The Overtime Effect of Social Position on Dental Caries Experience in a Group of Old-Aged Danes Born in 1914

Ulla Krustrup, DDS, MPH, PhD; Poul Holm-Pedersen, DDS, Dr Odont; Poul Erik Petersen, DDS, Dr Odont, BA, MSc; Rikke Lund, MD, PhD; Kirsten Avlund, PhD, DrmedSci

Abstract

Objectives: *The purpose of this study was to analyze the life-course effects of education, occupation, and income at ages 70, 75, 80, and 85 years, respectively, on dental caries experience of 85-year-olds.* ***Methods:*** *The present study includes follow-up data from a population-based study, which comprised a sample of 176 individuals aged 85 years. Data on social position were collected at ages 70, 75, 80, and 85 years by means of structured personal interviews. Clinical oral health examinations were conducted to obtain data on dental caries at age 85. Dental caries was recorded at tooth surface level and caries experience was expressed by the DMF Index: the decayed tooth surfaces (D component), missing tooth surfaces (M component), and filled tooth surfaces (F component).* ***Results:*** *The participants in the present study demonstrated a high level of dental caries experience; the prevalence rate for active dental caries (D-S) was 80 percent. Older adults with low education, low occupational status, and poor income tended to have more active dental caries compared to their counterparts. In contrast, individuals with high education (F-S = 35.5) and high occupational status (F-S = 36.0) had significantly more filled surfaces than persons with low education (F-S = 24.0) and low occupational status (F-S = 25.6). Individuals with high income at ages 75, 80, and 85 years had more filled surfaces (F-S = 31.9, 33.2, 34.1) compared to persons with low income (F-S = 25.5, 23.5, 22.8).* ***Conclusion:*** *The study identified social inequalities across age among the very old individuals in relation to dental caries experience.*

Key Words: dental caries experience, older adults, social position, education, occupation, income

Introduction

Oral health status in old age reflects the accumulated results of oral diseases during the life course. In Denmark, oral health of the older population is generally poor, although with sociodemographic variations (1,2). Despite a decline in edentulousness during the past three decades among older adults (1,3-6), levels of dental caries and periodontal disease remain high (2). Among the older population in Denmark, the current decayed + missed + filled tooth surfaces (DMF-S) is between 100 and 120, which is similar to the level of dental caries seen among older persons three decades ago (2) and consequently a continuous problem in the older population.

The number of older adults is increasing worldwide (7) and the global burden of oral disease among older people is high (8,9). It is estimated that the number of 85-year-old Danes will increase by 50 percent toward the year 2030 (10). As in other Scandinavian countries (11,12), an increasing number of older individuals in Denmark retain natural teeth; meanwhile, dental caries experience and the prevalence of periodontal disease have apparently not declined.

Oral health status among older adults is highly related to social position. Numerous studies show that individuals in disadvantaged socioeconomic groups have fewer teeth and high dental caries experience compared to persons in high socioeconomic groups (1-5,13). In a study of edentulousness among older Danes aged 65 years and over, the social gradient expressed by education remained stable when measured in 1994 and again in 2000 (1). The analyses of the relationship between social position and oral health in old age are complex (14). Social position in old age may be measured by several indicators, each relating to different stages of the life course (e.g., education, occupation, present income). Thus, studies on the association between indicators of social position, representing different stages throughout the life course and oral health in old age, may add to understanding the mechanisms in social inequality and oral health.

Most studies of the association between dental caries and social position have been conducted as cross-sectional surveys (1-5). The relationship between the effects of social position on dental caries has

Send correspondence and reprint requests to Ulla Krustrup, Department for Community Dentistry and Graduate Studies, Centre for Health and Society, School of Dentistry, Faculty of Health Sciences, University of Copenhagen, Oester Farimagsgade 5, P.O. Box 2099, DK-1014 Copenhagen K, Denmark. Tel.: +45-35-32-67-97; Tel/Fax: +45-35-32-67-99; e-mail: uk@odont.ku.dk. Ulla Krustrup and Poul Erik Petersen are with University of Copenhagen, Faculty of Health Sciences, School of Dentistry, Department for Community Dentistry and Graduate Studies, Copenhagen, Denmark. Ulla Krustrup and Poul Holm-Pedersen are with the University of Copenhagen, Faculty of Health Sciences, School of Dentistry, Copenhagen Gerontological Oral Health Research Centre, Copenhagen, Denmark. Rikke Lund and Kirsten Avlund are with the University of Copenhagen, Faculty of Health Sciences, Institute of Public Health, Department of Social Medicine, Copenhagen, Denmark. Kirsten Avlund is with the Research Centre for Prevention and Health, Glostrup University Hospital, Denmark. **Source of support:** The study was supported by a grant from the Velux Foundation. Manuscript received: 1/4/07; accepted for publication: 7/2/07.

