Worldwide prevalence of malocclusion in the different stages of dentition: A systematic review and meta-analysis

G. Lombardo[1], F. Vena[1], P. Negri[1], S. Pagano[1], C. Barilotti[1], L. Paglia[2] S. Colombo[2], M Orso[3], S. Cianetti[1]

[1]*Surgical and Biomedical Sciences, Unit of Paediatric Dentistry, University of Perugia, Perugia, Italy*
[2]*Department of Pediatric Dentistry, Istituto Stomatologico Italiano Italian Stomatologic Institute, Milan, Italy*
[3]*Health Planning Service, Regional Health Authority of Umbria, Perugia, Italy*

email: stefano.pagano@unipg.it

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Abstract

Aim The aim of this review is to quantify the prevalence and type of malocclusion among children and adolescents during the different stages of dentition worldwide.

Materials and Methods Recent studies (from 2009 to 2019), published in Medline, Web of Science and Embase and orthodontic text-books have been comprehensively reviewed herein. The methodological quality of the included studies was assessed using STROBE criteria.

Results After screening 450 records and analysing 284 relevant full-text publications, 77 studies were included in this review. A good degree of evidence was obtained due to the medium-high methodological quality level of included studies. The worldwide prevalence of malocclusion was 56% (95% CI: 11–99), without differences in gender. The highest prevalence was in Africa (81%) and Europe (72%), followed by America (53%) and Asia (48%). The malocclusion prevalence score did not change from primary to permanent dentition with a common score of 54%. Malocclusion traits such as Angle's classes, overjet, overbite, and asymmetrical midline shift essentially did not change their prevalence during different dentitions. Conversely, traits such as cross-bite and diastema reduced their prevalence during permanent dentition, while scissor-bite and dental crowding increased their scores.

Conclusion The worldwide high prevalence of malocclusion and its early onset during childhood should induce policymakers as well as paediatric physicians and dentists to devise policies and adopt clinical strategies for preventing malocclusion since younger children's ages.

KEYWORDS Down Syndrome, Distraction, Behaviour.

Introduction

Malocclusion is defined as an irregularity concerning teeth alignment and/or their relationship during dental occlusion beyond the range of what is accepted as normal [Jacobson and Alex, 1987]. Malocclusion is considered the third priority for oral health disease according to the World Health Organization [Varun Pratap Singh and Amita Sharma, 2004]; indeed, an orthodontic problem can affect several oral functions such as chewing, swallowing and speaking skills [Mohd Toseef Khan et al., 2013]. Moreover, malocclusion can also impact dentofacial aesthetics and psychosocial self-confidence with a negative impact on everyday life [Bellot-Arcís et al., 2013; Masood et al., 2013].

Although malocclusion in primary dentition represents a relevant risk factor for further occlusal disorders related to either mixed and permanent dentitions [Klocke et al., 2002; Stahl et al., 2008], no relevant aepidemiological data are available about deciduous dental malocclusions in the last 10 years. Indeed the only systematic review found about this topic did not show any information about primary dentition malocclusion and its evolution across the three children's and adolescents' types of dentition [Alhammadi et al., 2018]. For this reason, the scope of the present review is to investigate the worldwide prevalence of dental malocclusion during childhood and adolescence with special attention to aepidemiological variations during different stages of dentition.

Methods

The review was performed according to a designed protocol recommended for systematic reviews and meta-analyses [Henderson, 2010; Welch, 2016]. The most relevant bibliographic databases such as Medline, Web of Science and Embase were searched in April 2019, using a search strategy based on a combination of MeSH terms such as malocclusion/epidemiology AND (adolescent* or child*). In addition, we made a hand search taking other records from the list of references of selected full-texts (studies and/or review) and chapters of the most relevant orthodontic textbooks. Duplicate

literature and multiple publications of the same results were left out.

Study selection, data collection, and data items

Inclusion criteria

Publications from 2009, studies evaluating the prevalence of at least 1 malocclusion trait after clinical and/or cephalometric diagnosis, studies performed in children and/or adolescents (0 to 19 years old), studies specifying the setting where the presence of malocclusion was evaluated and studies published in English, Italian or Spanish.

Exclusion criteria

Studies with a quality assessment less than 3 (a six criteria STROBE statement), studies sample with less than 80 participants, studies carried out on groups of patients affected by general diseases or specific oral diseases, studies carried out on a group of patients undergoing orthodontic treatment.

