Community Dental Health (2013) **30,** 58–64
Received 24 May 2012; Accepted 23 August 2012

doi:10.1922/CDH_3038Jamieson07

Associations between oral health and height in an Indigenous Australian birth cohort

L.M. Jamieson[1], S.M. Sayers[2] and K.F. Roberts-Thomson[1]

[1]*Australian Research Center for Population Oral Health, The University of Adelaide, South Australia 5005, Australia;* [2]*Menzies School of Health Research, Charles Darwin University, Darwin, Australia*

Objective: Evidence suggests that taller individuals have better health than their shorter counterparts. This study aimed to test the hypothesis that shorter participants in Wave-3 of the Aboriginal Birth Cohort (ABC) study, a prospective longitudinal investigation of Indigenous Australian individuals born 1987–1990 at an Australian regional hospital, would have more caries and periodontal disease experience than their taller counterparts. ***Methods:*** Data were collected through oral clinical examinations, anthropometric measures and self-report questionnaires. The outcome variables were participants' caries (mean DMFT) and periodontal disease experience (moderate or severe periodontal disease as defined by the Centre for Disease Control), with height as an explanatory variable. Antecedent anthropometric, socio-demographic, sugar consumption frequency, dental behaviour and substance use variables were used as possible confounders. Linear regression was used in the analysis of caries experience, while adjusted prevalence ratios were used for prevalence of moderate or severe periodontal disease. ***Results:*** Higher DMFT was found among participants in the shortest tertile (B=1.02, 95% CI=0.02–2.02) and those who consumed sweets every day or a few days a week (B=1.08, 95% CI=0.11–2.05), while lower DMFT was found among those owning a toothbrush (B=0.80, 95% CI=-0.22–1.82). Periodontal disease was positively associated with the shortest tertile (adjusted PR=1.39, 95% CI=0.96–1.82) and negatively associated with toothbrush ownership (adjusted PR=0.50, 95% CI=0.34–0.66). ***Conclusion:*** The hypothesis that shorter participants in Wave-3 of the ABC study would have higher levels of caries and periodontal disease was confirmed.

Keywords: *dental caries, periodontal disease, Indigenous populations, body height*

Introduction

The literature suggests that, in developed countries at least, all-cause mortality is less and longevity greater among those who are tall (Cook *et al*., 1994; Davey Smith, 2002; Hebert *et al*., 1993; Montgomery *et al*., 2007; Osika *et al*., 2006; Song *et al*., 2003). Power and Mathews (1997) asserted that taller than normal height was associated with favourable childhood social circumstances, with taller adult stature being an indicator of more enhanced development and health associated with beneficial exposures in early life (Davey Smith *et al*., 1998; Lichtenstein *et al*., 1992; Terrel and Mascie-Taylor, 1991). In contrast, indicators of underlying nutritional and/or psychological disorders have been associated with interrupted growth patterns, which may manifest in the long term as deficient height (Montgomery *et al*., 2007).

Given its associations with social deprivation and nutritional deficiency throughout the life course, it is reasonable to expect that the most prevalent diseases of the oral cavity, namely, dental caries and periodontal disease, may be oral health-related outcomes associated with height. Evidence suggests that children with lower growth parameters have greater experience of dental caries in the deciduous dentition (Alvarez *et al*., 1993; Alvarez, 1995; Ayhan *et al*., 1996; El-Kashlan and Saleh, 1997; Li *et al*., 1996; Psoter *et al*., 2005), but there are less conclusive findings regarding the permanent dentition. Freire and colleagues (2008) reported that taller adolescents in Brazil had lower levels of dental caries after adjusting for social class, school performance, exposure to fluoride, frequency of sugar consumption and pattern of dental attendance. In Saudi Arabia, shorter boys aged 6–13 years had less caries in the permanent dentition after adjusting for age and social class (Abolfotouh *et al*., 2000), while in a cohort of Brazilians aged 13 years, taller individuals had lower caries severity in the permanent dentition after adjusting for demographic and social variables (Nicolau *et al*., 2005).

