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Childhood BMI trajectories and sociodemographic factors in an Italian pediatric population

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Childhood obesity is a growing global concern due to its long-term health consequences. Yet, more research relying on multiple time-point BMI measurements is warranted to gain further insight into obesity's temporal trends. We aimed to identify BMI trajectories in children aged 2–10 years and evaluate their association with sociodemographic factors. This retrospective cohort study utilized data from the PEDIANET registry, containing sociodemographic, clinical, and prescribing information on patients assisted by Italian family pediatricians, linked to the corresponding area deprivation index. 29,576 children with at least 10 years of follow-up, born at term with normal birthweight, and at least three plausible BMI measurements were identified. BMI z-score trajectories were calculated using Group-Based Trajectory Modeling, and mixed multinomial logistic regression was used to assess their association with the sociodemographic factors. A secondary analysis examined BMI trajectories from ages 2–7 years ($n = 58,509$). Four BMI z-scores trajectories, all with quadratic shape, were identified as the optimal fit: "stable-low-weight" (27.5%), "normal-weight" (40.9%), "stable-moderate-increase" (24.2%), and "overweight-to-obese" (7.5%). Females, children residing in Southern and Island regions, and those from more deprived socioeconomic areas had a higher probability of following the "overweight-to-obese" group compared to the "normal-weight" trajectory. Sex and area of residence had similar effects on the "stable-moderate-increase" trajectory. Conversely, females and children residing in Central Italy were less likely to belong to the "stable-low-weight trajectory". This study highlighted a considerable heterogeneity in BMI trajectories in pediatric age, emphasizing the effect of sociodemographic inequalities on growth patterns with models capable of capturing the dynamic nature of the phenomenon.

Keywords Body mass index, Trajectory, Childhood obesity, Sociodemographic factors, Childhood overweight, Social inequalities

Abbreviations

ADI	Area deprivation index
BIC	Bayesian Information Criterion
BMI	Body mass index
FP	Family pediatricians
GBTM	Group-based trajectory modelling
MMNL	Mixed multinomial logistic regression
n.a	Not applicable
OB	Obesity
<OW	Overweight

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Obesity is an important risk factor for multiple diseases, including cardiovascular and kidney diseases, diabetes, certain cancers, and musculoskeletal disorders. Early childhood appears critical for developing lifelong excess body mass index (BMI). A recent systematic review found children and adolescents with obesity were around five times more likely to have obesity in adulthood compared with children without obesity[1].

The prevalence of childhood obesity has been steadily increasing worldwide, raising concerns about the long-term consequences for children's health and well-being[2,3]. Understanding the factors contributing to these trends is crucial for developing effective interventions and policies to curb this public health challenge.

While social inequalities in childhood overweight and obesity are well-documented, there is a significant knowledge gap regarding the initial emergence and subsequent evolution of this social gradient. Addressing these social disparities is crucial due to the well-established short- and long-term detrimental health effects associated with early-life overweight (OW) and obesity (OB).

Socioeconomic inequalities in children's BMI trajectories may evolve over time[4]. This is because children from lower socioeconomic backgrounds may be more likely to experience certain factors early in life, like less breastfeeding, poorer feeding practices, and less healthy habits, and these can have a lasting impact on their weight trajectory[4]. To address these disparities effectively, we need to comprehend when and how they arise in early life and how they progress with increasing age.

While most epidemiological studies have focused on the association between early childhood BMI and later health outcomes, recent research has increasingly utilized group-based trajectory modelling to investigate the developmental trajectory of BMI or BMI z-score in childhood[5–8]. These studies have revealed variability in the timing at which distinct BMI trajectories emerge, suggesting that sociodemographic factors and other environmental influences may play a role in shaping these trajectories.

In an effort to provide further insights into the dynamic nature of paediatric growth patterns, this study aims to characterize the development of BMI trajectories among children aged 2 to 10 years old assisted by family paediatricians (FPs) and included in the PEDIANET network, a well-established electronic health record database specifically designed for pediatric care covering around 4% of the annual pediatric population[9]. Furthermore, this study aimed to determine whether these trajectories are associated with several sociodemographic factors.