Two authors (FV and SP) independently assessed the initial screening of records based on titles and abstracts. Subsequently, two authors choose the eligible studies for this review from the overall amount of obtained full texts. Discrepancies between authors were resolved through discussion. If the solution was still not found, a third reviewer (LP) made the final decision.

Data extraction and management

From the included studies a data extraction was performed independently by two review authors (PN and SC) and disagreement were resolved by debate or involving, where needed, a third review author (LP). The extracted data included the following topics: bibliographic details (first author, year of publication); demographic and participants' characteristics (setting, country, continent as well as age and gender); prevalence of general malocclusions and their traits such as Angle's class, overjet, overbite, crossbite, midline shift, dental crowding, and diastema.

Quality assessment

The quality assessment was performed by the other two reviewers (GL and MO), in the case of some of their disagreement, it was resolved with debate or consulting a third author.

Quality assessment of the included studies was performed using a six-criteria analysis selected from the STROBE statement [von Elm et al., 2007]. The assessment was performed relying on an adequate (or not) description of some study parameters such as setting (I), participants characteristics (II), sample size (III), dependent and independent variables (IV), outcome data (V), statistical analyses (VI). For each of these parameters there was a dichotomous issue: positive (+) or negative (-). Relying on these six parameters assessment, the available score for each of the included studies varied from 0 to 6.

Statistical analysis

Data analysis was performed using STATA/SE 13 software (Stata, College Station, TX, USA), and the metaprop package was used to conduct the meta-analyses. For each study, we summarised several characteristics of the participants such as gender, age, geographical distribution (continent and country), study setting, type and class of malocclusion, and type of dentition. The prevalence of malocclusion was meta-analysed using random-effects models. Subgroup analyses were performed for continent and type of dentition. Summary estimates were provided along with 95% confidence intervals (95% CI). We assessed heterogeneity among studies through I2 statistics.

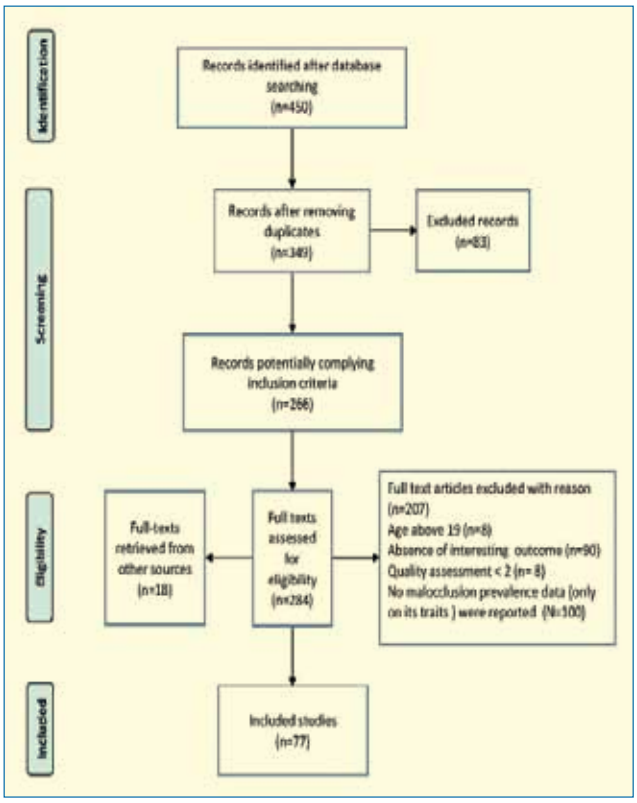

FIG. 1 Literature search flowchart (PRISMA 2009).

