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How do age and tooth loss affect oral health impacts and quality of life? A study comparing two national samples

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Abstract – Age and loss of teeth can be expected to have a complex relationship with oral health-related quality of life. This study aimed to explain how age and tooth loss affect the impact of oral health on daily living using the short form, 14-item Oral Health Impact Profile (OHIP-14) on national population samples of dentate adults from the UK (1998 UK Adult Dental Health Survey) and Australia (1999 National Dental Telephone Interview Survey). After correcting for key covariables, increasing age was associated with better mean impact scores in both populations. Those aged 30–49 years in Australia showed the worst (highest) scores. In the UK, those aged under 30 showed the highest scores. In both countries, adults aged 70+ showed much better scores than the rest ($P < 0.001$). When corrected for age, the independent effect of tooth loss was that the worst scores were found where there were fewer than 17 natural teeth in the UK and fewer than 21 teeth in Australia. People with 25 or more teeth averaged much better scores than all other groups ($P < 0.001$), although there were differences in pattern between countries. When Australians were analysed by region of birth, the pattern of scores by tooth loss for British/Irish immigrants was strikingly similar to that for the UK sample. First-generation immigrants from elsewhere showed much worse overall scores and a profoundly different pattern to the Australian- and British-born groups. Age, number of teeth and cultural background are important variables influencing oral health-related quality of life.

Key words: age distribution; cross-cultural comparison; dental health surveys; oral health; quality of life

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As people age, they remain susceptible to new and repeated episodes of oral disease. The accumulated history of disease can affect their quality of life and may lead to other oral conditions, such as tooth loss, which have an impact on day-to-day activities. This may happen as a direct result of altered function resulting from tooth loss, but possibly also as a result of changes in perceptions and values that occur with increasing age. A number of other factors may modify this process, for example, the social and cultural norms and socio-political events to which populations are exposed; these may differentially shape behaviours and perceptions of health for entire birth cohorts. Quality of life is affected in some way by oral health in the majority of people (1), so understanding the relationship between age-related, dental and cultural influences on quality of life has relevance if we wish to measure oral health inequalities within and between populations. At an individual level, an understanding of how age and tooth retention affect the impact of oral health on daily activities may inform the delivery of appropriate oral health services.

One concept that has received particular attention when setting health targets is that of a 'minimum threshold' for the number of teeth, below which oral function and health diminish rapidly. Such concepts originally arose with the work of Agerberg & Carlsson (2) and Kayser (3) two decades ago. Subsequent population-based oral health studies have frequently referred to the presence of a minimum of 20 teeth, or sometimes a certain number of contacting posterior pairs of teeth, as a simple way of defining 'satisfactory' oral health. In some cases, these have been enshrined into formal targets or policy (4, 5). At a functional and dietary level, there is now some scientific evidence to support this concept (6–8), but the relationship between the number of natural teeth and adverse impacts of oral health is not clear.

The Oral Health Impact Profile (OHIP) is one of a number of self-reported measurements of the adverse impacts of oral conditions on daily life. The original 49-item questionnaire (9) has been used in cross-sectional epidemiological studies of older adults in Australia, Canada and the US, where there was a linear relationship between the number of missing teeth and the number of impacts reported fairly often or very often (10). Longitudinal follow-up of Australian subjects from the study revealed an increase in the number of impacts among people who experienced incident tooth loss during the 2 years, but effectively no change among people who did not experience incident tooth loss (11). The subsequent development of a shortened questionnaire comprising of 14 items (OHIP-14; 12) allowed the use of a validated index of the impact of oral health in large surveys. Recently, the OHIP-14 has been used in national surveys of population samples from UK (13) and Australia (14).

This paper aims to explain how age and tooth loss relate to the impact of oral health on everyday life in two populations. We also aimed to evaluate whether the cultural variations associated with country of birth had any influence on the relationship between tooth loss and oral health-related quality of life.

Materials and methods

Data reported in this paper come from two sources: the 1998 UK Adult Dental Health Survey and the mail survey sent to adult interviewees in the Australian National Dental Telephone Survey. This analysis is restricted to dentate participants from each of the two samples.

