Clin Oral Invest (2012) 16:997–1006
DOI 10.1007/s00784-011-0588-x

ORIGINAL ARTICLE

# The psychological impact of prosthodontic treatment—a discrete response modelling approach

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Received: 3 June 2009 / Accepted: 26 June 2011 / Published online: 21 July 2011


**Abstract** Investigating the psychological impact of dental treatment is of high relevance to clinical decision makers and a promising approach for furthering patient satisfaction. This paper aims at detecting factors which influence the psychological impact of prosthodontic treatment and its relevance for the dentist. We apply microeconometric techniques and, specifically, control for sample selection bias in order to derive evidence from a panel database which measures oral health-related quality of life (OHIP-G) before and after treatment. The survey rests upon an initial evaluation of 381 patients between 2004 and 2005 and a follow-up in January 2006 (response rate 47%, corresponding to 180 patients) at the University Medical Centre Regensburg, Germany. Our findings indicate that persons of different age have unlike mindsets towards prosthodontic interventions and that there are gender differences with respect to the psychological sensitivity towards prosthodontic interventions. Moreover, the psychological impact attributable to treatment is influenced by the type of limitation in oral well-being before treatment. We could identify distinct factors including age, gender and the type of limitation in oral well-being as causing differentiation in the psychological impact of prosthodontic treatment. Specific patient characteristics may modulate the psychological impact of prosthodontic treatment.

**Keywords** Psychological impact of dental treatment · Oral health-related quality of life · Sample selection bias · Discrete response models · Dental fear and anxiety

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## Introduction

As a key factor for patient satisfaction, the potential benefits of precisely evaluating the patient's psychological perspective are manifold. Imagine a patient who is in need of prosthodontic treatment.

First, once the patient attends the dentist, there frequently exists a broad variety of alternative treatment strategies for a given oral health condition. It has often been commented that such a situation may lead to inefficient utilisation of services when the dentist gains utility from more (expensive) treatment while the patient is not able to appraise the according clinical necessity and, hence, fails to fully articulate her interests [1–4]. Therefore, an objective evaluation of the patient's psychological requirements may allow to more precisely define the type of intervention most successful for the patient, thereby optimizing and individualizing treatment strategies. This could not only enable to avoid costs of inefficient treatment but, in reply, also contribute to a furthered patient–doctor interaction.

Second, if the patient decides whether or not to attend the dentist, she will be influenced by the degree to which her psychological requirements are understood by the doctor. For the individual dentist, this may mean an improved prospect to recruit or retain patients if having a better understanding of the patient's actual desideratum than the colleagues. However, if on the aggregate level dentists fail to meet the subjective needs of their patients, this can lead to decreasing overall rates of attendance and considerable negative consequences of postponed treatment. In this context, one extreme result of unmet psychological patient needs could be seen in the case of dental anxiety whose occurrence has extensively been described in the literature (see, e.g. [5–10]).

Given such considerations, an in-depth analysis of the psychological impact of prosthodontic interventions appears to be of substantive importance in order to come up with systematic strategies against mismatches in the patient–dentist relationship. While previous literature has exclusively been investigating the impact of prosthodontic treatment on quality of life in general (see, e.g. [11–14]), it is this paper's specific objective to detect factors with utmost relevance for clinical decision making via influencing the psychological impact of prosthodontic treatment.

## Dataset and estimation strategy

### Dataset

The data used for our investigation were collected by means of the Oral Health Impact Profile in its German version (OHIP-G) [15]. This is a non-preference-based disease-specific measurement tool for oral health-related quality of life and consists of 49 items as originally established in the English version of OHIP [16] plus four additional items as identified as relevant to the German population by John et al. in 2002 [15]. Please note that in this paper we refer to the original 49 OHIP items as the difference between OHIP versions containing 49 and 53 items, respectively, is suggested to be only small [15].

The 49 single OHIP items are grouped into seven different subcategories, and the questionnaire delivers answers as ordered categorical variables on a scale from “0” (no problems within the last month) to “4” (very frequent problems within the last month). In particular, two categories measure psychological components of oral health-related quality of life. The according 11 questions detect *psychological discomfort* (items 19–23) and *psychological disability* (items 33–38).

After authorisation by the Ethics Committee of the University Medical Centre at the University of Regensburg, Germany (reference number 03/102), a clinical trial was accomplished which involved 381 patients at the Department of Prosthodontics and led to an appropriate panel dataset. Each patient's item scores were initially evaluated before treatment which either took place in the summer term 2004, the winter term 2004/2005 or the summer term 2005. Several months after treatment, a follow-up evaluation was conducted via letter mail in January 2006 which had a response rate of 47%, corresponding to 180 patients. The time span between the end of treatment and follow-up ranged between four and 21 months.

