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A nation-wide analysis of socioeconomic and geographical disparities in the prevalence of obesity and excess weight in children and adolescents in Spain: Results from the ENE-COVID study

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Summary

Objective: To estimate national and provincial prevalence of obesity and excess weight in the child and adolescent population in Spain by sex and sociodemographic characteristics, and to explore sources of inequalities in their distribution, and their geographical patterns.

Methods: ENE-COVID is a nationwide representative seroepidemiological survey (68 287 participants) stratified by province and municipality size (April–June 2020). Participants answered a questionnaire which collected self-reported weight and height, that allowed estimating crude and model-based standardized prevalences of obesity and excess weight in the 10 543 child and adolescent participants aged 2–17 years.

Results: Crude prevalences (WHO growth reference) were higher in boys than in girls (obesity: 13.4% vs. 7.9%; excess weight: 33.7% vs. 26.0%; severe obesity: 2.9% vs. 1.2%). These prevalences varied with age, increased with the presence of any adult with excess weight in the household, while they decreased with higher adult educational and census tract average income levels.

Obesity by province ranged 1.8%–30.5% in boys and 0%–17.6% in girls; excess weight ranged 15.2%–49.9% in boys and 10.8%–40.8% in girls. The lowest prevalences of obesity and excess weight were found in provinces in the northern half of Spain. Sociodemographic characteristics only partially explained the observed geographical variability (33.6% obesity; 44.2% excess weight).

Conclusions: Childhood and adolescent obesity and excess weight are highly prevalent in Spain, with relevant sex, sociodemographic and geographical differences. The geographic variability explained by sociodemographic variables indicates that there

Members of the study group are provided in Appendix.

are other potentially modifiable factors on which to focus interventions at different geographic levels to fight this problem.

KEYWORDS
adolescent obesity, child obesity, gender, geographical factors, health status disparities, Spain

1 | INTRODUCTION

Childhood and adolescent overweight and obesity—known as excess weight, when taken together—are a major public health problem worldwide. Childhood and adolescent obesity increases the risk of developing chronic diseases that were previously almost exclusive of adults, such as early-onset type 2 diabetes mellitus, hypertension, metabolic syndrome, hormonal, musculoskeletal or psychosocial disorders[1,2]; it is also associated with a higher likelihood of having excess weight in adulthood, an established risk factor for many cardiovascular diseases and several cancers.[3–5]

In the World Health Organization (WHO) European Region, it is estimated that 29.5% and 11.6% of children aged 5–9 years have excess weight and obesity, respectively, while in the age group 10–19 years, 24.9% and 7.1% of adolescents live with these conditions, respectively.[6] Additionally, the prevalence of both excess weight and obesity increased noticeably during the last decades, making obesity prevention a priority.[6,7]

The prevalence of childhood and adolescent obesity in Spain is monitored through different periodic surveys. The National Health Survey (2–17 years)[8] and the Health Behaviour in School-aged Children (HBSC) study (11–18 years)[9] use self-reported anthropometry data, while the ALADINO study,[10] focused specifically in children aged 6–9 years, includes objective measurements of height and weight, as well as data on food intake and physical activity, within the framework of the Childhood Obesity Surveillance Initiative from the WHO Regional Office for Europe. However, in order to design tailored health interventions against childhood obesity, we need to deepen into inequities linked to the risk of excess weight and obesity, and these surveys do not allow to explore in depth neither the geographical variability of these indicators, nor the contribution of structural factors (i.e., education or socioeconomic status) to their distribution.[11,12]

To address these issues, we took advantage of ENE-COVID, a nationwide representative population-based survey, conducted in 2020 by the Spanish Ministry of Health, the Instituto de Salud Carlos III and the Spanish Regional Health Services to assess the prevalence of SARS-CoV-2 infection.[13] With 10 543 participants between 2 and 17 years with parents reported and self-reported (16–17 years old) anthropometric data and individual, household and contextual socioeconomic information,[14] this large, longitudinal study was designed to obtain representative estimates of prevalence at the province level (Nomenclature of territorial units for statistics, NUTS 3).

The aims of this work were to describe the prevalence of obesity and excess weight in children and adolescents in Spain, along with their geographical pattern, and to study gender-related and socioeconomic inequalities in these prevalences. We also explored the contribution of these factors to the geographical variability of these adiposity indicators across Spain.

2 | METHODS

2.1 | Study design

ENE-COVID is a nationwide population-based study carried out in 2020 to estimate the prevalence of SARS-CoV-2 infection during the first wave of the pandemic in Spain. Its design has been reported elsewhere.[13,15] In brief, 1500 census tracts were sampled with probability proportional to their size, stratified by province and municipality size; subsequently, the National Institute of Statistics randomly selected up to 24 households within each census tract. Institutionalized people were not included in the study. Field work was carried out by staff from each of the region's health departments following a common protocol developed by the Ministry of Health and the Instituto de Salud Carlos III. Data collection was performed in three follow-up waves, with a 1-week break between them, from 27 April to 22 June 2020. The selected households were contacted by phone, and all residents, independently of their age, were invited to participate, either going to their primary health-care centres or allowing study nurses to visit their home. Participants—or their parents for those under 16 years, answered an epidemiological questionnaire containing information about sociodemographic characteristics, self-reported anthropometric measurements, risk factors for severe COVID-19, presence of any disability and chronic diseases. The questionnaire and study protocol can be found in Spanish in the ENE-COVID study website.[14] Prior to enrolment, written informed consent was obtained directly from participants aged 16 years or older, or from their parents/tutors if younger, supplemented by a child's assent document if aged 8–15 years. The study was approved by the Institutional Review Committee of the Institute of Health Carlos III (register number PI 39_2020).

2.2 | Participants

From the sample of 104 600 selected individuals of all ages, 5714 were not eligible (328 were deceased, 1173 were institutionalized and 4213 were not living in the selected households), 10 238 could not be contacted and 20 361 refused to participate. Of the remaining 68 287 participants (Figure S1), for this study, we included data from 10 543 child and adolescent participants aged 2–17 years (5375 boys and 5168 girls). The response rate was 68.9% among all eligible persons aged 2–17 years, with increasing response rates with age (Figure S2).