The UK Adult Dental Health Survey used a stratified random sample of adults aged 16 years and over living in the UK. A full report, including detailed sampling strategy and response, has been published (13). Briefly, 74% of all eligible households agreed to take part, and 92% of the 6764 adults in these households completed an interview that included the OHIP-14 scale. In total, 3817 of the 5281 interviewed dentate adults (72.3%) were also clinically examined.

The Australian sample comprised of adult interviewees in the 1999 National Dental Telephone Interview Survey, who completed the follow-up Dental Health and Lifestyle Factors (DHALF) mail survey that included the OHIP-14 scale. A stratified random sampling design was used in which approximately equal numbers of subjects were sampled from 13 geographically defined strata. The sampling frame was the electronic white pages from which residential households were identified, and one person aged 5 years or more was sampled at random from each residential household. From an original sample of 13 832 eligible phone numbers, 7829 people completed interviews (56.6%). Of these, 6152 were eligible for the postal follow-up questionnaire and 3973 individuals responded (64.6%). Small differences in response rates were present for sex, age group, education, geography and home language. Non-response was slightly higher among males (38%) than among females (34%), and among adults younger than 30 years (45%) and those aged 70+ (41%), compared with adults aged 30–69 years (32%). Non-response was also higher among those without postsecondary school education (40%) than among those with further education (33%), and among capital-city dwellers (38%) compared with their noncapital city counterparts (34%). Of note, however, differences based on country of birth (Australia or other) were not statistically significant.

All dentate subjects in both surveys were asked to complete the OHIP-14 questionnaire (12). The questionnaire asked about the frequency with which oral conditions had an impact on 14 aspects of daily life. For example, subjects were asked, 'how often during the past year have you had painful aching in your mouth because of problems with your teeth, mouth or dentures'. Respondents answered on a 5-point ordinal scale, ranging from 'very often' to 'never'. In the UK, the questionnaire was administered by a trained interviewer, whereas in Australia, it was self-completed. For this analysis, ordinal responses were coded 0 for 'never' through to 4 for 'very often', and all 14 ordinal responses were summed to produce an overall OHIP score that could range from 0 to 56, with higher scores indicating poorer oral health-related quality of life. In the small proportion of cases where responses were missing, or the response was marked 'don't know' (UK only), the sample mean for that response was substituted when computing an individual's overall OHIP score. However, subjects were omitted from data analysis when more than two questions were not answered, were missing or marked 'don't know'.

Evaluation of our first aim began with univariate analysis of OHIP scores and other selected variables in each country, followed by bivariate comparisons of the summed OHIP scores and the key variables: age and number of remaining teeth. Additional covariates were sex, denture wearing (partial or complete) and sampling stratum. For each population, a multivariate ANOVA model was then constructed using the OHIP scores as a dependent variable, and including the key variables and covariates that had statistically significant bivariate relationships with OHIP scores. Next, we assessed whether the effect of the number of natural teeth differed among age groups by testing for a statistical interaction between age and number of teeth. For pair-wise comparisons among all possible subgroups of age and tooth loss, we used Scheffe's post hoc test to adjust for multiple comparisons. Unweighted data were used in all analyses, because our primary interest was to contrast associations between age, tooth loss and OHIP scores between subjects in two distinct populations, rather than generating population estimates (which we have done in a separate paper).

Our second aim was addressed using the Australian data in which the respondent's country of birth was also collected. We categorised subjects into three categories on the basis of country of birth: Australia, UK/Ireland or other. We then added to the multivariate ANOVA model for Australia, an interaction between country of birth and number of remaining teeth, and generated adjusted mean OHIP scores for each combination of country of birth and tooth loss to examine the extent to which the relationship between tooth loss and OHIP scores was consistent among the three categories according to place of birth.

Because of our interest in combined effects of age and tooth loss, we restricted our analysis to subgroups, comprising at least 10 subjects within each cross-classification of four age groups and five tooth-loss groups (see Table 1 for group definitions). To achieve the minimum number of 10 subjects per cross-classified group, we eliminated nine UK and two Australian subjects aged less than 30 years (all with less than 21 teeth) from our analyses. Following removal of edentulous cases and those with any missing data for key variables, there were data from 3406 dentate subjects in Australia and 3662 dentate subjects in the UK.

