson, A., Kirk, R., Rosenblum, K. L., & Muzik, M. (2015). Enhancing breastfeeding rates among African American women: A systematic review of current psychosocial interventions. *Breastfeeding Medicine*, *10*(1), 45–62. https://doi.org/10.1089/bfm.2014.0023

Jung, T., & Wickrama, K. (2008). An introduction to latent class growth analysis and growth mixture modeling. *Social and Personality Psychology Compass*, *2*(1), 302–317. https://doi.org/10.1111/j.1751-9004.2007.00054.x

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. *Womens Health Issues*, *15*(2), 64–72. https://doi.org/10.1016/j.whi.2004.09.003

Kloeblen, A. S., Thompson, N. J., & Miner, K. R. (1999). Predicting breast-feeding intention among low-income pregnant women: A comparison of two theoretical models. *Health Education & Behavior*, *26*(5), 675–688. https://doi.org/10.1177/109019819902600508

Kloeblen-Tarver, A. S., Thompson, N. J., & Miner, K. R. (2002). Intent to breast-feed: The impact of attitudes, norms, parity, and experience. *American Journal of Health Behavior*, *26*(3), 182–187. https://doi.org/10.5993/ajhb.26.3.3

Lanza, S. T., Tan, X., & Bray, B. C. (2013). Latent class analysis with distal outcomes: A flexible model-based approach. *Structural Equation Modeling: A Multidisciplinary Journal*, *20*(1), 1–26. https://doi.org/10.1080/10705511.2013.742377

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. https://doi.org/10.1007/s10995-005-0008-5

Martin, J. A., Osterman, M. J., & Driscoll, A. K. (2023). Declines in cigarette smoking during pregnancy in the United States, 2016–2021. *NCHS Data Brief* (458), 1–8. https://www.cdc.gov/nchs/data/databriefs/db458.pdf

McLnnes, R. J., Love, J. G., & Stone, D. H. (2001). Independent predictors of breastfeeding intention in a disadvantaged population of pregnant women. *BMC Public Health*, *1*, 10. https://doi.org/10.1186/1471-2458-1-10

Meek, J. Y., & Noble, L. (2022). Technical report: Breastfeeding and the use of human milk. *Pediatrics*, *150*(1), e2022057989. https://doi.org/10.1542/peds.2022-057989

Mitra, A. K., Khoury, A. J., Hinton, A. W., & Carothers, C. (2004). Predictors of breastfeeding intention among low-income women. *Maternal and Child Health Journal*, *8*(2), 65–70. https://doi.org/10.1023/b:maci.0000025728.54271.27

Muthén, B., & Muthén, L. (2017). *Mplus*. Chapman and Hall/CRC. https://www.statmodel.com/

Nagin, D. S., & Odgers, C. L. (2010). Group-based trajectory modeling (nearly) two decades later. *Journal of Quantitative Criminology*, *26*(4), 445–453. https://doi.org/10.1007/s10940-010-9113-7

Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling: A Multidisciplinary Journal*, *14*(4), 535–569. https://doi.org/10.1080/10705510701575396

O'Donnell, M. L., Schaefer, I., Varker, T., Kartal, D., Forbes, D., Bryant, R. A., Silove, D., Creamer, M., McFarlane, A., & Malhi, G. (2017). A systematic review of person-centered approaches to investigating patterns of trauma exposure. *Clinical Psychology Review*, *57*, 208–225. https://doi.org/10.1016/j.cpr.2017.08.009

Oniwon, O., Tender, J. A., He, J., Voorhees, E., & Moon, R. Y. (2016). Reasons for infant feeding decisions in low-income families in Washington, DC. *Journal of Human Lactation*, *32*(4), 704–710. https://doi.org/10.1177/0890334416653739

Park, S., Lee, J. L., In Sun, J., & Kim, Y. (2018). Knowledge and health beliefs about gestational diabetes and healthy pregnancy's breastfeeding intention. *Journal of Clinical Nursing*, *27*(21–22), 4058–4065. https://doi.org/10.1111/jocn.14539

Perez-Escamilla, R. (2022). What will it take to improve breastfeeding outcomes in the United States without leaving anyone behind? *American Journal of Public Health*, *112*(Suppl. 8), S766–S769. https://doi.org/10.2105/AJPH.2022.307057

