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Oral health of community-dwelling older Australian men: the Concord Health and Ageing in Men Project (CHAMP)

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ABSTRACT

Background: The Concord Health and Ageing in Men Project (CHAMP) is a cohort study of the health of a representative sample of Australian men aged 70 years and older. The aim of this report is to describe the oral health of these men.
Methods: Oral health was assessed when the men were all aged 78 years or older. Two calibrated examiners conducted a standardized intraoral assessment. Descriptive data were analysed by statistical association tests. Participants were excluded from the collection of some periodontal assessments if they had a medical contraindication.
Results: Dental assessments of 614 participants revealed 90 (14.6%) were edentate. Men had a mean of 13.8 missing teeth and 10.3 filled teeth. Dentate participants had a mean of 1.1 teeth with active coronal decay. Those in the low-income group had a higher rate of decayed teeth and lower rate of filled teeth. Thirty-four participants (5.5%) had one or more dental implants, and 66.3% relied on substitute natural teeth for functional occlusion. Of those with full periodontal assessments; 90.9% had sites with pocket depths of 3 mm or more, 96.6% had sites with CAL of 5 mm or more, and 79.7% had three or more sites with GI scores of 2 or more.
Conclusions: There was a high prevalence of periodontal diseases and restorative burden of dentitions, which suggests that greater attention needs to be given to prevention and health maintenance in older Australian men.

Keywords: Ageing, cohort study, dental epidemiology, older Australian men, oral health.

Abbreviations and acronyms: ARCPOH = Australian Research Centre for Population Oral Health, The University of Adelaide; CAL = clinical attachment loss; CHAMP = Concord Health and Ageing in Men Project; CI = 95% confidence interval.; DFS = decayed and filled tooth surfaces; DMFT = decayed, missing and filled teeth index; FTU = functional tooth units; GI = gingival index; GR = gingival recession; SADLS = South Australian Dental Longitudinal Study; SCQ = Self Completed Questionnaire; NHANES = National Survey of Adult Oral Health; NHMRC = National Health and Medical Research Council; NSAOH = National Survey of Adult Oral Health; PD = pocket depth.

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INTRODUCTION

Although it has been recognized nationally and internationally that the world population is ageing, there have been few epidemiological studies of the oral health of community-dwelling older Australians. The Concord Health and Ageing in Men Project (CHAMP) was initiated in 2005, and supported by funding from the National Health and Medical Research Council of Australia (NHMRC) to investigate the causes and consequences of the major geriatric syndromes: falls; bone strength and fractures; cognitive impairment and dementia; urinary tract problems; poor mobility and functional dependence.[1] In 2014, the NHMRC funded the addition of an oral health component to the 8-year geriatric medical

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assessments of the surviving and consenting participants in the original study.

Information on the oral health of older Australians in residential care[2–5] and community-dwelling settings is limited.[6–8] The National Survey of Adult Oral Health (NSAOH) 2004–2006[8] provides the most recent comprehensive analysis of the dental status of adult and older community-dwelling adults. NSAOH reported that 31% of Australian men aged 75 years and over were edentulous, with 26.9% having untreated coronal decay and 1.3% of tooth sites exhibiting periodontal pockets of 4 mm or greater. An earlier survey by Slade and others[7,9] provided a detailed description of both dental caries experience and periodontal diseases from a large sample (N = 853) of community-dwelling older South Australians (South Australian Dental Longitudinal Study, SADLS) .There was a small but statistically significant higher severity of dental disease (decayed, missing and filled teeth index, DMFT) in women compared with men (mean DMFT of 22.8 in men compared with 23.8 in women). Men had a higher rate of untreated tooth decay (0.3 vs 0.2 in women), and a lower rate of filled teeth (7.4 vs 9.2 in women). In addition, the 60–69 year old age groups had a small but significant difference in both lower missing teeth and DMFT compared with older age groups. There were no gender differences in the percentage of root surface dental caries, but men had higher rates of both untreated decayed root surfaces and overall decayed or filled tooth surfaces, compared with women. The SADLS[10] and its 11-year follow-up report[11] demonstrate the consistent trend in older Australian men to exhibit greater risk behaviour than their female peers. In contrast to previous studies in Australia, the study we report in this paper is built into a longitudinal follow up of the general health and well-being of a representative sample of men drawn from three local government areas of an urban locality in Sydney, New South Wales. The aim of this report is to present the descriptive findings of the mouth assessment and demographic characteristics at the 8-year follow up of participants in the CHAMP study.

METHODS

The target population therefore was the 781 participants from the original CHAMP cohort of 1705 men who were available for re-examination of their general health situation during the 8th year of follow up (43.1% of the original sample). Over the 8-year period, 669 men from the original cohort (39.2%) had died. A further 301 men (17.6%) were unable to be contacted, had moved into a residential aged care facilities or had withdrawn from the project because of ill health or other reason over the period (Fig. 1, Table 1). Of the remaining men, 718 (91.9%) completed the nutrition questionnaire and 614 participants were available for dental assessments (78.6% of the 8th year population).

Standard intraoral assessments were conducted by two calibrated oral health therapists. Calibration exercises and protocols were developed in conjunction with the Australian Research Centre for Population Oral Health (ARCPOH) prior to commencement of the study. A 26-page illustrated manual was used for the calibration exercises with the ARCPOH 'gold-standard' examiner. The manual covered all aspects of dental data collection, sequencing, diagnostic codes and recording standards. Wherever possible, standards were matched against the diagnostic codes of the NSAOH 2004–2006.

