*Menopause: The Journal of The North American Menopause Society*
Vol. 15, No. 2, pp. 270-275
DOI: 10.1097/gme.0b013e31811ece0a


# Women are periodontally healthier than men, but why don't they have more teeth than men?

*Peter Meisel, PhD,[1] Jenni Reifenberger, PhD,[1,2] Romy Haase, MD,[3] Matthias Nauck, MD,[4] Christoph Bandt, PhD,[2] and Thomas Kocher, MD[3]*

**Abstract**

***Objective:*** Periodontal diseases are more prevalent in men than in women. However, in a population-based epidemiological study, we found that, on average, women have fewer teeth than men. The aim of this study was to test different hypotheses that could explain this obvious paradox.

***Design:*** In 4,290 randomly selected participants from the normal population (Study of Health in Pomerania), we determined diagnostic periodontal parameters, attachment loss, and number of teeth. Behavioral and environmental risk factors were assessed by interviews and questionnaires. Use of estrogens was assessed, and urinary excretion of collagen cross-links was determined.

***Results:*** Multiple regression analyses adjusted for caries and periodontitis revealed that in the women of this population, there is an inverse association between the number of children born and the number of teeth ($P < 0.01$). This relationship depends on socioeconomic status, bone metabolism, and the use of estrogens. In the group of the youngest (20-40 years), the bone turnover rate is positively related to the number of children born ($P < 0.01$). In postmenopausal women treated with estrogens, the number of teeth was higher than in men of the same age group. Only in women without hormone treatment were there fewer teeth.

***Conclusion:*** The apparent paradox of having fewer teeth despite better periodontal health in women compared with men is related to an increased bone turnover rate and socioeconomic conditions such as low education and low social status. Periodontal health is even worse if these factors are combined.

***Key Words:*** Periodontitis – Parity – Tooth loss – Gender – Menopause – Estrogen.

Periodontitis is a common disease caused by oral bacterial inflammation, leading to irreversible attachment loss, bone destruction, and eventually tooth loss. It is a multifactorial disease affected by numerous risk factors, including smoking, socioeconomic background, diabetes, genetic susceptibility, attitude toward health, and supragingival plaque control.[1]

A number of epidemiological studies have shown that there are gender differences in appearance as well as the social and psychological impact on oral health.[2] In a population-based, cross-sectional study performed in the northeastern German region of Pomerania, we showed that women are generally in better health than men (based on a number of chronic diseases) and that they have a lower mortality rate. We also studied the periodontal state of the participants. Again, women were in better periodontal health as assessed by attachment loss, probing depth, bleeding on probing, and plaque index. But on average they had fewer teeth than their male counterparts.

This paradoxical result was left unexplained by the first analyses. To find an explanation for this apparent inconsistency, we tested three hypotheses using data from the study to find a plausible explanation.

In this region, formerly belonging to East Germany, extracting periodontally affected teeth was the preferred practice over rigorous periodontal treatment.[3] Thus, the question was whether the frequency of dental appointments could be a reason for the gender-related difference with the assumption that women take better care of their health and therefore visit the dentist more frequently than men. If this were true, then dental visits might have been counterproductive because dentists start to treat at a very early stage of disease, which may result in excessive iatrogenic damage. Dentists may remove teeth more aggressively in women than in men or apply better oral hygiene in women, because "Teeth are very seldom lost; teeth are extracted by dentists."[4]

Received March 20, 2007; revised and accepted May 16, 2007.

From the [1]Department of Pharmacology, Clinical Chemistry, [2]Institute of Mathematics, [3]Dental Clinics, Unit of Periodontology, and [4]Clinical Chemistry, Ernst Moritz Arndt University of Greifswald, Greifswald, Germany.

Funding/support: This work is part of the Community Medicine Research net of the University of Greifswald, Germany, which is funded by the Federal Ministry of Education and Research (grant ZZ9603), the Ministry of Cultural Affairs, and the Social Ministry of the Federal State of Mecklenburgen–West Pomerania.