Quintero, S. M., Strassle, P. D., Londoño Tobón, A., Ponce, S., Alhomsi, A., Maldonado, A. I., Ko, J. S., Wilkerson, M. J., & Nápoles, A. M. (2023). Race/ethnicity-specific associations between breastfeeding information source and breastfeeding rates among U.S. women. *BMC Public Health*, *23*(1), 520. https://doi.org/10.1186/s12889-023-15447-8

Risica, P. M., & McCausland, K. (2017). Infant feeding decisions and behaviours among low-income smoke-exposed women: Timing and change during pregnancy. *Public Health Nutrition*, *20*(15), 2796–2805. https://doi.org/10.1017/S1368980017001690

Risica, P. M., Parker, D., Jennings, E., Gavarkovs, A., & Phipps, M. (2018). Reducing smoking and environmental tobacco exposure during and after pregnancy: Results of the Baby's Breath trial. *Annals of Public Health and Research*, *5*(2), Article 1078.

Schindler-Ruwisch, J., Roess, A., Robert, R. C., Kuehn, D., Woody, E., Vinjamuri, S., & Thompson, P. (2021). Smoking and race associated with decreased breastfeeding initiation and duration among a low income population. *Breastfeeding Medicine*, *16*(11), 878–885. https://doi.org/10.1089/bfm.2021.0136

Schindler-Ruwisch, J., Roess, A., Robert, R. C., Napolitano, M., Woody, E., Thompson, P., & Ilakkuvan, V. (2019). Determinants of breastfeeding initiation and duration among African American DC WIC recipients: Perspectives of recent mothers. *Women's Health Issues*, *29*(6), 513–521. https://doi.org/10.1016/j.whi.2019.07.003

Schwartz, G. (1978). Estimating the dimension of a model. *Annals of Statistics*, *6*(2), 461–464. http://www.jstor.org/stable/2958889

Shaker, I., Scott, J. A., & Reid, M. (2004). Infant feeding attitudes of expectant parents: Breastfeeding and formula feeding. *Journal of Advanced Nursing*, *45*(3), 260–268. https://doi.org/10.1046/j.1365-2648.2003.02887.x

Sinha, P., Calfee, C. S., & Delucchi, K. L. (2021). Practitioner's guide to latent class analysis: Methodological considerations and common pitfalls. *Critical Care Medicine*, *49*(1), e63–e79. https://doi.org/10.1097/ccm.0000000000004710

Sriraman, N. K., & Kellams, A. (2016). Breastfeeding: What are the barriers? Why women struggle to achieve their goals. *Journal of Women's Health*, *25*(7), 714–722. https://doi.org/10.1089/jwh.2014.5059

Stuebe, A. M., & Bonuck, K. (2011). What predicts intent to breastfeed exclusively? Breastfeeding knowledge, attitudes, and beliefs in a diverse urban population. *Breastfeeding Medicine*, *6*(6), 413–420. https://doi.org/10.1089/bfm.2010.0088

Tang, K., Wang, H., Tan, S. H., Xin, T., Qu, X., Tang, T., Wang, Y., Liu, Y., & Gaoshan, J. (2019). Association between maternal education and breast feeding practices in China: A population-based cross-sectional study. *BMJ Open*, *9*(8), Article e028485. https://doi.org/10.1136/bmjopen-2018-028485

Thomas, C., O'Riordan, M. A., & Furman, L. (2017). Effect of the knowledge and attitudes of a support person on maternal feeding choice. *Journal of Human Lactation*, *33*(1), 195–204. https://doi.org/10.1177/0890334416678821

U. S. Breastfeeding Committee. (2023). *Rhode Island breastfeeding report*. U. S. Breastfeeding Committee. https://www.usbreastfeeding.org/state-breastfeeding-reports.html

von Ash, T., Alikhani, A., Sharkey, K. M., Solano, P., Morales Aquino, M., & Markham Risica, P. (2023). Associations between perinatal sleepiness and breastfeeding intentions and attitudes and infant feeding behaviors and beliefs. *Nutrients*, *15*(15), 3435. https://doi.org/10.3390/nu15153435