The study was approved by the Sydney Local Health District Human Ethics Research Committee (HERC/14/CRGH/17) and funded by an NHMRC Project Grant (1065647, 2014). The clinical oral health assessment was one of four components of the study. The other components included a self-completed questionnaire from participants, a detailed diet and nutrition interview, and general health assessment for each participant. The self-completed questionnaire was sent to participants prior to the other assessments and took approximately 45 min to complete. All data were coded to ensure individual privacy and entered into an ACCESS database which was stored securely at the Centre for Education and Research on Ageing at Concord General and Repatriation Hospital. The sequence of data collection was: self-reported questionnaire; nutrition and general health assessment; and oral health assessment. Participants who had completed the 5-year follow-up clinical examination in 2010–2012 (N = 958)[12] were contacted by telephone and invited to participate in the 2015–2016 (8-year) follow up. Up to seven contact calls were made.

Demographic variables were measured through the self-completed questionnaire, and where necessary, checked during the clinical examination. Definitions of demographic characteristics in the 8-year follow up were kept consistent with previous data collection definitions.[1,12,13] Country of birth was categorized into five groups: Australia; UK; Italy; Greece; and other. An income-based assessment was used to characterize income level where the lowest income category was 'all income from the aged pension only'; the middle category was income received from the 'age pension plus other income'; and the highest category was 'income from any possible combinations of superannuation, private income, own business/farm/partnership, wage or salary income, repatriation or veteran's pension, or other income'. Marital status was categorized as: married/de facto relationship; widowed; divorced/separated; and never married/other.

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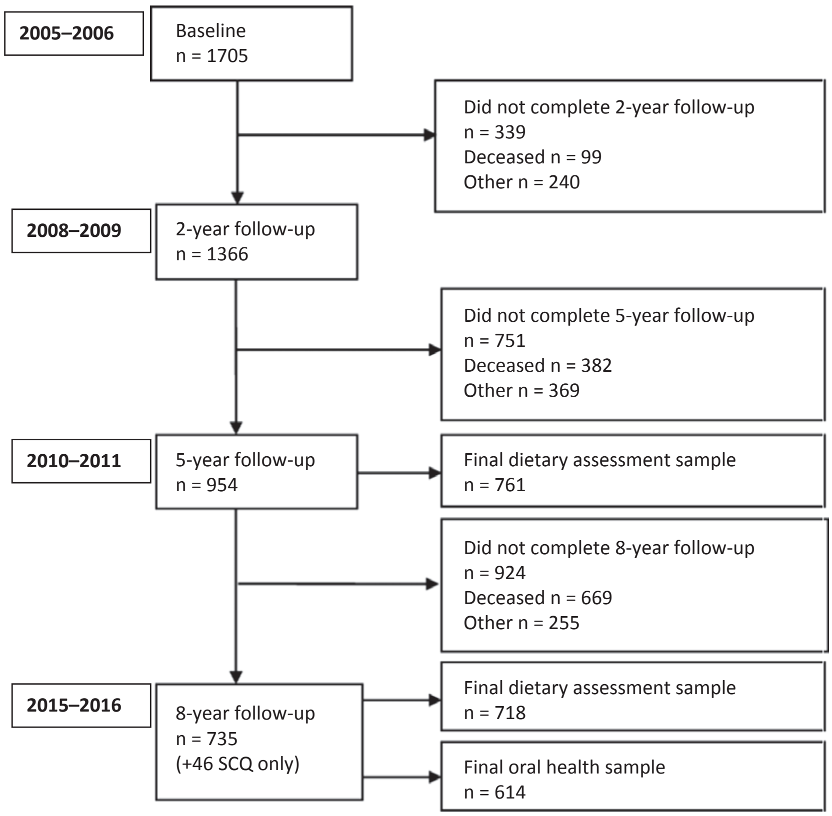

Fig. 1 Cohort trail of the 2015–2016 population from baseline (2005–2006) through 2, 5 and 8 years, remaining participants and reasons for loss. SCQ = 781.

Complete intraoral assessments were made on 614 participants with 90 of these men having all their natural teeth missing. The clinical protocol excluded, from the full periodontal assessment, any participant who answered positive to one or more of the following questions regarding their previous medical history: 'has a doctor ever told you that you must always take antibiotics (e.g. penicillin) before going to a dentist?'; 'have you ever had rheumatic fever?'; 'do you have kidney disease requiring renal dialysis?'; 'do you have haemophilia?'; 'do you have a pacemaker or automatic defibrillator?'; 'do you have artificial material in your heart, veins or arteries?'; 'have you had a hip or joint replacement that has been inserted during the past 3 months?'; 'do you have any transplanted organs?'; 'has your doctor ever told you that you have a heart murmur?'; 'have you ever had bacterial endocarditis?'; and 'has a doctor ever told you that you have heart valve problems?'. Of the 524 dentate participants, 296 (56.5%) were available for a full periodontal assessment including periodontal pocket depth (PD) and gingival index (GI) estimates. The most common medical reason for not completing the full periodontal assessment was 'artificial material in your heart, veins or arteries' (N = 119).

The great majority of participants were examined in their own homes with a standardized intraoral mirror and light source (Mirrorlite IN-7003 intraoral light; Mydent International, Hauppauge, NY, USA). A Hu Friedy PCP 2 periodontal probe (HuFriedy Manufacturing, Chicago, IL, USA) with a 2-mm marking was used for the periodontal assessments. No radiographs were taken and sharp dental explorers were not used.

