Master of Public Health

Master de Santé Publique

Association Between Body Mass Index and Primary Health Care Utilization in Children Aged 2 to 17 Years: A French Retrospective Cohort Study

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List of acronyms

AIC: Akaike Information Criterion

ARS: Agence Régionale de Santé

ATC: Anatomical Therapeutic Chemical Classification System

BMI: Body Mass Index

CDC: Centers for Disease Control and Prevention

CI: Confidence Interval

DAG: Directed Acyclic Graph

GP: General Practitioner

HAS: Haute Autorité de Santé

IOTF: International Obesity Task Force

IRR: Incidence Rate Ratio

ITS: Interrupted Time Series

NBZIMM: Negative Binomial and Zero-Inflated Mixed Models

NHS: National Health Service

OR: Odds Ratio

PRIMEGE: Plateforme Régionale d'Information en MEdecine GEnérale

SD: Standard Deviation

SQL: Structured Query Language

WHO: World Health Organization

US: United States

z-BMI: Age and sex adjusted Body Mass Index

Abstract

Background: Childhood obesity and overweight are associated with short and long-term consequences. However, data on how the Body Mass Index (BMI) affects primary healthcare use in children remain limited, especially in France.

Objective: This study aimed to assess the association between overweight, obesity and primary care utilization in children aged 2 to 17 years.

Methods: A retrospective cohort between 2012 and 2022 from the PRIMEGE health data warehouse was set, including 205,757 consultations from 10,067 children. International Obesity Task Force (IOTF) criteria were used to define BMI categories (underweight, normal BMI, overweight and obesity). The main outcome was the rate of general practitioner consultations per child. Secondary outcomes were prescriptions of antibiotics and asthma-related drugs. Logistic and linear mixed-effect models were used, aside to an interrupted time series design using a negative binomial zero-inflated mixed model.

Results: Children with overweight and obesity had significantly higher medical consultation rates than those with normal BMI. Becoming overweight from normal BMI was associated with an increased consultation rate of +42.4% [+33.4%; +52.1%]. Also, becoming obese from overweight significantly increased consultation rates +61.6% [+35.2%; 93.4%]. Overweight children aged 5–9 had higher antibiotic use (OR 1.17 [1.04; 1.32], p<0.008). Obese children aged 2–9 had more asthma-related prescriptions (OR = 1.56 [1.15; 2.12]; p=0.004) between 2 and 4 years old, OR=1.43 [1.19; 1.72]; p<0.001) between 5 and 9.

Conclusion: These results suggest that abnormal BMI increases healthcare needs in childhood and adolescence. Overweight and obesity influence not only the frequency of consultations but also drugs patterns. These findings support early prevention efforts and the need to adapt healthcare systems to better meet the needs of children with excess weight.

Key words: Obesity, overweight, general practice, primary health care, office visits, anti-bacterial agents

Introduction

Background

Obesity accounts for an estimated 3.7 million attributable deaths in 2021 (1). This burden is not confined to adults; paediatric overweight and obesity have likewise shown an increase on a global scale (2). Globally, the prevalence of obesity among children and adolescents is estimated at 8.5%, and that of overweight at 14.8%, with marked disparities observed across different regions (3). In France, in 2017, adolescents are not spared from this trend: in the 14–15 year-old age group, 18% are classified as Overweight and 5% as Obese, with these figures on the rise (4).

Paediatric overweight and obesity track into adulthood and are recognized as a key predictor of adult obesity, contributing to the risk of multiple chronic conditions in later life (5,6). However, evidence also indicates that paediatric obesity has a direct health burden from an early age, including elevated morbidity and mortality rates during childhood and adolescence (7) and significant psychosocial burden (8).

The influence of paediatric overweight and obesity on care pathways is not totally clear, and seems to vary across countries and healthcare systems, as well as by the child's age. Studies from European settings (e.g. Germany and England) and Australia have reported increased general practitioner (GP) visits and higher healthcare costs as early as ages 4–5 years (9–11). By contrast, in the United States, data have suggested no significant difference in healthcare consumption costs among children younger than 11 years with obesity compared to their healthy-weight peers, but differences appearing after this age (12).

Aside the consultation frequency, there is a question of drug consumption, such as antibiotics. Indeed, it has been described that overweight and obese children have a greater susceptibility to infections compared to children with normal BMI (13–16). Suggesting that excess weight may predispose this population to infectious diseases (17).

In this context of an increasing incidence of infections and other diseases in overweight and obese children, a rise in drug consumption has been reported (18). More specifically, a cohort study conducted in England showed trends of increasing in antibiotic use among obese children at age 5 over the three following years (11). The same trend was found on a Dutch study with children aged 8 years old, but part of the data came from declarative questionnaires (7). However, these findings remain fragmented and geographically limited, with scant data available from other regions and children's ages.

In addition to increased rates of infections and antibiotic, another domain affected by overweight and obesity is asthma. Indeed, Overweight and obesity are associated with a higher prevalence of asthma (19,20). Although they may act as confounding factors, asthma drugs in the absence of a confirmed asthma diagnosis are also more frequently prescribed in children with excess weight (21).

Despite the importance of understanding both primary care utilization and drug consumption among overweight and obese children, existing data remain scarce. Thus, few studies have focused on the French context. Enhanced knowledge of care pathways and care use would not only contribute to improved individual management of paediatric patients but also guide the broader adaptation of the healthcare system. In the French context, such exploration is especially pertinent: France already exhibits elevated antibiotic use levels (22), and its distinct healthcare system needs context-specific investigations to inform both clinical practice and health policy.

Objectives

Therefore, the primary research objective is to evaluate the association between childhood overweight and obesity and health care utilization through the evaluation of general practitioner consultation frequency.

Secondary research objectives will analyse variations in drug prescriptions (antibiotics, and anti-asthmatic drugs) according to childhood overweight and obesity.

Methods

Study design and population

A French retrospective cohort from the PRIMEGE health data warehouse was set in place. PRIMEGE is a primary care health data warehouse that was conducted between 2012 and 2022 in Normandie, France (23,24). It was created by extracting all consultation records from four general practice centres in the French region of Normandy, and centralized in a unique database.

Inclusion and Exclusion Criteria

Inclusion criteria required at least three consultations within the database after 2 years old and prior to the individual's 18th birthday. To be included, a birth date with year and month (to calculate age in months) was needed, as well as sex. Moreover, patients needed to have at least one recorded measurement of one height and weight. The threshold of three consultation was defined by the scientific committee of PRIMEGE to include only children with a follow-up.

Outcomes, exposure and covariates

Main outcome

The primary outcome measured was the medical consultation rate per child over time either with absolute count or with a z-score. A z-score of GP consultation rate was thus calculated at the patient level per 6-month period of age by standardizing the number of consultations for each child relative to peers of the same age. The use of z-scores allows for comparison between children by indicating where each child lies within the age-specific distribution of consultation rates. However, while higher or lower scores suggest relatively greater or lower use of GP consultation rate, z-scores cannot be directly interpreted in terms of the absolute consultation rate. For each patient, the mean z-score was calculated over their entire follow-up period. Each patient's data was analysed exclusively within their follow-up period, defined as the interval between their first and last recorded consultations in the database.

Secondary outcomes

The secondary outcomes of this study were antibiotics and anti-asthmatic prescriptions. We referred to the Anatomical Therapeutic Chemical (ATC) classification system. We included every drug with an ATC code, starting with J01 as an antibiotic and starting with R03 as anti-asthmatic drugs. Considering the available data, it was not possible to obtain detailed information on the posology prescribed by the GPs.

Exposure Assessment

To categorize children based on their weight status, we calculated the Body Mass Index BMI with the formula: BMI = weight (kg)/height ^{2} (m^2). BMI categories were used as a categorical variable with the normal BMI as a reference. But several possibilities exist for the references chart usable to calculate standard BMI adjusted on age (z-BMI) (Table 1). We applied the International Obesity Task Force (IOTF) criteria to define overweight (z-BMI> IOTF 25) and obesity (z-BMI> IOTF 30), as long as underweight (z-BMI <IOTF 16) and normal BMI for the remaining (26). This reference is the most suitable for the French population, as it was defined by the Haute Autorité de Santé (HAS), French Health Authority (27).

Table 1 Age-adjusted alternative references for child BM

Age (in years)																			Promoter	Reference
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
																			WHO (2006)	(28)
																			WHO (2007)	(29)
																			IOTA (2000)	(26,30)
																			CDC (2000)	(31)

The same patient could attend medical consultations multiple times per year, and without having a height measurement at each time. When height was missing, it was imputed from another consultation if available using strict age-based rules: within 1 month if less than 3 years old at the time of the consultation, 4 months if 3 to 15 years old, and 6 months if older than 15 years old. Then, if the medical consultation was surrounded by two medical consultations with the same BMI category, this category was applied to the surrounded medical consultation.

Extreme BMI values (<10 or>40) were excluded from the analysis, as they were highly probable to be due to data entry errors in the database.

Covariates

Age

Age in years and months was used as a continuous and categorical variable, depending on the analysis. But different standards exist about age groups, differing between countries but also within countries like in the USA (Table 2). First, the cut-off of 2 years old was used, as it is the age at which we have a consensus on the definition of obesity (Table 1). Also, we ended our age group at 18 years old, as our work was only focussed on children. Then, we used the categorization proposed by Diaz et al. in their call for the harmonization of age-disaggregated health data in the Lancet (32). To conclude, we used four age groups: [2–5 [, [5–10 [, [10–15[, [15–18[(Table 2).

Table 2 Alternative classification systems for age categories

Age (in years)																				Promoter	Reference
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
		Child's preschool				Child							Adolescent							PubMed	(33–35)
										Adolescent										WHO	(36)
	Young children				Older children					Young adolescents					Older adolescents					Diaz et al.	(32)
	Toddler			Child									Teenager							NHS	(37)
Infants and Toddlers				Young Children								Teens								CDC	(38–40)
			Maternelle			Primaire					Collège				Lycée					French school	
		Young children			Older children					Young adolescents										In this study	
										Adolescent											

Sex:

Sex was a dichotomized variable, 'Masculin' and 'Féminin' as available in the database.

General practitioner

Every GP in the database came from one of four medical centres (Rouen Carmes, Val de Reuil Plaine, Grand Quevilly Amstrong et Neufchatel Medisept), used as a qualitative variable.

Season

From the consultation date, we created a season variable (Autumn, Winter, Spring, Summer). Indeed, health issues, like epidemic diseases, are not constant over the year (41).

Statistical Analysis and Software

A directed acyclic graph (DAG) was drawn on Daggity.net to assess confounding factors. The minimal sufficient adjustment set contained age, medical centre and sex for estimating the total effect of BMI (Figure 1). No data were available for the socio-economic status. Aside to the DAG, we conducted AIC calculations and comparisons to confirm the variable to be included; we therefore also included season in the final models.

