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Utilities of dentin regeneration among insured and uninsured adults

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Abstract

Objectives: This population-based study measured utilities (preferences measured under conditions of uncertainty) of dentin regeneration (DR), a potential new therapy, root canal therapy (RCT), and extraction (EXT).

Methods: A representative sample of dentate adults (aged 18–69 years) was randomly selected from the Detroit area. A computer program was used to administer the standard gamble (SG) method and record utility score (US) for treatment options of a tooth with reversible pulpitis using the SG method. For the SG method, two anchor states were used: filled tooth with full oral health and filled tooth with severe and continuous pain leading to EXT. Additional data were obtained using a self-administered questionnaire.

Results: Out of the 807 adults who resided in 446 screened and selected households, a final sample of 630 adults who resided in 368 households were interviewed. The mean US for DR with 75 and 95% success rates were 72.5 and 86.2 (on a 0–100 scale), respectively. The US for RCT and immediate EXT were 75.6 and 31.3, respectively. Eleven per cent of the adults valued DR with 95% success probability higher than a simple filling with full oral health for life. There were no statistically significant differences in the average US of DR between insured and uninsured adults. Factors such as gender, race, education, income and insurance status, experiences with EXTs or root canal treatment, regularity of dental visits, quality of life, and quality of oral health were not significantly associated with the scores of DR. There was, however, a small but significant interaction between race and dental insurance, and race and gender.

Conclusion: This population-based study found that DR was highly preferred to other standard treatment options.

Keywords: decision making, dental enamel proteins, endodontics, quality of life, regeneration, tooth extraction

Dentin regeneration (DR) is a procedure that uses proteins (TGF-beta and BMP-2, BMP-4, and BMP-7) to regrow dentin. The success of DR in improving the oral health status of Americans will depend upon its adoption by the population at large, as well as by dentists. While the basic research on DR is in progress, this population-based study measured preferences (or utilities) for DR in order to determine the success level that would be acceptable by the public and their willingness to pay (WTP) for this new technology (data on WTP are presented in another paper).

The science of measuring preferences (or utilities) in populations is new to dentistry and medicine and there are no data on the determinants of preferences (or utilities) and choice of dental treatments by the population at large. In health economics, utility means preference for or desirability of a particular outcome (1). Utility assessment measures individual valuation of potential risks and benefits that are associated with a specific therapy (1).

Different methods have been used to measure utilities of medical and dental interventions. The most commonly used methods are the standard gamble (SG), time trade-offs (TTO), and WTP (2–4). The SG method is based on expected utility theory (2) under which the utility of the treatment under evaluation is measured by the balance of probabil-

ities of risk and benefit associated with a standard (alternative treatment) scenario. The utility score (US) generated from using the SG method is sometimes used either as part of a simple mathematical formula to calculate quality-adjusted life years (QALYs) or, as an input into a second measurement procedure, to measure healthy years equivalent (HYE) or health time equivalent (HTE; 1, 5). In dentistry, several derivations of these indicators have been used: quality-adjusted tooth year (QATY; 6, 7), quality-adjusted prostheses years (8), and the T-health index (9). These methods may yield different assessments of utilities because they are based on different assumptions for measuring values.

As we have described in a previous paper (1), clinical trials of new dental interventions should be based upon real-life estimates of acceptable outcomes (so-called effect measures). We also contend that there is a need for a different approach in technology transfer that is based on the demands of the public at large rather than only on the desires of dental providers. Hence, while assessing the preferences of dentists would be an interesting exercise, such information cannot be the only information used to support programs for technology transfer of new paradigm-shifting technologies. Policy makers simply need to know what the public wants, values, and expects. Moreover, clinical trials of new technologies will most likely provide better estimates of efficacy and potential adoption of a technology if they are designed to achieve an effective measure that the public considers worthwhile.

DR is a technology that could have significant impact on oral health. Epidemiological studies have reported that in American adults, filled tooth surfaces constitute at least 85% of the total decayed, missing, and filled tooth surfaces (10). With this high level of fillings and the increased retention of teeth, Americans may experience increased need for pulpal therapy. Moreover, while endodontic therapy is available in most of the economically developed countries, most teeth in need of pulpal therapy are usually extracted in other countries. Hence, DR could be highly useful in saving teeth, thus improving quality of life.

