

ORIGINAL ARTICLE

## Edentulism associated with obesity: a study of four national surveys of 16 416 Swedes aged 55–84 years

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### Abstract

**Objective.** To investigate the association between edentulism and obesity in the Swedish population aged 55–84 years over a 22-year period as a result of changes in health and socio-economic factors. **Material and methods.** Subjects aged 55–84 years ( $n = 16\,416$ ) were randomly sampled from the Swedish population by Statistics Sweden on four occasions (1980–81, 1988–89, 1996–97 and 2002). Trained interviewers collected information about dental status and anthropometric, demographic, socio-economic, lifestyle and health-related factors. Statistical analyses were based on logistic regression models. **Results.** Edentulism decreased from 43% to 14% in the age group 55–84 years from 1980 to 2002, and the proportion of subjects with removable dentures decreased from 68% to 33%. In the age group 55–74 years, the proportion of subjects with low education decreased from 60% to 28%, and the proportion of obese subjects (body mass index  $\geq 30$  kg/m<sup>2</sup>) increased from 9% to 15%. In women aged 55–74 years, the association between obesity and edentulism, adjusted for health, lifestyle and socioeconomic factors, was significant in all surveys, and the odds ratio for obesity changed from 1.64 (95% confidence interval 1.18–2.27) in 1980 to 3.17 (95% confidence interval 1.69–6.18) in 2002. In men, the association was weaker and was significant only in the sample that combined all surveys and included individuals aged 55–84 years. **Conclusion.** The study indicated an association between edentulism and obesity, which was most obvious in women aged 55–74 years.

**Key Words:** *Body mass index, lifestyle, population study, secular change, socio-economic*

### Introduction

Dental health has improved in many countries during the latter part of the twentieth century [1–3]. At the same time, the absolute and relative numbers of elderly people are increasing. Dental status is related to nutrition, health, dental care, socio-economic factors and lifestyle factors, such as smoking [4–13]. Studies have shown secular trends of weight gain and increasing obesity in Scandinavian and other European populations [14–19]. These and other studies also suggested that obesity was associated with demographic, socio-economic and lifestyle factors [16–21]. Obesity is an increasingly serious health problem in Western countries, as it is associated with diabetes and cardiovascular diseases [20,21].

Studies of the association between dental status and body weight in elderly people have not produced conclusive results [22–24]. Some studies have

shown that tooth loss is associated with weight gain and obesity in older people [25–28]. In a population study of elderly people there was an association, independent of background characteristics, between higher waist circumference and number of remaining teeth [4].

In Sweden, a population study on subjects aged 16–84 years during the 1980s found that dentures were more common in overweight and obese subjects [29].

In another study among Swedish women, higher body mass index (BMI) was independently associated with lower number of teeth [30].

Statistics Sweden performs regular investigations of living conditions in the population. Based on these investigations it is possible to study the time trends of obesity, edentulism and the association between obesity and edentulism at different times.

The aim of this study was to investigate the association between edentulism and obesity in four

national samples investigated over a period of 22 years, together consisting of 16 416 Swedish men and women aged 55–84 years.

## Material and methods

Statistics Sweden investigates the living conditions of the Swedish population. These annual investigations, which started in 1974, are based on interviews about welfare components, such as health, occupation, education, housing conditions and social network and support. The sampling and performance of the investigations have been published elsewhere [31]. The present study combines data from the surveys of 1980–81, 1988–89, 1996–97 and 2002, which included questions about dental status. The samples were drawn systematically from the register of the entire Swedish population in the age group 16–84 years in the investigations carried out in 1980–81 and 1996–97 and in all age groups  $\geq 16$  years of age in 1988–89 and 2002. The sample sizes and age distributions of the participants in the present study are given in Table I.

Altogether, 16 416 subjects participated. The participation rate in the separate surveys varied between 75% and 86%, with small differences between age groups [31]. Owing to some internal non-response the number of individuals varied somewhat in the analyses.

Trained persons from Statistics Sweden performed the interviews. Information about dental status was obtained using the following questions: “Do you have your own natural teeth only or do you have removable dentures?” The answers were classified in accordance with one of the following alternatives: dentate or edentulous.

