Neighborhood disadvantage, greenness and population density as predictors of breastfeeding practices: a population cohort study from Finland

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Conflict of interests

Samuli Rautava declares that he received the following: Honorarium for lecture from Nutricia and Honoraria for lectures and contribution to textbook from Nestle Nutrition Institute. All other authors declared they have no actual or potential financial interests.

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Running title: Neighborhood characteristics and breastfeeding

Abbreviations

NDVI	Normalized Difference Vegetation Index
SES	Socio-Economic Status
SFBC	Southwest Finland Birth Cohort

Abstract

Background: Many environmental factors are known to hinder breastfeeding, yet the role of the family living environment in this regard is still poorly understood.

Objectives: Therefore, we used data from a large cohort to identify associations between neighborhood characteristics and breastfeeding behavior.

Methods: Our observational study included 11,038 children (0-2 years) from the Southwest Finland Birth Cohort. Participant information were obtained from the Medical Birth Register and municipal follow-up clinics. Neighborhood socioeconomic disadvantage, greenness and population density were measured for a period of 5 years prior to childbirth within the residential neighborhood on a 250x250m grid. Any breastfeeding and breastfeeding at six months were the primary outcomes. Binary logistic regression models were adjusted for maternal health and socioeconomic factors.

Results: Adjusted analyses suggest that mothers living in less populated areas were less likely to display any breastfeeding (OR: 0.46; 95% CI 0.36, 0.59) and breastfeeding at six months (OR: 0.37; 95% CI: 0.34, 0.40). Mothers living in highly disadvantaged neighborhoods were less likely to display any breastfeeding if the neighborhood was less populated (OR: 0.54, 95% CI: 0.30, 0.95) but more likely to breastfeed at six months if the neighborhood was highly populated (OR: 3.74; 95% CI: 1.92, 7.29). Low greenness was associated with higher likelihood of any breastfeeding (OR: 3.82; 95% CI: 1.53, 9.55) and breastfeeding at six months (OR: 4.41; 95% CI: 3.44, 5).

Conclusions: Our results suggest that neighborhood characteristics is associated with breastfeeding behavior in Finland. Unravelling breastfeeding decisions linked to the living environment may help identify interventions that will allow the appropriate support for all mothers and infants across different environmental challenges.

Key words: Human milk, Health inequalities, Early life nutrition, Environmental health, Social disadvantage, Nursing behavior, Lactation, Mother-infant dyad

Introduction

Breastfeeding is regarded as the gold standard for infant nutrition. Maternal milk provides the optimal building blocks for postnatal growth and development (1) and confers health benefits for both short- and long-term health outcomes (2), including improved neurodevelopment (3) and a generalised reduction in the risk of obesity (4) and infectious diseases (5). By potentially improving intelligence quotient, school attendance, and lowering the risk for non-communicable diseases, it is likely that breastfeeding could help alleviate public health problems worldwide, if all infants between zero and 23 months were breastfed according to the WHO and UNICEF guidelines (6). Yet, in high income countries more than one in five infants are never breastfed (7) and the rates of prolonged breastfeeding after the first six months and up to 23 months are the lowest for developed countries. In Finland, for example, recent evidence suggests that only 60% of all infants might be breastfed (partially) at 12 months, although rates have been increasing since 2010 (8).

Breastfeeding challenges, which impact on breastfeeding guidelines adherence, have been hypothesized to be rooted in the society and environment in which mothers live (9). Factors affecting breastfeeding behavior include family's socioeconomic status (SES), education, income and lifestyle (10), neighborhood SES and population density/urbanization (11,12). All these may be related to adoption of suboptimal breastfeeding practices (13,14), altered maternal milk composition (15), and suboptimal growth trajectories in the infant beyond the first year of life (16). Yet, associations between the neighborhood SES and breastfeeding practices have only been explored in a few instances, with authors reporting that low neighborhood SES is associated with poor breastfeeding practices, at least in some groups of mothers (14,17,18). The link between population density and breastfeeding behavior has been studied in developing countries with conflicting results (13,19), and less data are available from western societies (20,21). The presence of green areas in the neighborhood has been associated to health outcomes throughout the lifespan and higher greenness has been linked to increased wellbeing (22). However, whether the presence of green spaces in the residential neighborhoods is associated with breastfeeding practices, remains, to our knowledge, unknown. Lastly, the significance of the duration or timing of exposure to the above-mentioned neighborhood characteristics and breastfeeding behavior is also at present unknown.

