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## Measuring adolescents' weight socioeconomic gradient using parental socioeconomic position

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**Background:** There is an evidence of social inequalities in weight status in adolescence but the diversity of family socioeconomic status (SES) indicators can lead to discrepant findings. We aimed to identify how combination of family SES indicators can help measuring weight socioeconomic gradient (WSG) among adolescents. **Methods:** Cross-sectional data from 2113 adolescents (13–18 years old) of the PRALIMAP-INÈS trial were used. Multiple SES indicators and assessment of weight status including body mass index (BMI), waist circumference (WC), waist-to-height ratio (WtHR) and self-perception of overweight were used. We used principal component analysis (PCA) followed by structural equation models to identify SES dimensions. A dimension normalized score was calculated ranging from 1 to 10 (a high score corresponding to high SES). Linear regression models (linear trend test) were used to assess the WSG. **Results:** Three SES dimensions were identified: (i) 'Family social status', (ii) 'Family education level' and (iii) 'Family income level'. BMI was significantly lower in highly advantaged compared with highly less advantaged [−1.64 (−2.39; −0.89) for family social dimension, −0.86 (−1.37; −0.36) for family education level and −2.35 (−3.65; −1.05) for family income level]. Similar results were observed for all weight indicators excepted for self-perception of overweight status. Socially less advantaged adolescents perceived themselves less fat than they were. **Conclusion:** Although WSG was evident in adolescence, association between SES and weight status differed according to objective or perceived weight indicators. The proposed SES dimension can be applied in other field and future studies are needed to confirm our findings.

## Introduction

Over the last decades, the prevalence of overweight and obesity among adolescents has increased worldwide, both in developed and developing countries, but at an uneven pace.<sup>1</sup> In France, the prevalence of overweight and obesity was estimated at 17% including 4% of obesity among adolescents.<sup>2</sup> Being overweight in

adolescence increases the likelihood of being obese in adulthood with several undesirable health consequences.<sup>3,4</sup>

Weight status can be assessed by using various anthropometric measurements that are built from combinations of weight, height and waist circumference (WC). The most commonly used measurements are body mass index (BMI) and WC. Other indicators include waist-to-height ratio (WtHR), a measure of the distribution of body

fat. In addition to the diversity of weight indicators, defining weight status in adolescence is difficult because of growth during this period. Several cut-offs defined by gender and age account for physiological variations and use national and international growth curves: the International Obesity Task Force (IOTF) thresholds for BMI<sup>5</sup> and high WC according to McCarthy cut-off values.<sup>6</sup>

Social inequalities in health are defined as differences in health according to the socioeconomic status (SES) that are unacceptable and potentially avoidable but, in addition, are also considered unfair.<sup>7,8</sup> Social inequalities in health is characterized by differences in indicators of mortality and morbidity according to the SES.<sup>9</sup> France is one of the European countries with the highest level of social inequalities in health.<sup>10,11</sup> Social inequalities in health are found, not just at the threshold of poverty, but at every level of SES hierarchy and is called social gradient (SG) in health.<sup>12,13</sup> The SG in health can be defined as health gradual differences found between all rungs of socioeconomic strata (each socioeconomic strata has higher levels of mortality and morbidity than the one above it).<sup>12</sup> Several studies have shown a potential SG in adolescent weight status characterized by a variation in weight depending on adolescent SES.<sup>11–13</sup> However, adolescents' SES is a multifactorial concept which can integrate both adolescents' perception of their own SES and parental objective SES indicators (education level, socio-professional category, income level, etc.). According to the French Public Health Council, adolescents tend to perceive their SES as equivalent to that of their parents.<sup>14</sup> The large number of social indicators available may lead to discrepant results according to the indicator which is used. Each of them may provide different information, but their combination may help to better estimate of adolescents' SES. Therefore, we aimed to identify how combination of family SES indicators can help measuring weight socioeconomic gradient (WSG) among adolescents.

