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Socio-economic contextual determinants and behavioral changes during pregnancy: evidence from the "MAMI-MED" cohort

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Abstract

Background Pregnancy is a period marked by significant physiological and psychological changes in women and increased fetal nutritional requirements, necessitating maternal adaptation and behavior modifications. Clinicians and health institutions recommend pregnant women engage in healthy practices, such as smoking and alcohol cessation, folic acid consumption, vaccinations, and the like. As behavioral changes in general, the individual's conduct during pregnancy is also influenced not only by personal socio-economic status but also by the socio-economic conditions of the individual's area of residence. This mechanism is recognized by the social epidemiological approach and relates to the concept of neighborhood effect on individual health-related choices. Leveraging such considerations, the work aims to explore the association between selected behaviors recommended by clinicians during pregnancy and specific contextual variables in the residential areas where pregnant women live.

Methods Data from the "MAMI-MED" cohort, recruiting pregnant women during the first prenatal visit at a hospital in Catania (Italy), were analyzed. The cohort provides a valuable resource for investigating the relationship between various exposures during pregnancy and the health outcomes of both mothers and infants. Geocoding techniques were employed to link individual-level data to selected contextual variables related to education, income, unemployment, and housing costs in the participants' residential areas. Mann–Whitney test, Kruskal–Wallis tests, logistic regressions and mixtures of regressions models with concomitant variables are implemented 1) to investigate the associations between contextual covariates and individual responses, 2) to assess the presence of latent subgroups of the population reacting differently to the same contextual factors.

Results The results of Mann–Whitney and Kruskal–Wallis tests, and logistic regressions indicated that neighborhood's socio-economic characteristics, such as educational level and unemployment rate, are associated with women's behaviors during pregnancy, smoking cessation in particular. Results from the logistic regression for BMI showed that obese and overweight individuals tend to live in neighborhoods where the percentage of individuals holding at least a bachelor's degree is comparatively lower. A mixture of regressions predicting individual BMI detected the presence of two latent groups in the population under analysis. The main finding seems to suggest that people living in worse socio-economic environments have a higher sensitivity to changes in education conditions, with respect to individuals living in better-off neighborhoods.

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Conclusions These findings highlight the importance of considering social and contextual dimensions in understanding and promoting healthy behaviors during pregnancy.

Keywords Birth cohort, Pregnancy, Public health, MAMI-MED, Neighborhood effect

Background

Pregnancy represents a pivotal phase characterized by profound physiological and psychological changes, requiring women to adopt behaviors that promote maternal and fetal health (Doyle 2016). International guidelines and recommendations emphasize the importance of healthy practices during this period, including smoking and alcohol cessation, proper nutrition, physical activity, and timely vaccinations [4, 5, 26]. However, adherence to these recommendations is not solely driven by medical advice but is influenced by a combination of individual, social, and environmental factors.

A growing body of research highlights how social networks, family habits, and socio-economic status shape pregnant women's behaviors [3, 30, 33, 41, 48]. Figure 1 illustrates a general conceptual framework outlining the factors that may influence pregnant women's behaviors at both the individual level and the broader social, community, and neighborhood levels. For instance, exposure to social contexts where smoking or unhealthy diets are prevalent can hinder behavioral change [25, 30], while interpersonal support can facilitate healthier choices [12, 16, 43, 44]. Beyond interpersonal influences, structural factors such as education, income, and neighborhood conditions play a critical role [13, 28, 45, 49]. Social epidemiology emphasizes that behaviors are not randomly distributed but follow clear social patterns linked to socio-economic conditions [15, 21]. In this regard, increasing attention has been given to the role of "place", defined as the social and physical environment where individuals conduct their daily lives [8]. Traditionally overlooked in disciplines such as public health and epidemiology, the impact of neighborhoods on health behaviors has gained prominence over the past two decades [31, 35]. Recent research highlights how living in disadvantaged areas can negatively affect behaviors like smoking cessation, diet quality, and physical activity [1]. For example, low socio-economic neighborhoods have been associated with higher rates of obesity and poor dietary patterns, due to factors such as limited access to healthy food options [22, 37]. These findings underscore how neighborhood characteristics contribute to health inequalities [46]. However, methodological challenges persist, particularly regarding causality and the generalizability of neighborhood effects (Jackson et al. 2009). Despite growing international interest in the relationship between socio-economic context and health behaviors, studies addressing neighborhood effects on pregnancy-related behaviors remain limited, especially in Italy.