Financial disclosure: None reported.

Address correspondence to: Peter Meisel, PhD, Department of Pharmacology, University of Greifswald, F.-Loeffler-Str. 23d, D-17487 Greifswald, Germany. E-mail: meiselp@uni-greifswald.de

An old saying states that for each child born, one tooth is lost.[5] Whether true or not, we took into account this folklore as a second possibility. Recently it was shown that parity is associated with tooth loss and dental disease in US women.[6]

Women are at higher risk of osteoporosis than men, especially in older age. Even though not unequivocally proven, it is assumed that there are associations between osteoporosis, periodontal disease, alveolar bone loss, and tooth loss.[7] For this reason, tooth loss might not be a reliable marker of past periodontal disease in postmenopausal women. This was the third hypothesis tested.

## METHODS

### Study population

A total of 7,008 participants was selected by a cluster sampling method from a population of 210,000 inhabitants of the northeastern German region of Pomerania as part of the Study of Health in Pomerania (SHIP). From 32 communities in the region, a random sample was drawn from residence registries, stratified by gender and age with 292 persons of each gender in each of twelve 5-year age strata (age range, 20-80 y). The net sample (without migrated or deceased persons) consisted of 6,267 eligible participants. The final SHIP sample comprised 4,310 participants (68.8% of eligible participants), 4,290 of whom had a dental examination. The dental part of SHIP, recruiting of participants, and the scope of this population-based, cross-sectional health survey were reported elsewhere.[8] The participants gave written informed consent, and the study was approved by the local ethics committee.

The field work was carried out between October 1997 and May 2001.

### Anamnestic and periodontal examinations

Periodontal status was assessed by specially trained dentists. The examination was conducted in a dental chair with optimal lighting but without a saliva ejector or air drying. Periodontal assessment parameters included probing depth, clinical attachment loss, plaque, bleeding on probing, and tooth count. Periodontal examination was carried out according to the half-mouth method on the left or right side in alternate participants. All fully erupted teeth were assessed excluding third molars. A maximum of 14 teeth per participant was examined. Attachment loss and probing depth were assessed with a periodontal probe (PCP 11, HuFriedy, Chicago, IL) at the mesiobuccal, distobuccal, mid-buccal, and midlingual aspect on each selected tooth. Attachment loss is represented by the distance from the cemento-enamel junction to the bottom of the periodontal pocket. Measurements were made in whole millimeters. Extent of periodontal disease was defined by the percentage of periodontal sites 4 mm or greater or as mean attachment loss. Each 6 months, calibration exercises were performed on a subset of persons not connected with the study, yielding an intraclass correlation of 0.82 to 0.91 per examiner and an interrater correlation of 0.84 for attachment level and probing depth.[8]

Caries were graded according to World Health Organization criteria, expressed as a percentage of decayed and filled teeth.[9] Sociodemographic and psychosocial factors of the women in SHIP recently were reported in this journal.[10] Smoking behavior and socioeconomic status were assessed with an extensive questionnaire and an interview. For socioeconomic status we used three educational categories: 12th grade, 10th grade, or less than 10th grade. For social