The objective of this paper is to present population-based estimates of the utilities of DR, root canal therapy (RCT), and immediate extraction (EXT) of a tooth with reversible pulpitis. The data were obtained from a representative sample of adults (18–69 years) living in 1999–2000 in the Detroit Metropolitan area (Wayne, Macomb, and Oakland counties), Michigan.

Methods

Sample selection

A random sample was selected to represent the approximately 4 million adults living in the Detroit Tri-County area (Oakland, Macomb, and Wayne). The sampling method used a list-assisted random digit dialing (RDD) protocol. RDD is a probability sampling of telephone numbers and telephone households, and thus generates samples that are representative of the population of interest. One major drawback associated with this method is the lack of coverage of individuals without telephones. In Michigan, the Federal Communication Commission reports that less than 5% of households do not have a telephone. In 1996, 85% of residents in the USA with an income of less than $10 000 per year had a telephone at home.

Telephone screening was carried out by several trained interviewers working for the Institute for Social Research (ISR), University of Michigan. The telephone screeners were trained in conducting telephone interviews and in general interviewing techniques. The screeners asked whether there was an adult between the age of 18 and 69 years living at the address contacted via telephone and if the adult or adults had at least one natural tooth. The screener also asked whether the respondent and other adults living in the sampled household had private dental insurance. In order to recruit a large sample of uninsured adults (30% of adults in the Tri-County area; 11), all households with at least one uninsured adult were included in the study. In households where all adults had private dental insurance, the computer-assisted telephone interviewing (CATI) system randomly selected one-half of such households to participate. Once a household was selected, all eligible adults in the household were invited to participate in the one-to-one home interview.

For eligible adults, who consent to participate in the study, the screeners scheduled a face-to-face interview. After the telephone screening, each potential interviewee received a self-administered questionnaire, a consent form, a letter confirming the appointment, and the name and telephone number of the face-to-face interviewer. The home interviews included obtaining informed consent, reviewing the self-administrative questionnaires, demonstrating each dental treatment, and administering the SG game. The demonstration of dental treatments and the SG game were administered using a notebook personal computer connected with an additional 15 inch LCD monitor facing the respondent.

The home interviewers were trained over a period of 6 months. The training included a step-by-step review of the protocols used to place a filling with or without RCT or DR, and tooth EXT. They were also trained by ISR in general interviewing skills. The home interviewers also conducted all the interviews completed during the pilot studies. The interviewers were hired full-time by the project for a period of 1 year. The conduct of this research was approved by the University of Michigan IRB for Health Sciences.

The number of randomly generated telephone numbers was 2372. This yielded 1569 residential telephone numbers (66.1%) and 803 nonresidential numbers. Out of the 1569 residential numbers, 925 resulted in positive contacts with potential participants (59.0%) and in those households, the screeners identified 621 households with dentate adults, aged 18–69 years, who had dental insurance. Of those, 314 households were randomly selected for further interviewing and 209 (68.8%) of these households agreed to participate. All the 304 households, with at least one uninsured adult, were selected. Of the households with at least one uninsured adult, 237 agreed to participate (78.0%). In total, 446 households agreed to participate in the study.

In the 446 selected and screened households, we identified 807 eligible adults. The telephone screeners were able to interview 796 of the 807 adults and schedule them for in-depth home interviews. However, for a number of reasons, such as refusal after the initial contact, inability to communicate in English, and safety concerns, the home interviews were administered only to 630 out of the 796 adults. These participants resided in 368 households. The number of interviewed adults is slightly more than the targeted number of participants (n = 614).

Assessment of utilities

The following methods were used to measure the utilities of DR: a visual analogue scale (VAS), SG, HYE, and WTP. This paper presents only the findings of utilities measured using the SG method.

Utility is a measure of personal preference or well being (1). For example, using the SG method, the US of DR estimates the value that an individual assigns relative to a standard treatment (for example, a filling) with two potential outcomes. These outcomes define the two end-points (or anchors) for the utility measurement scale (Figure 1). The first outcome represents absolute success, where a tooth is healthy and functional for the rest of the life and is given the US of 100. The second anchor represents absolute failure, where the tooth develops severe pain and is immediately extracted and is given the US of 0 for the worst possible health for this tooth. Because the treatments under evaluation (DR, RCT, and EXT) are not expected to produce full health with certainty, it is expected that subjects will generally have a US between these two anchor points. This is measured by asking the subject what probability of success P (i.e. full health) for the standard treatment (filling a tooth in this study) is of the same value to him/her as the treatment under evaluation. In the SG method, the values of P (and hence, the value of 1-P (the probability of failure for the standard treatment)) is changed until a respondent decides that the well being (risks and benefits) associated with the standard treatment is equal to that associated with the treatment under evaluation (e.g. DR). The value of P at this point of equal well being is the US for DR. Stronger preferences are associated with higher US because the probability of success for the standard treatment needs to be high in order for the subjects to rate it to be equivalent in value to the alternative treatment (e.g. DR).