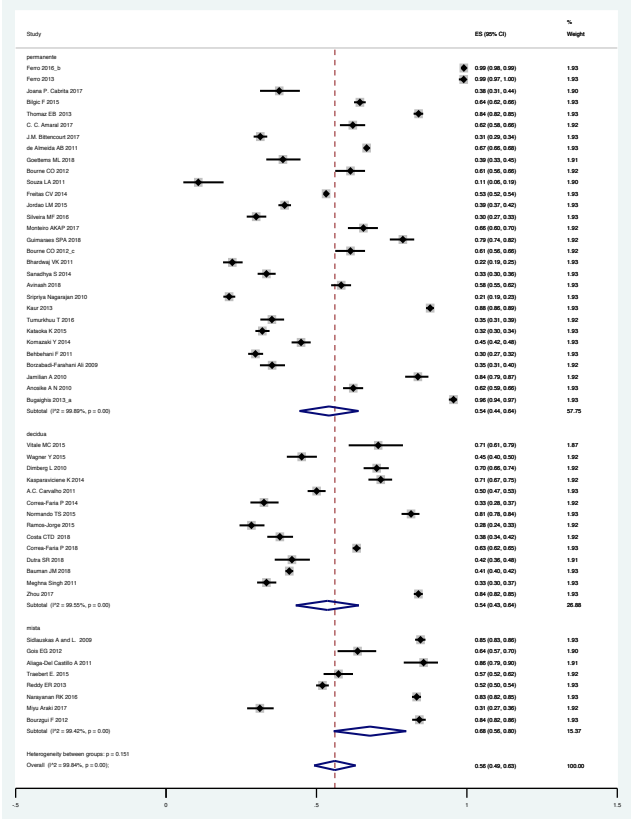

FIG. 2 Meta-analysis of malocclusion prevalence over primary, mixed and permanent dentitions found in the included studies.

N°	Author	Year	Population	Range	Country	Continent	Setting
1	Mtaya M	2009	1601	12-14	Tanzania	Africa	School
2	Borzabadi-Farahani A	2009	502	11-14	Iran	Asia	School
3	Sidlauskas A and L	2009	1681	7-15	Lithuania	Europe	School
4	Dias PF	2009	407	9-12	Brazil	America	School
5	Shivakumar KM	2009	1000	12-15	India	Asia	School
6	Lux JC	2009	494	9	Germany	Europe	School
7	Perillo L	2010	703	12	Italy	Europe	School
8	Murshid ZA	2010	1024	13-15	Arabia	Asia	School
9	Dimberg L	2010	457	3	Sweden	Europe	Clinic (Public Dental Health Clinic)
10	Anosike AN	2010	805	12-16	Nigeria	Africa	School
11	Sripriya Nagarajan	2010	1618	14-15	India	Asia	School
12	Neus Puertes-Fernández	2010	248	12	Spain	Europe	Clinic (Dental University Clinic, Stomatologic Department)
13	Jamilian A	2010	350	14-17	Tehran	Asia	School
14	Souza LA	2011	84	13-20	Brazil	America	Football Club
15	Bhardwaj VK	2011	622	16-17	India	Asia	School
16	Aliaga-Del Castillo A	2011	146	2-18	Perù	America	Clinic (Dental University Clinic)
17	Meghna Singh	2011	836	5-14	Brazil	America	School
18	de Almeida AB	2011	7993	12	Brazil	America	School
19	Behbehani F	2011	1299	13,3	kuwait	Asia	School
20	Urrego-Burbano PA	2011	436	5-12	Colombia	America	School
21	Uematsu S	2012	2378	12-16	Japan	Asia	School
22	Bourzgui F	2012	1000	8-12	Morocco	Africa	School
23	Gois EG	2012	212	8-11	Brazil	America	School
24	Sandesh Phaphe	2012	1000	12-14	India	Asia	School
25	Behbehani F	2012	1299	13,3	Kuwait	Asia	School
26	Bourne CO	2012	367	11-12	Trinidad,Tobago	America	School
27	Ferro R	2013	380	14	Italy	Europe	School
28	Laganà G	2013	2617	7-15	Albania	Europe	School
29	Anitha XL	2013	1836	3-6	India	Asia	Clinic (Department of Pedodontics)
30	Thomaz EB	2013	2037	12–15	Brazil	America	School
31	Bugaighis	2013	900	12-17	Libya	Africa	Preschool
32	Bugaighis	2013	800	3-5	Libya	Africa	Preschool
33	Kaur	2013	2400	13-17	India	Asia	School
34	Reddy ER	2013	2135	6-10	India	Asia	School
35	Carvalho AC	2013	1069	60-71 months	Brazil	America	Preschool
36	Janosevic P	2013	190	11-14	Serbia	Europe	School
37	Freitas CV	2014	16833	15-19	Brazil	America	Clinic