Changes (better, worse, unaltered) within a specific psychological OHIP item are revealed by variables [“Δ(OHIP_XY)”] which consist of the item score difference between the 1st and 2nd evaluation. Moreover, the different intervals between treatment and follow-up enable to analyse whether the impact of prosthodontic treatment differs according to different time delays after application of dental care. Therefore, appropriate dummy variables were constructed which reflect the delay of follow-up after initial intervention (“winter05_06”, “summer06”). We also include a variable which detects the highest score for a single item within the questionnaire as specified by the individual participant before treatment (“MaxScore”). Additionally, this proxy variable for the *level* of initial impairment is complemented by yet another dummy variable: “MaxScore_in_Nonpsych” detects whether the highest score for a single OHIP item before treatment is observed within a category which measures non-psychological outcomes (“MaxScore” within non-psychological OHIP items > “MaxScore” within psychological OHIP items). Therefore, it indicates two different *types* of limitation in oral well-being before treatment. Sixty-seven percent of the patients reported their “MaxScore” to be in a non-psychological OHIP category.

Besides the OHIP variables, the dataset incorporates the continuous covariate “Age” as well as binary variables for gender (52% of the sample are “female”) and type of restoration (“removable”). The latter distinguishes between treatment by means of removable denture (21% of the patient sample), i.e. complete and partially removable denture, and a therapy based on fixed dentures (79% of the patient sample). We also check whether model specifications with two separate explanatory variables for removable partial ($n$=11 followed-up patients) and “complete denture” ($n$=28 followed-up patients) will change the robustness of our results. Finally, the binary variable “answer” depicts whether an individual has participated at the follow-up and thus forms a basis for dealing with sample selection issues. Tables 3 and 4 in the appendix summarise all variables and interaction terms which were considered in this study.

Estimation strategy

The dependent variables consist of the difference between the ordered responses to OHIP-G items before and after treatment. Hence, discrete response models provide a feasible method for examining the impact of dental treatment on psychological components of oral health-related quality of life.

*Discrete response modelling*

Basically, this type of analysis rests on the assumption that the value of the observed discrete dependent variable Δ(OHIP_xy) is determined by a continuous latent dependent variable *δ*(OHIP_xy) for which a standard regression model is assumed. The range of the latent dependent variable is divided into as many consecutive intervals as there are possible values of the observable discrete variable. In the current case, the discrete dependent variable can take nine different values in the set −4, −3, −2, −1, 0, 1,…, 4. Thus, for the value of the latter, it matters in which interval the latent variable lies and this, in turn, depends on the relevant explanatory variables and the error term. Due to the unobservability of the latent variable, one can no longer use standard ordinary least squares estimation that works even without a full specification of the distribution of the errors. In the current case, one has to completely specify the distribution of the errors of the underlying regression model and can then use maximum likelihood (ML) estimation to obtain estimates of the model parameters and the boundaries of the intervals [17]. Based on these estimates, one can compute the probabilities of observing each of the nine different outcomes of Δ(OHIP_xy) given specific values of the explanatory variables. In the Results, we will summarise the outcomes into "better" (if Δ(OHIP_xy) takes values in −4, −3, −2, −1), "unchanged" (0) and "worse" (1, 2, 3, 4) and add up the relevant probabilities accordingly. Note that the probabilities for all three categories sum up to one. Also, the notation for the predicted probabilities will follow the structure P(category | "explanatory variables"), where "category" relates to better, unchanged or worse outcomes of treatment.

By construction, a change in an explanatory variable, while keeping everything else constant, leads to a change in the probabilities under investigation. For instance, consider Fig. 1 which shows a case of normally distributed errors. The depicted shift of the distribution function F[δ(OHIP_20)] relates to different alternations in self-consciousness of a patient who receives a removable denture (red line) as opposed to a patient who receives a fixed denture (green line), other things equal (Age=50, MaxScore=2, MaxScore_in_Nonpsych=0). The threshold values are set as follows: the blue line defines the probability to improve, while the purple line determines the probability of a change for the worse. Accordingly, distances on the ordinate indicate the probabilities for ameliorated, unaltered or declined outcomes. In the given example, this would mean that an individual who obtains a removable denture has a higher

