

Patterns of orthodontic treatment of children in Australia: a national population-based study

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Objective: This study aimed to describe orthodontic treatment patterns of children in Australia.

Methods: Using data from the 2012-2014 National Child Oral Health Study (NCOHS), a cross-sectional survey representative of children in Australia aged 5 to 14 years involving parental-completed questionnaires, standardised oral examinations and malocclusion severity assessment, the present study examined: sociodemographic characteristics, types and providers of orthodontic treatment, extraction rates, treatment need levels and orthodontic service access.

Results: Adolescents (31.7%), children from higher-income households (22.0%), and those with handicapping malocclusions (46.6%) accessed services more than their counterparts. Of those who had ever accessed services, pre-adolescents mostly had a consultation only (46.5%) and were predominantly treated using removable appliances (25.1%). Adolescents mostly had fixed appliances (38.0%). Extractions were involved in 31.0% of fixed appliance treatments. Private orthodontists provided the majority of treatment services (80.6%). There were greater numbers of higher-severity malocclusions affecting males, indigenous children, and children from lower-income households compared with their counterparts. In those with higher-severity malocclusions, males, children with high-school-only-educated parents, and children from lower-income households accessed services less than their counterparts.

Conclusions: The present study provides baseline information for Australian orthodontic services. Disparities in malocclusion severity and service access were noted. Increased malocclusion severity did not necessarily increase the likelihood of accessing services.

(Aust Orthod J 2024; 40: 22 - 39. DOI: 10.2478/aoj-2024-0019)

Received for publication: May, 2024
accepted: July, 2024.

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Introduction

When planning for population healthcare provision, policymakers must know the ‘lie of the land’. Information regarding the level of treatment need, how many people and which groups receive treatment, the types of treatment that are being provided and by whom, must be considered to ensure the optimal allocation of resources.

The 2012 to 2014 Australian National Child Oral Health Survey (NCOHS) was a national collaborative

effort, involving the Australian Research Centre for Population Oral Health, state and territory health departments and the Commonwealth Department of Health, to provide a snapshot of the oral health of children in Australia.¹ The information gathered included data regarding orthodontic treatment need and the use of orthodontic services. To the best of current knowledge, there had been no prior nationwide study conducted to examine the orthodontic status of children in Australia and patterns

of access to orthodontic services. Only two state level investigations have been reported,^{2,3} in contrast with the situation in other countries.⁴⁻⁷ Allister et al. found that, in the late 1980s in South Australia, the majority of fixed orthodontic treatment was performed by orthodontists, whilst most orthodontic extractions and removable appliance treatment were provided by public sector general dentists.² Sivaneswaran and Darendeliler, in a New South Wales study using private insurance records from 1992 to 1995, found that the majority of orthodontic treatment was provided by orthodontists (80%) and, also, that most fixed orthodontic treatment was provided by orthodontists.³ These previous state-level studies indicated that orthodontic care in Australia was largely provided in the private sector by orthodontists.^{2,3} A patient's eligibility for publicly funded orthodontic care in Australia usually requires ownership of a means-tested health care eligibility card. As orthodontic care through the private sector is comparatively expensive, and eligibility for public treatment is limited, a proportion of the population may be unable to access treatment during their adolescent years. However, the growing social acceptance of adult orthodontics and increased options for aesthetic appliances, has led to many individuals, whose parents could not afford treatment for them as children, to seek treatment as young adults.⁸

The national Australian orthodontic 'landscape' is uncharted territory which the present study hopes to identify. Using NCOHS data, the present study aimed to describe the patterns of orthodontic treatment for children in Australia aged 5 to 14 years according to sociodemographic characteristics, the types of treatment provided, and orthodontic treatment need for those aged 12 to 14 years.

Materials and methods

The present study used data from the 2012-2014 NCOHS¹ which involved 24,644 children, aged 5 to 14 years, from 841 participating schools across all Australian states and territories. A multistage, stratified sampling design was employed to obtain a representative sample of children, with weighting procedures used to account for possible variations in the probabilities of selection and response rates.¹ Data were gathered via questionnaires completed by the children's parents and standardised oral examinations conducted by calibrated dental professionals.

Of the wide range of areas investigated by the parental-completed questionnaire, the present study examined questions pertaining to sociodemographic characteristics (age, gender, indigenous identity, parents' country of birth, parental education, and household income) and the use of orthodontic services. The use of orthodontic services was assessed by asking parents:

- "Has your child been to see an orthodontist?",
- "What treatments has your child had?", and
- "Where has your child received orthodontic treatment?"

Parents were asked whether their child had received any of the following treatments:

- "Planned (Orthodontic) Extractions",
- "Removable Appliances",
- "Fixed Banding", or
- "Consultation Only".

Parents were also asked whether their child had received orthodontic treatment from any of these providers:

- "Public Clinic",
- "Child and Youth Dental Clinic",
- "Private General Dentist", or
- "Private Dental Specialist / Orthodontist".

The standardised oral examination involved the recording of occlusal traits of children aged 12-14 years and grading the traits using the Dental Aesthetic Index (DAI) by calibrated dental professionals.⁹ The DAI has been used as a tool to evaluate dental aesthetics, to determine eligibility for public programs, and in epidemiological surveys to assess treatment need in populations.¹⁰ Ten occlusal index traits (with various weightings) are scored and summed to generate a level of malocclusion severity or treatment need.^{9,11,12} The occlusal components assessed were: missing anterior teeth, anterior crowding, anterior spacing, diastemata, the greatest upper anterior irregularity, the greatest lower anterior irregularity, maxillary overjet, mandibular overjet, open-bite, and molar relationship.

The four levels of malocclusion severity and/or treatment need were (1) Normal occlusion or minor malocclusion (with no treatment need or slight treatment need), (2) Definite malocclusion (for which treatment is considered elective), (3) Severe

malocclusion (for which treatment is considered highly desirable), and (4) Very severe or handicapping malocclusion (for which treatment is considered mandatory).

The categories were established using a sample of 1306 study models of untreated adolescents from the National Centre of Health Statistics and meant to be representative of US youths aged 12 to 17 years. An evaluation of the study models indicated that 45.8% had a normal occlusion or mild malocclusion, 25.2% had a definite malocclusion, 15% had a severe malocclusion, and 14% had a handicapping malocclusion.^{11,12}

STATA 16.0 (StataCorp LLC, College Station, Texas) was used to generate descriptive statistics to estimate proportions, means, and 95% confidence intervals (CIs). Variables included sociodemographic characteristics, the types of treatment provided, the identity of the treatment providers, the frequency of planned (orthodontic) extractions, treatment need (overall and by sociodemographic characteristics), and access to orthodontic services according to malocclusion severity and sociodemographic characteristics. Statistical differences were denoted by non-overlapping 95% CIs.

To assess access to orthodontic services according to malocclusion severity and sociodemographic characteristics, children aged 12 to 14 years and evaluated by the DAI were dichotomised into two groups.¹³ Group 1 comprised children who had a normal occlusion or mild malocclusion, or definite malocclusion, (for which treatment would be considered unnecessary or elective). Group 2 comprised children who had a severe or handicapping malocclusion (for which treatment would be considered highly desirable or mandatory). The degree to which these two groups accessed orthodontic services was then assessed overall and by sociodemographic characteristics.

