# Cover letter

Dear Editor-in-chief Richard Rosenkranz,

We are pleased to submit our manuscript titled “Lifestyle patterns in European preschoolers: associations with socio-demographic factors and BMI” for consideration for publication in the *International Journal of Behavioral Nutrition and Physical Activity*.

To our knowledge, this is the first study to examine, in a holistic fashion and with a cross-European perspective, preschoolers’ energy balance-related behaviors (EBRBs) combined into the so-called ‘lifestyle patterns’. Our objectives were threefold: (i) to explore commonalities and differences in lifestyle patterns (identified using a data-driven method) among preschoolers from nine European birth cohorts (from 6 countries); (ii) to assess their associations with socio-demographic factors, and (iii) to investigate their link with Body Mass Index (BMI).

In this paper, we identified a consistent and rather unhealthy lifestyle pattern across cohorts, characterized by at least three of the following EBRBs: suboptimal dietary intake, high screen time, low outdoor play time and short sleep duration. We also observed commonalities and moderate country specificities concerning socio-demographic correlates, and association with BMI. All things considered, this unhealthy lifestyle pattern could be seen as another indicator of the established ‘negative’ stage of the nutrition transition in high-income countries. In fact, adherence to this pattern was most frequently higher in children from lower socio-economic backgrounds. Furthermore, it was associated with higher BMI z-scores for the Spanish and Italian cohorts, countries where the nutrition transition started later than in other European countries. Other socio-demographic factors were also found to be associated with this pattern: in particular, children born to younger and multiparous mothers, and boys, adhered more to it in most of the cohorts.We believe this type of trans-national research is important to inform early multi-behavioral interventions aimed at reducing social inequalities in health at a European scale.

We confirm that this work is original and has not been published elsewhere, nor is it currently under consideration for publication elsewhere. We have no conflicts of interest to disclose.

Looking forward to your favorable consideration,

Sincerely,

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# Title page

**Title**

Lifestyle patterns in European preschoolers: associations with socio-demographic factors and BMI

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**Word count:** 3906

# Abstract (344/350 words)

**Background:** Growing out of the forces of globalization, modernization, urbanization and economic development (occurring at different paces across the world), suboptimal energy balance-related behaviors (EBRBs) do not occur in isolation and tend to combine into the so-called ‘lifestyle patterns’, with a potential synergistic influence on health. This study aimed at exploring similarities and differences in lifestyle patterns among preschool-aged children across Europe, their associations with different socio-demographic factors and their links with body mass index (BMI).

**Methods:** Harmonized data on preschoolers (aged between 2 and 5 years) participating in nine European birth cohorts (UK, France, Greece, Italy, Norway and Spain) from the EU Child Cohort Network were used. Child EBRBs, i.e. dietary intake, screen, outdoor play and sleep times, as well as socio-demographic factors were assessed by parental questionnaires. Child weight and height were measured by trained professionals or reported by parents. Principal component analysis included all children EBRBs to identify cohort-specific lifestyle patterns. Multivariable linear and logistic regressions were used to analyze cross-sectional associations of lifestyle patterns identified across cohorts with socio-demographic factors, BMI z-scores and overweight status.

**Results:** Two distinct lifestyle patterns were identified across all the studied countries. The most consistent across datasets was an unhealthy lifestyle pattern, characterized by at least three of the following EBRBs: suboptimal dietary intake (discretionary consumption), high screen time, low outdoor play time and low sleep duration. The other identified pattern was a healthier one, characterized by high fruit, vegetables and fish intake. Children growing up in low-income households and born to mothers with low maternal education level tended to have higher scores on the unhealthy lifestyle pattern compared to their socio-economically advantaged counterparts. Children born to younger and multiparous mothers, and boys, adhered more to it in most of the cohorts. In addition, the unhealthy lifestyle pattern was associated with higher BMI z-scores in the Spanish and Italian cohorts (β=0.06, 95% CI: 0.02;0.10, in both cohorts).

**Conclusion:** The findings from this cross-cohort analysis are valuable in informing early multi-behavioral interventions aimed at reducing social inequalities in obesity-related behaviors and health outcomes among European children.

**Keywords:** European birth and pregnancy cohorts; preschool children; socio-demographics, socio-economics; lifestyle patterns; nutrition transition, overweight

# Introduction

Growing out of the forces of globalization, modernization, and urbanization, profound upheavals have occurred worldwide during the 20th century. Since the 1960s, economic growth has been accompanied by stark quantitative and qualitative changes in energy balance-related behaviors (EBRBs), though at different paces according to region [1]. On the one hand, the ‘Westernization’ of diet has especially resulted in the increase of energy-dense, nutrient-poor and ultra-processed foods. On the other hand, a change in movement behaviors is reflected in increased time spent in sedentary screen behavior, and reduced physical activity levels at work and during recreational time[2].

This lifestyle shift has been embedded into two other transitions, namely the demographic and the epidemiologic ones [3]. These have contributed to the increase in non-communicable diseases (NCDs), with overweight and obesity being recognized indicators of the ‘negative’ phase of the nutrition transition (NT) under way worldwide [3]. Young children represent one of the most vulnerable population groups with regards to long-term health consequences of obesity [4]. The NT has been conceptualized into five broad stages, (1) hunter-gatherer or Paleolithic, (2) modern agriculture and famine, (3) receding famine (as incomes grow), (4) nutrition-related chronic diseases or ‘negative’ stage, and (5) change toward more healthful behaviors [3]. Whereas high-income countries are, overall, further ahead in the NT compared with low- and middle-income countries, these shifts do not occur in a linear and uniform way between and within countries. Variations in the transition stages, or pace from one stage to another, can therefore be locally observed depending on various socio-economic, socio-demographic and cultural factors[5]. Likewise, across the European region a diverse picture of overweight and obesity prevalence among preschool children can be observed [6]. Although the latter has reached a plateau in some high-income countries [7], it still remains high and of concern because of its early socio-economic patterning [8] and adverse health and well-being consequences in the short and long term [4].

Whereas studies have mostly evaluated the independent effect of each EBRB on body mass index (BMI), these behaviors were shown to combine into so-called ‘lifestyle patterns’, with a potential synergistic influence on health*.* Previous reviews have highlighted three types of lifestyle patterns: unhealthy, healthy and mixed (the latter combining both unhealthy and healthy EBRBs) [9–13]. In high-income countries, the unhealthy lifestyle patterns (consistently characterized by high consumption of discretionary food and high screen time worldwide) have most often been shown to be associated with increased risk of overweight (albeit less consistently shown in cross-sectional studies) and inversely with socio-economic position (SEP) [9–13]. To date, studies that have taken up this theme mainly focused on school children and did not consider sleep, a movement behavior worth investigating when tackling overweight risk [11]. Furthermore, while this question was addressed at large geographical European scales [14,15], cross-European studies providing insights into country-specific EBRBs combinations are currently lacking, especially in preschoolers.