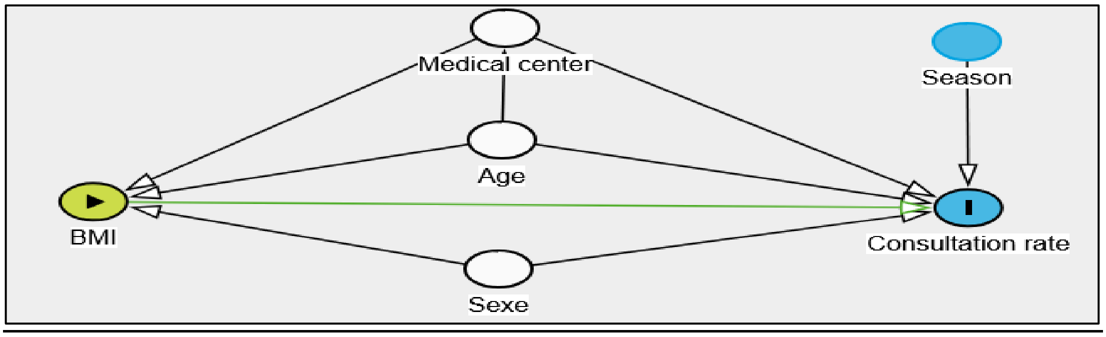

Figure 1 Causal Directed Acyclic Graph of potential confounding factors affecting medical consultation rate

Three analyses were performed. The main R codes are presented in Appendix 1.

First, the association between the highest BMI category over the follow-up period and the medical consultation rate was calculated. The mean z-score of medical consultation was calculated at the patient level (cf page 10). A linear regression model adjusted for sex and medical centre was then performed between the BMI category and the mean z-score of the GP consultation rate per patient.

Secondly, for intra-individual comparison, an Interrupted Time Series (ITS) design with a self-controlled approach was employed to examine changes in general practitioner (GP) consultation rates (per 6-month age periods), before and after a shift in the BMI category within the same individual. This design allowed each child to serve as their own control, thereby adjusting for all time-invariant individual-level confounders, including those not captured in the database. A zero-inflated negative binomial mixed-effect model (NBZIMM) was used to account for the overdispersed nature of the consultation count data and the high frequency of zero counts (42–44). These excess zeros reflect the fact that many children had no consultations during several 6-month periods within their follow-up, as many children consulted less than once every six months. This model was used to provide Incidence Rate Ratios (IRRs), reflecting the consultation rate per 6-month age periods. Interaction terms between time and BMI category were included to assess whether the slope of consultation rates changed following the BMI transition. Given the non-linear relationship between time and the frequency of GP consultations, spline-based models were used to allow flexible graphical representations of temporal trends. Due to the U-shape of the distribution, the location of a change point was identified using the Davies test, which indicated a significant inflection at 104.65 months (approximately 8.6 years of age). Then, to enable estimation of incidence rate ratios (IRRs) across time periods, a segmented linear regression approach was considered (Appendix 2). However, this modelling strategy yielded results that were not different from those obtained using a model in which time was treated as a continuous, non-segmented variable. Model comparison using the Akaike Information Criterion (AIC) and likelihood ratio (LR) tests supported the model without a time breakpoint as the best-fitting specification. Consequently, the model retained in this manuscript includes time as a continuous covariate without segmentation.

Thirdly, to compare drug rates per medical consultation according to the BMI category, a mixed-effects logistic regression model accounting for the random effect of the patient adjusting for season, sex and medical centre was performed. Analyses were stratified on the age group, as defined above, as age was found to be an effect modifier. Crude and adjusted Odds Ratios were calculated.

For mixed models, a verification of the variance of the random effects was realized, and AIC comparison and LR tests were performed to confirm the interest of these models over classical regressions. All model assumptions were verified (data on demand). As multiple tests were run, a sensitive analysis was done by applying the Benjamini-Hochberg procedure.

Data management was performed using MobaXterm v25.0 with SQL language, while statistical analyses were conducted on R version 2024.12.1 with packages: tidier, dyplr, stronger, ggplot2, spline, glmmTMB and lime 4.

Ethics statement

A declaration was submitted to the National Commission for Informatics and Liberties (No. 1585962). Information poster for the patients, detailing the procedures for accessing and correcting their data, was made available by the GPs. Patients retained the right to refuse authorization for the use of their personal health information. This study was reviewed and approved by the scientific and ethical committee of PRIMEGE (No. DA-CSE2025-001).

Results

Characteristics of the population

After applying the inclusion and exclusion criteria, 10,067 patients between 2 and 17 years old were included, for a total of 205,757 medical consultations, among them 108,791 medical consultations had a recorded BMI (53.4%) (Figure 2).

Medical consultations involved children of all ages. However, a higher proportion comes from younger age categories (Figure 3). The medical consultation rate also varies among ages with more frequent medical consultations for younger children (Figure 4).

Among the children included in the study, 64% were boys, with a mean age of 8.0 years. Obesity was recorded at least once for 8.6% of children, while 18.3% were classified as overweight. On average, each child had 10.9 medical consultations documented in the database. One medical centre accounted for a low volume of medical consultations (Rouen Carmes with 2.6%) (Table 3).

10.7% of the 108,791 medical consultations with a recorded BMI have been followed by an antibiotic prescription. The most frequently prescribed were amoxicillin (n= 7,308), Amoxicillin-Clavulanic acid (n= 1,293) and Cefpodoxim (n= 1,023) (Appendix 3). Asthma drugs were prescribed in 7.59% of the medical consultations. The most frequently prescribed asthma drugs were salbutamol (n= 6,408) followed by Fluticasone (n= 1,521), Salmeterol and Fluticasone (n= 1,032) (Appendix 4).

We see that the proportion of patients with the different categories of BMI varies by age. The obese category is almost increasing every year of age, except a transitory decrease between 9 and 11, which ended at 6.2% of the children at 17 years old. The maximum of overweight is found at 12 years old with 17% of the children at this age. The nadir of underweight is 10 years old, with 0.5% of the children (Figure 5).

The proportion of BMI categories per sex was not different (p=0.21) (Table 4).

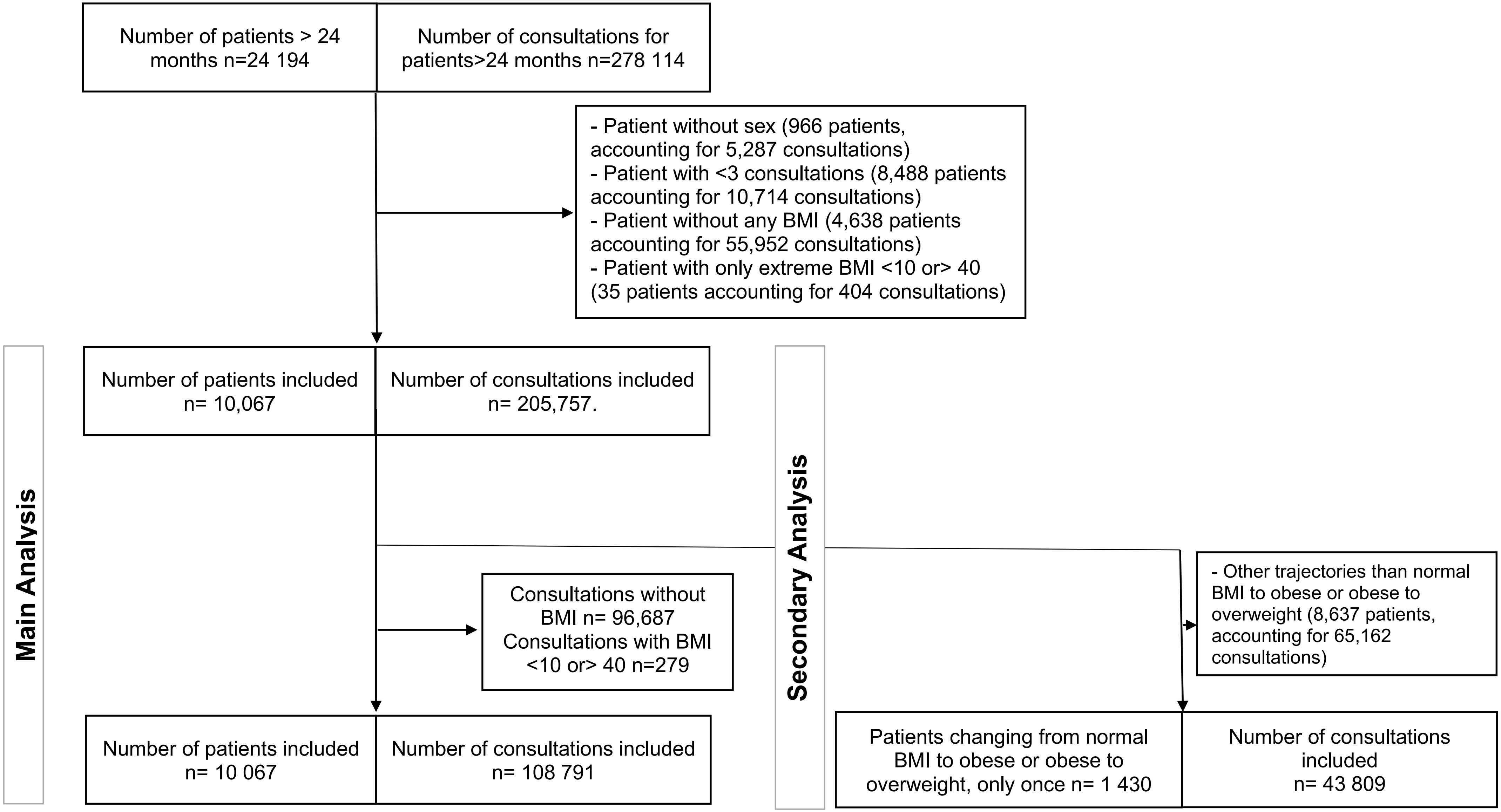

Figure 2: Study flow diagram of included patients and consultations

Table 3 Characteristics of patients (n = 10,067) and medical consultations (n = 108,791)

Patients' characteristics (n = 10,067)			
Category		Number (or mean)	% (or sd†)
Sex			
	Boys	6,442	64.0%
	Girls	3,625	36.0%
Mean age (years)		8.0 (mean)	4.1 (sd†)
Mean follow-up (years)		2.8 (mean)	2.9 (sd†)
Medical centre			
	Neufchatel	3,588	35.6%
	Val de Reuil	2,879	28.6%
	Grand Quevilly	2,854	28.4%
	Rouen Carmes	746	7.4%
Highest BMI‡ category once recorded per child			
	Underweight	40	0.4%
	Normal BMI‡	7,327	72.8%
	Overweight	1,839	18.3%
	Obese	861	8.6%
Last recorded BMI‡ on the database			
	Underweight	114	1.1%
	Normal BMI	8,028	79.7%
	Overweight	1,348	13.4%
	Obese	577	5.7%
Number of medical consultations per child		10.9 (mean)	12.3 (sd†)
Number of medical consultations per child considering the highest BMI‡ category over the period		(mean)	(sd†)
	Underweight	4.4	8.61
	Normal BMI	10.1	11.4
	Overweight	13.7	14.2
	Obese	7.68	9.55
Medical consultations' characteristics (with a BMI) (n= 108,791)			
Category		Number	%
Antibiotic prescription			
	Yes	11,542	10.7%
	No	97,249	89.3%
Asthma drug prescription			
	Yes	7,678	7.59%
	No	101,113	92.41%
Primary care centres			
	Neufchatel	42,401	39.0%
	Val de Reuil	37 421	34.4%
	Grand Quevilly	26,141	24.0%
	Rouen Carmes	2 828	2.6%