DOI: 10.1111/j.1752-7325.2007.00058.x

seldom been studied among older people where it is possible to investigate whether social position throughout life affects dental caries in old age. Meanwhile, it is important to ascertain distal and proximal risk factors in dental caries at old age in order to organize appropriate intervention programs.

An understanding of how the basic causes or social structures impact on oral health and disease is essential (15). In the present study, causal mechanisms will be highlighted in the analysis of the relationships between measures of social position and dental caries. The purpose of this study was to analyze the life-course effect of social position as measured by education, occupation, and income at ages 70, 75, 80, and 85 years, respectively, on dental caries experience of 85-year-olds.

Methods

The study is part of the longitudinal studies of the 1914 birth cohort in Glostrup, Denmark (The Glostrup Ageing Study) conducted by the Research Centre for Prevention and Health, Glostrup University Hospital, Glostrup, Denmark (16). The baseline survey used in this report took place in 1984 and included 734 70-year-old men and women. Follow-up studies were undertaken when the participants were 75 years ($n = 576$), 80 years ($n = 365$), and 85 years ($n = 182$) (16). All studies included a health examination and a home visit for interviews about social position, psychosocial factors, and functional ability. The 15-year follow-up (at age 85) also included a clinical oral health examination. The present study is based on those persons who participated in the 70-, 75-, and 80-year studies and in the oral health part of the 85-year study in 2000 ($n = 176$). The participation rate was 96.7 percent, calculated on the basis of those in the follow-up studies and not on the baseline survey of 1984.

Data Collection. Prior to the investigation, the Ethical Committee for Science of the County of Copenhagen approved the research procedures (16).

Clinical examinations were performed by one dentist assisted by a dental nurse and carried out in the homes of the participants. Clinical registrations were based on the methodology and the diagnostic criteria defined by the US National Institute of Dental and Craniofacial Research (17). The examinations were performed using mobile equipment, including fiber optic light and mirrors. A standardized dental explorer was used. Teeth were dried using air syringe, saliva ejector, and cotton rolls. Radiographs were not obtained because of ethical and practical reasons. Prior to the survey, the examining dentist was calibrated by an experienced clinical examiner (P. H. P.) and the interexaminer kappa statistic was 86 percent. Further details regarding the clinical oral health study have been published elsewhere (18).

Measures of Social Position. Social position is measured by different indicators that express social position at different life stages: a) education, describes social position in early adult life; b) occupation, describes social position in midlife; and c) income, is measured both at age 70, 75, 80, and 85 years and thus expresses material wealth in different stages of aging and present material wealth (at age 85 years). Also, included is a measure of accumulated material wealth during 15 years of old age (high income at age 70, 75, 80, or 85 years).

Education (vocational training only) was measured by questionnaire in the 70-year study as an indicator of social position early in adult life and the variable was dichotomized into less than 3 years versus 3 years or more. Vocational training is defined as education after completion of school years. The 3-year cut point is between basic vocational, upper secondary, general secondary, and higher education of short, medium, or long duration. Occupation was reported in the 75-year study and was defined by the last held position and categorized into self-employed, high managerial, low managerial, skilled worker, unskilled worker, persons on disability retirement, and housewives. Because of the small sample size, these categories were subsequently redefined into two groups: a) self-employed, high + low managerial positions and b) skilled and unskilled workers, persons on disability pension, and housewives. Actual income was registered as either having high income (income sources in addition to old-age pension) or low income (compulsory old-age pension only). Income was measured at four different points in time: at age 70, 75, 80, and 85 years. Moreover, accumulated income from age 70 to 85 years was categorized into a) high income at all ages 70, 75, 80, and 85 years; b) one low income at either age 70, 75, 80, or 85 years; c) two low incomes at either age 70, 75, 80, or 85 years; and d) three low incomes at 70, 75, 80, or 85 years. Because of the small number of participants, gender was included in multivariate analyses as a covariate rather than performing stratified analyses.