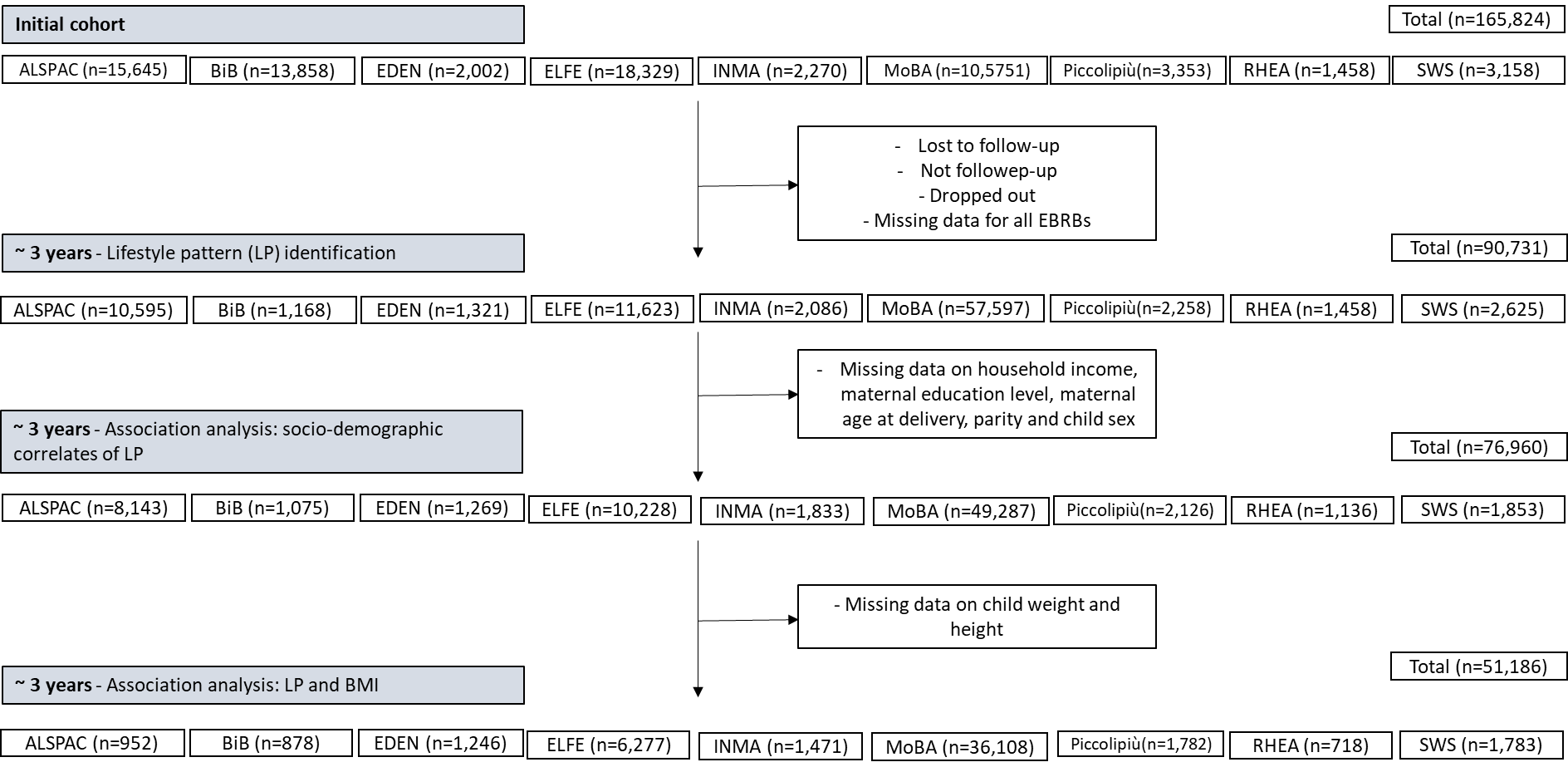
We therefore aimed to examine whether an unhealthy lifestyle pattern (and possibly others) emerged as early as preschool age across several European cohorts; and whether it was associated with not only BMI, but also other socio-demographic factors. We hypothesized that this unhealthy lifestyle pattern could represent another indicator of the established NT ‘negative’ phase at the European level, with expected nuances on the associations, as all the countries, and their population subgroups, have likely been experiencing different NT dynamics.

# Materials and methods

**Cohorts and participants - The EU Child Cohort Network**

This study was conducted as part of the Horizon 2020 EU LifeCycle Project which set up the EU Child Cohort Network (ECCN) to enable the use of an integrated and harmonized set of variables for identification of early-life stressors influencing cardio-metabolic, respiratory and mental developmental outcomes, and health trajectories, during the life course[16,17].

A cohort from the ECCN was eligible for inclusion in the present study if information was available on at least nine of the 11 EBRBs at preschool age being considered (refer to the *Measurements* section below). In total, we used data from nine cohort studies, established between 1990 (ALSPAC) and 2011 (ELFE, Piccolipiù): the Avon Longitudinal Study of Parents and Children (ALSPAC)[18,19], Born in Bradford (BiB)[20], and the Southampton Women’s Survey (SWS)[21] in the UK; the Etude des Déterminants pré et postnatals du développement de la santé de l'Enfant (EDEN))[22] and Etude Longitudinale Francaise depuis l’Enfance (ELFE)[23] in France; the INfancia y Medio Ambiente (INMA)[24] in Spain; the Norwegian Mother, Father and Child Cohort Study (MoBa)[25] in Norway; the Piccolipiù cohort in Italy[26]; and the Mother Child Cohort in Crete, Greece (RHEA)[27]. More details about the cohorts are provided in **Supplementary material 1**.

As illustrated in the flow chart (**Figure 1**), of the 165,824 children initially recruited in all cohorts, several participants were lost to follow-up, not followed-up (just a smaller subsample was followed-up with regards to EBRBs in BiB) or dropped out between enrolment and around 3 years of age. Additionally, children with missing information on all EBRBs of interest were excluded, resulting in 90,731 (54.7%) eligible children for lifestyle pattern identification at around 3 years of age. An additional 13,771 (15.2%) children were excluded due to lack of socio-demographic information; and 25,774 (33.5%) children did not have necessary data for inclusion in analyses on BMI outcomes, resulting in a final sample size of 51,186 children. Of note, only a 10% sample of the ALSPAC cohort, known as the Children in Focus (CiF) group, attended clinics at the University of Bristol at various time intervals between 4 to 61 months of age.

**Figure 1.** Flow chart illustrating participants included in the study.

**Measurements**

*EBRBs*

Information on children’s EBRBs was measured via parental questionnaires at preschool age, on average around 3 years (with a range of 2 to 5 years, depending on the cohort). If information was not available at 3 years, variables collected at 4 or 5 years were preferred to variables collected at 2 years of age, the focus having been placed on preschool age. The specific questions along with the harmonization procedure are provided in **Supplementary material 2**.

*Diet.* Data from validated Food Frequency Questionnaires (FFQs) were used to define frequencies of consumption for various dietary items [28–34]. Harmonized variables were created in each cohort describing how many times the following food groups were consumed a day: vegetables (excluding potatoes), fruit, fish, discretionary savory foods, discretionary sweet foods, processed meat, and sweet beverages.

*Screen time.*  Television watching (including videos and DVDs) was assessed as an indicator of screen time. In addition, due to variability in birth year across cohorts and thus media landscapes, only three cohorts had data available for time spent watching other screens (BiB, ELFE, and Piccolipiù): computers for BiB; computers, smartphones, video games and tablets for ELFE; tablets and smartphones for Piccolipiù. The harmonized screen time variables (TV time and other screen time) were expressed in hours/day.

*Physical activity.* Outdoor play time (BiB, EDEN, ELFE, Piccolipiù, RHEA) or time spent outside (ALSPAC, MoBa and SWS) were assessed as an indicator of physical activity. Due to evidence suggesting seasonal variations in physical activity taking place outdoors [35], the daily time spent (playing) outdoors was transformed to seasonal z-scores. Data on physical activity was unavailable for preschoolers in INMA and was only assessed at weekends for Piccolipiù.

*Sleep duration.* Total time spent sleeping per 24h (continuous, in hours) was obtained by summing night time sleep and nap durations. Data on naps were not available for INMA or MoBa.

*Socio-demographic factors*

Several maternal and household socio-demographic factors, as well as child sex, were hypothesized to be potential correlates of children’s lifestyle patterns and/or BMI and were thus included in the association analyses[9–11,36]. Log-equivalized disposable household income in quintiles was measured using the Equivalized Household Income Indicator (EHII) [37]. Maternal factors included mother’s age at her child’s birth (in years), maternal education level defined according to the International Standard Classification of Education 97/2011 (High: Short cycle tertiary, Bachelor, Masters, Doctoral or equivalent; Medium: Upper secondary, Post-secondary non-tertiary; Low: No education, early childhood, pre-primary, primary, lower secondary or second stage of basic education) and parity (primiparity vs. multiparity). All socio-demographic factors were measured at birth.

*BMI outcomes*

Child weight and height were measured either by clinicians, research staff, or parental self-report. We considered weight and height collected as close as possible to the time of EBRBs’ measurements involved in the lifestyle patterns derivation i.e., between 2 and 5 years depending on the cohort (**Supplementary material 2)** +/- 6 months. Age and sex-specific BMI z-scores were generated using the WHO growth standards [38], and each child was classified as having ‘overweight/obesity’’, or not, using WHO BMI standards (+/-2 SD) [38].

**Cohort-specific statistical analyses**

*Lifestyle patterns derivation*

For each cohort, we used principal component analysis (PCA) to derive a smaller number of lifestyle patterns from the 11 available EBRB items. In a given cohort, children with missing data for all EBRBs were excluded (**Figure 1**). Missing data for EBRBs ranged from 0.3% for the BiB sleep time variable to 60.9% for the RHEA time spent outdoors variable (**Supplementary Material 3**), thus we used the ‘missMDA’ package in R Software to impute missing values based on the correlations between EBRBs and similarities between children [39]. We determined the final number of principal components to retain using scree-plots, along with the criterion of eigenvalues above one [40]. Items with absolute values of the loadings >0.30 were considered to make a reasonable relative contribution to the principal components, and these were interpreted and labeled accordingly [41]. Each child had a score for each PCA-identified lifestyle pattern: a higher (lower) score representing a higher (lower) adherence to that pattern.