Season			
	Autumn	34,015	31.3%
	Winter	28,917	26.6%
	Spring	24,286	22.3%
	Summer	21,573	19.8%

† Standards deviation, ‡BMI = Body mass index

Table 4 Distribution of BMI‡ categories according to sex

BMI‡ categories	Girls n= 3,625		Boys n= 6,442	
	Number	%	Number	%
Underweight	182	5.0%	323	5.0%
Normal BMI	2426	66.9%	4436	68.9%
Overweight	692	19.1%	1147	17.8%
Obese	325	9.0%	536	8.3%

‡BMI = Body mass index

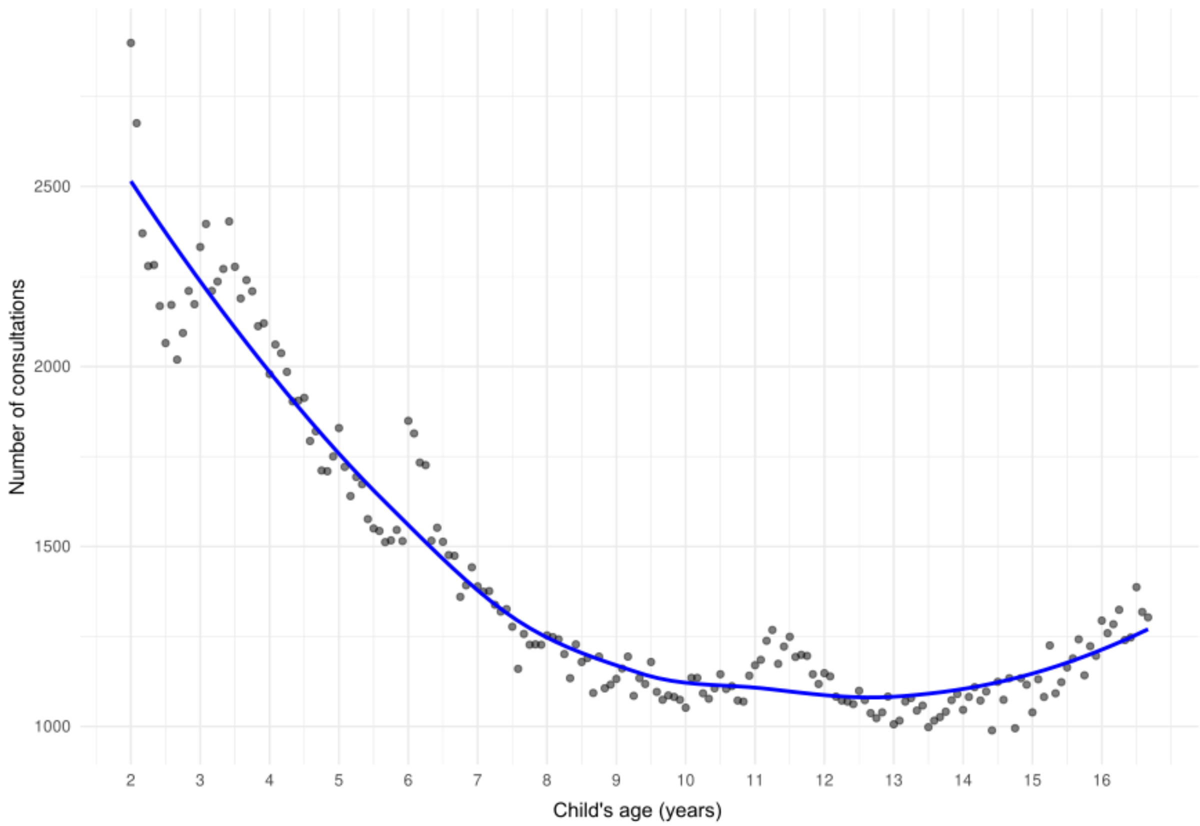

Figure 3 Number of medical consultations by child's age in years (n = 205,757)

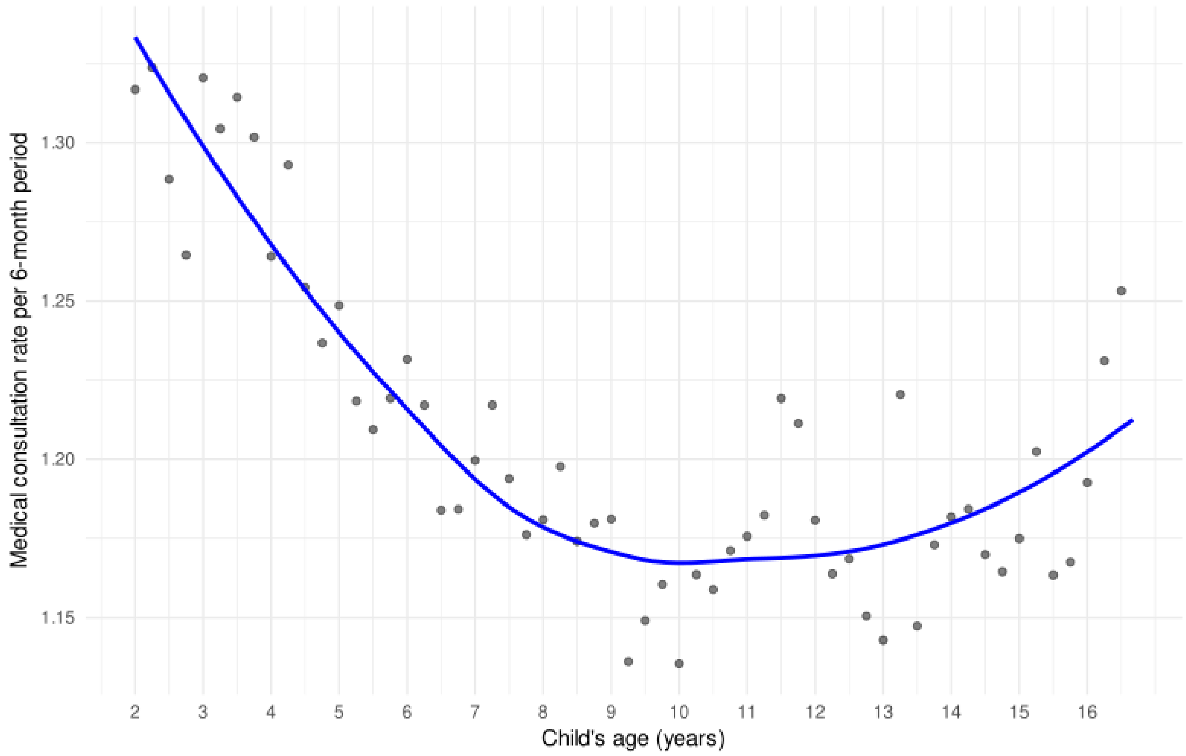

Figure 4 Age-Specific Medical Consultation Rates in 6-Month Intervals (n = 205,757)

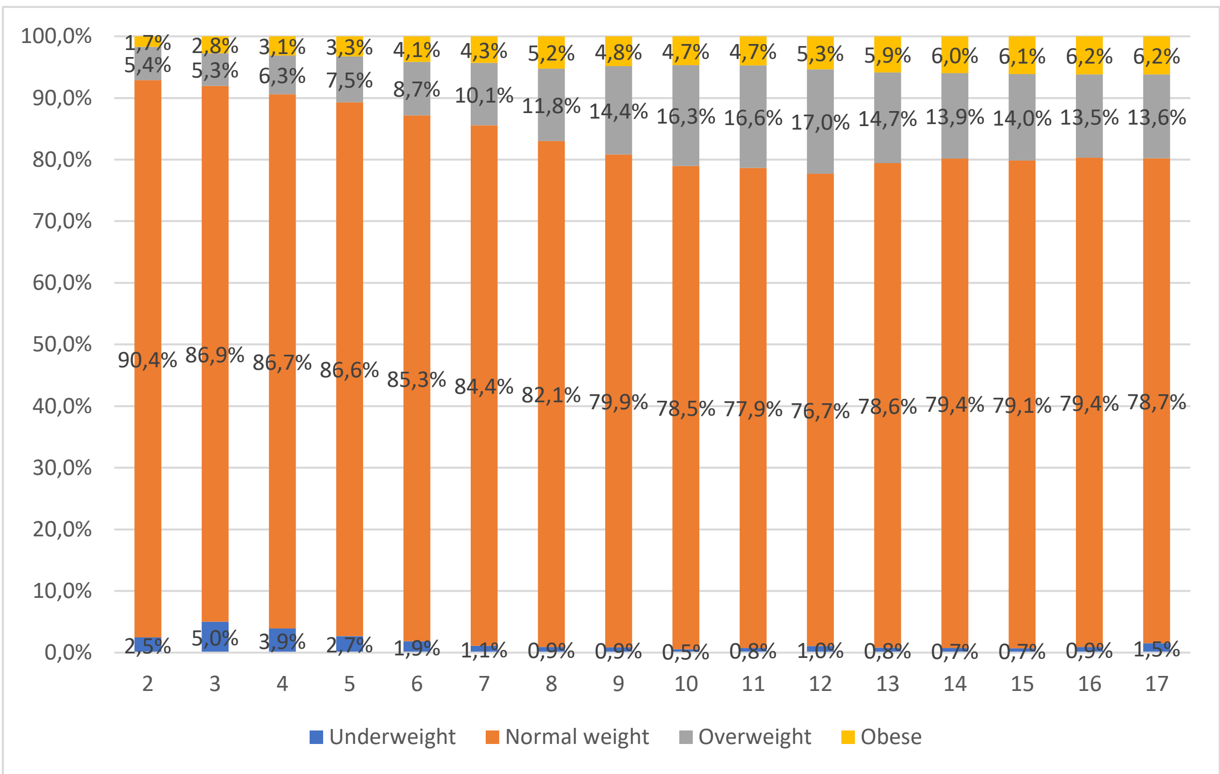

Figure 5 Age-Specific Distribution of BMI Categories Among Children Attending Medical Consultations (n = 10,067)

Frequency of medical consultation per patient according to the highest BMI category over the period

10,067 patients were included in the comparison of the frequency of consultation per patient according to the highest BMI category over the period (cf Flow chart page 16**Erreur ! Source du renvoi introuvable.**). Every consultation related to the 10,067 included patients was analysed i.e. 205,757 consultations to compare the mean z-score of the consultation rate for each patient (cf The primary outcome measured was the medical consultation rate per child over time either with absolute count or with a z-score. A z-score of GP consultation rate was thus calculated at the patient level per 6-month period of age by standardizing the number of consultations for each child relative to peers of the same age. The use of z-scores allows for comparison between children by indicating where each child lies within the age-specific distribution of consultation rates. However, while higher or lower scores suggest relatively greater or lower use of GP consultation rate, z-scores cannot be directly interpreted in terms of the absolute consultation rate. For each patient, the mean z-score was calculated over their entire follow-up period. Each patient’s data was analysed exclusively within their follow-up period, defined as the interval between their first and last recorded consultations in the database.

Secondary outcome).