Tooth loss, replacement teeth, decay experience on both coronal and tooth root surfaces were recorded for each subject. Functional tooth units (FTU) were calculated for both natural dentition alone and with prostheses, as described by Käyser[14] and Ueno *et al.*[15] Periodontal assessments were based on the criteria used in the NSAOH 2004–2006 where assessment was made of PD and gingival recession (GR) on three aspects of all natural teeth present; implants were excluded from PD measurement. Clinical attachment loss (CAL) was calculated for each tooth site measurement of PD and GR. The Löe and Silness Gingival Index (GI) was used to assess marginal gingivitis around all natural teeth present.[16]

Examiner reliability was assessed for the principal examiner (the examiner who performed 68.4% of the oral health assessments) on 38 replicate pairs of dentate participants within 4–12 weeks of the original assessment. Kappa values were calculated for coronal dental caries ($\kappa = 0.83$) for GR ($\kappa = 0.73$) and for periodontal PD ($\kappa = 0.74$). Repeatability for GR and

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Table 1. Sociodemographic characteristics of participants in the CHAMP study at baseline and at the 8-year follow up, including comparison of participants who completed the oral health assessment and those who did not

Characteristic	Baseline		8-year follow up total participants		8-year follow up oral health participants		*P*
	N	%	N	%	N	%	
Age group, years							
70–74	673	39.5	0	0	0	0	<0.05
75–79	536	31.4	103	13.2	90	14.7	
80–84	315	18.5	359	46.0	287	46.7	
85–89	135	7.9	228	29.2	174	28.3	
90–99	46	2.7	90	11.5	62	10.1	
≥100	0	0	1	0.1	1	0.2	
Country of birth							
Australia	849	49.8	389	49.8	316	51.5	NS
UK	78	4.6	35	4.5	28	4.7	
Italy	335	19.6	163	20.9	124	20.2	
Greece	65	3.8	36	4.6	23	3.8	
Other	378	22.2	1158	20.2	123	20.3	
Income group							
Low	668	39.8	328	42.6	250	40.9	NS
Mid	270	16.1	164	21.3	138	22.6	
High	742	44.1	278	36.1	224	36.6	
Marital status							
Married/de facto	1310	76.8	563	73.1	443	72.4	NS
Widowed	220	12.9	139	18.1	115	18.8	
Divorced/separated	90	5.3	31	4.0	21	3.4	
Never married	85	5.0	37	4.8	33	5.4	

Note that not all columns will add up to the total number of participants examined at year 8 (N = 781) or having year 8 oral health assessments (N = 614) because of missing values.
P-values compare the characteristics of the sample across the three groups: baseline participants; all participants at year 8; and year 8 participants who had an oral health assessment.
NS = not significant.

PD was accepted at the nearest ±1 mm. Repeatability for the GI was based on the reporting scores of GI of 2 or more, such that scores 0 and 1 were considered equivalent and scores 2 and 3 considered equivalent. Agreement of dichotomized GI counts was 73.9% with a kappa value of 0.75.

Statistical analyses were performed using Stata version 12 (StataCorp, College Station, TX, USA). Descriptive characteristics of the data are presented as means with standard deviations and proportions and 95% confidence intervals (95% CI) for categorical data. A *P*-value of 0.05 was set for determining the statistical significance of bivariate differences. Following consideration of the frequency distributions of age group data, the one centenarian was regrouped into the 90 year or more category.

RESULTS

Table 1 summarizes the sociodemographic characteristics of participants at baseline in the CHAMP study, all those who participated in the 8-year follow up and those who had the oral health examination. Consent rates for the oral health assessment declined with age: from 87% of those in the 75–79 year old group to 69% of those in the 90 year or more age group ($\chi^2 = 10.57$; d.f. = 3; $P < 0.05$). With this exception, the sociodemographic characteristics of those who completed the oral health assessments did not differ from those who underwent the full medical and nutritional assessments at the 8-year CHAMP follow up and the full group of 1705 CHAMP men at baseline in 2005.

General observations

Of all participants, 14.7% had no natural teeth (edentate; N = 90). Of these, 84 participants wore both upper and lower dentures with a further two not wearing any replacement dentures; one wore one full upper denture plus a partial lower denture (but had no natural teeth); one wore only a lower denture; and two participants wore only an upper denture. One participant had a full upper and lower denture over a retained root. The proportion of edentate men did not differ significantly by age group or marital status, but there were statistically significant differences in the distribution of edentate men by country of birth and income. Australian and UK born men had a higher proportion with one or more natural teeth (89.6% and 92.9%, respectively) compared with Italian men and those from 'other' countries (79.8% and 81.3%, respectively) and those men born in Greece, of whom only 69.6% had one or more natural teeth ($\chi^2 = 14.94$, d.f. = 4, $P < 0.01$). Only 76.4% of men

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in the lowest income group had one or more natural teeth present, compared with 91.3% in the mid-income group and 92.4% in the highest income group ($\chi^2 = 29.27$, d.f. = 2, $P < 0.001$).

Just under 39% of participants had 21 or more natural teeth, with 29.3% having 11–20 natural teeth and 17.1% having 1–10 natural teeth. While differences in distribution by age approached significance ($\chi^2 = 15.85$, d.f. = 9, $P = 0.07$) only variation by income was statistically significantly associated with number of teeth ($\chi^2 = 42.85$, d.f. = 6, $P < 0.001$). Forty-nine per cent of those in the highest income had 21 or more teeth, compared with 41.3% in the medium income group and 28.8% of those in the lowest income group. Thirty-four participants (5.5%) had one or more dental implants. This included one participant with denture-supported implants. A total of 101 dental implants had been placed.