2.3 | Study variables

Body mass index (BMI) was calculated as weight (kg) divided by squared height (m^2).[16] As this information was collected each round, we used mean height and weight for those who participated in more than one study round. *Z* scores with absolute values greater than or equal to 5 were set to missing.[17] The categorization of children's weight status was based on the 2007 WHO recommended growth reference for school-aged children and teenagers.[18] Its cut-offs were used to calculate BMI-for-age *Z*-scores to estimate the prevalence of excess weight, obesity and severe obesity (children aged 6–17 years), defined as BMI-for-age value >+1 *Z*-score, BMI-for-age value >+2 *Z*-scores and BMI-for-age value >+3 Z-scores, respectively. Of note, the estimated prevalence of excess weight includes participants with overweight and obesity, and prevalence of obesity covers any degree of obesity, including severe obesity. In addition, we provide prevalence estimates according to the International Obesity Task Force (IOTF) cut-off points, the other commonly used reference.[19]

Apart from children's BMI and weight status, other covariables were used in this study, defined as follows: age in years (in four groups: 2–5, 6–9, 10–13, 14–17); sex (male, female); nationality (Spanish, others); disability (any degree of recognized disability: yes; no), household highest education level (the highest level of education[20] successfully completed by an adult living in the household, in three categories: primary, secondary, university); presence of any adult with excess weight (any adult with BMI ≥25 kg/m^2: yes; no), census tract average income (based on percentiles from province-specific distributions of census tract average income in 2017, in four categories: <25th percentile; 25th- < 50th percentile; 50th- < 75th percentile; ≥75th percentile), and municipality size (based on the number of inhabitants in each municipality, in four categories: <5000; 5000–19 999; 20 000–99 999; ≥100 000 inhabitants).[15]

2.4 | Statistical analysis

As adiposity indicators, crude prevalences of excess weight, obesity and severe obesity and their corresponding 95% confidence intervals, were estimated for the overall population, and for girls and boys, by categories of sociodemographic factors. To calculate the absolute number of children and adolescents affected by these problems in Spain, we used population data from the latest available census.[21] We also estimated age-standardized prevalences by province (overall and by sex).

To control for confounding, the prevalences of excess weight and obesity by individual characteristics were standardized to the overall distribution of age, sex, nationality, household highest educational level, census tract income level, disability, presence of any adult with excess weight in the household and municipality size in ENE-COVID participants aged 2–17 years. These variables were selected based on epidemiological knowledge of their potential confounding effect. For estimating the standardized prevalences, we used a design-based logistic regression model adjusted for these sociodemographic factors, and then computed a weighted average of the predicted probabilities of having each weight status.[22] In addition, we estimated standardized prevalence ratios across categories of individual and contextual characteristics.

In addition, we quantified the proportion of the geographical variability in the prevalence of excess weight/obesity that could be explained by differences in sociodemographic characteristics across the 52 Spanish provinces. Thus, we first calculated both, the crude and standardized prevalences in each province, using the same model-based standardization and adjustment factors described above. Then, we estimated the between-province variances in crude and standardized prevalences by fitting inverse-variance weighted random-effects meta-analyses on logit-transformed prevalences through the method of moments.[23] Our estimate of the geographical variability explained by sociodemographic characteristics for each adiposity indicator was calculated as one minus the standardized-to-crude ratio of between-province variances.

To account for the complex design of ENE-COVID (i.e., different sampling selection probabilities) and to adjust for differential non-response based on sex, age and average income in the census tracts, we assigned sampling weights to each study participant. Extreme weights (upper 0.5%) were trimmed to prevent highly influential observations. All statistical analyses considered stratification by province and municipality size, and the clustering by household and census tract, when calculating standard errors (SEs) of prevalence estimates. Finite population corrections were applied since some sampling fractions of census tracts per stratum and households per census tract were not negligible. Confidence intervals (CI) were calculated using logit-transformed prevalences and log transformed ratios, with design-based degrees of freedom equal to the number of first-stage sampling units minus the number of strata, and they were back-transformed to the original scale for reporting. Analyses were performed using *survey*, *zbmicat* and *zanthro* commands in Stata (version 16).

3 | RESULTS

The crude prevalences of obesity (P_{obes}) and excess weight (P_{excess}) according to WHO growth reference are shown in Table 1. Overall P_{obes} was 10.7% (95%CI: 10.0–11.6) while P_{excess} was 30.0% (95%CI: 28.8–31.2). Both conditions were higher in boys (P_{obes} 13.4% [95%CI: 12.2–14.7]; P_{excess} 33.7% [95%CI: 31.9–35.5]) than in girls (P_{obes} 7.9% [95%CI: 7.0–9.0]; P_{excess} 26.0% [95%CI: 24.5–27.5]. In absolute population numbers, this means that, approximately, 790 366 children and adolescents aged 2–17 years would have obesity (509 651 boys and 283 075 girls) and 2 215 980 would have excess weight (1 281 735 boys and 931 641 girls) in Spain.[21] Excess weight was higher in the intermediate age groups (6–13 years) while obesity was higher in 6 to 9-year age group. The prevalence of severe obesity was 2.1% (95%CI: 1.7–2.5), being 1.7 percentage points higher in boys than in girls (Table S1). The prevalences according to IOTF criteria were lower than those according to WHO growth reference (P_{obes} 7.5% [95%CI: 6.9–8.2]; P_{excess} 24.9% [95%CI: 23.7–26.1]; $P_{severe\ obesity}$ 1.8% [95%CI: 1.5–2.1]), with the exception of severe obesity, that was slightly more prevalent in girls with IOTF cut-offs (Tables S1 and S2).

TABLE 1 Crude prevalence of obesity and excess weight in child and adolescent participants in ENE-COVID study by sociodemographic characteristics according to the WHO growth reference.