Methods

Study population

We used data from Pedianet (http://www.pedianet.it/en), an independent network of more than 200 family paediatricians (FPs) established in 1998 to collect information from outpatient routine clinical care in Italy. The network covers around 4% of the Italian paediatric population and has previously been described in detail[10]. Pedianet records several types of patient-level information, including demographic data, health status, clinical symptoms, and outcomes. In particular, this study used information regarding demographic data, prescriptions, healthcare co-payment exemptions, and growth parameters. In Italy, family paediatricians (FPs) have been considered by the Ministry of Health as physicians responsible for performing regular "mandatory" well-child visits for preventive medicine purposes at specific time points during which the child's anthropometric measurements are recorded. Data generated during routine patient care were collected and handled anonymously, in compliance with Italian regulations, and stored under a unique numerical identifier. In accordance with Italian data privacy regulations, data is anonymized by assigning a unique numerical identifier to each record. Anonymized data is transmitted monthly to a centralized database located in Padua for validation purposes. Participation in the Pedianet database is voluntary, and informed consent is obtained from parents or legal guardians for the storage and use of their child's anonymized data for research purposes.

We identified all children born between 2004 and 2012, followed from birth to at least ten years ($n = 57{,}811$). Children were required to be born at term (above 37 gestational weeks) and weighed more than 2500 g at birth, as preterm and low birth weight infants follow distinct growth patterns. Additionally, children with genetic diseases or syndromes, such as achondroplasia, Cornelia de Lange syndrome, Down syndrome, Prader-Willi syndrome, Turner syndrome, and Williams syndrome, as indicated by the presence of specific healthcare co-payment exemptions, were excluded due to their unique growth trajectories ($n = 53{,}406$)[11–13]. Children with chronic conditions that developed after birth were instead included in the analysis.

Finally, we included only children having at least one biologically plausible BMI measurement (i.e., z-score <-4 and z-score >8) for each selected time frame ([24–60) months, [60–96) months, [96–132) months) ($n = 33{,}627$) (Table S1 in Multimedia Appendix 1). The definition of biologically plausible BMI values derives from the recommendations made by the WHO expert committee in the mid-1990s during the development of the standard growth charts and has been widely used since then[14].

Children with inaccurate addresses (therefore having missing information on their census block section) were also excluded ($n = 4{,}051$; 11.9%). The final cohort comprised 29,576 children with 223,704 BMI measurements (Fig. S1 in Multimedia Appendix 1).

We adhered to the STROBE guidance for reporting on observational studies.

This study was conducted in accordance with the tenets of the Declaration of Helsinki and was compliant with the European Network of Centres for Pharmacoepidemiology and Pharmacovigilance's Guide on Methodological Standards in Pharmacoepidemiology. The Internal Scientific Committee of Società Servizi Telematici Srl, the legal owner of Pedianet, approved the study and access to the database. According to Italian law, observational, retrospective, non-interventional studies do not require the approval by an ethics committee in Italy.

Outcomes

Data for weight and height were retrieved from the growth parameters recorded during the well-child visits and ascertained longitudinally from 2 years until the end of the follow-up period. BMI was calculated as weight (kg)/height2 (m^2) and transformed into age-and-sex-specific z-score using the World Health Organization (WHO)

Growth References. BMI z-scores were calculated according to WHO growth standards before the analyses[15–17]. Biologically implausible BMI z-score values (i.e., z-score <− 4 and z-score > 8) were excluded from the analysis[18].

Covariates

We considered additional factors that may affect the growth patterns of children, such as birth year (subsequently classified in [2004–2008], (2008–2012]), sex, region of residence (subsequently classified in north-east, Northwest, centre, south & islands), and FP.

Socioeconomic position (SEP) was measured by means of an area deprivation index (ADI), computed at the census block level retrieved from the 2011 Italian Census[19], through a record linkage of children's geo-referenced addresses (for a more detailed description, see[20]). The index, calculated as the sum of 5 standardized indicators of social and material deprivation (low education, unemployment, living on rent, crowded households, and single-parent families), was then categorized in quintiles based on the regional ADI level to ensure within-region appropriately represented categories.

Statistical analyses

Defining BMI trajectories

Trajectories of childhood BMI status were identified by GBTM, a finite mixture semi-parametric model for longitudinal data[21].

