

Frequency of orthodontic treatment in German children and adolescents: influence of age, gender, and socio-economic status

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SUMMARY Orthodontic treatment is a common dental procedure in developed countries. However, the frequency and factors associated with treatment demand are different between countries. The aim of this study was to examine the frequency of orthodontic treatment in German children and adolescents and to analyse the influence of age, gender, and socio-economic status (SES; education and region) on the frequency of treatment. Subjects in a random population sample of 1538 German children and adolescents, aged 11–14 years, were interviewed at home in the autumn of 2008 regarding current orthodontic treatment and associated factors. Approximately one-third (33.5 per cent) of the subjects interviewed were undergoing orthodontic treatment at that time.

In a multivariable logistic regression model, the likelihood of receiving orthodontic treatment was higher for girls [odds ratio (OR) = 1.32, 95 per cent confidence interval (CI): 1.06–1.65], for high school pupils (OR = 1.19, 95 per cent CI: 1.06–1.34), and for children and adolescents living in the western part of Germany (OR = 1.45, 95 per cent CI: 1.00–2.08) and increased with age (OR = 1.13 per year, 95 per cent CI: 1.02–1.25). Subjects undergoing orthodontic treatment more often received prophylactic measures (OR = 2.06, 95 per cent CI: 1.63–2.59) compared with those not currently receiving orthodontic treatment. The frequency of orthodontic treatment in Germany largely depends on gender and SES.

Introduction

Two studies from the 1990's have reported high rates of children and adolescents in Germany receiving orthodontic treatment at the expense of the public health insurance system [Gesetzliche Krankenversicherung (GKV)]: 52 per cent in one study (Hensel, 2001) and 67 per cent in another (Schopf, 2001). These rates are substantially higher in comparison with international data (Harzer and Wiesner, 1998; Tickle *et al.*, 1999). Depending on age, country, region, and indices used, these authors reported rates of orthodontic treatment in Europe ranging from 15 to 63 per cent (mean 45 per cent). Taken together, these data indicate that Germany has an international leading position in providing orthodontic treatment (Micheelis, 1991). However, given that the available data are 20 years old and numerous changes in the German health care system have occurred over that time, it is likely that the frequency of orthodontic treatment in Germany has also changed.

In 2002, a system of orthodontic indication groups [Kieferorthopädische Indikationsgruppen (KIG)] was introduced in Germany (Schopf, 2004). The KIG system is a derivative of the Index of Orthodontic Treatment Need (IOTN) described by Brook and Shaw (1989) and Shaw *et al.* (1991b). The KIG is used to regulate access to

orthodontic treatment in the public health insurance system (Table 1). Before the introduction of the KIG, access to orthodontic treatment at the expense of the GKV in Germany was nearly unlimited because the need for treatment was determined by the orthodontist. Accordingly, after implementation of this system, it would be expected that the level of orthodontic treatment in Germany would be reduced, perhaps to levels comparable with those seen internationally. In terms of treatment need, recent studies have produced wide ranging results. Using the IOTN, Tausche *et al.* (2004) reported a 26.2 per cent need for treatment in 6- to 8-year-old children in East Germany. This finding is consistent with those observed for children 9–12 years old in France (21.3 per cent; Souames *et al.*, 2006). Perillo *et al.* (2010) found a 27.3 per cent treatment need according to the IOTN for 12-year-old schoolchildren in southern Italy. In a recent study of German schoolchildren using the KIG system, a need for treatment in 41.4 per cent of the sample was identified (Glasl *et al.*, 2006).

However, the frequency of subjects actually receiving orthodontic treatment is not only associated with treatment need based on morphological discrepancies but also with a number of other factors, such as gender (Burgersdijk *et al.*, 1991; Burden 1995; O'Brien *et al.*, 1996; Kerosuo *et al.*,

Table 1 Classification of orthodontic treatment need using German orthodontic indication groups (KIG).

Malocclusion	Severity grade				
	1 (mm)	2 (mm)	3 (mm)	4 (mm)	5 (mm)
A					Cleft palate and syndromes
U				Agensis or loss	
S				Impaction	Displacement
D	<3	3-6		6-9	>9
M	<1	1-2	>2-4	0-3	>3
O	>1-3	>3 with/without mucosal contact	>3 with traumatic mucosal impingement	>4 habitually open	>4 skeletally open
T				Scissor bite	
B				Unilateral crossbite	
K		Buccolingually cusp-to-cusp relationship	Bilateral crossbite	>5	
E	<1	>1-3	>3-5	>4	
P		<3	3-4		

A severity grade score more than or equal to 3 is the cut-off for orthodontic treatment for children (aged less than 18 years) in the public health insurance system (Schopf, 2004).