Table 1. Demographic characteristics of dentate subjects in each country

	Percentage of adults	
	Australia ($n = 3406$)	UK ($n = 3662$)
Sex		
Male	41.4	45.7
Age group (years)		
<30	15.4	19.7
30–49	40.7	44.5
50–69	33.6	28.3
70+	10.4	7.4
Remaining teeth		
1–8	5.1	4.5
9–16	8.1	7.0
17–20	5.2	8.3
21–24	14.1	17.0
25–32	67.5	63.0
Country of birth		
Australia/NZ/Oceania	80.6	Not available
Ireland/UK	10.5	Not available
Other	8.9	Not available

Results

Table 1 shows the demographic data for subjects in the two countries. There were small differences between countries that reflect differences in the underlying demography of the countries and the sampling strategies.

Higher OHIP scores indicate worse, and lower OHIP scores indicate better oral health-related quality of life. OHIP scores were worse in Australia than in the UK (Table 2), even after adjusting for the effects of age and tooth loss. However, data from both countries show a general trend towards better OHIP scores with increasing age, and worse OHIP scores with a reducing number of teeth.

In the multivariate ANOVA model (Table 3), age and tooth loss were both independently associated with the summed OHIP score in both countries ($P < 0.001$), as was denture wearing ($P < 0.001$ in Australia, $P < 0.003$ in UK). Sex and sampling stratum were marginally significant or nonsignificant. Although not shown in Table 3, the interaction between age and number of teeth was statistically nonsignificant in both Australia ($P = 0.12$) and the

Table 2. Unadjusted mean summed OHIP scores by demographic variables

	Mean OHIP score (SE)	
	Australia ($n = 3406$)	UK ($n = 3662$)
All	7.4 (0.13)	5.1 (0.11)
Sex		
Male	7.3 (0.20)	4.9 (0.14)
Female	7.5 (0.17)	5.3 (0.15)
Age group (years)		
<30	7.1 (0.32)	5.7 (0.26)
30–49	7.9 (0.21)	5.5 (0.16)
50–69	7.5 (0.23)	4.7 (0.19)
70+	6.0 (0.36)	3.3 (0.34)
Remaining teeth		
1–8	10.0 (0.71)	6.6 (0.68)
9–16	9.2 (0.54)	6.9 (0.52)
17–20	9.4 (0.72)	5.1 (0.39)
21–24	8.3 (0.37)	5.0 (0.26)
25–32	6.7 (0.14)	4.9 (0.12)
Country/region of birth (Australia)		
Australia/NZ/Oceania	7.3 (0.14)	Not available
Ireland/UK	6.9 (0.37)	Not available
Other	9.4 (0.54)	Not available

UK ($P = 0.30$). The low overall R^2 values reflect the many influences on oral health-related quality of life, and also the grouping of age and number of teeth variables.

Within each country, there was a similar relationship between age and adjusted mean OHIP scores obtained from the ANOVA model in Table 3. When mean scores were adjusted for the effect of the number of teeth and the other key covariables (see Fig. 1), subjects aged less than 30 years or 30–49 years had similarly high OHIP scores, indicating poorer oral health-related quality of life, and there was a sharp improvement in OHIP scores for the two older age groups.

Table 3. Multivariate ANOVA model for summed OHIP scores

Explanatory variables	Australia df	Australia F	Australia P	UK df	UK F	UK P
Remaining teeth	4	19.0	<0.001	4	7.9	<0.001
Age-group	3	25.6	<0.001	3	38.5	<0.001
Sex	1	0.1	0.71	1	3.5	0.06
Denture wearing	1	15.9	<0.001	1	9.3	0.002
Area (site code)	12	2.0	0.02	3	3.3	0.02

Model data: Australia ($F = 9.2$, df = 21, 3384, $R^2 = 0.053$, $P < 0.01$); UK ($F = 14.2$, df = 12, 3649, $R^2 = 0.044$, $P < 0.01$).
The P-values indicate the significance of the relationship for these covariables with total OHIP score within the multivariate model.