*Association analyses*

Complete-cases univariable and multivariable linear regression models were applied to assess the associations of socio-demographic factors with the lifestyle pattern scores, including: household income (EHII index), maternal education level, maternal age at delivery, parity, and child sex. The cross-sectional associations of lifestyle pattern scores with child BMI z-scores and overweight status were examined by a linear and a logistic regression model, respectively. All models were first run unadjusted and then adjusted for the socio-demographic factors mentioned above, all known to be associated with children EBRBs and BMI.

All statistical analyses by cohort were conducted using R and R-based DataSHIELD platform. DataSHIELD is a data infrastructure with series of R packages, that enables a remote federated analysis, without the need of physically transferring, pooling, sharing, or disclosing the individual-level data across the cohorts participating in the LifeCycle consortium [42].

# Results

*Participant characteristics*

The main characteristics of the studied populations are shown in **Table 1**. Children from the French (EDEN and ELFE), Norwegian (MoBa), and Italian (Piccolipiù) cohorts had the highest proportions of mothers having attained high levels of education, with 50% to 70% holding a Bachelor, Masters or Doctoral degree. The most common education level attained in the Spanish (INMA), Greek (RHEA), and English (SWS, ALSPAC) cohorts was secondary/vocational school with 40.7%, 50.5%, 59.7% and 69.1% of the mothers in this category, respectively. Noteworthy, the English BiB cohort - located in a more disadvantaged area – comprised 58.6% of mothers with low education levels. Most of the preschoolers’ mothers were born in the cohort country (90%), except for BiB (60%).

At preschool age (from 2 to 5 years), the lowest percentage of children with overweight/obesity was observed in the French (EDEN and ELFE) cohorts (2.3% and 2.9% respectively), whereas the Spanish (INMA) and the Greek (RHEA) cohorts had the highest percentages (8.9% and 11.9%, respectively).

*Lifestyle pattern identification*

Two lifestyle patterns, accounting for 24.5% (Piccolipiù) to 35.0% (RHEA) of the total variance, were identified in each cohort (**Table 2**).The most consistent pattern was characterized by at least three of the following EBRBs in each cohort: suboptimal dietary intake (low intake of fruit and vegetables, high intake of discretionary savory and sweet snacks, processed meat, and sweet beverages), high TV and other screens time (where available), lower outdoor play time and lower sleep duration. This lifestyle pattern was thus labeled ‘unhealthy’. Piccolipiù was the only cohort where this lifestyle pattern was entirely characterized by suboptimal movement behaviors but not dietary intake.

Relatively high fruit and vegetables intake, and to a lesser extent fish intake, commonly characterized the second pattern in all cohorts. However, the other diet and movement behavior items loaded differently depending on the cohorts. Thus, it was labelled ‘healthy’ (for ALSPAC, ELFE, INMA, Piccolipiù) or ‘mixed’ (for BiB, EDEN, MoBa, RHEA, SWS).

We thereafter focused, for the association analyses, on the unhealthy lifestyle pattern only.

*Association analyses*

In the multivariable models, household income and maternal education level were inversely associated with the unhealthy lifestyle pattern scores (**Tables 3a, 3b, 3c**), except for BiB (positive associations). Links between other socio-demographic factors and the unhealthy lifestyle pattern were not uniform across cohorts. In ALSPAC, ELFE, INMA, MoBa, Piccolipiù and SWS, the younger the mothers at the time of delivery, the higher the unhealthy pattern scores were. In ALSPAC, ELFE, MoBa and SWS the scores were higher for children from multiparous mothers. Lastly, boys scored higher than girls in ALSPAC, EDEN, ELFE, and MoBa.

Cross-sectional relations between the unhealthy lifestyle pattern scores, BMI and overweight status also differed by cohort (**Table 4**). While in most of them no associations were apparent from the multivariable models, unhealthy lifestyle pattern scores were positively associated with both BMI z-scores (β=0.06, 95% CI: 0.02;0.10) and higher odds of having overweight/obesity (OR=1.28, 95% CI: 1.13;1.44) in the Spanish INMA cohort, and BMI z-scores in the Italian Piccolipiù cohort (β=0.06, 95% CI: 0.02;0.10). In BiB and MoBa, a weak inverse association was observed with BMI z-scores (respectively, β=-0.05 95% CI: -0.10;0.00 and β=-0.03, 95% CI: -0.04;-0.02).

# Discussion

We identified two patterns of lifestyle behaviors in preschoolers in nine population-based European cohorts. One was labeled “unhealthy” and characterized by at least three of the following EBRBs: suboptimal dietary intake, high screen time, low outdoor play time, and low sleep duration. The other pattern was healthier given its characterization by high fruit, vegetables, and fish intake; however, it was not as consistent for other dietary items and movement behaviors, and so the pattern was considered either healthy or mixed depending on the cohort. Children from lower income households and those born to mothers with a lower education level, on the whole, tended to adhere more to the unhealthy pattern. Although the cohorts are set within different countries with different social, economic, and cultural landscapes, within each cohort analyses identified a distinctly identifiable ‘unhealthy’ lifestyle pattern. In addition, it was associated with similar socio-economic factors across the different cohorts with some differences in BiB cohort. Associations of this pattern with other socio-demographic characteristics, namely maternal age at delivery, parity and child sex, varied more between cohorts. Likewise, cross-sectional associations between the unhealthy lifestyle pattern and BMI differed, with positive relations only observed in the Spanish and Italian cohorts.

*Lifestyle patterns, socio-demographic factors and BMI: an overview of the NT dynamics in Europe*

The co-occurrence of unhealthy dietary intake, high consumption of sweet beverages, high screen time, low outdoor play time and/or sleep duration, along with the observed sex-specificity, have been described worldwide in different age groups in a number of pediatric studies [9–13,43,44]. Such an unhealthy lifestyle pattern could reflect the established ‘negative’ phase of the NT in Europe [45] given that for almost all cohorts included in this study, children from lower socio-economic backgrounds adhered more to it. Indeed, while in the early stages of NT, unhealthy lifestyle behaviors, obesity and non-communicable diseases affect individuals with higher SEP, the reverse has been observed when the NT is further developed [3]. The discordant findings in BiB may originate from the socio-cultural characteristics of this cohort population, as a large proportion of mothers originated from Pakistan, a middle-income economy still at an early stage of its NT [46,47]. Migrants, when not yet acculturated to the obesogenic food environment, tend to value fresh, traditional, and unprocessed healthy foods, along with skills and strategies to buy and cook these, in spite of often living in disadvantaged contexts [34]. At a community level, some studies have found that living in neighborhoods with a high representation of ethnic minorities (as is the case in BiB [35]) is associated with healthier diets [36]. Ultimately, other social factors not accounting for in this analysis may have confounded the observed associations. In this socio-demographic transitioning world, mothers, are not only more mobile but also more involved in the labor force[5], thus affecting the time devoted to domestic tasks. Having more than one child may further hamper the quantity of time allocated per child [48]. This could influence their ability to adopt optimal eating- and movement behavior-related practices as reflected by the inverse associations between unhealthy lifestyle pattern score and multiparity that we highlighted in some cohorts [49].

Of note, as industrialization and economic development began at different dates and occurred at different pace in the various regions of Europe, so did the NT ‘negative’ phase. By the 1960s, most countries in Western Europe — save the Mediterranean area — had gone through this phase, and have, since then, initiated the final stage towards healthier behaviors of the NT [50]. This may partly explain why the positive association between unhealthy lifestyle patterns and overweight was observed in the Spanish INMA and Italian Piccolipiù cohorts only. However, putting forward such a large-scale mechanism to explain these associations might not be sufficient, because it does not account for the heterogeneity across cohorts. Other proximal factors affect EBRBs and BMI, such as socio-economic inequalities. In the present study, setting BiB aside, INMA had the highest proportion of the least educated mothers (26.1%). Another explanation could be a longer cumulative effect of the adherence to the unhealthy lifestyle pattern in the Spanish and Italian cohorts, given that EBRBs were collected at around 4 years of age (versus 3 years in the others). It may be necessary for children to have prolonged exposure over time to potentially- detrimental EBRBs for associations with outcomes such as BMI to become evident. Ultimately, a satisfying explanation for these results would probably require the involvement of genetic, epigenetic and additional environmental factors and their mutual interactions.