The SG method is based on the theory of expected utility of Von Neuman & Morgenstern (2), which assumes that individuals accept a gamble between two opposing choices: a bad and unwanted outcome (usually death in medicine) and a highly wanted outcome (usually full health). These outcomes are called an-

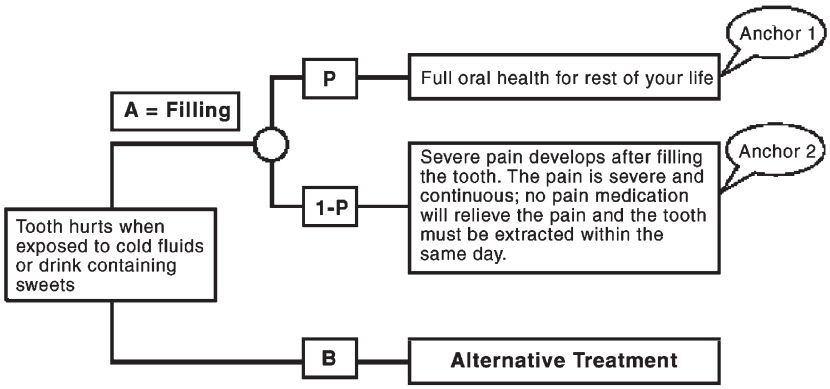

Figure 1. A decision tree of treatment of a tooth with reversible pulpitis.

chors. The basis of the theory is that individuals can choose a probability of occurrence of these outcomes between "0" and "100." The theory asserts that individuals playing the gambling game reject a standard treatment if it has a 100% probability of failure and choose a standard treatment if it has a 100% probability of success. As will be described later, these features do not sometimes hold in studies involving dental procedures when the best and worst outcomes cannot be defined as easily as when dealing with treatments that can result in life and death outcomes.

Development and testing of the utility assessment method

During the first year of the project, the research team developed and tested the protocols for measuring utilities, following the model described by Bennett & Torrance (12), for DR, RCT, and immediate EXT using the SG method. The steps followed to develop the measurement method and pilot studies are summarized in the following sections:

1 Health state identification: The dental condition that was presented to the adult participants described a tooth (not a third molar) with pain that lasts for a few seconds after eating food or drinking hot or cold fluids. The respondents were informed that the condition should be treated at the time of the dental visit because, if left untreated, the tooth may develop severe and continuous pain that cannot be relieved by pain medication and, hence, the tooth must be extracted. They were also informed that the treatment of the condition will be provided at no cost.

2 Treatment/outcome descriptions: Using input from an additional 13 volunteers, the research team developed the description of each treatment for the health state described earlier. The interviewee was informed that there are four potential treatments: filling the tooth, performing RCT, placing a dentin regenerative material on the "nerve" (pulp) of the tooth and then filling it after 2–3 weeks (DR), or immediate EXT of the tooth. The last option was included in order to test responses to an extreme treatment. The standard treatment selected for conducting the SG assessment was "filling the tooth." This treatment was selected because it is the first treatment option that may be considered and it presents potential uncertainties that were presented in the form of probabilities. The uncertainties were presented after thorough explanations, using colors, graphics, and a short test of what a probability or a gamble means to the interviewee. The two potential outcomes defined for the SG assessment were: "full oral health and no pain for the rest of the life" (anchor #1) or "severe and continuous pain that can only be resolved by extracting the tooth the same day the filling is placed" (anchor #2; Figure 2). The process of measuring utilities provides the respondent with two treatment options each time. The first choice is always filling the tooth; the second choice could be either RCT, DR, or RCT. Each second choice was presented in the same sequence to all respondents.

3 Health state content validity: Two experienced clinicians (an endodontist and a restorative dentist) reviewed the text describing the health state, anchors, and the treatment protocols. A Microsoft PowerPoint presentation, which included photographs and diagrams, was prepared to describe the step-by-step protocol for performing each treatment procedure. Testing of the presentations was conducted using the same 13 volunteers used in developing the description. All interviews were video-taped and reviewed for clarity and ease of presentation. The interviews were conducted by full-time interviewers who were hired for the project.