We estimated possible combinations of trajectory shapes (linear, quadratic, or cubic), in 2,3,4,5 trajectory models. We considered several factors to determine trajectory shape and number, including a model minimizing the Bayesian information criterion (BIC), enabling the best repartition of subjects and interpretation. Once the final model was determined, the posterior probabilities (on average should exceed the recommended 0.7 cutoff) and percentage of group membership (it is recommended that each group holds at least 5% group membership[22]) were assessed to ensure the most optimal model further. Per Proust-Lima's recommendations, models with two or more trajectories were run multiple times to avoid convergence issues often encountered in fitting mixture models.

We also performed several sensitivity analyses to assess the robustness of the optimal solution identified with the main approach: (1) modelling trajectories including children with missing information on the ADI; (2) modelling trajectories separately for boys and girls; (3) modelling trajectories including only children having a maximum number of BMI measurements below the 95th percentile (more than 15 measurements). To evaluate differences in the estimated trajectories across these approaches, misclassification errors (instances where individuals are assigned to a different trajectory group in the sensitivity analysis compared to their group in the main analysis) and mean errors (average deviation of the misclassification errors across each group).

Investigating the association with sociodemographic factors

To examine differences in the identified trajectories, we tested their associations with the considered set of sociodemographic factors using a multinomial logistic regression with a random intercept on the FP (MMNL). We calculated odds ratios (ORs) for membership in each trajectory vs. the reference group exhibiting normal growth, adjusting for sex, birth year, area of residence and ADI.

Moreover, we opted to investigate sociodemographic determinants of BMI trajectories separately for boys and girls, using the optimal solution selected via sex-specific GBTMs.

MMNL were also fitted including children lacking individual ADI measurements, aiming to assess the potential impact on the results had these children been included in the analyses (considering them as an additional category of the ADI).

Analyses on children up to 7 years old

In a secondary analysis, BMI z-score trajectories were only analyzed from the 2nd to the 7th year of age, while assessing their association with sociodemographic factors using the same step-by-step approach employed in the main analysis. This decision was made to include a larger number of children, as a significant portion were excluded due to incomplete follow-up data within the third time frame (96 to 132 months). This exclusion might be attributed to the fact that 7 years of age marks a national cutoff for well-child visits[23]. We identified all children born between 2004 and 2015, followed from birth to at least seven years ($n = 92{,}974$). We followed the same exclusion criteria applied in the overall population but included children having at least one BMI measurement in two of the selected time-frame instead of three ([24–60) months, [60–96) months) ($n = 66{,}944$). Children with missing information on the ADI were also excluded ($n = 8{,}435$; 12.6%), leaving 58,509 children in the final cohort (Figure S2 in Multimedia Appendix 1).

Analyses were performed using the statistical software R[24]. We employed "lcmm"[22], and "lme4"[25] packages to conduct GBTM and MMNL, respectively. Results with p-values < 0.05 were considered statistically significant.