Anthropometric data were based on the self-reported body height and weight of the participants. Obesity was defined as BMI  $\geq 30$  kg/m<sup>2</sup>. Demographic, socio-economic, lifestyle and health-related factors that may have an influence on the association between

dental status and obesity were included in the analyses. The covariates included in the analyses were coded as follows: marital status (not married, married), education (elementary school, more than elementary school), occupation (blue-collar worker, white-collar worker), economic problems (no, yes), native-born (no, yes), urbanization (living in cities or large municipalities versus rural areas), smoking habits (never smoker, previous smoker, current smoker), feeling healthy (no, yes), chronic disease or handicap (no, yes), regular physical activity (no, yes; not recorded for the age group 75–84 years in the 1980–81 investigation). In the interviews, no questions were asked about dietary habits.

### Statistical analyses

All statistical tests were based on binary logistic regression models with obesity as the outcome, using odds ratios (ORs) as effect measures. Significance is reported as *P*-value with 95% confidence interval (CI). *P* < 0.05 was considered significant. The associations between obesity and covariates were adjusted for the age of the subject and the year of investigation. For the analyses of the association between obesity and edentulism using logistic regression models with obesity as the outcome variable, the following covariates were included: age, year of investigation, education, occupation, economic problems, native-born, urbanization, smoking habits, feeling healthy, chronic disease or handicap, regular physical activity and body height. The analyses were carried out using SAS version 9.2 software (SAS Institute Inc., Cary, NC).

## Results

### Time trends of edentulism and obesity

The prevalence of edentulism in subjects aged 55–84 years was 43% in 1980–81 and 14% in 2002. In the youngest age group (55–64 years), only 4% were edentulous in 2002 (Figure 1). The differences in edentulism between the sexes found in the first two examinations (1980–81 and 1988–89) levelled out in the 55–74 years age group in the later investigations carried out in 1996–97 and 2002.

In both sexes, the prevalence of obesity was higher in the 55–74 years age group than in the 75–84 years age group (Table II). The prevalence of obesity in the 55–74 years age group increased from 10% to 14% in women and from 8% to 15% in men from 1980–81 to 2002.

### Association between edentulism and obesity

In both sexes, the prevalence of obesity was higher in edentulous than in dentate subjects at ages 55–64 and

Table I. Number of participants in three age groups from 55 years upwards in four investigations of living conditions in Sweden (ULF) conducted between 1980–81 and 2002<sup>a</sup>.

Year of investigation	Age group (years)			Total
	55–64	65–74	75–84	
1980–81	1962	1739	2269	5970
1988–89	1490	1685	1350	4525
1996–97	1439	1290	946	3675
2002	826	783	627	2585
Total	5727	5497	5192	16 416

<sup>a</sup>Statistiska Central Byrå (SCB) Sweden. Sample size and non-response rates in ULF 1975–2005. Available from: www.scb.se. ULF: Undersökning av levnadsförhållanden, in Swedish (Investigation of living conditions).

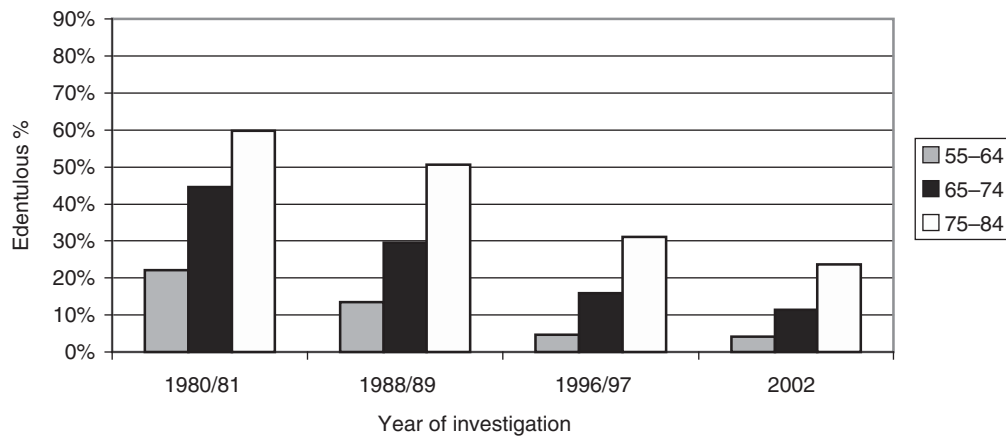


Figure 1. Prevalence of edentulism (%) with respect to age and the year when the investigation was performed.