4 Interview script development and pilot testing: A Microsoft Access program was written to present the SG method and record the US. After describing the treatment procedures using the PowerPoint slides, which were presented using an LCD monitor facing the interviewee, the interviewer ran the Access program. The first part of the assessment was to sort out five cards representing the three treatment options and the two anchors. These cards summarized the key points using diagrams and photographs related to each treatment and anchor. The interviewee was asked to rank the cards from the most preferable to the least preferable. It was expected that the interviewees will rank the card depicting a filling with no pain and full oral health for the rest of the life as the most desirable outcome. Conversely, the research team expected the interviewees to rank the card depicting patients with severe and continuous pain because of the failure of the filling, resulting in immediate EXT of the tooth, as the least preferable outcome. Following the ranking of the cards, the program presented the definition of the term "probability." Colored circles were used to depict different arrangements of red (worst anchor) and green (best anchor) sections of the circle showing different chances of success or failure (Figs 2 and 3). A probability in this context was explained as follows: An 80% chance of ending upon with the best outcome (anchor #1 or the

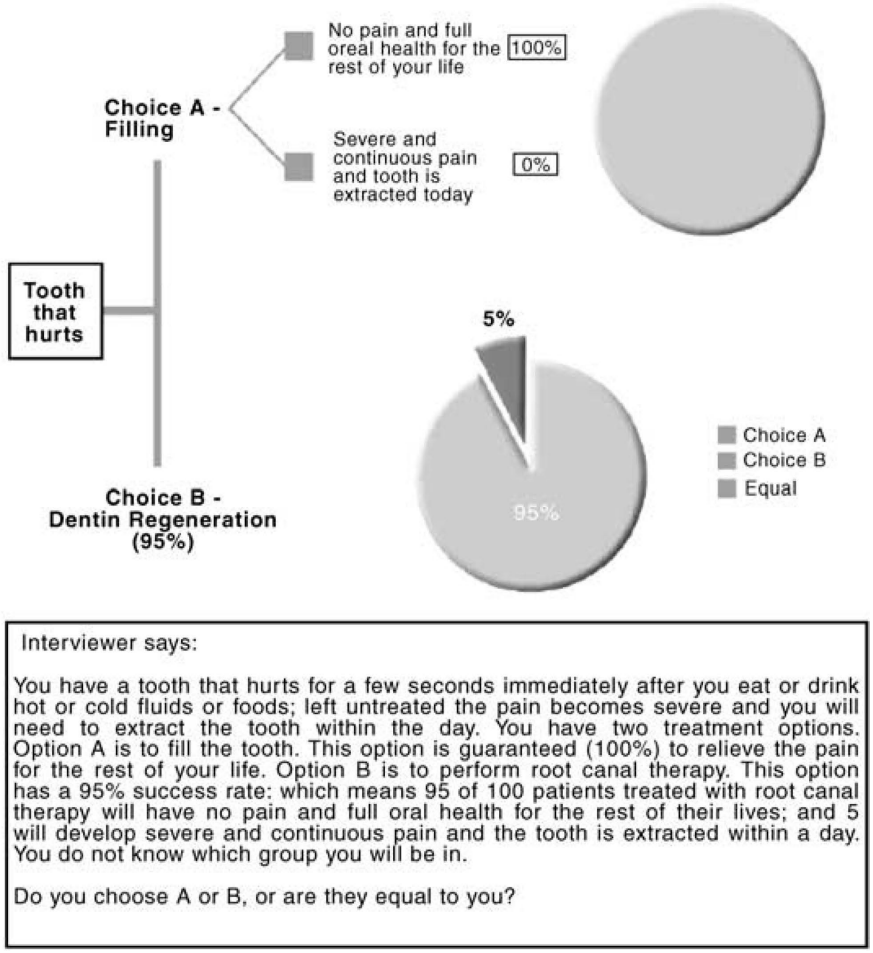

Figure 2. Decision tree depicting outcomes (anchors) of a standard choice (filling) and DR. The filling is certain to succeed.

best anchor) means that out of 100 patients who have their tooth in question filled, 80 of them may have full oral health and no pain for the rest of their lives and the other 20 may develop severe and continuous pain after the filling is placed, and the tooth must be extracted the same day. You do not know which of these two groups of patients you will belong to. Hence,