Among dentate participants, the mean number of natural teeth ranged from 19.3 (95% CI = 18.6–19.9) in the youngest age group (75–79 years) to 16.0 (95% CI = 15.3–16.6) for the oldest of the four age groups (≥90 years). In contrast, missing teeth replaced by a prosthesis (but not an implant) ranged upwards from a mean of 6.1 (95% CI = 5.5–6.7) in the youngest age group to 8.3 (95% CI = 7.6–8.9) in the oldest group. Just under 68% of men had missing teeth replaced by some form of prosthesis.

Status of the dentition

Table 2 presents the mean number of teeth which were sound, missing, decayed, filled or which presented only as retained roots, by characteristics of the dentate participants assessed (N = 524). The mean number of sound teeth per dentate participant was 6.8 (95% CI = 6.3–7.2) teeth.

There were no participants free from dental caries experience. Seventy-seven participants (14.7%) had one or more retained tooth root fragments, 40 of whom had sound root fragments, 31 of whom had one or more decayed root fragments and eight men with both sound and decayed root fragments.

Although there was a trend for a higher mean rate of decay in those participants aged 85 years and older, this was not statistically significant. Similarly, variation in mean decay rates by country of birth and by marital status were not statistically significant. In contrast, however, analysis by income showed a significant difference between the three categories, with those men in the lowest income group having almost twice the rate of active coronal decay compared with the highest income group

The number of sound teeth did not differ by income or marital status, but did show statistically different variation by age group and country of birth ($P < 0.05$). Those in the two older age groups (85–89 and ≥90) had on average fewer sound teeth than their younger peers. Those men born in Italy had a higher rate of sound teeth present (8.5 ± 6.9 teeth) compared with those born elsewhere.

Variation in the mean rates of missing teeth (all participants = 13.8, 95% CI = 13.2–14.4) was statistically significant for both age group ($P < 0.05$) and income ($P < 0.01$) but not for country of birth or marital status. As age group increased so too did the mean number of missing teeth. Similarly, the mean number of missing teeth by income showed a significant decrease by increasing income group.

Finally, variation in mean numbers of filled teeth (all participants = 10.3, 95% CI = 9.8–10.8) was statistically significantly different by country of birth ($P < 0.01$), income ($P < 0.01$) and marital status ($P < 0.05$) but not age group. Those born in Italy had a lower rate of filled teeth than those born elsewhere, and those in the medium and highest income groups had a significantly higher mean rate of filled teeth than those in the lowest income group. Men whose marital status was described as 'separated or divorced' had significantly fewer filled teeth than those who were widowed, married or never married.

Table 3 presents the mean number of root surfaces (mean, 95% CI) of decayed and filled tooth surfaces (DFS) and percentage of root surfaces either decayed or filled by the characteristics of the dentate sample assessed. Overall and by demographic characteristics, there was a low proportion of root surfaces either with active decay or that had received fillings of surfaces.

On average, participants had 2.5 (95% CI = 2.0–2.9)decayed coronal surfaces. There was a statistically significant difference by age group ($P < 0.05$) where the 85–89 year-old age group had the greatest mean number of untreated decayed surfaces compared with other age groups. There were no statistically significant differences in decayed coronal surfaces by country of birth, income or marital status.

Participants had on average 36.7 (95% CI = 34.4–38.9) filled tooth surfaces, with statistically significant different distributions in mean scores by country of birth ($P < 0.05$) and income ($P < 0.01$) but not by age group or marital status. Italian born men had the lowest rate of filled surfaces while Australian born men and those born in Greece had the highest scores. The lowest income group had the lowest mean filled surface score while the highest income group had the highest score ($P < 0.01$).

The distributions of total DFS largely followed the same pattern as the filled tooth surfaces, with statistically significant differences in mean DFS scores by country of birth and income ($P < 0.01$) but not by age groups and marital status.

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Table 2. Mean number of sound, decayed, missing and filled teeth of dentate participants at the 8-year follow-up assessment (N = 524)

