



Multilevel analysis of periodontal treatment response

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INTRODUCTION

- Hierarchical data (or clustered data) are common in dental research as adults may have up to 32 teeth and measurements taken from different teeth of the same individual are possibly correlated or clustered.
- Conventional statistical methods, which assume observations being independent, are not appropriate in analyzing clustered data. Thus special statistical analysis is required when data have a hierarchical structure.
- ‘Multilevel modelling’ (Goldstein, 1995) or equivalently ‘hierarchical linear modelling’ (Bryk and Raudenbush, 1992) is a class of techniques developed to analyze hierarchical data. Several studies using multilevel modelling in analyzing dental data have been published.
- In order to account for the hierarchical structure of periodontal disease measurements, i.e. sites measurements clustered around teeth and then teeth clustered within subjects, analyses using a multilevel approach were adopted in this study (Gilthorpe *et al.*, 2000).

OBJECTIVE

- To investigate baseline factors which may predict non-surgical periodontal treatment response using multilevel multiple regression.

MATERIALS AND METHODS

- 32 non-smoking, chronic periodontitis patients participated in a single-blinded, randomized controlled clinical trial of non-surgical periodontal protocols.
- Reductions in probing pocket depth (PPD) at 1-month, 3-months and 6-months (compared to baseline PPD) were analyzed using multilevel multiple regressions.
- A 3-level model was considered: site at level-1, tooth at level-2 and subject at level-3. Variance components models (with no independent variables included) were obtained initially to investigate the variance of the reduction in PPD across all the 3 levels.
- 12 independent variables were included in the multilevel multiple regression model.

Subject-level variables:

- Treatment group (*one-stage full-mouth mechanical debridement alone vs. one-stage full-mouth mechanical debridement & full-mouth disinfection*)
- Age (*in years*)
- Gender (*female vs. male*)
- Number of missing teeth at baseline
- % plaque at baseline
- % BOP at baseline
- % diseased sites at baseline (*sites with PPD ≥ 4.6mm*)
- % Spirochaetes and curved rods at baseline

Tooth-level variable:

- Tooth type (*non-molar vs. molar*)

Site-level variables:

- PPD at baseline
- Presence or absence of plaque at baseline
- Presence or absence of BOP at baseline

- All the continuous variables were centered (subtracted from the mean) before the analysis. Only significant variables were retained in the final multilevel regression models. All the analyses were performed using the software MLwiN 2.1 (Rasbash *et al.*, 2000). The level of significance was set to be at 0.05.

RESULTS

- Altogether, 4836 sites distributed on 806 teeth (not including 3rd molars) in these 32 subjects were included for the analyses of reduction in PPD at 1-month and 3-months. Since 1 subject in the treatment group of one-stage full-mouth mechanical debridement & full-mouth disinfection did not attend the 6 months review, only 4680 sites measurements on 708 teeth in the remaining 31 subjects were used for the analysis of reduction in PPD at 6-months.
- The overall mean reduction in PPD at 1-, 3- and 6-months were 0.83mm, 1.00mm and 1.19mm respectively (Table 1). The variance component models showed that significant variations existed at all three levels of the multilevel structure (all 95% confidence intervals did not cover the value of 0). Site-level variation contributed almost 90% of the total variation in reduction in PPD at 1-, 3- and 6-months.

Table 1. Variance components (VC) models for reduction in PPD (95% C.I. in parenthesis).

	1-month	Reduction in PPD 3-month	6-month
Mean (intercept)	0.83 (0.72, 0.94)	1.00 (0.87, 1.13)	1.19 (1.05, 1.34)
<i>Variance</i>			
Subject (level-3)	0.09 (0.04, 0.13)	0.13 (0.06, 0.20)	0.15 (0.07, 0.24)
Tooth (level-2)	0.12 (0.08, 0.15)	0.12 (0.08, 0.16)	0.10 (0.06, 0.14)
Site (level-1)	1.45 (1.38, 1.51)	1.61 (1.53, 1.68)	1.77 (1.69, 1.85)
Total variance	1.65	1.85	2.02
<i>% total variance</i>			
Subject (level-3)	5	7	8
Tooth (level-2)	7	6	5
Site (level-1)	88	87	88

Table 2. Final multilevel multiple regression models for reduction in PPD

Variables	1-month Estimate (SE)	3-month Estimate (SE)	6-month Estimate (SE)
Intercept	0.70 (0.06)	0.74 (0.07)	0.83 (0.07)
<i>Subject-level</i>			
Gender (female vs. male)	—	0.16 (0.07) ^a	0.17 (0.08) ^a
% plaque at baseline	-0.01 (<0.01) ^b	-0.01 (<0.01) ^a	-0.02 (<0.01) ^a
% BOP at baseline	—	0.01 (<0.01) ^a	0.01 (<0.01) ^a
<i>Tooth-level</i>			
Tooth type (non-molar vs. molar)	0.28 (0.04) ^a	0.31 (0.04) ^a	0.34 (0.04) ^a
<i>Site-level</i>			
PPD at baseline	0.48 (0.01) ^a	0.56 (0.01) ^a	0.57 (0.01) ^a
Presence of plaque at baseline	-0.10 (0.04) ^a	-0.08 (0.04) ^a	—
a. p<0.001; b. p<0.01; c. p<0.05			
Variance			
Subject	0.04	0.03	0.03
Tooth	0.08	0.10	0.07
Site	0.92	0.87	0.10
Total variance	1.04	0.99	1.09
% reduction in variance (compared to VC models)			
Subject	51	77	79
Tooth	32	16	24
Site	36	46	44
Total variance	37	46	46

- Table 2 shows the final multilevel multiple regression models. The intercept in the model for the reduction in PPD 1-month was 0.70 indicating that sites from molar teeth with the mean level of PPD (3.4mm) and absence of plaque at baseline from subjects with mean levels of % plaques (77%) at baseline had 0.70mm (mean) reduction in PPD at 1-month.
- From the final regression models, it was found that there was no difference in the reduction in PPD at 1-, 3- and 6-months between the two treatment groups.
- Consistently, sites from non-molar teeth, sites with deeper PPD at baseline or sites from subjects with lower % plaque at baseline were associated with significantly greater reduction in PPD at 1-, 3- and 6-month (p<0.05). Sites with the presence of plaque at baseline had significantly lower reduction in PPD at 1- and 3-months (p<0.05) but not for the reduction in PPD at 6-months. Sites from females subjects or subjects with higher % BOP at baseline were associated with greater reduction in PPD at 3- and 6-months.
- The variations at each level were reduced markedly with the inclusion of the significant variables. The total variance of the final models were reduced by 37%, 46% and 46% respectively for reduction in PPD at 1-, 3- and 6-months, when compared to the corresponding variance components models.

CONCLUSIONS

- The use of multilevel analysis enables researchers to incorporate in the same model predictor variables measured at different levels.
- Multilevel analysis appears to be a powerful statistical tool for the analysis of periodontal data.

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