Accordingly, in the present study we investigated the association between five-year cumulative exposure to neighborhood socioeconomic disadvantage, greenness and population density, and breastfeeding practices in an unselected population-based cohort of all children born in Southwest Finland in a three-year period. We hypothesized that high neighborhood disadvantage is linked with suboptimal breastfeeding practices, while high greenness and lower population density would be linked to a breastfeeding behavior more compliant with the current guidelines.

Methods

Study population

The present study is based on data collected within the Southwest Finland Birth Cohort (SFBC), a longitudinal three-year birth cohort consisting of all children born between January 1, 2008 and December 31, 2010 (*n*=14,946) in the Hospital District of Southwest Finland and their mothers (*n*=13,436). At the time of the study, the district included two hospitals (23). Consequently, the study cohort consists of all children born in the geographical area during the three-year period. For the purpose of the present study only the first child born from each mother during this time period and for which breastfeeding information were collected was included (*n*=11,038). Additionally mother-infant dyads with missing information on neighborhood socioeconomic disadvantage (*n*=472), missing information on population density (*n*=85) and missing information on greenness (*n*=86) were excluded from models which included these variables (Supplemental Figure 1). The study was approved by the Ethics Committee of the Finnish Institute for Health and Welfare. The legal basis for processing of personal data is public interest and scientific research (EU General Data Protection Regulation 2016/679 (GDPR), Article 6(1)(e) and Article 9(2)(j); Data Protection Act, Sections 4 and 6).

Pre- and perinatal characteristics

Pre- and perinatal characteristics including child sex, maternal age at birth, number of previous births, marital status, maternal occupational status, smoking during pregnancy, maternal pre-pregnancy BMI, maternal chronic and pregnancy diagnoses, mode of delivery and gestational age were extracted from the national register on parturients, deliveries and births maintained by the Finnish Institute for Health and Welfare. Maternal chronic and pregnancy diagnoses based on ICD-10 codes included cancer, diseases related to the nervous system, mental and behavioral disorders, cardiovascular diseases, respiratory diseases, digestive tract diseases, diseases of the musculoskeletal system, diseases of the genitourinary system, hypertension, pre-eclampsia and gestational diabetes.

Breastfeeding information

Information on breastfeeding habits were obtained from well-baby clinics. All municipalities in Finland are obliged by law to organise a minimum of 15 preventive child care visits during the first six years of the child's life. Whether the child is breastfed is routinely recorded by healthcare providers at these visits. Breastfeeding information derived from the visit records were grouped in two variables: any breastfeeding, indicating whether the infant was ever breastfed or not, and breastfeeding at six months of age (with 0.5 month error margin), indicating whether the infant was breastfed at six months or not.

Neighborhood characteristics

Characteristics of the living environment for each mother in the cohort were calculated based on residential addresses. Latitude and longitude coordinates and dates of all moves in the five years prior to child birth were obtained from the Population Register Centre. Using open-source Geographical Information Systems (QGIS, http://www.qgis.org), data on the residential neighborhoods were linked to the cohort participants' home addresses by the latitude and longitude coordinates. Data for social living environment originated primarily from the Statistics Finland's grid database, which contains socioeconomic information of the Finnish residents at spatial resolution of 250m x 250m. These data include almost one hundred key variables describing the structure of the population including level of education, median household income, unemployment rate, population density as well as buildings and workplaces within each map grid. Using the first three variables, we calculated a relative index of neighborhood SES for each grid (24).

The greenness variable was derived from multispectral satellite images (Landsat TM/OLI, 30 m x 30m of spatial resolution), which were used for the calculation of the normalized difference vegetation index (NDVI), as a measure of the green vegetation cover and density of plant growth (biomass) (25). Water bodies were masked out from the images and the NDVI values ranged from zero to one, where values close to zero indicate areas with the lowest vegetation and values close to one indicate areas with the highest dense vegetation. Neighborhood greenness was estimated as the mean of the NDVI within 250 m x 250 m at the participants' home addresses. NDVI is an unspecific measure of green vegetation presence. Different plant types, composition and landscapes can have similar NDVI profiles as NDVI is unspecific regarding green land cover types or their combinations (e.g. forests, grasslands, shrubs, mires). As a reference, low NDVI values may represent impervious asphalt covered residential and industrial areas.