38	Sanadhya S	2014	947	12-15	India	Asia	School
39	Correa-Faria P	2014	381	3-5	Brazil	America	Preschool
40	Komazaki Y	2014	938	12-15	Japan	Asia	School
41	Kasparaviciene K	2014	503	5-7	Lithuanian	Europe	Preschool
42	Jordao LM	2015	2075	12 y	Brazil	America	School
43	Laganà G	2015	1200	16-19 y	Albania	Europe	School
44	Kataoka K	2015	1503	18-19 y	Japan	Asia	Clinic (University Health Service Center)
45	Wagner Y	2015	377	3 y (3.31+-0.7)	Germany	Europe	Clinic (Department Of Paediatric Dentistry)
46	Vitale MC	2015	95	3-6 y	italy	Europe	School
47	Normando TS	2015	652	3-6 y	Brazil	America	Kindergarten
48	Ramos-Jorge	2015	451	3-5 y (4,25)	Brazil	America	Kindergarten
49	Traebert E	2015	389	10-15y	Brazil	America	School
50	Bilgic F	2015	2329	12,5-16,2 y	Turkey	Europe	School
51	Tumurkhuu T	2016	557	11-16 y	Mongolia	Asia	School
52	Ferro R	2016	1187	14 y	Italy	Europe	School
53	Ferro R	2016	1960	3-5Y	Italy	Europe	Preschool
54	Silveira MF	2016	761	15-19 y	Brazil	America	School)
55	Narayanan RK	2016	2366	10-12 y	India	Asia	School
56	Akbari M	2016	28693	3-18 y	Iran	Asia	Kindergarten And School
67	Miyu Araki	2017	420	10-16 y	Mongolia	Asia	School
58	Zhou	2017	2335	3-5 y	China	Asia	Kindergarten
59	Steinmassl O	2017	157	8-10 y	Austria	Europe	School
60	Amaral CC	2017	155	13-18 y	Brazil	America	School
61	Bittencourt JM	2017	1612	11-14 y	Brazil	America	School
62	Nagalakshmi S	2017	1078	12-15	India	Asia	School
63	Monteiro AKAP	2017	346	11-14	Brazil	America	School
64	Reboucas AG	2017	4276	15-19	Brazil	America	School
65	Bauman JM	2018	6855	5 y	Brazil	America	School
66	Costa CTD	2018	489	2-5 y	Brazil	America	School
67	Guimaraes SPA	2018	390	8-10 y	Brazil	America	School
68	Correa-Faria P	2018	5278	5 y	Brazil	America	School
69	Dutra SR	2018	270	8-10 y	Brazil	America	School
70	Bauman JM	2018	5539	12 y	Brazil	America	School
71	Avinash B	2018	845	12 y	India	Asia	School
72	Marchena-Rodriguez A	2018	189	6-9	Spain	Europe	School
73	Gudipaneni RK	2018	500	14-18	Saudi Arabia	Asia	Private Dental Clinic
74	Fadia M. Al-Hummayani	2018	670	12-19	Saudi Arabia	Asia	School
75	Nur Yilmaz RB	2018	1016	7-18 a	Turkey	Europe	Clinic
76	Saccomanno S	2018	732	6-17 a	Italy	Europe	Orthodontic University Clinic
77	Perrotta S	2019	700	9-11	Italy	Europe	School