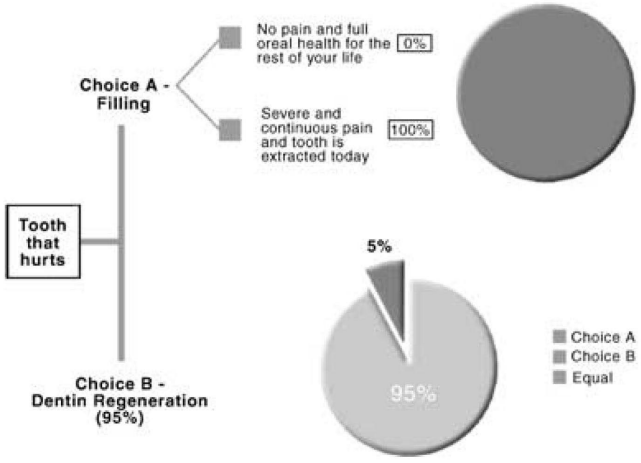

Figure 3. Decision tree depicting outcomes (anchors) of a standard choice (filling) and DR. The filling is certain to fail.

uncertainty was explained by changing the probabilities of the green and red sections of the circle (Figure 2). The circle was connected to the standard treatment or filling arm of the decision tree. The other arm of the tree described only one alternative treatment at a time. The first was RCT, which was presented as having a success rate of 95% (13); the second was DR with 75% success rate (DR75%); the third was DR with 95% success rate (DR95%); and finally, immediate EXT. DR was tested at two success levels in order to test the sensitivity of the method to detect changes in success rates and to evaluate the utilities for DR if it has a lower success probability compared with RCT. The ACCESS program presented each pair of treatments (filling vs. RCT, filling vs. DR75%, filling vs. DR95%, and filling vs. immediate EXT) in sequence. For each pair, the program first presented a scenario where the best anchor is guaranteed (100% success or full green circle; Figure 2). The chance of failure (worst anchor) is 0%. The interviewee was asked whether he or she chooses treatment A (standard treatment or filling) or treatment B (alternative treatment), or whether they are equal to him or her. The

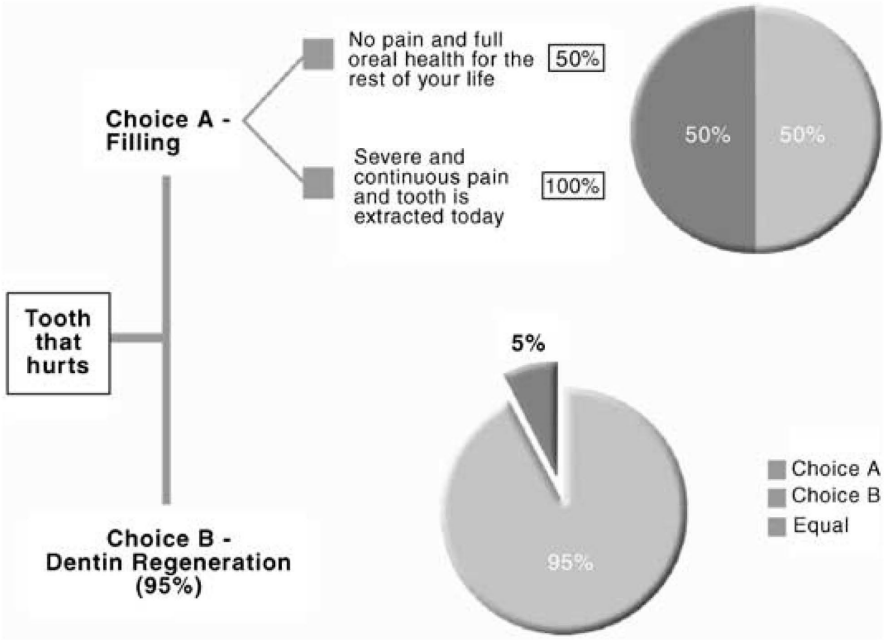

Figure 4. Decision tree depicting outcomes (anchors) of a standard choice (filling) and DR. The filling has a 50/50 chance of succeeding in relieving the pain for the rest of life.

expected response was to choose the standard treatment because the full oral health outcome is guaranteed. Then, the program presented a scenario where it was guaranteed that the filling will fail, and the interviewee developed severe, continuous pain and the tooth was extracted the same day (full red circle; Figure 3). Again when asked, "Do you choose treatment A or B, or are they equal to you?," the expected choice was treatment B (the alternative treatment).