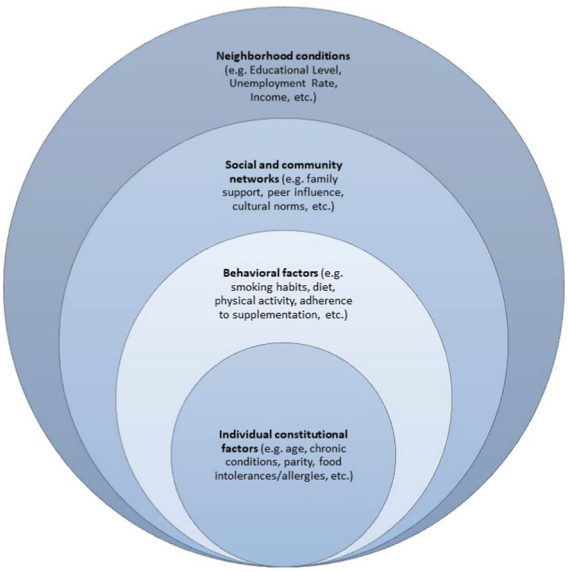

Fig. 1 General conceptual framework outlining the factors that may influence pregnant women's behaviors at both the individual level and the broader social, community, and neighborhood levels

To address this gap, the MAMI-MED cohort offers a useful framework by combining individual health and behavioral data with geocoded socio-economic indicators in an Italian urban context. This prospective study of mother–child pairs in Catania (Italy) allows the analysis of how neighborhood characteristics—such as educational attainment, unemployment rate, median income, and housing costs—are associated with key health behaviors during pregnancy, including smoking cessation, adherence to the Mediterranean diet, and folic acid intake. By integrating individual-level information with contextual data, this study aims to improve the understanding of how the socio-economic environment influences maternal behaviors during pregnancy.

Methods

The MAMI-MED Cohort

This study is based on data from the MAMI-MED cohort, an ongoing prospective study launched in December 2020 in Catania (Italy), focusing on the evaluation of social, environmental, behavioral, and molecular factors affecting maternal and child health. Pregnant women

were recruited during their first trimester at the "*Azienda di Rilievo Nazionale e di Alta Specializzazione (ARNAS) Garibaldi Nesima*" hospital, as part of routine prenatal care, ensuring a high participation rate (>95%). The study includes scheduled follow-ups at delivery and at 12, 24, and 48 months postpartum to monitor maternal and child outcomes. For the present analysis, data collected during the first prenatal visit were used. Trained epidemiologists administered standardized questionnaires to gather information on sociodemographic characteristics and lifestyle behaviors. Specifically, variables included:

- Smoking status categorized as current, former, or never smoker. Participants who had quit were asked if cessation was due to pregnancy;
- Folic acid supplementation categorized as current, former, or never user.
- Pregestational BMI calculated from self-reported height and weight and categorized according to the World Health Organization criteria into underweight (<18.5), normal weight (18.5–24.9), overweight (25–29.9), and obese (≥30).
- Dietary habits assessed via a validated 95-item semi-quantitative Food Frequency Questionnaire (FFQ). The Mediterranean Diet Score (MDS) was calculated and categorized as low (<3), medium (3–6), or high (≥7) adherence. For analysis purposes, medium and high adherence were combined due to low frequencies in the high category.

Ethical approval was obtained from the relevant Ethics Committee "Catania 2" (protocol number 487/CE, 71/2020/CECT2), and informed consent was secured from all participants. Comprehensive details regarding the cohort design and its continuity with the earlier 'Mamma and Bambino' study are available in Appendix 1 and have been previously described [4, 5].