## Methods

### *PRALIMAP-INÈS trial*

The PRALIMAP-INÈS trial is a mixed, prospective, multicentre trial that aimed to evaluate the effectiveness of a school-based intervention to address social inequalities in adolescent overweight. It included overweight and obese adolescents from 13 to 18 years old who were attending state-run middle (grade 9) or high (grade 10) schools. A total of 35 schools (21 high schools and 14 middle schools) participated. Adolescents were recruited during an inclusion session (T0) organized in each school over three waves: 2012–13, 2013–14 and 2014–15 academic years. Adolescents were first measured (weight, height and WC) and when eligible (overweight: BMI greater than the IOTF age and gender specific overweight threshold<sup>5</sup> for age and gender and/or WC greater than the McCarthy age and gender specific cut-off;<sup>15</sup> close to overweight: BMI greater than the IOTF age and gender specific overweight threshold<sup>5</sup> – 1 kg/m<sup>2</sup>), they were invited to complete questionnaires and have a medical visit. If the overweight was confirmed, the physician proposed them to be included in the PRALIMAP-INÈS care program. More details on the PRALIMAP-INÈS trial protocol are given elsewhere.<sup>16</sup> The trial was approved by the French consultative committee for treatment of information in health research (no. 12.299), the French National Commission for Data Protection and Liberties (no. 912 372) and the French Persons Protection Committee (no. 2012/15) and was registered at ClinicalTrials.gov (NCT01 688 453).

### *Study sample*

This study sample included eligible (overweight or close to overweight) adolescents who completed the PRALIMAP-INÈS inclusion questionnaires. Among the 8735 students with available anthropometric measurements, 2283 were eligible for the

PRALIMAP-INÈS trial: adolescents between 13 and 18 years old, with BMI greater than the IOTF overweight threshold<sup>5</sup> reduced by 1 kg/m<sup>2</sup> for age and gender and/or with WC greater than the McCarthy cut-off value for age and gender.<sup>15</sup> A total of 2113 eligible adolescents completed the questionnaires and constituted our study sample.

## Measurements

This study used cross-sectional data collected over the three waves of the main study.

**Anthropometric measures:** Weight (kg), height (cm) and WC (cm) were measured twice by a school and a clinical research nurses and used to calculate BMI (weight in kg divided by the square of height in m<sup>2</sup>) and WHtR (WC in cm divided by height in cm). The weight excess was determined by overweight/obesity prevalence according to the IOTF cut-off,<sup>5</sup> high WC according to McCarthy,<sup>6</sup> high WHtR defined as WHtR  $\geq 0.5$ <sup>17,18</sup> and adolescents self-perception of their weight status using the Sorensen silhouettes.<sup>19</sup>

**Socioeconomic measures:** Age, gender, school type, family status (living with no, one or two parents), perception of family financial level, scholarship holder and parents (father and mother) education level, social and professional classes and employment status. These data were collected both from the adolescents (self-reported) and the Academic Board of Education.

A specific questionnaire on measuring a score of financial affluence of the family (FAS: family affluence scale) was administrated.<sup>20,21</sup> The score ranges from 0 (less affluent) to 9 (highest affluence). All these variables were ordinal and reconstructed in ascending order from the less advantaged to the more advantaged.

## Statistical analysis

Socioeconomic and anthropometric characteristics were described as mean (SD) for continuous variables or *N* (%) for categorical variables. Statistically significant and linear association (social gradient) between each anthropometric and each SES variables was tested using bivariate linear or logistic regression. Significant SES variables were selected for principal component analysis (PCA) followed by structural equation modelling (SEM) to identify adolescents' SES dimensions. The PCA was used for dimensions identification and the SEM for confirmation. The PCA used the varimax rotation (orthogonal transformation) method and dimension with eigen-value  $\geq 1$  were retained.<sup>22,23</sup> The SEM was used for confirmation (goodness of fit) and scoring of the identified dimensions. The root mean square error approximation (RMSEA, acceptable fit if  $< 0.08$ ), the comparative fit index (CFI, acceptable fit if  $\geq 0.90$ ) and the normed fit index (NFI, acceptable fit if  $\geq 0.90$ ) were examined to evaluate the fit of the models.<sup>24</sup> For each confirmed SES dimension, a normalized score was calculated using SEM path coefficients. To test the internal validity of the identified SES dimensions, the same analysis (PCA followed by SEM) was repeated in a random 50% sample of the initial study sample. We repeated a sub-sample analysis (PCA and SEM) with a random 50% sample of the initial sample. The agreement of SES dimensions was tested with the Cramer *V* statistic (good agreement corresponding to Cramer  $V \geq 0.80$ ).<sup>25,26</sup>

