ORIGINAL

Prevalence of anterior open bite in basque primary schoolchildren: a cross-sectional study on behavioral and ethnic factors

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Abstract:

Introduction:
Non-nutritive sucking habits negatively affect the quality of life of children by affecting aesthetic outcomes and future occlusion if maintained over a long period of time.

Objectives:
This study aimed to describe the prevalence of anterior open bite among pupils in primary schools in Bilbao, as well as to compare the prevalence by sociodemographic characteristics and identify which most influence the presence of anterior open bite after 6 years of age.

Methods:
A cross-sectional study was conducted using a representative sample (n = 1663) of 5- to 7-year-old pupils. The dependent variable was the prevalence of anterior open bite, determined by oral examination. The independent variables were assessed using questionnaires given to families and teacher report.

Results:
The prevalence of anterior open bite was 2.3% in the total sample, 3.9% in children <6 years of age, and 1.7% in those ≥6 years of age.

Conclusions:
Maintaining prolonged non-nutritive sucking habits (odds ratio =15) and to a lesser extent belonging to the Roma ethnic group (odds ratio =22.6), were related to the develo-

pment of anterior open bite in ≥ 6-year-old schoolchildren. Non-nutritive sucking habits were related to anterior open bite.

Prevalencia de mordida abierta anterior en escolares vascos de primaria: un estudio transversal sobre conducta y factores étnicos

Resumen:
Introducción:
Los hábitos de succión no nutritivos repercuten negativamente en la calidad de vida de los niños y niñas, al afectar a los resultados estéticos y a la oclusión futura si se mantienen durante un largo periodo de tiempo.

Objetivos:
El objetivo de este estudio fue describir la prevalencia de mordida abierta anterior entre el alumnado de los centros de educación primaria de Bilbao, así como comparar la prevalencia según características sociodemográficas e identificar cuáles son las que más influyen en la presencia de mordida abierta anterior después de los 6 años de edad.

Métodos:
Se realizó un estudio transversal con una muestra representativa (n= 1663) de alumnado de 5 a 7 años. La variable dependiente fue la prevalencia de mordida abierta anterior, determinada mediante examen oral. Las variables independientes se evaluaron mediante cuestionarios entregados a las familias y el informe del profesor.

Resultados:
La prevalencia de mordida abierta anterior fue del 2,3% en la muestra total, del 3,9% en el alumnado <6 años y del 1,7% en alumnado ≥6 años.

Conclusiones:
Mantener hábitos de succión no nutritivos de manera prolongada (odds ratio =15) y en menor medida pertenecer a la etnia gitana (odds ratio= 22,6), se relacionan con el desarrollo de mordida abierta anterior en escolares ≥ 6 años. Los hábitos de succión no nutritivos se relacionaron con la mordida abierta anterior.

Aurreko hozkada irekiaren nagusitasuna lehen hezkuntzako euskal ikasleen artean: portaera eta faktore etnikoei buruzko zeharkako azterketa

Laburpena:
Sarrera:
Xurgatze-ohiturak eragin negatiboa dute eskola-umeen bizi-kalitatean, estetikan zein etorkizuneko oklusioan eragiten dutelako.

Helburuak:
Azterketa honen helburua Bilboko lehen hezkuntzako eskoletako eskola-umeen aurreko hozkada irekiaren prebalentzia deskribatzea izan zen, ezaugarri soziode-mografikoen araberako prebalentzia konparatzea eta 6 urtetik gorako aurreko ho-zkada irekiaren presentzian zerk eragiten duen identifikatzea.

Metodoak:
Zeharkako azterketa bat egin zen 5 eta 7 urte bitarteko ikasleen lagin adierazgarri bat (n = 1663) erabiliz. Mendeko aldagaia aurreko horzkada irekiaren prebalentzia izan zen, ahozko azterketa bidez zehaztua. Bestalde, aldagai askeak familiek eta ikasleek betetako galdetegien bidez lortu ziren, irakasleen laguntzarekin.

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Emaitzak:
Aurreko hozkada irekiaren prebalentzia %2,3koa izan zen lagin osoan, %3,9koa 6 urtetik beherako ikasleetan eta %1,7koa 6 urtetik gorakoetan.