Neighborhood data

To assess the influence of contextual factors, individual data were linked to socio-economic indicators describing participants' neighborhoods. Residential addresses were geocoded using Google Maps API and processed through R software to assign each participant to the appropriate census tract or postal code area. Four contextual variables were selected based on their relevance in analyzing neighborhood socio-economic conditions and health outcomes:

- Percentage of residents with a bachelor's degree (%);
- Unemployment rate (%);
- Average rent cost per square meter (€/m^2)
- Median income (€)

These indicators, sourced from national sources (*Istituto Nazionale di Statistica*, ISTAT; *Osservatorio del Mercato Immobiliare*, OMI; *Ministero dell'Economia e delle Finanze*, MEF) and referred to 2021, were selected based on theoretical relevance, applicability to the Italian context, and data availability. In Figure S1 (Appendix 2), participants' household locations in Catania are mapped according to the levels of the four contextual socio-economic indicators. Detailed descriptions of data sources, geocoding procedures, and variable construction are included in Appendix 1.

Statistical analysis

Descriptive statistics were computed to summarize individual characteristics and contextual variables. Group comparisons were conducted using non-parametric tests due to the nature of the data. The Mann–Whitney U test was applied to compare variables across binary categories. The Kruskal–Wallis test was used for comparisons involving more than two groups. To explore associations between neighborhood socio-economic conditions and pregnancy-related behaviors, logistic regression models were employed. An additional model specifically examined factors associated with smoking cessation attributed to pregnancy. Results are presented as odds ratios (OR) with 95% confidence intervals (CI). To investigate potential unobserved heterogeneity in responses to contextual factors, we applied finite mixture models with concomitant variables. These models allow for the identification of latent subgroups within the population, capturing differential behavioral patterns not observable through standard regression techniques. A Gaussian distribution was used for continuous outcomes (BMI), while binomial distributions were applied for binary outcomes (smoking status, folic acid intake). The full mathematical specification of the mixture models, including the EM algorithm implementation and model selection criteria (Bayesian information criterion, BIC), is provided in Appendix 1. Statistical analyses were conducted using R software (version 4.3.1), utilizing its packages for data management and modeling, with the significance threshold established at $\alpha = 0.05$.

Results

Study population

The geocoding process assigned coordinates to the residential addresses of 1112 pregnant women enrolled in the MAMI-MED cohort up to December 2022. However, for the purposes of this analysis, attention was focused on the 325 women residing within the municipality of Catania, where detailed census data were available. Table 1 provides an overview of the individual characteristics collected during the first trimester visit. Due to

Table 1 Frequencies and proportions for the MAMI-MED individual-level variables (total = 325)

Characteristics	Frequency	Proportion (%)
Smoking status		
Current	41	12.6
Former	86	26.5
Never	198	60.9
Folic acid supplement use		
Current	304	93.5
Former	18	5.5
Never	3	1
Pregestational BMI categories		
Underweight	11	3.4
Normal weight	147	45.2
Overweight	60	18.5
Obese	30	9.2
NA	77	23.7
Adherence to the mediterranean diet		
Low	114	35.1
Medium–high	211	64.9

Fig. 2 "MAMI-MED" cohort respondents' household location (green points) in the municipality of Catania. In the background, smooth pycnophylactic interpolation (Tobler 1979) of population counts for census tracts (2021 General Population Census, http://dawinci.istat.it). The exact address locations have been jittered for privacy concerns. Source: authors' own elaboration

missing data on BMI (n = 77) and the very limited number of women reporting no folic acid supplementation (n = 3), these cases were excluded from specific analyses to ensure robustness. The spatial distribution of participants is illustrated in Fig. 2, which highlights the catchment area of the healthcare facility involved in the study. This visualization also reveals areas within the city characterized by higher or lower concentrations of pregnant women.