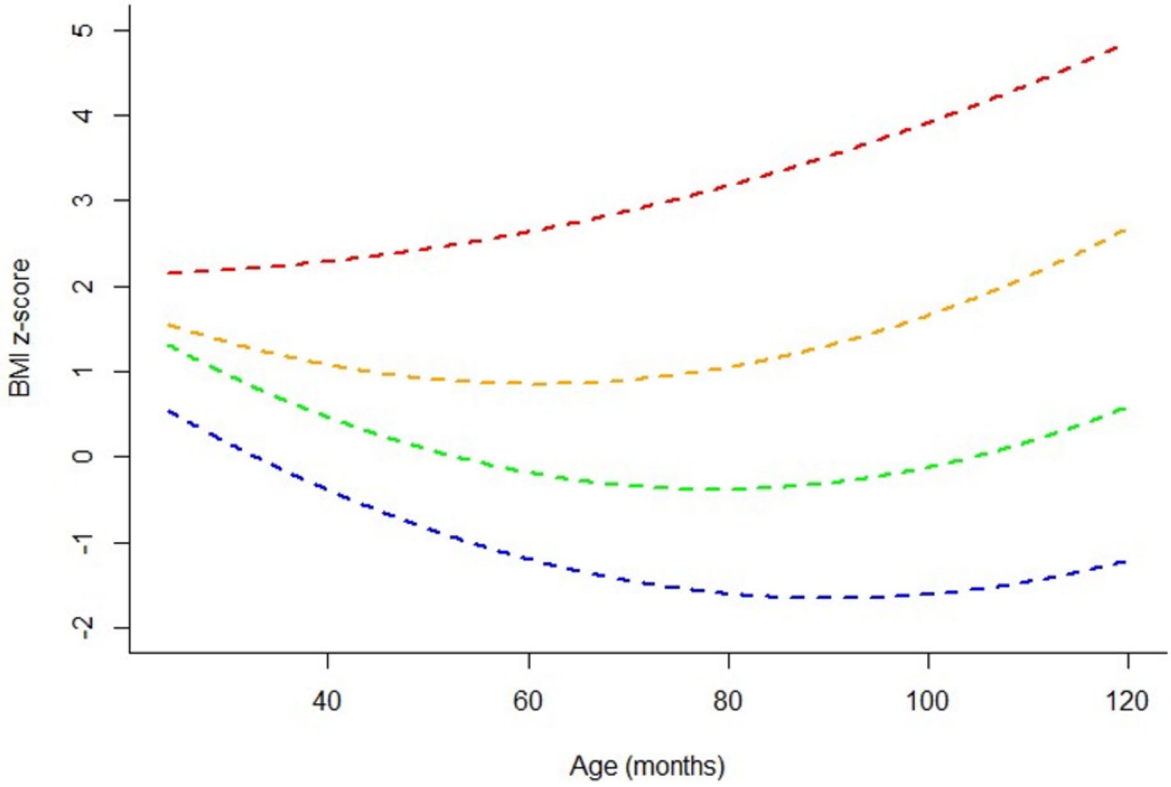
Results

Description of the cohort

The general characteristics of the study population are reported in Table S2 (Multimedia Appendix 1). Among the 29,576 children included in the study, 15,469 were boys (52.3%), and 14,107 were girls (47.7%). They were followed by 178 FPs with a median number of BMI measurements of 7 (IQR:5–9, min-max:3–44). Of the overall cohort, most children were born between 2004 and 2008 (67%), and resided in the North-east (39%). The distribution of the ADI quintiles of the children in the study exhibited a lower percentage of individuals in the most deprived category (16.4%).

Number of classes	BIC	% of children per class	Mean posterior probabilities	% of posterior probabilities > 0.7
1	820,461.40	100	n.a	n.a
2	686,451.7	66.97/33.03	0.98/0.96	97.57/95.21
3	625,389.9	43.2/42.86/13.95	0.96/0.95/0.97	95.14/93.71/95.56
4	**594,291.3**	**27.49/40.86/24.17/7.48**	**0.94/0.92/0.94/0.97**	**92.37/90.62/92.64/95.25**
5	576,216.8	35.7/28.26/16.86/14.46/4.73	0.91/0.91/0.93/0.94/0.96	88.45/89.28/90.95/92.00/94.78

Table 1. Model comparison indices for models with different numbers of quadratic trajectory shape classes. *BIC* Bayesian Information Criterion, *n.a* not applicable. The best-fitting model is highlighted in bold.



Class		n° measurements (%)	n° subjects (%)
	1^{st}: stable-low weight	62,139 (27.88)	8,132 (27.49)
	2^{nd}: normal weight	89,057 (39.81)	12,085 (40.86)
	3^{rd}: stable-moderate increase	54,882 (24.53)	7,148 (24.17)
	4^{th}: overweight to obese	17,626 (7.88)	2,211 (7.48)

Fig. 1. BMI z-score trajectories identified via GBTM ($n = 29{,}576$).

Estimated trajectories of BMI z-scores

Quadratic trajectory shapes (Table S3 in Multimedia Appendix 1) with a 4-trajectory solution had the best-fitting minimizing BIC, and enabling an adequate repartition of subjects (at least 5% participants per group) and interpretation (Table 1). The four identified trajectories were labelled based on their shape over time as "stable-low weight" (27.5%), "normal weight" (40.9%), "stable-moderate increase" (24.2%), and "overweight to obese" (7.5%), as shown in Fig. 1.

Sensitivity analyses confirmed the robustness of the trajectory model. Excluding participants with missing ADI data (Fig. S3 in Multimedia Appendix 1), stratifying by sex (Figure S4 in Multimedia Appendix 1), and limiting the analysis to individuals with a number of BMI measurements above the 95th percentile (which corresponded to 15 measurements, $n = 28{,}151$) (Fig. S5 in Multimedia Appendix 1), yielded consistent results.