TABLE 1 The populations' features and the settings where participants' occlusion was evaluated.

	Author	Setting description	Descriprion of study Participants	Sample Size	Variables	Outcome data	Statistical Analysis	TOTAL QUALITY
1	Mtaya M 2009	+	+	+	+	+	+	6
2	Borzabadi-Farahani Ali 2009	+	+	-	-	+	+	4
3	Sidlauskas A and L 2009	+	+	-	+	+	+	5
4	Dias PF 2009	+	+	+	-	+	+	5
5	Shivakumar KM 2009	+	+	-	-	+	+	4
6	Lux J C 2009	+	+	+	-	-	+	4
7	Perillo L 2010	+	+	+	-	+	+	5
8	Murshid ZA 2010	-	+	-	-	+	+	3
9	Dimberg L 2010	-	+	-	+	+	+	4
10	Anosike A N 2010	+	+	-	-	+	+	4
11	Sripriya Nagarajan 2010	+	+	-	-	+	+	4
12	Puertes-Fernándes N 2010	-	+	-	-	+	+	3
13	Jamilian A 2010	+	+	-	-	+	+	4
14	Souza LA 2011	+	-	-	+	+	+	4
15	Bhardwaj VK 2011	+	+	+	+	+	+	6
16	Aliaga-Del Castillo A 2011	-	-	-	+	+	+	3
17	Meghna Singh 2011	+	+	+	-	+	+	5
18	de Almeida AB 2011	+	+	+	+	+	+	6
19	Behbehani F 2011	+	+	+	-	+	+	5
20	Urrego-Burbano PA 2011	+	+	+	-	+	+	5
21	Uematsu S 2012	+	+	-	-	+	+	4
22	Bourzgui F 2012	+	+	+	+	+	+	6
23	Gois EG 2012	+	-	+	+	+	+	5
24	Sandesh Phaphe 2012	+	+	-	+	+	+	5
25	Behbehani F 2012	-	+	-	-	+	+	3
26	Bourne CO 2012	+	+	+	-	+	+	5
27	Ferro R 2013	+	+	+	+	+	+	6
28	Laganà G 2013	+	+	+	-	+	+	5
29	Anitha XL 2013	-	+	-	+	+	+	4
30	Thomaz EB 2013	+	+	+	-	+	+	5
31	Bugaighis 2013	+	+	-	+	+	+	5
32	Bugaighis 2013	+	+	-	+	+	+	5
33	Kaur	+	+	+	+	+	+	6
34	Reddy ER 2013	+	+	-	+	+	+	5
35	Carvalho AC 2013	+	+	+	-	+	+	5
36	Janosevic P 2013	+	-	-	-	+	+	3
37	Freitas CV 2014	-	+	+	-	+	+	4
38	Sanadhya S 2014	+	+	+	-	+	+	5
39	Correa-Faria P 2014	+	+	-	-	+	+	4
40	Komazaki Y 2014	+	+	-	-	+	+	4
41	Kasparaviciene K 2014	+	+	+	+	+	+	6
42	Jordao LM 2015	+	+	+	-	+	+	5
43	Laganà G 2015	+	+	+	-	+	+	5
44	Kataoka K 2015	-	+	-	-	+	+	3
45	Wagner Y 2015	-	+	-	+	+	+	4
46	Vitale MC 2015	+	-	-	-	+	+	3
47	Normando TS 2015	+	+	+	+	+	+	6
48	Ramos-Jorge 2015	+	+	+	-	+	+	5
49	Traebert E 2015	+	+	+	-	+	+	5
50	Bilgic F 2015	+	+	-	+	+	+	5
51	Tumurkhuu T 2016	+	+	+	+	+	+	6
52	Ferro R 2016	+	+	+	+	+	+	6
53	Ferro R 2016	+	+	+	-	+	+	5
54	Silveira MF 2016	+	+	+	-	+	+	5
55	Narayanan RK 2016	+	+	+	-	+	+	5
56	Akbari M 2016	+	+	-	-	+	+	4
57	Miyu Araki 2017	+	+	-	-	+	+	4

58	Zhou 2017	+	+	+	-	+	+	5
59	Steinmassl O 2017	+	-	-	-	+	+	3
60	Amaral CC 2017	-	+	+	-	+	+	4
61	Bittencourt JM 2017	-	+	-	-	+	+	3
62	Nagalakshmi S 2017	+	+	+	-	+	+	5
63	Monteiro AKAP 2017	+	+	+	-	+	+	5
64	Reboucas AG 2017	+	+	+	-	+	+	5
65	Bauman JM 2018	+	+	+	+	+	+	6
66	Costa CTD 2018	+	+	+	-	+	+	5
67	Guimaraes SPA 2018	+	+	+	-	+	+	5
68	Correa-Faria P 2018	+	+	+	-	+	+	5
69	Dutra SR 2018	+	-	+	+	+	+	5
70	Bauman JM 2018	-	+	+	+	+	+	5
71	Avinash 2018	+	+	+	-	+	+	5
72	Marchena-Rodriguez A 2018	+	-	+	-	+	+	4
73	Gudipaneni RK 2018	-	+	+	-	+	+	4
74	Fadia M. Al-Hummayani 2018	+	+	+	-	+	+	5
75	Nur Yilmaz RB 2018	-	+	-	-	+	+	5
76	Saccomanno S. 2018	-	+	-	-	+	+	3
77	Perrotta S. 2019	+	+	-	-	+	+	4

TABLE 2 The quality assessment of included studies (relying on a modified STROBE Statement criteria).

Results

Four hundred and fifty records were found from searched databases. After the titles and abstracts screening, 83 records were excluded, and in addition further 101 were removed as duplicates. Further 18 records were identified through additional hand searching. Overall 284 records were selected and after obtained in their full-text version. One hundred and seven of them were excluded because did not meet the inclusion criteria established in this review, while 77 were selected and included (Table 1). The flowchart reported in Figure 1 shows the entire study selection process. Year of publication of selected studies ranged from 2009 to 2019 .