Spatial distribution and contextual variables

To explore spatial patterns in neighborhood socio-economic conditions, Moran's I statistics were calculated for the contextual variables. The results indicated significant positive spatial autocorrelation, particularly for the percentage of individuals with a bachelor's degree and the average rent cost (I = 0.602 and 0.609, respectively). Moderate clustering was observed for median income (I = 0.470), while the unemployment rate showed a weaker spatial dependence (I = 0.144). These findings suggest that socio-economic characteristics tend to cluster geographically within Catania.

Correlation analyses between contextual variables, presented in Table S1 (Appendix), confirmed expected relationships: higher education levels, median income, and rent costs were positively correlated, whereas the unemployment rate was negatively associated with all other indicators. The assessment of multicollinearity through Variance Inflation Factors (VIFs) showed values well below critical thresholds, indicating no significant issues in the inclusion of these variables within regression models.

Socio-economic context by individual characteristics

Subsequent analyses examined how contextual socio-economic conditions varied across individual characteristics. As shown in Table 2, women who reported being former smokers, as well as those classified as underweight or of normal weight, tended to reside in neighborhoods with higher educational attainment, higher incomes, and lower unemployment rates. These patterns were less clear for other individual variables. Supporting boxplots, provided in Figures S2, S3 and S5 (Appendix 2), further illustrate these distributions and variability.

Statistical testing of group differences

To statistically assess these differences, a series of Mann–Whitney U tests were performed. The results, summarized in Table S2 (Appendix), indicated that smoking status was the only individual characteristic consistently associated with significant differences in neighborhood socio-economic indicators, with the exception of median income. The Kruskal–Wallis tests, reported in Table S3 (Appendix), reinforced these findings by highlighting significant variations in education and unemployment levels

Table 2 Mean values for the contextual variable considered based on the levels of selected MAMI-MED individual variables. Standard deviations in brackets

Individual variable	Level	Contextual variable			
		High educational level	Unemployment rate	Mean rent cost	Median income
Smoking status	Current	5.58 (5.62)	17.22 (12.37)	4.14 (0.69)	14,102.70 (2483.78)
	Never	9.56 (10.00)	14.64 (6.80)	4.19 (0.77)	14,734.43 (3289.03)
	Former	12.80 (12.37)	12.72 (6.95)	4.39 (0.82)	15,363.96 (3560.22)
Pregestational BMI	Underweight	13.51 (13.79)	13.82 (3.65)	4.45 (1.02)	15,247.04 (3663.26)
	Normal weight	10.90 (10.83)	13.86 (7.60)	4.27 (0.83)	15,037.40 (3517.39)
	Overweight	8.79 (10.09)	14.27 (6.11)	4.22 (0.75)	14,582.30 (3132.52)
	Obese	7.12 (7.83)	15.47 (7.59)	4.22 (0.69)	13,822.80 (2555.32)
Folic acid supplement use	Current	9.90 (10.54)	14.41 (7.92)	4.24 (0.77)	14,802.89 (3276.20)
	Former	11.00 (9.53)	15.01 (7.15)	4.25 (0.98)	15,569.72 (3584.65)
Adherence to the Mediterranean diet	Low	9.97 (10.66)	14.10 (6.70)	4.25 (0.83)	14,578.21 (3280.18)
	Medium–high	9.86 (10.45)	14.67 (8.41)	4.23 (0.75)	14,953 (3292.87)

Table 3 Logistic regression analysis of the association between contextual variables and smoking status

Contextual variables	Smoking status								
	Smokers—Ex smokers			Smokers—Non-smokers			Ex smokers—Non-smokers		
	OR	CI (95%)	*p* value	OR	CI (95%)	*p* value	OR	CI (95%)	*p* value
Unemployment rate	1.06	1.01–1.11	0.011	1.04	1–1.08	0.067	1.04	1–1.09	0.028
High educational level	0.92	0.88–0.97	< 0.001	0.94	0.89–0.99	0.013	0.97	0.95–1	0.019
Mean rent cost	0.68	0.40–1.15	0.144	0.94	0.59–1.51	0.797	0.74	0.54–1.02	0.069
Median income	0.99	0.99–1	0.074	1	0.99–1.00	0.42	0.99	0.99–1	0.128

across smoking categories, while only marginal non-significant differences were observed for rent costs. Similarly, no significant associations were found with other individual characteristics.