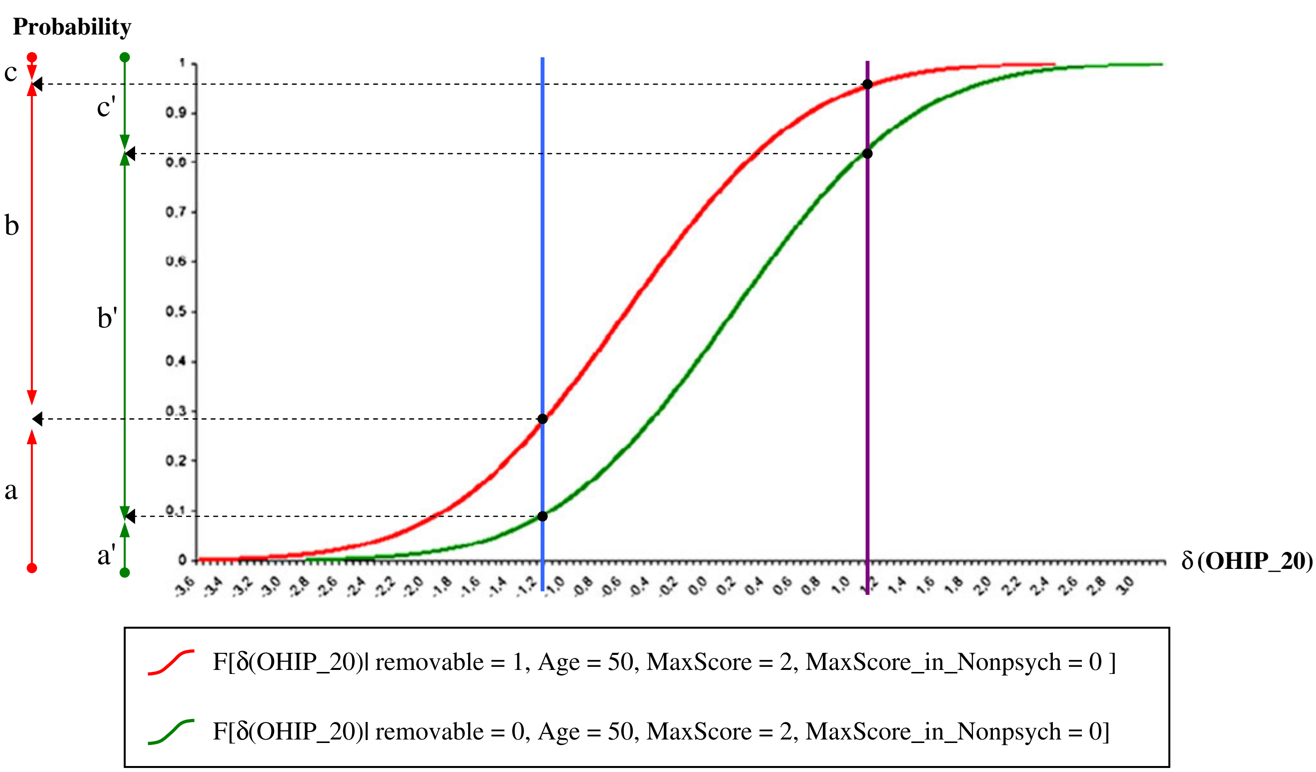


**Fig. 1** The principle of discrete response modelling

probability to improve ($a > a'$) and a lower probability to worsen ($c < c'$) in comparison to an individual who obtains a fixed denture. This *relative* effect appears plausible if considering that the successful mitigation of adverse circumstances may mean a comparably high upgrade in oral well-being for patients with an indication for removable denture.

### *Sample selection bias*

Notably, though, the possibility of sample selection can lead to systematically distorted estimation results. Such a problem may arise if the sample of the follow-up differs from the first evaluation, i.e. patient characteristics are not proportionally represented in both samples. For continuous dependent variables, specific regression methods are available to address this possible statistical imperfection. The most popular solution for sample selection is Heckman's two-stage approach [18]. However, this assumes linear structures and, hence, is only approximate for ordinal dependent variables. Hence, the use of ML or simulated ML techniques appears superior. For instance, generalised linear latent and mixed models (gllamm) follow the ML approach by performing two sequential estimation procedures [19].

### *Model specification*

This paper considers two different model types. First, standard ordered probit models describe results without consideration of sample selection. Second, gllamm models are used in order to ensure both an amendment of sample selection and consistency with the ordered nature of the data. According to the parameter estimators obtained from these two different model specifications, the impact of sample selection becomes appraisable. Subsequently, adjusted probabilities for improved, worse or unaltered psychological outcome as compared to the status quo before treatment can be computed.

For the selection model, the covariates for sums in OHIP subcategories a) to g) ("Σ(OHIP[a])"=functional limitation, "Σ(OHIP[b])"=physical pain, "Σ(OHIP[c])"=psychological discomfort, "Σ(OHIP[d])"=physical disability, "Σ(OHIP[e])"=psychological disability, "Σ(OHIP[f])"=social disability, and "Σ(OHIP[g])"=handicap) and for OHIP item 4 ("OHIP_04", i.e. the patient's perceived impairment in terms of appearance) were also included as potential parameters (see Table 4). The latter turned out to be the most significant single OHIP item with respect to the dependent variable "answer". These additional variables were considered because differences in feeling affected by oral disease as evaluated before treatment may link to a patient's motivation to participate at the follow-up.