The level of evidence obtained from results reported in this review is good due to fact that 47 studies (61%) were considered of high quality (with a STROBE's score by 5-6) and 30 (39%) of medium quality (with a STROBE's score of 3/4) (Table 2). However, a highly relevant degree of heterogeneity (I2) was found among included studies either among and between four continents (Africa, America, Asia, Europe) where it was calculated by ranging 99.65 to 99.84% (p-value = 0.001).

The worldwide prevalence of malocclusion among children and adolescents was 56% (95% CI: 11–99) without relevant gender difference. Considering the aepidemiological malocclusion distribution among continents, higher percentage scores were found in Africa with 81% (95% CI: 64–98) and in Europe, 71% (95% CI: 0.62–0.82) followed by America with 53% (95% CI: 47–59) and Asia 48% (95% CI : 34–62). Oceania was the only continent where no studies dealing with this topic were found. The meta-analysis of pooled data (after their extraction from each study) performed in this review is described in Figure 2. A subgroup analysis for single traits of malocclusion, concerning Angle's classes, overjet, overbite, posterior crossbite, scissor-bite, midline-line shift, crowding, diastema, was also carried out in this review. The complete panel of results is reported in three tables (Tables 3, 4, 5) each of them describing the malocclusion traits related to any single type of dentitions.

Discussion

Knowing the world aepidemiological data helps in determining and directing the priorities in regard to malocclusion treatment need, and the resources required to offer treatment in terms of work capacity, skills, agility and materials to be employed. National public health services should know the prevalence of malocclusion traits in order to organise the rational planning of preventive and therapeutic orthodontic measures. In addition, assessment of malocclusion prevalence by different populations and locations may reflect the existence of determining genetic and environmental factors.

This systematic review provided an accurate aepidemiologic worldwide picture on the malocclusion prevalence in the primary, mixed and permanent dentitions. According to our data, more than half of children and adolescents in the world suffer from one type of malocclusion, without significant differences between male and female. This high prevalence did not decrease under 50% in any of the world continents with the exception, though negligible, of Africa (48%). No studies dealing with this topic were found in Oceania.

Due to the good level of methodological quality of all included studies, their worldwide dissemination and high number of articles (n=77), this review constitutes a good degree of evidence concerning the aepidemiological relevance of malocclusion.

Malocclusion reaches its highest prevalence worldwide in early childhood during the deciduous dentition period (54%) and keeps unvaried in permanent dentition (54%). According to these prevalence data, malocclusion represents a relevant oral health problem as well as an economic burden for either family of affected children and dental health public services.

Considering the possibility to prevent the malocclusion onset since the earliest age (i.e. avoiding children's bad oral habits), health policy makers as well as paediatricians and dentists should be prompted to devise preventive or early diagnosis and appropriate treatment strategies [D'Apuzzo et al., 2019; Lione et al., 2015].

Primary dentition												
	Malocclusion Traits	Europe		America		Africa		Asia		Worldwide		
		Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	NPMs (%)**
Sagittal	Angle Class I	29.5	*	70.22	47			49.68	20.2	62.3	31.5	54.2
	Angle Class II	19.3	10.8	20.47	36			33.27	11	23.29	20.5	35.3
	Angle Class III	13	*	6.37	1.8			13.18	8.9	7.76	6.1	10.5
	Normal overjet	40.76	22	69	17.3					69	14.8	72.6
	Increased overjet	36.8	8.5	20	5.9	11.4	*	33.90		23	14.4	24.2
	Reverse overjet			3.10	*	1.4	*			3	1.2	3.2
Vertical	Normal overbite	52.05	45	65.40	*	56.50	*			66	16.6	69.5
	Open bite	34	29.7	2	1.8	2.6	*			5	17.5	5.3
	Deep bite			12.80	8.2	36	*	63.70	*	24	21.1	25.2
Transverse	Crossbites	7	0.07			5.6	*			10	8.5	10
	Posterior Crossbite	3.82	1.3	17	8					14	7.7	14
	Scissorbite					0.4				0.4	*	0.4
	Midline shift							26.6	*	27	*	27
	Crowding			28.40	*	41.5	*	6.5	*	16	17.6	16
	Diastema											