Measures of Dental Caries. Dental caries (either crown or root) was recorded at tooth surface level, and caries experience was measured by the DMF Index. The decayed tooth surfaces (D-S) component expresses tooth surfaces with active dental caries; the missing tooth surfaces (M-S) component includes all tooth surfaces missing because of caries or missing because of other causes; and the filled tooth surfaces (F-S) component indicates tooth surfaces filled or restored because of dental caries. The DMF-S Index measures lifetime accumulated dental caries experience, and the bases for the DMF-S calculations were 32 teeth, i.e., all teeth including third molars (19).

Statistical Analysis. Bivariate analysis and multivariate linear regression were conducted. Means were calculated for the number of tooth surfaces affected by caries, and mean values were evaluated statistically by Student's *t*-test or analysis of variance. Data were

Table 1
Dental Caries Experience (mean D-S, F-S, M-S, and DMF-S) among 85-Year-Old Danes in Relation to Vocational Education, Occupation, and Income (n = 176) (95% Confidence Interval in Parentheses)

	Dentate participants (n = 104)			All participants (n = 176)		
	n	D-S	F-S	n	M-S	DMF-S
Vocational education†						
≥3 years full time	61	8.4 (6.0-10.9)	35.5* (29.3-41.7)	87	101.3 (92.1-110.5)	132.3 (127.2-137.4)
<3 years	37	9.2 (4.8-13.7)	24.0 (18.0-30.0)	73	121.3* (113.3-129.4)	138.3 (133.9-142.8)
Occupation†						
High + low managerial	54	8.3 (5.4-11.4)	36.0* (29.1-42.9)	76	98.7 (88.7-108.8)	130.6 (125.0-136.1)
Skilled + unskilled workers, disability pensioners, housewives	30	10.4 (5.7-15.0)	25.6 (18.8-32.4)	67	123.4* (115.2-131.6)	140.2* (136.0-144.3)
Income at age 70, 75, 80, 85†						
Never	59	9.0 (5.8-12.3)	34.4 (28.2-40.6)	89	104.9 (95.9-114.0)	133.9 (129.1-138.6)
Once low income	20	8.1 (4.7-11.5)	29.6 (18.4-40.7)	32	109.8 (94.8-124.8)	133.5 (125.0-142.0)
Twice low income	13	6.9 (4.1-9.7)	18.3 (7.6-29.0)	28	129.9* (118.5-141.3)	141.0 (134.8-147.1)
Three times low income	12	9.7 (1.2-18.1)	29.2 (12.4-45.9)	20	118.4 (103.0-133.9)	138.0 (130.2-145.8)
Income at 70						
High	94	8.5 (6.2-10.8)	29.7 (24.9-34.6)	159	112.4 (106.0-118.8)	135.2 (131.8-138.7)
Low	10	10.2 (5.2-15.2)	41.2 (25.8-56.6)	17	109.5 (89.0-130.0)	139.7 (133.2-146.2)
Income at 75						
High	87	8.5 (6.2-10.8)	31.9 (26.8-36.9)	139	109.4 (102.4-116.4)	134.8 (131.2-138.4)
Low	17	9.4 (3.7-15.1)	25.5 (13.4-37.6)	37	122.5 (110.6-134.5)	138.8 (132.2-145.3)
Income at 80						
High	79	8.9 (6.4-11.5)	33.2 (27.9-38.4)	123	107.4 (99.9-114.9)	134.6 (130.6-138.6)
Low	25	7.8 (3.8-11.8)	23.5 (13.7-33.2)	53	123.2* (113.4-133.0)	138.1 (133.0-143.3)
Income at 85						
High	74	9.0 (6.4-11.7)	34.1* (28.6-39.6)	115	106.4 (98.6-114.3)	134.6 (130.3-138.4)
Low	30	7.8 (4.2-11.4)	22.8 (14.6-31.1)	61	123.0* (114.1-131.8)	138.1 (133.1-143.2)
All	104	8.7 (6.5-10.8)	30.8 (26.2-35.5)	176	112.2 (106.1-118.2)	135.7 (132.5-138.8)

* Statistically significant finding ($P < 0.005$).
† Because study participants failed to respond, there are missing cases for vocational education, occupation, and income.
D-S, decayed tooth surfaces; F-S, filled tooth surfaces; M-S, missing tooth surfaces; DMF-S, decayed + missing + filled tooth surfaces.