Results

Sociodemographic characteristics

The sociodemographic characteristics of the population sample, and children who had visited an orthodontist are displayed in Table I. Overall, 16.9% of children aged 5 to 14 years had visited an orthodontist. Children ages 5 to 8 years had lower levels of attendance (4.3%) compared to

children aged 12 to 14 years (31.7%). Children from lower income backgrounds were less likely to have accessed orthodontic services (12.0%), compared to those from higher income backgrounds (22.0%). Similar differences were observed when examining gender (male 14.6% versus female 19.4%), indigenous identity (indigenous 11.9% versus non-indigenous 17.2%), and the level of parental education (high school 13.5% versus tertiary education 19.0%).

Children aged 12 to 14 years identified with handicapping malocclusions were more likely to have visited an orthodontist (46.6%) compared to all other malocclusion levels. The second most likely malocclusion severity group to visit an orthodontist had the lowest treatment need, with 33.0% of children aged 12 to 14 years with a normal occlusion or a mild malocclusion having visited an orthodontist.

Patterns in orthodontic treatment, treatment providers, extraction frequency, and orthodontic treatment need of Australian children

One in ten (10.4%) children aged 5 to 11 years had visited an orthodontist for which the most common reason was consultation only (46.5%), and the most likely form of active treatment was by removable appliances (25.1%) (Table II). In contrast, children aged 12 to 14 years had higher levels of accessing orthodontic treatment (31.7%), and the most common form of treatment was by fixed appliances (38.0%) (Table II).

Table II and Appendix I display the findings regarding the providers of orthodontic treatment. Private orthodontists and other private specialists (paediatric dentists) comprised the majority of providers for all forms of treatment. An estimate of the frequency of planned extractions is reported in Appendix II. Planned extractions were found in 31.0% of all fixed appliance cases and 33.8% of fixed appliance treatment in children aged 12 to 14 years.

The prevalence of the different levels of malocclusion as assessed by the DAI in children aged 12 to 14 years according to sociodemographic characteristics is displayed in Figure 1. Furthermore, the distributions of various sociodemographic characteristics by malocclusion severity are shown in Appendices III-VI. Higher levels of severe and handicapping malocclusions were observed in males, indigenous children, and children from lower income households.

Table 1. Sociodemographic characteristics of children in Australia by orthodontist visit 2012-14

	Study sample		Children who have visited an orthodontist			
			Yes		No	
	<i>n</i>	col % (95%CI)	<i>n</i>	row % (95%CI)	col % (95%CI)	col % (95%CI)
Age (Years)						
5-8	10599	40.2 (38.4-42.0)	405	4.3 (3.7-4.9)	10.0 (8.5-11.7)	95.7 (95.1-96.3)
9-11	7561	29.6 (28.4-30.9)	1370	18.5 (17.0-20.1)	32.4 (29.2-35.7)	81.5 (79.9-83.0)
12-14	6504	30.2 (27.6-32.9)	2022	31.7 (29.6-33.9)	57.7 (53.6-61.7)	68.3 (66.1-70.4)
Sex						
Male	12348	51.2 (49.8-52.6)	1722	14.6 (13.5-15.8)	44.0 (40.8-47.3)	85.4 (84.2-86.5)
Female	12316	48.8 (47.4-50.2)	2075	19.4 (17.7-21.2)	56.0 (52.7-59.2)	80.6 (78.8-82.3)
Indigenous Identity						
Non-indigenous	23113	95.1 (94.3-95.8)	3641	17.2 (16.0-18.5)	97.2 (96.2-98.0)	82.8 (81.5-84.0)
Indigenous	1102	4.9 (4.2-5.7)	109	11.9 (8.8-15.8)	2.8 (2.0-3.8)	88.1 (84.2-91.2)
Parents' Country of Birth						
Australian Born	16146	64.6 (62.6-66.4)	2543	17.8 (16.4-19.2)	67.1 (64.6-69.6)	82.2 (80.8-83.6)
Overseas Born	7913	35.4 (33.6-37.4)	1187	15.8 (14.3-17.3)	32.9 (30.4-35.4)	84.2 (82.7-85.7)

Parental Education									
School	4767	28.9 (27.3–30.6)	611	13.5 (11.9–15.2)	22.7 (20.4–25.2)	3986	86.5 (84.8–88.1)	29.8 (28.1–31.6)	
Vocational Training	4213	22.5 (21.4–23.6)	653	17.1 (15.3–19.1)	22.7 (20.3–25.3)	3451	82.9 (80.9–84.7)	22.5 (21.3–23.7)	
Tertiary Education	14160	48.6 (46.6–50.6)	2490	19.0 (17.5–20.6)	54.6 (51.4–57.7)	11338	81.0 (79.4–82.5)	47.7 (45.6–49.8)	
Household Income									
Low	6390	31.9 (29.9–33.9)	754	12.0 (10.8–13.4)	22.4 (20.1–24.9)	5438	88.0 (86.6–89.2)	33.5 (31.4–35.6)	
Medium	9550	38.7 (37.3–40.1)	1525	17.0 (15.6–18.5)	39.1 (36.6–41.6)	7789	83.0 (81.5–84.4)	38.7 (37.2–40.3)	
High	6290	29.4 (27.5–31.4)	1310	22.0 (19.9–24.3)	38.5 (35.4–41.7)	4859	78.0 (75.7–80.1)	27.8 (25.8–29.8)	
Dental Aesthetic Index (DAI)* n=5112									
Normal/Mild Malocclusion	2577	48.4 (45.9–50.9)	766	33.0 (29.7–36.6)	48.9 (44.8–53.0)	1661	67.0 (63.4–70.3)	48.5 (45.6–51.4)	
Definite Malocclusion	1170	23.3 (21.7–25.1)	320	26.3 (22.8–30.2)	18.7 (16.2–21.5)	770	73.7 (69.8–77.2)	25.7 (23.5–27.9)	
Severe Malocclusion	709	14.2 (12.9–15.6)	231	29.4 (24.5–34.9)	12.4 (10.2–15.0)	428	70.6 (65.1–75.5)	14.6 (12.9–16.4)	
Handicapping Malocclusion	656	14.0 (12.5–15.7)	309	46.6 (40.5–52.7)	20.0 (17.0–23.4)	306	53.4 (47.3–59.5)	11.2 (9.6–13.1)	
Total	24664	100	3797	16.9 (15.8–18.2)	100	19060	83.1 (81.8–84.2)	100	

* Includes only children aged ≥ 12 , as the DAI is only used in the permanent dentition.

Col %, column percentage; CI, confidence interval; Row %, row percentage.

Table II. Prevalence of orthodontic visit, type of orthodontic treatment received, and treatment provider, by age group, of children in Australia 2012-14