Characteristics		Stable-low weight (*n* = 8132)	Normal weight (*n* = 12,085)	Stable-moderate increase (*n* = 7148)	Overweight to obese (*n* = 2211)	Total (*n* = 29,576)
Sex—no. (%)	Males	4873 (59.92)	6087 (50.37)	3421 (47.86)	1088 (49.21)	15,469 (52.3)
	Females	3259 (40.08)	5998 (49.63)	3727 (52.14)	1123 (50.79)	14,107 (47.7)
Birth cohort—no. (%)	[2004–2008]	5374 (66.08)	8177 (67.66)	4793 (67.05)	1485 (67.16)	19,829 (67.04)
	(2008–2012]	2758 (33.92)	3908 (32.34)	2355 (32.95)	726 (32.84)	9747 (32.96)
Area of residence—no. (%)	North-east	3339 (41.06)	4829 (39.96)	2639 (36.92)	726 (32.84)	11,533 (38.99)
	Northwest	1139 (14.01)	1729 (14.31)	862 (12.06)	233 (10.54)	3963 (13.4)
	Center	1609 (19.79)	2592 (21.45)	1414 (19.78)	342 (15.47)	5957 (20.14)
	South & Islands	2045 (25.15)	2935 (24.29)	2233 (31.24)	910 (41.16)	8123 (27.46)
ADI quintile—no. (%)	1	1745 (21.46)	2605 (21.56)	1475 (20.64)	385 (17.41)	6210 (21)
	2	1760 (21.64)	2633 (21.79)	1493 (20.89)	441 (19.95)	6327 (21.39)
	3	1717 (21.11)	2552 (21.12)	1559 (21.81)	513 (23.2)	6341 (21.44)
	4	1568 (19.28)	2379 (19.69)	1412 (19.75)	500 (22.61)	5859 (19.81)
	5	1342 (16.5)	1916 (15.85)	1209 (16.91)	372 (16.82)	4839 (16.36)

Table 2. Descriptive characteristics of the study population by BMI z-score trajectory groups.

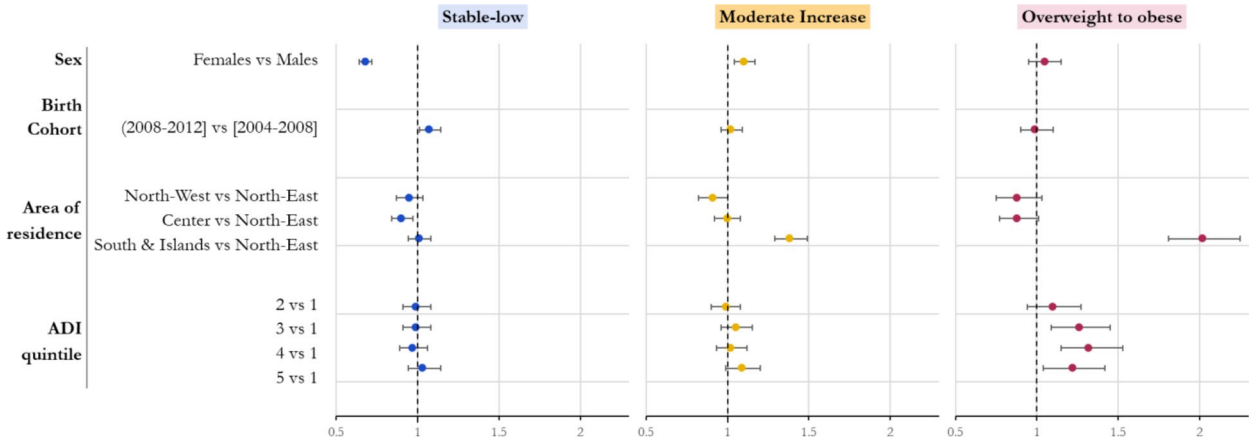


Fig. 2. Association between sociodemographic factors and BMI z-score trajectories in children aged 2–10 years (*n* = 29,576). Odds ratios and corresponding 95% confidence intervals (OR (95% CI)) for membership to each trajectory compared to the "normal weight" trajectory.

These analyses demonstrated minimal misclassification errors (mean errors < 10%) and maintained the 4-class quadratic trajectories as solution.

Association with BMI trajectories

Characteristics of the participants in each BMI z-score trajectory are described in Table 2.

Multivariate analysis revealed several significant associations between factors influencing children's weight trajectories and deviations from a "normal weight" path (Fig. 2, Table S4 in Multimedia Appendix 1).