processed and analyzed using the Statistical Package for the Social Sciences (SPSS 14.0, SPSS, Inc., Chicago, IL, USA). The dependent variables introduced in the linear regression model were D-S, F-S, M-S, and DMF-S. In Table 2, D-S and F-S (Model 1) were analyzed including education, occupation, income at 85 years, and gender as independent variables. In Table 3, M-S (Model 1) was analyzed including education, occupation, accumulated income, and gender. In Model 2, accumulated income was substituted with actual income measured at the different points in time. DMF-S was analyzed including education, occupation, accumulated income, income at 80 and 85 years, and gender. The variables in the linear regression analysis were chosen to evaluate whether a causal relationship exists between dental caries experience and social position.

Results

Dental Caries Experience (DMF-S). The bivariate analyses of DMF-S (Table 1) demonstrate a tendency of higher DMF-S for low educated persons and for persons with low income, but these results were not statistically significant. However, the bivariate analysis of the DMF-S showed that significantly higher DMF-S was found for skilled and unskilled workers, disability pensioners, and housewives. This association disappeared in the multivariate linear regression analysis (Table 3).

In the following analyses, the DMF-S Index was broken down into the components D-S, F-S, and M-S used as outcome variables.

Decayed Tooth Surfaces (D-S). A relatively high level of active dental caries was found. Almost 80 percent had at least one tooth surface with active dental caries on either crown or root. The associations between education, occupation, and income with active dental caries (D-S) are presented in Table 1. No associations were found between the social position variables and number of decayed tooth surfaces (D-S), but there was a tendency of more active dental caries among persons with low education; among skilled and unskilled workers, disability pensioners, and housewives; among persons with accumulated low income three times from age 70 to 85 years; and among persons with low income at age 70 and 75 years; however, these results were not statistically signifi-

Table 2
Bivariate Analysis of Dependent Variable D-S, and Bivariate and Multivariate Linear Regression Analysis of Dependent Variable F-S for Dentate 85-Year-Old Danes (n = 104) (95% Confidence Interval in Parentheses)

	D-S	F-S	
	Bivariate mean	Bivariate mean	Multivariate b Model 1†
Vocational education			
<3 years	0.8 (−3.9-5.4)	−11.5 (−20.6-(−2.3))*	−11.9 (−25.2-1.4)*
Skilled + unskilled workers, disability pensioners, housewives	2.0 (−3.2-7.2)	−10.4 (−20.7-(−0.1))*	−5.7 (−16.8-5.4)
Income at 85 years			
Low	−1.3 (−6.0-3.4)	−11.2 (−21.21-(−1.3))*	−7.0 (−18.8-4.7)
Gender			
Women	1.2 (−3.1-5.5)	6.4 (−2.9-15.7)	10.3 (−0.4-20.9)
R^2	–	–	0.134

* Statistically significant finding ($P < 0.05$).
† Model 1: adjusted for social position variables and gender.
D-S, decayed tooth surfaces; F-S, filled tooth surfaces.

cant. Similarly, the bivariate analysis showed no significant results (Table 2).

Filled Tooth Surfaces (F-S). The bivariate analyses in Table 1 showed that older adults with low education and low occupational status had significantly fewer filled tooth surfaces compared to those with some education and higher occupational status. Also, significantly more filled tooth surfaceswere seen among participants with high income at age 85. In Model 1 (Table 2), the associations of occupation and income with filled surfaces were attenuated when adjusted by the other variables while education remained significant.

Missing Tooth Surfaces (M-S). The bivariate analysis revealed that relatively more missing tooth surfaces were found among persons with low education; among skilled and unskilled workers, disability pensioners, and housewives; among persons with accumulated low income twice at either age 70, 75, 80, or 85 years; and for persons with low income at ages 80 and 85 years (Table 1). When introducing the independent variables into the multivariate analyses (Model 1 + 2) (Table 3), occupation was significantly associated with missing tooth surfaces, whereas the associations for the other social position variables became insignificant (Table 3).

Discussion

The present study indicates that oral disease is associated with measures of social position in a group of very old individuals. Persons with low social positions tended to have more tooth surfaces with active dental caries, significantly more missing tooth surfaces, and fewer tooth surfaces with dental fillings compared to persons in higher social positions. Data on dental caries were only obtained at age 85 years, which do not allow the analysis of the incidence of dental caries.