There is less evidence of the association between height and periodontal disease. Based on the theory that short stature in adulthood was associated with increased risk of health problems, Meisel and colleagues (2007) tested the hypothesis that predisposition to inflammatory diseases was associated with impaired leg growth and imposed a lifelong inflammatory burden, using periodontal disease as a biomarker of that inflammatory burden. Their findings indicated that shorter participants had more periodontal disease and increased concentrations of systemic inflammation markers than their taller counterparts, thus confirming their hypothesis.

The objective of this study was to test the hypothesis that shorter participants in a birth cohort of Indigenous Australian young adults would have higher levels of caries and periodontal disease.

Correspondence to: Lisa M. Jamieson, Australian Research Center for Population Oral Health, The University of Adelaide, South Australia 5005, Australia. Email: lisa.jamieson@adelaide.edu.au

Materials and methods

Data were from Wave-3 of the Aboriginal Birth Cohort (ABC) study, a prospective, longitudinal investigation of a birth cohort of Indigenous Australians. Babies were eligible for enrolment if they were live born singletons delivered at the Royal Darwin Hospital, Northern Territory, between January 1987 and March 1990 to a mother recorded as Aboriginal (Sayers *et al*., 2007). Within the local region at that time, 90 percent of pregnant Aboriginal mothers come to the Royal Darwin Hospital to deliver their babies (Northern Territory Department of Health and Community Services, 1992). Follow-ups were conducted at mean ages 4, 11 and, most recently (Wave-3), 18 years, when participants were located in over 40 communities in the Northern Territory's Top End.

The Human Research Ethics Committee of the Northern Territory Department of Health and Community Services and Menzies School of Health Research (including an Aboriginal sub-committee with absolute right of veto) granted ethics approval for each assessment phase. Study members gave informed consent before participating.

The two outcome variables were dental caries and periodontal disease. The mean DMFT (sum of decayed, missing and filled teeth in the permanent dentition) index was used to assess dental caries outcomes. Information about clinical oral health status was collected during standardised clinical examinations conducted by two calibrated dentists. Examining dentists followed a standardised protocol to record levels of tooth loss and dental decay experience. All teeth present were divided into five tooth surfaces; occlusal/incisal, mesial, buccal, palatal/lingual and distal. Each dental surface was assessed and categorised using visual criteria only. Untreated dental decay was defined as 'cavitation of enamel or dentinal involvement or both being present' or 'visible caries that is contiguous with a restoration'. Filled due to decay was recorded when a tooth contained one or more permanent restorations placed to treat caries, while missing was recorded when a tooth had been extracted due to pathology. In the few cases where it was not obvious whether a restoration had been placed due to caries or whether a tooth had been extracted due to pathology, the participant was asked.

To measure periodontal disease, two sites (mesiobuccal and buccal) per tooth, excluding third molars, were examined. Probing depth (the distance from the probe tip to the gingival margin) and gingival recession (the distance from the gingival margin to the amelo-cemental junction) were measured using disposable probes with 2–3mm markings. The combined attachment loss for each site was computed by summing gingival recession and probing depth. Mid-buccal measurements for molars were made at the mid-point of the mesial root. All measurements were rounded down to the nearest whole millimetre. The US Centres for Disease Control and Prevention and the American Academy of Periodontology definitions were used to describe moderate and severe periodontal disease; whereby moderate periodontal disease was defined as the presence of either two sites between adjacent teeth (mesio-buccal of one and buccal of another) with 4mm or more attachment loss, or at least two such sites with 5mm pockets or deeper. Severe periodontal disease was classified as having at least two sites between adjacent teeth with 6mm or greater attachment loss and with at least one pocket of 5mm depth or greater (Page and Eke, 2007). One of the two examiners was aware of the study hypothesis. Repeat examinations for examiner reliability were not possible due to logistical and time constraints imposed by the study's multidisciplinary nature.

The exposure variable, standing height at mean age 18 years was measured to the nearest millimetre with a portable wall-mounted stadiometer while participants were wearing light clothing and no shoes.