In the present study, the combination into a rather healthier lifestyle pattern of ‘Western’ dietary items, alongside recommended foods and movement behaviors, could reflect an on-going shift into this ultimate ‘behavioral change’ phase from the NT theory[45]. This hypothesis is empirically supported by a recent review summarizing published research on NT patterns in European adult populations over the last three decades (1990–2020)[1]. However, among ethnic minorities that may be in their early transition (e.g. most mothers in BiB), emergence of such patterns could also mirror the switch towards the ‘negative’ phase where some sporadic aspects of the pre-transitional epoch persists [45].

*Public health implications*

Despite the growing evidence of both a switch toward the ‘behavioral change’ phase[1] and a plateauing of the prevalence of childhood overweight in most of European countries[7], the ‘negative’ NT stage does not seem to be restricted to the periods in which it first arose. It does continue to concern ethnic minorities and socio-economic disadvantaged population groups [5], with its potential subsequent short- and long-term consequences on obesity and non-communicable diseases. These social inequalities in lifestyle patterns and health at the European scale, as early as preschool age, call for early multi-behavioral interventions.

Most public health interventions aimed at modifying EBRBs are based on individual health behavior models centered on the individual agency [51]. In general, such models relegate to second place the economic, social and cultural environments in which people function and the embeddedness of their actions in larger ecological layers. Structural interventions that aim to foster the individual autonomy by changing the social determinants of health could be more successful in promoting widespread behavioral change and equity [52]. Notably, the consistent inverse associations of household income and maternal education level with the unhealthy lifestyle patterns highlighted in almost all countries indicate that family-based multi-behavioral interventions should be adapted to address the various characteristics of socio-economic disadvantage. Such targeted and proportionate interventions should also consider other socio-demographics factors, such as children’s sex, maternal age (at delivery) and parity. Finally, it is also of paramount importance to better understand how socio-cultural factors influence the development of children’s EBRBs within families.

Certainly, all these above-mentioned points should be taken into consideration. However, for better policy development and coordination within countries, improvements should also be implemented at the European level, especially given the transboundary nature of many distal factors impacting EBRBs, but not studied here, for example the built environment or commercial determinants of health [1]. For example, modern food retailers sell inexpensive and highly processed food and beverage items and these are considered to be “more fashionable” than items sold the traditional food retail sector.

*Limitations and strengths*

This study is subject to several limitations and strengths. Much of the data were obtain by report from the principal caregivers, which may have introduced recall errors and social desirability bias. We also adjusted for a parsimonious set of confounders when investigating associations, but residual confounding could still be present, as reflected by the (borderline) inverse relations identified between unhealthy lifestyle pattern scores and BMI z-scores in BiB and MoBa. Of note, in the Norwegian (MoBa) cohort, children included in the analyses had their anthropometric data obtained before or at the same time as the collection of date for the lifestyle patterns. This may in part explain the reverse association highlighted between the unhealthy lifestyle pattern and BMI. In general, the cross-sectional nature of the analyses limits our capacity to draw temporal inferences from our findings. However, the relative stability of the studied socio-demographic factors makes the temporality chain more plausible (e.g. parental education level is relatively stable over time). Reflecting their high socio-economic position, the low proportion of EDEN and ELFE children who were overweight might partly explain the null associations found in those cohorts between unhealthy lifestyle patterns and BMI. Although all levels of maternal education were represented in this study, samples were generally highly educated in some cohorts (especially, EDEN, ELFE, and MoBa). In addition, mothers excluded from the analyses tended to be less educated and younger (data not shown). Whereas these characteristics may have implications for generalizability of the findings, the lifestyle patterns derived here are rather consistent with other studies performed in school-aged children worldwide [9–13,43]. In the same vein, the consistent socio-economic unhealthy lifestyle pattern relations identified across cohorts support external validity. Finally, the harmonization within the ECCN was not perfect and certain constraints resulted in a loss of information and precision. Especially, not every EBRB was available in each cohort and the available socio-demographic variables did not necessarily capture the specificities of individual cohorts: for example, a non-negligible number of BiB participants were foreign-educated mothers and their qualifications were not always able to be captured. However, it is remarkable to see that we still obtained great consistency in the patterns, allowing us a broad and European vision of NT phenomena in young children. Indeed, the study populations were at a critical period regarding lifestyle EBRBs acquisition, thus offering interesting opportunities for promotion, prevention and intervention.

# Conclusion

The identification of similar unhealthy lifestyle patterns, their socio-economic patterning and links to BMI as early as preschool age provides new evidence regarding the NT dynamic across different European high-income countries. This signals the urgent need for regional and context-specific policies to avert negative and costly consequences for health-care systems and societal well-being. Family-based policies and multi-behavioral interventions that consider the social settings may hold promise for promoting optimal EBRBs over the life course, and challenge one-size-fits-all approaches.

# Declarations

**Ethics approval and consent to participate**

ALSPAC: Ethical approval for the study was obtained from the ALSPAC Ethics and Law Committee and the Local Research Ethics Committees. Initial approval references are: [1] Bristol and Weston Health Authority: E1808 Children of the Nineties: Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC). (28th November 1989); [2] Southmead Health Authority: 49/89 Children of the Nineties -"ALSPAC". (5th April 1990); [3] Frenchay Health Authority: 90/8 Children of the Nineties. (28th June 1990). Informed consent for the use of data collected via questionnaires and clinics was obtained from the participants following the recommendations of the ALSPAC Ethics and Law Committee at the time.

BiB: Ethics approval was obtained for the main platform study and all of the individual sub-studies from the Bradford Research Ethics Committee.

EDEN: The study received approval from the ethics committee (CCPPRB) of Kremlin Bicêtre on 12 December 2002 and from CNIL (Commission Nationale Informatique et Liberté), the French data privacy institution. All subjects gave their informed consent for inclusion before they participated in the study. Consent for the child was obtained from both parents after the child's birth.

ELFE: The cohort was approved by the Committee for the Protection of People Participating in Biomedical Research (Comité de Protection des Personnes [CPP]), the national advisory committee on information processing in health research (Comité Consultatif sur le Traitement de l’Information en matière de Recherche dans le domaine de la Santé [CCTIRS]) and the French National Data Protection Authority (Commission Nationale de l’Informatique et des Libertes [CNIL]). Recruitment and data collection occurred only after the families had received information and agreed to participate in this cohort with informed consent.

INMA: This study was performed in line with the principles of the Declaration of Helsinki. This study was approved by the regional ethical committees of each cohort for each study phase. All participants or their parents gave written informed consent at each data collection phase.

MoBa: This study was performed in line with the principles of the Declaration of Helsinki. Approval as granted by the Regional Ethics Committee of South East Norway (2018/427).

Piccolipiù: The Piccolipiù’ study was approved by the Ethics Committee of the Local Health Unit Roma E, national coordinator of the project (Prot. CE/82 09/06/2011), and of each local centerRHEA: All procedures were in accordance with the ethical standards established by the Declaration of Helsinki. The study was approved by the ethics committee of the University Hospital in Heraklion, Crete, Greece, and all participants provided written informed consent after complete description of the study.

SWS: The study had full approval at each wave from the Southampton and Southwest Hampshire Local Research Ethics Committee. All participants or their parents gave written informed consent for data collection and analysis.

**Competing interests**

ALSPAC: AE discloses that he is an Editorial Board Member at International Journal of Behavioral Nutrition and Physical Activity. AE receives part of his salary from the EU Horizon 2020 research and innovation program under grant agreement No 874739 (LongITools project).

BiB: The authors have no conflicts of interests to declare.

EDEN: None to declare.

ELFE: None to declare.

INMA: The authors have no conflicts of interest to declare.

MoBa: The authors have no conflicts of interest to declare.

Piccolipiù: None.

RHEA: The authors have no conflicts of interest to declare.

SWS: The authors have no conflicts of interest to declare.

**Funding**

The LifeCycle project received funding from the European Union’s (EU's) Horizon 2020 research and innovation programme (grant 733206 LifeCycle) and was supported by the EUCAN-Connect project under the EU’s Horizon 2020 research and innovation programme (grant 824989). All study-specific fundings are presented below:

ALSPAC: The UK Medical Research Council and Wellcome (Grant ref: 217065/Z/19/Z) and the University of Bristol provide core support for ALSPAC.