There are some limitations to the present analysis that have to be considered. The study has a small number of participants, which has an impact on the external validity of the findings. The participants comprised predominantly of healthy community-dwelling older adults, and it could be assumed that community-dwelling individuals possess better functional abilities in maintaining oral health compared to institutionalized individuals who may depend on caregivers or nursing personnel in dental care. Additionally, premature death among older adults linked with poor oral health may also be considered a factor leading to selection bias. In the present study, the high dropout in the follow-up is therefore explained by mortality and the high age-related morbidity. This resulted in reduced participation from the 735 participants at age 70 to 182 participants at age 85 years, and the sample size has limited the complexity of the analyses possible to conduct.

However, it should be taken into account that the overtime data presented in the current study are difficult and expensive to obtain. Despite the limitations imposed by the sample size, the results nevertheless show significant associations between dental caries experience and social position among the old-aged participants. Dental caries could have been experienced at a young age for several participants and therefore, it cannot be stated that the observed experience of caries is because of the effect of the social factors studied. Additionally, other social norms in terms of not seeking dental health care services when needed should be taken into account. Unfortunately, information on lifetime dental visiting habits was not available.

The data on dental caries experience were collected following the criteria defined by the National Institute of Dental and Craniofacial Research (NIDCR) (17), and according to the NIDCR diagnostic criteria, remaining roots were recorded as coronal caries for all surfaces. This may result in some inaccuracy in the number of decayed coronal tooth surfaces. However, in most studies of dental caries, there is a risk of underestimating the level of disease because of the field conditions. Accordingly, in the present study, the level of dental caries experience is most probably underestimated not only because of the difficulties in the examination procedures but also because of the lack of radiographs for identification of proximal lesions. The DMF Index was constructed and in agreement with the recommenda-

Table 3
Bivariate Effects and Multivariate Linear Regression Analysis of Dependent Variables M-S and DMF-S for All 85-Year-Old Danes (n = 176) (95% Confidence Interval in Parentheses)

	M-S			DMF-S	
	Bivariate mean	Multivariate b		Bivariate mean	Multivariate b
		Model 1†	Model 2‡		
Vocational education					
<3 years	20.0 (7.6-32.4)	12.7 (−2.6-28.0)	11.9 (−3.7-27.6)	6.0 (−0.8-12.9)	2.1 (−6.4-10.5)
Occupation					
Skilled + unskilled workers, disability pensioners, housewives	24.7 (11.6-37.8)*	19.2 (4.4-33.9)*	19.3 (4.4-34.2)*	9.6 (2.6-16.7)*	7.7 (−0.4-15.8)
Income at age 70, 75, 80, 85 years					
Three times low income	7.1 (1.8-12.4)*	3.8 (−2.6-10.2)		2.1 (−0.7-4.9)	1.4 (−2.2-4.9)
Income at 80 years					
Low	15.8 (2.8-28.9)*		6.5 (−12.6-25.7)	3.5 (−3.4-10.4)	
Income at 85 years					
Low	16.5 (4.0-29.1)*		4.8 (−13.0-22.6)	3.8 (−2.9-10.4)	
Gender					
Women	−1.1 (−13.5-11.2)	−9.3 (−23.7-5.1)	−8.7 (−23.5-6.1)	1.8 (−4.7-8.3)	0.7 (−7.3-8.6)
R^2	–	0.150	0.151	–	0.052

* Statistically significant finding ($P < 0.05$).
† Model 1: adjusted for income at different ages and gender.
‡ Model 2: adjusted for income at 80 and 85 years and gender.
M-S, missing tooth surfaces; DMF-S, decayed + missing + filled tooth surfaces.

tions of the World Health Organization (WHO) for oral health surveys (20). The M component includes surfaces missing because of any reason, i.e., dental caries, periodontal disease, prosthetic treatment, or aplasia. This may result in some information bias (2), but the potential error is probably small in populations with high caries prevalence (20). Furthermore, old-aged persons were previously exposed to more radical dental treatment as tooth extraction was conventional dental procedure in case of dental decay. Finally, the underestimation of the F component may occur, as composite fillings may be difficult to distinguish from the natural tooth color.

The DMF Index was used for the assessment of dental caries experience as recommended by the WHO (20). The present results indicate that it gives valuable information to split the DMF-S Index into separate components (D-S, M-S, and F-S), when the focus is on social position in dental caries. The effects of the social position variables on D-S and F-S go in opposite directions; the well-off persons have little active dental caries but many tooth fillings. This is similar to the findings from other studies (2,3).

