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ORIGINAL ARTICLE

Developing a scale for measuring expectancy of retaining natural teeth for life and comparison of results obtained using a global item and a multi-item scale of measurement

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Abstract

Objective. To develop and test a scale for measuring expectancy of retaining teeth for life and to compare the estimates when using a global item with those obtained with a multi-item scale of measurement. ***Material and Methods.*** The design of the study was cross-sectional selected and random sample surveys using a self-administered questionnaire or interview. There were two groups of patients and a national sample aged 16–79 years ($n = 1{,}274$); response rate 64%. The main results pertain to dentate subjects in a global group ($n = 615$) and in a scale group ($n = 609$). The outcome measure was expectancy of retaining natural teeth for life. ***Results.*** When using the global item, 92% (95% CL 89.8, 94.1) of the respondents believed they would definitely or possibly retain their natural teeth for life, significantly higher than the 81% (95% CL 77.6, 84.0) obtained with the 4-item conditional scale. Cronbach's alpha was 0.89 for the 4-item scale and the test–retest reliability moderate (kappa = 0.51; 0.77 for ± 1). The adults' belief in retaining teeth for life was significantly associated with having a live-in partner ($p = 0.009$) when the global question was the dependent variable; and sex ($p = 0.000$) and education ($p = 0.004$) when the 4-item scale was the dependent variable. Explained variance was 3.8% and 4.5%, respectively. ***Conclusions.*** The internal reliability of the 4-item scale was high. A significantly lower proportion of people reported belief in retaining natural teeth for life when employing the 4-item conditional scale than when the unconditional global question was used.

Key Words: *Belief, expectancy, longevity, measurement scale (teeth)*

Introduction

Past studies of people's expectancy of retaining natural teeth for life have employed a single global item [1–6], and since 1985 the rates of expectancy have been relatively high (>80%), except in a group of Chinese people in the United Kingdom, where only 47% of dentate respondents were confident about retaining their teeth [4]. The approach to measurement of expectancy has been unconditional in so far as the global question used did not refer to past and/or present oral health problems, self-care, dental attendance, or oral health-related beliefs. Evidence of optimistic bias in comparative risk judgment has been reported for tooth decay, gum disease, and wearing of dentures [7], as well as for other aspects of life (for review, see [8]). The extent to which a mention of the possibility of needing dentures [5] or 'everything considered' [6] may have affected expectancy rates and reduced optimistic bias is unknown. However, it cannot be precluded that a conditional approach based on a number of items might improve the reliability and validity of estimates of people's expectation of retaining teeth for life [6].

Awareness of optimistic bias in people's expectancy of retaining natural teeth for life might be helpful in dental health education when attempting to motivate for improvement of oral self-care. Hence, the purpose of the present study was (i) to develop and test a multi-item scale for measuring people's expectancy of retaining natural teeth for a lifetime, and (ii) to compare the estimates when using a global item with those obtained with the new multi-item instrument.

Method

Subjects

Three samples were used in the present investigation:

1. *Sample for pre-testing ($n = 96$).* One-hundred-and-three patients who attended the Clinic of Dental

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Hygiene or the Reception Clinic at the Faculty of Dentistry, University of Bergen between February and April 2001 completed a questionnaire. Seven patients were excluded because they had not answered all questions. The mean age was 49.3 years (SD = 21.0; 58% females) for the patients used for selection of items.

2. *Sample for test–retest (n = 32)*. To assess the test–retest reliability of the global item and the multi-item instrument, patients attending the Restorative Dentistry Clinic, University of Bergen between May 2002 and April 2003 completed a self-administered questionnaire containing the four items of the scale as well as the global question independently twice. Their mean age was 52.1 years (SD = 19.0; 45% female).