Statistical analyses

Mean differences in neighborhood SES index, greenness index and population density (continuous variables) across different classes of variables describing population characteristics were tested through ANOVA. Correlations between continuous descriptive variables and exposure variables were tested through Pearson correlations. For the purpose of the following analyses, both the neighborhood disadvantage score and the greenness score were divided into three categories. The neighborhood disadvantage score was classified based on national means: ≤ -0.5 (low disadvantage), from -0.5 to +0.5 (average disadvantage) and > +0.5 was (high disadvantage). For greenness, a score ≤ 0.3 was categorised as low greenness, 0.3-0.6 as average greenness, and > 0.6 as high greenness. The population density variable was used to derive a two category variable describing whether the neighborhood was highly populated (≥200 inhabitants/(250m x 250m)) or scarcely populated (<200 inhabitants/(250m x 250m)) (26). Differences in the distribution of any breastfeeding behavior (ever/never over the first 2 years of life) and at six months (breastfed/not breastfed) across different classes of the neighborhood disadvantage (low, average, high), greenness (low, average, high) and population density (scarcely populated, highly populated) variables were first checked through chi-square tests.

The presence of associations between the exposure to the neighborhood categorical variables (disadvantage, greenness and population density) and the outcome variables (breastfed ever/never, breastfed at six months yes/no) were tested through unadjusted and adjusted binary logistic regression models. In this context, the three exposure variables were tested both in separate models and together in the same model, although separate models were preferred due to the correlations between the three exposure variables. Each adjusted regression model was adjusted for factors that were associated with breastfeeding practices in this cohort: individual SES variables (marital status, maternal occupation), maternal health (pre-pregnancy BMI, smoking during pregnancy, maternal disease diagnoses), infant and pregnancy characteristics (delivery mode, gestational age, sex, twin) and parity. Subgroups analyses, stratified by population density, were run in order to understand if the association of greenness and disadvantage with breastfeeding behavior was different in scarcely versus highly populated settings. Sex-specific interactions were also tested by including the interaction term (e.g. exposure variable*infant sex) in each adjusted model. Similar models were tested with longer measurement intervals of cumulative disadvantage and greenness (up to 15 years) with similar results and they have not been reported in this manuscript. All statistical analyses were performed using IBM SPSS (version 25) and graphs generated using Graph Pad Prism 8. The effects are expressed as adjusted odd ratios (OR) unless otherwise specified.

Results

Table 1 summarises the background characteristics and primary outcomes in relation to the exposure variables for the study population (total *n*=11038). Mean maternal age in the study population was 29±5 years, and the average BMI was 24.3 ±4.8 kg/m2. Most mothers were healthy (81.4% had no chronic disease), and gave birth to singletons (98.5 % of infants). Mean gestational age at birth was 39.8 ± 1.8 weeks. Of the infants in the cohort, 97% were breastfed at some point in the first 2 years of life, but breastfeeding at six months was reported only for 60% of the infants. The correlation between each exposure variable is presented in supplementary table 1. Supplementary table 2 shows the distribution of individual SES across the different classes of each exposure variable.

The distribution of any breastfeeding behavior varied significantly across neighborhood socio-economic disadvantage, greenness and population density classes according to chi-square analyses: the percentage of never breastfed infants increased with disadvantage (3.8% in high disadvantage, versus 2.8% and 2.3% in average and low disadvantage respectively, Figure 1A *P*-value=0.037) and greenness (4.8% in high greenness versus 3.0% and 0.8% in average and low greenness respectively, Figure 1B *P*-value <0.001) while it decreased with population density (2% in high density neighborhoods versus 4.2% in low density ones, Figure 1C *P*-value <0.001), although over 90% of infants were breastfed across all classes. Breastfeeding practices were associated with all exposure factors according to unadjusted logistic regression models (Supplementary Table 3). Breastfeeding at six months across the different classes of socio-economic disadvantage, greenness and population density was also significantly different according to chi-square analyses (Figure 1 D, E, F). In this context the greatest differences were observed across greenness classes, where 82% of the infants living in low greenness areas were breastfed at six months compared to 60% and 50% in the average and high greenness areas, respectively (Figure 1E *P*-value <0.001), and across population density classes, with 71% of infants from highly populated areas vs 48% of infants from scarcely populated areas being breastfed at six months (1F *P*-value <0.001). Unadjusted logistic regression models showed similar results (Supplementary Table 3).