Ondorioak:
6 urte gorako ikasleetan, elikagarriak ez ziren xurgatze-ohitura luzeei eustea (odds ratio= 15) eta, neurri txikiagoan, ijitoen etniakoa izatea (odds ratio= 22,6), horzka-da irekiarekin lotu ziren.

Introduction

Open bite is a malocclusion characterized by a lack of contact between the maxillary and mandibular incisors in centric relation, that may be present in Angle classes I, II and III[1]. Open bite negatively affects the quality of life of children by affecting aesthetic outcomes and future occlusion if maintained over a long period. While it may be lateral or posterior, anterior open bite (AOB) is the most common[2]. In children between 6 and 8 years of age, anterior open bite can generate functional repercussions such as speech disorders in pronunciation and difficulty in biting with anterior teeth[3,4].

AOBs are classified as skeletal and/or dental, depending on their origin. Skeletal AOBs are related to the genetically inherited skeletal pattern of a patient. Such patients have an increased vertical facial dimension, as well as possibly a backward mandibular growth rotation pattern and often only their terminal teeth are in contact[5]. The aetiology of dental AOBs is totally different and involves various factors that have a major influence on the development of this malocclusion, such as anterior tongue interposition habit, oral breathing, enlarged lymphatic tissue, nutritive sucking habits, ankylosed incisors, and a lack of space for permanent teeth to erupt leading to impaction6. Nonetheless, non-nutritive sucking habits (NNSHs) are considered the most common factor in the appearance of dental AOB.

NNSHs can be described as habits that calm children and increase their well-being, and include the use of pacifiers and thumb sucking. These habits are closely related to AOB, affecting its prevalence, which varies widely among studies (see Table I)[7-19]. Nonetheless, the prevalence of malocclusion also varies with other variables such as ethnic background and the length of time that NNSHs persist[20]. For example, a strong association has been observed between the appearance of AOB and the use of pacifiers (when compared to rates in children who do not use them)[21], and specifically, the use of pacifiers for more than 36 months is associated with AOB[22]. As children grow older, the prevalence of AOB decreases because usually these NNSHs cease, and a mature swallowing pattern develops along with their facial structures. Therefore, habits such as pacifier sucking do not usually have a negative influence on the future occlusion if stopped by 3 years of age or earlier, correcting themselves in the following years.

Nonetheless, if such habits are continued until 4 to 5 years of age, a critical point is reached, after which children may require clinical treatment and present tongue interposition. If they are continued beyond 7 years of age, the adult dentition may be permanently affected and self-correction is less likely. In persistent or severe cases, evaluation by an orthodontist may be considered to determine if orthodontic intervention is needed.

No recent data are available on the influence of NNS-Hs on the occurrence of AOB and its distribution among ethnic minorities in Spain. This research aimed to describe the prevalence of AOB among pupils in public primary schools in the city of Bilbao, northern Spain, overall and stratified by sociodemographic characteristics. We hoped that the data gathered might be useful to identify which variables most influence the presence of dental AOB, especially after 6 years of age.

Methods

This is a cross-sectional prevalence study based on data collected from oral examinations performed by a single dentist. The study population were pupils of public schools in the municipality of Bilbao, the tenth most populous city in Spain, with over 350 thousand inhabitants in 2021[23]. The schools were stratified by district (eight in total) and at least two schools were selected per district by simple random sampling. The study was carried out in 21 schools, which represented over half (55.26%) of all public schools in the city.

The dental examinations were performed on pupils in the last course of the kindergarten (early childhood education for 5-year-olds) and the first and second years of primary education (for 6- and 7-year-olds). These examinations were conducted during the 2015/2016 and 2016/2017 academic years, beginning in May 2016 and concluding in June 2017. This sample was chosen to measure the prevalence of AOB in children with deciduous dentition and those who were in the early stages of mixed dentition, allowing us to assess the prevalence of AOB in both types of dentition.

Data related to the oral examination were collected in the medical office of each school. The oral health examinations were conducted over the course of one year. Before these oral examinations, the parents or other caregivers (legal guardians or foster carers) had

Table I
Percentage and prevalence of anterior open bite according to the existence of non-nutritive sucking habits in previous studies and in the current research.