3. *National Omnibus sample (n = 1274)*. The Central Bureau of Statistics (CBS) of Norway drew a two-stage proportional random sample of 2,000 residents aged 16–79 years in October 2001 (age per 31.12.2001). The sample was divided into two groups according to odd or even numbers; one half answered the 4-item measurement scale, the other half the global question about belief in keeping teeth for a lifetime. The overall response rate was 64.2%. The main reasons for non-response were refusal (56%) and no contact (28%). Thirty-seven respondents (2.9%) were excluded because of edentulousness and 13 because of refusal to answer all questions. This left 1224 subjects, of whom 615 answered the global question and 609 all the questions of the 4-item instrument (Table I). The mean age of all respondents was 42.64 years (SD = 16.99); 42.25 (SD = 17.05) and 41.14 years (SD = 15.74) for subjects answering the global question and the four items of the scale, respectively. The respondents ($n = 1{,}274$) were representative of the Norwegian population 16–79 years of age with respect to age, sex, and place of residence.

Table I. Sample size, non-response, exclusions and group size

Description	No. of subjects
Sample	2000
Dead or resident abroad	16
Non-response	710
Respondents	1274
Edentulous (global 13; scale 24)	37
Refused to answer (global: 6; scale: 7)	13
Participants	1224
Global question	615 (F: 316)1
4-item scale	609 (F: 310)

[1] F = Female.

Instruments

Pre-testing of items. Items for a measurement scale may be selected on either an empirical or a theoretical basis [9]. The questionnaire used for the pre-testing contained seven potential items for inclusion in a scale of measurement of belief in retaining teeth for life (Table II). The selection of items was empirically based because dental caries, periodontal disease, and their sequelae are the major reasons for tooth loss among adults (e.g. [10,11]) and because oral health-related factors have been the most consistent and prominent predictors of tooth loss [12,13]. The four items *toothbrushing* (Q3), *dental floss* (Q4), *diet/eating habits* (Q5), and *dental visits* (Q6) relate to prevention and control of caries and periodontal disease. The item *family trait* (Q7) (Table II) may indirectly reflect whether one perceives oneself as being in control of one's own health (internal locus of control) or whether one believes that one's health is determined by external influences (external locus of control) or simply by fate [14–16]. The patients were also asked to give their year of birth, sex, and level of education.

Table II. Wording of one global question (GQ) and seven candidate items (Q1–Q7) for a scale of measurement of expectancy to retain natural teeth for life (coding)

GQ	If you have any of your natural teeth, do you expect that you will be able to keep them for life? Do you believe definitely, possibly, possibly not, definitely not? *Alternatives*: Yes, definitely (5); Yes, possibly (4); Don't know (3) [hidden alt.]; No, possibly not (2); No, definitely not (1), and I have no natural teeth.
Q1	Considering how prone you are/have been to develop tooth decay, do you expect to keep your natural teeth for life? Do you believe definitely, possibly, possibly not or definitely not? *Alternatives*: Same as GQ, and I have no natural teeth.
Q2	Considering how healthy or unhealthy your gums are/have been, do you expect to keep your natural teeth for life? Do you believe ... (Same as Q1 minus I have no natural teeth).
Q3	Considering how careful or careless you are/have been about cleaning your teeth, do you expect to keep your natural teeth for life? Do you believe ... (Same as Q2).
Q4	Considering your use/non-use of dental floss or tooth picks for cleaning between your teeth, do you expect to keep your natural teeth for life? Do you believe ... (Same as Q2).
Q5	Considering your diet and eating habits, do you expect to keep your natural teeth for life? Do you believe ... (Same as Q2).
Q6	Considering how regularly or irregularly you visit/have visited the dentist after 15 years of age, do you expect to keep your natural teeth for life? Do you believe ... (Same as Q2).
Q7	Some people believe that poor teeth are inherited/run in families. Considered against this background, do you expect to keep your natural teeth for life? Do you believe ... (Same as Q2).

Test–retest reliability. The four items of the measurement scale (Q1–Q3 and Q5; Table II) were presented in different order when assessing the test–retest reliability. Between 4 days and 18 weeks (mode = 7 days) elapsed between the first and second completion of the questionnaire.

If the mean inter-item correlation is taken to be approximately 0.70, then 4 items would be required to obtain a reliability of 0.90 according to the Spearman–Brown formula stepped-up reliability [17]. These criteria were adopted when considering items for inclusion in the multi-item instrument to measure expectancy of retaining teeth for a lifetime.