The inclusion of variables into the models drew upon automatic backward stepwise selection. The significance level above of which a variable was removed from the initial model was set at $p=0.05$, and the significance level below of which a variable was reintegrated was set at $p=0.01$. We used the software package STATA 10.0 in combination with the wrapper programme "ssm" [20]. The prediction of probabilities was based upon the software package Ox version 4.04 [21].

## Results

Table 1 shows the specification of the sample selection equation which originates from binary probit regression on the individual's decision to participate at the follow-up ("answer"). By way of example, Table 1 indicates that a study participant's probability to participate in the follow-up increases with increasing maximum impairment before treatment (maximum score amongst all OHIP items according to variable "MaxScore"). Accordingly, it is corrected for a systematic non-participation at the second evaluation by means of gllamm models. As is evident from the estimation results in Tables 5, 6 and 7 (see Appendix) considering this phenomenon is relevant, albeit only to a small extent. More precisely, alterations in parameter values and confidence intervals between ordered probit and gllamm model specifications primarily occur within the determination of cut points. Note that all findings described below refer to gllamm estimation.

As outlined in Table 2, the explanatory variables for the response models are of varying significance with respect to individual psychological items. However, the sign and size of the according parameter estimates have similar dimensions across different items. Therefore, the results can be narrowed down to an exemplary illustration of the impact of different variables on the psychological impact of prosthodontic treatment. For this purpose, we refer to items Δ(OHIP_20) (*self-conscious*), Δ(OHIP_21) (*miserable*) and Δ(OHIP_38) (*been embarrassed*). Only one variable ("MaxScore") is significant for all psychological items, at least in

**Table 1** Specification of the sample selection model

| Binary probit | | |
|---|---|---|
| *Answer* | Coef | Se |
| Selection model | | |
| Constant | −1.392*** | 0.456 |
| Σ(OHIP[a]) | 0.046** | 0.022 |
| Σ(OHIP[b]) | −0.034** | 0.016 |
| OHIP_04 | −0.259*** | 0.080 |
| MaxScore | 0.472*** | 0.177 |
| MaxScore*Age | −0.007** | 0.004 |
| Age | 0.025** | 0.010 |

***$p<0.01$; **$p<0.05$; *$p<0.1$

**Table 2** The “menu” of parameters for psychological perception

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Δ(OHIP_19)* | *worried* | + | + | | | - | - | | | | | | |
| *Δ(OHIP_20)* | *self-conscious* | | + | | | | | - | | - | + | | |
| *Δ(OHIP_21)* | *miserable* | | + | | | | - | | | | | - | + |
| *Δ(OHIP_22)* | *appearance* | | | | | - | - | | | | | | |
| *Δ(OHIP_23)* | *tense* | + | | | | - | - | | | | | | |
| *Δ(OHIP_33)* | *sleep interrupted* | | | | | | - | | | | | | |
| *Δ(OHIP_34)* | *upset* | | | + | | | - | | | | | | |
| *Δ(OHIP_35)* | *difficult to relax* | | + | | | | - | | | | | | |
| *Δ(OHIP_36)* | *depressed* | | + | | + | | - | | - | | | | |
| *Δ(OHIP_37)* | *concentration* | | + | | | | - | | | | | | |
| *Δ(OHIP_38)* | *been embarrassed* | | + | | | | - | | | | | | |

1 = MaxScore_in_Nonpsych
2 = MaxScore_in_Nonpsych*removable
3 = MaxScore_in_Nonpsych*age
4 = MaxScore_in_Nonpsych*female
5 = MaxScore
6 = MaxScore*removable
7 = MaxScore*age
8 = MaxScore*female
9 = removable*age
10 = age
11 = age*female
12 = female

parameter estimates:
(blank cell) not significant
+ significant, positive sign
- significant, negative sign

combination with other variables. This emphasises that the *level* of impairment as perceived before treatment matters.

“Age” is particularly relevant for Δ(OHIP_20), i.e. for the patient's self-consciousness. Figure 2 illustrates the findings for the case of fixed dentures and distinguishes between a marginal (“MaxScore”=1) and a pronounced (“MaxScore”=4) maximum impairment before treatment. While in the case of *severe initial impairment* the probabilities to improve are relatively low for young individuals, the probabilities to worsen are remarkably high when a person of greater age has had an only *marginal initial impairment* before treatment.