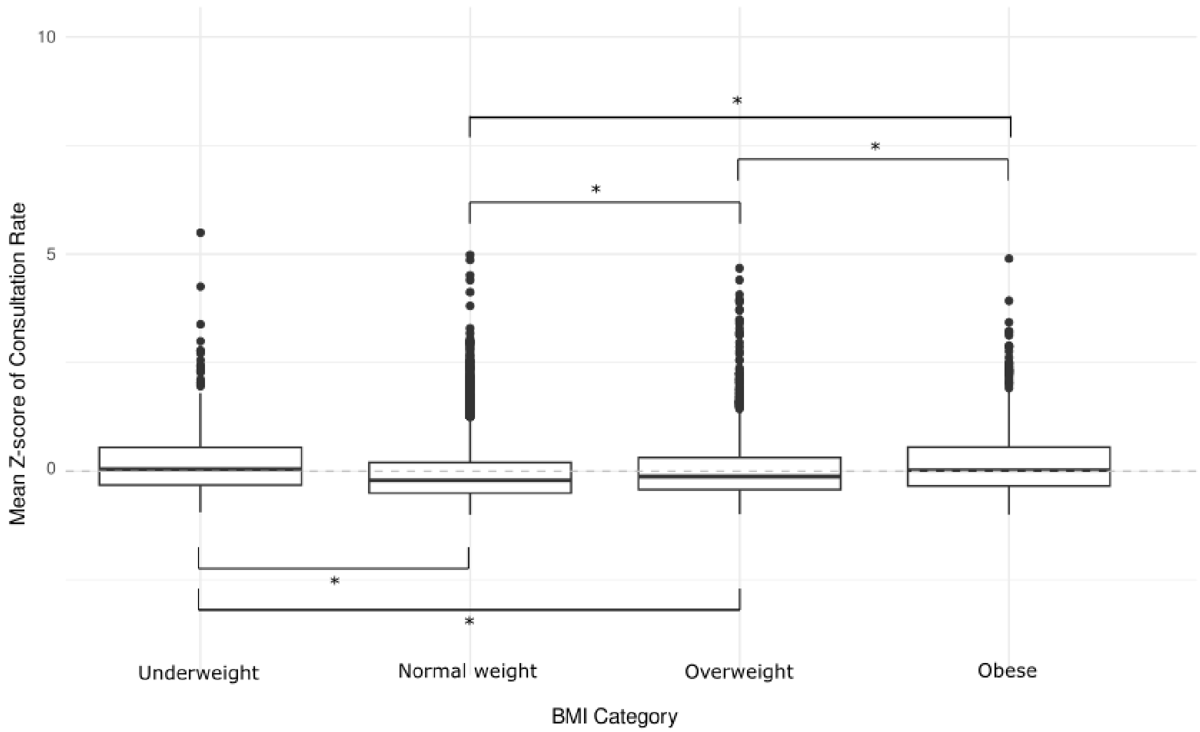

Figure 6 Unadjusted comparison of annual consultation rate z-scores according to the highest BMI‡ category once recorded during follow-up (ages 2–17 years)

Although the raw number of consultations over the period is lower among obese children (Table 3), when focussing on the follow-up period in univariate analysis, it was found that among children aged 2 to 17 years, having presented overweight, obesity and underweight were all significantly associated with a higher mean z-score of consultation rates over the follow-up period, compared with normal weight (Figure 6).

After adjustment and considering each child's maximum recorded BMI over the study period, overweight children showed an increased consultation z-score of 0.14 (95% CI [0.11; 0.17]; p <0.001); obese children, 0.25 (95% CI [0.21; 0.30]; p <0.001); and underweight children, 0.23 (95% CI [0.17; 0.28]; p <0.001), compared to those with normal BMI (Table 5). All these results are being adjusted for sex and medical centres. Unadjusted estimates do not differ and are presented at Appendix 5.

Table 5 Adjusted association between the highest BMI‡ category once recorded, sex and evolution of the mean z-score of medical consultation rate per child between 2 and 17 years old (n=10 067)

Variable	Adjusted Estimate (CI 95%)	p-value†
BMI‡		
Underweight	0.23 [0.17; 0.28]	<0.001*
Normal BMI‡	Ref	-
Overweight	0.14 [0.11; 0.17]	<0.001*
Obese	0.25 [0.21; 0.30]	<0.001*

†*Results from a linear regression model, adjusted for sex and the medical centre, comparing the mean of the reduced centred medical consultation rates to consider the variation in medical consultation rate per year, *significant results with alpha = 0.05,* ‡*BMI = Body mass index*

Stratified analysis per age category found the same results except between 15 and 17 years old, where overweight was not associated with a modification of medical consultation rate compared to normal BMI, p-value = 0.52 (Appendix 6).

In the sensitive analysis with the Benjamini-Hochberg procedure, the found associations didn’t differ.

Interrupted Time Series (ITS) Analysis

In this section, patients were compared to themselves to study the association between BMI changes and medical consultation rates per 6-month period. The number of patients included in ITS analysis is presented in Table 6, with 1,230 patients eligible and included in ITS for the transition from Normal BMI to Overweight and 200 patients from Overweight to Obese (Table 6).

Table 6 Descriptive characteristics by transition pathways in the self-controlled interrupted time series models

Transition path	Category at the time of the medical consultation	Number of medical consultations	Mean medical consultations per Patient
Normal BMI → Overweight (n = 1230)	Normal BMI	19,126	15.55
	Overweight	18,849	15.32
	Total	37,975	30.87
Overweight → Obese (n = 200)	Overweight	2,364	11.82
	Obese	3,470	17.35
	Total	5,834	29.17

Normal BMI to Overweight

In the self-controlled NBZIMM regression, a change of BMI category from normal BMI to overweight was associated with a significant modification of the incidence rate of medical consultations per 6-month period (IRR = 1.43; CI95% [1.34; 1.52], p <0.001). The Age effect showed a significant decrease of the consultation rate with time (IRR = 0.99; CI95% [0.98; 0.99], p <0.001). The interaction between category change and time was also statistically significant (IRR = 0.99; CI95% [0.99; 0.99], p <0.001),

Table 7.

Table 7 Association between transition from Normal BMI to Overweight and medical consultation rates per 6-month period at the patient level

Variable	IRR† [95% CI]	p-value
Incidence rate at baseline	2.32 [2.17; 2.47]	<0.001*
Category change (Normal BMI to Overweight)	1.43 [1.34; 1.52]	<0.001*
Age	0.99 [0.99; 0.99]	<0.001*
Interaction: category change × time	0.99 [0.99; 0.99]	<0.001*

*† Incidence Rate Ratio from a zero-inflated negative binomial mixed model with interaction terms, under self-controlled (each patient as their own control) and Interrupted Time Series design, *significant results with alpha = 0.05, ‡BMI = Body mass index*

Although IRRs remained constant over time, including in the segmented linear model with a breakpoint at 8.6 years (Appendix 2), the graphical modelling using spline functions showed overlapping confidence intervals across weight status categories prior to the age of 8 years, whereas a clear divergence in the consultation rate curves was observed beyond this age (Figure 7).

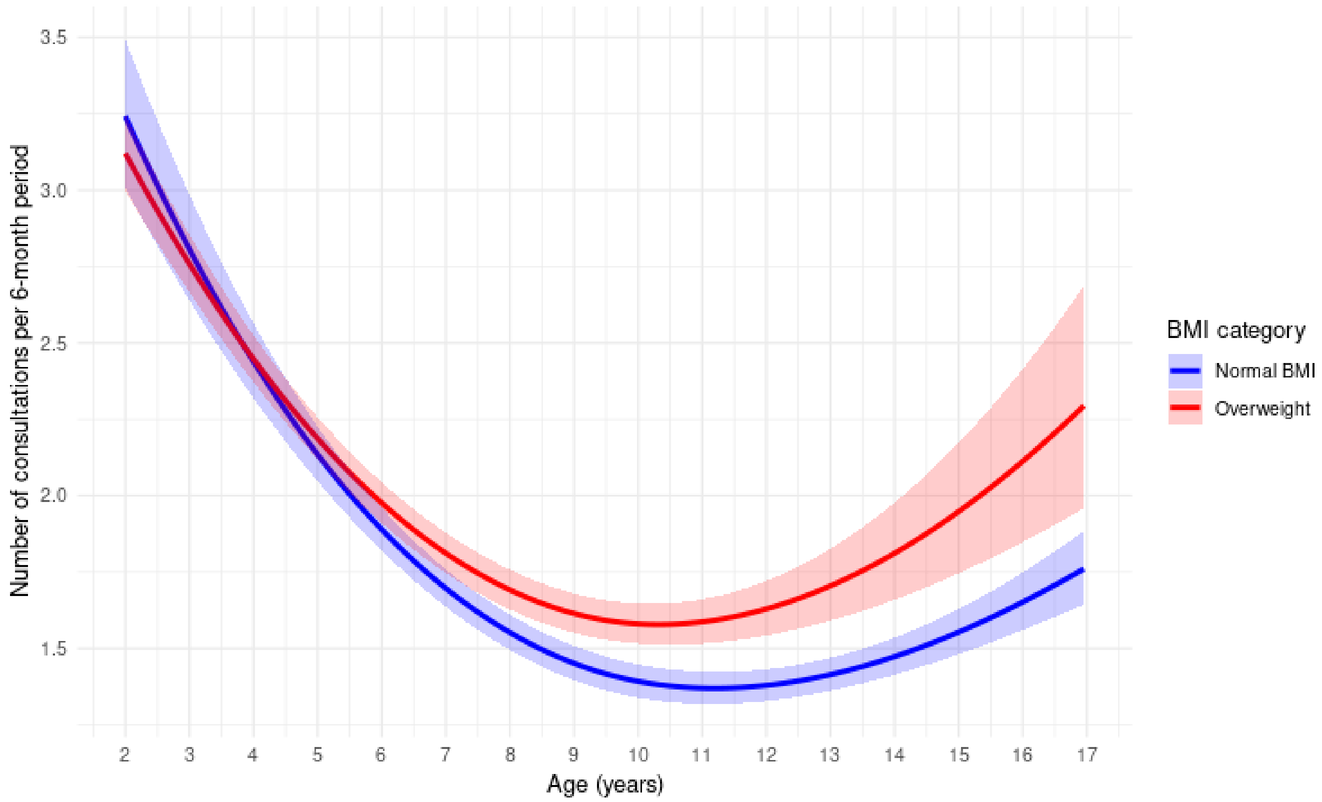

Figure 7 Predicted evolution of medical consultation rate before and after the transition from Normal BMI to Overweight in children: interrupted time series analysis with spline interaction model

Overweight to Obese

In the self-controlled NBZIMM regression, a change of BMI category from Overweight to Obese was associated with a significant increase in the incidence rate of medical consultation per 6-month period (IRR = 1.62; 95% [1.36; 1.94], p <0.001). Age was not associated with a modification in incidence (IRR = 1.00; IC95% [0.99; 1.01], p = 0.97). The interaction between category change and age was statistically significant (IRR =0.99; IC95% [0.99; 0.99], p <0.001) (Table 8).