Adjusted logistic regression models confirmed the results gained from chid-square tests and unadjusted models, showing that greenness and population density were related to any breastfeeding, with mothers living in less green areas being more likely to breastfeed compared to mothers living in high greenness areas, and mothers living in highly populated areas having higher probability to breastfeed at all compared to mothers living in scarcely populated areas (Figure 2A). Adjusted models showed that neighborhood disadvantage, greenness and population density were all significantly associated with breastfeeding at six months. In this context, mothers living in the highest disadvantage neighborhoods were more likely to breastfeed at six months compared to mothers living in most affluent neighborhoods. Mothers living in less green and more populated areas were also more likely to breastfeed at six months compared to mothers living in the greenest areas and in least populated neighborhoods (Figure 2B).

In subgroup analyses, where the total sample was divided by population density category, neighborhood disadvantage was associated with any breastfeeding behaviour in mothers inhabiting scarcely populated areas (*P*-value =0.05). Here more disadvantaged neighborhoods were linked to lower probability of breastfeeding at all compared to least disadvantaged neighborhoods (OR: 0.54, 95% CI: 0.30, 0.95). No statistically significant association between breastfeeding at all and disadvantage was observed in highly populated areas.

At six months, in subgroup adjusted analyses, where the total sample was divided by population density category, neighborhood greenness was significantly associated with breastfeeding behavior in mothers inhabiting highly populated areas (*P*-value <0.001). Here mothers were more likely to breastfeed if they lived in neighborhoods with the least green spaces compared to mothers living in neighborhoods with the most green spaces (OR: 2.54, 95% CI: 1.74, 3.69). No similar effect was observed in scarcely populated areas (*P*-value >0.05). Breastfeeding at six months was also linked to disadvantage in highly populated areas (*P*-value <0.001), with mothers living in the most disadvantaged neighborhoods being more likely to breastfeed at six months compared to mothers living in the least disadvantaged neighborhoods (OR: 3.74, 95%CI: 1.92, 7.29). This association was not observed in scarcely populated areas.

Discussion

Our results show that neighborhood characteristics where the family lived up to five years before childbirth are linked to breastfeeding behavior. Therefore, the study provides an insight on the long-lasting role of neighborhood characteristics on breastfeeding behavioral patterns and suggests that more urbanized neighborhoods (e.g. less green and more populated) might be protective of breastfeeding.

Specifically, we observed that low neighborhood greenness and high population density were associated with higher probability to observe any breastfeeding and breastfeeding at six months. Low greenness was associated with higher breastfeeding probability especially for mothers and children living in the most populated and less disadvantaged neighborhoods. While it is well known that urban settings usually represent an increased opportunity to access healthcare services (21), the association between higher breastfeeding probability and low greenness in highly populated and most affluent neighborhoods was unexpected and contrary to our hypothesis, as previous studies have shown that maternal mental wellbeing is positively associated with breastfeeding behavior (27) and that the presence of green areas in the neighborhood positively affects mental wellbeing of the inhabitants (22).

Neighborhood disadvantage in the present study was significantly associated with breastfeeding at six months in the whole cohort and in highly populated areas, and with any breastfeeding in mothers inhabiting scarcely populated areas. In this context we found that, cohort-wide, mothers living in more disadvantaged settings were more likely to breastfeed at six months compared to mothers living in less disadvantaged settings. This was shown to be especially significant for mothers living in highly populated neighborhoods. In scarcely populated neighborhoods we instead observed that mothers living in more disadvantaged settings were less likely to breastfeed at all compared to mothers in least disadvantaged neighborhoods.

The observation that mothers would more likely breastfeed at six months if inhabiting more disadvantaged settings in highly populated areas appears to be in contrast with previous literature which supports the idea that low neighborhood purchasing power is linked to early cessation of breastfeeding (18) and that breastfeeding is economically more costly to mothers than formula feeding (28). However, according to Finnish legislation, more than four months of paid parental leave is to be provided for mothers and further parental allowance to support childcare is also universally available. This might encourage more disadvantaged mothers to take extra parental leave and breastfeed their infant for longer, as opposed to resume their full-time work schedule and choose to formula-feed (29). The pattern might instead be reversed for mothers in higher occupational positions. Yet, this is merely speculation as, although we did correct for mothers' occupational level, we did not have access to data on parental leave and other benefits for this cohort. Further analyses of individual SES factors in relation to neighborhood SES, governmental resources and use, and reasons for breastfeeding cessation are needed for a deeper insight on this matter. Additionally, some studies show that the amount of support that mothers receive from fathers can also influence in infant feeding choices (30). Future studies should investigate the associations between paternal support and breastfeeding rates in relation to neighborhoods SES.