	Total		Boys		Girls	
	N	% (95% CI)	N	% (95% CI)	N	% (95% CI)
Obesity (WHO)						
Overall	10 543	10.7 (10.0–11.6)	5375	13.4 (12.2–14.7)	5168	7.9 (7.0–9.0)
Age (years)						
2–5	1973	9.7 (8.2–11.6)	978	11.0 (8.7–13.8)	995	8.5 (6.6–10.9)
6–9	2534	17.0 (15.1–19.0)	1368	20.6 (17.9–23.7)	1166	12.6 (10.3–15.3)
10–13	3003	10.7 (9.4–12.3)	1526	13.6 (11.5–16.0)	1477	7.7 (6.1–9.7)
14–17	3033	6.2 (5.1–7.4)	1503	8.2 (6.5–10.2)	1530	4.1 (3.0–5.6)
Nationality						
Spanish	10 061	10.6 (9.8–11.5)	5131	13.2 (12.0–14.5)	4930	7.9 (6.9–8.9)
Other	459	11.5 (8.5–15.4)	232	13.4 (9.1–19.4)	227	9.4 (5.9–14.6)
Disability						
No	9872	10.3 (9.5–11.1)	5003	12.7 (11.5–14.0)	4869	7.7 (6.8–8.8)
Yes	136	21.4 (13.3–32.7)	86	22.6 (12.4–37.5)	50	18.9 (8.8–36.1)
Household highest education level						
Primary	473	17.2 (13.0–22.4)	231	22.7 (15.9–31.5)	242	11.4 (7.6–16.7)
Secondary	5602	13.7 (12.5–15.0)	2831	17.3 (15.5–19.2)	2771	9.9 (8.5–11.5)
University	4468	6.9 (5.9–7.9)	2313	8.3 (6.9–9.9)	2155	5.4 (4.2–6.8)
Any adult with excess weight in the household						
No	2361	5.2 (4.2–6.5)	1181	6.5 (4.9–8.6)	1180	4.0 (2.8–5.6)
Yes	8182	12.4 (11.5–13.5)	4194	15.4 (14.0–17.0)	3988	9.2 (8.1–10.4)
Census tract average income[a]						
<25th percentile	2772	14.1 (12.4–15.9)	1412	17.0 (14.5–19.9)	1360	11.0 (9.1–13.2)
25th- < 50th percentile	2707	11.6 (10.2–13.1)	1402	14.6 (12.4–17.1)	1305	8.3 (6.6–10.5)
50th- < 75th percentile	2459	10.5 (8.8–12.5)	1264	13.5 (11.2–16.2)	1195	7.1 (5.2–9.6)
≥75th percentile	2605	6.6 (5.4–7.9)	1297	8.0 (6.2–10.3)	1308	5.1 (3.7–6.8)
Municipality size (inhabitants)						
<5000	1691	12.6 (10.7–14.8)	880	16.3 (13.0–20.1)	811	8.5 (6.3–11.5)
5000-19 999	2269	10.7 (9.1–12.5)	1154	12.3 (10.1–15.0)	1115	8.8 (6.7–11.6)
20 000-99 999	3416	11.0 (9.5–12.7)	1729	14.2 (12.0–16.8)	1687	7.6 (6.1–9.4)
≥100 000	3167	10.1 (8.9–11.5)	1612	12.6 (10.8–14.6)	1555	7.6 (6.1–9.4)
Excess weight (WHO)						
Overall	10 543	30.0 (28.8–31.2)	5375	33.7 (31.9–35.5)	5168	26.0 (24.5–27.5)
Age (years)						
2–5	1973	21.7 (19.3–24.3)	978	23.3 (19.9–27.0)	995	20.1 (17.1–23.4)
6–9	2534	37.3 (34.8–39.9)	1368	41.0 (37.4–44.7)	1166	33.0 (29.7–36.4)
10–13	3003	35.4 (33.2–37.7)	1526	40.1 (37.0–43.2)	1477	30.5 (27.4–33.7)
14–17	3033	23.6 (21.7–25.5)	1503	27.1 (24.4–30.0)	1530	20.0 (17.5–22.7)
Nationality						
Spanish	10 061	29.8 (28.5–31.0)	5131	33.5 (31.7–35.4)	4930	25.8 (24.3–27.4)
Other	459	32.9 (27.6–38.6)	232	34.3 (26.6–42.9)	227	31.4 (24.7–38.9)
Disability						
No	9872	29.7 (28.5–31.0)	5003	33.4 (31.6–35.3)	4869	25.8 (24.3–27.4)
Yes	136	38.3 (27.8–50.0)	86	43.5 (29.8–58.3)	50	26.9 (14.7–44.1)

TABLE 1 (Continued)

	Total		Boys		Girls	
	N	% (95% CI)	N	% (95% CI)	N	% (95% CI)
Household highest education level						
Primary	473	38.5 (32.3–45.0)	231	40.2 (31.4–49.8)	242	36.6 (29.7–44.1)
Secondary	5602	34.6 (32.9–36.4)	2831	38.9 (36.4–41.4)	2771	30.1 (27.9–32.4)
University	4468	24.0 (22.3–25.8)	2313	27.4 (25.0–29.9)	2155	20.3 (18.2–22.7)
Any adult with excess weight in the family						
No	2361	20.0 (17.9–22.3)	1181	23.9 (20.8–27.2)	1180	16.2 (13.7–19.0)
Yes	8182	33.0 (31.7–34.4)	4194	36.6 (34.6–38.5)	3988	29.2 (27.4–30.9)
Census tract average income[a]						
<25th percentile	2772	35.1 (32.7–37.6)	1412	38.0 (34.5–41.7)	1360	32.1 (29.2–35.1)
25th- < 50th percentile	2707	31.5 (29.4–33.7)	1402	35.9 (32.5–39.4)	1305	26.9 (24.1–29.8)
50th- < 75th percentile	2459	28.6 (26.1–31.2)	1264	32.0 (28.6–35.6)	1195	24.8 (21.8–28.1)
≥75th percentile	2605	24.2 (22.0–26.6)	1297	28.5 (25.1–32.3)	1308	19.8 (17.1–22.9)
Municipality size (inhabitants)						
<5000	1691	30.1 (26.9–33.6)	880	36.1 (31.6–40.9)	811	23.6 (19.5–28.1)
5000–19 999	2269	30.9 (28.4–33.5)	1154	32.8 (29.1–36.6)	1115	28.8 (25.5–32.4)
20 000–99 999	3416	31.2 (28.9–33.6)	1729	34.6 (31.3–38.1)	1687	27.5 (25.1–30.1)
≥100 000	3167	28.5 (26.6–30.4)	1612	32.8 (30.0–35.8)	1555	24.0 (21.6–26.6)

Note: Population prevalence and 95% confidence intervals (CI) accounting for sampling weights, nonresponse rates by sex, age, and census tract average income, stratification by province and municipality size, and clustering by household and census tract. *N*: number of participants.
[a]Categories based on percentiles from province-specific distributions of census tract average income in 2017. There were only missing values in two variables: disability ($n = 23$) and nationality ($n = 35$).

