Demographic Variables and Tooth Color: Evidence from Eleven Randomized Clinical Trials

R.D. Gibb*, X. Zhou, P.A. Sagel, R.W. Gerlach
Procter & Gamble Co., Mason, OH, USA

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ABSTRACT

Cross-sectional survey research suggests a relationship exists between various demographic parameters and tooth color (Odioso, Compend Contin Educ Dent 2000). Recently, a series of randomized clinical trials was conducted as part of development of a new tooth whitening system. A total of 11 clinical studies were conducted over a 2 year period at 6 different US sites. In these trials, digital image analysis was used to objectively measure pre-treatment, anterior tooth color in CIELab color space as b* (yellow-blue), L* (lightness) and a* (green-red). Using these pooled pre-treatment data from 473 subjects, demographic parameters (age, gender and ethnicity) were assessed for impact on tooth color using multiple regression analysis. The study population exhibited considerable variation in tooth color, with a mean b* of 17.7, ranging from 10.8-23.4. After adjusting for study, gender and age both significantly ($p<0.001$) affected yellow color (b*). Among females, teeth were 1.1 b* units less yellow on average, while each year of increasing age was estimated to contribute to a 0.06 unit increase in b* for both genders. Similar significant effects were observed with respect to relationships between age/gender and brightness (L*). These data, drawn from a large sample of clinical trials participants, demonstrate relationships between tooth color and various demographic parameters. **Of these, age is the most significant predictor of tooth color, with study participants averaging a 0.6 unit increase in b* and a 1.3 unit decrease in L* for each decade of life.**

OBJECTIVE

The purpose of this research was to assess the impact of age, gender and ethnicity on tooth color. The tooth color measures of primary interest are yellowness (b*) and brightness (L*).

MATERIALS AND METHODS

Eleven clinical studies involving 473 subjects were conducted over a two year period at six US sites as part of development of a new tooth whitening system.

Prior to treatment, anterior tooth color was objectively measured using digital image analysis in CIELab color space as b* (yellow-blue), L* (lightness) and a* (green-red). b* and L* were statistically modeled separately in terms of age, gender and ethnicity with clinical study included as a random effect. Two-factor interactions and non-linear age effects were investigated. Final model selection was guided by graphical exploration of variable relationships and statistical significance testing.

RESULTS

The number of subjects (473 total) in each clinical study ranged from 21 to 100 with a mean of 38. Most subjects were white (89%) and female (73%) with an average age of 38.1 years. Over the combined population, subjects ranged in age from 18 to 74 years. Subjects were similar with respect to demographics across the studies.

Considerable variation in tooth color was observed with respect to both b* and L*. The average value for b* (mean ± SE) was 17.7 ± 0.1, ranging from 10.823.4 in mean value across the studies. The mean of L* ranged from 62.381.3 for an overall mean of 74.0 ± 0.1.

Table 1. Statistical Model Results
b* and L* Modeled Separately

Response/ Explanatory Variable	Parameter Estimate	*F*-Statistic	*p*-Value
b*			
intercept	18.7 (0.35)	2,921.4	<0.0001
age[a]	0.06 (0.0076)	71.6	<0.0001
gender (female)	-1.1 (0.18)	35.2	<0.0001
L*			
intercept	73.5 (0.48)	23,796.1	<0.0001
age[a]	-0.13 (0.0096)	183.4	<0.0001
gender (female)	1.2 (0.22)	26.5	<0.0001

[a] Age was location transformed to have mean zero

The final statistical model for b* included age and gender, each highly statistically significant ($p<0.0001$). The data do not provide significant evidence ($p>0.1$) of a gender-by-age interaction or higher order polynomial effects of age. In populations for which these data are representative, the model suggests that men's teeth are on average 1.1 ± 0.18 b* units more yellow than women's teeth. The model also suggests that men and women's teeth increase in yellowness at an average rate of 0.06 b* units annually. This represents a 3.0unit increase in b* over the approximate 50 year age range of the study population (Table 1, Figure 1).

Age and gender were also highly statistically significant in the model for L* ($p<0.0001$). There was insufficient evidence to support an age-by-gender interaction or higher order polynomial effects of age.

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The model interpretation is that women's teeth are on average 1.2 ± 0.22 L* brighter/lighter than men's teeth. The model also suggests that men and women's teeth decrease in lightness/brightness by 0.13 L* units for every year of life. Over a span of 50 years this corresponds to an average decrease of 6.5 L* units (Table 1, Figure 2).

Figure 1:
Baseline b* vs. Age by Gender

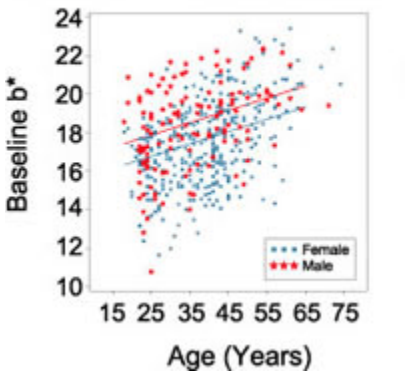
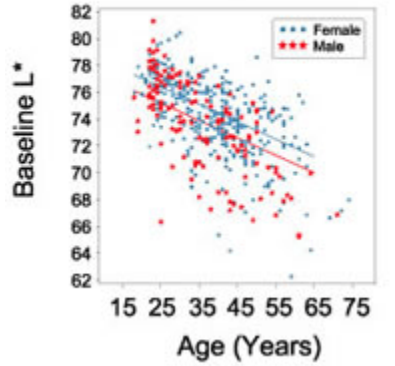


Figure 2:
Baseline L* vs. Age by Gender



With respect to the relative impact of age and gender on b* and L*, age describes a larger component of the data variability, as evidenced by the model F-statistics (Table 1). The magnitude of the model parameter estimates also suggest that age may have a greater impact on tooth color over the course of a lifetime than gender.

Ethnicity was considered in the models of b* and L* and found to be statistically significant ($p<0.05$) in both cases. The parameter estimates suggest that whites tend to have less yellow, brighter teeth than non-whites. However, due to the sparseness of data for non-whites and the potential for confounding, the validity of this result was unclear and, therefore, was not included in the final model. Model estimates for age and gender were negligibly affected by the exclusion of ethnicity.

CONCLUSION

In populations for which the data analyzed are representative, the models of b* and L* suggest:

-Men's teeth are on average 1.1 ± 0.18 b* units more yellow and on average 1.2 ± 0.22 L* units darker than women's teeth.

-Both men's and women's teeth become darker and more yellow with age at an average rate of 1.3 L* units and 0.6 b* units per decade of life.

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