While our data do not support an explanation on why more disadvantaged neighborhoods in highly populated areas seem to have a protective effect on breastfeeding, the difference between scarcely populated and highly populated areas is very interesting and consistent with the hypothesis that even in wealthy countries such as Finland, families inhabiting scarcely populated areas might be disadvantaged in terms of healthcare support and/or education. This could be especially true if the family lives in neighborhoods with low SES. In highly populated areas, low SES does not seem to negatively affect breastfeeding.

The main strength of the present study is the large sample size of the unselected, population-based cohort and the high attendance of mothers to well-baby clinic follow-up. Furthermore, another major strength of our study was the utilization of a high resolution (250m x 250m) grid database linked to data from all residential addresses of the study participants over a period of 5 years until childbirth. These strengths combined allowed an accurate assessment of neighborhood characteristics on breastfeeding practices in the population of southwest Finland, although approximately 16% of the original birth cohort was excluded from this study as it was missing breastfeeding information. In this context, adherence to the visits at municipal clinics (where breastfeeding is collected) is generally high, and the proportion of those not attending any visits has been estimated to be as low as 0.5% based on vaccination coverage. A small proportion of the missing data may be explained by the study subjects moving to geographical areas outside of Southwest Finland. Thus, the likely explanation to most missing breastfeeding data is related to gaps in data acquisition from municipalities using different electronic record systems. It is finally possible that recording of breastfeeding information varied or was inaccurate in some communities. Yet, the present study was to our knowledge the first to comprehensively analyze the association between long-term (five years) environmental exposures and breastfeeding practices using detailed information on neighborhood disadvantage, geographical characteristics and population density.

Unfortunately, due to the lack of detailed information around individual SES, our analyses could not be adjusted for factors such as education and household income. However we did correct the analyses for maternal occupational level which is strongly related to education and income. Moreover, in this study we did not control for immigration status although it is possible that immigrants have different breastfeeding patterns and are more likely to live in lower SES urban setting. However, only 6% of the mothers were immigrants in this birth cohort (31), thus a major bias from immigration status is unlikely. Additionally we were not able to include information on smoking after pregnancy as a confounder in our models. This factor could potentially confound the results as the rate of smoking is likely to increase after birth compared to the one observed in pregnancy. However this information was unfortunately not collected. Another weakness of the present study was the availability of only general breastfeeding outcomes. However, while the study could have benefitted from further information such as duration of exclusive breastfeeding, supplementation with formula feeding, total duration of breastfeeding and reason for breastfeeding cessation, it is also practically very difficult to obtain a very specific level of information from a large cohort such as the one used in this study.

Overall, the cost that breastfeeding entails for mothers, paired with adverse or inappropriate environmental exposures, could impact on breastfeeding behavior. The resources and characteristics of the neighborhoods might contribute to whether and for how long mothers breastfeed their infants. The present study suggests that this might be the case even in countries like Finland, where social welfare and education are well developed and seemingly accessible to everyone at similar levels. The presence of marginalised and disadvantaged neighborhoods within societies that are thought of as uniformly wealthy should be acknowledged and acted on. The present study reveals that the combination of high neighborhood disadvantage, high greenness and low population density of family neighborhoods in southwest Finland shortens breastfeeding practices and therefore might contribute to the establishment of early life health inequalities for babies that are born in these settings. Future interventional studies should aim at understanding what action can be taken to ensure that the different environments where families live have equal resources to support mothers who intend to breastfeed. These resources might include community based interventions highlighting the importance of prolonged breastfeeding for newborns, and improved family and societal childcare support. Breastfeeding is an essential part of maternal and infant health, and global efforts are being made to highlight the right of every infant to be breastfed according to guidelines. Therefore, the acquisition of knowledge around specific neighborhood and environmental factors that might affect the breastfeeding likelihood for children in different settings worldwide is essential. This will allow us to better channel efforts aimed at reducing health inequality and early life disparities.

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Contributors

LG performed the literature search, data analyzes, figures, tables, data interpretation and wrote the initial version of the manuscript. ML and HO assisted with the statistical analyzes and together with HL verified the data. ML, HL and VL, oversaw the project from start to end and contributed to manuscript development and data interpretation. JV, CGI, MK, JP, ST and SR provided critical feedback and specific knowledge relative to the fields of public health, geography, nutrition, pediatrics and statistics. All authors contributed to writing and critically revising the manuscript. All authors have seen and approved the submission of the final version of the manuscript, and take full responsibility for its content.

Data sharing

The dataset supporting the conclusions of this article can be made available upon request from the corresponding author after approval is obtained from the STEPS Study Executive Committee.