Based on the literature, antecedent anthropometric measures, socio-demographic, sugar consumption frequency and dental behaviour variables were included as confounding factors. Antecedent anthropometric measures included height at mean age 11 years (Wave-2), which was measured using the same procedures described above. Included as socio-demographic factors were gender, age-group, residential location, source of household income, household size and car ownership. Location was dichotomised into 'regional', encompassing participants living in the three regional centres included in the study, and 'rural/remote' which included participants living outside the regional jurisdictions. Source of household income was defined as 'job' (ie employment) or 'welfare' (ie unemployment or various government welfare programs). Household size was assessed by the question 'How many people stayed in your house last night?' and dichotomised into 'three or fewer' and 'four or more'. While car ownership was ascertained by the question 'Does someone in your house own a car?' Participants were asked how many times a week they consumed soft drink, fruit juice, cordial, milk, tea, fruit and sweets with responses dichotomised into 'every day or a few times per week' and 'once a week or less often'. Participants were also asked if they took sugar with their tea. Finally, confounders relating to dental behaviours were defined as 'having seen a dentist before', 'toothbrush ownership', 'toothbrushing frequency' and 'age of toothbrushing onset'.

In data analysis, height was not used as a continuous variable because some participants were likely to have been still growing, meaning individual variations in growth rate may have masked structural influences of interest. The height variable was therefore converted to dummy variables representing tertiles. The point biserial coefficient correlation (statistic used to estimate degree of relationship between nominal and interval scales) between gender and height was 0.8, indicating that the two variables were highly correlated. Gender was consequently not used in analysis. Tests of association confirmed no other collinearity among the variables used. The potential for effect measure modification was also determined and differences between strata evaluated by examining the overlap of confidence intervals; there were no variables identified as effect measure modifiers.

Bivariate analysis was used to determine associations between the outcome measures (caries and periodontal disease) with height and confounding factors. Linear regression was used in multivariate modelling to determine associations between caries experience and height after adjusting for confounding factors significant at the $p<0.05$ level in bivariate analysis. Adjusted prevalence ratios were used for prevalence of moderate or severe periodontal disease. All analyses were done using Intercooled Stata 8.

Results

Of the original 686 ABC study participants, 618 were traced at mean age 18 years, of which 27 were known to have died. Of the 591 available for examination, 121 participants were not examined but only 11 refused outright and the remainder were not seen because of logistic reasons relating to poor weather, mobility of participants and single participants living in very remote locations. Basic anthropometric measures at a mean age of 18 years were obtained for 468 participants; a response rate of 73 percent. The numbers of participants undergoing procedures varied because some were seen by an incomplete study team, some had disabilities that prevented all measurements and others refused some procedures. Of the 468 for whom vital status was obtained, 441 agreed to be dentally examined and provided complete information in a self-report dental questionnaire, which was 95 percent of the total number of participants examined at mean age 18 years and 69 percent of those recruited at birth who were still alive.

The mean DMFT was 4.83 (range 0 to 31) and 27 percent of participants had moderate or severe periodontal disease. The mean height was 167.5cm (range 140.8 to 192.9cm) and the age range was 16 to 20 years. Mean DMFT and prevalence of periodontal disease was higher among those in the shortest tertile and those aged 19–20 years (Table 1). Mean DMFT was higher among participants who reported consuming soft drink or sweets every day or a few days a week, or who took sugar with tea (Table 2). Non-ownership of a toothbrush was associated with both DMFT and periodontal disease prevalence (Table 3). A higher proportion of participants who smoked tobacco had periodontal disease.

After adjusting for confounding factors in multivariate modelling, being in the shortest tertile continued to be associated with dental caries experience, as did sweet consumption every day or a few days a week and non-ownership of a toothbrush (Table 4). Being in the shortest tertile and non-ownership of a toothbrush continued to be associated with periodontal disease after adjusting for confounding (Table 5).