Year[a]	Country	Design of the study	Sample size	Age[b]	AOB(%) NNSH+	AOB(%) NNSH-
1976	Denmark	Cohort study	310	3	66.5	10.56
1993	Finland	Randomized trial	1018	3	83.8	5.1
1997	Saudi Arabia	Cross sectional	583	3-5	14.9	3.58
1999	Finland	Randomized trial	148	3	60	7.6
2004	Italy	Cross sectional	1099	3-5	17	4
2005	Brazil	Longitudinal study	330	4-5	78	8.2
2006	Mexico	Longitudinal study	1160	4-5	48.4	51.8
2008	Brazil	Cohort study	287	4-6	79	6.9
2011	Brazil	Cross sectional	1308	2.5-5	68.1	8
2011	Sweden	Longitudinal study	457	3	63	1
2012	Nigeria	Cross sectional	1031	2-5	10.9	0
2014	Brazil	Cross sectional	176	3-6	60	2.2
2016	Italy	Cross sectional	235	3-5	22	6.5
2024	Spain	Cross sectional	433	<6	26.7	0.6

Abbreviations: AOB, anterior open bite; NNSH+, children with non-nutritive sucking habits; NNSH-, children who did not have non-nutritive sucking habits. [a]year of publication; [b]age in years.

been informed about the procedures and objectives of this research and had signed an informed consent statement. Oral examinations were performed with a flat mirror number 5, an exploratory dental probe and a periodontal probe for each pupil, following the recommendations of the World Health Organization. Most explorations were carried out with natural light and only exceptionally artificial illumination with white light (100 watts) was used. During the study a calibration was made to ensure that this research provided accurate and reliable results; 10% of the children were randomly re-examined to assess the reproducibility of the criteria. The examiner also repeated the first 50 examinations to ensure the accuracy of the intra-observer agreement. The agreement rate exceeded 95% in terms of simple concordance across the entire sample.

An ad hoc questionnaire was given to each family to collect data on NNSHs of the children and the socio-demographic characteristics of the caregivers as well as their views on NNSHs. It was explained that answering these questions was voluntary and some families handed in incomplete questionnaires. Teachers were responsible for assessing and recording the ethnicity of the children. This research was approved by the Ethics Committee of the University of the Basque Country (M10_2016_157). All parents or other caregivers signed a statement of informed consent.

The presence of AOB was considered the main outcome of the research. No distinction was made between dental and skeletal anterior open bites. Patients under 6 years of age with primary dentition were considered to have AOB in centric relation when the incisal surfaces of the deciduous mandibular central incisors were below the level of the incisal surfaces of the deciduous maxillary central incisors. The diagnosis of AOB in patients aged 6 years and older proved to be a major challenge.

At around 6 years of age, the exfoliation of the primary incisors and the eruption of the permanent incisors begin, and hence, many children were experiencing the eruption of their permanent incisors or still had their primary ones when examined. That is, at the time of the examination, the occlusion of these children was not stable, let alone definitive. For this reason, when determining whether these children had AOB, the dentist first checked whether the permanent incisors had completely erupted.

An exclusively visual-tactile method was used to determine this, the examiner assessed incisors position and alignment, ensuring they were fully visible and properly aligned with the other temporary and permanent teeth in the dental arch. Additionally, the gums needed to be well-defined around the teeth. Palpation was also utilized to confirm that the teeth felt firm and securely anchored in the alveolar bone, helping to verify that

they were fully erupted and stabilized. If incisors had completely erupted, the child was considered to have AOB when the incisors in the lower and upper jaws failed to overlap on a completed bite.

If children still had their primary incisors, despite being 6 years of age or older, they were considered to have AOB if the criteria described above for children under 6 years of age were met. In some cases, the main outcome of the research could not be determined for various reasons, the most common being the loss of the incisors before the permanent ones had erupted. In all such cases, it was considered that the students did not have an anterior open bite; however, they were not excluded from the total sample of examined students.