Gender proves significant for Δ(OHIP_21) and Δ(OHIP_36). In the latter case, the impact of treatment

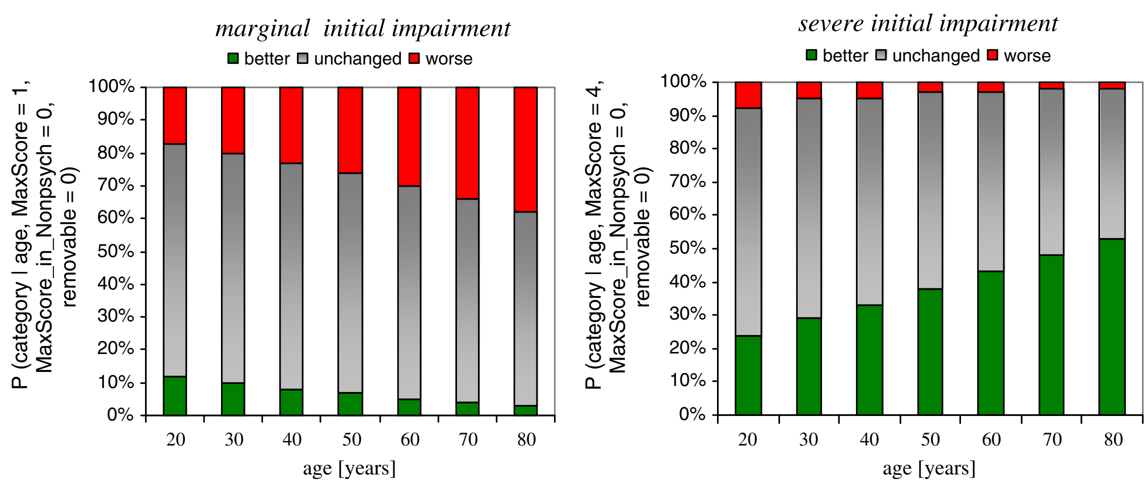


**Fig. 2** The effect of age on self-consciousness—Δ(OHIP_20)

on feeling depressed varies with the *type* ("MaxScore_in_Non-psych") and *level* of primary impairment ("MaxScore") for women but not for men. In the case of feeling miserable, i.e. Δ(OHIP_21), male patients have probabilities which are constant across age (see Fig. 3). In contrast, female individuals have a comparably low (high) probability to improve when at young (old) age.

The covariate "MaxScore_in_Nonpsych" detects the *type* of impairment before treatment in terms of mainly non-psychological OHIP items or mainly psychological OHIP items and, hence, allows distinguishing between two sorts of initial limitation in oral well-being. It is significant for all items except for Δ(OHIP_22) and Δ(OHIP_33). As a stand-alone parameter, it influences Δ(OHIP_19) as well as Δ(OHIP_23) and, in interaction with the variable "removable", plays a role for Δ(OHIP_19), Δ(OHIP_20), Δ(OHIP_21), Δ(OHIP_35), Δ(OHIP_36), Δ(OHIP_37) and Δ(OHIP_38). For example, Fig. 4 illustrates the effect of different *types* of initial impairment on being embarrassed as determined by receiving a removable denture. A predominant limitation in psychological OHIP items is shown to cause higher probabilities of improvement after treatment than a predominant limitation in non-psychological OHIP items. In both cases, a likewise stratification takes place with respect to "MaxScore" which indicates the *level* of impairment before treatment.

Finally, regarding the robustness of different model specifications, the parameter estimates for "removable partial denture" ($n$=11 followed-up patients) and "complete denture" ($n$=28 followed-up patients) turned out not statistically significant when including them simultaneously or if including only one of both at a time.

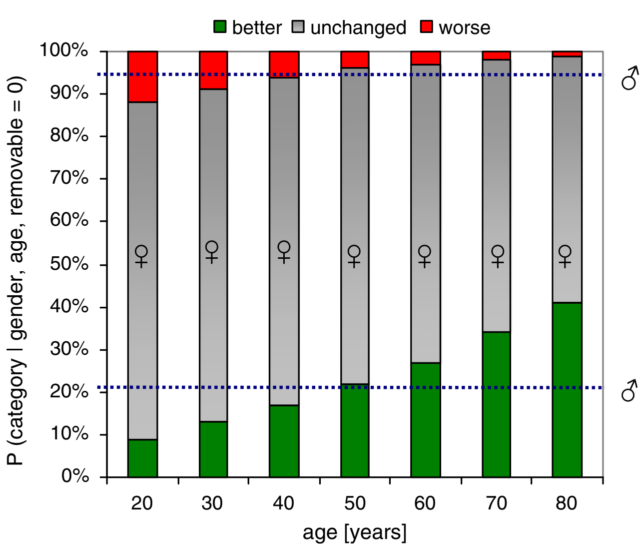


**Fig. 3** The effect of gender on feeling miserable—Δ(OHIP_21)

## Discussion

For all psychological OHIP items, a significant stratification of treatment outcomes relates to the *level* of impairment before treatment. This appears plausible as the *relative* impact of treatment is investigated, and as expected, the chance to feel better should be higher for an individual who feels pronouncedly miserable than for a patient who feels only slightly affected by oral health issues. Whilst a high *relative* improvement does not necessarily lead to a higher *absolute* impairment after treatment in comparison to an individual who did not improve that much, this study yet enables informative conclusions about the patient's psychological perspective.