Table 1. Mean DMFT of ABC study participants by height, demographic, socio-economic and behavioural factors

	n	*Mean DMFT (95% CI)*	*Prevalence of moderate/ severe periodontal disease*
Overall	441	4.83 (4.36–5.30)	27.0 (22.86–31.14)
Anthropometric			
Height at mean age 18 years (Wave-3, tertiles)			
Shortest (shortest through to 163.1 cm)	147	**5.61 (4.68–6.54)***	**34.7 (27.02–42.38)***
Middle (163.2 to 170.6 cm)	147	4.83 (4.10–5.56)	25.2 (18.11–32.29)
Tallest (170.7 cm to tallest)	147	4.05 (3.26–4.84)	21.1 (14.40–27.80)
Height at mean age 11 years (Wave-2, tertiles)			
Shortest (shortest through to 137.5 cm)	140	4.76 (3.99–5.53)	27.1 (19.61–34.59)
Middle (137.6 cm to 146.0 cm)	138	4.43 (3.62–5.24)	29.7 (22.02–37.38)
Tallest (146.1 cm to tallest)	142	5.22 (4.29–6.15)	25.4 (18.11–32.69)
Demographic			
Age-group			
16–18 years	300	**4.51 (3.96–5.06)***	**24.3 (19.38–29.23)***
19–20 years	141	5.50 (4.57–6.43)	32.6 (24.92–40.28)
Residential location			
Regional	94	4.28 (3.47–5.09)	21.3 (13.03–29.57)
Rural/remote	347	4.97 (4.40–5.54)	28.5 (23.77–33.23)
Socio-economic			
Source of household income			
Job	52	4.52 (3.08–5.96)	23.1 (11.67–34.53)
Welfare	389	4.87 (4.36–5.38)	27.5 (22.97–32.03)
Household size			
Three or fewer people	52	4.13 (2.48–5.78)	23.1 (11.67–34.53)
Four or more people	369	4.93 (4.42–5.44)	27.6 (23.07–32.13)
Car ownership			
Yes	35	4.06 (3.25–4.87)	22.9 (8.91–36.89)
No	406	4.89 (4.30–5.48)	27.3 (22.97–31.63)
Car ownership by someone in household			
Yes	200	4.96 (4.25–5.67)	26.0 (19.89–32.11)
No	241	4.72 (4.09–5.35)	27.8 (22.09–33.51)

* $p<0.05$

Table 2. Mean DMFT of ABC study participants by diet and dental service utilisation factors

	n	*Mean DMFT* (95% CI)	*Prevalence of moderate/ severe periodontal disease*
Overall	441	4.83 (4.36, 5.30)	27.0 (22.86–31.14)
Diet			
Soft drink consumption			
Every day or a few times a week	304	**5.24 (4.67–5.81)***	-
Once a week or less often	137	3.91 (3.06–4.76)	-
Fruit juice consumption			
Every day or a few times a week	319	4.90 (4.33–5.47)	-
Once a week or less often	122	4.64 (3.75–5.33)	-
Cordial consumption			
Every day or a few times a week	288	5.07 (4.48–5.66)	-
Once a week or less often	153	4.38 (3.59–5.17)	-
Milk consumption			
Every day or a few times a week	305	4.71 (4.12–5.30)	-
Once a week or less often	136	5.10 (4.31–5.89)	-
Tea consumption			
Every day or a few times a week	317	5.05 (4.46–5.64)	-
Once a week or less often	124	4.25 (3.52–4.98)	-
Sugar taken with tea			
Yes	365	**5.07 (4.54–5.60)***	-
No	76	3.68 (2.71–4.65)	-
Fruit consumption			
Every day or a few times a week	288	4.70 (4.15–5.25)	-
Once a week or less often	153	5.05 (4.14–5.96)	-
Sweet consumption			
Every day or a few times a week	238	**5.54 (4.87–6.21)***	-
Once a week or less often	203	4.00 (3.35–4.65)	-
Dental service utilisation			
Previous dental visit	412	4.81 (4.32–5.30)	26.5 (2.17–30.83)
No previous dental visit	29	5.14 (3.25–7.03)	34.5 (17.16–51.84)