The social class and education variables were constructed from the data about the parents or other caregivers collected in the questionnaires. Specifically, the questionnaires asked about the occupation and occupational status of each of the caregivers, and based on the most privileged occupation listed, the pupils were assigned to one of five categories according to a Spanish classification of social class, these subsequently being regrouped into three categories: 1) high; 2) intermediate; and 3) low. Further, they asked about the education that had been completed by each caregiver, with the following response options: 1) elementary; 2) compulsory secondary; 3) upper secondary/vocational; and 4) university. Children's educational background was classified based on the highest educational level among those listed for their mother and/or father or other caregivers. If caregivers did not provide information concerning their occupation or educational level, but did give written informed consent for the oral examination, the children's social class and educational background were classified as "not recorded". Further, the questionnaires asked how long it was appropriate for children to continue NNSHs, classifying parents'/caregivers' responses as until 2, 3 or 4 years of age or until children decide to give them up. Lastly, as mentioned before, teachers reported the ethnicity of their pupils, children being assigned to a specific ethnic group if both the mother and the father belonged to the same ethnic group, and otherwise classified as "other". Six ethnic groups were established: 1) European; 2) Roma; 3) South American; 4) Black African; 5) North African and 6) Other.

Data analysis was performed with SPPS Statistics 25 (IBM). Descriptive analyses were conducted to describe sociodemographic characteristics and NNSHs. Differences between pupils from different groups were assessed with parametric tests (X^2), using a significance level α=0.05.

Logistic regression was performed to identify explanatory variables for the presence of AOB beyond 6 years of age and assess the relationship of the disease with sociodemographic characteristics, NNSHs and caregivers' views on these habits. The pupils with AOB were assigned to the "disease group", while pupils without the malocclusion were assigned to the "no disease group". Before performing the regression, collinearity diagnostics were applied, and VIF scores indicated that there was no multicollinearity.

Results

A total of 1843 pupils were enrolled in the schools selected for this research. Finally, 1709 families gave written informed consent (92.73%) and 1682 examinations were carried out, some pupils not undergoing examinations despite the provision of consent because they had not attended school on the days the dentist visited or had transferred to a different school, or for other reasons not reported. The mean age of the pupils was 6.77 (95% CI: 6.72, 6.81) years. Figure 1 summarises how the sample was obtained.

The frequency distribution of sociodemographic and NNSH variables is shown in Table II. Three-quarters of the children examined were aged ≥ 6 years and more than half were classified as European. A total of 124 caregivers (7.4%) reported that their child had NNSHs while two-thirds (n=945, 66.6%) considered that these habits should be abandoned by the early age of 2 years.

The prevalence of dental AOB in the total sample is presented in Table III. Note that all children found to have AOB in this study were classified as having dental AOB, no cases of skeletal AOB having been detected. The overall prevalence of AOB was somewhat higher in girls than boys, though the difference did not reach significance. Considering ethnicity, by far the highest prevalence was observed in the Roma ethnic group. As expected, the overall prevalence was also notably high in children with NNSHs. Further, stratifying by caregivers' views of NNSHs, the prevalence was highest among children whose caregivers considered NNSHs acceptable until 4 years of age.

Table IV presents the prevalence of AOB by age group: under 6 years of age and aged 6 years or older. In both groups, the prevalence was highest among children whose caregivers had a lower level of education, were unemployed, or belonged to the Roma ethnic group. Additionally, the prevalence tended to be higher among children classified in a lower social class or for whom the corresponding data were not reported, though the differences did not reach significance. Children with NNSHs and those whose caregivers thought it acceptable for these habits to be continued until 4 years of age also had higher rates of AOB prevalence in both age groups. In the younger group, the prevalence of AOB was similar in the two sexes, while from 6 years of age onwards, it tended to be higher among girls, though the difference did not reach significance. Table 1 details the prevalence rates of AOB in schoolchildren under and over 6 years of age stratified by gender and ethnicity.