**TABLE 1.** *Demographic and diagnostic characteristics of the 4,290 participants of the Study of Health in Pomerania*

| | Age group | | | | | |
|---|---|---|---|---|---|---|
| | 20-40 y | | >40-60 y | | >60 y | |
| | Men | Women | Men | Women | Men | Women |
| No. of participants | 630 | 722 | 721 | 816 | 758 | 643 |
| Mean age, y | 31 | 31 | 50 | 50 | 69 | 68 |
| Smokers at present, % | 46 | 35[a] | 34 | 23[a] | 14 | 7[a] |
| Mean no. of pack-years | 7 ± 9 | 4 ± 6[b] | 16 ± 18 | 5 ± 9[b] | 17 ± 20 | 3 ± 7[b] |
| Mean no. of teeth[c] | 25.0 ± 3.7 | 24.8 ± 4.0 | 19.6 ± 7.3 | 18.9 ± 7.4[b] | 8.8 ± 8.7 | 8.5 ± 8.6 |
| % CAL ≥ 4 mm, mean | 7 ± 14 | 5 ± 13[b] | 37 ± 31 | 28 ± 28[b] | 62 ± 31 | 51 ± 32[b] |
| CAL, mm, mean | 1.4 ± 1.0 | 1.2 ± 0.9[b] | 3.2 ± 1.8 | 2.7 ± 1.5 | 4.7 ± 2.0 | 3.9 ± 1.6[b] |
| Caries, % DFT | 47 ± 21 | 54 ± 21[b] | 49 ± 26 | 61 ± 22[b] | 54 ± 32 | 61 ± 31[b] |
| Dental appointments previous year | 2.5 | 3.2[b] | 2.4 | 3.0[b] | 2.0 | 2.2[b] |
| Education, 10th grade or higher, % | 86 | 94[b] | 64 | 67 | 26 | 19[b] |
| Tooth brushing less than twice daily, % | 25 | 7[a] | 25 | 5[a] | 22 | 9[a] |
| DPD, nmol/mmol creatinine ± SD | 4.4 ± 1.9 | 5.3 ± 2.2[b] | 4.1 ± 1.6 | 5.1 ± 2.0[b] | 4.9 ± 2.0 | 6.3 ± 2.5[b] |
| Mean no. of babies | — | 1.17 | — | 1.98 | — | 2.41 |
| Mean no. of pregnancies | — | 1.48 | — | 2.48 | — | 2.66 |
| Nulliparae, % | — | 32 | — | 7 | — | 10 |

CAL, clinical attachment loss; DFT, decayed or filled related to number of teeth assessed; DPD urinary deoxypyridinoline.
[a] $P < 0.01$ ($\chi^2$).
[b] $P \leq 0.01$ (Mann-Whitney).
[c] Excluding the third molars.

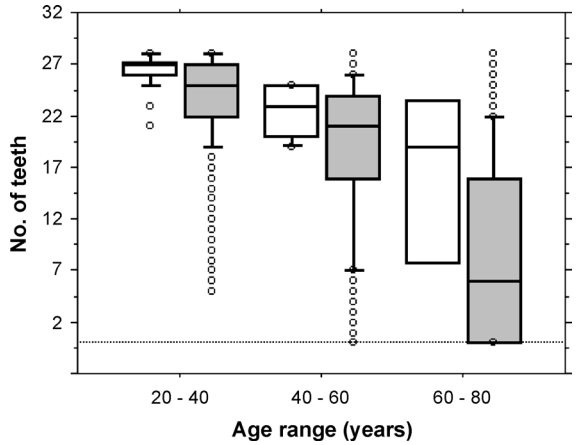


**FIG. 1.** Box plot for comparison of the number of teeth in nulliparous women (open boxes) with women who had given birth to one or more children (shaded boxes) in three age categories. $P < 0.0001$ for the youngest; there were too few childless women in the older groups for this analysis.

position of women's spouses, we also used three categories: manual worker, office worker, employer or university graduate, or the household income. Likewise, the use of medications containing estrogen was assessed and recorded according to the ATC index codes G03A, G03C, G03D, and G03F.[11] To confirm a regular intake of the medicines, participants were asked to present evidence of their use, ie, prescriptions or package inserts.

### Clinical chemistry studies and statistics

Urinary excretion of deoxypyridinoline (DPD) was determined by a chemiluminescence enzyme immunoassay (Fa. DPC Biermann, Bad Nauheim, Germany). All values were related to the creatinine concentration in urine. Creatinine, fibrinogen according to Clauss, and glycosylated hemoglobin (HbA1c) were determined by standard laboratory methods.