For each dimension, a normalized score was calculated ranging from 1 (lowest SES) to 10 (highest SES). Each score was then categorized into five classes in order to assess the weight social gradient: highly less advantaged (1–2), less advantaged (3–4), intermediate (5–6), advantaged (7–8) and highly advantaged (9–10). Weight social gradient was assessed as a linear association between each dimension categories and weight indicators using linear regression models adjusted for sex and age. For these analyses, social classes were used as categorical variable to measure differences between social classes and 'Highly less advantaged' adolescents constituted the reference group. Then the same analyses were

**Table 1** Baseline socioeconomic and anthropometric characteristics of adolescents

	N	%
SOCIOECONOMIC		
Age (year), mean (SD)	2113	15.3 (0.7)
Gender (girls)	1188	56.2
School type		
Vocational high school	720	34.1
General and technological high school	1013	48.0
Middle schools	378	17.9
Scholarship holder	507	29.2
Parental place of birth		
Both outside France	156	7.9
One in France	144	7.3
Both in France	1668	84.8
Perception of family financial level		
Not at all	28	1.3
Slightly	151	7.2
Moderately	919	43.6
Rather affluent	1012	48.0
Father education level (ISCED <sup>a</sup> )		
< Level 3	1556	25.1
≥ Level 3	444	22.2
Mother education level (ISCED <sup>a</sup> )		
< Level 3	1364	20.9
≥ Level 3	712	34.3
Father employment status		
Job search	101	5.3
Others	151	7.9
Employed	1668	86.9
Mother employment status		
Job search	179	8.8
Others	391	19.1
Employed	1475	72.1
Father social and professional class (ISCO-08 <sup>b</sup> )		
Other people unemployed	243	11.6
Elementary occupations	125	6.0
Plant and machine operators, and assemblers	776	37.1
Craft and related trades workers	101	4.8
Skilled agricultural, forestry and fishery workers	42	2.0
Service and sales workers	164	7.8
Clerical support workers	182	8.7
Technicians and associate professionals	162	7.7
Professionals	183	8.8
Managers	113	5.4
Mother social and professional class (ISCO-08 <sup>b</sup> )		
Other people unemployed	466	22.5
Elementary occupations	121	5.8
Plant and machine operators, and assemblers	322	15.5
Craft and related trades workers	25	1.2
Skilled agricultural, forestry and fishery workers	25	1.2
Service and sales workers	352	17.0
Clerical support workers	299	14.4
Technicians and associate professionals	85	4.1
Professionals	346	16.7
Managers	32	1.5
Family affluence scale score, mean (SD)	2113	5.8 (1.7)
ANTHROPOMETRIC MEASUREMENTS		
BMI (kg/m <sup>2</sup> ), mean (SD)	2113	25.6 (3.9)
BMI Z-score, mean (SD)	2113	1.4 (0.8)
Obesity (IOTF <sup>c</sup> classification)	344	16.3
WC (cm), mean (SD)	2112	85.4 (10.6)
High WC <sup>d</sup> (McCarthy classification)	1701	80.5
WHtR, mean (SD)	2112	0.5 (0.1)
High WHtR	1019	48.2
Overweight self-perception	704	37.3

Data are N (%) unless indicated. BMI, body mass index; WC, waist circumference; WHtR, waist to height ratio;

a: International Standard Classification of Education;

b: International Standard Classification of Occupations—08;

c: International Obesity Task Force;

d: Waist Circumference.