By year of age, the lowest P_{obes} (WHO) in both sexes was found in adolescents, around 16 years of age, while the highest prevalence was observed at 6 years of age (Figure 1; Table S3). The prevalence in pre-schoolers, up to 5 years, was also lower than in school-age children, aged 6 or more. Regarding P_{excess}, the maximum was observed at 8 years, while the lowest prevalence was found in preschool children (2–4 years), with intermediate prevalences for adolescents. Both adiposity indicators were higher in boys than in girls in all age groups, with a wider gap between sexes in the intermediate age groups (Figure 1, Table S3). Also, obesity and severe obesity (Table S1) were higher among children with disability. With IOTF cut-offs, P_{obes} by age had a different behaviour, with the highest prevalences in pre-school children and lowest among adolescents, while for excess weight prevalences were quite constant among age groups, except for a decrease in adolescent girls (Table S3).

We also explored the distribution of all the adiposity indicators by selected household and socioeconomic factors (Table 1; Table S1). There were inverse associations in the prevalences for both sexes with the household highest educational level in the household, except for severe obesity in girls. Also, those living in households with any adult with excess weight had higher P_{obes} and P_{excess} than participants without adult excess weight at home.

Additionally, there was an inverse relationship between P_{obes} and P_{excess} and census tract average income level, with a difference of 7.5 percentage points for obesity and 10.9 for excess weight, between the wealthiest and the most deprived census tracts, with a higher difference for obesity in boys. In contrast, there were no significant differences by municipality size (Table 1). In general, gradients in the same direction than the ones seen for P_{obes} and P_{excess} were found for prevalence of severe obesity in children aged 6 years or older (Table S1) and for all three adiposity indicators when applying IOTF cut-offs, except for girls and household highest educational level, in whom no gradient was observed (Table S2).

We also calculated P_{obes} and P_{excess} (WHO cut-offs) standardized to the overall distribution of sociodemographic variables (age, sex, nationality, disability, household highest educational level, household adult excess weight, census tract average income level and municipality size) in the study population (Tables 2 and 3), as well as their ratios across the different categories of each variable. Our results show that boys had higher prevalences for both indicators. Also, small kids (2–5 years) had the lowest P_{obes}, while those between 6 and 9 years had the highest estimates in both sexes. Disability was a clear risk factor for obesity, but not for excess weight, while there were no differences depending on nationality. In regard to household factors, lower level of household education and the presence of any adult with excess weight were associated to P_{excess}, and, specially, to P_{obes}. On the other hand, the inverse association with census tract average income was clearly more evident among girls. P_{obes} and P_{excess} (IOTF cut-offs) standardized to the overall distribution of sociodemographic variables are shown in Tables S4 and S5.

Figure 2 shows the geographical distribution of crude P_{obes} and P_{excess} (WHO cut-offs) by province, for the total population and by

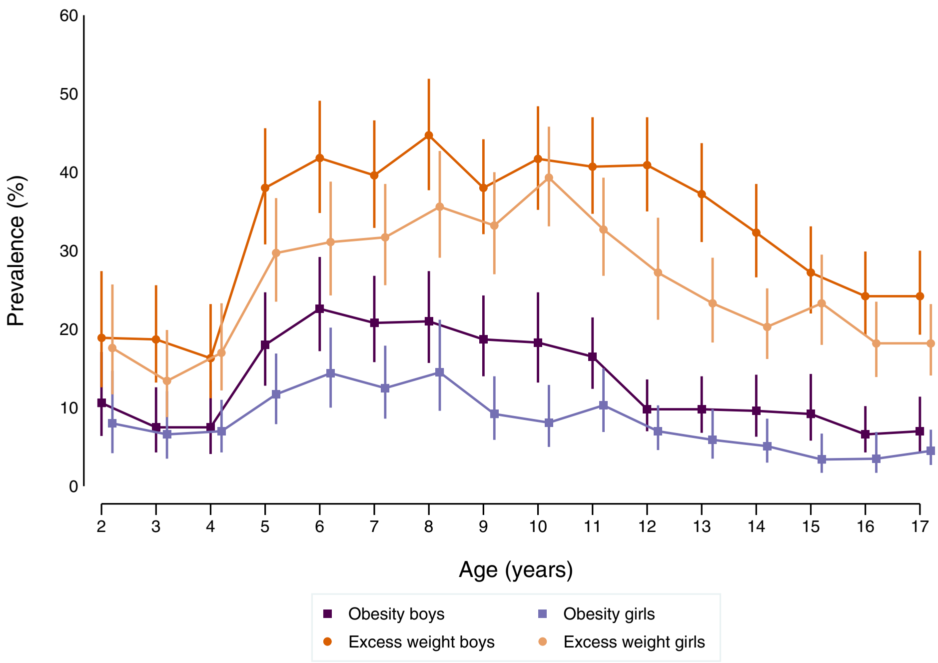

FIGURE 1 Prevalence (%) of obesity and excess weight (WHO cut-offs) by sex and age in child and adolescent participants from ENE-COVID study.

sex (numerical figures are shown in Tables S6 and S7). For obesity, geographical variability was more marked in boys, with provincial prevalences ranging between 1.8% and 30.5%, while, in girls, they were between 0% and 17.6%. Provinces with the lowest prevalences of obesity were mainly located in the north half of the country in both sexes. Provinces with the highest prevalences in the case of boys were distributed throughout all the country, without a clear geographic pattern, while for girls they were concentrated in the south half of Spain. The provinces with the highest P_{obes} were Huelva (30.5%) in boys and Ceuta and Melilla (both 17.6%) in girls (name and location of each province is described in Figure S3). The geographic pattern of P_{obes} under IOTF cut-offs did not differ from that under WHO cut-offs (Figure S4 and Table S8).

P_{excess} (WHO cut-offs) by province ranged between 15.2% and 49.9% in boys and between 10.8% and 40.8% in girls. The lowest prevalences were, in general, located in provinces in the north half of the country in the case of boys, and in the north and centre in girls. On the contrary, the provinces with the highest prevalences were located all over the country without a clear pattern. Specifically, the highest P_{excess} in boys were found in Burgos (49.9%) and Córdoba (49.3%), while for girls they were in Zamora (40.8%) and Ceuta (39.9%). A similar distribution of P_{obes} and P_{excess} was observed under IOTF cut-offs than the ones observed with WHO cut-offs in both sexes (Figure S4 and Table S9). Age-standardized P_{obes} and P_{excess} by province and sex showed no relevant differences compared to crude prevalences, either using WHO or IOTF cut-offs (Figures S5 and S6, Tables S10–S13).