		Age group (years)				Study sample			
		5 to 11		12 to 14					
	n	row % [95%CI]	col% [95%CI]	n	row % [95%CI]	col% [95%CI]	n	row % [95%CI]	col% [95%CI]
Has visited an orthodontist									
Yes	1775	42.3 (38–46.4)	10.4 (9.5–11.3)	2022	57.7 (53.6–61.7)	31.7 (29.6–33.9)	3797	100	16.9 (15.8–18.2)
No	14935	74.6 (72.1–77.0)	89.6 (88.7–90.5)	4125	25.4 (23.0–27.9)	68.3 (66.1–70.4)	19060	100	83.1 (81.8–84.2)
Type of orthodontic treatment#									
Cons. Only	930	49.3 (44.4–54.2)	4.7 (4.2–5.2)	770	50.7 (45.8–55.6)	10.9 (9.8–12.2)	1700	100	6.6 (6.0–7.1)
Rem. App.	410	37.8 (32.3–43.6)	2.5 (2.1–3.0)	581	62.2 (56.4–67.7)	9.5 (8.4–10.7)	991	100	4.6 (4.1–5.2)
Fix. App.	247	25.5 (21.0–30.6)	1.8 (1.4–2.2)	751	74.5 (69.4–79.0)	11.8 (10.6–13.2)	998	100	4.8 (4.3–5.5)
Exo	324	33.5 (28.4–39.1)	1.8 (1.6–2.2)	527	66.5 (60.9–71.6)	8.3 (7.3–9.4)	851	100	3.8 (3.4–4.3)
Rem. + Fix.	79	25.4 (18.9–33.3)	0.6 (0.5–0.9)	270	74.6 (66.7–81.1)	4.3 (3.6–5.1)	349	100	1.7 (1.5–2.1)
Rem. + Exo	82	25.5 (18.8–33.5)	0.4 (0.3–0.6)	177	74.5 (66.5–81.2)	2.9 (2.3–3.6)	259	100	1.2 (1.0–1.4)
Fixed + Extraction	66	18.7 (13.6–25.0)	0.4 (0.3–0.5)	262	81.3 (75.0–86.4)	4.0 (3.3–4.8)	328	100	1.5(1.3–1.8)
Rem. + Fix. + Exo	26	14.4 (8.7–22.8)	0.1 (0.1–0.2)	115	85.6 (77.2–91.3)	1.8 (1.4–2.4)	141	100	0.6 (0.5–0.8)
Type of orthodontic treatment*#									
Cons. Only	930	49.3 (44.4–54.2)	46.5 (42.7–50.4)	770	50.7 (45.8–55.6)	35.0 (32.0–38.1)	1700	100	39.9 (37.4–42.4)
Rem. App.	410	37.8 (32.3–43.6)	25.1 (21.8–28.7)	581	62.2 (56.4–67.7)	30.4 (27.4–33.6)	991	100	28.2 (25.8–30.6)
Fix. App.	247	25.5 (21.0–30.6)	17.7 (15.0–20.9)	751	74.5 (69.4–79.0)	38.0 (35.0–41.0)	998	100	29.4 (27.1–31.8)

Exo	324	33.5 (28.4–39.1)	18.1 (15.6–20.9)	527	66.5 (60.9–71.6)	26.8 (24.0–29.7)	851	100	23.1 (21.2–25.1)
Rem. + Fix.	79	25.4 (18.9–33.3)	6.3 (4.7–8.6)	270	74.6 (66.7–81.1)	13.6 (11.6–16.0)	349	100	10.6 (9.1–12.1)
Rem. + Exo	82	25.5 (18.8–33.5)	4.2 (3.2–5.7)	177	74.5 (66.5–81.2)	9.3 (7.5–11.4)	259	100	7.1 (6.0–8.5)
Fixed + Extraction	66	18.7 (13.6–25.0)	4.0 (3.0–5.5)	262	81.3 (75.0–86.4)	12.9 (11.0–15.0)	328	100	9.1 (7.9–10.5)
Rem. + Fix. + Exo	26	14.4 (8.7–22.8)	1.3 (0.8–2.2)	115	85.6 (77.2–91.3)	5.8 (4.5–7.5)	141	100	3.9 (3.1–4.9)
Treatment provider*#									
Public Clinic	144	46.7 (38.0–55.5)	7.7 (5.9–9.9)	119	53.3 (44.5–62.0)	6.7 (5.2–8.5)	263	100	7.1 (5.9–8.5)
Child and Youth Dental Clinic	138	60.4 (50.9–69.2)	7.2 (5.5–9.3)	88	39.6 (30.8–49.1)	3.4 (2.6–4.6)	226	100	5.0 (4.1–6.2)
Private General Dentist	166	38.1 (29.7–47.1)	10.2 (7.9–13.1)	237	61.9 (52.9–70.3)	12.3 (10.2–14.6)	403	100	11.4 (9.8–13.2)
Private Specialist	1378	40.7 (36.5–44.9)	75.2 (71.6–78.6)	1683	59.3 (55.1–63.5)	80.6 (77.6–83.3)	3061	100	78.3 (75.9–80.6)

* The denominator includes children who have visited an orthodontist.

The categories are not mutually exclusive, as children can have multiple types of visits by different providers.

App., Appliance; Col %, column percentage; CI, confidence interval; Cons., Consultation; Exo, Extraction; Fix., Fixed; App; Row % = row percentage; Rem., Removable.

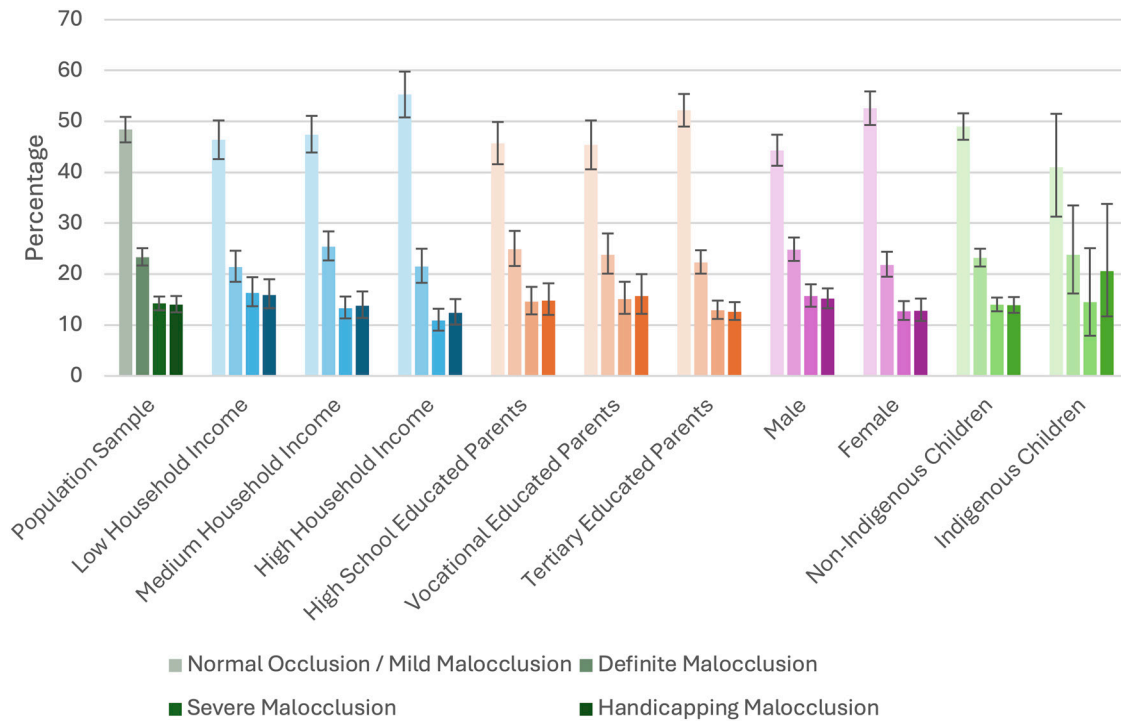


Figure 1. Prevalence of malocclusion by sociodemographic characteristics.

Prevalence of orthodontic visit by sociodemographic characteristics and malocclusion severity

Figure 2 presents the prevalence of orthodontic attendance according to malocclusion severity and sociodemographic characteristics. In addition, the distributions of sociodemographic characteristics by malocclusion severity and orthodontic attendance are presented in Appendices VII-X.