**Table 2** Principal component analysis of family socioeconomic dimensions

	Dimension 1 Family social status	Dimension 2 Family education level	Dimension 3 Family income level
Parents' education level			
Father	0.06	0.88	0.08
Mother	0.19	0.83	0.07
Parents' employment status			
Father	-0.01	0.02	0.64
Mother	0.73	-0.02	0.17
Parents' social and professional classes (ISCO <sup>a</sup> classification)			
Father	0.57	0.30	0.06
Mother	0.86	0.14	0.00
Family affluence scale in 5 classes	0.31	0.13	0.61
Scholarship holder	0.51	0.06	0.44
Perception of family financial level	0.07	0.04	0.68

a: International Standard Classification of Occupations. Data are factor scores.

repeated using social classes as continuous variable to obtain the *P* values for linear trend test. Statistical analysis involved use of SAS 9.3 (SAS Inst., Cary, NC, USA). *P* < 0.05 was considered statistically significant.

## Results

### Characteristics of the study sample

Socioeconomic and anthropometric characteristics are presented in table 1. Among the 2113 adolescents, the mean age was 15.3 ± 0.7 years, 56.2% were girls, 48% attending general high schools and the mean affluence FAS score was 5.8 ± 1.7. The BMI was 25.6 ± 3.9 kg/m<sup>2</sup>, the WC was 85.4 ± 10.6 cm, 16.3% were obese according to the IOTF classification and 80.5% had a high WC according to the McCarthy classification.

### Identification of socioeconomic dimensions

The following social indicators were linearly and significantly associated with anthropometric measurements and were selected for PCA: FAS score, scholarship holder, perception of family financial level, parents' (mother and father) education level, social and professional category and employment status. PCA identified three dimensions labelled as followed: (i) '**Family social status**' (including scholarship holder, mother employment status and father and mother social and professional category), (ii) '**Family education level**' (including education level of each parent) and (iii) '**Family income level**' (including FAS score, perception of family financial level and father's employment status) (table 2). SEM confirmed an acceptable fit of the three dimensions (RMSEA = 0.08 (95% CI 0.07–0.09), CFI = 0.91 and NFI = 0.90) and allowed a calculation of each dimension score using path coefficient:

- '**Family social status**' = +0.4988\*(Scholarship holder) + 0.5898\*(mother's employment status) + 0.5147\*(father's social and professional category) + 0.7638\*(mother's social and professional category)
- '**Family education level**' = +0.6378\*(father's education level) + 0.8635\*(mother's education level)
- '**Family income level**' = +0.3936\*(perception of family financial level) + 0.6840\*(FAS) + s0.2727\*(father's employment status).

Each score was then normalized ranging from 0 to 10 (the higher social class). The mean score of the dimensions were 5.2 ± 2.4 for '**Family social status**', 4.7 ± 3.4 for '**Family education level**' and 7.1 ± 2.0 for '**Family income level**'. For internal validated, the same analyses in a random 50% subsample led to similar dimensions