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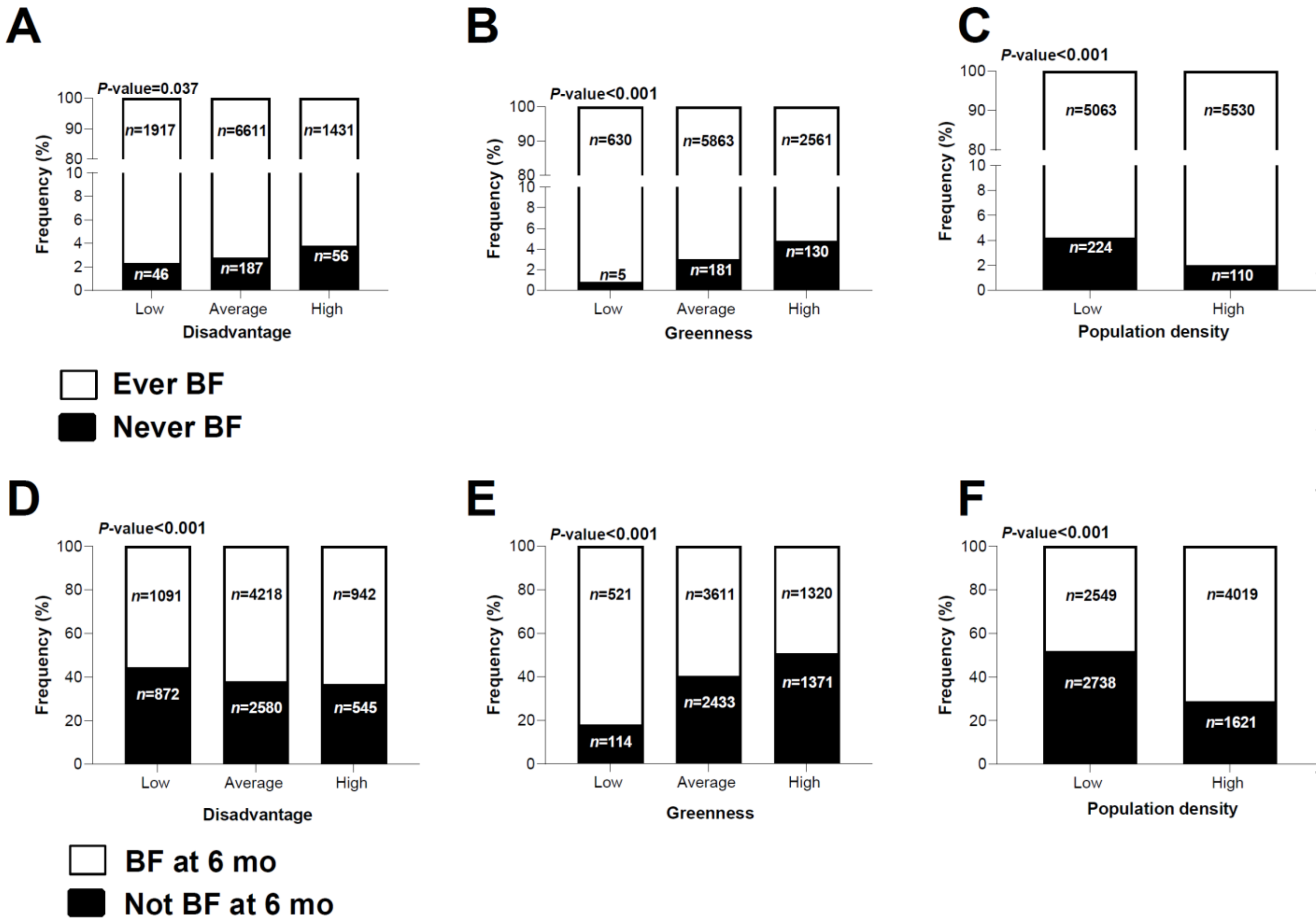

Figure 1. Distribution of any breastfeeding behavior and breastfeeding behavior at 6 months after birth across categories of neighborhood disadvantage (A and D), greenness (B and E) and population density (C and F). *P*-values are obtained from Pearson Chi-square tests and indicates general associations between the two categorical variables represented in each figure.

BF, Breastfed.