Most of the dental measures show a very skewed distribution. Therefore, differences in distribution of continuous measures were tested by the Mann-Whitney *U* test for two groups of observations or the Kruskal-Wallis test for three groups; $\chi^2$ was used for contingency tables. We used linear multiple regression analyses to adjust the effects for confounding variables. The statistical analyses were conducted with STATVIEW 5.0 (SAS, Cary, NC).

## RESULTS

### Periodontal risk factors

In all six 10-year age strata, the means of attachment loss and extent of sites 4 mm or greater were significantly lower in women than in men. Although this is a sign of healthier periodontium, the number of teeth was lower for women than for men in all age strata except the youngest (30 years or younger). Reasons for gender-related differences may be related to differences in the impact of risk factors for periodontal disease and tooth loss between women and men. The most important risk factors are smoking, oral hygiene, socioeconomic status (represented here by education), and diabetes. Table 1 gives the demographic and diagnostic characteristics of the study participants, including data on these risk factors. It is obvious that the health-related behavior of the women is less risky than that of the men. This may explain the better periodontal status in women, but it contradicts women having the same or even lower number of teeth. Additionally, a higher prevalence of caries was recorded in the women.

### Hypothesis I

Female participants reported a higher frequency of dental appointments than their male counterparts. This difference was significant at $P < 0.01$ for ages 30 to 40 years; significance for all other age groups was $P < 0.05$. A

**TABLE 2.** *Multiple regression with number of teeth as the dependent variable and effect of number of born children in three social categories of women (according to income), adjusted for confounding variables*[a]

| | Income[b] | | | | | |
|---|---|---|---|---|---|---|
| | ≤$1,200 US | | >$1,200-$≤2,400 US | | >$2,400 US | |
| Independent variables | Coefficient | *P* | Coefficient | *P* | Coefficient | *P* |
| Intercept | 32.21 | <0.001 | 29.11 | <0.001 | 30.38 | <0.001 |
| Age, y | −0.16 | <0.001 | −0.09 | <0.001 | −0.10 | <0.001 |
| DFT, 10% increments | −0.36 | <0.001 | −0.45 | <0.001 | −0.36 | <0.001 |
| CAL >4 mm, 10% increments | −1.08 | <0.001 | −1.10 | <0.001 | −0.88 | <0.001 |
| Last dental appointment | −0.27 | 0.732 | −1.26 | 0.032 | −0.33 | 0.694 |
| Education ≥10th grade | 0.38 | 0.518 | 2.22 | <0.001 | 1.02 | 0.103 |
| No. of children born | | | | | | |
| 1-2 | −0.41 | 0.437 | −0.25 | 0.630 | −0.85 | 0.129 |
| 3-4 | −1.57 | 0.038 | −1.03 | 0.106 | −0.97 | 0.177 |
| >4 | −4.03 | 0.005 | −2.80 | 0.020 | −2.22 | 0.194 |
| N | 411 | | 806 | | 514 | |
| $R^2$ | 0.674 | | 0.569 | | 0.397 | |

DFT, decayed or filled related to number of teeth assessed; CAL, clinical attachment loss.

[a]Confounding variables: age (continuous, 1-year increments), caries (% decayed or filled related to number of teeth assessed), periodontitis (CAL ≥ 4 mm in percentage of sites assessed), last dental appointment > 1 year (dichotomous), education (dichotomous), and number of children born (categorized, nulliparae as reference)

[b]Monthly income per household, 1,000 Deutsche marks converted to $672 US.