**Table 3** Association of family socioeconomic dimensions and adolescent weight measurements

	BMI $\beta$ (95% CI) <sup>#</sup>	P	BMI Z-score $\beta$ (95% CI) <sup>#</sup>	P	WC $\beta$ (95% CI) <sup>#</sup>	P	WHtR ratio (*100) $\beta$ (95% CI) <sup>#</sup>	P
Dimension 1: family social status								
Highly less advantaged (17.2%)	0.0		0.0		0.0		0.0	–
Less advantaged (23.9%)	–0.44 (–1.02; 0.15)	0.14	–0.07 (–0.19; 0.04)	0.22	–0.48 (–2.08; 1.12)	0.56	–0.54 (–1.47; 0.39)	0.26
Intermediate (22.8%)	–0.73 (–1.33; –0.13)	0.02	–0.14 (–0.26; –0.02)	0.02	–1.31 (–2.89; 0.27)	0.10	–1.55 (–2.5; –0.6)	0.001
Advantaged (26.3%)	–0.67 (–1.25; –0.09)	0.02	–0.12 (–0.24; –0.01)	0.04	–1.59 (–3.22; 0.03)	0.05	–1.51 (–2.43; –0.59)	0.001
Highly advantaged (9.8%)	–1.64 (–2.39; –0.89)	<0.0001	–0.33 (–0.48; –0.18)	<0.0001	–3.06 (–5.1; –1.02)	0.003	–2.53 (–3.71; –1.34)	<0.0001
P value for linear trend	0.0001		<0.0001		0.003		<0.0001	
Dimension 2: Family education level								
Highly less advantaged (37.5%)	0.0		0.0		0.0		0.0	–
Less advantaged (10.5%)	0.11 (–0.48; 0.7)	0.71	–0.01 (–0.12; 0.11)	0.92	0.58 (–1.04; 2.2)	0.48	0.28 (–0.66; 1.22)	0.56
Intermediate (22.8%)	–0.17 (–0.62; 0.28)	0.46	–0.03 (–0.12; 0.06)	0.46	–0.33 (–1.56; 0.9)	0.60	–0.56 (–1.27; 0.16)	0.13
Advantaged (13.3%)	–0.61 (–1.15; –0.07)	0.03	–0.12 (–0.23; –0.01)	0.03	–1.58 (–3.06; –0.1)	0.04	–1.21 (–2.07; –0.35)	0.006
Highly advantaged (15.9%)	–0.86 (–1.37; –0.36)	0.0008	–0.15 (–0.25; –0.05)	0.004	–2.42 (–3.8; –1.03)	0.0007	–2.08 (–2.89; –1.27)	<0.0001
P value for linear trend	0.0003		0.001		0.0003		<0.0001	
Dimension 3: Family income level								
Highly less advantaged (1.9%)	0.0		0.0		0.0		0.0	–
Less advantaged (14.4%)	–1.32 (–2.63; –0.01)	0.049	–0.25 (–0.51; 0.005)	0.05	–3.22 (–6.74; 0.3)	0.07	–2.09 (–4.20; 0.02)	0.05
Intermediate (16.8%)	–1.50 (–2.81; –0.2)	0.02	–0.29 (–0.55; –0.03)	0.03	–3.79 (–7.29; –0.3)	0.03	–2.60 (–4.69; –0.50)	0.02
Advantaged (49.1%)	–1.90 (–3.16; –0.64)	0.003	–0.37 (–0.62; –0.13)	0.003	–4.94 (–8.32; –1.55)	0.004	–3.40 (–5.43; –1.37)	0.001
Highly advantaged (17.8%)	–2.35 (–3.65; –1.05)	0.0004	–0.45 (–0.71; –0.19)	0.0006	–5.52 (–9.01; –2.02)	0.002	–3.90 (–5.99; –1.81)	0.0003
P value for linear trend	<0.0001		<0.0001		<0.0001		<0.0001	

BMI, body mass index; WC, waist circumference; WHtR, waist to height ratio;

#: Beta coefficient of linear regression (95% confidence interval) adjusted for age and gender.

and scoring with a good agreement (Cramer's V statistic ranged from 0.77 to 1.0).

### Social gradient analysis

We found a significant social gradient in weight status for each identified SES dimension (table 3). From all the three dimensions, the higher the score, the lower the weight status (BMI, BMI Z-score, WC and WHtR) with significant linear trend test. For the '**Family income level**' dimension, c with highly less advantaged, highly advantaged adolescents had lower weight: –2.35 (–3.65; –1.05) kg/m<sup>2</sup> for BMI, –0.45 (–0.71; –0.19) for BMI Z-score, –5.5 (–9.01; –2.02) cm for WC, –3.9 (–5.99; –1.81) for WHtR. Similar but slightly less significant results were found for '**Family social status**' and '**Family education level**' dimensions. The figure 1 shows the association between measured or perceived weight excess and socioeconomic dimensions. For measured weight excess indicators, there was a significant social gradient. Proportion of obesity (IOTF), high WHtR and high WC (McCarthy) significantly increased with the decrease SES. In contrast to measured weight excess, no social gradient was observed with the perceived weight status. Socially less advantaged adolescents did not perceived themselves more overweight than socially advantaged adolescents.