Of those with milder malocclusions, 30.9% had visited an orthodontist. There were significant disparities in the levels of orthodontic attendance between males (23.1%) versus females (38.2%), indigenous children (10%) versus non-indigenous children (31.5%), children from low-income households (18.2%) versus children from higher-income households (42.6%), and children whose parents' highest level of education was at high school (22.7%) versus children whose parents had a tertiary level education (37.4%).

Of children with more severe malocclusions, 38.1% had accessed treatment. In this category, the levels of orthodontic attendance were relatively lower in males (33.3%) versus females (43.8%), children from lower income households (28.8%) versus higher income

households (50.5%), and children whose parents' highest level of education was high school (28.3%) versus vocational (44.4%) or tertiary (41.3%).

Discussion

The present study appears to be the first nationwide survey conducted to examine the orthodontic status of children and access to orthodontic services in Australia. The findings provide valuable information regarding the sociodemographic characteristics of the child orthodontic population and patterns of orthodontic treatment provision. It also explored the relationship between orthodontic treatment need and the prevalence of orthodontic attendance by sociodemographic characteristics and malocclusion severity.

The findings indicated that adolescents, children from higher income households, children with tertiary-level educated parents, and those with handicapping malocclusions were more likely to visit an orthodontist, which supports previous literature. Adolescence is when most people seek orthodontic treatment.^{6,14–22} This may be due to the recent establishment of the permanent dentition,²³ treatment taking advantage of growth,²⁴ and

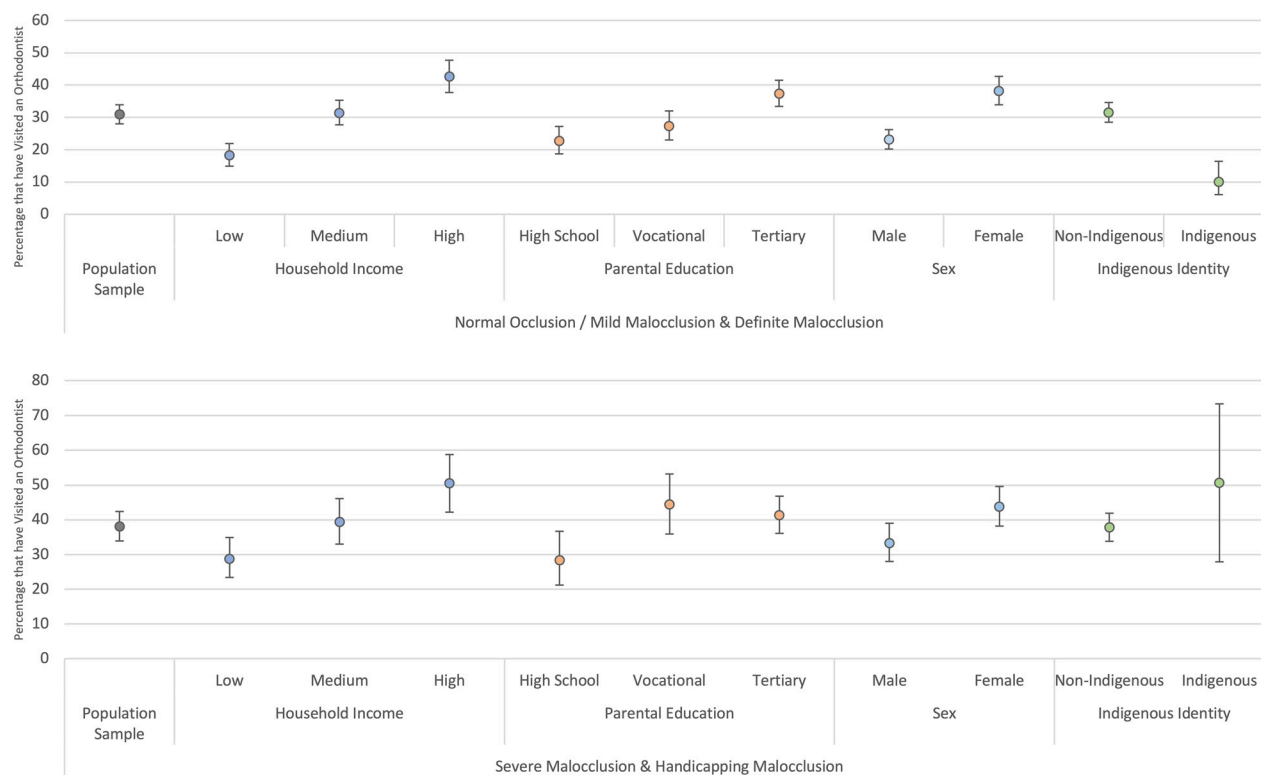


Figure 2. Prevalence of orthodontic visits by sociodemographic characteristics and malocclusion severity.

possibly the social norm of having treatment at this time in life. Those with higher incomes, greater socioeconomic status, and affluence were more likely to access treatment, whilst those with lower incomes were less likely.^{4,6,7,16,22,25-31} This may be because those with the financial means to access treatment were more likely to seek care regardless of the level of objective treatment need. Those of higher education backgrounds tend to access orthodontic services more commonly.^{6,19,20,26,28} This association may be related to higher income and/or an increased awareness of orthodontic problems and services. Females seek orthodontic treatment to a greater extent compared to males across the different age groups, time periods, and countries.^{2,4,6,14-17,19,20,22,27,28,30-34} This difference between the genders may be due to differing self-perceived or parentally perceived aesthetics, treatment need or differing societal demands.³³

The current study revealed that pre-adolescent children mainly attended for a consultation only, were predominantly treated using removable appliances, compared to adolescents who were mostly treated using fixed appliances. Furthermore, private specialists and orthodontists provided most

treatment. The methodological differences between previous Australian state-based studies make direct comparison challenging.^{2,3} However, there appears to have been relatively little change when assessing treatment providers. In South Australia, Allister et al. found in the late 1980s that specialist orthodontists had provided most fixed orthodontic treatment.² Furthermore, in NSW, Sivanewaran and Darendeliler found that specialist orthodontists provided 80% of all treatment and 91% of fixed appliance treatment.³ These figures are similar to the findings of the present study, in which private specialists and orthodontists remained the providers of fixed appliances (91.4%) and all treatment at approximately 80%.

The reported frequency of orthodontic extractions in the present study was 31.0% overall and 33.8% in conjunction with fixed appliance treatment in children aged 12 to 14 years. This is comparable to extraction rates reported elsewhere which range from 15% to 45.8% and is reflective of the changes in extraction rates over the past three decades.^{5,35-38} However, these data must be interpreted with caution as there is reliance on parents correctly

understanding and recalling what was meant by 'orthodontic extractions'. A recent 2022 Australian survey by Meade and Dreyer found the frequency of extractions in Class I malocclusions with moderate crowding for all ages was just over 20%.³⁹ The decrease in extraction frequency was attributed, in part, to increased interproximal reduction and arch lengthening procedures. Care is also advised as the survey finding was based on respondent estimates, and not a scientific evaluation of orthodontic extraction practices.

The distribution of malocclusion severity found in the present study was comparable to that of the original benchmarks from the National Centre of Health Statistics used to create the malocclusion severity categories of the DAI.^{11,12} Of children between the ages of 12 to 14 years, 48.4% had a normal occlusion or mild malocclusion, 23.3% had a definite malocclusion, 14.2% had a severe malocclusion, and 14.0% had a handicapping malocclusion.