65–74 years. The difference between edentulous and dentate subjects was greater among women than men (Figure 2). Edentulous women had higher odds for obesity in all age groups and at all investigations except in 2002 for the age group 75–84 years (data not shown). A similar association between edentulism and obesity was found in men but was significant only in the age group 65–74 years in 1988–89 ( $P < 0.01$ ) (data not shown). The prevalence of obesity increased between surveys in the age group 55–74 years, a trend most obvious among the edentulous subjects. The prevalence of obesity in edentulous women aged 55–64 years increased from 18% in 1980–81 to 43% in 2002, and in the age group 65–74 years from 12% to 29%.

#### Association between obesity and covariates

In 55–74-year-old women, obesity was associated with all of the covariates except not being married and previous smokers; in men, a similar pattern was observed, although demographic and lifestyle factors were not so strongly associated (Table III). Consistent results in both sexes and all age groups showed that blue-collar work, low education, physically non-active and not feeling healthy were positively

associated with obesity, while being a current smoker and being tall showed negative associations.

#### Logistic regression analysis of edentulism and obesity

Edentulism was associated with obesity independent of age, year of investigation and other covariates (Table IV). For edentulous women aged 55–84 years, the OR for obesity was 1.80 (95% CI 1.48–2.17), and for men it was 1.26 (95% CI 1.00–1.59). The interaction effect of sex on the association between edentulism and obesity was significant in the total model. In women aged 55–74 years, edentulism was associated with obesity independent of covariates in each of the four investigations, with the OR changing from 1.64 (95% CI 1.18–2.27) in 1980–81 to 3.17 (95% CI 1.62–6.18) in 2002 (Table V). In the age group 75–84 years, edentulism was not associated with obesity in 1980–81 and 1988–89. Corresponding analyses in men showed that edentulism was not associated with obesity at any of the four separate surveys (data not shown).

#### Discussion

This study indicates an association between obesity and edentulism. The causality of this association is obscure but our findings may be of both clinical and theoretical importance. We adjusted for risk indicators for obesity and edentulism suggested in the literature, such as marital status, economic factors, smoking, physical activity and self-reported health status. Of extreme importance to obesity is the relationship between energy intake and consumption, e.g. nutritional intake and physical activity. Unfortunately nutritional data were not collected in this survey, which is an obvious weakness. However, physical inactivity was assessed and was found to be associated with obesity (Table IV).

Table II. Prevalence (%) of obesity (BMI  $\geq 30$  kg/m<sup>2</sup>) among women and men in different age groups from four investigations over the period 1980–81 to 2002.

Year of investigation	Women		Men	
	55–74 years	75–84 years	55–74 years	75–84 years
1980–81	10	8	8	6
1988–89	10	7	8	6
1996–97	12	8	10	4
2002	14	11	15	6