## Discussion

### Main results

This population-based study demonstrates that an adequate combination of parental socioeconomic position is an effective way of measuring WSG in adolescence. The study also highlighted two interesting points. First, mother's employment status was found to

be a component of 'Dimension 1: Family social status' while father's employment status was in the 'Dimension 3: Family income level'. Consequently, in study including adolescents, father and mother employment status may not be substitutable social indicators. Second, the WSG was significant for objective measures of weight status while it was not for subjective measures. Adolescents of socially less advantaged classes perceived themselves less overweight than they are.

### Identified SES dimensions

The combinations of parental SES indicators yielded three clear and consistent family-related dimensions: '**Family social status**', '**Family education level**' and '**Family income level**'. This result confirmed that SES is a composite indicator which combines education level, social status and income level and with a different weight for each SES among each dimension. It should be noted that being employed reflected different SES component of adolescent depending on whether it was the status of mother or father. Studies often used the head of household SES (education level or employment status) as the SES of adolescent which can result in different findings depending on which parent is consider as head of household.<sup>27,28</sup> Moreover, each component of identified SES dimensions had a specific weight and highlighted the importance of building composite index of SES when investigating socioeconomic. To ensure a great understanding of socioeconomic disparities, studies should consider these components simultaneously. Unfortunately, this studies often focus on one or some of them with debatable combinations methods.<sup>28</sup> The result of this study can be the base of creating a composite scoring of adolescents SES using parents SES.

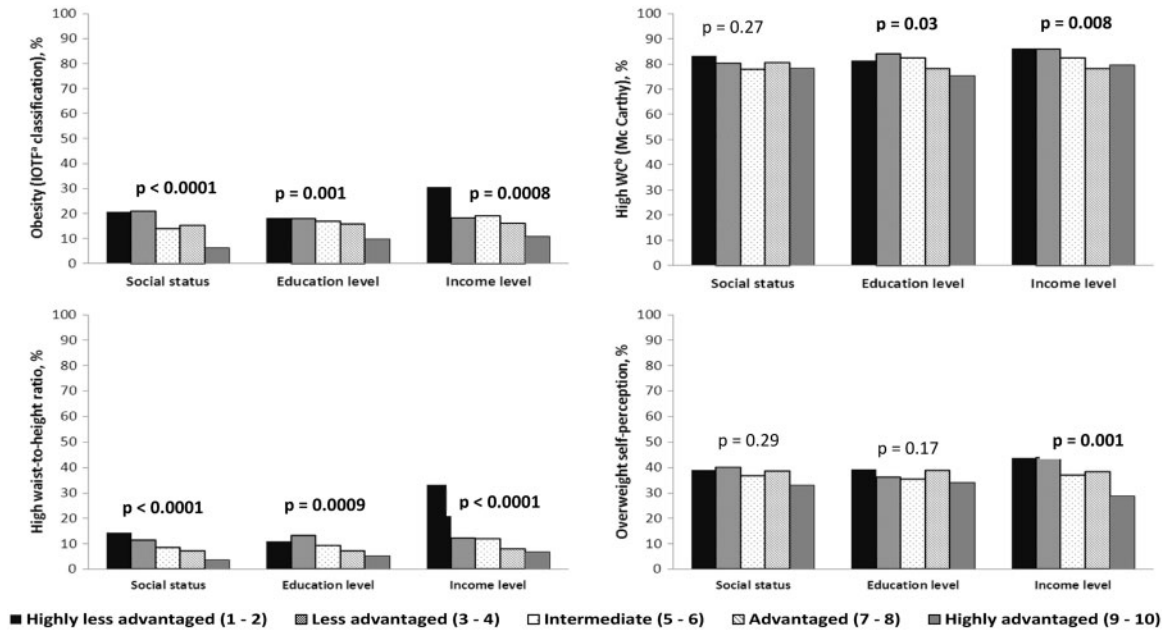


Figure 1 Associations between socioeconomic dimensions and objective or perceived weight excess