* $p<0.05$

Table 3. Mean DMFT of ABC study participants by dental behaviour and substance use factors (95% CI in parentheses)

	n	*Mean DMFT*	*Prevalence of moderate/ severe periodontal disease*
Overall	441	4.83 (4.36–5.30)	27.0 (22.86–31.14)
Dental behaviour			
Toothbrush ownership			
Yes	302	**4.43 (3.90–4.96)***	**19.9 (15.37–24.43)***
No	139	5.68 (4.71–6.65)	42.4 (34.13–50.67)
If yes, did brush teeth yesterday?			
Yes	219	4.49 (3.86–5.12)	18.7 (13.58–23.82)
No	85	4.35 (3.38–5.32)	23.5 (14.44–32.56)
If yes, what age when started to brush?			
When had little teeth	163	4.33 (3.64–5.02)	19.6 (13.49–25.71)
When had big teeth	128	4.62 (3.77–5.47)	18.8 (11.91–25.70)
If yes, do use toothpaste?			
Yes	292	4.52 (3.99–5.05)	-
No	10	1.80 (0.22–3.38)	-
Substance use			
Tobacco smoking	301	-	**29.9 (24.78–35.02)***
No tobacco smoking	123	-	18.7 (11.81–25.60)

* $p<0.05$

Table 4. Multivariate analysis for mean DMFT of ABC study participants

	Mean DMFT Unadjusted B (95% CI)	*Mean DMFT Adjusted B (95% CI)*	*Comparison reference*
Anthropometric			Middle to Tallest
Shortest to Middle (≤163.1 cm)	**1.17 (0.17–2.17)***	**1.02 (0.02–2.02)***	(>163.132 cm)
Demographic			
Age 16–18 years	0.99 (-0.03–2.01)	0.85 (-0.35–2.05)	19–20 years
Diet			
Soft drink consumption			
Every day or a few times a week	**1.34 (0.32–2.36)***	0.78 (-0.26–1.82)	Once a week or less
Do take sugar with tea?			
Yes	**1.38 (0.12–2.64)***	0.90 (-0.36–2.16)	No
Sweet consumption			
Every day or a few times a week	**1.54 (0.59–2.49)***	**1.08 (0.11–2.05)***	Once a week or less
Dental behaviour			
Toothbrush ownership, Yes	**1.25 (0.23–2.27)***	**0.80 (-0.22–1.82)***	No

* $p<0.05$

Table 5. Multivariate analysis for moderate/severe periodontal disease of ABC study participants

	Unadjusted Prevalence Ratios (95% CI)	*Adjusted Prevalence Ratios (95% CI)*
Anthropometric - Height		
Shortest (≤163.1 cm, >163.1 as reference)	**1.50 (0.90–1.92)***	**1.39 (0.96–1.82)***
Demographic - Age-group		
16–18 years (19–20 years as reference)	**0.75 (0.41–1.02)***	**0.82 (0.56–1.08)**
Dental behavior - Toothbrush ownership		
Yes (No as reference)	**0.47 (0.29–0.59)***	**0.50 (0.34–0.66)***
Substance use - Tobacco smoking		
Yes (No as reference)	**1.60 (0.92–1.75)***	1.36 (0.79–1.93)

* $p<0.05$

Discussion

The hypothesis that shorter participants in Wave-3 of the ABC study had higher levels of caries and periodontal disease was confirmed in the present study. Based on the literature, participant height at mean age 18 years may be considered a surrogate measure of early influences on growth and development, and of early childhood circumstances (Alvarez *et al*., 1993; Alvarez, 1995; Ayhan *et al*., 1996; El-Kashlan and Saleh, 1997; Li *et al*., 1996). It is tempting to conclude that taller participants had better oral health due to exposure to more oral health-promoting than oral health-damaging environments experienced along the life course (Barker, 1998). However, it is important to note that there were no associations between birth weight and intrauterine growth retardation measures, together with height at mean age 11 years, with oral health outcomes at mean age 18 years. Whilst one could argue that oral health manifestations associated with early life circumstances may not become apparent until young adulthood, it is clear that more research using prospective longitudinal birth cohort designs is required. It is also important to consider that height may be a surrogate marker of other causative factors not explored in the study.

Other factors associated with caries experience included regular consumption of sweets and non-ownership of a toothbrush. However, none of the social determinant measures persisted in the multivariate modelling. It could be that our group were too homogenous in this social determinant regard, or that other factors had greater influence in regards to caries outcomes. Nicolau *et al*. (2005) also found associations with oral health related-behaviours on dental caries, whilst Freire *et al*. (2008) noted a greater influence of social determinants.