Girls, children living in the Central area and those born earlier were less likely to be classified in the lowest weight trajectory compared to boys (OR: 0.68; 95% CI: 0.64, 0.72), those living in the Northeast (OR: 0.90; 95% CI: 0.84, 0.97), and those born later (OR: 1.07; 95% CI: 1.01, 1.14), respectively. Girls and children living in the South & Islands were more likely to follow the "stable-moderate increase" trajectory than boys and those residing in the Northeast (ORs: 1.10 with 95% CI: 1.04, 1.17; and 1.38 with 95% CI: 1.29, 1.49, respectively). Moreover, children in the Northwest were less likely to be in this group than Northeast children (OR: 0.91; 95% CI: 0.82, 0.99). Last, we observed that the risk of membership to the "overweight to obese" trajectory more than doubled for children living in the South & Islands (OR: 2.02; 95% CI: 1.81, 2.25) and significantly increased (ORs: 1.26 with 95% CI: 1.09, 1.45;1.32 with 95% CI: 1.15, 1.53; and 1.22 with 95% CI: 1.04, 1.42) for children being in the 3rd, 4th, and 5th ADI quintiles, compared to children residing in the Northeast and in the least deprived areas, respectively.

Including children with missing ADI data in the yielded to broadly similar associations to those found in the primary analysis. Those belonging to the "missing ADI" category showed an increased risk of membership to both the "stable-moderate increase" and "overweight to obese" trajectory compared to the reference (ORs: 1.15; 95% CI: 1.04, 1.28; and 1.27; 95% CI: 1.08, 1.49, respectively) (Table S5 in Multimedia Appendix 1).

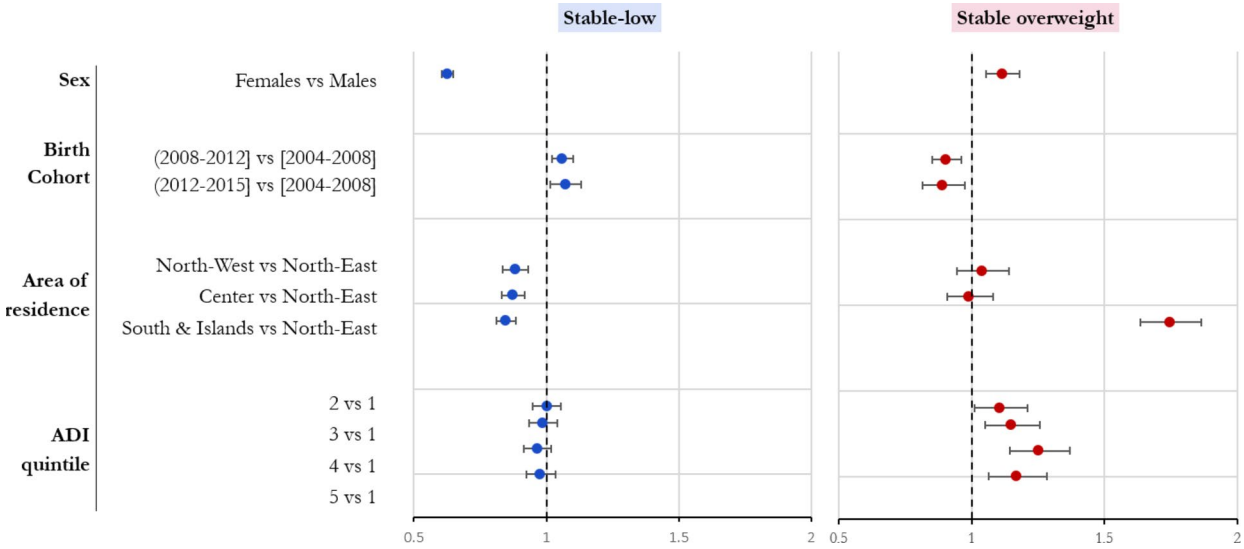


Fig. 3. Association between sociodemographic factors and BMI z-score trajectories in children aged 2–7 years ($n = 58,509$). Odds ratios and corresponding 95% confidence intervals (OR (95% CI)) for membership to each trajectory compared to the "normal weight" trajectory.