Although the present study found higher levels of severe and handicapping malocclusions in males, indigenous children, and children from lower income households, this should be interpreted with caution due to overlapping CIs. A similar finding was seen in the UK, where two studies found that those of lower income or socioeconomic background had higher levels of treatment need.^{4,5} Potential explanations are that those from lower income households are less able to afford treatment or children from lower income households have higher levels of dental disease (early loss of primary teeth can lead to crowding or impactions of permanent teeth due to space loss).⁴⁰

The findings of the present study indicated that those with very severe malocclusions were more likely to receive orthodontic treatment (46.6%), which corresponded with previous studies.^{18,20,29,31,34} However, an increase in the severity of malocclusion did not necessarily mean a child was more likely to access orthodontic services, as those with a normal occlusion or a mild malocclusion (33.0%) were more likely to have visited an orthodontist than those with a definite malocclusion (26.3%) and a severe malocclusion (29.4%). This suggested that the severity of a malocclusion was only a consideration when accessing orthodontic services in the most severe cases, with other factors driving the decision to seek treatment in those with mild and moderate malocclusions. Possible reasons why a substantial

proportion of those with severe malocclusions (70.6%) and why even more than half of those with handicapping malocclusions (53.4%) have not accessed orthodontic services include: children or parents not perceiving any aesthetic, functional, or health problems that would call for treatment,⁴¹ or parents not being able to afford or access treatment for their children.⁴²

Disparities persist when examining access to orthodontic services in relation to malocclusion severity. Children from lower income households and males access treatment less compared to children from higher income households, females, and those with greater malocclusion severity. The disparities are further increased as a higher proportion of both of these groups were found to have severe and handicapping malocclusions. The findings highlight the importance of ensuring public dental services identify and reach those from disadvantaged groups with severe malocclusions. A notable difference when comparing the prevalence of orthodontic attendance between children with lower and higher malocclusion severities, was that, although indigenous children possessing a lower malocclusion severity appeared less likely to have access to treatment (10.1%), those with a higher malocclusion severity potentially had the highest level of access to treatment (50.7%) compared to other sociodemographic groups. This finding suggests that government programs may have their intended effect in increasing access to treatment for indigenous children with high treatment need.⁴³

Given the evident shortfall in access to treatment in certain sociodemographic groups for those with more severe malocclusions, the current framework of orthodontic service provision clearly has shortcomings. There are a number of possible pathways to increase access for those with greater treatment need. However, existing services in the public sector need to judiciously prioritise those with the greatest treatment need, and a further step would be the expansion of existing services. In the private sector, increased access can possibly be achieved by increasing the supply of available treatment providers and the encouragement of pro bono work. However, decisions should be tempered with the awareness that, for most people, orthodontic treatment is an elective procedure, which may have psychosocial and aesthetic benefits, but is unlikely to have a significant benefit towards oral health.^{44,45}

As with all studies, there are several potential limitations. Response bias is a risk in surveys as the information gathered in the questionnaire relies on parents correctly understanding the questions and providing accurate responses. Furthermore, possible changes may have occurred in the past decade since data collection, and comparison with other studies is difficult due to differing methodologies. However, this was the first Australian national-level survey of its kind, and provides valuable information to healthcare planners, dental educators, and health funds. It also establishes baseline data for future comparisons within Australia and abroad. A second NCOHS, with a review of some of the children from the first study is planned. In addition, the population sample only extended up to 14 years of age. Further research is required to investigate the patterns and characteristics of orthodontic treatment of older children. Further research is also required to investigate the associations that sociodemographic characteristics may have with malocclusion severity and access to orthodontic treatment, as explanations of these associations are presently speculation. The use of the DAI to assess malocclusion severity also has its limitations. The weightings of the malocclusion traits and the malocclusion categories may no longer be applicable to contemporary aesthetic standards. However, all malocclusion indices have their shortcomings and the use of a widely applied index such as the DAI allows easier comparison between studies. Future surveys that seek to update the orthodontic 'landscape' could explore additional areas to provide more information. Possibilities are the inclusion of clear aligners as a mode of treatment, extending the upper age limit of children, and including another index to assess treatment need, such as the Index of Orthodontic Treatment Need.^{46,47}

Conclusions

The present study provides important baseline information on orthodontic service provision in Australia. The major findings were that sociodemographic disparities in malocclusion severity and access to orthodontic services were observed and that increased malocclusion severity did not necessarily translate to increased access to orthodontic services. Given the shortfall in access to treatment for those with more severe malocclusions, efforts should be made to identify children with more

severe malocclusions and to ensure that they have appropriate pathways to seek treatment.

Conflicts of interest

The authors declare that there is no conflict of interest.

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Appendix I Type of orthodontic treatment, by treatment provider, among children in Australia 2012-14