Dental caries experience found in the study population is relatively high; almost 80 percent of the dentate participants had active dental caries (D-S) on either crown or root. DMF-S was also considerably higher compared to an earlier study carried out in Denmark on old-aged Danish pensioners (67+ years) (21). Overall, the level of dental caries experience is much higher than found among very old (80+ years) community-dwelling persons in Sweden (12). Dental caries experience appears thus to be a serious public health problem among old-aged Danish individuals.

Old persons with less than 3 years of vocational education, skilled and unskilled workers, disability pensioners and housewives, and persons with low income at age 70 and 75 years have a relatively high level of active dental caries (D-S). More active dental caries among individuals in disadvantaged social groups might be explained by reluctance to receiving restorative dental treatment because of high costs of dental care. This group of susceptible persons is not covered by insurance or any public assistance. Only a limited group of the very weak individuals including old-aged persons are offered almost free public dental treatment.

Furthermore, in this study, the M-S component is relatively high particularly among individuals with low social position, and this observation is concordant with results reported in previous studies (2,3,5). A preference of more radical dental treatment in terms of tooth extractions could explain that missing teeth is more prevalent in disadvantaged social groups, because this is a low-cost dental treatment in Denmark. In addition, the choice of radical dental treatment might also rely on past dental treatment traditions where tooth extraction was the acknowledged dental treatment procedure in case of pain or symptoms.

A large number of national and international studies have shown that dental caries in adults is closely linked to social position (1-5,13). Studies have focused on different age groups, but evidence of an associa-

tion between social position and dental caries experience among very old persons in the population is limited (22). In the present paper, social risk factors, in terms of education, occupation, accumulated income from 70 to 85 years, and income at different points in time (70, 75, 80, and 85 years), were studied to investigate whether an association between social position and dental caries was consistent over time among the very old-aged persons. Education is used as a measure of social position early in life. Educational level predicts occupation in future life, as higher education generally results in better jobs in terms of better working conditions, higher income level, and better housing conditions (23). It would have improved the information on education if more categories were available and also if information was present regarding the participants' years of school education. The present findings showed that persons with more than 3 years full-time education had more filled tooth surfaces, which is in agreement with the results from a Danish study of 65- to 74-year-olds (2) and in agreement with results from surveys conducted in other industrialized countries (24). The findings from the present study, i.e., persons with high education have received significantly more fillings compared to persons with low education, could be explained by social norms in relation to oral health care. For example, several studies have shown that persons with high education make use of dental services more often compared to less educated persons (1,3-5,23,25,26). A positive oral health behavior among highly educated persons is generally found, possibly because these persons are more likely to seek information about health as well as seek help from health professionals. Furthermore, it is noteworthy that education early in life had an effect on old-age dental caries experience, which is a measure of accumulated disease throughout life.

Information about occupation for the study participants was collected on the basis of last held occupation. Occupation could be looked upon as a structural link between education and income. Educational level influences the employment acquired and this employment then determines the level of income (14). In the present study, bivariate and multivariate analyses showed an association between F-S, M-S, and DMF-S and occupation. Similar results were found in other studies (2,3).

Unfortunately, no comparable Danish studies are available showing parallel associations among very old persons. Thus, this study shows social inequalities in dental caries experience in very old-aged persons, and education and occupation seem to be strong indicators of relationships between social position and dental caries.

Studies on life-course effect of social position on dental caries at old age are very limited. This paper considers how some distal social determinants of dental caries operate; however, the complex causal web is still to be explored. In conclusion, the study revealed an association between education, occupation and income, and dental caries experience. The group of older adults may not have benefited from systematic oral health care during their lifetime and the social inequality found calls for the establishment of community-based programs to meet the needs of improvement of oral health among older adults.

Acknowledgment

The study was supported by the Velux Foundation.