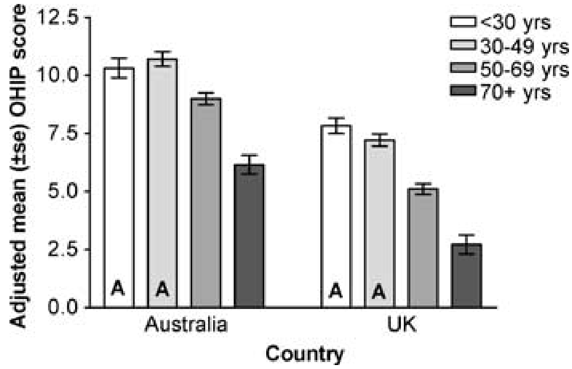

Fig. 1. Age variations in adjusted mean OHIP scores among Australian and UK subjects. Adjusted means were calculated from separate ANOVA models for each country controlling for sex, denture wearing, number of teeth and sampling strata (state/capital within Australia; country within UK). Within countries, OHIP scores differ significantly ($P < 0.05$ with Scheffe's correction) between all pairs of age groups except for those labelled with identical letters.

As expected, the model in Table 3 also revealed a general pattern of poorer adjusted mean OHIP scores as the number of remaining teeth decreased, although there were subtle differences in the pattern of the relationship between the two countries (Fig. 2). In both countries, people with 25 or more teeth had significantly better OHIP scores than all other groups. In the UK, there was a significant improvement in OHIP scores as the number of teeth increased: 9–16 to 17–20 or 21–24 teeth, and another significant improvement as the number of teeth increased from 25–32 teeth. In contrast, in Australia, there were no significant differences between the

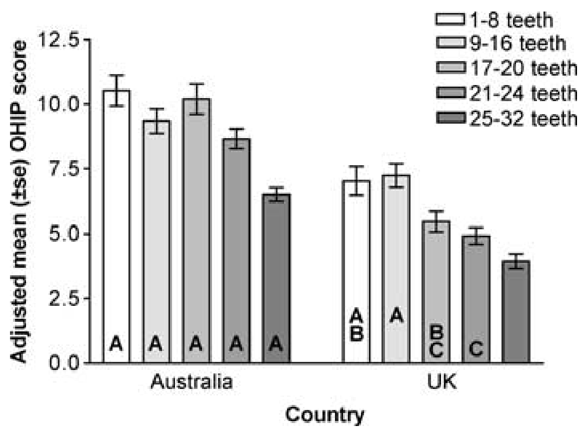

Fig. 2. Mean and SE for OHIP scores in UK and Australia according to number of teeth. Adjusted means were calculated from separate ANOVA models for each country controlling for sex, denture wearing, age and sampling strata (state/capital within Australia; country within UK). Within countries, OHIP scores differ significantly ($P < 0.05$ with Scheffe's correction) between all pairs of age groups except for those labelled with identical letters.

three groups with less than 25 teeth, with the only significant improvement observed for people retaining 25–32 teeth.

The influences on the relationship between tooth loss and OHIP scores were explored further through additional analysis of the Australian data, which were stratified into the three categories of place of birth described in Table 1. Justification for stratification was provided first by adding an interaction term between country of birth and number of teeth to the ANOVA model in Table 3, revealing a statistically significant ($P = 0.003$) interaction. Adjusted means from this model revealed subtle differences in gradients between number of teeth and adjusted OHIP scores (Fig. 3). For the numerically largest group of Australians, those born in Australia, people with 25–32 teeth had the lowest mean OHIP scores, while the four groups with less than 25 teeth did not differ consistently among one another. For Australian subjects born in the UK or Ireland, mean OHIP scores were lowest (best) for those with 25–32 teeth, and increased (got worse) monotonically for the three groups with decreasing numbers of teeth – a pattern that was strikingly similar to the results for all subjects from the UK survey (Fig. 2). The most conspicuous pattern of OHIP scores was observed for Australians born in countries other than Australia, UK or Ireland, where all four subgroups with fewer than 25 teeth had equivalent mean OHIP scores that were substantially worse than any other subgroup (Fig. 3).