Table V lists the explanatory variables for AOB in pupils aged 6 years and older. "The main factor accounting for the presence of this malocclusion is the Odds Ratio (OR) associated with Non-Nutritive Sucking Habits (NNSHs), which is 15." Belonging to the Roma ethnic group (OR=22.6) also seems to play a key role in the
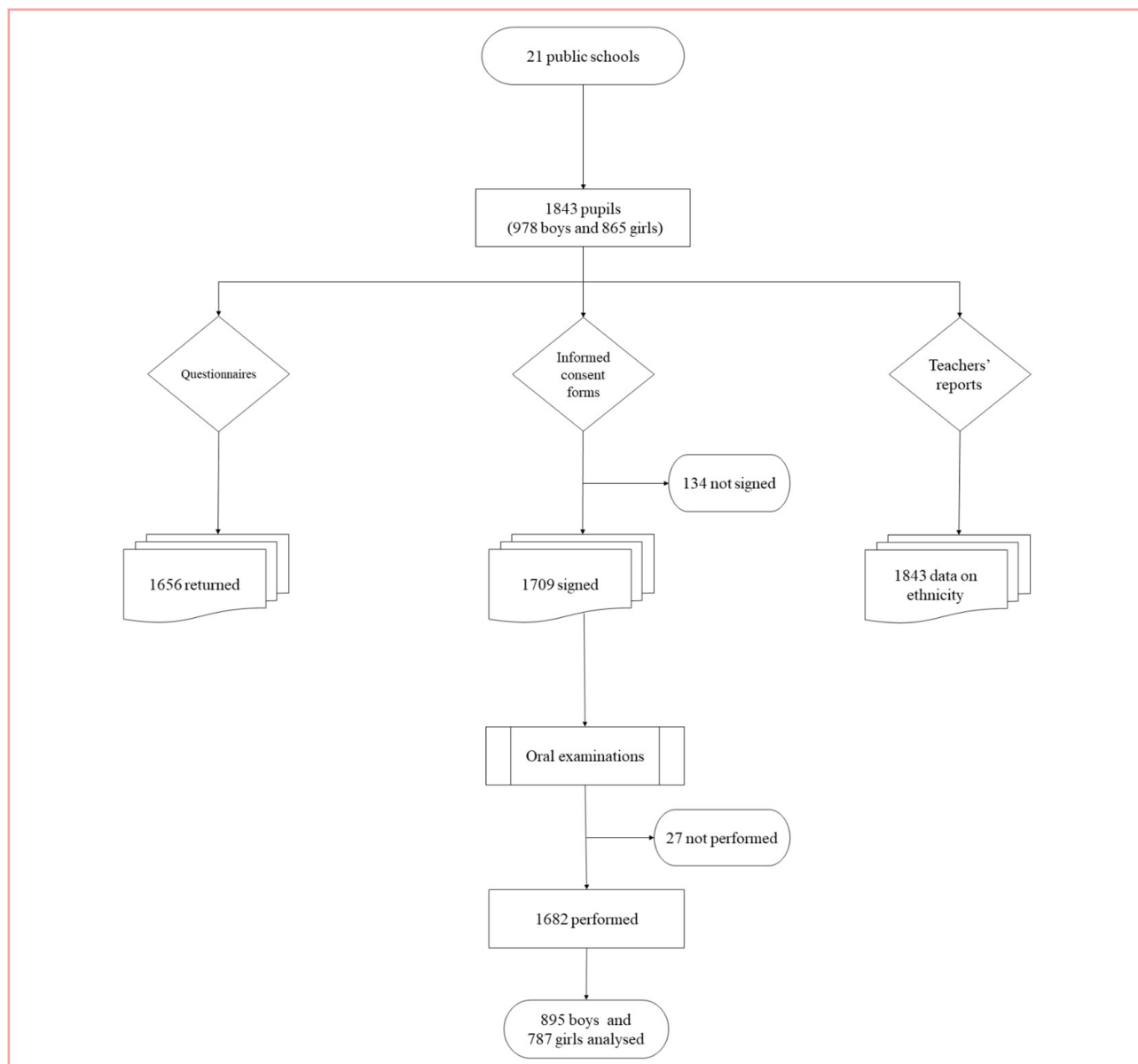
Figure 1. Flow chart of the study population.

development of this malocclusion, although to a lesser extent than the child having an NNSH.