Finally, according to our results, 33.6% of the variability in crude prevalences of obesity across provinces (32.1% in boys and 31.5% in girls) could be explained by regional differences in sociodemographic distribution of the kids (age, sex, nationality, disability) or in household and contextual factors (educational level, adult excess weight in the household, census tract average income and municipality size). For excess weight the explained geographic variability was 44.2% (41.1% in boys and 37.3% in girls).

4 | DISCUSSION

Obesity and excess weight are a major public health problem and a priority in children and adolescent health in Spain. Our results point out that one in three boys and one in four girls has excess weight and one in ten in both sexes has obesity. In absolute numbers, that means that almost 1 million children and adolescents aged 2–17 years have obesity and more than 2 million have excess weight in Spain. Prevalences vary with age and with the presence of disability, but our data show that also some household-related factors (i.e., lower household educational level or having an adult with excess weight at home) are associated with twice the prevalence of obesity. For other contextual factors (i.e., census tract average income) the relationship with adiposity indicators is different by sex, existing a greater difference in girls, except for severe obesity. Finally, we have explored the geographical pattern of these conditions: one third of the regional differences in the prevalence of obesity and more than 40% of the variability in prevalence of excess weight can be explained by the previously mentioned determinants; nevertheless, a relevant proportion of these differences remains unexplained by the variables explored in this work.

The prevalences of obesity and excess weight observed in our study support previous figures from the last National Health Survey in Spain 2017 in 2–17 years old population (self-reported data; WHO cut-offs 12.3% and 32.4%, respectively).[8,12] However, the reference

TABLE 2 Standardized[a] prevalence and prevalence ratio of obesity (WHO growth reference) by sociodemographic variables in child and adolescent participants in ENE-COVID study.

	Total (*N* = 10 543)		Boys (*N* = 5375)		Girls (*N* = 5168)	
	Standardized prevalence	Standardized prevalence ratio	Standardized prevalence	Standardized prevalence ratio	Standardized prevalence	Standardized prevalence ratio
	% (95% CI)	Ratio (95% CI)	% (95% CI)	Ratio (95% CI)	% (95% CI)	Ratio (95% CI)
Sex						
Boys	12.7 (11.6–14.0)	1.59 (1.37–1.85)				
Girls	8.0 (7.0–9.1)	Ref.				
Age group (years)						
2–5	9.8 (8.2–11.8)	Ref.	10.9 (8.6–13.8)	Ref.	8.6 (6.3–11.6)	Ref.
6–9	16.8 (14.9–18.8)	1.71 (1.38–2.10)	20.4 (17.7–23.5)	1.87 (1.44–2.43)	12.9 (10.3–16.0)	1.50 (1.07–2.10)
10–13	10.8 (9.4–12.3)	1.09 (0.87–1.37)	13.5 (11.4–15.8)	1.23 (0.93–1.63)	7.9 (6.0–10.4)	0.92 (0.64–1.33)
14–17	5.7 (4.7–6.9)	0.58 (0.44–0.76)	7.2 (5.7–9.1)	0.66 (0.47–0.93)	4.0 (2.6–6.1)	0.47 (0.31–0.73)
Nationality						
Spanish	10.5 (9.7–11.4)	Ref.	12.8 (11.6–14.1)	Ref.	8.0 (6.8–9.3)	Ref.
Other	9.8 (7.2–13.3)	0.94 (0.68–1.29)	11.7 (7.8–17.2)	0.92 (0.61–1.38)	7.8 (4.3–13.9)	0.98 (0.59–1.62)
Disability						
No	10.3 (9.5–11.2)	Ref.	12.6 (11.4–13.8)	Ref.	7.8 (6.7–9.2)	Ref.
Yes	18.8 (12.1–27.9)	1.82 (1.19–2.78)	21.1 (12.4–33.5)	1.67 (1.00–2.80)	17.9 (9.6–30.9)	2.28 (1.10–4.73)
Household highest education level						
Primary	15.8 (11.1–22.0)	2.16 (1.47–3.18)	19.3 (12.1–29.3)	2.25 (1.37–3.68)	11.6 (5.3–23.2)	1.96 (1.13–3.40)
Secondary	12.8 (11.6–14.1)	1.75 (1.45–2.11)	15.8 (14.1–17.7)	1.85 (1.48–2.31)	9.5 (7.8–11.5)	1.61 (1.21–2.14)
University	7.3 (6.3–8.5)	Ref.	8.6 (7.1–10.3)	Ref.	5.9 (4.5–7.7)	Ref.
Any adult with excess weight in the household						
No	5.4 (4.3–6.8)	Ref.	6.5 (4.9–8.6)	Ref.	4.2 (2.7–6.5)	Ref.
Yes	11.9 (10.9–12.9)	2.20 (1.72–2.80)	14.5 (13.1–16.0)	2.23 (1.64–3.03)	9.1 (7.7–10.6)	2.14 (1.47–3.14)
Census tract average income						
<25th	11.8 (10.3–13.4)	1.50 (1.18–1.91)	13.6 (11.4–16.1)	1.43 (1.05–1.95)	9.7 (7.6–12.2)	1.59 (1.09–2.32)
25th- < 50th	10.9 (9.6–12.5)	1.40 (1.10–1.79)	13.6 (11.4–16.0)	1.43 (1.05–1.96)	8.1 (6.1–10.7)	1.34 (0.89–2.03)
50th- < 75th	10.6 (9.0–12.5)	1.36 (1.06–1.74)	13.4 (11.1–16.0)	1.41 (1.04–1.91)	7.6 (5.5–10.4)	1.26 (0.83–1.91)
≥75th	7.8 (6.4–9.5)	Ref.	9.5 (7.3–12.2)	Ref.	6.1 (4.1–9.0)	Ref.
Municipality size (inhabitants)						
<5000	11.2 (9.5–13.2)	1.05 (0.85–1.29)	14.3 (11.4–17.9)	1.12 (0.85–1.46)	7.8 (5.1–11.7)	0.93 (0.65–1.33)
5000–19 999	9.8 (8.3–11.5)	0.91 (0.74–1.12)	11.2 (9.0–13.8)	0.87 (0.67–1.13)	8.3 (6.2–11.1)	1.00 (0.70–1.43)
20 000–99 999	10.3 (9.0–11.8)	0.97 (0.81–1.16)	13.0 (11.0–15.3)	1.01 (0.82–1.26)	7.5 (5.6–10.0)	0.90 (0.67–1.23)
≥100 000	10.7 (9.4–12.2)	Ref.	12.8 (11.0–14.9)	Ref.	8.3 (6.6–10.5)	Ref.