Characteristic	N	Sound (95% CI)	Decayed (95% CI)	Missing (95% CI)	Filled (95% CI)
All participants	524	6.8 (6.3–7.2)	1.1 (0.9–1.2)	13.8 (13.2–14.4)	10.3 (9.8–10.8)
Age group, years		*		*	
75–79	81	7.2 (6.1–8.6)	0.7 (0.5–1.0)	12.6 (10.9–14.3)	11.4 (9.9–12.8)
80–84	241	7.3 (6.7–8.0)	0.9 (0.8–1.2)	13.1 (12.2–13.9)	10.5 (9.7–11.1)
85–89	148	5.9 (5.0–6.7)	1.4 (0.9–1.8)	14.9 (13.8–16.1)	9.7 (8.7–10.7)
≥90	54	5.8 (4.5–7.0)	1.1 (0.7–1.6)	15.7 (13.9–17.7)	9.3 (7.8–10.7)
Country of birth		*			*
Australia	283	6.1 (5.6–6.6)	0.9 (0.7–1.2)	13.6 (12.8–14.)	11.3 (10.6–11.9)
UK	26	6.2 (4.8–7.5)	1.5 (0.6–2.5)	13.9 (10.8–17.2)	10.3 (7.6–12.9)
Italy	99	8.5 (7.1–9.9)	1.2 (0.9–1.6)	14.4 (13.0–16.0)	7.6 (6.6–8.67)
Greece	16	6.6 (4.1–9.2)	0.6 (0.2–1.2)	13.9 (10.8–17.3)	10.7 (8.0–13.2)
Other	100	7.1 (5.9–8.3)	1.3 (0.9–1.7)	13.5 (11.8–15.3)	10.0 (8.8–11.2)
Income group			*	*	*
Low	191	6.9 (6.2–7.8)	1.4 (1.1–1.7)	15.5 (14.4–16.7)	7.9 (7.2–8.8)
Mid	126	6.1 (5.3–7.0)	1.0 (0.7–1.4)	13.6 (12.4–14.8)	11.2 (10.2–12.2)
High	207	6.9 (6.2–7.7)	0.8 (0.6–0.9)	12.2 (11.4–13.2)	11.8 (11.0–12.6)
Marital status					*
Married/de facto	382	7.0 (6.5–7.6)	1.0 (0.9–1.2)	13.6 (12.8–14.4)	10.2 (9.6–10.8)
Widowed	93	5.9 (4.9–6.8)	1.1 (0.8–1.4)	14.1 (12.7–15.6)	10.7 (9.5–12.0)
Divorced/separated	17	6.0 (3.3–9.1)	2.1 (0.8–3.5)	17.1 (13.5–20.7)	6.9 (4.9–8.9)
Never married	32	6.2 (4.6–7.9)	0.7 (0.4–1.1)	12.9 (10.3–15.5)	12.1 (9.9–14.4)

*ANOVA/Kruskal–Wallis Test, $P < 0.05$.
95% CI = 95% confidence interval for estimated means.

Table 3. Mean number of tooth surfaces of dentate participants decayed or filled, and percentage of root surfaces decayed or filled, at the 8-year follow-up assessment (N = 524)

Characteristic	N	Decayed (95% CI)	Filled (95% CI)	DFS (95% CI)	% of root surfaces with DF
All participants	524	2.5 (2.0–2.9)	36.7 (34.4–38.9)	39.4 (36.9–41.5)	19.2
Age group, years					
75–79	81	1.3 (0.8–1.9)	40.8 (34.9–46.7)	42.2 (36.3–47.9)	17.7
80–84	241	2.2 (1.7–2.9)	36.0 (32.8–39.2)	38.2 (35.0–41.4)	19.2
85–89	148	3.4 (2.3–4.8)	37.0 (32.6–41.01)	40.5 (36.1–44.6)	19.6
≥90	54	2.5 (1.3–3.7)	36.7 (34.4–38.9)	39.1 (36.9–41.5)	19.2
Country of birth			*	*	*
Australia	283	2.2 (1.6–3.0)	40.3 (37.2–43.2)	42.5 (39.4–45.7)	16.1
UK	26	3.6 (1.2–7.0)	34.3 (24.7–44.7)	37.9 (29.3–48.0)	20.0
Italy	99	2.8 (1.7–3.9)	28.3 (23.8–33.4)	31.1 (26.7–35.9)	22.3
Greece	16	0.9 (0.3–1.6)	40.3 (27.8–52.5)	41.2 (28.9–53.4)	15.6
Other	100	2.7 (1.8–3.7)	34.9 (29.9–39.9)	37.6 (32.7–42.5)	25.4
Income group			*	*	
Low	191	3.0 (2.3–3.8)	27.9 (24.9–31.1)	31.0 (27.8–34.1)	24.1
Mid	126	2.6 (1.5–4.1)	40.2 (35.5–44.5)	42.8 (38.2–47.1)	17.2
High	207	1.9 (1.3–2.5)	42.5 (38.8–46.3)	44.4 (40.8–48.3)	16.0
Marital status					
Married/de facto	382	2.4 (1.8–2.9)	36.6 (33.9–39.3)	38.9 (36.2–41.6)	19.1
Widowed	93	2.6 (1.7–3.6)	37.8 (3 2.5–42.9)	40.4 (35.1–45.5)	19.4
Divorced/separated	17	4.9 (1.4–9.7)	25.9 (16.3–35.1)	30.8 (21.1–40.5)	23.1
Never married	32	1.9 (0.8–3.3)	40.4 (30.9–51.1)	42.3 (32.4–53.1)	17.2

*ANOVA/Kruskal–Wallis Test, $P < 0.05$.
95% CI = 95% confidence interval for estimated means.

Overall, 19.2% of root surfaces were either filled or decayed. The average number of DFS sites was 6.2 (95% CI = 5.6–6.8) root surface sites. There were no significant differences in the proportion of DFS sites by age group or marital status, but differences in pattern were significant for income group and country of birth ($P < 0.01$). Men born in Greece and Australia had a lower proportion of DFS rates than those from UK, Italy and other countries ($P < 0.01$). The lowest income group had the highest proportion of DFS sites (24.1%) compared with the highest income group (16.0%)

Periodontal status

Table 4 presents percentage of tooth sites with 3 mm or more periodontal PD, or 5 mm or more CAL, and

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a Gingival Index score of 2 or greater, by characteristics of the dentate sample assessed.