Discussion and conclusions

This research aimed to describe the prevalence of AOB from a sample taken in public schools in Bilbao, comparing rates by socioeconomic characteristics, to determine the most vulnerable groups. The study also aimed to identify explanatory variables for the presence of dental AOB from the age of 6 years. This study shows that the prevalence of AOB goes down from the age of 6 years onwards, likely because NNSHs cease. Indeed, it is these habits that best explain the presence of the malocclusion. Nonetheless, belonging to the Roma ethnic minority also seems to play a role in the development of AOB. To our knowledge, this factor has not previously been described in the scientific literature.

For this study, we obtained a large sample size and the participation of a range of ethnic groups, some of

which do not usually take part in dental research. In addition, our sample included pupils under and over 6 years of age with similar sociodemographic characteristics, allowing us to estimate and compare the prevalence of this malocclusion in both primary and mixed dentition. Moreover, a single dentist carried out all examinations, following the same diagnostic criteria. On the other hand, only pupils from public schools were selected to take part in this study, and this implies a selection bias. That is, the proportion of children from lower socioeconomic groups is higher in these schools than in maintained and private schools, and hence, the sample may not be representative of the overall child population in our city. Specifically, as higher rates of AOB have been found in lower socioeconomic groups[15,24], our prevalence rates may be overestimates. Rates of response to the questionnaires and provision of informed consent for the oral examination varied by the ethnicity of the participants; this may also represent a selection bias.

Table II
Description of the independent variables of the children who underwent the oral examination (n=1,682).

	All children examined N (%)
Sex	
Boys	895 (53.2%)
Girls	787 (46.8%)
Age	
≥6 years	1249 (74.6%)
<6 years	433 (25.4%)
Ethnicity	
European	919 (54.6%)
Roma	181 (10.8%)
South American	181 (10.8%)
North African	95 (5.6%)
Black African	92 (5.5%)
Other	214 (12.7%)
Caregivers' education	
University	445 (26.5%)
Upper secondary/Vocational	615 (36.6%)
Compulsory	205 (12.2%)
Elementary	270 (16.1%)
Not recorded	147 (8.7%)
Social class	
High	274 (16.3%)
Intermediate	178 (10.6%)
Low	833 (49.5%)
Not recorded	397 (23.6%)
At least one member of the household unemplo-yed[a]	
Yes	781 (53.6%)
No	677 (46.4%)
NNSH[b]	
Yes	124 (8%)
No	1435 (92%)
Appropriate limit for non-nutritive sucking habits?[c]	
2 years old	945 (66.6%)
3 years old	240 (16.9%)
4 years old	56 (3.9%)
Until the child decides to give them up	177 (12.5%)

[a]Answered by 1458 caregivers. [b]Answered by 1559 caregivers. [c]Answered by 1418 caregivers.

Table III
Prevalence of anterior open bite stratified by independent variables.

	N (with AOB/total)	Prevalence	95% CI	P-value[a]
All combined	38/1682	2.3%	1.55-2.97	------
Gender				0.165
Girl	22/787	2.8%	1.64-3.95	
Boy	16/895	1.8%	0.92-2.66	
Age				0.007**
<6 years	17/433	3.9%	2.09-5.76	
≥6 years	21/1249	1.7%	0.97-2.40	
Caregivers' education				<0.001***
University	3/445	0.7%	0-1.44	
Upper secondary/Vocational	5/615	0.8%	0.1-1.52	
Compulsory secondary	3/205	1.5%	0-3.12	
Elementary	22/270	8.1%	4.86-11.43	
Not recorded	5/147	3.4%	0.44-6.37	
Social class				0.009**
High	3/274	1.1%	0-2.33	
Intermediate	1/178	0.6%	0-1.67	
Low	17/833	2%	1.08-3	
Not recorded	17/395	4.3%	2.29-6.31	
Ethnicity				<0.001***
Caucasian	5/914	0.5%	0.1-1	
Roma	28/181	15.5%	10.15-20.79	
North African	1/95	1.1%	0-3.14	
Black African	1/92	1.1%	0-3.25	
South American	1/181	0.6%	0-1.64	
Other	2/214	0.9%	0-2.23	
Unemployed				0.007**
Yes	22/781	2.8%	1.65-3.98	
No	6/677	0.9%	0.18-1.59	
NNSH				<0.001***
Yes	19/124	15.3%	8.89-21.75	
No	13/1435	0.9%	0.42-1.40	
Appropriate limit for NNSHs?				0.301
2 years old	17/945	1.8%	0.95-2.65	
3 years old	4/240	1.7%	0-3.30	
4 years old	3/56	5.4%	0-11.44	
Until the child decides to give it up	4/177	2.3%	0.1-4.47	