Table 8 Association between transition from Overweight to Obese and medical consultation rates per 6-month period at the patient level

Variable	IRR† [95% CI]	p-value
Incidence rate at baseline	1.65 [1.37; 1.99]	<0.001*
Category change (Overweight to Obese)	1.62 [1.36; 1.94]	<0.001*
Age	1.00 [0.99; 1.01]	0.97
Interaction: category change × time	0.99 [0.99; 0.99]	0.001*

*† Incidence Rate Ratio from a zero-inflated negative binomial mixed model with interaction terms, under self-controlled (each patient as their own control) and Interrupted Time Series design, *significant results with alpha = 0.05, ‡BMI = Body mass index*

As previously, although IRRs remained constant over time, including in the segmented linear model with a breakpoint at 8.6 years (Appendix 2), the graphical modelling using spline functions showed overlapping confidence intervals across weight status categories prior to the age of 11 years, whereas a divergence in the consultation rate curves was observed beyond this age (Figure 7).

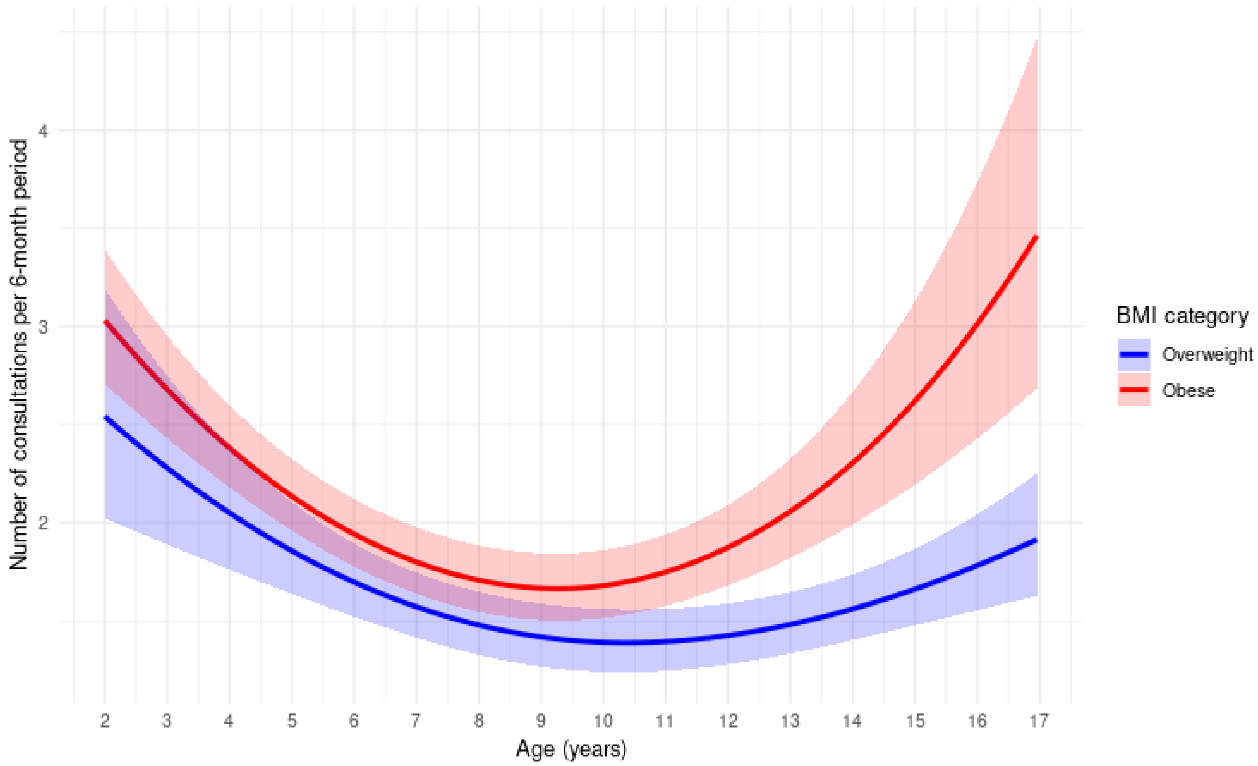

Figure 8 Predicted evolution of medical consultation rate before and after the transition from Overweight to Obese in children: interrupted time series analysis with spline interaction model

To summarize the results, combining the main effect of the weight status category with its interaction with age revealed that transitioning from normal BMI to overweight was associated with a significant +42.4% [+33.4%; +52.1%] increase in the consultation rate. Similarly, moving from overweight to obese was associated with a significant +61.6% [+35.2%; 93.4%] increase in the consultation rate (Table 9).

Table 9 Estimated Increases in 6-month consultation rates following transitions in BMI categories

Transition path	**Increase in the medical consultation rate per 6-month period [IC95%]**
Normal BMI‡ → Overweight (n = 1230)	+42.4% [+33.4%; +52.1%]
Overweight → Obese (n = 200)	+61.6% [+35.2%; 93.4%]

‡BMI = Body mass index

In the sensitive analysis with the Benjamini-Hochberg procedure, the found associations didn’t differ.

Association between BMI categories during a medical consultation and drug prescription

Every consultation mentioning a BMI at the time of the medical consultation, from the 10,067 patients of the cohort was included in this analysis, i.e. 108,791 medical consultations (Figure 2). For this part, the age groups defined in the method part were used (page 11).

Antibiotic Prescription

In the adjusted models, no significant association was observed between BMI category and an antibiotic prescription at any age except for overweight but not obese children between 5 and 9 years old (OR 1.17 [1.04; 1.32], p <0.05) (Table 10).

Anti-asthmatic Drug Prescriptions

Between 2 and 9 years old, being obese at the time of the medical consultation was associated with an increase in prescription of asthma drugs (OR 1.56 [1.15; 2.12] between 2 and 4, OR 1.36 [1.04; 1.79] between 5 and 9). No other BMI category was significantly associated with asthma drug at any age. In particular, overweight is not associated with increased prescriptions for asthma drugs (Table 11).

In the sensitive analysis with the Benjamini-Hochberg procedure, the association of antibiotic medication and obesity between 5 and 9 was still consistent (p=0.02), between 2 and 4 asthma medication was still significantly associated (p=0.01). But between 5 and 9, it became un-significant (p=0.07).

Table 10 Crude and adjusted associations between BMI category and age-specific ***antibiotic*** *prescription rates in children*

Age (years)	BMI category§	Crude† Odds Ratio (CI 95%)	p-value	Adjusted‡ Odds Ratio (CI 95%)	p-value
Overall	Underweight	1.30 [1.11; 1.51]	**<0.001***	1.13 [0.95; 1.34]	0.18
	Normal BMI§	Ref	-	Ref	-
	Overweight	0.92 [0.87; 0.99]	**0.017***	1.02 [0.95; 1.11]	0.56
	Obese	0.88 [0.80; 0.97]	**0.009***	0.96 [0.85; 1.08]	0.50
[2–4]	Underweight	1.08 [0.88; 1.31]	0.46	1.16 [0.93; 1.44]	0.18
	Normal BMI§	Ref	-	Ref	-
	Overweight	1.20 [1.05; 1.36]	**0.006***	1.14 [0.99; 1.31]	0.08
	Obese	0.99 [0.83; 1.19]	0.95	0.99 [0.80; 1.22]	0.90
[5–9]	Underweight	1.04 [0.77; 1.41]	0.8	1.05 [0.75; 1.47]	0.76
	Normal BMI§	Ref	-	Ref	-
	Overweight	1.19 [1.08; 1.31]	**0.001***	1.17 [1.04; 1.32]	**0.008***
	Obese	0.98 [0.85; 1.14]	0.83	0.91 [0.76; 1.09]	0.30
[10–14]	Underweight	1.14 [0.64; 2.06]	0.66	1.10 [0.54; 2.22]	0.80
	Normal BMI§	Ref	-	Ref	-
	Overweight	0.94 [0.81; 1.08]	0.35	0.88 [0.74; 1.06]	0.18
	Obese	0.97 [0.78; 1.21]	0.78	0.98 [0.74; 1.30]	0.87
[15–18[	Underweight	0.91 [0.40; 2.09]	0.82	0.36 [0.08; 1.66]	0.19
	Normal BMI§	Ref	-	Ref	-
	Overweight	0.93 [0.70; 1.22]	0.59	0.95 [0.66; 1.36]	0.78
	Obese	1.14 [0.81; 1.61]	0.46	1.00 [0.61; 1.64]	0.99

**significant results with alpha = 0.05, †Results from a non-adjusted non-clustered logistic regression, ‡Results from a mixed-effects logistic regression model accounting for the random effect of the patient adjusting for season, sex and medical center. The overall model was also adjusted on age group, §Body Mass Index*

*Table 11 Crude and adjusted associations between BMI category and age-specific **asthma**-related drug prescriptions per age*

Age (years)	BMI category§	Crude Odds Ratio† (CI 95%)	p-value	Adjusted‡ Odds Ratio (CI 95%)	p-value
[2–4]	Underweight	0.79 [0.59; 1.06]	0.11	0.78 [0.55; 1.12]	0.18
	Normal BMI§	Ref	-	Ref	-
	Overweight	1.35 [1.15; 1.58]	**<0.001***	1.22 [0.99; 1.51]	0.06
	Obese	1.63 [1.33; 1.99]	**<0.001***	1.56 [1.15; 2.12]	**0.004***
[5–9]	Underweight	1.15 [0.81; 1.63]	0.45	1.10 [0.69; 1.75]	0.68
	Normal BMI§	Ref	**-**	Ref	-
	Overweight	1.41 [1.26; 1.57]	**<0.001***	1.16 [0.97; 1.68]	0.11
	Obese	1.93 [1.68; 2.14]	**<0.001***	1.36 [1.04; 1.79]	**0.025***
[10–14]	Underweight	0.50 [0.21; 1.22]	0.13	1.10 [0.31; 3.93]	0.89
	Normal BMI§	Ref	-	Ref	-
	Overweight	1.13 [0.99; 1.30]	0.07	1.19 [0.86; 1.66]	0.30
	Obese	1.29 [1.06; 1.58]	0.013*	1.10 [0.31; 3.93]	0.87
[15–18[	Underweight	0.45 [0.11; 1.81]	0.26	0.20 [0.01; 13.15]	0.45
	Normal BMI§	Ref	-	Ref	-
	Overweight	0.96 [0.69; 1.33]	0.80	1.40 [0.56; 3.50]	0.48
	Obese	1.17 [0.77; 1.76]	0.47	1.13 [0.26; 4.84]	0.87

**significant results with alpha = 0.05, †Results from a non-adjusted non-clustered logistic regression, ‡Results from a mixed-effects logistic regression model accounting for the random effect of the patient adjusting for season, sex and medical centre, §Body mass index*

Discussion

Main findings

This study identifies an association between BMI categories and general practice consultation rate. Thus, children who experienced underweight, overweight or obesity had significantly higher z-score rates of GP consultations compared to children with normal BMI. Although z-scores capture each child's position within the distribution of consultation rates, their increase cannot be directly interpreted as a percentage increase in the number of consultations. Nevertheless, the interpretation of intra-individual analyses is more straightforward and enabled the identification of a significant increase in GP consultation rates associated with transitions from normal BMI to overweight, or from overweight to obesity.

Aside to these medical consultation rates, analyses found a higher likelihood of antibiotic prescriptions for overweight children aged 5 to 9 and increased asthma drug prescriptions among obese children between 2 and 9.