[a]Standardized to the overall distribution of age, sex, nationality, disability, household highest education level, presence of any adult with excess weight in the household, census tract income and municipality size. There were only missing values in two variables: disability (*n* = 23) and nationality (*n* = 35).

study in Spain for obesity surveillance with objectively measured data in school children (6–9 years), the 2019 ALADINO study, reported prevalences of both conditions noticeably higher than in our study (WHO cut-offs 17.3% and 40.6%, respectively).[10] Such differences could be due to inaccurate estimation by parents of their children's anthropometric measures, and could lead to a wrong estimate of the prevalence of childhood obesity.[10] In adolescent population (11–18 years old), the prevalence of obesity in the HBSC study 2018 (self-reported data, IOTF cut-offs) was 3.1%, similar to our findings, while excess weight was 17.8%, slightly lower than in ENE-COVID study.[9] In any case, all these surveys show a major public health problem to face, given that at least 1 in 10 children and adolescents has obesity and 3 in 10 have excess weight, representing one of the highest figures in the WHO European region.[6]

TABLE 3 Standardized[a] prevalence and prevalence ratio of excess weight (WHO growth reference) by sociodemographic variables in child and adolescent participants in ENE-COVID study.

	Total (*N* = 10 543)		Boys (*N* = 5375)		Girls (*N* = 5168)	
	Standardized prevalence	Standardized prevalence ratio	Standardized prevalence	Standardized prevalence ratio	Standardized prevalence	Standardized prevalence ratio
	% (95% CI)	Ratio (95% CI)	% (95% CI)	Ratio (95% CI)	% (95% CI)	Ratio (95% CI)
Sex						
Boys	33.4 (31.6–35.2)	1.28 (1.19–1.38)				
Girls	26.1 (24.6–27.6)	Ref.				
Age group (years)						
2–5	22.2 (19.7–24.9)	Ref.	23.6 (20.2–27.4)	Ref.	20.5 (17.1–24.3)	Ref.
6–9	37.1 (34.5–39.7)	1.67 (1.47–1.91)	41.2 (37.6–44.9)	1.74 (1.47–2.07)	32.6 (29.1–36.4)	1.59 (1.32–1.93)
10–13	35.7 (33.5–38.0)	1.61 (1.41–1.84)	40.4 (37.4–43.6)	1.71 (1.45–2.02)	30.8 (27.7–34.0)	1.50 (1.23–1.83)
14–17	22.9 (21.0–24.9)	1.03 (0.89–1.19)	26.0 (23.3–28.8)	1.10 (0.91–1.32)	19.5 (16.9–22.4)	0.95 (0.77–1.17)
Nationality						
Spanish	29.8 (28.6–31.1)	Ref.	33.4 (31.6–35.2)	Ref.	26.0 (24.2–27.8)	Ref.
Other	30.3 (25.0–36.2)	1.02 (0.84–1.23)	33.0 (25.4–41.5)	0.99 (0.77–1.27)	27.4 (20.1–36.2)	1.06 (0.79–1.41)
Disability						
No	29.8 (28.5–31.0)	Ref.	33.2 (31.5–35.0)	Ref.	26.1 (24.3–27.9)	Ref.
Yes	34.5 (25.5–44.8)	1.16 (0.87–1.54)	41.7 (29.4–55.1)	1.25 (0.91–1.72)	24.1 (13.3–39.5)	0.92 (0.53–1.61)
Household highest education level						
Primary	39.8 (32.1–48.0)	1.59 (1.28–1.98)	41.2 (30.5–52.7)	1.47 (1.10–1.97)	37.6 (27.1–49.4)	1.73 (1.30–2.28)
Secondary	33.5 (31.8–35.3)	1.34 (1.23–1.46)	37.7 (35.2–40.2)	1.35 (1.21–1.50)	29.0 (26.6–31.6)	1.33 (1.16–1.53)
University	25.0 (23.3–26.8)	Ref.	28.0 (25.6–30.5)	Ref.	21.8 (19.4–24.4)	Ref.
Any adult with excess weight in the family						
No	20.6 (18.4–23.0)	Ref.	24.1 (21.0–27.6)	Ref.	16.9 (13.9–20.5)	Ref.
Yes	32.6 (31.3–33.9)	1.58 (1.41–1.78)	36.1 (34.2–38.1)	1.50 (1.30–1.73)	28.7 (26.8–30.7)	1.70 (1.42–2.03)
Census tract average income						
<25th	31.9 (29.5–34.4)	1.17 (1.04–1.31)	34.0 (30.5–37.6)	1.07 (0.91–1.25)	29.4 (26.0–33.0)	1.30 (1.09–1.55)
25th- < 50th	31.0 (28.9–33.1)	1.13 (1.01–1.27)	35.1 (31.9–38.5)	1.10 (0.95–1.28)	26.5 (23.4–29.9)	1.18 (0.98–1.42)
50th- < 75th	28.8 (26.5–31.2)	1.05 (0.94–1.19)	32.3 (29.0–35.8)	1.01 (0.87–1.18)	25.1 (21.9–28.6)	1.11 (0.93–1.34)
≥75th	27.3 (25.0–29.8)	Ref.	31.8 (28.2–35.7)	Ref.	22.5 (19.0–26.5)	Ref.
Municipality size (inhabitants)						
<5000	28.3 (25.3–31.5)	0.96 (0.84–1.08)	34.3 (29.9–38.9)	1.03 (0.88–1.20)	22.0 (17.8–26.8)	0.86 (0.70–1.06)
5000–19 999	29.8 (27.4–32.2)	1.00 (0.91–1.11)	31.6 (27.9–35.4)	0.95 (0.82–1.09)	27.8 (24.3–31.7)	1.09 (0.93–1.28)
20 000–99 999	30.6 (28.4–32.8)	1.03 (0.94–1.13)	34.2 (31.0–37.5)	1.02 (0.90–1.16)	26.9 (23.8–30.2)	1.05 (0.92–1.21)
≥100 000	29.6 (27.8–31.6)	Ref.	33.4 (30.6–36.3)	Ref.	25.5 (22.8–28.4)	Ref.

[a]Standardized to the overall distribution of age, sex, nationality, disability, household highest education level, presence of any adult with excess weight in the household, census tract income and municipality size. There were only missing values in two variables: disability ($n = 23$) and nationality ($n = 35$).