Abbreviations: AOB, anterior open bite; 95% CI, 95% confidence interval; NNSHs, non-nutritive sucking habits. [a]χ² tests, significant P-values at 5% level marked in bold. *p<0.05 **p<0.01 ***p<0.001.

Table IV
Prevalence of anterior open bite for <6-year-olds (n=433) and ≥6-year-olds (n=1,249) stratified by sex, socio-demographic variables and NNSHs.

	<6-year-olds				≥6-year-olds			
	AOB	Prev.	95% CI	P-value[a]	AOB	Prev.	95% CI	P-value[a]
Gender								
Girl	8/209	3.8%	1.21-6.45		14/578	2.4%	1.17-3.68	0.059
Boy	9/224	4%	1.43-6.61	0.919	7/671	1%	0.3-1.81	
Caregivers' education								
University	1/130	0.8%	0-2.29		2/315	0.6%	0-1.52	<0.001***
Upper secondary/Vocational	2/154	1.3%	0-3.11	<0.001***	3/461	0.7%	0-1.39	
Compulsory secondary	2/53	3.8%	0-9.08		1/152	0.7%	0-1.96	
Elementary	12/96	12.5%	5.76-19.24		10/174	5.7%	2.25-9.24	
Not recorded	--	--	--		5/147	3.4%	0.44-6.37	
Social class								
High	2/87	2.3%	0-5.51		1/187	0.5%	0-1.59	0.058
Intermediate	0/46	0%	--	0.166	1/132	0.8%	0-2.26	
Low	8/201	4%	1.25-6.71		9/632	1.4%	0.05-2.35	
Not recorded	7/99	7.1%	1.93-12.21		10/296	3.4%	1.31-5.45	
Ethnicity								
European	2/231	0.9%	0-2.07		3/688	0.4%	0-0.93	<0.001***
Roma	13/47	27.7%	14.38-40.94	<0.001***	15/134	11.2%	5.79-16.60	
North African	0/23	0%	--		1/72	1.4%	0-4.16	
Black African	0/36	0%	--		1/56	1.8%	0-5.36	
South American	0/43	0%	--		1/138	0.7%	0-2.16	
Other	2/53	3.8%	0-9.08		0/161	0%	--	
Unemployed								
Yes	8/198	4%	1.27-6.81		14/583	2.4%	1.16-3.65	0.007**
No	4/182	2.2%	0.01-4.35	0.305	2/495	0.4%	0-0.96	
NNSHs								
Yes	12/45	26.7%	13.23-40.10		7/79	8.9%	2.45-15.27	<0.001***
No	2/357	0.6%	0-1.34	<0.001***	11/1078	1%	0.42-1.62	
Appropriate limit for NNSHs?								
2 years old	9/267	3.4%	1.19-5.55		8/678	1.2%	0.37-1.99	0.287
3 years old	2/49	4.1%	0-9.82	0.628	2/191	1%	0-2.50	
4 years old	1/9	11.1%	0-36.73		2/47	4.3%	0-10.25	
Until children decide	1/42	2.4%	0-7.19		3/135	2.2%	0-4.74	

Abbreviations: AOB, anterior open bite; Prev, Prevalence; NNSHs, non-nutritive sucking habits; Appropriate limit for NNSHs?, Until when it is appropriate for children to continue non-nutritive sucking habits?; Until children decide, Until children decide to give them up. Results expressed as: n (with AOB/total). [a]χ^2 tests, significant P-values at 5% level marked in bold.*p<0.05 **p<0.01 ***p<0.001.

Table V
Estimated odds ratio of having anterior open bite by age, sex and sociodemographic characteristics in ≥6 years old schoolchildren (n=1,249).