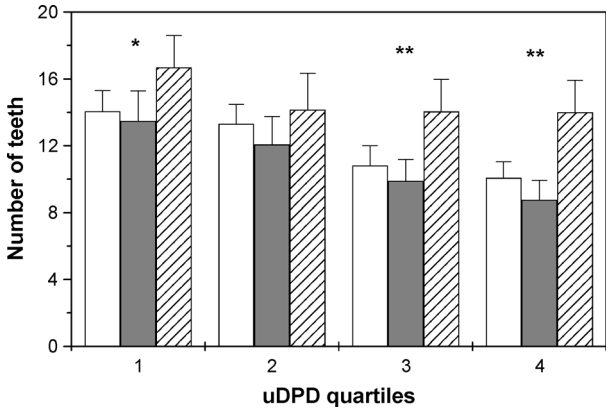


**FIG. 2.** Number of teeth in men older than 50 years (open columns) and postmenopausal women who had not (shaded columns) and had taken (hatched columns) hormone therapy according to the sex-specific quartiles of excretion of urinary deoxypyridinoline collagen cross-links (uDPD). *$P < 0.05$, **$P < 0.01$ (Kruskal-Wallis test).

multiple regression analysis with the number of teeth as the dependent variable revealed that the frequency of dental visits during the previous 12 months was negatively correlated with the number of teeth. In the age groups of the 20- to 60-year-old participants, there was no difference between the sexes in this relationship, even after adjusting for age, smoking, diabetes, dental hygiene, and education. In participants older than 60 years, there was a positive correlation ($P < 0.0001$). The more frequent dental appointments that participants in this age group had, the more teeth they had. Again, there was no difference between sexes. Therefore, hypothesis I is to be rejected.

### Hypothesis II

The box plot in Figure 1 shows a crude relationship between the number of teeth and age in women without children compared with those having given birth to one or more children. In all age strata, mothers with children have lost more teeth than their childless counterparts. Because the relationship is confounded by different risk factors, we performed a linear multiple regression analysis adjusting for different factors that influence the number of teeth, including caries and periodontitis. With every child born, the number of teeth was reduced by nearly one tooth ($-0.775$, $P < 0.0001$, analysis not shown). Separating the analysis for the different social groups, we found that this relationship was greater in the lowest income class and was much attenuated in the group of the highest social level (Table 2). In all age strata, there was a clear dose-effect relationship. A similar but weaker relationship was observed between the number of pregnancies and number of teeth, where the regression coefficient was $-0.430$ ($P < 0.0001$). Thus, hypothesis II is to be accepted.

### Hypothesis III

In this study bone density was not assessed. To address the question of whether tooth loss is associated with osteoporosis, we estimated the bone turnover by determination of the excretion of collagen DPD cross-links as a proxy for osteoporosis. As expected, women have a higher bone turnover rate, which is attenuated by estrogen supplementation. In Figure 2 the adjusted number of teeth is shown in relation to urinary DPD in postmenopausal women with and without estrogen-containing hormone therapy (HT) compared with men older than 50 years. Comparison suggests that only those women who do not use estrogens after menopause have fewer teeth than men (Fig. 2). This may be indicative of osteoporosis in this group of women. Women using estrogen even have more teeth than men. In all three subgroups, male, female with and without estrogens, and participants with a higher educational level had significantly lower DPD excretion than their less educated counterparts with a difference of 5% to 10% ($P < 0.0001$, data not shown). Moreover, all these differences are much attenuated in participants with a higher educational level. Women using HT were younger than their hormone-free counterparts. The mean difference was 5 years for low educational level and negligible for women with higher education.

Thus, hypothesis III is to be accepted.

The regression in Table 3 relates the concentration of urinary DPD cross-links to birth rate. There is a significant association with the number of children born, especially in the youngest age group. Additionally, age, education as a proxy for socioeconomic status, and fibrinogen as a marker of