First, the change in self-consciousness Δ(OHIP_20) due to treatment varies by age and severity of the initial condition. Particularly, if having a *severe* limitation in oral health, older patients seem to cope better than younger individuals. However, the relationship seems reversed for a *marginal* limitation in oral health. This may lead to the conjecture that persons of different age have unlike mind-sets towards dental interventions.

On the one hand, young patients could perceive treatment as considerable negative confrontation when having a poor oral health condition. This appears plausible if envisaging that the benchmark of complete oral intactness could play a more distinct role at an early age. A suggesting consequence for daily practice would be to consider an amplified effort of patient motivation for young patients with a severe limitation in oral health.

If, on the other hand, an older patient does not feel markedly impaired, dental treatment could lead to a comparably high rate of adverse psychological consequences. Potential explanations may be that the general adaptiveness towards new circumstances decreases with age or that treatment may lead to more negative side effects when at old age. From a patient's perspective, no treatment could then even be better than the most sophisticated therapy at all [22, 23].

Second, gender influences some psychological dimensions as affected by prosthodontic treatment. Strikingly, in terms of feeling miserable (Δ(OHIP_21)), female individuals appear to receive more negative impacts attributable to prosthodontic treatment when young in contrast to more positive impacts when older. Of note, the male patients' psychological ranking does not seem to depend on age. Based on these findings, dentists planning treatment should be aware that the same therapy may lead to different degrees of psychological impact between women and men.

Third, the psychological impact of prosthodontic treatment seems to differ by the *type* of impairment before treatment as exemplarily shown for Δ(OHIP_38) (*been embarrassed*). Patients appear to be comparably satisfied

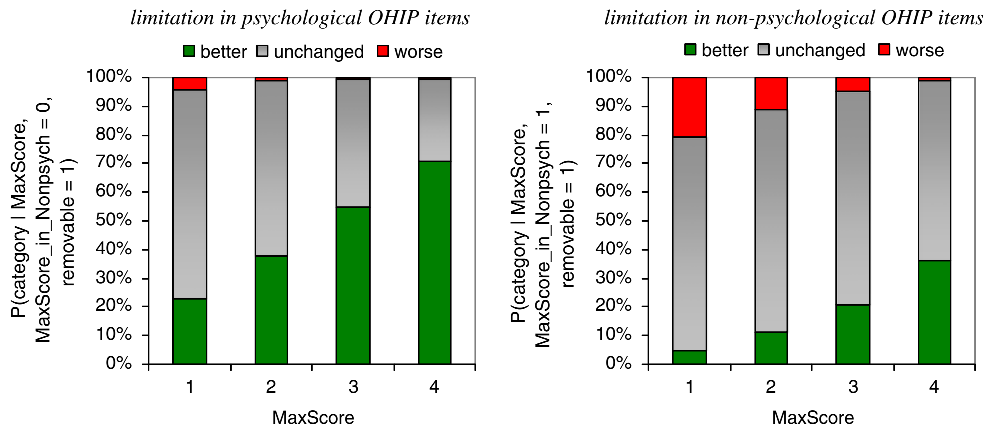


**Fig. 4** The effect of different predominant limitations on being embarrassed—Δ(OHIP_38)

with dental treatment when the discontentment in terms of oral well-being before treatment was mainly due to psychological matters. On the opposite, if the primary affectedness is predominantly related to non-psychological causes, this seems to lead to relatively poor psychological treatment outcomes.

Regarding the robustness of our model specifications, there may be two potential explanations for the fact that parameter estimates for "removable partial denture" ($n$=11 followed-up patients) and "complete denture" ($n$=28 followed-up patients) turned out not statistically significant when including them simultaneously or by including only one of both at a time. First, one may argue that, from a patient's perspective, the fact of receiving a removable (as compared to fixed) denture is psychologically more meaningful than the actual extent of such a denture. Second, the number of observations for removable partial and complete dentures in our sample may be too small to capture statistical significance regarding psychological treatment outcomes. We thus suggest that future studies with larger sample sizes should focus on differential psychological treatment outcomes between removable partial in comparison with complete dentures. Another methodological limitation of our study may be that follow-up evaluations by means of the OHIP did not comply with a standardized time interval after treatment. This may be relevant because the extent of prosthodontic treatment effects might be influenced by the time span after which re-evaluation takes place.

All in all, this study gives insights into the patient's psychological impact of prosthodontic treatment and, thus, supports the evolution of systematic treatment pathways. In particular, the findings indicate that the impact of treatment outcomes is considerably influenced by distinct patient characteristics which may also modulate the relationship between patients and dentists [24–26]. Based on our results, the dentist's communication during the treatment procedure cannot be regarded as a *unidirectional* process but has to be interpreted as *bidirectional*, decisively influenced by a distinct set of patient characteristics.