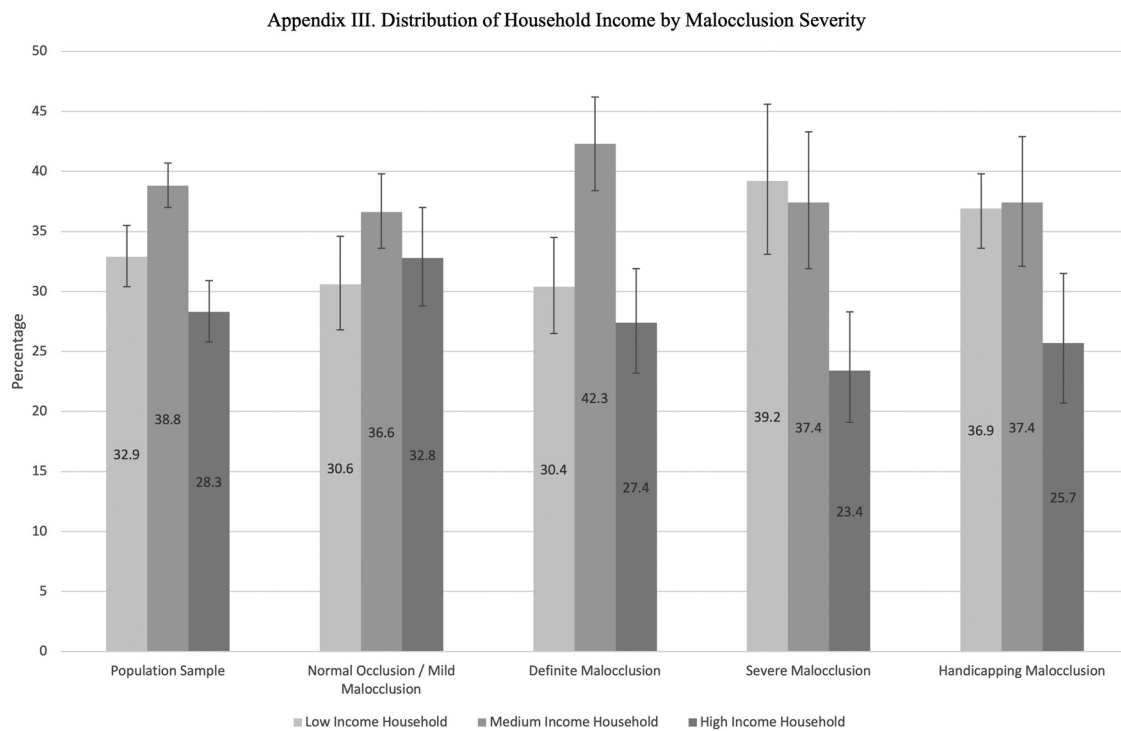
Treatment provider*	Type of treatment											
	Consultation only			Removable appliance			Fixed appliance			Extractions		
	N	row % (95%CI)	col% (95%CI)	N	row % (95%CI)	col% (95%CI)	N	row % (95%CI)	col% (95%CI)	N	row % (95%CI)	col% (95%CI)
All participants												
Public Clinic	114	38.2 (30.4-46.6)	7.1 (5.4-9.1)	70	28.2 (20.6-37.2)	7.4 (5.2-10.3)	35	17.2 (11.3-25.4)	4.3 (2.8-6.7)	98	39.1 (31.0-47.9)	12.5 (9.4-16.3)
Child and Youth Dental Clinic	111	44.9 (36.5-53.5)	5.7 (4.4-7.4)	51	22.6 (16.0-31.0)	4.1 (2.8-5.9)	31	14.0 (9.5-20.1)	2.4 (1.6-3.7)	69	34.5 (26.2-43.9)	7.6 (5.4-10.5)
Private General Dentist	152	33.9 (26.9-41.8)	9.7 (7.6-12.4)	136	34.5 (27.9-41.8)	14.0 (11.1-17.5)	122	30.8 (24.7-37.8)	12.0 (9.2-15.5)	156	34.7 (27.8-42.3)	17.1 (13.5-21.5)
Private Specialist	1437	42.1 (39.1-45.1)	82.5 (79.2-85.3)	852	31.2 (28.5-33.9)	86.4 (82.7-89.4)	923	34.3 (31.7-37.0)	91.4 (88.1-93.9)	697	23.8 (21.6-26.2)	80.5 (75.7-84.5)
5 to 11 years old												
Public Clinic	61	28.8 (20.4-39.0)	5.0 (3.6-7.0)	36	31.0 (20.7-43.6)	10.0 (6.4-15.4)	13	18.0 (9.4-31.8)	8.3 (4.0-16.3)	52	39.7 (28.6-51.9)	17.6 (12.3-24.5)
Child and Youth Dental Clinic	77	49.2 (37.8-60.7)	7.7 (5.6-10.5)	21	19.8 (11.6-31.6)	5.7 (3.2-9.7)	12	10.9 (5.9-19.4)	4.5 (2.3-8.4)	35	29.2 (18.7-42.5)	11.5 (7.0-18.4)
Private General Dentist	71	33.3 (22.8-45.7)	7.4 (5.3-10.1)	53	34.5 (25.8-44.4)	14.1 (9.4-20.6)	25	19.1 (10.9-31.2)	11.1 (5.6-21.0)	62	35.5 (26.1-46.2)	19.9 (13.7-28.0)
Private Specialist	785	51.9 (47.3-56.5)	83.8 (79.5-87.3)	340	27.9 (24.0-32.1)	83.0 (77.0-87.8)	226	21.3 (17.8-25.2)	90.2 (82.5-94.8)	248	17.5 (14.9-20.5)	71.8 (62.2-79.7)
12 to 14 years old												
Public Clinic	53	46.3 (34.9-58.1)	9.0 (6.3-12.6)	34	25.7 (16.4-38.0)	5.8 (3.6-9.1)	22	16.5 (9.5-27.0)	3.0 (1.7-5.1)	46	38.7 (27.9-50.7)	9.9 (6.6-14.5)
Child and Youth Dental Clinic	34	38.2 (25.9-52.3)	3.8 (2.4-5.9)	30	26.9 (17.5-39.0)	3.1 (2.0-4.7)	19	18.6 (10.9-29.9)	1.7 (1.0-2.9)	34	42.7 (30.0-56.4)	5.6 (3.7-8.3)
Private General Dentist	81	34.4 (25.3-44.8)	12.0 (8.6-16.6)	83	34.6 (25.3-45.2)	14.0 (10.5-18.4)	97	38.0 (29.3-47.6)	12.3 (9.3-16.1)	94	34.2 (24.8-44.9)	15.7 (11.6-21.1)
Private Specialist	652	35.4 (31.9-39.0)	81.1 (76.0-85.3)	512	33.4 (30.2-36.9)	88.4 (83.8-91.9)	697	43.3 (40.0-46.5)	91.8 (87.9-94.6)	449	28.1 (25.0-31.5)	84.8 (80.0-88.7)

*The denominator includes children who have visited an orthodontist. The categories are not mutually exclusive, as children can receive multiple treatment types from different providers. Row %, row percentage; Col %, column percentage; CI, confidence interval.

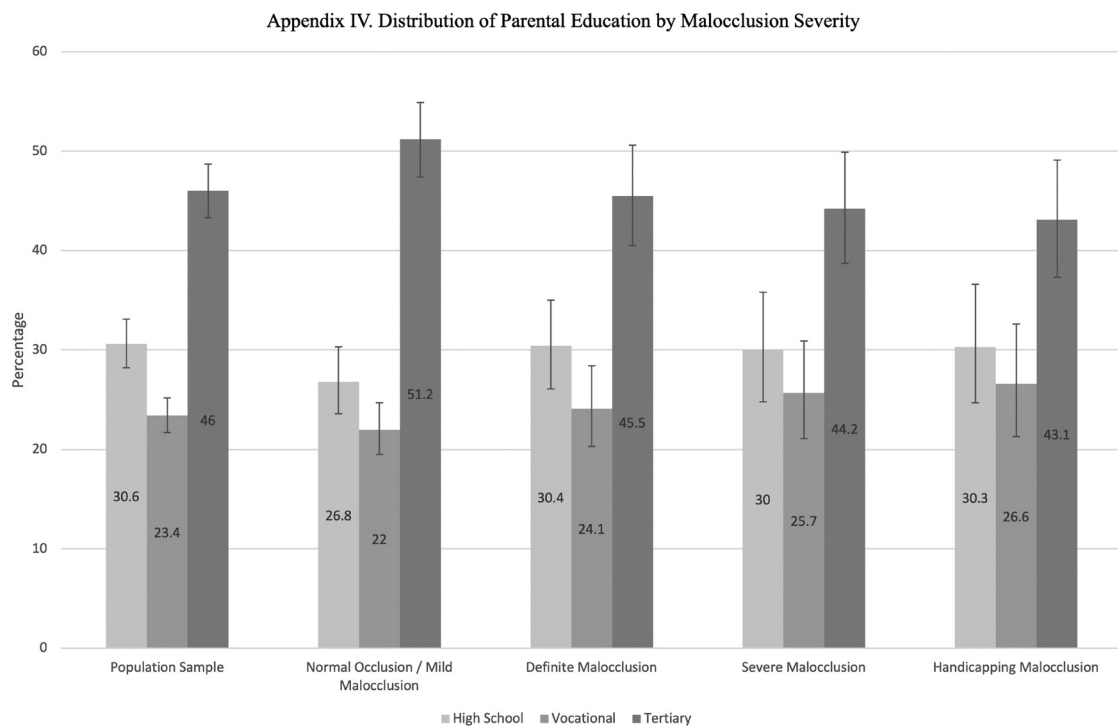
Appendix II Prevalence of planned extractions with appliances, by age, among children in Australia 2012-14

Age groups																		Total	
Age 5-11 Years										Age 12-14 Years									
Appliance used										Appliance used									
Removable appliance					Fixed appliance					Removable appliance				Fixed appliance				Total	
N	col% (95%CI)	N	col% (95%CI)		N	col% (95%CI)	N	col% (95%CI)		N	col% (95%CI)	N	col% (95%CI)		N	col% (95%CI)	N	col% (95%CI)	
Planned extractions																			
Yes	82	17.1 (13.0-22.1)	66	22.6 (17.0-29.4)	324	1.8 (1.6-2.2)	177	30.4 (25.3-35.9)	262	33.8 (29.3-38.6)	527	8.3 (7.3-9.4)	259	25.3 (21.8-29.3)	328	31.0 (27.3-34.9)	851	3.8 (3.4-4.3)	
No	328	82.9 (77.9-87.0)	181	77.4 (70.6-83.0)	16992	98.2 (97.8-98.4)	404	69.6 (64.1-74.7)	489	66.2 (61.4-70.7)	5740	91.7 (90.6-92.7)	732	74.7 (70.7-78.2)	670	69.0 (65.1-72.7)	22732	96.2 (95.7-96.6)	
Total	410	100	247	100	17316	100	581	100	751	100	6267	100	991	100	998	100	23583	100	