Logistic regression analyses

Logistic regression analyses were conducted to further explore these associations. As shown in Table 3, smokers were more likely to live in socio-economically disadvantaged areas, particularly those characterized by lower educational levels and higher unemployment rates. A supplementary analysis focused on women who reported quitting smoking due to pregnancy revealed that living in neighborhoods with higher educational attainment and lower unemployment significantly increased the likelihood of smoking cessation (Table 4). In this context, neighborhood education emerged as the strongest predictor of behavioral change.

Regarding BMI, logistic regression results (Table 5) suggested a weak but positive trend between normal weight status and higher neighborhood education levels; however, the association did not achieve statistical

Table 4 Logistic regression analysis of the association between contextual variables and smoking cessation due to pregnancy

Contextual variables	Ex smokers due to pregnancy—smokers		
	OR	CI (95%)	*p* value
Unemployment rate	0.96	0.91–1.01	0.063
High educational level	1.08	1.02–1.14	0.003
Mean rent cost	1.36	0.72–2.58	0.335
Median income	1.0001	1–1.0003	0.128

Table 5 Logistic regression analysis of the association between contextual variables and BMI

Contextual variables	BMI (normal weight—overweight/obese)		
	OR	CI (95%)	*p* value
Unemployment rate	0.99	0.95–1.02	0.425
High educational level	1.02	1–1.05	0.072
Mean rent cost	1.06	0.75–1.49	0.737
Median income	1.00	1–1.0001	0.147

significance. No other significant associations were detected for the remaining individual characteristics.

Finite mixture models

To capture potential unobserved heterogeneity in the relationship between neighborhood socio-economic conditions and BMI, finite mixture models with concomitant variables were applied (Fig. 3). For this outcome, a two-component Gaussian mixture model was identified as the best fitting solution based on the BIC. As detailed in Table 6, the estimation revealed that only one subgroup, representing approximately 16% of the participants, showed a significant negative association between neighborhood education levels and BMI. This suggests that, within this subgroup, higher contextual education is linked to lower BMI values.

Further exploration of the latent groups highlighted distinct socio-economic and demographic profiles. Women in the first group were generally exposed to more disadvantaged neighborhood conditions, as indicated by lower mean values across the socio-economic predictors (Table 7). Analysis of the concomitant variables (Tables S4, S5 in the Appendix) provided additional insights into group composition. Although the 30–36 age class was the most represented overall, the first group displayed a more heterogeneous age distribution,