TABLE 3 Classification of the different traits of malocclusions affecting the deciduous teeth, with their percentage prevalence scores and related standard deviations (SD).
(*) The asterisk shows absence of SD value due to fact that its related prevalence mean score is derived by only one study
(**) NPMs = prevalence mean scores normalized to 100%

Guidance of eruption and development of the primary, mixed, and permanent dentitions is an integral component of comprehensive oral health care for all paediatric dental patients. Early diagnosis and successful treatment of developing malocclusions can have both short- and long- term benefits while achieving the goals of occlusal harmony and function and dentofacial aesthetics [American Academy of Pediatric Dentistry, 2009]. Moreover, an improved regional and/or ethnicity-specific malocclusion knowledge may change the health policy toward developing the specialists' skills and offering the resources required for specific malocclusions [Alhammadi et al., 2018].

Once the basic needs for caries control in a child population have been met, the problems of organising orthodontic care come into focus. Traditionally, the responsibility for initiating orthodontic treatment and its economic burden have rested mainly with the patients, or rather with their parents. Thus, the the probability of starting an orthodontic treatment (likewise for many other fields of oral health) has been determined more by the cultural and socio-economic levels of the family, rather than by the severity of the patient's malocclusion [Cianetti et al., 2017a]. As a matter of fact, new policies involving early children's dental visits, preventive interventions and minimally invasive treatments should be adopted in order to facilitate an early and adequate oral health preservation [Paglia et al., 2017; Cianetti et al., 2018; D'Ambrosio et al., 2020; Cianetti et al., 2017_b].

Subgroup analysis of most relevant traits of malocclusion

The first occlusion parameter analysed in this review was Angle's occlusal class. About two-third of the population exhibited a dental Class I during both primary and permanent dentitions. In the remaining one-third of the population, Class II resulted three-fold most prevalent than Class III in both the permanent and primary dentitions. Class I prevalence seems to decrease from primary to mixed and permanent dentition, probably due to genetic manifestation or environmental conditioning, while Angle's Class II and III remain substantially stable over the three different dentitions.

When overjet was considered, about 70% of children and adolescents showed normal parameters, with a similar percentage in both the primary and permanent dentitions. Among the remaining 30% of population, increased overjet resulted the most prevalent trait, seven times most frequent than reversed overjet in both primary and permanent dentitions, in agreement with the worldwide higher prevalence of Class II division 1 inside this Angle's class [da Silva et al., 2008].

As for overbite, the children and adolescents showing normal parameters represented the most relevant part of the population, ranging from 69.5% to 64.5 % in the primary and permanent dentitions, respectively.

Among the subjects with overbite, deep bite prevalence was much more common than open bite, with an increased score ranging from 3.5 times in the permanent teeth to 5 times in the primary teeth.

A further malocclusion trait, which is substantially constant during the different stages of dentition, was the midline shift with a prevalence of 27% in the primary dentition and 28% in the permanent dentition.

Conversely, some malocclusion traits such as scissor bite and dental crowding increased from primary to permanent dentition. Scissor bite, indeed, raised from 0.4 to 5% and dental crowding from 16 to 39%.

The only two malocclusion traits which decreased from primary to permanent dentitions were upper interincisive diastema and posterior cross-bite. The diastema reduced its prevalence from 35% to 5%. This was likely due to a dimensional increase of permanent incisors when compared with their deciduous homologous, with a subsequent interdental space reduction. Similarly to diastema, crossbite reduced its prevalence

Mixed dentition												
	Malocclusion Trait	Europe		America		Africa		Asia		Worldwide		
		Mean(%)	SD	Mean(%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	NPMs (%)**
Sagittal	Angle Class I	53	11.6	41	15.4	61	*	57	12	54	12.5	60.7
	Angle Class II	30	5.1	50	14.4	24	*	23	7.9	29	11	32.6
	Angle Class III	3	3.2	8	1.9	10	*	6	1.8	6	2.9	6.7
	Normal overjet	70	19.9	68	19.4	70	*	75	6.1	71	15.7	71.6
	Increased overjet	24	13.75	29	9.8	24	*	24	3.4	27	9.5	30.3
	Reverse overjet	3	0.9	1	3.7	3	*	1	2.6	1	2.4	1.1
Vertical	Normal overbite	76	12.3	52.3	*	76	*	63	2.5	69	10.1	70.4
	Open bite	3	0.7	6	5.9	3	*	2	1.6	3	4.4	3.4
	Deep bite	19	8	20	16.2	19	*	35	0.7	26	10.1	26.5
Transverse	Crossbites	36	*			7.1	*			11	20.6	11
	Posterior Crossbite	11	4.1	29.20	*			5	4.7	8	8.9	8
	Scissorbite	1.9	*					2	*	2	0.07	2
	Midline shift	21.9	*			42.20	*			35	14.3	35
	Crowding	42	*	50	15.8			11.8	*	37	37	37
	Diastema	52.5	*	33	25.9					35	22.7	35