When multivariate analyses were conducted separately for boys and girls, the observed findings closely aligned with those derived from the entire cohort, thereby corroborating the significance of the examined sociodemographic factors on BMI trajectory membership (Table S6 in Multimedia Appendix 1). Living in the South & Islands or more deprived areas significantly increased the probability of membership in the highest trajectory compared to living in the North-East or the least deprived areas, respectively (Table S6 in Multimedia Appendix 1).

Secondary analysis: children up to 7 years old

58,509 children with 286,746 measurements were included in the secondary analysis for modelling trajectories from the 2nd to the 7th year of age (Fig. S2 in Multimedia Appendix 1). These were followed by 187 FPs with a median number of measurements of 4 (IQR: 3–6, min-max:2–40).

Quadratic trajectory shapes with a 3-trajectory solution had the best fitting minimizing BIC, and enabling an adequate repartition of subjects and interpretation (Fig. S6 in Multimedia Appendix 1). The three identified trajectories were labelled as "stable-low weight" (44.9%), "normal weight" (44.8%), and "stable overweight" (10.3%) (Fig. S6 in Multimedia Appendix 1); and descriptive characteristics by trajectory groups are reported in Table S7 (Multimedia Appendix 1).

When investigating the multivariate association of the BMI z-score trajectories with the considered factors, the associations observed in the 2 to 10-year-old children were generally confirmed (Fig. 3, Table S8 in Multimedia Appendix 1).

Discussion

Principal results and comparison with prior work

This study used longitudinal data collected from early childhood to the beginning of adolescence, identifying four groups of children with distinct BMI trajectories. While many participants were classified as being in the normal-weight group (40.9%), a large proportion were classified as having low BMI trajectory (e.g., "stable-low weight"; 27.5%) or high BMI trajectories (e.g., "stable-moderate increase" and "overweight to obese"; 24.2% and 7.5%, respectively).

Our findings align with previous research in identifying a four-trajectory model as the best fit for categorizing patients based on weight changes[6,8]. Notably, the group transitioning from overweight to obese showed distinct BMI levels from the others as early as two years old. This suggests potential risk factors influencing weight gain, even in early childhood. Identifying and targeting these factors through large-scale public health interventions is crucial.

Our findings reveal sociodemographic variations across trajectories, notably influenced by sex, birth cohort, and area of residence. In multivariate analyses, child's sex and area of residence emerged as main determinants, with girls and those in South & Islands more likely to belong to higher BMI trajectories. Conversely, females and children in the Center had lower risk of the "stable-low weight" trajectory. Additionally, the 2004–2008 cohort had higher probability compared to 2008–2012 and ADI was associated with increased obesity risk in higher deprivation quintiles.

Regarding sex differences, the higher proportion of overweight or obesity in girls compared to boys is consistent with what is described in previous literature[26]. This pattern may be explained by two main factors: lower basal metabolism and macronutrient metabolism imbalance favoring lipid synthesis and adipose tissue

accumulation in females compared to males[27,28]. Furthermore, our analyses performed separately for both sexes have confirmed the remaining findings described for the population as a whole.

Another fundamental factor related to the risk of belonging to the "overweight to the obese" trajectory is the region of residence, with a significant increase in risk for the South & Island group. These data are consistent with what is described in Italian epidemiological studies[29]. Differences in income levels, access to healthy food options, and availability of safe physical activity spaces might vary across regions.

Longitudinal studies consistently highlight socioeconomic disparities in childhood obesity onset, with deprivation elevating the risk of the "overweight to obese" trajectory. Economic constraints on maintaining a healthy diet and limited nutritional education are significant contributors[5].

In the sensitivity analysis where patients with inaccurate addresses were also included, this subpopulation had a significant association with the overweight to obese trajectory. This finding leads to the hypothesis, as discussed by other researchers, that those who reported incomplete or incorrect data on their residence might belong to socially vulnerable groups[8].

Another point of discussion revolves around the age at which the SEP begins to impact BMI trajectories. While our study observes associations between SEP and BMI trajectory groups, it does not allow us to pinpoint the exact timing of when such differences emerge. However, the results suggest that SEP-related factors may influence BMI trajectories from early ages, potentially reflecting the role of risk factors in the early development of obesity (such as prenatal maternal factors, breastfeeding, etc.), which are intricately linked with the SEP of the family unit. This interpretation aligns with findings from other studies conducted in France and Denmark[30,31].