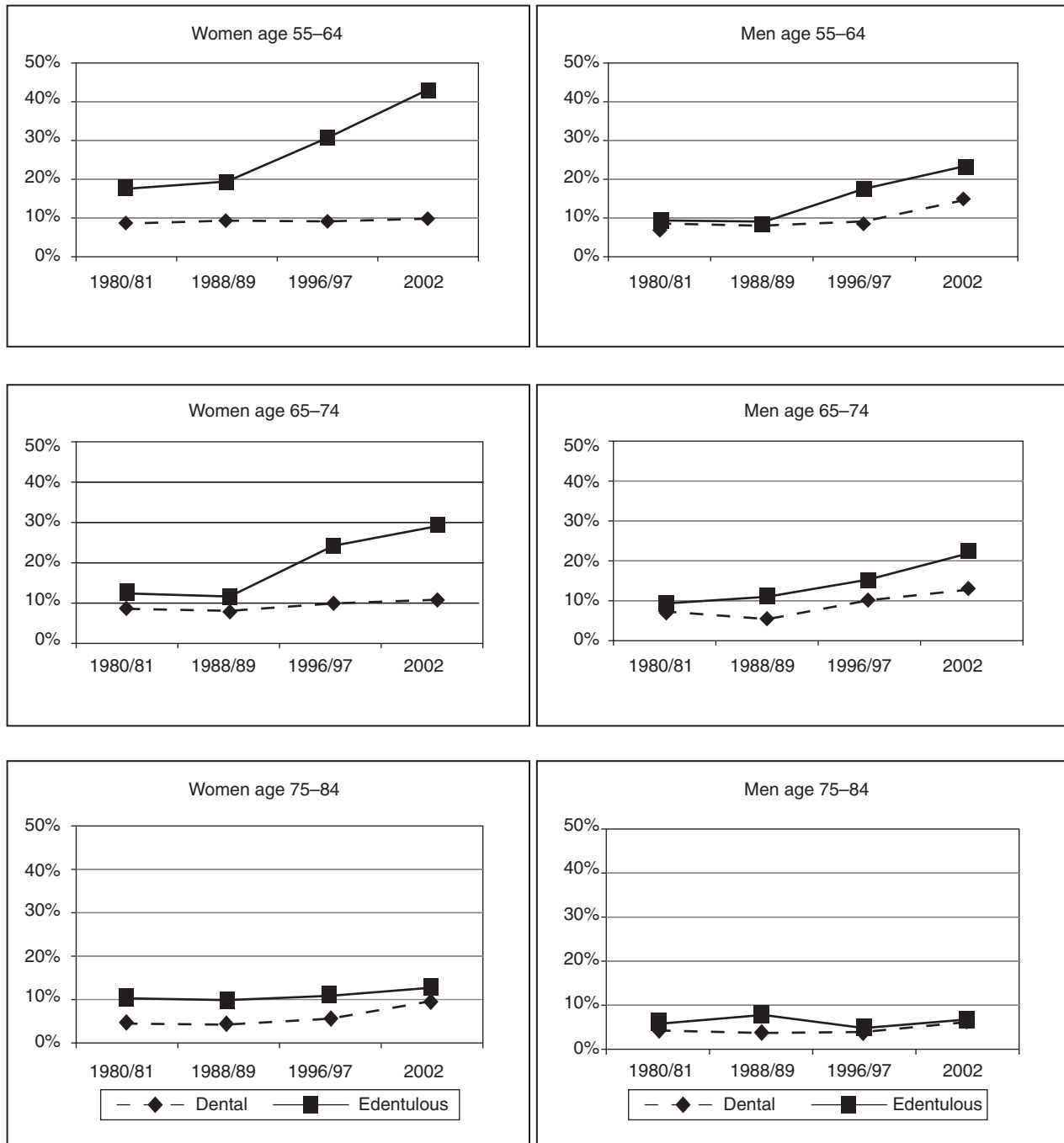


Figure 2. Trends in the prevalence (%) of obesity ( $\text{BMI} \geq 30 \text{ kg/m}^2$ ) from 1980–81 to 2002 with respect to age, sex and dental status group.

A further limitation of this study, with its cross-sectional design, is that it does not give the opportunity to examine the direction of the association. We are not in a position to study whether edentulism is a risk factor for obesity, or alternatively whether obesity is a risk factor for edentulism.

The strength of the associations between obesity and edentulism differed between women and men, between age groups and between the years of investigation. Women showed the strongest associations between edentulism and obesity, and the strength of

the association also increased with time. The prevalence of obesity in edentulous women aged 55–74 years was 14% in 1980–81 and 33% in 2002. The trend was similar in men (increasing from 8% to 22%). The situation in the age group 75–84 years was different, with an overall lower prevalence of obesity and less change over time. When trying to interpret the conflicting results in the literature regarding the association between dental status and obesity, differences in age must be considered. In the present study the results showed substantial differences between the

Table III. Prevalence (%) of covariates and OR<sup>a</sup> (95% CI) for their association with obesity (BMI ≥30 kg/m<sup>2</sup>) among women and men in different age groups.