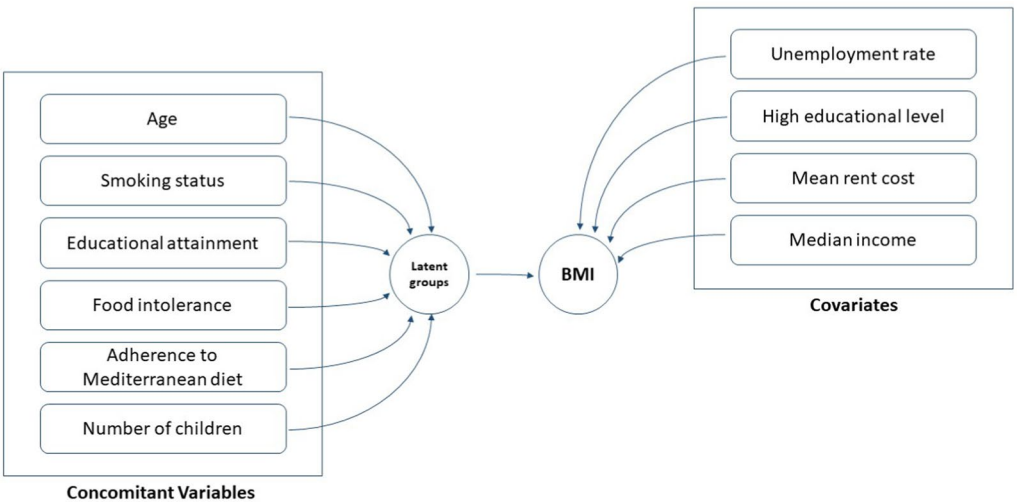

Fig. 3 Graphical representation of the structure of a mixture model used to analyze Body Mass Index (BMI). The model includes a latent variable, representing latent groups whose membership probabilities are influenced by concomitant variables (Smoking status, Age, Educational attainment, Food intolerance, Adherence to Mediterranean diet, Number of children). BMI is directly influenced by both the latent groups and the covariates (Unemployment rate, High educational level, Mean rent cost, Median income). Arrows indicate the direction of influence, clearly distinguishing between variables affecting group membership and those directly affecting BMI

Table 6 Parameters estimates for model with two latent groups (s = 2) predicting the individual BMI

		s = 1	s = 2
Covariates	Unemployment rate	−0.0243	0.2440
	High educational level	−0.0664*	−0.0704
	Mean rent cost	0. 2722	0.7366
	Median income	0.0000	−0.0002
Concomitant variables	Smoking status	0.0000	−0.1732
	Age	0.0000	0.0186
	Educational attainment	0.0000	−0.7849**
	Food intolerance	0.0000	0.7190
	Adherence to Mediterranean diet	0.0000	−0.3666
	N° of children	0.0000	−0.6109
Relative size of the groups		0.16	0.84

Significance level notation: * significant at 0.05; ** significant at 0.01. The relative size of the groups is also reported at the bottom of the table

Table 7 Mean values within latent groups

Group	Unemployment rate	High educational level	Mean rent cost	Median income
1	14.952	8.049	4.118	13,630.09
2	14.062	10.381	4.275	14,973.48
Sample mean	14.206	10.006	4.250	14,756.98

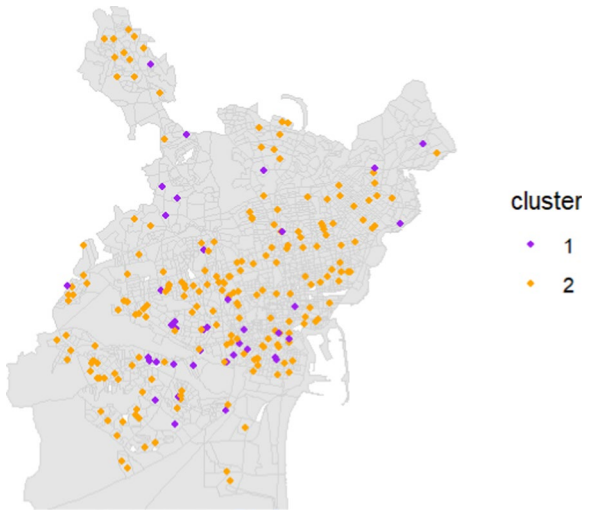

Fig. 4 Spatial arrangement of the "MAMI-MED" cohort respondents' household locations based on the latent groups detected by the mixture of regressions models predicting the individual BMI. The exact address locations have been jittered for privacy concerns. Source: authors' own elaboration

whereas the second group included about 81% of women within the central age ranges (23–29 and 30–36 years). Both groups showed similar distributions in terms of smoking status, food intolerance, and adherence to the Mediterranean diet, suggesting that these lifestyle factors did not significantly differentiate the latent classes. However, a notable distinction emerged regarding educational attainment and parity: the first group included a larger proportion of women with low educational levels and a higher likelihood of already having children, while the second group exhibited greater variability in these characteristics. These findings indicate that the subgroup most affected by neighborhood socio-economic factors on BMI is characterized by a cumulative disadvantage, combining both adverse contextual conditions and individual vulnerabilities such as lower education and higher parity.

Figure 4 depicts the spatial distribution of the two latent groups. Women belonging to the first cluster were predominantly located in the historical center of Catania, whereas the second cluster appeared more dispersed throughout the urban area.

Finally, mixture models applied to smoking status and folic acid intake did not identify latent subgroups within the population. As such, these results are not presented here but are available upon request.