### Weight socioeconomic gradient

Weight status was significantly and inversely associated with the SES of adolescents (for each SES dimension) confirming the presence of WSG as described in numerous studies. Adolescents with low SES were more likely to have high weight status. Despite the fact that overweight or obesity prevalence has remained relatively stable in recent years, it still increasing in low SES classes resulting in the worsening of this WSG.<sup>29–32</sup> Worst still, the perceived WSG was not significant while the measured one was. It highlights a potential weight misperception according to the SES. Socially less advantaged adolescents may perceive themselves less corpulent than they were or advantaged adolescents may perceive themselves more corpulent than they were. This studies have pointed the importance of weight misperception among adolescents. Lu et al. showed that only 21% of boys and 36% of girls who are overweight, and 58% of boys and 73% of girls with obesity, accurately perceive their weight status.<sup>33</sup> An accurate perception of one's weight is believed to be necessary to motivate weight loss intention because misperception of weight status is known to be associated with unhealthy weight-related behaviours.<sup>34,35</sup> Differential weight misperception according to adolescents' SES may contribute to maintain or worsen WSG. Public health intervention may also act on reducing weight misperception for more effectiveness.

Although the WSG was significant for all the three SES dimensions when using objective weight status, the dimension of the 'family income level' seemed to have the strongest association with adolescent weight status and it raises the question of how relevant is each SES dimension in social inequalities in health. The SES dimensions may not equally impacted adolescents weight status. It is well established that health-related behaviours such as physical activity, sedentary behaviour and diet are significantly associated with adolescents' weight status. It is also known that the affluence of the adolescents' family can impact their health-behaviours.<sup>35</sup> So understanding the causal mechanism of possible mediating effect of the relationship between health-related behaviours and weight status through SES (mediation effect of SES) can help developing more effective public health interventions to reduce WSG in adolescents.

### Limitations and strengths

The main limitation of this study is the cross-sectional design with could not allowed for a causal relationship between weight status

and SES. Even if analyzing the relationship between SES and weight status is a relevant issue, in this study we were more interested in how to measure efficiently the WSG but combining SES indicators rather than analyzing the causality relationship between weight status and SES. Other limitations include the use of self-reported questionnaire to assess SES with a potential reporting bias. However, adolescents' self-reported SES was completed by data collected from the Academic Board of Education with a view to ensure consistency of these data. Despite these limitations, a number of aspects of the study should provide confidence in its findings. This is the first study to describe a socioeconomic gradient in weight status among adolescents by combining parental SES indicators. The identified SES dimensions were consistent to what we expected. Other strengths were the large sample size, multicentre design and valid measure of weight status.

### Conclusion

Beyond the confirmation of significant WSG in adolescence, the result of this study highlights the importance of an adequate combination of parental SES to determine adolescents SES. The results of this study can help to develop multicomponent tool for measuring socioeconomic gradient in adolescence. A difference between objective and perceived weight status according to the SES of the adolescent was also observed. Adolescent misperception of one's weight status according to their SES may be one of the explaining factors of maintaining or worsening social inequalities in health. Reducing weight misperception especially in socially less advantaged adolescents can help changing health-related behaviour in public health intervention. Longitudinal studies focusing on weight misperception are needed.

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## Key points

- Adolescents' SES is multidimensional and each dimension is composed of different parental socioeconomic indicator.
- Mother's and father's employment status are components of two different dimensions of adolescents' SES (father's employment status is a component of family income dimension while mother's employment status is a component of family social status).
- Weight social gradient is significant when used objective measures (BMI, BMI Z-score and obesity proportion) but not significant when using adolescent perceived weight status. Socially less advantaged adolescents perceived themselves less overweight than they were.

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