A noteworthy aspect is that the prevalences differ depending on the reference used, with higher prevalences generally observed with WHO cut-offs, which have been also reported in previous works.[24] These discrepancies are justified by the differences between the reference populations used for the development of growth curves and to define the cut-off points that best identify the groups at risk of morbidity and mortality associated with excess weight.[25] Although there is no consensus on the best criteria to classify weight status of school-age population, it is considered appropriate to express them under different cut-offs to facilitate comparison between countries and with previous studies. Recently, an attempt to harmonize prevalence rates calculated with both cut-offs has been made[26] which

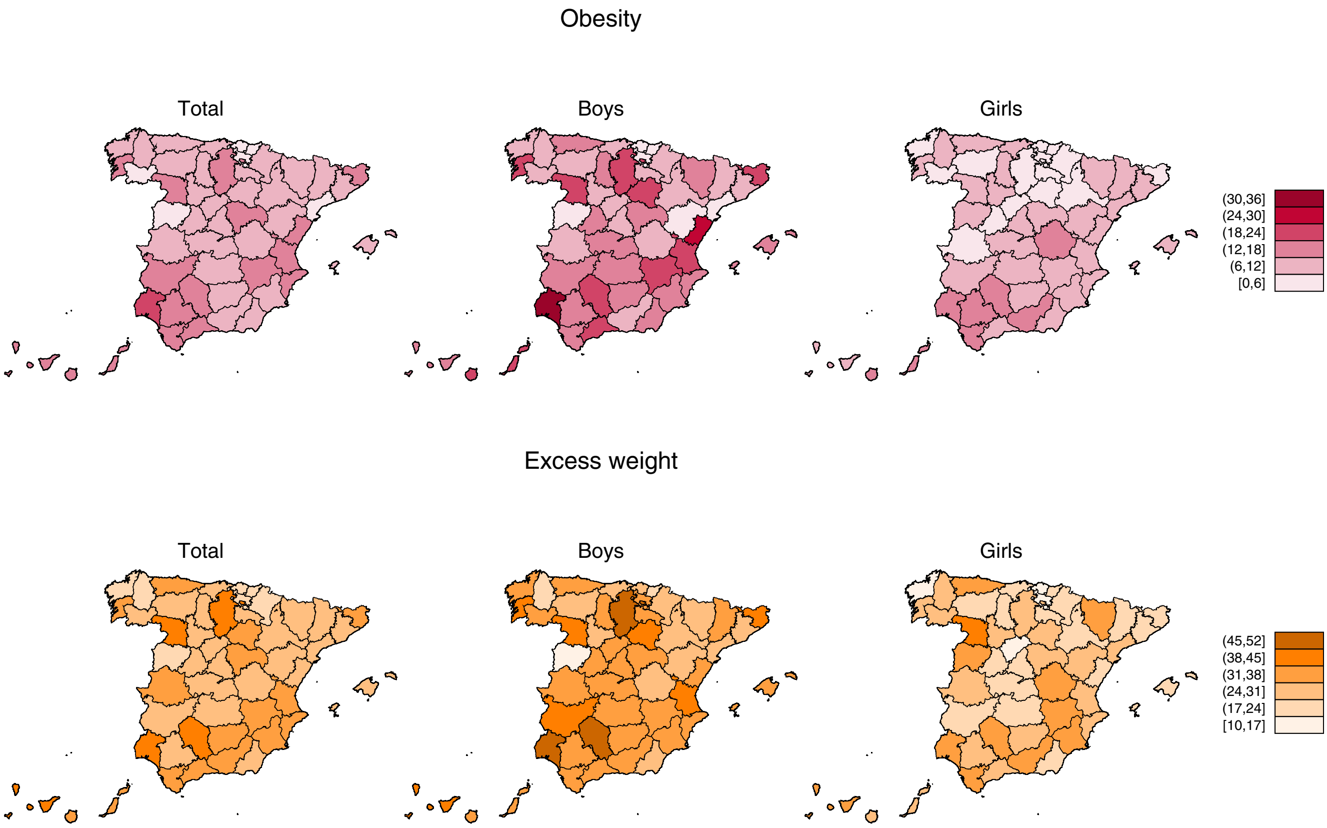

FIGURE 2 Crude prevalences (%) of obesity and excess weight (WHO cut-offs) by province and sex in child and adolescent participants from ENE-COVID study.

could be of help when defining high-priority groups to intervene to prevent obesity through public health policies.

In addition to sex, age is another major determinant of obesity and excess weight. With WHO cut-offs, the highest proportions of obesity and excess weight were found between 6 and 12 years of age, while with IOTF cut-offs the highest prevalence of obesity was found at pre-school age (≤5 years). Knowing the differences in the distribution of this problem is important when designing policies aimed at combating it, although in general, the most successful interventions are those that are implemented from an early age, when many of the eating and physical activity habits are acquired.[27]

Another interesting result of our study is the estimation of the prevalences of obesity and excess weight in Spanish children and adolescents living with a disability; after adjusting by age and other confounders, they had higher risk of suffering obesity, especially among girls, and severe obesity in boys, but not of excess weight. Sedentary lifestyle and a lower degree of physical activity could be an explanation behind these differences.[28]

Also, a noteworthy result is the approximately double prevalence of obesity and excess weight among children living with at least one adult with excess weight at home. This phenomenon, known as intergenerational transmission of obesity, has been widely reported in the scientific literature, somewhat more marked for obesity in children than for excess weight.[10,29] Despite part of this phenomenon can be explained by a shared genetic background, the heritability component cannot totally explain a two-fold risk of having obesity in children living with overweight adults. Weight status of the family, and especially of parents, also determine obesity and excess weight in children through lifestyle influence to a large extent on their children's habits.[30] Therefore, when developing interventions to combat the problem of childhood and adolescent obesity, the family environment should be taken into account.

In regard to socioeconomic factors, in our study we observed that, for obesity, excess weight and severe obesity there was an inverse gradient with the household educational level, except in girls with severe obesity, and the relative income level of the census tract, with ratios slightly larger for girls, that could be related to a lower physical activity compared to boys.[31] This gradient has been described in most European countries with a high level of development, such as Spain.[32] Both, socioeconomic and educational level are key factors associated with differences in lifestyle, for example, in dietary or physical activity habits, thus leading to differences in weight status.[31,33,34] In contrast, although the highest prevalences of both indicators were found in rural areas, similar to what is reported in other studies,[35] after standardization for the remaining socio-demographic variables, there were no differences by municipality size, suggesting that the observed differences could be related to the different distribution of the other socio-demographic factors.