Finally, the secondary analysis conducted in the population from 2 to 7 years of age identified only three trajectories for the best fit, which, however, confirmed the associations previously described in our study, mainly referring to the preschool population, with a caseload almost double that of the main analysis. As previously mentioned, the preschool population belonging to the "stable overweight" group presents a high risk of maintaining the obesity condition into adulthood, with the consequent associated metabolic risk[1].

These findings underscore the importance of identifying factors that might increase a child's susceptibility to taking on unhealthy growth trajectories. By identifying these potential risks and implementing corrective interventions from early childhood, we can potentially prevent the onset of overweight or obesity in children or mitigate the worsening of an existing condition during their preschool years.

The strengths of this study include the large sample size and the prospective assessments of weight and height over an extended follow-up period, enabling the analysis of BMI trajectories from early childhood through early adolescence.

By utilizing BMI z-scores, we focused on relative deviations in BMI from normative growth patterns and tracked how these deviations evolve over time. This approach is crucial for identifying distinct growth trajectories and their associations with socio-demographic factors. Growth modelling was particularly advantageous, as it allowed us to estimate predicted growth at any age accounting for variations in the timing and frequency of real-word measurements, thereby minimising the risk of misclassification and attrition bias.

Although the potential for selection bias at inclusion cannot be completely ruled out, its impact on the generalizability of findings is likely minimal. The analysis was restricted to children with available BMI measurements across the study period; however, the distribution of ADI quintiles among participants closely mirrored that of the national population, supporting the representativeness of the sample.

Although BMI measurements were objective, the possibility of reporting errors cannot be excluded. Implausible values were identified and removed during data cleaning to ensure accuracy and variability in measurement practices across family clinics was addressed by controlling for inter-pediatrician differences in the modelling design. While clothing weight was not explicitly accounted for, we assume its average influence on the results to be negligible.

A notable limitation of this study is the absence of comprehensive individual-level socioeconomic data. Although the census block-level deprivation index is a simplified measure that may not fully capture individual factors, it serves as a reliable proxy for socioeconomic status and provides a meaningful comparative measure of socioeconomic background. Furthermore, while BMI standardization accounts for some demographic variability, this study could not explicitly examine differences in BMI trajectories among migrant populations due to the absence of individual-level data on migration status. Nevertheless, our previous work suggests that the lowest ADI quintile likely includes a higher proportion of foreign-born individuals, underscoring the ADI's utility in identifying socioeconomically disadvantaged groups[20].

Finally, our focus on a limited set of demographic and socioeconomic characteristics highlights the need for future research to incorporate a broader range of personal risk factors, such as acute illnesses or other conditions that may influence BMI changes.

Conclusions

This study shows heterogeneity in patterns of growth trajectories, emphasizing the need to investigate dynamic patterns of children's body mass changes. Our findings also point to the possibility that social inequalities may contribute to the development of specific BMI trajectories over time. By considering multiple time points, this work can assess the potential impact of sociodemographic factors, uncover underlying determinants and inform targeted interventions to mitigate health disparities.

While our findings provided insights into characterizing these trajectories and their associations with socio-demographic factors, they do not allow for conclusions about the specific ages at which these determinants begin to influence BMI. Nonetheless, these findings may serve as a foundation for future research aimed at reducing health disparities in childhood.

Data availability

The data supporting this study's findings are available on request from the corresponding author (AC). The data are not publicly available due to restrictions (containing information that could compromise the privacy of research participants).

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Author contributions

All authors contributed to the study's conception and design. E.B., A.C. and C.C. performed material preparation, data collection, and analysis. E.B., J.GdRD, G.P., S.B., E.Barbieri, C.G., A.C. and C.C. wrote the first draft of the paper. All authors read and approved the final paper.

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Declarations

Competing interests

The authors declare no competing interests.

Ethical approval

This is an observational, retrospective, noninterventional study. According to a bylaw on the classification and implementation of observational drug-related research, as issued by the Italian National Drug Agency (an entity belonging to the Italian Ministry of Health), this study does not require approval by an ethics committee in Italy (Italian Drug Agency note on August 3, 2007). This study was conducted in accordance with the tenets of the Declaration of Helsinki and was compliant with the European Network of Centers for Pharmacoepidemiology and Pharmacovigilance's Guide on Methodological Standards in Pharmacoepidemiology. The Internal Scientific Committee of Società Servizi Telematici Srl, the legal owner of Pedianet approved ethical approval of the study and access to the database.

Additional information

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