The only factor that remained associated with periodontal disease in multivariate modelling was non-ownership of a toothbrush. Non-ownership of a toothbrush is problematic in remote Australian Indigenous communities, and may be a result of constant movement either between households within a given community or to environs beyond the community. Chronic overcrowding of households predisposes to non-ownership of a toothbrush, as does the high cost of toothbrushes and their nonavailability in some community stores (Jamieson *et al*., 2007). Oral hygiene may also not be a priority for some, for while toothbrush ownership and use is encouraged in many primary school settings in Indigenous Australian communities, there is no reinforcement for this once participants have ceased schooling.

The present findings corroborate the evidence that taller stature indicates early life advantages and better health outcomes, including oral health. As the study was carried out among young adults aged 16–20 years, height may identify individuals with the potential for better oral health throughout adulthood, which in turn may predispose to greater oral health-related quality of life and economic performance. It is important that these variables continue to be collected in future waves of the study, as the strength of the longitudinal design is that true causality can ultimately be determined.

The study has a number of limitations. One of the two dental examiners was aware of the study hypothesis. Whilst it was impossible for this examiner to be blinded to the main explanatory variable (height) when undertaking examinations, the utmost care was taken to ensure that no bias was introduced in the examination process. It is worth bearing in mind that the multidisciplinary nature of the study meant that time was extremely pressed when participants were seen, with multiple examinations being undertaken in a short amount of time. It was not possible to determine whether restorations were placed because of caries or whether or not a tooth was extracted due to pathology. However, it is important to point out that many participants in the study had irregular access to dental care and would almost always attend because of reasons owing to pain (that is, dental disease) than because of non-pathology. The consequences of using a partial recording system need also to be discussed, as there is some argument that disease may be missed. We elected to use two sites per tooth for our periodontal disease assessment due to time constraints, participant burden and evidence from the literature that two sites per tooth able to satisfactorily establish periodontal disease existence (Do *et al*., 2003).

Having 'seen a dentist before' may represent either preventive-oriented behaviour or be symptom-driven in relation to a dental problem. This was not accounted for in the analysis. It is also important to discuss that the proposed association may operate in either direction, or indeed be bidirectional. Tall stature may be a marker of early life advantage positively affecting dental health through one of the pathways discussed, but it is also possible that poor oral health may affect nutritional intake, or periods of systemic illness which in turn may negatively affect stature. A detailed life course epidemiology approach is required in order to disentangle the temporal relationships.

It is also important to describe the potential threats to the validity of our results emanating from the study design (prospective birth cohort) and conduct. Ideally, the sample would be representative of all Indigenous children born in Australia's Northern Territory during the recruitment phase, with height and dental outcomes measured during each of the study waves. That this was not done limits our ability to describe consequences such as direction of potential effect.

Acknowledgments

We thank the dedicated ABC research team who traced participants and assisted with organisation of follow-up, Andrew Lee who assisted with the dental examinations and especially the Aboriginal participants who agreed to be part of this study

References

Abolfotouh, M.A., Hassan, K.H., Khattab, M.S., Youssef, R.M., Sadek, A. and El-Sebaiei, M. (2000): Dental caries: experience in relation to wasting and stunted growth among schoolboys in Abha, Saudi Arabia. *Annals of Saudi Medicine* **20**, 360–363.

Alvarez, J.O. (1995): Nutrition, tooth development, and dental caries. *American Journal of Clinical Nutrition* **61**: 410S–416S.

Alvarez, J.O., Caceda, J., Woolley, T.W., Carley, K.W., Baiocchi, N., Caravedo, L. and Navia, J.M. (1993): A longitudinal study of dental caries in the primary teeth of children who suffered from malnutrition. *Journal of Dental Research* **72**, 1573–1576.

Ayhan, H., Suskan, E. and Yildirim, S. (1996): The effect of nursing or rampant caries on height, body weight and head circumference. *Journal of Clinical Pediatric Dentistry* **20**, 209–212.

Barker, D.J.P. (1998): *Mother, Babies and Health in Later Life*, 2nd edn. rev. p217. Edinburgh: Churchill Livingstone.

Cook, N.R., Hebert, P.R., Satterfield, S., Taylor, J.O., Buring, J.E. and Hennekens, C.H. (1994): Height, lung function, and mortality from cardiovascular disease among the elderly. *American Journal of Epidemiology* **139**, 1066–1076.