Comparison with France

Data on childhood overweight and obesity are not consistently available at a local level in France. Nevertheless, comparisons at key ages suggest that the prevalence estimates observed in this retrospective cohort are in line with existing national and regional data. For instance, in 2013, at age 5, national estimates reported 12% of children as overweight and 3.5% as obese (45), compared to 7.5% and 3.3%, respectively, in the PRIMEGE cohort. At age 12, regional data from Normandy indicated a prevalence of excess weight (Overweight + Obesity) of 14.8% (46), while our cohort showed 17.0% Overweight and 5.3% Obesity. At age 14, national data from 2017 reported 18% Overweight and 5.2% obese (47), versus 13.9% and 6.0%, respectively, in our study (Figure 9). These comparisons suggest that, despite some differences, this retrospective cohort presents broadly comparable estimates, supporting the external validity of our findings.

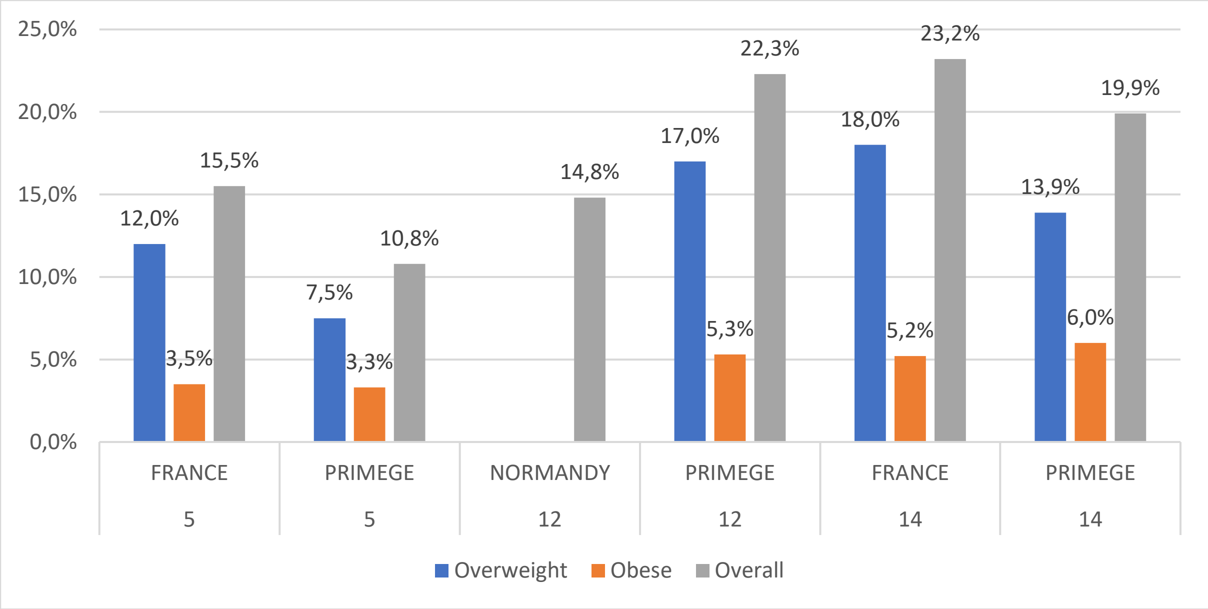

Figure 9 Comparison of excess weight frequency PRIMEGE and French data (45–47)

The gender distribution of Overweight and Obesity is also coherent with findings reported in the literature. While some French data indicate that, around the age of 5, excess weight is more prevalent among girls (45), national data covering the 5 to 19-year age range suggest the opposite trend (48). On the other hand, a meta-analysis does not report any significant sex differences before the age of 12 (49). Although our data do not reveal a statistically significant difference, the observed trend toward higher prevalence among girls appears to be consistent with these findings.

However, it should be noted that the PRIMEGE database presents an atypical sex ratio compared to the general French population, with 64% of boys versus 51% at birth nationally (50). This difference is likely attributable to software-related issues leading to default male gender assignment upon initial record creation. As a result, this limits the ability to draw conclusions regarding sex-specific differences.

Comparison with the literature

In this study, overweight and obesity were found to be associated with an increased rate of medical consultations at any age.

The observed association between obesity and increased GP consultation rates is consistent with existing literature across all age groups. Data from a 2019 English cohort study involving children aged 5 to 8 years showed higher consultation rates among children with Obesity compared to their peers with Normal BMI (11). Similar findings were reported in a Dutch cohort published in 2010 involving 8-year-old children (7). At older ages, data are more limited. In the United States, it has been shown that Obesity in adolescents aged 12 to 17 years is associated with more frequent primary care consultations (12).

But the effect of overweight on consultation frequency observed at any age and this cohort differs with findings from the studies cited above. Thus, the English cohort reported no association between overweight and consultation rates among children aged 5 to 8 years (11). The same findings were found in the Dutch cohort, where the 8-year-old children had no increased odds of GPs consultations if they were overweight (7). Also for the older age groups, the US study reported no significant association between overweight and consultation rates between 12 and 17 years old (12).

Nevertheless, when focusing more specifically on the field of health economics, consistent findings to those reported in the present study can be observed, although the analytical perspectives differ. For instance in Europe, a German study reported increased physician-related healthcare costs for both overweight and obese children between 9 and 12 years of age, although no specific information was provided regarding the frequency of medical consultations (9).

Regarding asthma, this study is in line with the literature. Thus, a strong and well-documented association with obesity has been consistently reported in the literature (51,52). Accordingly, the observed increase in anti-asthmatic drug prescriptions among children aged 2 to 9 years in our study is consistent with findings from other cohort studies (11).

However, results about antibiotics differ from those reported in previous publications. The findings of this study differ from those reported in previous publications. Thus, prior literature has shown that obesity, but not overweight, was associated with increased antibiotic prescriptions between the ages of 5 and 8 years (6,11). As presented, a different pattern was found in the PRIMEGE cohort despite a substantial sample size. It is worth noting that the existing literature on this topic remains limited, and publication bias cannot be excluded, particularly for studies reporting null associations between obesity and antibiotic use.

Still, the previously published results are coherent with the fact that obese children are more frequently affected by infections, and these infections tend to present with greater severity (8,9). In this context, an increased rate of antibiotic prescriptions among children with obesity would appeared appropriate.

The absence of such a pattern in the present findings may reflect underprescription among children with obesity. Another explanation could be that children with obesity who develop infections may be less likely to consult their GP and may instead seek care from other healthcare providers, particularly hospital emergency departments. Future research examining the full continuum of care—including emergency and specialist services—rather than only GP consultations, would be valuable to better understand antibiotic exposure among obese children.

A specific feature of the French healthcare system could be implicated in the atypical results observed in this study. Thus, France is characterized by a particularly high overall rate of antibiotic prescriptions, even when compared to countries with a similar level of development (16). In particular, prescription rates in France are higher than those observed in the Netherlands or in the UK, where the comparable studies were conducted (24). This generalized overprescription across the population may obscure potential differences, making individual characteristics such as obesity less influential in this context. Further qualitative and quantitative studies are needed to better understand these discrepancies.

Strengths

One of the strengths of this study lies in the large cohort of children followed over an extended period, allowing for a comprehensive assessment of care trajectories. Furthermore, the use of a routinely collected health data warehouse enables the capture of information that closely reflects real-world clinical practice, providing a reliable representation of the healthcare delivered to children. Moreover, aside to the gender ratio mentioned above, this cohort appears to have good external validity.

The use of a self-controlled design through ITS analysis allows for control of all time-invariant confounding factors, thereby compensating for the absence of certain data, such as sociodemographic variables. This methodological approach strengthens the robustness of the conclusions regarding the impact of overweight and obesity on increased medical consultation rates.

Additionally, the consistency between inter-individual (z-score) and intra-individual (ITS) analyses supports the likelihood of a causal effect of overweight and obesity on the increase in GP consultation frequency.

Finally, it is worth noting that in the field of research on the impact of overweight and obesity on healthcare use, available data remain limited, particularly in the French context. This study therefore contributes to a better global understanding of how trends in weight gain influence patterns of healthcare use.

Limitations

A potential limitation of this study is the risk of information bias due to the manual entry of BMI data, which may introduce errors in recording height and weight measurements. Moreover, there is a probable differential bias related to the completion rate of BMI measurements, as healthcare providers may be more likely to record BMI for children with abnormal values. This selective recording could lead to an overestimation of the observed associations.

Also, BMI is a convenient measure, as it can be done in routine and with low investment. Nevertheless, it has been shown to be specific but not very sensitive to identify part of the children concerned by excess body fat, compared to gold standards, such as DXA or body composition (56).

Moreover, there is a risk of selection bias due to the exclusion of certain patients, such as patients without a follow-up (as requested by the ethical committee), and the patient without the possibility of the calculation of a z-BMI (missing data on BMI or sex). The highest BMI category values were also excluded from the analysis, as they were highly likely to result from data entry errors. These represented a very small proportion of the dataset (<0.3% of both patients and consultations).

Also, drug prescriptions may not be fully captured, as patients could have obtained prescriptions from healthcare providers outside the included centres, leading to a potential underestimation of drug use. Moreover, handwritten prescriptions were not included in the analysis. However, given the level of computerization of health centres required to be included in the PRIMEGE database, the occurrence of manually recorded prescriptions, while possible, is likely to be limited in volume and is unlikely to introduce differential bias. Moreover, drug data reflect prescriptions rather than diagnoses confirmed by a clinical gold standard. As previously shown in the context of asthma, drugs are sometimes prescribed in the absence of a formal diagnosis, particularly among children with overweight or obesity (21). Consequently, it is not possible to determine whether the prescribed drugs (antibiotics, or asthma drugs) were clinically justified.

Another limitation is the lack of adjustment for some confounding factors, particularly socio-economic status, as they were not available in the database, which may lead to residual confounding in the observed associations that could have overestimated the observed associations. Nevertheless, the self-controlled ITS analysis allowed to overcome this limitation for the analysis of the consultation rates.

Finally, as this study is observational, it is not possible to conclude causality. Moreover, multiple tests have been run. The sensitive analysis by applying the Benjamini-Hochberg had no impact on the analysis on consultation frequency or the antibiotic analysis and strengthened these results. The association found on asthma medication remained significant before 5 years old but became unsignificant between 5 and 9. A specific study on these subpopulations should be needed to confirm the findings of this study. It would also be useful to replicate this type of study in other contexts, as well as in the French context, to confirm these results more broadly and with larger cohorts. Furthermore, this study was unable to examine the impact of other changes in BMI categories on consultation frequencies, particularly the effect of BMI normalization. Such studies would be valuable in enhancing our understanding and the relevance of public health policies for managing abnormal BMI.

The increased frequency of consultations observed among children with overweight or obesity appears in line with specific healthcare needs that have been described in the literature for this subpopulation (7, 19, 20). This pattern of healthcare utilization may therefore be aligned with medical needs and represents an encouraging signal regarding the capacity of the French primary care system to provide follow-up for children with pathological BMI. The study also underscores the potential strain on the healthcare system resulting from the rising prevalence of weight-related conditions. These findings provide additional support for strengthening the presence of primary care providers, to ensure optimal management of these patients in the current context of workforce shortages in the French healthcare system.

Conclusion

This study contributes original data specific to the French setting, and underscores the importance of anticipating the evolving healthcare needs of children with elevated BMI, particularly in a context of rising overweight and obesity prevalence in France and globally. Such anticipation is crucial not only to adapt healthcare systems to adequately meet the needs of these children but also to strengthen preventive strategies aimed at limiting pathological BMI trajectories that contribute to increased healthcare use over time.