References

1. Petersen PE, Kjøller M, Christensen LB, Krustrup U. Changing dentate status of adults, use of dental health services, and achievement of national dental health goals in Denmark by the year 2000. J Public Health Dent. 2004;64:127-35.
2. Krustrup U. Clinical-epidemiological study of oral health among adults in Denmark 2000/2001 [Phd thesis]. Copenhagen, Denmark: University of Copenhagen; 2004.
3. Petersen PE. Dental visits, dental health status and dental treatment needs among workers and staff members of a Danish shipyard. Odense: Odense University Press; 1981.
4. Christensen J. Oral health status of 65- to 74-year-old Danes: a preliminary report of the replication of W.H.O.'s international collaborative study in Denmark. J Dent Res. 1977;56:149-53.
5. Kirkegaard E, Borgnakke WS, Grønbæk L. Oral health status, dental treatment need, and dental care habits in a representative sample of the adult Danish population. Survey of oral health of Danish adults. Aarhus: Dental Colleges of Copenhagen and Aarhus; 1982.
6. Grabowski M, Bertram U. The oral status and dental treatment needs of the older population in West Zealand County. Dan Dent J. 1976;80:1-7.
7. UN. World population ageing. 1950-2050. New York: United Nations; 2002.
8. Petersen PE, Yamamoto T. Improving the oral health of older people: the approach of the WHO Global Oral Health Programme. Community Dent Oral Epidemiol. 2005;33:81-92.
9. Lamster IB. Oral health care services for older adults: a looming crisis. Am J Public Health. 2004;94:699-702.
10. Statistics Denmark. StatBank Denmark [database on the Internet]. Copenhagen, Denmark: Internet Communication; 2005. [cited 2006 Oct 10]. Available from: www.dst.dk.
11. Ainamo A, Osterberg T. Changing demographic and oral disease patterns and treatment needs in the Scandinavian populations of old people. Int Dent J. 1992;42:311-22.
12. Morse DE, Holm-Pedersen P, Holm-Pedersen J, Katz RV, Viitanen M, von Strauss E, Winblad B. Dental caries in persons over the age of 80 living in Kungsholmen, Sweden: findings from the KEOHS project. Community Dent Health. 2002;19:262-7.
13. Antoft P, Rambusch E, Antoft B, Christensen HW. Caries experience, dental health behaviour and social status – three comparative surveys among Danish military recruits in 1972, 1982 and 1993. Community Dent Health. 1999;16:80-4.
14. Avlund K, Holstein BE, Osler M, Damsgaard MT, Holm-Pedersen P, Rasmussen NK. Social position and health in old age: the relevance of different indicators of social position. Scand J Public Health. 2003;31:126-36.
15. Newton JT, Bower EJ. The social determinants of oral health: new approaches to conceptualizing and researching complex causal networks. Community Dent Oral Epidemiol. 2005;33:25-34.
16. Avlund K. Disability in old age. Longitudinal population-based studies of the disablement process. Dan Med Bull. 2004; 51:315-49.
17. United States Department of Health and Human Services. Oral Health of United States Adults. The national survey of oral health in U.S. employed adults and seniors: 1985-6, national findings. Bethesda, MD: US Department of Health and Human

Services, Public Health Service: 1987. Publication No. 87-2868.
18. Vilstrup L, Holm-Pedersen P, Mortensen EL, Avlund K. Dental status and dental caries in 85-year-old Danes. Gerodontology. 2007;24:3-13.
19. Hunt R, Beck J. Methodological considerations in a dental epidemiologic survey of an elderly population. J Public Health Dent. 1985;45:257-60.
20. World Health Organization. Oral health surveys – basic methods. 4th ed. Geneva: World Health Organization; 1997.
21. Petersen PE, Nørtov B. Evaluation of a dental public health program for old-age pensioners in Denmark. J Public Health Dent. 1994;54:73-9.
22. Avlund K, Holm-Pedersen P, Morse DE, Viitanen M, Winblad B. The strength of two indicators of social position on oral health among persons over the age of 80 years. J Public Health Dent. 2006;65: 231-9.
23. Lynch J, Kaplan G. Socioeconomic position. In: Berkman LF, Kawachi I, editors. Social epidemiology. Oxford: Oxford University Press; 2000. p. 13-35.
24. Hescot P, Bourgeois D, Berger P. Le programme international de recherche de l'Organisation Mondiale de la Santé sur les déterminants et la santé buccodentaire. La situation en France pour la période 1993-1995. Londres: FDI World Dental Press Ltd.; 1996.
25. Petersen PE. Social inequalities in dental health – towards a theoretical explanation. Community Dent Oral Epidemiol. 1990;18:153-8.
26. Petersen PE, Aleksejuniene J, Christensen LB, Eriksen HM, Kalo I. Oral health behavior and attitudes of adults in Lithuania. Acta Odontol Scand. 2000;58: 243-8.