National Omnibus survey. The interviews were conducted by trained interviewers employed by the Central Bureau of Statistics of Norway between 5 November 2001 and 14 January 2002. The interviews were carried out by telephone (97%) or face-to-face (3%) when the respondent was without a telephone. The subjects provided demographic particulars, information about dental status and expectancy of retaining natural teeth for life. One half of the sample answered a global question (GQ) concerning their belief in keeping teeth for a lifetime; the other half Q1–Q3 and Q5 (Table II). The questions had fixed response alternatives, as shown in Table II.

In previous studies, a significant association has been found between gender and the rate of expectancy of retaining natural teeth for a lifetime [3,6]. For this reason gender was the external criterion when assessing the construct validity of the new multi-item instrument [17]. The response alternatives for the dependent variable in multiple logistic regression analysis was dichotomized as 0 = yes, definitely (5), and 1 = other response options [1–4] for the global question (Table II). The 4-item measurement scale was re-coded into three classes, where 0 = 18–20, 1 = 16–17, and 2 = 4–15 for an ordinal regression analysis.

Predictor variables. Age was dichotomized as 0 = 16–54 years and 1 = 55–79 years; gender as females = 0 and males = 1; education as high (> 13 years) = 0, low (⩽ 13 years) = 1; income as 0 = > NOK 230,000, 1 = ⩽ NOK 230,000, and civilian status as 0 = married/cohabiting and 1 = other. Judged by the variance inflation factor (VIF = 1.34) collinearity between the predictor variables was not a problem [18].

Statistical analysis. The pre-test and test–retest data sets were computerized and proofread by the research team. The Omnibus data file was established and quality controlled by the CBS. The Statistical Package for Social Sciences (SPSS, versions 9.0 and 11.0 for PC) was used for the analyses. Test–retest reliability was assessed using Cohen's kappa [19] and internal consistency in terms of Cronbach's alpha [20]. Student's *t*-test for paired observations was used to test for systematic error. Chi-square tests were employed to compare the distribution of subjects on categorical variables; the Friedman chi-square test for related samples to assess the significance of differences among items assessed for possible inclusion in a new measurement scale because of significantly skewed frequency distributions [18].

Chi-square tests and Nagelkerke's R^2 provided the estimated fit of the logistic and the ordinal regression models. Ninety-five percent confidence limits (CL) are given for the odds ratios (OR), which were considered statistically significant if both values were either greater than or less than 1. The significance level was otherwise 5%.

Results

Reliability

In the pre-test to select items for the measurement instrument, the item-to-total correlation ranged from 0.73 (dental visits) to 0.82 (tooth decay); Cronbach's alpha if the item was deleted from 0.915 (diet/eating habits) to 0.923 (dental visits) (Table III). The corresponding ranges for the four items in the Omnibus survey were 0.72 (tooth decay) to 0.80 (gum disease); alpha from 0.84 (gum disease) to 0.87 (tooth decay)

Table III. Item mean score[1] and standard deviation (SD), corrected item total correlation and Cronbach's alpha according to item and study group

		Pre-testing sample ($n = 96$)			Omnibus ($n = 609$)[2]		
Items		Mean (SD)	Item total correlation	Alpha (item deleted)	Mean (SD)	Item total correlation	Alpha (item deleted)
Tooth decay	Q1	3.67 (1.18)	0.82	0.912	3.75 (1.18)	0.72	0.87
Gum disease	Q2	3.56 (1.12)	0.78	0.917	3.98 (1.06)	0.80	0.84
Toothbrushing	Q3	3.59 (1.11)	0.80	0.915	4.07 (0.99)	0.77	0.85
Dental floss	Q4	3.24 (1.17)	0.75	0.920	– (–)	–	–
Diet/eating habits	Q5	3.55 (1.16)	0.80	0.915	3.93 (1.05)	0.74	0.86
Dental visits	Q6	3.49 (1.27)	0.73	0.923	– (–)	–	–
Family trait	Q7	3.13 (1.33)	0.74	0.921	– (–)	–	–

[1] Scale 1–5 where 1 = No, definitely not and 5 = Yes, definitely.
[2] The 4-item scale group.