2000), residence (urban versus rural; Bergström *et al.*, 1998; Dragan *et al.*, 2007), and ethnicity (Josefsson *et al.*, 2005; Bissar *et al.*, 2007). To date, the influence of socio-economic status (SES) on the frequency of orthodontic treatment has not been clearly established. Kenealy *et al.* (1989) found such a connection, that is, a different rate of orthodontic treatment by families from different social classes, in a study of 1018 children in Wales. In contrast, Burden (1995) reported that familiarity with orthodontic appliances among a subject's peer group had a greater influence on the uptake of orthodontic treatment than the subject's social class or gender. Furthermore, the effects of insurance systems (Proffit *et al.*, 1998; Kerosuo *et al.*, 2002) or the density of dentists (O'Mullane and Robinson, 1977) on orthodontic treatment frequency have been observed. Therefore, the aim of the present population-based study was to investigate the frequency of orthodontic treatment in German children and adolescents and to analyse the influence of age, gender, and indicators of SES (region and education) on treatment frequency.

Subjects and methods

The subjects were drawn from the 'Oral Health Related Quality of Life in Children and Adolescents' project that was conducted in Germany during 2008. The study protocol was approved by the Institutional Review Board of the University of Leipzig (Registration Number 112-2007).

A market research organization selected a random sample of addresses of families with children and adolescents aged 11-14 years of age. This sample, known as the Arbeitsgemeinschaft Deutscher Marktforschungsinstitute (ADM), was designed as a three-step area sample covering all populated areas of Germany (ADM, 2010). It is based on Germany's topology, organized by states, counties, and communities, the statistical areas within communities described by public data, and the geographic data created for traffic navigation systems. Combining these data, the area sample is made up of approximately 53 000 areas, each containing at least 350 but on average about 700 private households. Prior to sampling, the areas are first regionally stratified according to counties and the types of communities differentiated according to the number of inhabitants resulting in 1500 strata. Based on this stratification, 128 'nets' are extracted containing 210 areas in former West Germany and 48 areas in former East Germany (first step). These 258 sampling points (= areas) are drawn proportionally to the distribution of private households. In the second step, the private households and within them, the individuals (third step) are selected randomly using systematic selection methods with a random start. The sampling procedure according to the ADM technique actually reaches a response proportion of 69 per cent (Weidner *et al.*, 2009). The aim in this study was to reach a sample with more than 1500 subjects. Overall, 1538 responding families took part and the 11- to 14-year-old children/adolescents (one per family)

were interviewed in person by a trained female interviewer at their home. All responding subjects/parents gave their written consent to participate. Subjects were interviewed in the autumn of 2008.

Variables

The outcome of interest was the frequency of orthodontic treatment. The interviewer asked each subject the question 'Do you have an orthodontic appliance?', as well as examining the subject for the presence of fixed or removable orthodontic appliances. All types of appliances (or parts of them) were scored as 'orthodontic treatment yes'. The interviewer also gathered information on age, gender, region, and type of school attended by each subject. Age and gender were assessed as potential factors associated with the frequency of orthodontic treatment. The region (east-west) and type of school (high school and secondary school) were considered indicators for higher or lower SES (Geißler and Meyer, 2008), which was also assessed as a potential factor associated with treatment frequency. The type of school was chosen as a variable to describe SES of the study subjects because more than 65 per cent of high school pupils in Germany come from a family with higher education and income (Geißler and Meyer, 2008). Therefore, the type of school is a good proxy for SES in Germany. In addition, subjects were asked about whether they had participated in prophylactic programmes at their dentist's office during the previous year.

Statistics

The distribution of orthodontic treatment (treatment yes or no and fixed or removable) in the study population was

reported by age and tested for statistical significance using the chi-square test. A *t*-test for independent samples was used to determine the statistical significance of the continuous variable of age, and the chi-square test to evaluate the statistical significance of the categorical variables (gender, school type, region, and prophylactic measures). The odds ratios (ORs) and 95 per cent confidence intervals (CIs) were estimated to indicate the likelihood of receiving orthodontic treatment and prophylactic treatment by a multivariable logistic regression model, adjusting for age (per year), gender (female versus male), region (West versus East Germany), and education (high school versus secondary school). A *P*-value of <0.05 was considered statistically significant.

Results

Of the 1538 subjects, approximately one-third (33.5 per cent) were receiving orthodontic treatment. The treatment frequency was significantly different in the various age groups (Table 2). Fixed and removable appliances were observed in 17.5 and 16.0 per cent of the subjects, respectively. No significant difference in the use of fixed or removable appliances was found among the age groups (Table 2) or between East and West Germany (data not presented).