**TABLE 3.** *Multiple regression with the urinary excretion of DPD as the dependent variable (nmol DPD/mmol creatinine) and effect of number of born children in three age categories of women, adjusted for age (continuous, 1-year increments), estrogen use (nominal 0, 1), serum fibrinogen concentration (continuous), estrogen use (yes/no), income (nominal, reference <$1,200 US), and number of born children*

| | Age group | | | | | |
|---|---|---|---|---|---|---|
| | 20-40 y (N = 665) | | >40-60 y (N = 745) | | >60-80 y (N = 541) | |
| Independent variable | Coefficient | *P* | Coefficient | *P* | Coefficient | *P* |
| Intercept | 7.20 | <0.001 | 3.01 | <0.001 | 1.54 | 0.241 |
| Age, y | −0.12 | <0.001 | 0.04 | 0.002 | 0.05 | 0.003 |
| Fibrinogen, g/L | 0.64 | <0.001 | 0.21 | 0.077 | 0.28 | 0.062 |
| Estrogen use | −0.87 | <0.001 | −0.84 | <0.001 | −1.05 | 0.004 |
| Income,[a] $1,200-$2,400 US | 0.09 | 0.652 | −0.53 | 0.006 | −0.11 | 0.646 |
| Income,[a] >$2,400 US | 0.17 | 0.458 | −0.73 | <0.001 | −0.14 | 0.722 |
| No. of children born | 0.25 | 0.012 | 0.16 | 0.019 | 0.08 | 0.192 |

DPD, deoxypyridinoline.
[a]Monthly income per household, 1,000 Deutsche marks converted to $672 US.

systemic inflammation have an influence on bone turnover. In a 1:1 matched-pair analysis comprising 350 women using and 350 not using HT, the data were confirmed (age 59.7 ± 7.7 years in each group). Use of HT supplements reduced urinary DPD excretion (6.0 ± 2.4 vs 5.5 ± 2.2, $P = 0.016$), reduced the extent of attachment loss (clinical attachment loss: mean 3.4 ± 1.6 vs 3.0 ± 1.6 mm, $P = 0.014$), and was associated with a higher number of teeth (13.7 ± 9.1 vs 14.6 ± 9.2, not significant).

## DISCUSSION

In this study we examined why women have better periodontal health than men but nevertheless have fewer teeth than men on average. As shown, this difference is associated with the number of children born and socioeconomic status. Obviously, the results of this analysis support the assumption that giving birth to children is associated with an increased risk of tooth loss. However, this association was detected only in participants with a low socioeconomic status of the husband or low education level. It is well known that dental status is linked with socioeconomic status. Especially during pregnancy, when gestational gingivitis occurs, this may be important.[12] Bleeding on probing is a diagnostic sign of gingivitis. After correction for possible confounding factors, bleeding on probing was positively correlated with the number of children born ($P < 0.0001$, data not shown). Thus, pregnancy-associated gingivitis seems to have some impact on long-term dental health, even though this gingivitis is considered a temporary disturbance.[13] Socioeconomic status has been discussed as an important risk factor in periodontitis, tooth loss, and systemic diseases such as diabetes and cardiovascular diseases. However, in a 24-year follow-up study in Swedish women, the association between periodontitis and the systemic diseases could not be explained by measures of socially defining factors such as occupational status, income, and educational level.[14] Similarly, level of education was not found to be associated with an increase in caries.[15] Therefore, most of this association can be explained by biological interaction, probably modified by socioeconomic status. Socioeconomic influences are important for each condition per se but not for their interaction. In another cross-sectional study no evidence was found supporting the hypothesis that the more children that a woman has the more teeth she loses.[16]

Evidence from prospective studies supports the contention that individuals with osteoporosis may be at an increased risk of the manifestations of oral osteoporosis, although such a risk is not definitively proved.[7] In women with periodontal disease and concomitant postmenopausal osteoporosis, there is the possibility that the lack of estrogen influences the activities of bone cells and immune cells in such a way that the progression of alveolar bone loss will be enhanced.[17] Alveolar bone loss is a strong and independent predictor of incident tooth loss in postmenopausal women.[18] Conversely, the number of teeth is no predictor of bone density.[19]