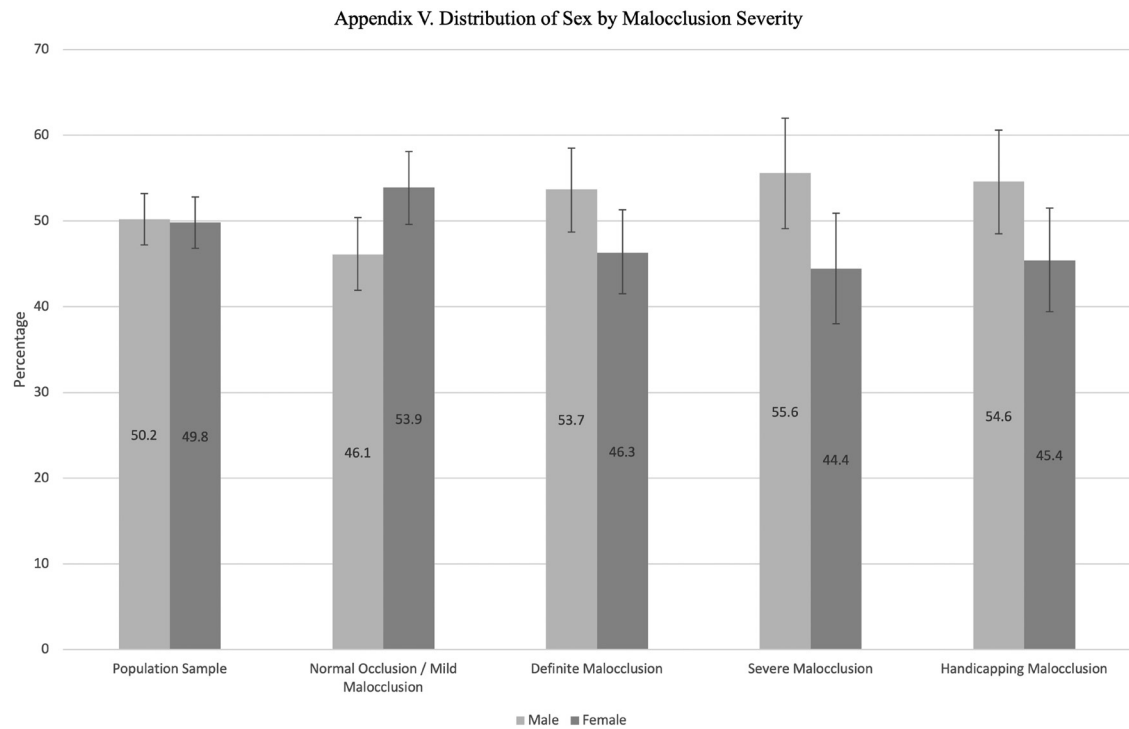
Appendix III Distribution of Household Income by Malocclusion Severity



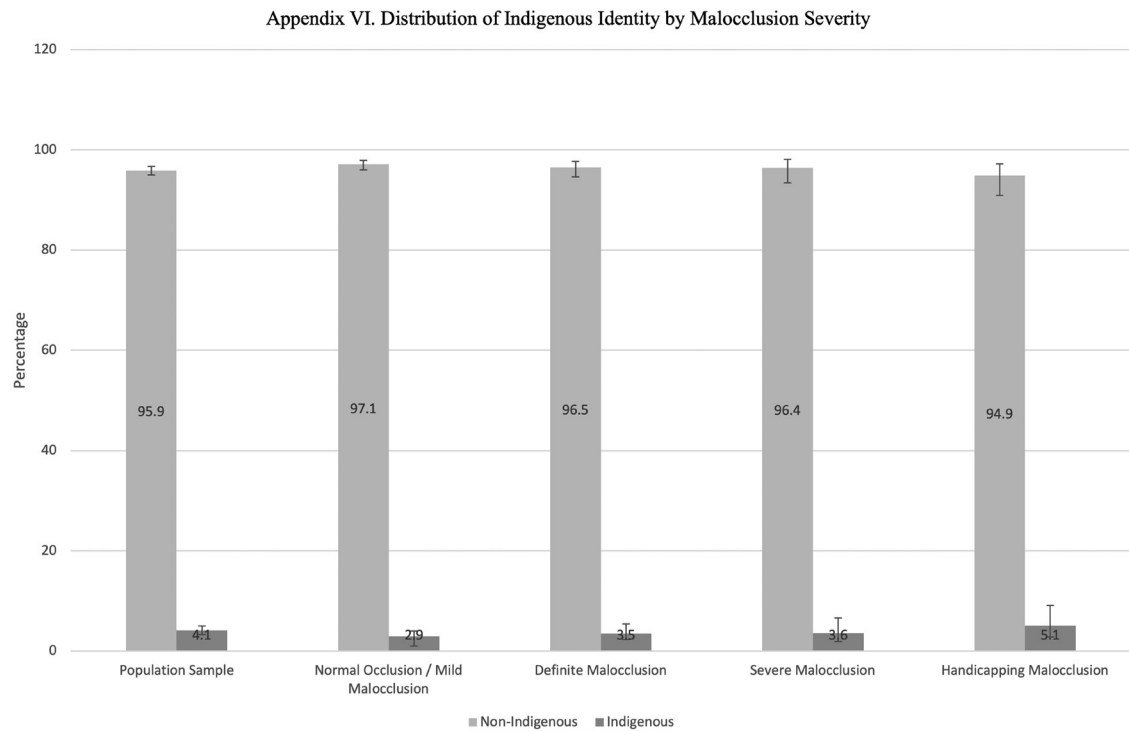
Appendix IV Distribution of Parental Education by Malocclusion Severity