No substantial difference was observed in the mean age of the subjects currently receiving orthodontic treatment compared with those not undergoing orthodontic treatment, although the difference was statistically significant (Table 3). In contrast, a clear difference was found in the proportion of subjects receiving prophylactic treatment (Table 3). The data also showed that subjects undergoing orthodontic

Table 2 Frequency of current orthodontic treatment in German children and adolescents aged 11-14 years in 2008.

Orthodontic treatment	All (<i>N</i> = 1538)	11 years (<i>N</i> = 388)	12 years (<i>N</i> = 385)	13 years (<i>N</i> = 380)	14 years (<i>N</i> = 385)	<i>P</i>
	% (<i>N</i>)					
No	66.5 (1023)	73.2 (284)	63.9 (246)	66.8 (254)	62.0 (239)	0.006
Yes	33.5 (515)	26.8 (104)	36.1 (139)	33.2 (126)	38.0 (146)	
Fixed	17.5 (269)	15.7 (61)	21.3 (82)	14.0 (53)	19.0 (73)	>0.05
Removable	16.0 (246)	11.1 (43)	14.8 (57)	19.2 (73)	19.0 (73)	

Table 3 Sample characteristics stratified according to orthodontic treatment. SD, standard deviation.

Variables	All subjects (<i>N</i> = 1538)	Orthodontic treatment yes (<i>N</i> = 515)	No orthodontic treatment (<i>N</i> = 1023)	<i>P</i>
Mean age in years (SD)	12.5 (1.2)	12.6 (1.1)	12.4 (1.1)	0.004
Females % (<i>N</i>)	49.1 (755)	55.1 (284)	46.2 (473)	0.001
High school % (<i>N</i>)	30.6 (470)	36.5 (188)	27.6 (282)	0.002
Prophylaxis participation % (<i>N</i>)	53.7 (826)	65.8 (339)	47.7 (488)	<0.001
West Germany % (<i>N</i>)	84.9 (1305)	87.2 (449)	83.7 (856)	>0.05

Table 4 Results of the multivariate analysis: likelihood of receiving current orthodontic treatment for German children and adolescents aged 11–14 years in 2008.

Variables	Odds ratio	Confidence interval	P
Age (per year)	1.13	1.02–1.25	0.017
Gender (female versus male)	1.32	1.06–1.65	0.013
Region (West versus East Germany)	1.45	1.00–2.08	0.047
School type (high school versus secondary school)	1.19	1.06–1.34	0.003

treatment were more often females and attended a high school. The proportion of subjects in the sample undergoing orthodontic treatment who came from the western part of Germany was slightly, but not statistically significantly, higher than those from the east (unadjusted data, Table 3). The multivariable model confirmed the observation that the frequency of orthodontic treatment increased with age and was more prevalent in girls and in high school pupils (Table 4). The likelihood of receiving orthodontic treatment for subjects living in the western part of Germany became statistically significant in this model (i.e. the 95 per cent CI of the estimate does not include '1'). Subjects currently undergoing orthodontic treatment were more than twice as likely to take part in prophylactic programmes in the dental office (OR = 2.06, 95 per cent CI: 1.63–2.59) compared with those not currently undergoing orthodontic treatment.

Discussion

The frequency of orthodontic treatment in Germany in approximately one-third of the population of 11–14 years old analysed was high. It was also found that the frequency of orthodontic treatment largely depends on gender and indicators of SES (education and region); that is, high school girls in West Germany were twice as likely to be treated orthodontically compared with boys from the East.

The data presented in this study are recent and, due to the sampling procedure used, representative of all German children and adolescents aged 11–14 years. It is considered that the sample is representative because the proportion of subjects attending a high school (31 per cent) is nearly the same (33 per cent) reported by Geißler and Meyer (2008) for Germany in a national survey. A further advantage of this study in contrast to the research of Whitesides *et al.* (2008) was that all subjects were interviewed personally, and the trained interviewer had the opportunity to confirm first-hand the presence or absence of orthodontic appliances.

Compared with data from the 1990s that reported on orthodontic treatment frequency before unlimited access to orthodontic treatment at the expense of the GKV was controlled by introduction of the KIG system, the current frequency (33.5 per cent) identified in this study for German

children 11–14 years of age represents a decrease of 20–30 per cent. Despite this reduction over the past 20 years, the frequency of orthodontic treatment provision in Germany still exceeds that in other countries for this age group: USA, 18 per cent (Brunelle *et al.*, 1996) and UK, 8–14 per cent (Chestnutt *et al.*, 2006). However, the sample was not assessed for early orthodontic treatment (tooth extractions and interceptive orthodontic treatment) because it was not expected that valid information could be obtained given previous reports that parents/children exhibit poor recall of earlier orthodontic treatment (Baird and Kiyak, 2003). The sample was also not assessed for orthodontic treatment need based on morphological or aesthetic criteria. For this reason, it was not possible to analyse the association between treatment need/demand and treatment frequency, which is a limitation of the study.