BiB: BiB receives core infrastructure funding from the Wellcome Trust (WT101597MA) and a joint grant from the UK Medical Research Council (MRC) and Economic and Social Science Research Council (ESRC) (MR/N024397/1). This study has received support the European Union’s Horizon 2020 research and innovation programme (LifeCycle, grant agreement number 733206; ATHLETE, grant agreement number 874583), and National Institute for Health Research Applied Research Collaboration Yorkshire and Humber (NIHR200166). The views expressed in this publication are those of the author(s) and not necessarily those of the National Institute for Health Research or the Department of Health and Social Care.

EDEN: The EDEN study was supported by Foundation for medical research (FRM), National Agency for Research (ANR), National Institute for Research in Public health (IRESP: TGIR cohorte santé 2008 program), French Ministry of Health (DGS), French Ministry of Research, INSERM Bone and Joint Diseases National Research (PRO-A) and Human Nutrition National Research Programs, Paris-Sud University, Nestlé, French National Institute for Population Health Surveillance (InVS), French National Institute for Health Education (INPES), the European Union FP7 programmes (FP7/2007- 2013, HELIX, ESCAPE, ENRIECO, Medall projects), Diabetes National Research Program (through a collaboration with the French Association of Diabetic Patients (AFD)), French Agency for Environmental Health Safety (now ANSES), Mutuelle Générale de l’Education Nationale a complementary health insurance (MGEN), French national agency for food security, French speaking association for the study of diabetes and metabolism (ALFEDIAM).

ELFE: The ELFE cohort is a joint project between the French Institute for Demographic Studies (INED) and the National Institute of Health and Medical Research (INSERM), in partnership with the French blood transfusion service (Etablissement français du sang, EFS), Santé publique France, the National Institute for Statistics and Economic Studies (INSEE), the Direction générale de la santé (DGS, part of the Ministry of Health and Social Affairs), the Direction générale de la prévention des risques (DGPR, Ministry for the Environment), the Direction de la recherche, des études, de l’évaluation et des statistiques (DREES, Ministry of Health and Social Affairs), the Département des études, de la prospective et des statistiques (DEPS, Ministry of Culture), and the Caisse nationale des allocations familiales (CNAF), with the support of the Ministry of Higher Education and Research and the Institut national de la jeunesse et de l’éducation populaire (INJEP). It receives a government grant managed by the National Research Agency under the “Investissements d'avenir” programme (ANR-11-EQPX-0038, ANR-19-COHO-0001).

INMA: The INfancia y Medio Ambiente cohort study was funded as described below. The Gipuzkoa cohort received funding from Instituto de Salud Carlos III (PI06/0867 FIS-PI18/01142, FIS-PI09/00090 and FIS-PI18/01142 incl. FEDER funds), Department of Health of the Basque Government (2005111093, 2009111069 and 2013111089),  Provincial Government of Gipuzkoa (DFG06/002, DFG08/001), and annual agreements with the municipalities of the study area (Zumarraga, Urretxu , Legazpi, Azkoitia y Azpeitia y Beasain). The Sabadell cohort was funded by grants from Instituto de Salud Carlos III (Red INMA G03/176; CB06/02/0041; PI041436, PI081151, incl. FEDER funds), Generalitat de Catalunya-CIRIT 1999SGR 00241, and, Fundació La marató de TV3 (090430). We acknowledge support from the Spanish Ministry of Science and Innovation and the State Research Agency through the “Centro de Excelencia Severo Ochoa 2019-2023” Program (CEX2018-000806-S), and support from the Generalitat de Catalunya through the CERCA Program. Finally, Valencia cohort received support from grants from UE (FP7-ENV-2011 cod 282957 and HEALTH.2010.2.4.5-1), Spain: ISCIII (Red INMA G03/176, CB06/02/0041; FIS-FEDER: PI03/1615, PI04/1509, PI04/1112, PI04/1931, PI05/1079, PI05/1052, PI06/1213, PI07/0314, PI09/02647, PI11/01007, PI11/02591, PI11/02038, PI13/1944, PI13/2032, PI14/00891, PI14/01687, PI16/1288, and PI17/00663; Miguel Servet-FEDER CP11/00178, CP15/00025, and CPII16/00051), Generalitat Valenciana: FISABIO (UGP 15-230, UGP-15-244, and UGP-15-249), and Alicia Koplowitz Foundation 2017. JJ holds a Miguel Servet-II contract (grant CPII19/00015) awarded by the Instituto de Salud Carlos III (Co-funded by European Social Fund "Investing in your future").

MoBa: The Norwegian Mother, Father and Child Cohort Study is supported by the Norwegian Ministry of Health and Care Services and the Ministry of Education and Research. Work by JRH is supported, in part, through the Research Council of Norway, Centres of Excellence funding scheme, project (number 262700).

Piccolipiù: The study was funded by the Italian National Centre for Disease Prevention and Control (CCM grant 2010 and 2014), through the Italian Ministry of Health (art 12 and 12bis Dl .gs. vo 502/92).

RHEA: The Rhea project was financially supported by European projects (EU FP6-2003-Food-3-NewGeneris, EU FP6. STREP Hiwate, EU FP7 ENV.2007.1.2.2.2. Project No 211,250 Escape, EU FP7-2008-ENV-1.2.1.4 Envirogenomarkers, EU FP7-HEALTH-2009- single stage CHICOS, EU FP7 ENV.2008.1.2.1.6. Proposal No 226,285 ENRIECO, EU- FP7- HEALTH-2012 Proposal No 308,333 HELIX, H2020 LIFECYCLE, grant agreement No 733206, H2020 ATHLETE, grant agreement No 874583), and the Greek Ministry of Health (Program of Prevention of obesity and neurodevelopmental disorders in preschool children, in Heraklion district, Crete, Greece: 2011–2014; “Rhea Plus”: Primary Prevention Program of Environmental Risk Factors for Reproductive Health, and Child Health: 2012–15). Additional funding from NIEHS supported Dr Chatzi (R01ES030691, R01ES029944, R01ES030364, R21ES029681, R21ES028903, and P30ES007048).

SWS: The SWS is supported by grants from the Medical Research Council, National Institute for Health Research Southampton Biomedical Research Centre, British Heart Foundation, University of Southampton and University Hospital Southampton National Health Service Foundation Trust, and the European Union’s Seventh Framework Programme (FP7/2007-2013), project EarlyNutrition (grant 289346) and from the European Union's Horizon 2020 research and innovation programme (LIFECYCLE, grant agreement No 733206). Study participants were drawn from a cohort study funded by the Medical Research Council and the Dunhill Medical Trust.

**Acknowledgements**

ALSPAC: We are extremely grateful to all the families who took part in this study, the midwives for their help in recruiting them, and the whole ALSPAC team, which includes interviewers, computer and laboratory technicians, clerical workers, research scientists, volunteers, managers, receptionists, and nurses. Please note that the ALSPAC study website contains details of all available data is available through a fully searchable data dictionary and variable search tool (http://www.bristol.ac.uk/alspac/researchers/our-data/).

BiB: The Born in Bradford (BiB) cohort is only possible because of the enthusiasm and commitment of the Children and Parents in BiB. We are grateful to all the participants, health professionals, and researchers who have made BiB happen. The BiB cohort is only possible because of the enthusiasm and commitment of the children and parents in BiB. We are grateful to all the participants, health professionals, schools, and researchers who have made BiB happen.

EDEN: The authors thank the cohort participants and the EDEN mother-child study group, whose members are: I. Annesi-Maesano, J.Y. Bernard, J. Botton, M.A. Charles, P. Dargent-Molina, B. de Lauzon-Guillain, P. Ducimetière, M. de Agostini, B. Foliguet, A. Forhan, X. Fritel, A. Germa, V. Goua, R. Hankard, B. Heude, M. Kaminski, B. Larroque†, N. Lelong, J. Lepeule, G. Magnin, L. Marchand, C. Nabet, F Pierre, R. Slama, M.J. Saurel-Cubizolles, M. Schweitzer, O. Thiebaugeorges.

ELFE: The authors would like to thank the participants of the ELFE study and their families for their

continued participation.

INMA: The authors want to express their gratitude to all the families for taking part in this cohort study. We also appreciate the generous contribution made to the study by all the members of INMA. A full roster of the INMA Project Investigators can be found at http://www.proyectoinma.org/presentacion-inma/listado-investigadores/en\_listado-investigadores.html.

MoBa: The authors are grateful to all the participating families in Norway who take part in this on-going cohort study.