In terms of dental fear and anxiety, the study's findings add a new perspective to the existing literature. Particularly, this investigation considers one course of treatment as a stimulus unit which may or may not lead to adverse psychological outcomes. While many other studies seek to analyse ex post which characteristics are prevalent amongst phobics, this study delivers ex ante evidence for a gradual evolution of according diseases. That is to say the results indicate that age, gender as well as type and level of the patient's impairment before treatment decisively influence whether one particular course of treatment is experienced as positive or negative. In turn, this could trigger the occurrence of phobic behaviour at subsequent courses of treatment.

Even if an *experienced* dentist may consider some of our findings as commonplace, it is nevertheless connoting that questionnaires like the OHIP provide a *survey-based* source for conclusions about patient-centred psychological issues. Shed into this light, our findings encourage the routine use of such measurement tools for two purposes. First, this provides a feasible method to detect patients with particular psychological needs. Second, this can be used as a core for future research which aims at an empirically enhanced investigation of alternative treatment strategies and the associated outcomes. Specifically, datasets over larger time periods appear highly desirable in order to assess the long-run benefits of dental interventions. This study has, not least, established the application of suitable microeconometric techniques.

In conclusion, the findings in this paper suggest that (1) persons of different age have unlike mindsets towards prosthodontic interventions and that (2) there are gender differences with respect to the psychological sensitivity towards prosthodontic interventions. Moreover, (3) the psychological impact attributable to treatment is influenced by the type of limitation in oral well-being before treatment (psychological vs. non-psychological).

**Conflicts of interest** The authors declare that they have no conflict of interest.

## Appendix

**Table 3** General set of variables (summary statistics)

| Variable | Observations | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Δ(OHIP_19) [worried] | 173 | −0.3294798 | 1.360189 | −4 | 4 |
| Δ(OHIP_20) [self-conscious] | 175 | −0.4342857 | 1.069414 | −4 | 2 |
| Δ(OHIP_21) [miserable] | 175 | −0.1942857 | 0.9266002 | −4 | 3 |
| Δ(OHIP_22) [appearance] | 179 | −0.301676 | 0.9648587 | −4 | 2 |
| Δ(OHIP_23) [tense] | 177 | −0.1073446 | 1.041635 | −4 | 3 |
| Δ(OHIP_33) [sleep interrupted] | 175 | −0.0571429 | 0.7634938 | −3 | 3 |
| Δ(OHIP_34) [upset] | 178 | −0.1235955 | 0.9721573 | −3 | 4 |
| Δ(OHIP_35) [difficult to relax] | 176 | −0.0568182 | 0.8261159 | −3 | 3 |
| Δ(OHIP_36) [depressed] | 178 | −0.0561798 | 0.6947674 | −2 | 3 |
| Δ(OHIP_37) [concentration] | 178 | −0.0898876 | 0.6829721 | −3 | 3 |
| Δ(OHIP_38) [been embarrassed] | 178 | −0.1573034 | 0.868779 | −4 | 3 |
| MaxScore_in_Nonpsych | 381 | 0.6745407 | 0.4691623 | Dummy | |
| MaxScore_in_Nonpsych*removable | 381 | 0.1469816 | 0.3545532 | Dummy | |
| MaxScore_in_Nonpsych*Age | 381 | 32.77428 | 27.37395 | 0 | 105 |
| MaxScore_in_Nonpsych*female | 380 | 0.3368421 | 0.4732535 | Dummy | |
| MaxScore | 381 | 2.64042 | 1.109454 | 0 | 4 |
| MaxScore*removable | 381 | 0.6220472 | 1.285112 | 0 | 4 |
| MaxScore*Age | 381 | 131.6982 | 81.9585 | 0 | 420 |
| MaxScore*female | 380 | 1.478947 | 1.607068 | 0 | 4 |
| Removable*Age | 381 | 11.93176 | 23.97478 | 0 | 90 |
| Removable*female | 380 | 0.1131579 | 0.3172034 | Dummy | |
| Age | 381 | 47.67979 | 18.31601 | 18 | 105 |
| Age*female | 380 | 24.78684 | 27.3545 | 0 | 105 |
| Female | 380 | 0.5210526 | 0.5002152 | Dummy | |
| Removable | 381 | 0.2178478 | 0.4133262 | Dummy | |
| Summer05 | 381 | 0.4041995 | 0.4913817 | Dummy | |
| Winter05_06 | 381 | 0.3228346 | 0.4681749 | Dummy | |
| Answer | 381 | 0.4724409 | 0.4998964 | Dummy | |