Table IV. Distribution (%) of dental patients and respondents in the Omnibus 2001 survey according to reply option and item concerning belief in retaining natural teeth for a lifetime

Item	Definitely %	Probably %	Don't know %	Probably not %	Definitely not %
Dental patients ($n=96$)					
Tooth decay	25.0	43.8	10.4	14.6	6.3
Gum disease	16.7	51.0	9.4	17.7	5.2
Toothbrushing	15.6	56.3	5.2	17.7	5.2
Dental floss	9.4	49.0	3.1	33.3	5.2
Diet/eating habits	17.7	51.0	5.2	20.8	5.2
Dental visits	20.8	46.9	0.0	25.0	7.3
Family trait	16.7	33.3	7.3	31.3	11.5
Global	17.7	47.9	5.2	18.8	10.4
Omnibus survey					
Items					
Tooth decay*	28.2	46.6	1.3	19.5	4.3
Gum disease*	34.2	48.1	1.3	14.1	2.3
Toothbrushing*	35.6	50.1	1.5	10.8	2.0
Diet/eating habits*	31.0	50.2	1.5	15.3	2.0
*Scale ($n=609$)**	*32.3*	*48.8*	*1.4*	*14.9*	*2.6*
Global ($n=615$)	64.9	27.3	0.5	4.4	2.9

* Scale items.

(Table III). For the 4-item scale, Cronbach's alpha was found to be 0.89.

Test–retest reliability of the four items of the scale in terms of Cohen's kappa ($n=32$) varied from 0.67 (toothbrushing and diet/eating habits) to 0.79 (tooth decay). The corresponding estimate for the global item was 0.48 and for the 4-item scale 0.51 or 0.77 when allowing a disagreement of ± 1. The corrected item-to-total correlation ranged from 0.78 to 0.95. The four items' reliability coefficient (Cronbach's alpha) was 0.93 on the first occasion and 0.95 on the second. Furthermore, the test–retest for items, the 4-item scale, and the global question revealed no significant systematic error ($p>0.05$, paired t-test).

The belief in *yes, definitely* or *yes, possibly* retaining natural teeth for life varied from 50% for "family trait" to 72% for "toothbrushing" in the pre-test to select items (Table IV); the mean scores from 3.13 for "family trait" to 3.67 for "tooth decay" on a scale from 1 (*no, definitely not*) to 5 (*yes, definitely*) (Table III). The Friedman χ^2 test for related samples revealed a statistically significant difference among items in the ranking of patients according to their belief in retaining teeth for life ($\chi^2=39.23$, 6 d.f., $p<0.001$), but not among the 4 items used in the measurement scale ($\chi^2=2.53$, 3 d.f., $p=0.47$). Nearly 66% of the patients answering the global question believed that they would definitely or possibly retain their natural teeth for life (Table IV). Their mean score was 3.44 (SD = 1.27).

Global item versus multi-item instrument

In the 2001 Omnibus survey, the belief in definitely or probably retaining natural teeth for life varied from 74.8% (tooth decay) to 85.5% (toothbrushing) (Table IV); the item mean scores from 3.75 to 4.07 (Table III). A Friedman χ^2 test for related samples found a significant difference among items ($\chi^2=72.69$, 3 d.f., $p<0.001$). The mean additive index score was 15.72 (SD = 3.72) on a scale from 4 to 20. The respondents used the whole scale. There was no floor effect, but a limited tendency towards a ceiling effect in as far as 19% of the respondents returned the maximum score on the measurement scale (Figure 1).

When using the global item, 92.2% of the respondents reported that they would definitely or probably retain their natural teeth for a lifetime; the mean score was 3.93 (SD = 0.93). The results obtained employing the global item returned a significantly higher rate of belief in keeping teeth for life than the 4-item instrument (92.2% versus 81.1%; $p<0.001$). While the