Davey Smith, G. (2002): The conundrum of height and mortality. *Western Journal of Medicine* **176**, 209.

Davey Smith, G., Hart, C., Blane, D. and Hole, D. (1998): Adverse socioeconomic conditions in childhood and cause specific adult mortality: prospective observational study. *BMJ* **316**, 1631–1635.

Do, L.G., Spencer, A.J., Roberts-Thomson, K.F., Ha, D.H., Tran, T.V. and Trinh, H.D. (2003): Periodontal disease among the middle-aged Vietnamese population. *Journal of the International Academy of Periodontology* **5**, 77–84.

El-Kashlan, M.K. and Saleh, S.M. (1997): Growth parameters and dental caries experience among preschool children. *Official Journal of the Egyptian Dental Association* **43**, 2183.

Freire, M.C., Sheiham, A. and Netuveli, G. (2008): Relationship between height and dental caries in adolescents. *Caries Research* **42**, 134-140.

Hebert, P.R., Rich-Edwards, J.W., Manson, J.E., Ridker, P.M., Cook, N.R., O'Connor, G.T., Buring, J.E. and Hennekens, C.H. (1993): Height and incidence of cardiovascular disease in male physicians. *Circulation* **88**, 1437–1443.

Jamieson, L.M., Armfield, J.M. and Roberts-Thomson, K.F. (2007): *Oral health of Aboriginal and Torres Strait Islander children*. Canberra: Australian Institute of Health and Welfare.

Li, Y., Navia, J.M. and Bian, J.Y. (1996): Caries experience in deciduous dentition of rural Chinese children 3–5 years old in relation to the presence or absence of enamel hypoplasia. *Caries Research* **30**, 8–15.

Lichtenstein, P., Harris, J.R., Pedersen, N.L. and Mc-Clearn, G.E. (1992): Socioeconomic status and physical health, how are they related? An empirical study based on twins reared apart and twins reared together. *Social Science and Medicine* **36**, 441–450.

Meisel, P., Kohlmann, T. and Kocher, T. (2007): Association of height with inflammation and periodontitis: the Study of Health in Pomerania. *Journal of Clinical Periodontology* **34**, 390–396.

Montgomery, S.M., Netuveli, G., Hildon, Z., Wiggins, R.D. and Blane, D. (2007): Does financial hardship at older ages eliminate the potential for better health? *Journal of Epidemiology and Community Health* **61**, 891–895.

Nicolau, B., Marcenes, W., Allison, P. and Sheiham, A. (2005): The life course approach: explaining the association between height and dental caries in Brazilian adolescents. *Community Dentistry and Oral Epidemiology* **33**, 93–98.

Northern Territory Department of Health and Community Services (1992): Annual Report. *1991/1992. Darwin: Government Printer of the Northern Territory.*

Osika, W., Ehlin, A. and Montgomery, S.M. (2006): Does height modify the risk of angina associated with economic adversity? *Economics and Human Biology* **4**, 398–411.

Page, R.C. and Eke, P.I. (2007): Case definitions for use in population-based surveillance of periodontal disease. *Journal of Periodontology* **78**, 1387–1399.

Power, C. and Matthews, S. (1997): Origins of health inequalities in a national population sample. *Lancet* **350**, 1584–1589.

Psoter, W.J., Reid, B.C. and Katz, R.V. (2005): Malnutrition and dental caries: a review of the literature. *Caries Research* **39**, 441–447.

Sayers, S., Mackerras, D., Halpin, S. and Singh, G. (2007): Growth outcomes for Australian Aboriginal children aged 11 years who were born with intrauterine growth retardation at term gestation. *Paediatric and Perinatal Epidemiology* **21**, 411–417.

Song, Y.M., Smith, G.D. and Sung, J. (2003): Adult height and cause-specific mortality: a large prospective study of South Korean men. *American Journal of Epidemiology* **158**, 479–485.

Terrell, T.R. and Mascie-Taylor, C.G.N. (1991): Biosocial correlates of stature in a 16-year-old British cohort. *Journal of Biosocial Science* **23**, 401-408.