A total of 296 participants (56.5% of the dentate sample) were available for complete periodontal assessments. A further 207 dentate participants completed certain components of the assessment, where PD and gingival probing were not carried out because of a pre-existing medical condition. Twenty-one dentate participants refused periodontal assessment. The mean number of teeth per participant completing the PD assessment was 16.9; providing an average of 50.7 measurement sites per participant. Two hundred and sixty-nine participants (90.9%) of those who had PD measurements had one or more sites with a PD of 3 mm or greater. Fifty-two participants (17.6%) had three or four sites with a PD of 3 mm or more, while 166 participants (56.1%) had five or more sites with a PD of 3 mm or greater. There was no statistically significant difference in number of sites of 3 mm or more by age group or income level.

In total, 15 009 sites were available for periodontal pocket measurement. Some 83.1% of sites (N = 12 474) had a periodontal pocket measurement of 2 mm or less, with a further 2228 sites (14.8%) having a PD of 3–4 mm or more. Two per cent of sites had a PD of 5 mm or more.

The prevalence of CAL by one or more sites of 5 mm or more was 96.6% (N = 286), with 248 participants (83.8%) having five or more sites with a CAL of 5 mm or more. Of the 15 009 sites measured, 10 595 (70.6%) had a CAL of 4 mm or less, with the remaining sites (29.4%) having a CAL of 5 mm or more.

Two hundred and seventy-three participants (92.2%) had GI scores of 2 or more and 236 participants (79.7%) had three or more sites with GI scores of 2 or more. Of the 15 009 sites examined, 4241 (28.3%) had scores of 2 or greater.

Functional tooth units

Participants (N = 614) were classified by three forms of FTU: natural teeth only; prosthetic (partial/full denture) FTU only; or a combination of prosthetic (including implants and bridges) and natural teeth. Forty per cent of participants (N = 248) relied on prosthetic FTU for posterior mastication of foods. Thirty-two per cent (N = 198) had natural teeth only as their posterior occlusion, and 25.2% relied on a combination of prosthetic (including implants and bridges) and natural teeth. There was no statistical difference in the distributions of class of FTU by age group.

Functional tooth units were also divided into three categories for all participants (N = 614): less than seven FTU; 7–11 FTU; and 12 (full complement) FTU. Many participants (38.1%) had fewer than six occluding pairs of posterior teeth (FTU). Less than one-third of participants (28.0%) had a full complement of occluding posterior pairs of teeth made up of natural and or prosthetic FTU. There was no statistical difference in the distribution of participants in number of FTU by age group.

DISCUSSION

This study reports a relatively low prevalence of edentulism (14.7%) in male Australians aged 78 years and

Table 4. Percentage of tooth sites with 3 mm or more periodontal pocket depth (PD), clinical attachment loss (CAL) of 5 mm or more, and Gingival Index (GI) score of 2 or more (N = 296)

Characteristic	N	PD ≥ 3 mm (95% CI)	CAL ≥ 5 mm (95% CI)	GI ≥ 2 (95% CI)
All participants	296	16.9 (16.3–17.5)	30.1 (29.3–30.8)	28.3 (27.5–29.0)
Age group, years				
75–79	43	16.6 (15.2–18.2)	27.5 (25.7–29.3)	27.2 (25.4–29.1)
80–84	144	17.4 (16.6–18.3)	28.1 (27.1–29.1)	30.0 (28.9–31.9)
85–89	87	15.5 (14.4–16.6)	31.9 (30.5–33.3)	25.9 (24.6–27.3)
≥90	22	19.0 (16.6–24.6)	44.8 (41.6–48.0)	27.0 (24.2–29.9)
Country of birth				
Australia	153	13.4 (12.7–14.2)	28.5 (27.5–29.5)	25.2 (24.2–26.1)
UK	14	13.7 (11.4–16.3)	24.8 (21.9–28.0)	25.2 (21.1–27.2)
Italy	62	23.1 (21.5–24.5)	31.4 (29.8–33.1)	36.2 (34.5–37.9)
Greece	9	28.5 (24.2–33.1)	38.2 (33.5–42.8)	45.7 (40.8–50.6)
Other	58	19.1 (17.6–20.6)	33.3 (31.5–35.0)	26.9 (25.2–28.5)
Income group				
Low	110	20.4 (19.3–21.5)	30.3 (29.1–31.6)	31.1 (29.9–32.4)
Mid	114	13.9 (12.8–15.1)	32.7 (31.1–34.2)	25.2 (23.8–26.7)
High	72	15.7 (14.8–16.6)	28.3 (27.2–29.5)	27.6 (26.5–28.8)
Marital status				
Married/de facto	222	16.5 (15.8–17.2)	29.2 (28.4–30.1)	28.3 (27.5–29.2)
Widowed	50	21.2 (19.7–22.9)	35.0 (33.2–36.9)	28.3 (26.5–30.1)
Divorced/separated	8	14.6 (11.4–18.3)	22.6 (18.8–26.8)	20.1 (16.4–24.2)
Never married	16	10.5 (8.5–12.7)	30.1 (27.1–33.3)	31.1 (28.1–34.3)

95% CI = 95% confidence interval for estimated means.

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over. A decade previously by Slade *et al.*[8] reported that 35.7% of those aged 75 years or more (men and women) in the 2004–2006 NSAOH were edentulous, with a slightly lower rate of 31% for men. Various national goals for rates of edentulism by 2020 have been reported in Europe[17] and the USA.[18] The US target of 21.6% of those aged 65–74 years, and of less than 15% in Spain and Germany, has already been achieved by the CHAMP men. While a marked decline in the rates of edentulism has been reported, both internationally[22,23] and in Australia, the 15% prevalence of edentulism in the CHAMP study is in the lower expectancy range. In 2007, the ARCPOH projected estimates for compete tooth loss for Australians largely based on the outcomes of the 2004–2006 NSAOH data.[23] Their projections ranged from a low of 12.9% edentulism in the 75–79-year-olds by 2021, to a high of 23.4% in those aged 85 years and older.