Previous studies have reported crude prevalences of obesity/excess weight at national and regional level.[36,37] However, our study provides, for the first time, a detailed geographical distribution of these conditions in Spain, with representative estimates of obesity and excess weight for the 52 Spanish provinces. There are remarkable geographical differences, although a clear geographical pattern is not evident. Some of the lowest prevalences are in some provinces located in the in the centre and north areas of Spain, while the highest prevalences are spread all over the country, without a specific pattern. Some estimates for specific provinces have been published, and they are in accordance with our results.[8,38]

The observed geographical differences in obesity and excess weight cannot be partly explained by a different distribution of sociodemographic characteristics such as age and sex as we have shown in our study, with no relevant differences between crude and standardized provincial prevalences of both indicators. In contrast, standardized prevalences still show differences when comparing by other factors, as disability and household factors. Nonetheless, the variability we can account for in the present study is higher in children and adolescents than in adults (25.2% of the variability in crude prevalences of adult obesity across provinces [24.0% in men and 22.0% in women]; Gutiérrez González et al, under review), probably because in the case of children we have also considered the 'obesogenic' home environment, shown by the presence of at least one adult with excess weight in the household, which could also be a proxy indicator of the dietary patterns and lifestyle factors to which children and adolescents are exposed. However, our analyses show important unexplained differences between regions, probably due to other factors (genetic, cultural, dietary, psychological, physical activity, sedentarism, sleep duration, comorbidity, factors related to parents, other members of the family individually or the family as a whole, peer groups, neighbourhood, food environment, infrastructures and facilities of the residential neighbourhood, among others) not taken into account in ENE-COVID.[39,40] Unfortunately, we do not have enough data to evaluate possible geographical differences in dietary or physical activity patterns in children and adolescents in Spain, which would be relevant regarding the geographical variability not yet explained.

Epidemiological data may help to target and design tailored interventions to control childhood and adolescent obesity. Since in Spain public health competencies are decentralized, and many health policies are designed and implemented at regional, provincial or municipal levels, it is crucial to set up surveillance programs to monitor prevalence of obesity and the role of contextual risk factors at these levels. In this sense, our results may be useful to establish priorities and to identify high-risk population subgroups or areas on which to focus prevention, detection and treatment of obesity and overweight. Among these possible subgroups, our study identified several health inequalities (i.e., youngest children, those from lower level of family income or educational level, presence of adiposity in their family or those with any disability) that would need to be investigated and tackled under a regional and provincial perspective.

A strength of our study is its representative sample and population-based design, that allows to estimate prevalence figures of obesity and excess weight with 95% confidence intervals, representative at provincial level, and makes it possible to appreciate the geographical distribution of these conditions and to explore the contribution of relevant sociodemographic variables, not available through available surveillance systems of obesity in Spain.[41] In order to get more consistent estimations, since these rounds were conducted only 2 weeks apart and that it is not expected that relevant variations of weight could have happened in this short period of time, we used mean height and weight from the three rounds. In addition, the high rate of participation, as well as the inclusion of postestimation weights to take into account non-response differences, strengthen the reliability and validity of our results.

One of the limitations of our study is the use of self-reported data for participants aged 16 and over, or weight and height data reported by parents for the youngsters, which usually contribute to inaccurate estimations of children's adiposity.[42,43] It is also necessary to consider that institutionalized population are not included in our study, although in the case of children and adolescents this would represent a negligible percentage (approximately 0.28%).[21,44] In addition, the epidemiological questionnaire, that was mainly focused in COVID-19 risk factors, lacked key variables in the study of adiposity, such as dietary habits, physical activity or household income level, so it was not possible to evaluate their contribution to the observed geographical disparities.

The main implications for science of this study are that it provides detailed information on the prevalence of obesity and excess weight by province in the child and adolescent population in Spain, showing that only a third part of childhood obesity is explained by structural factors, which implies that there is ample room for intervention. Among the implications for practice on a public health level, are that our results can help to develop effective interventions and policies aimed at reducing the prevalence of obesity and excess weight in the child and adolescent population in Spain, focusing on addressing sources of inequalities in the distribution of obesity and excess weight.

One third of the child and adolescent population in Spain has excess weight and 1 in 10 children and adolescents have obesity. Male sex, being aged 6–9 years, having a disability, the presence of any adult with excess weight in the household, a lower household educational level and living in census tracts with lower relative income level, are factors associated with excess weight and obesity in children and adolescents, and specifically these last two, associated with a greater gradient in girls. These disparities persisted after standardization by sociodemographic variables. There is a high intracountry geographical variability in the prevalence of obesity and excess weight, with the lower ones in some provinces located in the north half of Spain while the highest prevalences were spread through the whole country. Sociodemographic characteristics only partially explained the geographical variability observed, suggesting that there are other factors that contribute to obesity and excess weight which do not depend on the sociodemographic composition of each province, and that could be potentially modifiable, like diet and physical activity. Public health interventions should take into account the disparities observed to efficiently fight this problem at different geographic and administrative levels.

AUTHOR CONTRIBUTIONS

Enrique Gutiérrez-González: analysis and interpretation of data, drafting of the manuscript, statistical analysis supervision. **Marta García-Solano**: analysis and interpretation of data, drafting of the manuscript, critical revision of the manuscript for important intellectual content, supervision. **Roberto Pastor-Barriuso**: acquisition of the data, analysis and interpretation of data, drafting of the manuscript, critical revision of the manuscript for important intellectual content, statistical analysis, supervision. **Nerea Fernández de Larrea-Baz**: acquisition of the data, analysis and interpretation of data, drafting of the manuscript, critical revision of the manuscript for important intellectual content. **Almudena Rollán-Gordo**: analysis and interpretation of data; critical revision of the manuscript for important intellectual content, supervision. **Belén Peñalver-Argüeso**: analysis and interpretation of data; statistical analysis, critical revision of the manuscript for important intellectual content. **Isabel Peña-Rey**: critical revision of the manuscript for important intellectual content, supervision. Marina Pollán: acquisition of the data, analysis and interpretation of data, critical revision of the manuscript for important intellectual content, obtaining funding, supervision. Beatriz Pérez-Gómez: acquisition of the data, analysis and interpretation of data, drafting of the manuscript, critical revision of the manuscript for important intellectual content, statistical analysis, obtaining funding, supervision.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX A: ENE-COVID STUDY GROUP

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