References

1. Zhou XD, Chen QF, Yang W, Zuluaga M, Targher G, Byrne CD, et al. Burden of disease attributable to high body mass index: an analysis of data from the Global Burden of Disease Study 2021. eClinicalMedicine. 1 oct 2024;76.

2. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in underweight and obesity from 1990 to 2022: a pooled analysis of 3663 population-representative studies with 222 million children, adolescents, and adults. Lancet Lond Engl. 16 mars 2024;403 (10431):1027-50.

3. Zhang X, Liu J, Ni Y, Yi C, Fang Y, Ning Q, et al. Global Prevalence of Overweight and Obesity in Children and Adolescents: A Systematic Review and Meta-Analysis. JAMA Pediatr. 1 août 2024;178(8):800-13.

4. DRESS. En 2017, des adolescents plutôt en meilleure santé physique mais plus souvent en surcharge pondérale | Direction de la recherche, des études, de l'évaluation et des statistiques. Etudes et Résultats. août 2019;

5. Horesh A, Tsur AM, Bardugo A, Twig G. Adolescent and Childhood Obesity and Excess Morbidity and Mortality in Young Adulthood - a Systematic Review. Curr Obes Rep. sept 2021;10(3):301-10.

6. Llewellyn A, Simmonds M, Owen CG, Woolacott N. Childhood obesity as a predictor of morbidity in adulthood: a systematic review and meta-analysis. Obes Rev Off J Int Assoc Study Obes. janv 2016;17(1):56–67.

7. Wijga AH, Scholtens S, Bemelmans WJ, de Jongste JC, Kerkhof M, Schipper M, et al. Comorbidities of obesity in school children: a cross-sectional study in the PIAMA birth cohort. BMC Public Health. 9 avr 2010;10:184.

8. Warnick JL, Darling KE, West CE, Jones L, Jelalian E. Weight Stigma and Mental Health in Youth: A Systematic Review and Meta-Analysis. J Pediatr Psychol. 5 mars 2022;47(3):237-55.

9. Breitfelder A, Wenig CM, Wolfenstetter SB, Rzehak P, Menn P, John J, et al. Relative weight-related costs of healthcare use by children — Results from the two German birth cohorts, GINI-plus and LISA-plus. Econ Hum Biol. 1 juill 2011;9(3):302-15.

10. Clifford SA, Gold L, Mensah FK, Jansen PW, Lucas N, Nicholson JM, et al. Health-care costs of underweight, overweight and obesity: Australian population-based study. J Paediatr Child Health. déc 2015;51(12):1199-206.

11. Kelly B, West J, Yang TC, Mason D, Hasan T, Wright J. The association between body mass index, primary healthcare use and morbidity in early childhood: findings from the Born In Bradford cohort study. Public Health. févr 2019;167:21-7.

12. Wright DR, Prosser LA. The Impact of Overweight and Obesity on Pediatric Medical Expenditures. Appl Health Econ Health Policy. 1 avr 2014;12(2):139-50.

13. Willershausen B, Haas G, Krummenauer F, Hohenfellner K. Relationship between high weight and caries frequency in German elementary school children. Eur J Med Res. 31 août 2004;9(8):400-4.

14. Grier WR, Kratimenos P, Singh S, Guaghan JP, Koutroulis I. Obesity as a Risk Factor for Urinary Tract Infection in Children. Clin Pediatr (Phila). sept 2016;55(10):952-6.

15. Jedrychowski W, Maugeri U, Flak E, Mroz E, Bianchi I. Predisposition to acute respiratory infections among overweight preadolescent children: an epidemiologic study in Poland. Public Health. mai 1998;112(3):189-95.

16. Lee YL, Chen YC, Chen YA. Obesity and the occurrence of bronchitis in adolescents. Obes Silver Spring Md. janv 2013;21(1): E149-153.

17. Huttunen R, Syrjänen J. Obesity and the risk and outcome of infection. Int J Obes 2005. mars 2013;37(3):333-40.

18. Solmi F, Morris S. Association between childhood obesity and use of regular medications in the UK: longitudinal cohort study of children aged 5–11 years. BMJ Open. 1 mai 2015;5(6):e007373.

19. Lang JE, Bunnell HT, Hossain MJ, Wysocki T, Lima JJ, Finkel TH, et al. Being Overweight or Obese and the Development of Asthma. Pediatrics. déc 2018;142 (6): e20182119.

20. Peters U, Dixon A, Forno E. Obesity and Asthma. J Allergy Clin Immunol. avr 2018;141(4):1169-79.

21. Lentferink YE, Boogaart NE, Balemans WAF, Knibbe CAJ, van der Vorst MMJ. Asthma medication in children who are overweight/obese: justified treatment? BMC Pediatr. 11 mai 2019;19(1):148.

22. ECDC. Antimicrobial consumption in the EU/EEA - Annual epidemiological report for 2018. 2019.

23. Lacroix-Hugues V, Darmon D, Schuers M, Touboul P, Pradier C. Création d'une base de données en médecine générale – projet pilote PRIMEGE PACA. Rev DÉpidémiologie Santé Publique. 1 déc 2016;64:S301.

24. Lacroix-Hugues V, Darmon D, Pradier C, Staccini P. Creation of the First French Database in Primary Care Using the ICPC2: Feasibility Study. Stud Health Technol Inform. 2017;245:462-6.

25. Norwegian Institute of Public Health. ATCDDD - ATC/DDD Index 2025 [Internet]. 2024. Disponible sur: https://atcddd.fhi.no/atc_ddd_index/

26. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 6 mai 2000;320(7244):1240-3.

27. HAS. Surpoids et obésité de l'enfant et de l'adolescent, recommandations de bonnes pratiques. 2011.

28. WHO Multicentre Growth Reference Study Group. WHO Child Growth Standards based on length/height, weight and age. Acta Paediatr Oslo Nor 1992 Suppl. avr 2006;450:76-85.

29. Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ. sept 2007;85(9):660-7.

30. Cole TJ, Flegal KM, Nicholls D, Jackson AA. Body mass index cut offs to define thinness in children and adolescents: international survey. BMJ. 28 juill 2007;335 (7612):194.

31. Kuczmarski RJ, Ogden CL, Guo SS, Grummer-Strawn LM, Flegal KM, Mei Z, et al. 2000 CDC Growth Charts for the United States: methods and development. Vital Health Stat 11. mai 2002;(246):1–190.

32. Diaz T, Strong KL, Cao B, Guthold R, Moran AC, Moller AB, et al. A call for standardised age-disaggregated health data. Lancet Healthy Longev. 1 juill 2021;2(7): e436-43.

33. NCBI. Child, Preschool - MeSH [Internet]. 2025. Disponible sur: https://www.ncbi.nlm.nih.gov/mesh/68002675

34. NCBI. Child - MeSH [Internet]. 2025. Disponible sur: https://www.ncbi.nlm.nih.gov/mesh/68002648

35. NCBI. Adolescent - MeSH [Internet]. 2025. Disponible sur: https://www.ncbi.nlm.nih.gov/mesh/68000293

36. WHO. Adolescent health [Internet]. 2025 [cité 11 mars 2025]. Disponible sur: https://www.who.int/health-topics/adolescent-health#tab=tab_1

37. NHS. nhs.uk. 2025. Age. Disponible sur: https://service-manual.nhs.uk

38. CDC. Parent Information. 2025 [cité 11 mars 2025]. Information About Infants & Toddlers (Ages 0-3). Disponible sur: https://www.cdc.gov/parents/infants/index.html

39. CDC. Parent Information. 2024. Information About Teens (Ages 12-19). Disponible sur: https://www.cdc.gov/parents/teens/index.html

40. CDC. Parent Information. 2024 [cité 11 mars 2025]. Information About Young Children (Ages 4-11). Disponible sur: https://www.cdc.gov/parents/children/index.html

41. Moriyama M, Hugentobler WJ, Iwasaki A. Seasonality of Respiratory Viral Infections. Annu Rev Virol. 29 sept 2020;7(1):83-101.

42. He Q, Huang HH. A framework of zero-inflated Bayesian negative binomial regression models for spatiotemporal data. J Stat Plan Inference. 1 mars 2024;229:106098.

43. Zhang X, Yi N. NBZIMM: negative binomial and zero-inflated mixed models, with application to microbiome/metagenomics data analysis. BMC Bioinformatics. 30 oct 2020;21(1):488.

44. FANG R, WAGNER BD, HARRIS JK, FILLON SA. Zero-inflated negative binomial mixed model: an application to two microbial organisms important in oesophagitis. Epidemiol Infect. août 2016;144(11):2447-55.

45. DRESS. La santé des élèves de grande section de maternelle en 2013 : des inégalités sociales dès le plus jeune âge. 2015. (Études et résultats). Report No.: 924.

46. ARS Normandie. Projet régional de santé, Normandie (2023-2028). 2025.

47. DRESS. L’état de santé de la population en France. Doss DREES. 2022;(102).

48. Lobstein CT, Brinsden H. World Obesity Federation Charles Darwin 2, 107 Gray's Inn Road, London, WC1 X8TZ.

49. Xuefeng Chen WW. Gender Difference and Changes in the Prevalence of Obesity Over Time in Children Under 12 Years Old: A Meta-analysis [Internet]. Journal of Clinical Research in Pediatric Endocrinology; 2025 [cité 7 avr 2025]. Disponible sur: https://jcrpe.org/articles/gender-difference-and-changes-in-the-prevalence-of-obesity-over-time-in-children-under-12-years-old-a-meta-analysis/doi/jcrpe.galenos.2024.2023-11-11

50. Insee. Les femmes plus nombreuses dans la population, surtout aux âges avancés. Insee Flash Auvergne-Rhône-Alpes; 2019. Report No.: 54.

51. Malden S, Gillespie J, Hughes A, Gibson AM, Farooq A, Martin A, et al. Obesity in young children and its relationship with diagnosis of asthma, vitamin D deficiency, iron deficiency, specific allergies and flat-footedness: A systematic review and meta-analysis. Obes Rev Off J Int Assoc Study Obes. mars 2021;22(3): e13129.

52. Liu PC, Kieckhefer GM, Gau BS. A systematic review of the association between obesity and asthma in children. J Adv Nurs. juill 2013;69(7):1446-65.

53. Schröder W, Sommer H, Gladstone BP, Foschi F, Hellman J, Evengard B, et al. Gender differences in antibiotic prescribing in the community: a systematic review and meta-analysis. J Antimicrob Chemother. 1 juill 2016;71(7):1800-6.

54. Smith DRM, Dolk FCK, Smieszek T, Robotham JV, Pouwels KB. Understanding the gender gap in antibiotic prescribing: a cross-sectional analysis of English primary care. BMJ Open. 22 févr 2018;8(2): e020203.

55. Zhou W, Tang J. Prevalence and risk factors for childhood asthma: a systematic review and meta-analysis. BMC Pediatr. 20 janv 2025;25(1):50.

56. Javed A, Jumean M, Murad MH, Okorodudu D, Kumar S, Somers VK, et al. Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents: a systematic review and meta-analysis. Pediatr Obes. juin 2015;10(3):234-44.