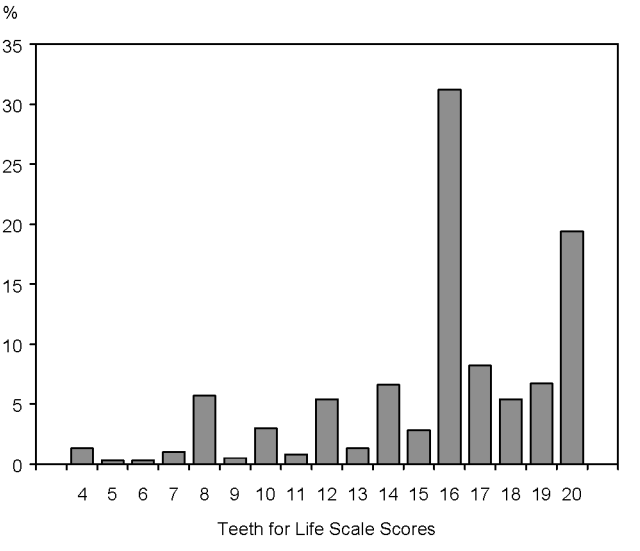

Figure 1. Distribution (%) of Norwegians 16–79 years of age in 2001 according to score on the conditional 4-item measurement instrument.

majority of subjects (64.9%) answered *yes*, *definitely* on the global question, *yes, probably* received the highest percentage of answers (48.8%) when the 4-item scale was used (Table IV).

When the subjects who answered the global item in the Omnibus survey were asked, '*Compared with others of the same age and sex, what do you consider your own chances are that you will lose all your natural teeth later in life?*' the mean score was –0.33 (SD = 3.86) on a scale from –3 (much lower) to +3 (much higher). Using a one sample *t*-test to test the null hypothesis that $\mu = 0$, the observed mean score was found to be significantly different from zero ($t = 6.81$, 597 d.f., $p < 0.001$). This means that on average the respondents considered their own chances of becoming edentulous less than that of their peers.

Bivariate and multivariate analysis. With the global question as dependent variable, a significant bivariate association was found with education, income, and being married/cohabiting ($p < 0.05$). Only the latter predictor retained an independent significant impact in the multivariate logistic regression analysis (OR = 1.60, 95% CL 1.13, 2.27) when controlling for age, sex, education, and income. Sex and education were negatively associated with expectancy scale score (Wald-based $p \leqslant 0.004$) when controlling for age and civilian status. The ordinal regression model explained 4.5% of total variance in expectancy scale score (model $\chi^2 = 24.62$, 5 d.f., $p = 0.000$), thus providing support for the hypothesized association between sex and expectancy of retaining teeth for life after controlling for age, education, and civilian status. The regression models explained a significant ($p < 0.05$) but small proportion of the variance in belief in retaining natural teeth for a lifetime (global: 3.1% and 4-item scale: 4.5%).

Discussion

Reliability and validity

When the 4-item instrument was administered to a self-weighting national random sample of Norwegian adults, Cronbach's alpha was 0.89, i.e. close to the predetermined (0.90) high level of internal consistency. The item-to-total correlation ranged from 0.72 to 0.82 (Table III), results that compare favorably with those reported for the Dental Value Questionnaire [21]. The test–retest reliability was substantial for the 4 items of the scale, but only moderate for the global item [22]. There was no evidence of systematic error. This means that the proposed instrument for assessing people's belief in retaining natural teeth for life performed satisfactorily in the present test, but testing of its sensitivity to change in longitudinal studies (responsiveness) is needed before a definite conclusion can be reached.

While it may be claimed that the number of items considered for inclusion in the scale was too limited, it should be pointed out that the internal consistency improved marginally (Cronbach's alpha: 0.91 to 0.93) when the number of items was increased from 4 to 7 in the pre-test of items. This suggests that items other than those considered in the present study (Table II and III) would have to be tested for inclusion in an effort to improve the 4-item scale. Any gain achieved by employing more than four items would, however, have to be weighed against disadvantages and costs accruing from the need for more questions.

The measurement instrument displayed face validity in that its four items pertain to variables known to be associated with oral health/disease and hence with tooth retention. It exhibited content validity to the extent that the four items cover a range of experiences and perceived susceptibility to caries and periodontal disease (Q1 and Q2) as well as the most important oral health-related behaviors (Q3 and Q5) (Table II). Indirect evidence for construct validity is provided by the significant association between sex and the scale score in the multivariate ordinal regression analysis [17], an association predicted on the basis of previous findings [3,6]. Considering the low explained variance (Nagelkerke's $R^2 = 0.045$), the predictive validity of the instrument would appear to be low, but further studies, including oral health-related predictors, are needed before a definite conclusion may be drawn.