Characteristic	Women						Men					
	55-74 years (n = 5712)			75-84 years (n = 2627) <sup>b</sup>			55-74 years (n = 5204)			75-84 years (n = 2015) <sup>b</sup>		
	%	OR (95% CI)	%	OR (95% CI)	%	OR (95% CI)	%	OR (95% CI)	%	OR (95% CI)		
<b>Socio-economic factors</b>												
Unmarried	39	1.00 (0.85-1.19)	70	1.09 (0.80-1.48)	27	1.26 (1.03-1.55)*	36	1.94 (1.32-2.86)***				
Blue-collar job	58	1.48 (1.24-1.77)***	67	1.63 (1.18-2.26)**	53	1.47 (1.21-1.78)***	61	2.06 (1.31-3.23)**				
Low education	49	1.60 (1.34-1.91)***	73	2.04 (1.41-2.96)***	47	1.72 (1.42-2.10)***	70	2.14 (1.27-3.62)**				
Economic problems	12	2.17 (1.75-2.69)***	15	2.05 (1.48-2.84)***	8	1.61 (1.19-2.18)**	9	1.35 (0.74-2.46)				
Not native-born	9	1.68 (1.31-2.14)***	5	1.31 (0.75-2.29)	8	1.33 (0.97-1.82)	3	1.54 (0.60-3.94)				
Living in rural area	15	1.36 (1.09-1.68)**	14	1.22 (0.83-1.78)	14	1.24 (0.96-1.61)	15	0.81 (0.45-1.44)				
<b>Lifestyle</b>												
Previous smokers <sup>c</sup>	19	1.21 (0.98-1.48)	11	0.76 (0.47-1.22)	44	1.37 (1.10-1.70)**	49	0.82 (0.54-1.25)				
Current smokers <sup>c</sup>	18	0.60 (0.46-0.78)***	6	0.61 (0.31-1.23)	26	0.85 (0.64-1.12)	20	0.46 (0.24-0.88)*				
Physically non-active	57	2.02 (1.68-2.43)***	86	3.45 (1.93-6.17)***	53	1.98 (1.63-2.42)***	78	1.70 (0.95-3.07)				
<b>Health-related</b>												
Feeling unhealthy	41	1.89 (1.60-2.24)***	55	1.55 (1.16-2.07)**	36	1.60 (1.33-1.94)***	48	1.94 (1.30-2.89)**				
Chronic diseases/handicap	62	2.00 (1.65-2.42)***	78	2.07 (1.36-3.13)***	58	1.94 (1.58-2.38)***	71	1.48 (0.94-2.34)				
Body height cm (SD)	163 (5.7) <sup>d</sup>	0.78 (0.72-0.85)***	162 (6.0) <sup>d</sup>	0.73 (0.63-0.84)***	176 (6.5) <sup>d</sup>	0.75 (0.68-0.82)***	174 (6.4) <sup>d</sup>	0.66 (0.54-0.81)***				
Edentulism	22	2.27 (1.86-2.77)***	49	1.46 (1.26-1.70)***	18	1.53 (1.20-1.96)***	44	1.25 (1.03-1.54)*				

<sup>a</sup>Adjusted for year of investigation and age.

<sup>b</sup>In the 1980-81 investigation there was no information about physical activity for the subjects in age group 75-84 years and so these individuals were excluded from the analyses.

<sup>c</sup>Compared with non-smokers.

<sup>d</sup>Shown as mean (SD).

\* $P < 0.05$ , \*\* $P < 0.01$ , \*\*\* $P < 0.001$ .

Table IV. Factors significantly associated with obesity in 55–84-year-old subjects. OR (95% CI) from logistic regression, adjusted for year of investigation and age (not shown in Table).

Factor	Women ( <i>n</i> = 8234) <sup>a</sup>	Men ( <i>n</i> = 7133) <sup>a</sup>
Unmarried		1.33 (1.11–1.60)**
Low education	1.24 (1.04–1.47)*	1.54 (1.27–1.87)***
Economic problems	1.66 (1.35–2.04)***	
Not native-born	1.28 (1.00–1.64)*	
Current smokers <sup>b</sup>	0.49 (0.37–0.63)***	0.65 (0.49–0.85)***
Physically inactive	1.79 (1.48–2.17)***	1.73 (1.43–2.10)***
Feeling unhealthy	1.25 (1.04–1.49)*	1.25 (1.02–1.52)*
Chronic diseases/handicap	1.50 (1.22–1.85)***	1.64 (1.34–2.01)***
Body height (quintiles)	0.97 (0.96–0.99)***	0.96 (0.95–0.97)***
Edentulism	1.80 (1.48–2.17)***	1.26 (1.00–1.59)*

<sup>a</sup>In the 1980–81 investigation there was no information about physical activity for the subjects in the age group 75–84 years and so these individuals were excluded from the analyses.

<sup>b</sup>Compared with non-smokers.

\**P* < 0.05, \*\**P* < 0.01, \*\*\**P* < 0.001.

three age groups analysed. It may be speculated that the conflicting results of other studies reflect similar age differences to those we have seen, although they have not been specifically reported.