TABLE 4 Classification of the different traits of malocclusions affecting the mixed dentition, with their percentage prevalence scores and related standard deviations (SD).
(*) The asterisk shows absence of SD value due to fact that its related prevalence mean score is derived by only one study
(**)NPMs = prevalence mean scores normalized to 100%

Permanent dentition												
	Malocclusion Traits	Europe		America		Africa		Asia		Worldwide		
		Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	NPMs (%)**
Sagittal	Angle Class I	34.5	15.2	49.62	28.9	83.85	19.1	67.55	26.8	55.5	24.6	61
	Angle Class II	36.7	18.1	22.69	10.8	11.7	15.1	18.52	9.3	24.7	13.6	27.2
	Angle Class III	14.2	11.2	26.24	17.1	2.61	1.2	4.86	5.5	10.7	9.5	11.8
	Normal overjet	54.5	*			51	*	57	14.4	57	11.7	70.4
	Increased overjet	30	19.7	18	14	25	26	19	19.3	21	21.2	25.9
	Reverse overjet	7.1	3.9	0.2	0.1	6	5.5	10	7.1	3	5.5	3.7
Vertical	Normal overbite	65	18.3	9		56	17.8	30	34.3	49	27	64.5
	Open bite	12	10.2	5	18.7	5	2.6	9	6.5	6	12	7.9
	Deep bite	14	28.1	5	*	31	2.6	27	19.6	21	20.4	27.6
Transverse	Crossbites	10	0.35		*	5.4	*	2.3	*	5	4.1	5
	Lateral Crossbite	5	0	4	1.5			8	2.8	7	2.3	7
	Scissorbite	0.30	0					5	*	5	6.5	5
	Midline shift	32	*	37	*	21.6	*	29.7	*	28	5.6	28
	Crowding	51	16.5	39	14.5	13	0	50	28.9	39	23.6	39
	Diastemas	4	14.8	1	1.2	20.9	*	22	5.6	5	8.5	8.5

TABLE 5 Classification of the different traits of malocclusions affecting the permanent dentition, with their percentage prevalence scores and related standard deviations (SD).
(*) The asterisk shows absence of SD value due to fact that its related prevalence mean score is derived by only one study

from 14% to 7%. This could be explained (particularly in thedeveloped countries) by the aepidemiological impact of orthodontic treatments (i.e. rapid palatal expander) carried out during primary and mixed dentitions up to adolescence [Rosa et al., 2016; Lanteri et al., 2018].

Study limitations

The most relevant methodological limit of this study could be the lack of accuracy in describing the prevalence changes of the malocclusion traits from the primary to permanent dentition. This limit is due to the design of such a study: a systematic review. Indeed, for analysing a variable (such as a malocclusion trait) variation over time in a cohort study is the most appropriate. In a cohort design, indeed, all measures are always performed in the same population, while in a systematic review multiple and, therefore, different populations (with heterogeneous characteristics) are used for measuring data. This heterogeneity of population generates a certain degree of bias when a variable evolution over time has to be evaluated.

Another study limitation was a very high heterogeneity of prevalence among studies (with regard to the high variability of the malocclusion mean scores among single assessed populations), likely due to differences of age and ethnic population' groups as well as measurement methods and analysed malocclusion parameters or, finally, environmental and genetic factors [Vázqueznava et al., 2006; Góis et al., 2008].

Conclusion

Children's and adolescents' malocclusion is a highly prevalent condition worldwide, affecting one out of two individuals (or more). Due to the early onset of malocclusion from early childhood, health strategies should be adopted by both clinicians and policy-makers to prevent and manage this condition. In a subgroup analysis concerning several traits of the malocclusion, most of them showed similar prevalence during primary and permanent dentition (i.e. Angle's class, overjet, overbite, midline shift).

These results support the idea that the dimensional growth of the oral cavity from childhood to adolescence is not able alone to correct the majority of the malocclusion traits detected during the primary dentition phase.

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