Comparative findings

Employing a global question to determine people's belief in retaining natural teeth for life, 92% answered definitely or probably in the present study. This compares with 88% when a nation-wide sample of Norwegian adults were asked about their belief in retaining 20 or more teeth for life in 1999 [6]. A difference between estimates of 4 percentage points is surprisingly small considering that the question used in 1999 specified 20 or more teeth whereas the present study pertained to retention of any number of natural teeth (Table IV).

Comparing the findings employing the global question for subjects 16–54 years of age in the present Omnibus study with expectations of retaining natural teeth for life in the United Kingdom in 1998 [5], the rates were 93% and 81%, respectively. A significant difference which may be attributable to differences in the questions asked and the response alternatives presented to the respondents. Another reason for the difference may be that the possibility of needing dentures was mentioned in the United Kingdom survey. The mention of needing dentures may have influenced the British respondents negatively, as people find the thought of requiring dentures upsetting [5] or difficult to cope with [23–25]. In this context it was interesting to find that the results obtained using

the conditional 4-item scale (81.6%) agreed with the results from the United Kingdom.

Whether and to what extent the respondents' belief in retaining natural teeth for life may be over-optimistic is undecided. The presence of optimistic bias is likely, firstly because compared to people of their own age and sex participants answering the global question in the present study judged their own chances of becoming edentulous as significantly lower (–0.33; scale −3 to +3) than their peers' chances. They believed more often that they would definitely retain their teeth for life than the subjects answering the four items of the measurement scale (Table IV). Secondly, Åstrøm et al. [7] reported evidence of optimistic bias in comparative risk judgments concerning tooth decay (–0.32), gum disease (–0.35), and the wearing of dentures (–0.48) among 25-year-old Norwegian females, i.e. an optimistic bias approximately of the same magnitude as in the present study (–0.33). Thirdly, optimistic bias has been reported for other aspects of life (for review, see [8]). This may be taken to indicate that the respondents considered their chances of losing all their natural teeth to be 5.5% lower than those of their peers. If this is accepted, then the global unconditional estimate would be reduced form 92.2% to 87% and the 4-item scale estimates from 81.1% to 77%. These adjusted estimates are probably more realistic in the short term, considering that nearly 24% of persons 65–79 years old were edentulous in Norway in 1999/2000 (data on file from a previous Omnibus study, [26]) and that 48% of Norwegians 80 years of age or older were edentulous in 1995 [27].

The self-reported conditional belief in retaining natural teeth for a lifetime varied from 75% to 85% for the individual items of the 4-item scale. It was found that the 4-item instrument yielded a significantly ($p < 0.001$) less optimistic result (81%) than the global unconditional question (92%). This finding provides support for the hypothesis that a conditional approach to determining people's belief in retaining some natural teeth for life would return a lower and probably more realistic estimate than a global unconditional question [6]. If for any reason only one question could be employed in a survey situation, then, according to the present Omnibus findings, the conditional item focusing on diet/eating habits would appear to be the item of choice.

In the present study, only being married/cohabiting was significant in the multivariate logistic regression analysis when the global question was the dependent variable. In the ordinal regression analysis with the 4-item scale (3 categories) as the dependent variable, sex and education had a significant bivariate effect, which persisted in the ordinal regression analysis. In a study of Norwegian adults in 1999, belief in keeping teeth for life was found to be significantly associated with sex, appearance, and chewing ability. The confirmation of the hypothesized association between gender and expectation of retaining natural teeth for life based on previous findings [6] may be taken as evidence in support of construct validity [17]. The difference between studies in predictor variables showing a significant independent association and in the proportion of explained variance (4.5% or less versus 9.3%) is likely to be ascribable to different predictors in the models, i.e. appearance and chewing ability were not included in the present study for financial reasons.

Concluding remarks

The 4-item conditional measurement instrument displayed high internal reliability and higher test–retest reproducibility than the unconditional global item previously used to assess people's belief in retaining natural teeth for life. Evidence was also presented in support of face, content, and construct validity.

As predicted, the percentage of adults who expected to retain their natural teeth for a lifetime was significantly lower when employing the conditional 4-item instrument than when an unconditional global question was used. The low explained variance found in the present study is probably partly attributable to the lack of oral health-related predictors in the multivariate logistic regression model [6,12,13].

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