The increasing difference in the prevalence of obesity between edentulous and dentate subjects over time occurs in parallel with a dramatic decrease in the prevalence of edentulism and an increase in obesity. It is probable that, as the rate of edentulism decreases, edentulous people become a special group regarding socio-economic and lifestyle factors, with a possible influence on obesity. In a study of four cohorts of 70-year-old individuals, the difference in mortality between edentulous and dentate subjects increased over time. This result indicates that edentulous people today constitute a more vulnerable group, with a hazardous lifestyle and higher risks of illness and mortality [13].

It is not only dental status that is related to inadequate dietary habits and nutrition. Inadequate

nutritional intake was independent of teeth and denture status but showed correlations with overweight, obesity, low physical activity and high alcohol intake [32]. The trends in changes in BMI reflect those of obesity, with an increase in mean values in both sexes over time and with greater differences between the dental status groups in women than men (data not shown).

Recently, obesity has been associated with a high level of inflammation, and it has been suggested that obesity causes inflammation, possibly via accumulation of macrophages in fatty tissue [33–35]. Chronic low-grade inflammation is also found in subjects with periodontitis and tooth loss. Some earlier epidemiological studies have indicated an association between periodontitis and obesity in humans [36–40]. It has recently been suggested that oral bacteria may participate in the pathology leading to obesity in women [41]. An experiment showed that diet-induced obesity in mice decreased several aspects of the immune response to inoculation with *Porphyromonas gingivalis* and increased the severity of periodontal disease [42]. It remains to be seen whether this is also relevant in humans.

It has been suggested that obesity is related to increased risks of the metabolic syndrome and type II diabetes [35]. Several studies have shown that increased serum levels of the inflammatory markers interleukin-6 and C-reactive protein are also related to periodontitis as well as obesity [43–45]. The present results indicate that both obesity and edentulism, independent of each other, contribute to an increase in the risk of diabetes (ongoing analyses to be presented in a forthcoming publication).

Over the last 40 years, ongoing simultaneous secular trends of decreased tooth loss, decreased

Table V. Association between obesity and edentulism [OR (95% CI)] based on logistic regression in each investigation from 1980 to 2002 in 8234 women: adjusted for age and the covariates listed in Table III and, in the total model, also for year of investigation.

Year of investigation	55–74 years ( <i>n</i> = 5638)	75–84 years ( <i>n</i> = 2596)
1980 <sup>a</sup>	1.64 (1.18–2.27)**	1.87 (1.10–3.16)*
1988	1.54 (1.05–2.28)*	2.24 (1.30–4.53)**
1996	2.76 (1.79–4.25)***	1.64 (0.83–3.25)
2002	3.17 (1.62–6.18)**	1.24 (0.52–2.97)
Total	1.83 (1.48–2.26)***	1.73 (1.28–2.32)**

<sup>a</sup>The variable “physical activity” was not included in the analysis used in the model.

\**P* < 0.05, \*\**P* < 0.01, \*\*\**P* < 0.001.

smoking and increased obesity have been noticed. Furthermore, there has been a marked increase in educational level among adults during the same period. Most of these trends seem to be cohort effects rather than being age-related. Ageing is however related to decreasing body weight above the age of 75 years. Below this age, most studies show an increasing BMI.

Tobacco smoking is an established major risk factor for tooth loss. However, during the last 25 years the prevalence of smoking has decreased. We assume that the decreased prevalence of smoking is a contributory factor to the increased strength of the relation between obesity and tooth loss since elderly tobacco smokers tend to have a lower BMI as well as a higher rate of edentulism.

Strengths of this study include the large number of individuals from different socio-economic levels and from all different geographic areas in Sweden and the high response rate (75–86%). Moreover, the present study gave the opportunity to test our hypothesis in four independent investigations in different years and to analyse cohort, gender and age interactions on the association between edentulism and obesity. A weakness of the study is the limitations imposed by the cross-sectional design and its reliance on interview data. Nutrition data were not included, nor were hereditary factors for tooth loss and obesity. Our study with cross-sectional measurements does not include all confounding factors. Prospective studies, with more specific confounding factors for obesity, are desirable to further analyse the associations found in this study.

## Conclusions

In this study based on cross-sectional interview data from four investigations from 1980–81 to 2002 there were secular trends of decreasing edentulism and increasing obesity in the Swedish population aged 55–84 years. The results indicated an association between obesity and edentulism in the age group 55–84 years. The associations were stronger in women than in men and in the age group 55–74 years than in the age group 75–84 years. In the age group 55–74 years, edentulous women showed the highest prevalence of obesity, which also increased over the 22-year study period.

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