Discussion

This study aimed to investigate the impact of socio-economic contextual determinants on women's behavior during pregnancy using data from the MAMI-MED cohort in Catania, Italy. The findings contribute to our understanding of how social and structural factors influence health-related choices made by pregnant women. Recently, there has been a surge in research linking neighborhoods' socio-economic status to various health risk behaviors that significantly contribute to the prevalence of diseases [19]. Less attention has been paid to analyzing the conduct of specific groups of individuals or groups experiencing a critical life stage, such as pregnancy, in relation to the socio-economic characteristics of the neighborhoods where they live. The application presented so far aimed precisely to fill this gap in the literature. Taking its premises from the social epidemiology and neighborhood-effect concepts, this work attempted to assess the influence that contextual conditions might exert on the health-related actions put in place by individuals experiencing a delicate life phase, i.e., pregnancy.

Linking individual-level data to census-level data (or other spatial data sources such as those from the OMI database or the Italian MEF open data repository) represented a pivotal initial phase, offering significant value to health studies in various ways. This linkage enriches the scope and depth of health research, fostering a deeper understanding of the intricate interplay between individual and contextual factors. Moreover, it helps identify areas with specific health needs and disparities [32, 40]. Such integration facilitates evidence-based decision-making, optimal resource allocation, and targeted interventions to enhance population health and advance health equity [14, 42].

The present analysis revealed that smoking cessation during pregnancy is associated with specific contextual variables related to the socio-economic dimensions of the residential areas. The positive correlations observed between high educational levels, median income, and mean rent cost suggest that neighborhoods with

better socio-economic conditions together with the negative correlation between the unemployment rate and the other variables indicate a geographical distinction between neighborhoods according to their socio-economic conditions. The information conveyed by the correlations combined with the Mann–Whitney test, Kruskal–Wallis test, and logistic regressions results regarding the smoking status (and in a slighter manner also the BMI level) have highlighted that smokers generally reside in more deprived urban areas with respect to non- and ex-smokers. Further, the focus on the women who quit smoking due to pregnancy has highlighted that the chances of compliance with a "pregnancy safe conduct", and hence the choice to change unhealthy behavioral patterns because of pregnancy, increase among women living in well-educated and low-unemployed areas.

Results of the mixture of regressions models with concomitant variables have highlighted the presence of two latent groups with different influences of the regressors. In particular, for the group characterized by women of younger ages, lower education and who are already mothers, the increase in the educational level of the place of residence predicts a reduction in their BMI, whereas the effect of the same covariate appears to be not significant for the group composed mainly by relatively older and more educated individuals. Given the socio-economic profile characterizing the first group, this finding could suggest that people living in worse socio-economic environments have a higher sensitivity to changes in education conditions than individuals living in better-off neighborhoods. Moreover, the geographical visualization of the arrangement of individuals based on the latent group of belonging has uncovered a sort of spatial concentration of the members of the first group in the historical center of Catania, highlighting the neighbourhoods where the relationships between the covariates and the response variable require particular investigation. The consideration of additional individual variables highlights that whereas the two clusters show a similar distribution in terms of vaccination status against selected diseases, the share of women who engage in the responsible choice of getting vaccinated because of their pregnancy is very low and is detected in the sole second cluster.

These results emphasize the need for targeted health initiatives and support systems for women in socioeconomically disadvantaged areas to ensure optimal maternal and infant health outcomes. The aim should be to reduce the physical and geographical distance between women living in different urban contexts. Leveraging the processes of imitation and word of mouth, health policymakers could indeed facilitate behavior change, improving maternal and newborn health status. According to well-established sociological theories of diffusionism [38] and social influence, compliance to new behaviors, ideas, and knowledge can be mediated by social interaction in the context of social networks such as family, workplace, peer groups, and the like [6, 7, 9, 29, 47]. The basic idea is that engagement in a specific course of action could spread across a population as social contagion via interpersonal communication and imitation of others. In the context of health-related behavior, effects of imitation and word of mouth have been detected in the diffusion of practices and beliefs related to food choices [34], obesity [11], smoking [10], alcohol consumption [39], vaccinations [24], and most recently to social distancing during the COVID-19 pandemic [20]. In the case of pregnant women, healthcare providers could foster the interaction between women from different socio-economic environments, e.g. via the organization of antenatal education groups, to promote healthy conduct among individuals living in deprived areas. Emulation is indeed activated the most by peers or people sharing similar life experiences [2, 17, 27]. Overall, by understanding the complex interplay between individual, social, and structural determinants, policymakers and healthcare providers can develop effective strategies and interventions to improve maternal and infant health outcomes. Future research should continue to explore these relationships and identify additional factors that may influence pregnant women's behaviors.