Piccolipiù: Our thanks go to all the families who took part in this study and to the whole Piccolipiù research group.

RHEA: We are grateful to all the participating families who took part in this cohort study.

SWS: The authors are grateful to the women of Southampton who gave their time to take part in the Southampton Women’s Survey and to the research nurses and other staff who collected and processed the data.

**Authors' contributions**

PDM and SL conceived and designed this specific analysis. LC, MC and AD performed the statistical analysis under the supervision of PDM and SL. AD wrote the paper under the supervision of PDM and SL. LC, MC, BH, MAC, AE, DA, HI, JRH, JLTN, JW, JJ, KM, MVa, MVr, MS-P, SFB, SLl, SM, SB, TC, TR, TS, TY, PDM, SL were involved in preparation and provision of cohort data, interpreting the results and editing the manuscript for important intellectual content. All authors read and approved the final manuscript.

**Availability of data and materials**

The cohort data can only be accessed with permission/request procedure.

**Authors' information (optional)**

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# Tables

**Table 1.** Characteristics of the study samples.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | ALSPAC, 1991 (n=10,595) | | | BiB, 2007  (n=1,168) | EDEN, 2003 (n=1,321) | ELFE, 2011 (n=11,623) | INMA, 2003 (n=2,086) | MoBa, 1999 (n=57,597) | Piccolipiù, 2011 (n=2,258) | RHEA, 2003 (n=1,458) | SWS, 1998 (n=2,625) |
| **Household level** | |  | |  |  |  |  |  |  |  |  |
| Income (EUSILC-score, quintiles1) | |  |  | |  |  |  |  |  |  |  |
| First | | 1556 (17.2) | | 233 (21.3) | 173 (13.6) | 1398 (13.5) | 383 (19.9) | 8469 (16.6) | 330 (15.5) | 230 (20.0) | 366 (19.7) |
| Second | | 1795 (19.8) | | 229 (20.9) | 240 (18.9) | 1989 (19.2) | 387 (20.1) | 9593 (18.8) | 422 (19.8) | 230 (20.0) | 370 (20.0) |
| Third | | 1881 (20.7) | | 218 (19.9) | 280 (22) | 2225 (21.5) | 387 (20.1) | 10705 (21.0) | 454 (21.4) | 230 (20.0) | 377 (20.3) |
| Fourth | | 1922 (21.2) | | 214 (19.5) | 282 (22.1) | 2317 (22.4) | 385 (20.0) | 10657 (20.9) | 451 (21.2) | 230 (20.0) | 374 (20.2) |
| Fifth | | 1913 (21.1) | | 201 (18.4) | 297 (23.3) | 2414 (23.3) | 385 (20.0) | 11507 (22.6) | 469 (22.1) | 231 (20.1) | 367 (19.8) |
| Missing data2 | | 1528 (14.4) | | 73 (6.3) | 49 (3.7) | 1280 (11.0) | 159 (7.6) | 6666 (11.6) | 132 (5.8) | 307 (21.1) | 771 (29.4) |
| **Maternal factors** | |  | |  |  |  |  |  |  |  |  |
| Age at delivery | |  | |  |  |  |  |  |  |  |  |
| Mean age | | 27.0 (5.8) | | 27.7 (5.6) | 29.9 (4.7) | 30.9 (4.7) | 31.76 (4.2) | 30.43 (4.4) | 33.9 (4.8) | 29.3 (5.1) | 30.3 (3.8) |
| Missing data2 | | 1365 (12.8) | | 0 (0.0) | 0 (0.0) | 47 (0.4) | 154 (7.4) | 83 (0.1) | 0 (0.0) | 50 (3.4) | 0 (0.0) |
| Education level at inclusion3 | |  | |  |  |  |  |  |  |  |  |
| High | | 1440 (14.2) | | 284 (26.4) | 786 (59.7) | 7824 (67.3) | 688 (33.1) | 37778 (69.3) | 1087 (48.1) | 382 (28.2) | 757 (28.9) |
| Medium | | 7023 (69.1) | | 161 (15.0) | 471 (35.8) | 3263 (28.1) | 846 (40.7) | 15788 (29.0) | 935 (41.4) | 683 (50.5) | 1562 (59.7) |
| Low | | 1703 (16.8) | | 630 (58.6) | 59 (4.5) | 534 (4.6) | 543 (26.1) | 935 (1.7) | 236 (10.5) | 288 (21.3) | 299 (11.4) |
| Missing data2 | | 429 (4.1) | | 93 (8.0) | 5 (0.4) | 2 (0.0) | 9 (0.4) | 3096 (5.4) | 0 (0.0) | 105 (7.2) | 7 (0.3) |
| Country of birth | |  | |  |  |  |  |  |  |  |  |
| Born in country of cohort | | 8946 (95.7) | | 728 (62.4) | 1271 (97.1) | 10512 (90.4) | 1881 (90.2) | NA | 2074 (92.6) | 1212 (91.1) | 2451 (94) |
| Missing data2 | | 1244 (11.4) | | 1 (0.1) | 12 (0.9) | 0 (0.0) | 0 (0.0) | NA | 19 (0.8) | 127 (8.7) | 18 (0.7) |
| Parity (first child) | |  | |  |  |  |  |  |  |  |  |
| Yes | | 4619 (45.4) | | 449 (39.4) | 615 (46.7) | 5278 (46) | 1143 (55) | 28358 (49.6) | 1314 (58.6) | 585 (42.7) | 1384 (52.8) |
| Missing data | | 411 (3.9) | | 29 (2.5) | 3 (0.2) | 149 (1.3) | 7 (0.3) | 463 (0.8) | 19 (0.8) | 89 (6.1) | 3 (0.1) |
| **Child factors** | |  | |  |  |  |  |  |  |  |  |
| Sex | |  | |  |  |  |  |  |  |  |  |
| Females | | 5120 (48.3) | | 607 (52) | 627 (47.4) | 5685 (49) | 981 (48.6) | 27178 (48.8) | 1122 (49.7) | 727 (49.9) | 1258 (47.9) |
| Missing data2 | | 0 (0.0) | | 0 (0.0) | 0 (0.0) | 22 (0.2) | 68 (3.3) | 1949 (3.4) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| BMI status at preschool age | |  | |  |  |  |  |  |  |  |  |
| Mean age in months | | 42.5 (1.6) | | 36.6 (1.1) | 37.6 (1.0) | 41.3 (3.8) | 52.2 (1.9) | 36.0 (0.0) | 52.6 (2.4) | 50.0 (1.8) | 36.8 (1.1) |
| Normal or underweight | | 995 (92.1) | | 907 (92.5) | 1245 (97.7) | 6788 (97.2) | 1397 (91.1) | 37819 (93.2) | 1688 (94.7) | 746 (88.1) | 2328 (92.9) |
| Overweight or obese | | 85 (7.9) | | 73 (7.5) | 29 (2.3) | 196 (2.8) | 137 (8.9) | 2758 (6.8) | 94 (5.27) | 101 (11.9) | 178 (7.1) |
| Missing data2 | | 9515 (89.8) | | 188 (16.1) | 47 (3.5) | 4639 (39.9) | 552 (26.5) | 17020 (29.6) | 476 (21.1) | 611 (41.9) | 119 (4.5) |

For each variable, distribution values are provided for children with lifestyle pattern scores and expressed as means (SD) or number (%); NA : Not available

1The higher the quintiles, the higher the income

2 Missing data for children with lifestyle pattern scores

3Classification according to International Standard Classification of Education 97/2011 (ISCED-97/2011) - High: Short cycle tertiary, Bachelor, Masters, Doctoral or equivalent (ISCED-2011: 5-8, ISCED-97: 5-6); Medium: Upper secondary, Post-secondary non-tertiary (ISCED-2011: 3-4, ISCED-97: 3-4); Low: No education, early childhood, pre-primary, primary, lower secondary or second stage of basic education