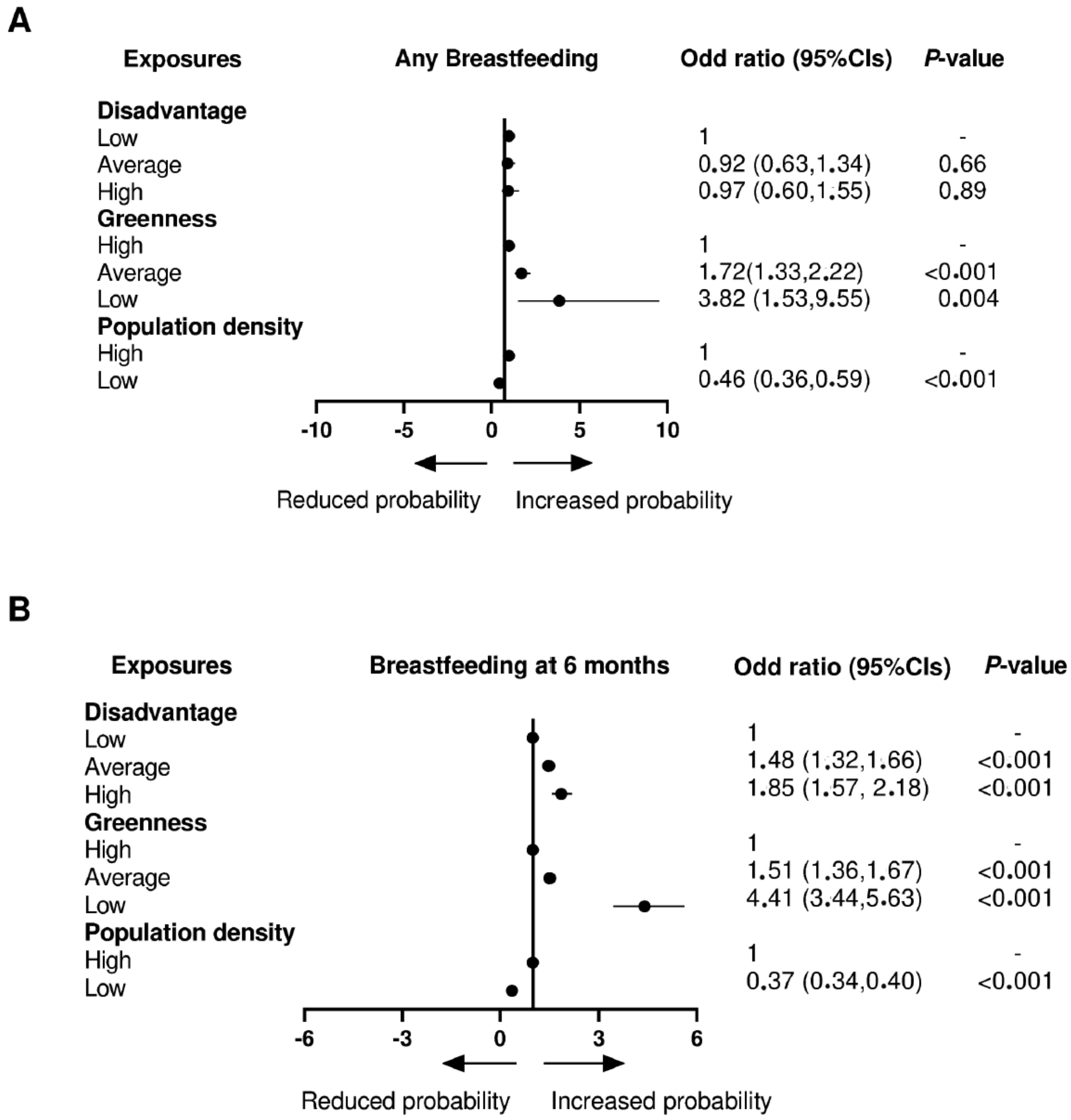

Figure 2. Odd ratios for the any breastfeeding behavior (A, ever/never) and breastfeeding at 6 months (B, yes/no) in relation to exposure to living environment factors (neighborhood disadvantage, greenness and population density). Logistic regression models were adjusted for the following confounders: infants sex, maternal age, maternal pre-pregnancy BMI, parity, maternal occupational status, maternal diagnoses, gestational age, mode of delivery, marital status, smoking during pregnancy. OR>1 indicates that infants are more likely to be breastfed compared to the reference category and vice versa for OR<1. Neighborhood disadvantage score: ≤ -0.5 (low disadvantage), -0.5 to +0.5 (average disadvantage) and > +0.5 (high disadvantage). Greenness score: ≤ 0.3 (low greenness), 0.3-0.6 (average greenness) and >0.6 (high greenness). Population

density: highly populated (≥200 inhabitants/(250m x250m)) and scarcely populated neighborhood (<200 inhabitants/(250m x 250 m)).