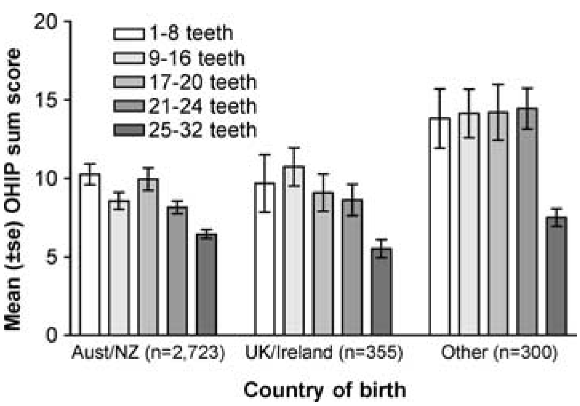

Fig. 3. Mean and SE for OHIP scores of Australians born in different regions (Australia or New Zealand, Britain and Ireland and all other regions) according to number of teeth. Adjusted means were calculated from separate ANOVA models for each country controlling for age, sex, denture wearing, number of teeth and sampling strata (state/capital within Australia; country within UK).

Discussion

This study is the first to have examined relationships between age, tooth loss and adverse impacts of oral conditions among adults of all ages in the two national samples. As expected, the number of remaining natural teeth played a central role as a determinant of subjective oral health. There was also an unexpected but independent inverse relationship between age and adverse impacts on oral health. Furthermore, in Australia, the relationship between tooth loss and adverse impacts on oral health appears to be modified by cultural factors, as represented by place of birth.

The data reported here are derived from national surveys of oral health based on random samples of the respective populations. Further details of the sampling and the characteristics of the final samples can be found elsewhere (13, 14). Both samples were stratified by age, sex and geography, and weights to adjust for the stratified sampling are available for use. Our analyses were conducted without the use of sampling weights and, instead, we used sampling stratum as a covariate in analyses. Although not reported, in separate weighted analyses, we found that associations between OHIP scores, age and tooth loss were very similar to the results reported here. We elected to present unweighted results so that our analysis of country of birth, using the Australian data, would not be affected by geographic regional factors that are known to be associated with patterns of immigration and which were the main factors influencing sampling weights. We have no reason to believe that the association between tooth loss and OHIP scores in each country would be biased within these randomly selected subjects from both the UK and Australia, and the analysis provides a valid contrast of associations between the UK and Australia.

OHIP has now been used in a number of age and cultural contexts to measure oral health-related quality of life (10, 11). The way in which the OHIP-14 questionnaire was administered differed slightly between the two surveys. In the UK, statements were delivered face to face by a trained interviewer, and the response was entered by the respondent directly on to a computer, while in Australia, the questionnaire was self-administered. Although this may account for some of the differences between countries in overall OHIP scores, existing evidence suggests that the method of delivery should not have a major impact on total scores (15). Nonetheless, in view of this methodological difference, our main emphasis in this analysis has been the patterns of association within countries, rather than absolute differences in OHIP scores between countries.

The findings from this study suggest that age and tooth loss have independent effects on oral health-related quality of life. This is important if we are to develop our understanding of the key influences in health variation and how best to target scarce resources. Furthermore, it is impossible to understand the impact of tooth loss without understanding the independent effect of age, and vice versa. By using samples of two different populations, we can also start to see the importance of the country or place of birth on perceived oral health in context.

Data from both countries demonstrate that the impact of oral health problems on the quality of life reduces with increasing age, which is independent from the effect of tooth loss. Before assuming that this is an entirely age-related trend, it is important to put this observation into context. As the data are cross-sectional, it is feasible that some of these age-related effects are cohort-dependent. The current generation of older adults in both countries had the lowest scores, but in a rapidly changing health environment, may also have historically had the lowest expectations. Further studies in the same populations in future years should clarify this, but whatever the reasons, this study demonstrates that age and/or generation is a fundamental influence on oral health-related quality of life.

Data from both countries demonstrate that loss of teeth is associated with a reduction in oral health-related quality of life (the impact scores increase), independent from the effect of age. However, the relationship between increasing tooth loss and more severe impacts on oral health was not a simple, monotonic one. Instead, there appears to be a plateau in the trend, and a point is reached where fewer remaining teeth are no longer associated with worsening quality of life. For example, in the UK, mean OHIP scores were worst for people with 16 or fewer teeth. In Australia, OHIP scores were much worse for people with fewer than 25 teeth, but did not differ significantly among the subgroups with 1–8, 9–16, 17–20 or 21–24 teeth (Fig. 2). Although, the most striking finding in both groups is that people with 25 or more natural teeth had significantly better oral health-related quality of life than all other groups.