**Table 2**. PCA loadings for lifestyle patterns (LP) derived at preschool age1.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | ALSPAC, 1991  (n=10,595)  3 years | | BiB, 2007 (n=1,168)  3 years | | EDEN, 2003  (n=1,321)  3 years | | ELFE, 2011  (n=11,623)  3.5 years | | INMA, 2003  (n=2,086)  4 years | | MoBa, 1999  (n=57,597)  3 years | | Piccolipiù, 2011  (n=2,258)  4 years | | RHEA, 2003(n=1,458)  4 years | | SWS, 1998 (n=2,625)  3 years | |
|  | LP1 | LP2 | LP1 | LP2 | LP1 | LP2 | LP1 | LP2 | LP1 | LP2 | LP1 | LP2 | LP1 | LP2 | LP1 | LP2 | LP1 | LP2 |
| Vegetables | -0.19 | **0.69** | **-0.58** | **0.53** | **-0.32** | **0.57** | **-0.30** | **0.69** | 0.05 | **0.75** | **-0.52** | **0.32** | 0.05 | **0.72** | **-0.31** | **0.67** | **-0.54** | **0.55** |
| Fruit | **-0.30** | **0.55** | **-0.30** | **0.63** | -0.20 | **0.66** | -0.17 | **0.71** | 0.14 | **0.65** | **-0.44** | **0.44** | 0.05 | **0.61** | **-0.35** | **0.65** | **-0.47** | **0.49** |
| Fish | -0.06 | **0.56** | **-0.44** | **0.48** | 0.23 | **0.57** | 0.01 | **0.51** | 0.11 | **0.68** | **-0.36** | **0.55** | 0.05 | **0.32** | **-0.45** | **0.42** | **-0.45** | **0.41** |
| Discretionary savory foods | **0.61** | 0.05 | 0.26 | **0.67** | **0.71** | 0.12 | **0.61** | 0.17 | **0.47** | -0.08 | **0.48** | **0.40** | -0.24 | -0.04 | NA | NA | **0.40** | **0.45** |
| Discretionary sweet foods | **0.80** | 0.27 | **0.46** | **0.58** | **0.64** | 0.01 | **0.53** | 0.14 | **0.42** | -0.25 | **0.50** | **0.40** | 0.01 | -0.16 | **0.41** | **0.47** | **0.57** | **0.33** |
| Processed meat | **0.38** | -0.07 | -0.27 | 0.19 | **0.51** | **0.45** | **0.48** | 0.20 | **0.55** | 0.24 | **-0.17** | **0.61** | -0.08 | **-0.40** | **0.56** | **0.38** | **0.41** | **0.47** |
| Sweet beverages | **0.74** | 0.25 | **0.30** | **0.61** | **0.61** | -0.05 | **0.59** | 0.21 | **0.60** | -0.03 | **0.47** | **0.34** | -0.06 | **-0.42** | **0.41** | **0.39** | **0.61** | 0.20 |
| TV screen time | **0.51** | -0.21 | **0.62** | 0.13 | **0.52** | -0.20 | **0.53** | -0.12 | **0.55** | -0.20 | **0.46** | 0.16 | **0.68** | -0.10 | **0.54** | 0.13 | **0.51** | -0.02 |
| Other screen time | NA | NA | **0.44** | 0.10 | NA | NA | **0.49** | -0.04 | NA | NA | NA | NA | **0.67** | -0.11 | NA | NA | NA | NA |
| Outdoor play time | 0.12 | **0.34** | 0.09 | 0.15 | 0.17 | 0.20 | 0.21 | 0.06 | NA | NA | -0.25 | 0.13 | **-0.38** | -0.11 | -0.09 | 0.29 | 0.10 | **0.36** |
| Sleep duration | 0.00 | 0.08 | -0.10 | 0.06 | -0.28 | 0.12 | -0.23 | 0.08 | -0.20 | **0.33** | **-0.43** | -0.20 | **-0.39** | 0.10 | -0.24 | 0.14 | -0.10 | 0.01 |
| Variance explained | 20.6 | 14.1 | 15.1 | 19.4 | 20.6 | 14.1 | 17.8 | 13.4 | 15.7 | 18.9 | 18.1 | 14.7 | 11.8 | 12.7 | 16.5 | 18.5 | 19.9 | 14.3 |

1 For each cohort, the indicated year in the table refers to the one when the majority of EBRBs was ascertained

LP1: ‘unhealthy’ lifestyle pattern

LP2: ‘healthy’ lifestyle pattern (ALSPAC, ELFE, INMA, Piccolipiù) or ‘mixed’ lifestyle pattern (BiB, EDEN, MoBa, RHEA, SWS)

NA: Not available

**In bold:** factor loadings >0.30 or <-0.30

**Table 3a.** Associations between socio-economic and socio-demographic factors and the unhealthy lifestyle pattern in different European countries: β (95% CI) from complete-cases linear regressions.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **ALSPAC, 1991**  **(n=8,143)1** | | **BiB, 2007**  **(n=1,075)1** | | **EDEN, 2003**  **(n=1,269)1** | |
|  | Univariable | Multivariable | Univariable | Multivariable | Univariable | Multivariable |
| **Household income (EHII-score, quintiles2)** |  |  |  |  |  |  |
| Fifth | ref | ref | ref | ref | ref | ref |
| Fourth | 0.41 (0.31;0.50) | 0.26 (0.16;0.36) | -0.25 (-0.50;-0.01) | -0.26 (-0.52;0.00) | 0.04 (-0.18;0.27) | -0.04 (-0.27;0.18) |
| Third | 0.53 (0.43;0.63) | 0.22 (0.12;0.33) | -0.15 (-0.39;0.09) | -0.13 (-0.39;0.12) | 0.19 (-0.03;0.42) | -0.09 (-0.33;0.16) |
| Second | 0.72 (0.62;0.82) | 0.27 (0.16;0.38) | -0.66 (-0.90;-0.42) | -0.80 (-1.17;-0.44) | 0.76 (0.53;0.99) | 0.29 (0.00;0.57) |
| First | 1.03 (0.93;1.14) | 0.48 (0.35;0.60) | -0.43 (-0.67;-0.20) | -0.41 (-0.70;-0.12) | 1.08 (0.82;1.34) | 0.43 (0.10;0.77) |
| **Maternal education level at inclusion** |  |  |  |  |  |  |
| High | ref | ref | ref | ref | ref | ref |
| Medium | 0.94 (0.84;1.01) | 0.79 (0.70;0.89) | -0.24 (-0.49;0.00) | -0.48 (-0.75;-0.20) | 0.77 (0.62;0.93) | 0.57 (0.35;0.78) |
| Low | 1.54 (1.44;1.65) | 1.23 (1.09;1.37) | 0.27 (0.09;0.45) | -0.18 (-0.45;0.10) | 1.39 (1.03;1.75) | 0.97 (0.55;1.40) |
| **Maternal age at delivery (years)** | -0.02 (-0.03;-0.01) | -0.02 (-0.02;-0.01) | -0.01 (-0.02;0.01) | 0.01 (0.00;0.03) | -0.03 (-0.05;-0.01) | -0.01 (-0.03;0.01) |
| **Parity** |  |  |  |  |  |  |
| Primiparity | ref | ref | ref | ref | ref | ref |
| Multiparity | 0.32 (0.26;0.38) | 0.19 (0.12;0.26) | 0.06 (-0.10;0.21) | -0.10 (-0.28;0.08) | 0.09 (-0.07;0.24) | 0.05 (-0.11;0.22) |
| **Child's sex** |  |  |  |  |  |  |
| Girls | ref | ref | ref | ref | ref | ref |
| Boys | 0.09 (0.03;0.15) | 0.08 (0.02;0.15) | -0.14 (-0.29;0.01) | -0.15 (-0.31;0.00) | 0.17 (0.01;0.32) | 0.17 (0.02;0.32) |

CI: Confidence intervals, ref: reference category

1n for multivariable analyses (adjusted for all variables displayed in the table)