__Table 1.__ Descriptives of pre- and peri-natal characteristics of the study population and their relationship with the exposure variables (continuous).

Maternal characteristics	**Total *n* (%)**	**Disadvantage index[1]**	***P*-value**	**Greenness index[1]**	***P*-value**	**Population density (inhabitants/(250m x 250 m))[1]**	***P*-value**
Age (years)	11038 (100)	-0.24	<0.001	0.03	<0.001	-0.07	<0.001
Pre-pregnancy (BMI, kg/m^2)	10995 (91.5)	0.06	<0.001	0.10	<0.001	-0.01	<0.001
Gestational age (weeks)	11030 (99.9)	0.00	0.53	0.00	0.59	0.00	0.94
Previous births			0.008		<0.001		<0.001
None	5587 (50.6)	0.01± 0.56		0.49 ± 0.12		305 ± 231	
≥ 1	5451(49.4)	-0.02 ± 0.67		0.54 ± 0.10		225 ± 204	
Maternal soscioeconomic status			<0.001		<0.001		<0.001
Higher-grade non-manual	2352 (24.9)	-0.21 ± 0.51		0.49 ± 0.13		293 ± 242	
Lower-grade non-manual	2199 (23.3)	-0.14 ± 0.53		0.52 ± 0.12		240 ± 205	
Manual	3187 (33.8)	0.07 ± 0.61		0.54 ± 0.11		230 ± 204	
Student	1214 (12.9)	0.12 ± 0.61		0.49 ± 0.12		328 ± 235	
Full-time mother	480 (5.1)	0.41 ± 0.76		0.52 ± 0.11		263 ± 204	
Birth mode			0.92		0.84		0.94
Vaginal	9502 (86.1)	-0.01 ± 0.62		0.51 ± 0.12		265 ± 221	
C-section	1536 (13.9)	-0.01± 0.61		0.51 ± 0.12		265 ± 221	
Maternal disease (any)			0.01		0.49		0.92
No	8981 (81.4)	-0.015 ± 0.61		0.51 ± 0.12		266 ± 222	
Yes	2057 (18.6)	0.03 ± 0.62		0.51 ± 0.12		265 ± 221	
Infant sex			0.85		0.39		0.29
Male	5406 (51.2)	-0.01 ± 0.61		0.51 ± 0.12		263 ± 218	
Female	5170 (48.8)	-0.01 ± 0.62		0.51 ± 0.12		268 ± 226	
Twin			0.96		0.81		0.68

No	10872 (98.5)	-0.01 ± 0.61		0.51 ± 0.12		265 ± 222	
Yes	166 (1.5)	-0.01 ± 0.68		0.51 ± 0.11		272 ± 223	
Marital status			<0.001		0.003		<0.001
Married	6211 (56.3)	-0.06 ± 0.64		0.52 ± 0.12		258 ± 223	
Not-married	4813 (43.7)	0.06 ± 0.57		0.50 ± 0.12		274 ± 220	
Smoking during pregnancy			<0.001		<0.001		0.70
No	9150 (83.1)	-0.06 ± 0.60		0.51 ± 0.12		266 ± 225	
Yes	1862 (16.9)	0.23 ± 0.60		0.52 ± 0.10		264 ± 206	
Any Breastfeeding			<0.001				<0.001
Never	338 (3.1)	0.15 ± 0.67		0.56 ± 0.09	<0.001	165 ± 150	
Ever	10700 (96.9)	-0.01 ± 0.61		0.52 ± 0.12		269 ± 223	
Breastfeeding at 6 months			0.01		<0.001		<0.001
No	4396 (39.8)	-0.03 ± 0.61		0.54 ± 0.12		197 ± 182	
Yes	6642 (60.2)	0.0 ± 0.62		0.49 ± 0.12		311 ± 234	

[1]Values represent Pearson coefficients for continuous variable (i.e. maternal age, BMI and gestational age) and Mean ± SD of the exposure variables (i.e. neighborhood disadvantage index, neighborhood greenness index and population density), for categorical factors. *P*-values were obtained from ANOVA. ANOVA and Pearson correlation tests aimed at assessing associations and correlations between the categorical and continuous confounders and the continuous exposure variables. These variables have been calculated based on spatial resolution grid of 250 m x 250 m based on the residential neighborhood of the study participants. Disadvantage range: from -2.377 to 4.050, higher values mean higher disadvantage. Greenness range: from 0.1 to 0.8. Higher values mean higher greenness.