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APPENDIX 1 R CODES PRESENTATION

Model for the pathway analysis

```
modelg <- lm (zscore_mean ~ imc_extreme + sexe + origine_med, data = ever_Obese_consultation_quimc, control = lmerControl (optimizer = ‘bobyqa"))
```

zscore_mean: mean z-score of the consultation rate

imc_extreme: BMI category with 4 categories and Normal BMI as reference

sexe: binary variable for sex

id_patient: individual patient identification number

origine_med: medical centre

Model for the Time Serie analysis

```
model_ITS <- glmmTMB ( n_consult ~ exp_bin * temps_absolu + (1 | id_patient), ziformula = ~1, family = nbinom2 (link = ‘log’), data = donees_du_model )
```

n_consult: number of consultations per 6-month period

exp_bin: binary variable with 0 before BMI category change and 1 if change

temps_absolu: months of life

id_patient: individual patient identification number

ziformula = ~1 : Constant zero-inflation component

Model for the consultation comparison

```
model <- glmer(ATB_cat ~ imc + saison + sexe + (1 | id_patient) + origine_med, data = data_filtered, family = binomial, control = glmerControl (optimizer = ‘bobyqa"))
```

ATB_cat: binary variable yes/no

imc: BMI category with 4 categories and Normal BMI as reference

saison: factorial variable with 4 categories with autumn as reference

sexe: binary variable for sex

id_patient: individual patient identification number

origine_med: medical centre

APPENDIX 2 ASSOCIATION BETWEEN CHANGING BMI‡ CATEGORIES AT THE PATIENT LEVEL FROM NORMAL WEIGHT TO OVERWEIGHT AND OVERWEIGHT TO OBESE AND THE MEDICAL CONSULTATION RATE PER 6-MONTH PERIOD, WITH A SEGMENTED TIME APPROACH.

Normal Weight to Overweight

Variable	IRR†	IC 2.5%	IC 97.5%	p-value
Incidence rate at baseline	1.67	1.58	1.75	<0.001*
Category change (Overweight to Obese)	1.64	1.55	1.73	<0.001*
Time before 8.75 years of age	1.0	0.99	1.0	0.67
Time after 8.75 years of age	1.0	0.99	1.01	0.64
Interaction time category/time before 8.75 years of age	0.99	0.99	0.99	<0.001*
Interaction time category/time after 8.75 years of age	0.99	0.99	0.99	<0.001*

Overweight to Obese

Variable	IRR†	IC 2.5%	IC 97.5%	p-value
Incidence rate at baseline	1.58	1.36	1.84	<0.001*
Category change (Overweight to Obese)	1.47	1.25	1.72	<0.001*
Time before 8.75 years of age	0.99	0.99	1.01	0.26
Time after 8.75 years of age	1.00	1.00	1.01	0.08
Interaction time category/time before 8.75 years of age	1.00	0.99	1.01	0.87
Interaction time category/time after 8.75 years of age	0.99	0.99	1.01	0.25

*† Incidence Rate Ratio from a zero-inflated negative binomial mixed model with interaction terms, under self-controlled (each patient as their own control) and Interrupted Time Series design, *significant results with alpha = 0.05, ‡BMI = Body mass index*

APPENDIX 3 MOST FREQUENTLY PRESCRIBED ANTI INFECTIOUS DRUGS OVERALL AND PER AGE.

2 to 17 years old	
Drug name	**Number of prescriptions**
AMOXICILLINE	7308
AMOXICILLINE ET INHIBITEUR D'ENZYME	1293
CEFPODOXIME	1023
CEFIXIME	368
JOSAMYCINE	300
AZITHROMYCINE	251
CLARITHROMYCINE	241
DOXYCYCLINE	187
SULFAMETHOXAZOLE ET TRIMETHOPRIME	141
ACICLOVIR	89

2 to 4 years old		5 to 9 years old	
Drug name	**Number of prescriptions**	**Drug name**	**Number of prescriptions**
AMOXICILLINE	3194	AMOXICILLINE	3030
CEFPODOXIME	588	AMOXICILLINE ET INHIBITEUR D'ENZYME	442
AMOXICILLINE ET INHIBITEUR D'ENZYME	583	CEFPODOXIME	326
JOSAMYCINE	122	CEFIXIME	163
CEFIXIME	103	JOSAMYCINE	138
AZITHROMYCINE	72	CLARITHROMYCINE	123
CLARITHROMYCINE	69	AZITHROMYCINE	110
SULFAMETHOXAZOLE ET TRIMETHOPRIME	51	SULFAMETHOXAZOLE ET TRIMETHOPRIME	57
ACICLOVIR	28	ACICLOVIR	30
CLARITHROMYCINE	19	CEFUROXIME	15
10 to 14 years old		**15 to 19 years old**	
Drug name	**Number of prescriptions**	**Drug name**	**Number of prescriptions**
AMOXICILLINE	908	AMOXICILLINE	176
AMOXICILLINE ET INHIBITEUR D'ENZYME	200	DOXYCYCLINE	120
CEFIXIME	89	AMOXICILLINE ET INHIBITEUR D'ENZYME	68
CEFPODOXIME	87	FOSFOMYCINE	36
DOXYCYCLINE	62	LYMECYCLINE	31
AZITHROMYCINE	49	CEFPODOXIME	22
CLARITHROMYCINE	39	AZITHROMYCINE	20
JOSAMYCINE	37	PRISTINAMYCINE	15
PRISTINAMYCINE	35	CEFIXIME	13
SULFAMETHOXAZOLE ET TRIMETHOPRIME	29	CLARITHROMYCINE	10

APPENDIX 4 MOST FREQUENTLY PRESCRIBED ASTHMA DRUGS

Asthma-related drugs	Number of prescriptions
SALBUTAMOL	6,408
FLUTICASONE	1,521
SALMETEROL ET FLUTICASONE	1 032
FENSIPIRIDE	411
MONTELUKAST	377
BECLOMETASONE	338
BUDESONIDE	115
FORMOTEROL ET BUDESONIDE	71
TERBUTALINE	49
SALMETEROL	28

Appendix 5 Unadjusted association between BMI, sex and evolution of the mean z-score of medical consultation rate per children between 2- and 17-year-old n=10 067

Variable	Unadjusted Estimate (CI 95%)	p-value†
BMI‡		
Underweight	0.23 [0.17; 0.28]	<0.001*
Normal BMI‡	Ref	-
Overweight	0.13 [0.10; 0.16]	<0.001*
Obese	0.25 [0.21; 0.29]	<0.001*

*†Results from a linear regression model, comparing the mean of the reduced centred medical consultation rates to consider the variation in medical consultation rate per year *significant results with alpha = 0.05, ‡BMI = Body mass index*

APPENDIX 6 FACTORS ASSOCIATED WITH AN INCREASE IN THE MEDICAL CONSULTATION RATE FOR CHILDREN CONSIDERING THE HIGHEST BMI CATEGORY OVER THE FOLLOW-UP AND ITS ASSOCIATION WITH THE Z-SCORE OF THE MEDICAL CONSULTATION RATE, RESULTS PER AGE CATEGORY.

Children between 2 and 4 years old (n= 5,593)

Variable	Estimate	IC 95%		Valeur p†
(Intercept)	-0.13	-0.25	-0.01	0.03*
BMI‡				
Underweight	0.36	0.28	0.44	<0.001*
Normal BMI‡	ref	-	-	-
Overweight	0.22	0.17	0.28	<0.001*
Obese	0.40	0.32	0.48	<0.001*

Children between 5 and 9 years old (n= 6,804)

Variable	Estimate	IC 95%		Valeur p†
(Intercept)	-0.15	-0.26	-0.04	0.01
BMI‡				
Underweight	0.29	0.22	0.37	<0.001*
Normal BMI‡	ref	-	-	-
Overweight	0.22	0.17	0.27	<0.001*
Obese	0.35	0.29	0.41	<0.001*

Children between 10 and 14 years old (n= 5,576)

Variable	Estimate	IC 95%		Valeur p†
(Intercept)	-0.08	-0.17	0.01	0.08
BMI‡				
Underweight	0.16	0.06	0.25	<0.05*
Normal BMI‡	ref	-	-	-
Overweight	0.10	0.05	0.15	<0.001*
Obese	0.23	0.16	0.29	<0.001*

Children between 15 and 17 years old (n= 3,427)

Variable	Estimate	IC 95%		Valeur p†
(Intercept)	0.10	0.00	0.20	0.04
BMI‡				
Underweight	0.27	0.09	0.45	<0.05*
Normal BMI‡	ref	-	-	-
Overweight	0.02	-0.04	0.10	0.52
Obese	0.20	0.10	0.30	<0.001*

*†Results from a mixed-effect logistic regression model accounting for the random effect of the medical centre, adjusted for sex, comparing the mean Mean of the reduced centred medical consultation rates to take into account the variation in consultation rate per year *significant results with alpha = 0.05, ‡BMI = Body mass index*

Abstract in French

Contexte : L'obésité et le surpoids chez l'enfant sont associés à des problèmes de santé à court et long terme. Toutefois, les données sur le lien entre l'indice de masse corporelle (IMC) et le recours aux soins primaires chez les enfants restent limitées, notamment en France.

Objectif : Évaluer l'association entre l'IMC et le recours aux soins primaires chez les enfants âgés de 2 à 17 ans.

Méthodes : Une cohorte rétrospective issue de la base de données de soins primaires PRIMEGE a été utilisée, sur la période 2012–2022, incluant 205 757 consultations de 10 067 enfants. Les critères de l'International Obesity Task Force (IOTF) ont été utilisés pour définir les catégories d'IMC (Maigreur, IMC normal, Surpoids, Obésité). Le critère de jugement principal était le taux de consultations en médecine générale par enfant. Les critères secondaires incluaient les prescriptions d'antibiotiques et de traitements liés à l'asthme. Des modèles mixtes, logistiques ou linéaires ont été utilisés, ainsi qu'une analyse de type série temporelle interrompue (ITS) avec modèle mixte binomial négatif à inflation de zéros.

Résultats : Les enfants présentant une maigreur, un surpoids ou une obésité avaient des taux de consultations significativement plus élevés que ceux avec un IMC normal. À l'échelle individuelle, devenir en surpoids était associé à un taux accru de consultations de +42.4% [+33.4%; +52.1%]. Aussi, devenir obèse augmentait le taux de consultation de +61.6% [+35.2%; 93.4%]. Les enfants en surpoids âgés de 5 à 9 ans avaient une utilisation accrue d'antibiotiques (OR=1.17[1.04; 1.32], p<0.008). Les enfants obèses de 2 à 9 ans avaient davantage de prescriptions liées à l'asthme (OR=1.56 [1.15; 2.12], p=0.004) entre 2 et 4 ans ; OR=1.43[1.19; 1.72], p<0.001) après 4 ans.

Conclusion : Ces résultats suggèrent qu'un IMC anormal augmente les besoins en soins chez les enfants et adolescents. Le surpoids et l'obésité sont associés non seulement à une fréquence accrue de consultations, mais aussi de certaines prescriptions médicamenteuses. Ces résultats soutiennent l'importance d'une politique de prévention et la nécessité d'adapter le système de santé aux besoins des enfants en surcharge pondérale.

Mots clés : consultation médicale, soins de santé primaires, médecine générale, surpoids, obésité