A threshold of 20 or 21 teeth has been widely used as a broad indicator of a functional dentition for some years. With such a complex and heterogeneous system as the mouth, any such figure is likely to be difficult to validate and will never be universally applicable. However, the 20–21 teeth threshold has been justified using clinical principles, and there is also empirical evidence that this threshold is associated with functional and nutritional adequacy (6–8). However, the current findings indicate that adverse impacts of oral health increase rapidly for people with fewer than 25 teeth, and that, if there is any levelling-off in the rate of increase, it occurs at a different threshold of tooth retention among different cultures. The OHIP-14 captures a range of impacts in addition to those concerned with function and nutrition, which may account for the absence of a 'critical threshold' at around 20 remaining teeth. This does not invalidate the 20-tooth minimum as a purely functional concept, but the relationship between tooth retention and quality of life appears to work on a more complex basis.

The influence of cultural factors on OHIP scores is apparent in the difference between the UK and Australia, when the pattern of scores according to number of teeth is analysed. The plateau of highest scores is reached at less than 24 teeth in Australia, but less than 17 teeth in the UK. When the number of teeth drops below 25, and certainly below 20, the chance of a person requiring a partial denture in order to function increases dramatically (13), although the position of the teeth lost is also a key factor (16). The high scores in the Australian sample at this point may partially reflect this change of status from being able to rely on natural teeth alone to being reliant on a removable prosthesis. The reduction in scores in the UK sample starts at a lower threshold (17 or more teeth), and this, combined with better scores overall, perhaps indicates a more functional approach to oral health.

These differences in the relationship between the number of teeth and OHIP in the two samples, and the possible reasons for the differences, are brought into sharp focus when the Australians were stratified by country of birth. Historically, Australia and the UK share strong ties, and until the late 1940s, most migrants to Australia were from the UK and Ireland (17). More recent migration patterns are characterised by migrants arriving from non-English speaking backgrounds, predominantly from other European countries and the regions of the Middle East and South-east Asia. Within Australia, the mean OHIP scores for the British-/Irish-born sample starts higher, but the relationship of OHIP scores to number of teeth is strikingly similar to that of the UK sample (Fig. 3). We can safely assume the UK-born subjects in the UK sample to have a relationship between tooth loss and OHIP scores that is very similar to the overall UK sample. This assumption is based on the Australian results, where the relationship between tooth loss and OHIP scores for the majority of the Australian-/New Zealand-born group (Fig. 3) was virtually identical to the overall Australian sample (Fig. 2) based on known demographics; a much smaller proportion of the UK population (less than 5%) is overseas-born than is the case in Australia, where almost a quarter (24%) of the population is overseas-born (17).

The different relationships between tooth loss and OHIP scores observed among Australian subgroups defined by country of birth probably reflects a persistence of cultural influences on health and health expectancies in first-generation immigrants. The 'other' country-of-birth group in Australia, which consists of people born in many countries, shows a quite markedly different picture, with consistently high scores associated with any significant tooth loss, and a large drop in OHIP scores where there are 25 or more teeth.

This illustrates how perceptions of oral health-related quality of life may have a cultural dimension, or are at least related to where you were born. This is demonstrated here for the first time in two national samples, but supports previous studies showing marked cultural variations in OHIP (10, 18, 19). Furthermore, Tsakos et al. (20) showed that a UK national sample had significantly better impact scores than a sample of Greek older adults using a similar measure. Given the population groups concerned, this has resonance here.

Conclusion

Age and tooth loss are closely associated, but have independent effects on oral health-related quality of life. Tooth loss (which is associated with increasing age) is associated with more negative impacts, while increasing age independently results in fewer. If both of them are not accounted for in analyses involving whole populations, each variable will tend to dilute the effect of the other when using OHIP and probably other oral health-related quality of life measures. In all the populations and subpopulations studied, a complete or almost complete natural dentition was associated with the best oral health-related quality of life. However, the relationship of place of birth and domicile with oral health-related quality of life is another important consideration when using this, or any similar measure.

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