One of the key limitations of this study is the potential for sampling bias. Recruitment occurs at a single healthcare facility, which may not be representative of the broader population. Consequently, the generalizability of the findings to other settings and populations may be limited. It is also important to note that, as with most neighborhood studies, our findings indicate associations rather than causal relationships. The geocoding reflects participants' residence at the time of recruitment, which may not capture long-term exposure to neighborhood conditions. Therefore, interpretations should consider this potential limitation in assessing the cumulative impact of socio-economic context. Additionally, reliance on self-reported data introduces the possibility of recall bias and social desirability bias, which may impact the accuracy of reported information, particularly regarding smoking status and dietary habits. Furthermore, excluding cases with missing data, such as BMI categories, may introduce selection bias and affect the representativeness of the analyzed sample. Despite these limitations, the study possesses several strengths. Despite these limitations, the study exhibits several strengths. The choice of geocoding services provided by Google offers a significantly faster response speed compared to alternatives like OpenStreetMap, enhancing efficiency in data processing.

Moreover, Google Maps' frequent updates and extensive coverage, particularly in remote areas, render it comparable, and at times preferable, to other services [18, 23, 36]. Integrating multiple data sources, including individual- and census-level data, enriches the analytical framework and allows for a more nuanced exploration of health disparities. This approach enhances the granularity of analysis and enables the exploration of contextual influences on health outcomes. Furthermore, while not conducted in the present study, the prospective cohort design will allow for the investigation of temporal relationships between exposures and outcomes. This design facilitates the identification of potential causal pathways and permits the exploration of changes in health status over time.

Conclusions

Although these results provide valuable insights into the differences in the distribution between the groups, it is essential to consider the limitations of the present study. In some cases, the sample size was relatively small, which may limit the generalizability of the findings. Future research with newer respondents recruited under the MAMI-MED project will provide larger and more diverse samples, which will extend these results.

Abbreviations

BMI	Body mass index
WHO	World health organization
FFQ	Food frequency questionnaire
MDS	Mediterranean diet score
OMI	Osservatorio del mercato immobiliare
MEF	Ministry of economics and finance
OR	Odds ratio

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12963-025-00382-0.

Additional file 1

Additional file 2

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Not applicable.

Author contributions

Conceptualization, A.M., M.B., C.E.S., and A.A.; methodology, F.B., A.M., M.B., A.Mau., C.E.S., and A.A.; software, F.B., A.M. and A.Mau.; formal analysis, F.B., R.M.S.L., M.C.L.R., C.L.M., G.F., F.G., E.P., C.E., G.E., and F.M.; resources, A.A.; data curation, F.B., M.B., A.Mau., R.M.S.L., M.C.L.R., C.L.M., G.F., F.G., E.P., C.E. G.E., and F.M.; writing—original draft preparation, F.B. and A.M.; writing—review and editing, all the authors; supervision, A.A.; funding acquisition, A.A. All authors have read and agreed to the published version of the manuscript.

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Availability of data and materials

De-identified data and analysis code are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The study adheres to the principles outlined in the Dec-laration of Helsinki and received approval from the Ethics Committee 'Catania 2' under protocol number Prot. N. 487/CE, 71/2020/CECT2; Prot. N. 762/CE, 83/2021/CECT2; Prot. N. 108/CE, 100/CECT2. Informed consent was obtained from all subjects involved in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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