	≥6-year-olds with anterior open bite	≥6-year-olds with anterior open bite
	OR	95% CI
Age	1.88	0.83-4.28
Sex		
Boys	Ref.	
Girls	3.48	0.87-13.85
Sucking habit		
No	Ref.	
Yes	15***	3.47-64.75
Maximum sucking age		
2 years old	Ref.	
3 years old	1.68	0.27-2.60
4 years old	2.67	0.34-20.77
Until they decide	2.43	0.46-12.96
Unemployed		
No	Ref.	
Yes	1.24	0.18-8.33
Caregivers' education		
University		
Upper secondary/Vocational	Ref.	
Compulsory secondary	0.76	0.04-14.05
Elementary	0.52	0.02-16.47
Not recorded	1.61	0.05-48.16
Social class		
High	Ref.	
Intermediate	3.32	0.13-83.77
Low	0.81	0.05-14.59
Not recorded	1.96	0.09-40.92
Ethnicity		
European	Ref.	
Roma	22.58**	2.27-224.52
North African	2.30	0.12-43.17
South American	2.59	0.17-40.18
Black African	--	--
Other	--	--

Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval; Ref., reference category.
Results significant at 5% level marked in bold. *p<0.05 **p<0.01 ***p<0.001.

Previous studies have already shown that NNS-Hs are strongly linked to the development of AOB[5,10-12,14,15,18,19,25]. Our study shows higher rates of AOB in children whose caregivers (parents, legal guardians or foster carers) think it acceptable for children to maintain these habits until as old as 4 years of age. This suggests that it is essential to make efforts to raise awareness among caregivers of the potential impact of NNSHs, and hence, the importance of helping children to stop such sucking habits between 3 and 7 years of age[26]. On the other hand, the prevalence of AOB was higher in children of families with lower social class and educational level, and also those with at least one unemployed caregiver. These results are similar to

those of the majority of dental health studies, which show that the lower the sociodemographic level, the higher the rate of AOB[15,24]. Moreover, campaigns for the prevention of NNSHs from the age of 6 should focus on girls, as their higher prevalence from the age of 6 across all ethnicities seems to be attributable to them continuing these habits for longer.

We have also noted that the prevalence of AOB is much higher in the Roma minority than in the rest of the population. In fact, beyond the age of 6, belonging to this ethnic group is an explanatory variable for the presence of this malocclusion. These results merit discussion, as they could be misinterpreted. It should be underlined that no cases of skeletal AOB were detected and the very high prevalence of AOB observed in the Roma minority is likely to be attributable not to genetic factors but to NNSHs. Some teachers told the dentist who carried out the examinations that many Roma children keep using pacifiers for a long time, even until the age of 5. According to these teachers, pacifiers tend to be used by Roma families to soothe crying children and, though not used continuously, they are widely used occasionally, and our finding imply that this may be sufficient to influence the development of AOB. It has been already shown that AOB is more noticeable and becomes visible earlier among pacifier-sucking children than among digit-suckers[27,28]. Therefore, paediatric dentists and teachers should remind parents, especially if they are Roma, that stopping NNSHs, especially pacifier sucking, is very important to prevent the appearance of this malocclusion.

Roma report worse health than the general population in Spain. The health status of the Roma population is largely determined by various social determinants of health and exposure to poor living conditions. This minority also has less access to health care services and makes less use of the services of different medical specialities as well as prevention services[29]. Roma girls and young women are particularly vulnerable in this minority group. Therefore, future research should be conducted to further analyse NNSHs in this ethnic minority, especially in relation to the duration of pacifier use. Paediatric dentists should make sure from the first check-up that children of Roma ethnicity do not have NNSHs, and if they do, they should talk to the family to make them aware of the importance of stopping these habits as soon as possible. Awareness-raising campaigns should be run with Roma families, encouraging them to help their children give up pacifiers earlier.

The current study pointed out that AOB is related to NNSHs. Children are at greater risk of developing this malocclusion if parents think it acceptable for these habits to be maintained until older ages. Roma pupils have the highest prevalence of AOB among all ethnic groups studied. Finally, girls are at slightly greater risk of developing AOB in their mixed dentition, likely because they continue NNSHs for longer, sometimes beyond the eruption of their first permanent teeth.

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