The edentulism rate in CHAMP contrasts with some reports of European and New Zealand rates. Data from the 1998 adult oral health survey in the UK reported a prevalence of edentulism for those aged 75 years and over (men and women) at approximately 58%,[18] while the National Health and Nutrition Examination Survey (NHANES) 2003–2004 survey in the USA reported a prevalence of edentulism in those aged 75 years and older of 31.3%.[20] In contrast, the 2012 New Zealand survey of those aged65 years and over[21] reported that 52.2% of home-based residents were edentulous, with a higher prevalence of edentate women (56.8%) compared with men (43.5%). Marked variation in rates of edentulism has also been noted in a 14-nation (largely European) study by Stock *et al.*[17] Differences in rates of edentulism relate not only to the organization of dental services, financial arrangements for oral health care and dental workforce availability, but also to individual socioeconomic and income variations.[24]

Just over 60% of CHAMP men had fewer than 21 natural teeth, similar to the 56% of men aged75 years and older in the 2004–2006 NSAOH.[8] The mean number of missing teeth in CHAMP men was 13.8, compared with 14.6 for men aged 75 years an older in the 2004–2006 NSAOH and 15.0 missing teeth in the SADLS.[7] Comparison of missing to filled teeth ratios over time suggest that there have been rapidly changing patterns of dental treatment occurring in the Australian community for older people. For example, the SADLS of 1991–1992 for men aged 65 years and older, showed a missing to filled teeth ratio of 15.0:7.4. That is, on average, twice as many missing teeth than filled teeth. In the present study, the ratio of 13.8:10.3 has on average fewer missing teeth and a higher rate of filled teeth. Also, the trends in accumulated restorative dentistry in Australia across generations of older Australians are evident in the comparison of data on filled teeth per person between the two national Australian surveys.[8] The mean number of filled teeth in those aged 75 years or more increased from 6.1 teeth in the 1987–1988 survey to 10.9 in the NSAOH in 2004–2006.

In the current study, 101 dental implants were recorded in 34 of the 614 CHAMP participants. The increased promotion and accessibility to dental implants, especially when multiple implants are placed[25] in older persons – without due reflection on changing medical, pharmacological and physical conditions of older people –may lead to increasing risk of new oral disorders such as peri-implantitis. As Dudley[26] points out, there have been few studies 'solely and specifically set out to investigate' the impact of ageing on dental implant success. Müller and Schimmel[27] recommend adding the ability of the patient to 'autonomously manage and clean the restoration' as a criterion for successful outcomes of implants.

Active coronal tooth surface caries was relatively high in the CHAMP participants (mean = 2.8 surfaces) in comparison with the 2004–2006 NSAOH where men aged 75 years and older had on average 0.7 decayed tooth surfaces.[8] The mean number of teeth with coronal dental caries was 1.1 teeth, considerably higher than the 2004–2006 NSAOH findings (0.3) and the SADLS of 0.4 but about half the rate of that reported in the New Zealand study for 'home-based' men aged 75 years or over.[21] The average number of filled surfaces of participants in this study (36.7) was considerably higher than the 2004–2006 NSAOH mean of 25.3 surfaces for men aged 75 year and older[8] and the 1997 report of the SADLS of 19.1 filled surfaces for men aged 60 years and older. However, the prevalence of men with untreated dental decay in the CHAMP study (N = 30, 5.7%) is substantially less than the 2004–2006 NSAOH prevalence of 26.9% in men aged 75 years and over.

Men born in Italy had a higher mean number of sound teeth and significantly lower mean numbers of filled teeth and filled tooth surfaces compared with those born elsewhere. Differences in dental outcomes between men from different culturally and linguistically diverse backgrounds requires further exploration with regards to oral health preventive behaviours, service utilization and general health conditions.[28]

The association between income and oral health outcomes that we found is not new, and has been recognized nationally[7–9] and internationally over previous decades.[9,17,19] The findings of this study confirm these disparities in the distribution of active dental decay in low-income older men and also show higher access to treatment for dental decay by restorative treatments in higher income older men with lower income men receiving a higher treatment pattern of extractions.

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The number of teeth, and number of occluding pairs of teeth required for satisfactory social and biological function, has received considerable attention over the past two decades[29–32] with the consensus that 20 teeth (10 occluding pairs of teeth) provide adequate oral function. Thirty-nine per cent of CHAMP men had 21 or more natural teeth, and just over 65% relied on prosthetic teeth to provide satisfactory occlusion (≥10 FTU). In the present study, posterior FTU were estimated using the same criteria as Käyser,[33] attributing one pair of occluding premolars a score of one FTU and a pair of occluding molar teeth as two FTU. Only 28% of participants had a full complement of 12 FTU (equivalent to eight pairs of occluding premolar/molar teeth), and 33% had between seven and 11 FTU. Thirty-eight per cent of men in the CHAMP study had fewer than seven FTU, made up of naturally occluding posterior teeth, a combination of natural and prosthetic replacements, or dentures (partial or full dentures). It is suggested that those within this latter category may pose a risk for adequate nutritional intake and chewing function. Further analyses of the association between components and types of FTU with health, function and quality of life factors are required.