In our study the implication of osteoporosis is possible at least as far as bone turnover is indicative of osteoporosis. The pyridinoline cross-links used in this study were shown to be related to radiographic alveolar bone loss.[20] These breakdown products originate from bones and dentin matrix.[21] There is also a strong association between osteoporosis and alveolar bone loss.[22] The effect of estrogen supplementation shown in our study supports the assumption that alveolar bone loss may be related to osteoporosis. This is in accordance with other reports,[23,24] and HT seems to be beneficial for tooth retention. Characteristics of the female population in this study are the high prevalence of ever using both oral contraceptives and menopausal hormone substitution therapy.[25]

Pregnancy is characterized by high bone turnover with resorption and a significant decrease in bone mineral density. This was shown by data from dual-energy x-ray absorptiometry as well as urinary excretion of collagen cross-links (DPD).[26,27] Bone remodeling processes and decreasing bone mineral density affect tooth retention during pregnancy and later, after menopause. The association between the number of children born (and also of pregnancies) and collagen turnover (Table 3) confirms such findings. Thus, these effects may explain the paradox of having fewer teeth with better periodontal health. The influence of estrogen deficiency directly on alveolar bone seems likely to only partially explain the association between the lack of estrogen and tooth loss.[28] There is possibly a beneficial influence of estrogen directly on gingival and periodontal tissues, probably due to effects on the immune response induced by inflammatory stimuli.[29] The effects of socioeconomic factors or environmental risks may be distributed similarly between both sexes or be even greater in men, eg, smoking or oral hygiene.

Because of its cross-sectional design, the study has some limitations. A causative sequence cannot be deduced from the interacting relationships between birth rate, tooth loss, and signs of osteoporosis. For analysis regarding the use of estrogens, no data were obtained on the duration of therapy. Complications due to secular trends must be assumed since nearly four generations are included. Possible cohort effects cannot be elucidated in this study setting. In particular, attitudes toward the use of estrogens change with time.[30] Also, the results may be distorted by a sampling bias since participants who retain higher numbers of teeth have more periodontal disease, or vice versa, those with fewer teeth have less periodontitis.[31]

## CONCLUSION

In conclusion, the paradox stated in the article title may have rational explanations. Longitudinal data should be assessed to confirm these results.

## REFERENCES

1. Pihlstrom BL, Michalowicz BS, Johnson NW. Periodontal diseases. *Lancet* 2005;366:1809-1820.
2. McGrath C, Bedi R. Gender variations in the social impact of oral health. *J Irish Dent Assoc* 2000;46:87-91.

 