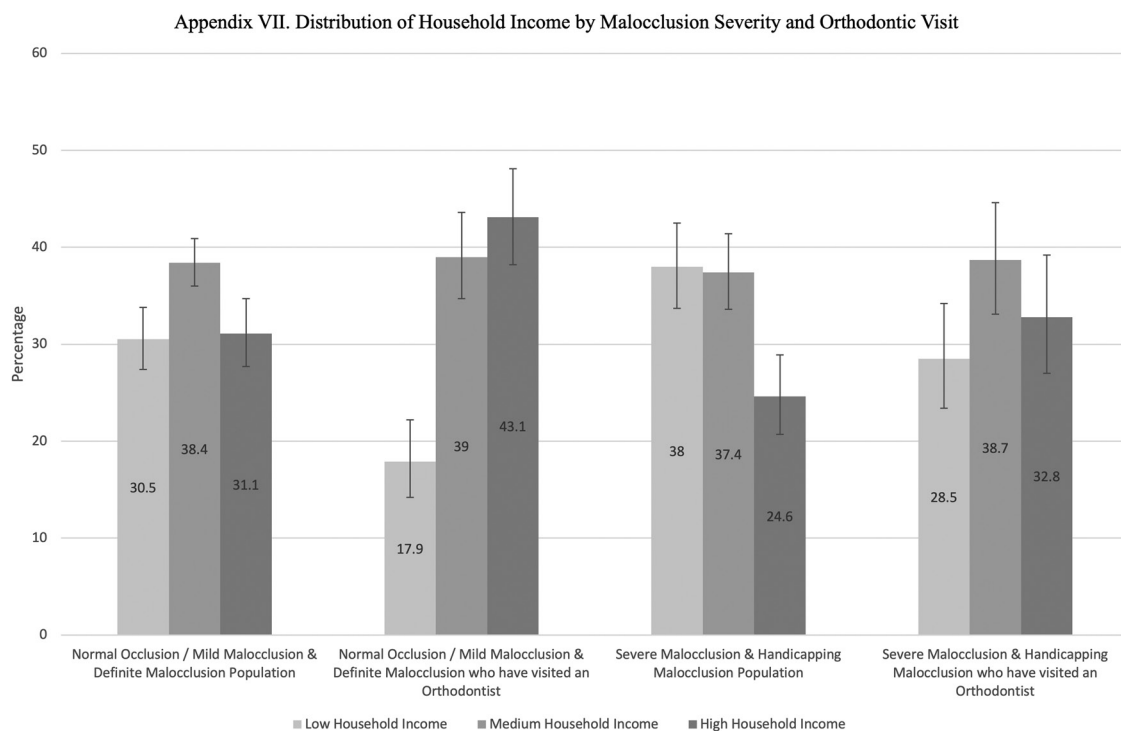
Appendix V Distribution of Sex by Malocclusion Severity



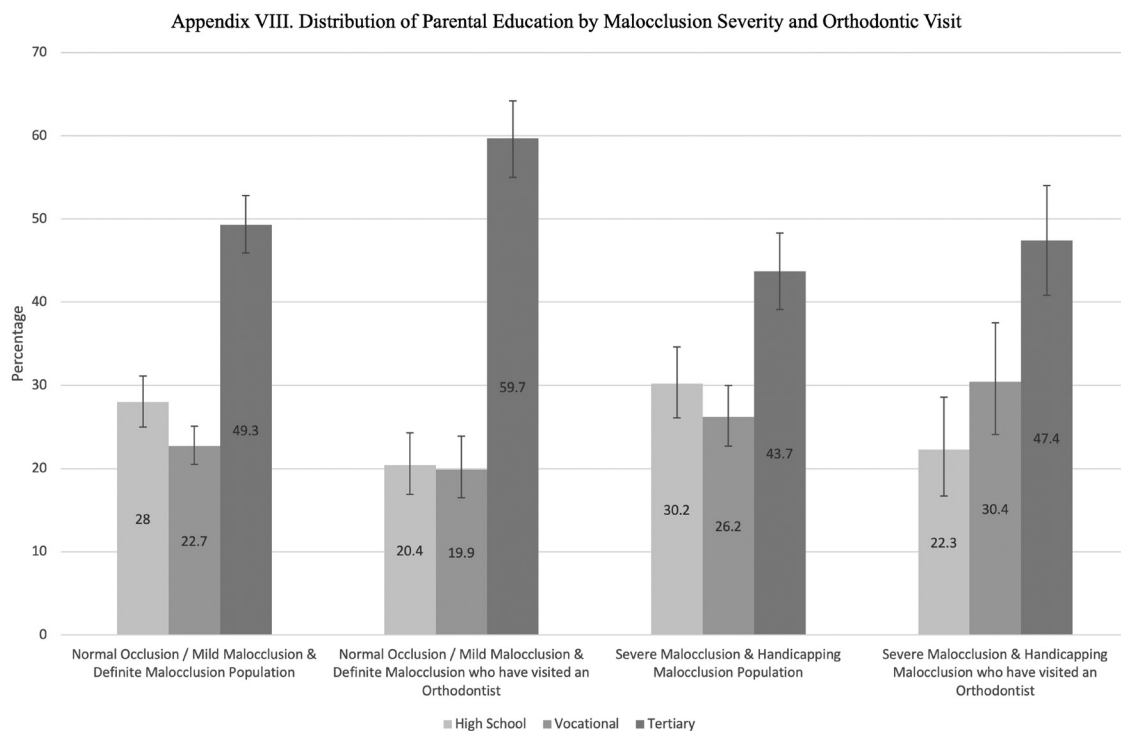
Appendix VI Distribution of indigenous Identity by Malocclusion Severity



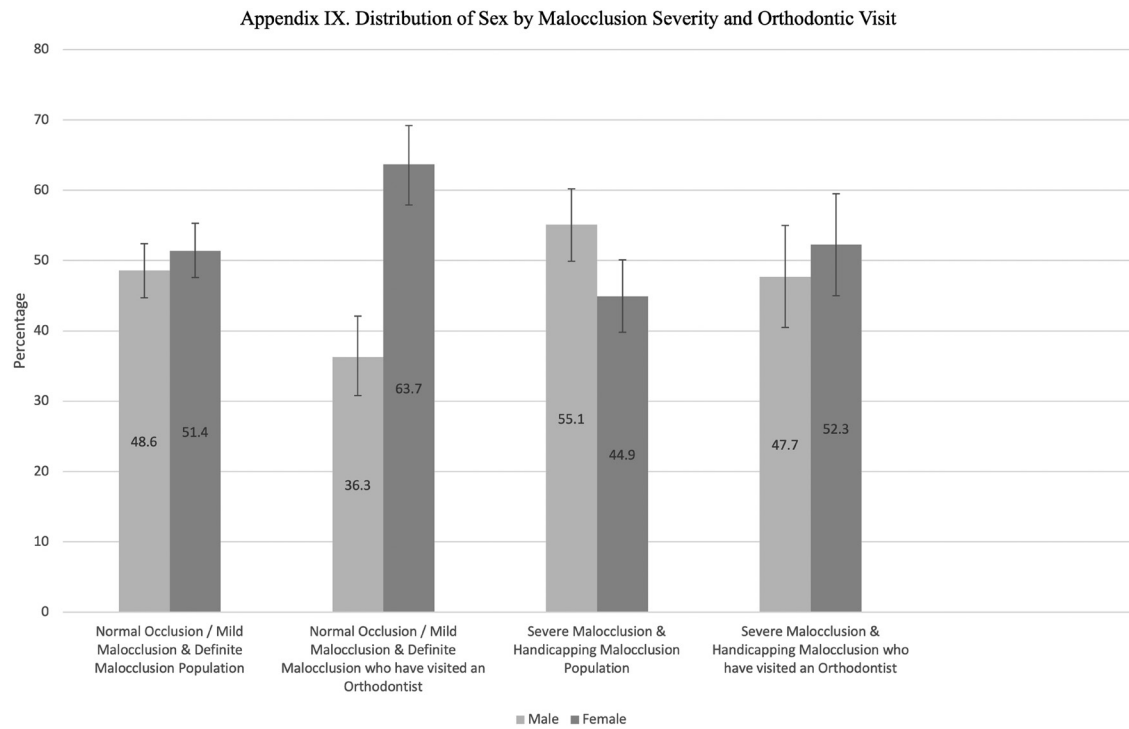
Appendix VII Distribution of Household by Malocclusion and Orthodontic Visit



Appendix VIII Distribution of Parental Education by Malocclusion Severity and Orthodontic Visit



Appendix IX Distribution of Sex by Malocclusion Severity and Orthodontic Visit



Appendix X Distribution of indigenous Identity by Malocclusion Severity and Orthodontic Visit