**Table 4** Additional OHIP variables for the selection equation (summary statistics)

| Variable | Observations | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| OHIP_04 [appearance affected] | 377 | 0.8196286 | 1.222283 | 0 | 4 |
| Σ(OHIP[a]) [functional limitation] | 381 | 6.650919 | 6.144868 | 0 | 29 |
| Σ(OHIP[b]) [physical pain] | 381 | 6.847769 | 5.744831 | 0 | 26 |
| Σ(OHIP[c]) [psychological discomfort] | 381 | 3.635171 | 4.433215 | 0 | 18 |
| Σ(OHIP[d]) [physical disability] | 381 | 3.341207 | 5.648391 | 0 | 33 |
| Σ(OHIP[e]) [psychological disability] | 381 | 2.409449 | 3.745217 | 0 | 19 |
| Σ(OHIP[f]) [social disability] | 381 | 0.9868766 | 2.472445 | 0 | 20 |
| Σ(OHIP[g]) [handicap] | 381 | 1.963255 | 3.564993 | 0 | 23 |

**Table 5** Model specifications for Δ(OHIP_20) [self-conscious]

| Δ(OHIP_20) | Ordered Probit | | GLLAMM | |
|---|---|---|---|---|
| | Coef | Se | Coef | Se |
| Selection model | | | | |
| Constant | (N/A) | | −1.390*** | 0.455 |
| MaxScore | | | 0.476*** | 0.177 |
| Σ(OHIP[a]) | | | 0.045** | 0.022 |
| Σ(OHIP[b]) | | | −0.035** | 0.016 |
| OHIP_04 | | | −0.260*** | 0.079 |
| MaxScore*Age | | | −0.007** | 0.004 |
| Age | | | 0.025** | 0.010 |
| Response model | | | | |
| MaxScore_in_Nonpsych*Removable | 1.130*** | 0.359 | 1.070*** | 0.369 |
| MaxScore*Age | −0.008*** | 0.002 | −0.008*** | 0.002 |
| Removable*Age | −0.016*** | 0.005 | −0.015*** | 0.005 |
| Age | 0.021*** | 0.007 | 0.019** | 0.008 |
| Cut points | | | | |
| 1 | −0.653** | 0.281 | −0.955** | 0.450 |
| 2 | 1.545*** | 0.303 | 1.182** | 0.592 |

***$p<0.01$; **$p<0.05$; *$p<0.1$

**Table 6** Model specifications for Δ(OHIP_21) [miserable]

| Δ(OHIP_21) | Ordered Probit | | GLLAMM | |
|---|---|---|---|---|
| | Coef | Se | Coef | Se |
| Selection model | | | | |
| Constant | (N/A) | | −1.373*** | 0.460 |
| MaxScore | | | 0.463*** | 0.179 |
| Σ(OHIP[a]) | | | 0.047** | 0.022 |
| Σ(OHIP[b]) | | | −0.034** | 0.016 |
| OHIP_04 | | | −0.256*** | 0.080 |
| MaxScore*Age | | | −0.007** | 0.004 |
| Age | | | 0.024** | 0.010 |
| Response model | | | | |
| Age*Female | −0.020** | 0.008 | −0.018** | 0.008 |
| Female | 1.005** | 0.424 | 0.941** | 0.447 |
| MaxScore*Removable | −0.373*** | 0.097 | −0.371*** | 0.097 |
| MaxScore_in_Nonpsych*Removable | 1.466*** | 0.381 | 1.465*** | 0.379 |
| Cut points | | | | |
| 1 | −0.922*** | 0.164 | −0.738* | 0.429 |
| 2 | 1.600*** | 0.196 | 1.753*** | 0.327 |

***$p<0.01$; **$p<0.05$; *$p<0.1$

**Table 7** Model specifications for Δ(OHIP_38) [been embarrassed]

| Δ(OHIP_38) | Ordered probit | | GLLAMM | |
|---|---|---|---|---|
| | Coef | Se | Coef | Se |
| Selection model | | | | |
| Constant | (N/A) | | −1.393*** | 0.460 |
| MaxScore | | | 0.473*** | 0.177 |
| Σ(OHIP[a]) | | | 0.045** | 0.022 |
| Σ(OHIP[b]) | | | −0.034** | 0.016 |
| OHIP_04 | | | −0.260*** | 0.082 |
| MaxScore*Age | | | −0.007** | 0.004 |
| Age | | | 0.025*** | 0.010 |
| Response model | | | | |
| MaxScore*Removable | −0.439*** | 0.099 | −0.439*** | 0.099 |
| MaxScore_in_Nonpsych*Removable | 0.935** | 0.363 | 0.933** | 0.364 |
| Cut points | | | | |
| 1 | −1.174*** | 0.131 | −1.189*** | 0.331 |
| 2 | 1.301*** | 0.140 | 1.286*** | 0.350 |

***$p<0.01$; **$p<0.05$; *$p<0.1$

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