In Germany, according to the regulations of the KIG system, most orthodontic treatment is carried out at the end of the second phase of the dentition (i.e. when the age of children is between 11 and 14 years). Fluctuations in the prevalence of orthodontic treatment frequency within the age groups were observed, but in general, a moderate increase between 11 and 14 years of age was present. The data further confirmed previous findings of a higher frequency of orthodontic treatment for girls (Burgersdijk *et al.*, 1991; Burden *et al.*, 1994; Burden, 1995; O'Brien *et al.*, 1996; Kerosuo *et al.*, 2000). This fact seems to be independent of the particular country or health service system and may be an indicator of a higher health care utilization by females in general. According to Perillo *et al.* (2010), no significant differences in treatment need between genders could be found. Despite this finding regarding treatment need, one reason for a difference in orthodontic treatment frequency might be that the social acceptance of dental deviations is lower for females (Zhang *et al.*, 2010).

The observed influence of SES on orthodontic treatment frequency is not surprising. A high social status of parents is associated with higher education as well as an increased demand for orthodontic treatment for their children (Shaw *et al.*, 1991a; Reichmuth *et al.*, 2005). Moreover, the likelihood of discontinuation of orthodontic treatment in families with low SES is also assumed to be higher (Rölling, 1982; Turbill *et al.*, 2003). The lower proportion of orthodontic treatment of subjects with a lower SES might be due to financial constraints (Page and Thomson, 2005) and a possible higher tolerance for dental deviations in these social groups.

The German system of public health insurance provides free orthodontic treatment for children upon reaching the agreed limits of the KIG classification for a particular dental anomaly. The availability of free medical treatment has an effect on the demand for orthodontic treatment (Kerosuo *et al.*, 2002). A public health insurance system should produce a comparable orthodontic treatment frequency for all patients in all regions. The higher proportion of subjects

receiving orthodontic treatment in West Germany observed in this study may be due to a proportion of those subjects in the sample being treated on a private basis, without KIG indication, based on the ability of their parents to finance treatment. This financial ability is directly related to the SES of the parents, which in turn is related to the place of residence (e.g. purchasing power is lower in East Germany; *Gesellschaft für Konsumforschung*, 2008). However, information regarding private orthodontic treatment was not asked for because valid information was not expected for two reasons: nearly all orthodontic treatments in Germany are linked with an additional payment by the parents, even if the main part of the treatment is provided by the GKV and only a minority (8 per cent) of the population has private health insurance. It could be, however, that the inability to afford the additional payment associated with GKV orthodontic treatment may be a factor for the lower utilization of the GKV orthodontic treatment service in East Germany.

The number of orthodontists per capita in Germany (1:27 779) is higher than that of other European countries (e.g. Spain 1:100 000; UK 1:73 333.; *van der Linden et al.*, 2004). No significant difference exists in the number of orthodontists per capita between the former East and West Germany (*Bundeszahnärztekammer*, 2009). In a previous study, the number of dentists was found to be correlated with the number of individuals receiving dental treatment (*O'Mullane and Robinson*, 1977); thus, it was assumed that a similar correlation exists for orthodontists and orthodontic treatment. On the other hand, general dentists also play a key role in determining orthodontic treatment levels (*Birkeland et al.*, 1999).

The high proportion of removable appliances observed in the current sample can be explained through historical context as a higher use of these devices is known to occur in the German-speaking area based on the concepts of Andresen, Häupl, Petrik, Eschler, and Balters (*Schmuth*, 1983). Another reason for the frequent use of removable appliances is the payment structure in the GKV system in Germany, which favours removable appliances.

Finally, a higher proportion of participation in dental prevention programmes (65.8 per cent) was observed for orthodontically treated children when compared with children who were not receiving orthodontic treatment (47.7 per cent). This participation in prophylactic treatment by orthodontic patients is a positive side-effect of orthodontic treatment as the specific risks of demineralization under conditions of poor oral hygiene in association with fixed appliances can be more regularly monitored.

Conclusions

The data suggest that the frequency of orthodontic treatment in German children and adolescents largely depends on their gender and SES. With the introduction of

the KIG system, the number of German children undergoing orthodontic treatment has decreased, although it still exceeded the levels observed for other countries. A free public insurance system that covers orthodontic treatment does not necessarily produce an equal utilization of such treatments, due to differences between girls and boys and the influence of SES on the availability and rate of treatment, as indicated in this study. The higher proportion of prophylactic measures in subjects receiving orthodontic treatment is a positive side-effect of orthodontic care.

Funding

GABA International, Therwil, Switzerland (S-200703X).

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