3. Splieth C, Giesenberg J, Fanghaenel J, Bernhardt O, Kocher T. Periodontal attachment level of extractions presumably performed for periodontal reasons. *J Clin Periodontol* 2002;29:514-518.
4. Scheutz F, Poulsen S. A tooth per child? *Lancet* 1998;352:1387.
5. Christensen K, Gaist D, Jeune B, Vaupel JW. A tooth per child? *Lancet* 1998;352:204.
6. Russell SL, Yaffee R, Ickovics J. Exploring pathways between parity and dental health in US women [abstract]. Presented at: 83rd General Session and Exhibition of the International Association of Dental Research; March 2005; Baltimore, MD. Abstract 0244.
7. Dervis E. Oral implications of osteoporosis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2005;100:349-356.
8. Hensel E, Gesch D, Biffar R, et al. Study of Health in Pomerania (SHIP), a health survey in an east German region. Objectives and design of the oral health section. *Quintessence Int* 2003;34: 370-378.
9. World Health Organization. *Oral Health Surveys: Basic Methods, 4th ed*. Geneva, Switzerland: World Health Organization, 1997. Available at: http://www.whocollab.od.mah.se/expl/methods.html. Accessed September 14, 2007.
10. Schwarz S, Voelzke H, Alte D, et al. Menopause and determinants of quality of life in women at midlife and beyond: the Study of Health in Pomerania (SHIP). *Menopause* 2007;14:123-134.
11. *ATC Index*. Oslo, Norway: WHO Collaborating Centre for Drug Statistics Methodology, 2003. Available at http://www.whocc.no/atcddd. Accessed September 14, 2007.
12. Yalcin F, Eskinazi E, Soydinc M, et al. The effect of sociocultural status on periodontal conditions in pregnancy. *J Periodontol* 2002;73: 178-182.
13. Moss KL, Beck JD, Offenbacher S. Clinical risk factors associated with incidence and progression of periodontal conditions in pregnant women. *J Clin Periodontol* 2005;32:492-498.
14. Cabrera C, Hakeberg M, Ahlqwist M, et al. Can the relation between tooth loss and chronic disease be explained by socio-economic status? A 24-year follow-up from the Population Study of Women in Gothenburg, Sweden. *Eur J Epidemiol* 2005;20:229-236.
15. Siukosaari P, Ainamo A, Narhi TO. Level of education and incidence of caries in the elderly: a 5-year follow-up study. *Gerodontology* 2005; 22:130-136.
16. Scheutz F, Baelum V, Matee MI, Mwangosi I. Motherhood and dental disease. *Community Dent Health* 2002;9:67-72.
17. Lerner UH. Inflammation-induced bone remodeling in periodontal disease and the influence of post-menopausal osteoporosis. *J Dent Res* 2006;85:596-607.
18. Tezal M, Wactawski-Wende J, Grossi SG, Dmochowski J, Genco RJ. Periodontal disease and the incidence of tooth loss in postmenopausal women. *J Periodontol* 2005;76:1123-1128.
19. Earnshaw SA, Keating N, Hosking DJ, et al. Tooth counts do not predict bone mineral density in early postmenopausal Caucasian women. *Int J Epidemiol* 1998;27:479-483.
20. Giannobile WV. C-telopeptide pyridinoline cross-links. Sensitive indicators of periodontal tissue destruction. *Ann N Y Acad Sci* 1999; 30:404-412.
21. Seibel MJ. Molecular markers of bone turnover: biochemical, technical and analytical aspects. *Osteoporos Int* 2000;6:18-29.
22. Wactawski-Wende J, Hausmann E, Hovey K, Trevisan M, Grossi S, Genco RJ. The association between osteoporosis and alveolar crestal height in postmenopausal women. *J Periodontol* 2005;76(Suppl): 2116-2124.
23. Taguchi A, Sanada M, Suei Y, et al. Effect of estrogen use on tooth retention, oral bone height, and oral bone porosity in Japanese postmenopausal women. *Menopause* 2004;11:556-562.
24. Drozdzowska B, Pluskiewicz W, Michno M. Tooth count in elderly women in relation to their skeletal status. *Maturitas* 2006;55:126-131.
25. Schwarz S, Voelzke H, Alte D, Hoffmann W, John U, Doeren M. Gynaecological health care utilization and use of sex hormones—the Study of Health in Pomerania. *Hum Reprod* 2005;20:2916-2922.
26. Black AJ, Topping J, Durham B, Farquharson RG, Fraser WD. A detailed assessment of alterations in bone turnover, calcium homeostasis, and bone density in normal pregnancy. *J Bone Miner Res* 2000; 15:557-563.
27. Ulrich U, Miller PB, Eyre DR, Chesnut CH, Schiebusch H, Soules MR. Bone remodeling and bone mineral density during pregnancy. *Arch Gynecol Obstet* 2003;268:309-316.
28. Daniell HW. Periodontitis in estrogen-deficient women. *Arch Intern Med* 2002;162:2634-2635.
29. Bouman A, Heineman MJ, Faas MM. Sex hormones and the immune response in humans. *Hum Reprod Update* 2005;4:411-423.
30. Lindh-Astrand L, Brynhildsen J, Hoffmann M, Liffner S, Hammar M. Attitudes towards the menopause and hormone therapy over the turn of the century. *Maturitas* 2007;56:12-20.
31. Joshi A, Douglass CW, Feldman H, Mitchell P, Jette A. Consequences of success: do more teeth translate into more disease and utilization? *J Public Health Dent* 1996;56:190-197.