2The higher the quintiles, the higher the incomes

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **ELFE, 2011**  **(n=10,228)1** | | **INMA, 2003**  **(n=1,833)1** | | **MoBa, 1999**  **(n=49,287)1** | |
|  | Univariable | Multivariable | Univariable | Multivariable | Univariable | Multivariable |
| **Household income (EHII-score, quintiles2)** |  |  |  |  |  |  |
| Fifth | ref | ref | ref | ref | ref | ref |
| Fourth | 0.19 (0.12;0.26) | 0.15 (0.08;0.22) | 0.20 (0.03;0.37) | 0.09 (-0.09;0.28) | -0.06 (-0.10;-0.03) | -0.04 (-0.08;-0.01) |
| Third | 0.42 (0.34;0.49) | 0.31 (0.23;0.39) | 0.45 (0.28;0.62) | 0.21 (-0.01;0.42) | 0.19 (0.16;0.23) | 0.15 (0.12;0.19) |
| Second | 0.77 (0.70;0.85) | 0.53 (0.44;0.62) | 0.65 ( 0.48;0.82) | 0.36 (0.14;0.59) | 0.44 (0.41;0.48) | 0.22 (0.18;0.26) |
| First | 1.57 (1.48;1.65) | 1.16 (1.05;1.27) | 0.66 (0.49;0.83) | 0.31 (0.07;0.55) | 0.42 (0.38;0.46) | 0.19 (0.14;0.24) |
| **Maternal education level at inclusion** |  |  |  |  |  |  |
| High | ref | ref | ref | ref | ref | ref |
| Medium | 0.81 (0.75;0.86) | 0.29 (0.22;0.36) | 0.41 (0.29;0.52) | 0.25 (0.09;0.42) | 0.47 (0.44;0.49) | 0.31 (0.27;0.34) |
| Low | 1.49 (1.37;1.60) | 0.78 (0.64;0.92) | 0.58 (0.45;0.72) | 0.39 (0.18;0.58) | 0.74 (0.66;0.83) | 0.56 (0.46;0.66) |
| **Maternal age at delivery (years)** | -0.04 (-0.04;-0.03) | -0.01 (-0.02;-0.01) | -0.03 (-0.05;-0.02) | -0.03 (-0.04;-0.01) | -0.02 (-0.02;-0.01) | -0.01 (-0.02;-0.01) |
| **Parity** |  |  |  |  |  |  |
| Primiparity | ref | ref | ref | ref | ref | ref |
| Multiparity | 0.22 (0.16;0.27) | 0.14 (0.09;0.20) | 0.02 (-0.08;0.12) | 0.07 (-0.05;0.19) | 0.23 (0.21;0.25) | 0.28 (0.25;0.30) |
| **Child's sex** |  |  |  |  |  |  |
| Girls | ref | ref | ref | ref | ref | ref |
| Boys | 0.13 (0.08;0.18) | 0.14 (0.09;0.18) | 0.14 (0.03;0.24) | 0.10 (-0.01;0.22) | 0.14 (0.12;0.16) | 0.14 (0.12;0.17) |

**Table 3b.** Associations between socio-economic and socio-demographic factors and the unhealthy lifestyle pattern in different European countries: β (95% CI) from complete-cases linear regressions.

CI: Confidence intervals, ref: reference category

1n for multivariable analyses (adjusted for all variables displayed in the table)

2The higher the quintiles, the higher the incomes

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Piccolipiù, 2011**  **(n=2,126)1** | | **RHEA, 2003**  **(n=1,136)1** | | **SWS, 1998**  **(n=1,853)1** | |
|  | Univariable | Multivariable | Univariable | Multivariable | Univariable | Multivariable |
| **Household income (EHII-score, quintiles2)** |  |  |  |  |  |  |
| Fifth | ref | ref | ref | ref | ref | ref |
| Fourth | 0.21 (0.07;0.36) | 0.17 (0.03;0.32) | 0.30 (0.08;0.53) | 0.18 (-0.07;0.43) | 0.48 (0.29;0.66) | 0.13 (-0.05;0.32) |
| Third | 0.26 (0.11;0.41) | 0.17 (0.02;0.33) | 0.17 (-0.06;0.39) | -0.01 (-0.28;0.26) | 0.74 (0.55;0.93) | 0.22 (0.01;0.43) |
| Second | 0.17 (0.02;0.32) | 0.04 (-0.13;0.21) | 0.48 (0.26;0.71) | 0.28 (-0.00;0.57) | 1.14 (0.95;1.33) | 0.44 (0.23;0.66) |
| First | 0.41 (0.25;0.57) | 0.28 (0.08;0.47) | 0.65 (0.42;0.87) | 0.44 (0.12;0.75) | 1.52 (1.33;1.71) | 0.63 (0.40;0.85) |
| **Maternal education level at inclusion** |  |  |  |  |  |  |
| High | ref | ref | ref | ref | ref | ref |
| Medium | 0.24 (0.15;0.34) | 0.20 (0.08;0.31) | 0.31 (0.15;0.46) | 0.21 (-0.01;0.42) | 0.92 (0.81;1.04) | 0.55 (0.39;0.72) |
| Low | 0.35 (0.19;0.51) | 0.29 (0.10;0.48) | 0.45 (0.26;0.64) | 0.18 (-0.10;0.46) | 1.64 (1.47;1.82) | 1.10 (0.85;1.34) |
| **Maternal age at delivery (years)** | 0.01 (0.00;0.02) | 0.02 (0.00;0.03) | -0.03 (-0.04;-0.01) | -0.01 (-0.03;0.00) | -0.07 (-0.08;-0.05) | -0.05 (-0.07;-0.04) |
| **Parity** |  |  |  |  |  |  |
| Primiparity | ref | ref | ref | ref | ref | ref |
| Multiparity | 0.17 (0.07;0.26) | 0.09 (-0.01;0.19) | -0.07 (-0.20;0.06) | -0.09 (-0.24;0.07) | 0.74 (0.64;0.85) | 0.53 (0.41;0.65) |
| **Child's sex** |  |  |  |  |  |  |
| Girls | ref | ref | ref | ref | ref | ref |
| Boys | -0.01 (-0.11;0.08) | -0.02 (-0.12;0.07) | 0.11 (-0.02;0.23) | 0.10 (-0.05;0.24) | 0.14 (0.04;0.25) | 0.08 (-0.05;0.18) |

**Table 3c.** Associations between socio-economic and socio-demographic factors and the unhealthy lifestyle pattern in different European countries: β (95% CI) from complete-cases linear regressions.

CI: Confidence intervals, ref: reference category

1n for multivariable analyses (adjusted for all variables displayed in the table)

2The higher the quintiles, the higher the income

**Table 4.** Cross-sectional associations between the unhealthy lifestyle pattern and BMI z-scores or overweight status in different European countries: β or OR (95% CI) from complete-cases linear or logistic regressions.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | BMI status at preschool age1 | | | |
|  |  | BMI z-scores  β (95% CI) | | Overweight  OR (95% CI) | |
|  |  |
|  | | Univariable | Multivariable2 | Univariable | Multivariable2 |
| Unhealthy lifestyle pattern at preschool age3 | |  |  |  |  |
| **ALSPAC (n=952), 3 years** |  | 0.02 (-0.02;0.06) | 0.01 (-0.03;0.06) | 1.02 (0.88;1.19) | 0.98 (0.82;1.16) |
| **BIB (n=878), 3 years** |  | -0.05 (-0.10;0.00) | -0.05 (-0.10;0.00) | 0.94 (0.78;1.13) | 0.95 (0.77;1.16) |
| **EDEN (n=1,246), 3 years** |  | 0.00 (-0.03;0.04) | 0.00 (-0.03;0.04) | 1.09 (0.88;1.34) | 1.04 (0.83;1.31) |
| **ELFE (n=6,277), 3.5 years** |  | 0.03 (0.01;0.04) | 0.00 (-0.02;0.02) | 1.15 (1.06;1.26) | 1.00 (0.89;1.12) |
| **INMA (n=1,471), 4 years** |  | 0.06 (0.02;0.09) | 0.06 (0.02;0.10) | 1.26 (1.13;1.42) | 1.28 (1.13;1.44) |
| **MOBA (n=36,108), 3 years** |  | -0.03 (-0.03;-0.02) | -0.03 (-0.04;-0.02) | 0.99 (0.96;1.02) | 0.97 (0.94;1.00) |
| **Piccolipiù (n=1,782), 4 years** |  | 0.06 (0.02;0.10) | 0.06 (0.02;0.10) | 1.19 (1.00.1.42) | 1.18 (0.99.1.42) |
| **RHEA (n=718), 4 years** |  | 0.03 (-0.02;0.09) | 0.02 (-0.05;0.09) | 1.15 (0.99;1.32) | 1.12 (0.96;1.31) |
| **SWS (n=1,783), 3 years** |  | 0.02 (-0.01;0.05) | 0.00 (-0.04;0.03) | 1.22 (1.10;1.36) | 1.11 (0.96;1.28) |

1On average BMI ascertained at – mean in years (SD), for ALSPAC: 3.5 (0.1); BiB: 3.1 (0.1); EDEN: 3.1 (0.1); ELFE: 3.4 (0.3); INMA: 4.3 (0.1); MoBa: 3.0 (0.0); Piccolipiù: 4.4 (0.2); RHEA: 4.2 (0.1); SWS: 3.1 (0.09)

2 Analyses adjusted for: household income, maternal age at delivery, maternal educational level, parity, and child sex

3 For each cohort, the indicated year refers to the one when the majority of EBRBs was ascertained