The epidemiological definition of periodontal diseases are not consistent across studies and reports.[21,34–37] This study used the standard diagnostic criteria of the 2004–2006 NSAOH, which was based on the methods used in the 2005 US NHANES and 'two threshold levels' for PD (≥3 mm) and CAL (≥5 mm). These definitions appear also to be in keeping with the with risk-factor identification for periodontal diseases suggested by the 5th European Workshop in Periodontology and international comparison of prevalence rates suggested by Eke *et al.*[38] from the NHANES 2009–2012 analyses. The selection of the 3 mm or more PD threshold in this study was based on the case definition analyses of Page and Eke[39] where they noted that in older populations PD measurement as an indicator of periodontal disease was influenced by high levels of GR in older participants.

Over 90% of CHAMP men with full periodontal assessments had one or more sites with a PD of 3 mm or more, and some 56.1% had five or more sites with a PD of 3 mm or more. The 2004–2006 NSAOH reported that 23.3% of males aged 75 years or more had at least one 4 mm or more periodontal pocket; while the MrOS study reported that 85% of their sample had at least one site with a PD of 4 mm or more and 36% had a PD at one or more sites of 6 mm or more.[35] The recent New Zealand study (using the Community Periodontal Index definitions) reported that 20.8% of men living in their own homes had periodontal pockets of 4 mm or more. The 2004–2006 NSAOH reported that in men aged 75 years or more there were only 1.4% of tooth sites with 4 mm or more pockets, while the 2009–2012 NHANES report stated that 44.9% of persons aged 30 years and over had five or more sites with a PD of 3 mm or more, and 6.3% had five or more sites with pockets of 5 mm or more. Further, some 14.8% of sites measured in CHAMP participants were 3–4 mm, and 2.0% of sites had a PD of 5 mm or more. Despite the differences in reporting measures, the CHAMP findings indicate a higher extent and severity of periodontal disease, as indicated by prevalence and extent of PD of 3 mm or more, compared with the 2004–2006 NSAOH, and similar levels to those reported in the US MrOS and the NHANES studies.

Just less than 24% of Australian men aged 75 years or older were reported with GI in the 2004–2006 NSAOH. The MrOS dental study reported the prevalence of gingival bleeding around one or more teeth at 53% of their older population. In the CHAMP study, 97% of participants with full periodontal assessment had a GI score of 2 or more, that is, inflammation with bleeding after gentle periodontal probing or marked inflammation with spontaneous bleeding. These findings indicate a higher prevalence rate than the NSAOH and the US MrOS study.

Taken together with previous Australian studies, the findings from the CHAMP suggest an acquisition of restorative treatments for dental caries and a decreasing management of dental caries in later adulthood by extraction of teeth. Further analyses of these differences in dental caries experience is warranted with a need to look more carefully at access to oral health services, social and insurance drivers which may be impacting on these differences as well as the general improvement in oral health of older Australians by retaining more natural teeth presenting more risk to dental caries and periodontal diseases.

Limitations of the study

Comparison of data across populations is difficult often because sample sizes of those aged 75 years and over are relatively small when surveys have been based on the broad adult population of 18 years and over. While many of the characteristics of the CHAMP participants were broadly similar in terms of income and socioeconomic characteristics to the Australian population, sample characteristics in other studies are measured and reported in different ways. Further, comparisons with the NSAOH should be viewed with caution not only because of sampling differences (e.g. a national survey from city and regional areas, different measures of economic status) but also as clinical assessments in the NSAOH were conducted in clinical settings whereas our oral health assessments were largely conducted in the participants'

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homes. This paper presented only bivariate analysis with no assumption being made about inter-variable confounding effects. A further limitation of this study was the loss to follow up of participants, many of whom may have been more likely to become edentate or have higher rates of missing teeth. It may well also be that a 'survival bias' exists whereby the general health (and oral health) status of the surviving participants is better compared with those who died or withdrew from the original cohort. For medical reasons, there was a high exclusion rate for periodontal assessments of PD (consequently CAL estimates) and gingival probing with respect to ascertaining GI.

CONCLUSIONS

Taken together with findings from other studies, however, it can be concluded that older Australian males are retaining more natural teeth and accumulating restored teeth at a higher rate than previous reports. Disparities are evident in the distribution of dental conditions by sociodemographic variation in this group, especially by country of birth and by income status. Periodontal diseases are more prevalent in this population of older Australian men than found in previous Australian and many international studies.

The greater retention of natural teeth and the acquisition of complex restorative and rehabilitative dental care found in participants in this study support the need for more critical recognition of periodontal diseases and the consequences of restorative and prosthodontic interventions in older Australian men. The consequences of more teeth and more restorations in an older population require sober thought about sensible planning of access to dental care and the dental services which will be required to meet the functional needs of an ageing population with lower purchasing capacity and wide cultural variations in dental status and perceptions. Findings from this study suggest that the focus for population interventions should be on prevention and oral health maintenance while professional interventions should be geared to prevention of deterioration of highly restored (fillings, crowns, bridges, implants, partial dentures) dentitions and periodontal diseases. Maintenance of oral health must be the key clinical intervention.

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DISCLOSURE

The views expressed are those of the authors, not of the funders. Data analysis and interpretation were carried out by the authors independently of the funding sources based on the available data. The corresponding author had full access to the survey data and had final responsibility for the decision to submit for publication.

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