5 After assessing the rating of the anchors for each pair of treatments, the ACCESS program proceeded to measure the US. The program was designed to start with a 50/50 chance of success or failure (a half-red and half-green circle; Figure 4). Based upon the choice, the program presented different probabilities of success or failure using an algorithm. After each set of chances of success and failure, the interviewer asked, "do you choose treatment A or B, or are they equal to you?" When the respondent identified a probability set that, in her opinion, represents the point of equilibrium between the filling and the alternative treatment, the interviewer confirmed the choice and pressed a recording button. The probability at which an interviewee considers that the chance of the best anchor to be equivalent to the conditions and risks associated with the alternative treatment is the US of the alternative treatment (3, 12).

Pilot testing and reliability assessment

Testing of clarity, language, and understanding of the protocol was pilot-tested using 90 volunteers selected from the patient population of the School of Dentistry, University of Michigan. In 40 of the volunteers, the methods used to measure the US were administered two times during a period of 1 week to measure the test–retest reliabilities. After assessing the test–retest reliability of the methods, the full study started with the adults sampled as described earlier.

Sampling weights

The basic probability of selection for each person aged 18–69 years in the Detroit Tri-county areas was equal, except for the higher probability among persons with no one in their household who had dental insurance. Each person coming from a household with all adults with private dental insurance coverage (insured household) was assigned a weight of 2.0 to compensate for the unequal probability of selection of the household. All other persons received a weight of 1.0.

A population-based weighing adjustment was computed to correct for inconsistencies between the weighted sample distribution by age, race, and gender for the Tri-county area population counts from the 2000 Census, conducted on April 1, 2000. Because the sampling units in this study were households rather than individuals, the measurements of US from individuals in a household might be correlated and dependent. Hence, SUDAAN was used to account for clustering and weighing effects.

Statistical analysis

All the analyses are presented stratified by insurance status. There were six individuals who answered

that they did not know if they had dental insurance. Four of these individuals came from households classified as uninsured, a classification which does not exclude the possibility that an individual living in that household had dental insurance. Two individuals came from insured households. To avoid misclassification, we decided to assign them missing values for their insurance information.

In order to simplify the presentation of the findings, this paper presents only percentages and standard errors. Testing for differences between groups were carried out using a two-sample t-test, ANOVA, and linear regression with correction for weights and clustering of respondents within families.

The distribution of the US was skewed to the right. Two transformations of the US were tested: logarithmic and logit; but, using these transformations did not improve the explanatory power of the model and did not change the conclusions. Findings using raw US are presented in this paper.

The variables considered in the construction of regression models were selected based on a theoretical model hypothesizing that utilities are determined by socio-demographic (education, sex, age, race/ethnicity, employment, dental insurance, and income), treatment (effectiveness, mode of delivery, side-effects, and complexity), and socio-behavioral factors (dental anxiety, previous dental experiences, general health status, quality of life, quality of oral health, and satisfaction level with dental care). Not all factors could be measured in the study because of time and cost restrictions. The regression model included all socio-demographic factors. Attitudinal factors were added if they were found to be statistically significant at the 0.1% level. Plausible interactions were tested in the regression model. Of interest were the interactions among education, race, income, and insurance status – the main focus of the hypothesis tested in this study.

Results

Except for DR with 95% success probability, the choice of the best and worst anchors (anchors #1 and #2) or outcomes of the standard treatment (filling) relative to each alternative treatment (DR75%, RCT, and EXT) had test–retest agreement of at least 90%. For DR with 95% success probability, the best anchor was only re-ranked as such only 70% of the time. For some interviewees, DR with 95% success probability was better than having "full oral health and no pain" when a tooth is filled without DR. For the average US of DR, RCT, and EXT, there was no statistically or clinically significant difference between the first and second measurements.

The characteristics of the adults who completed the home interviews are presented in Table 1. About 49% of the respondents were males, 65.7% were whites, 72.2% had dental insurance, and 68.1% had completed at least high school education. Forty-one per cent of the respondents earned more than $60 000 annually (median household income in the Detroit Metropolitan areas in 2002 was $56 000), while 15.8% earned less than $20 000. Out of the 630 adults interviewed, no information on preferences was obtained from four individuals and another nine provided the same US for all procedures. We considered these data to be invalid and they were excluded from the data analyzed for this paper. The characteristics of the 13 adults excluded from the analysis were not ostensibly different from the other 617 adults (Table 1).

When respondents were asked whether they would consider each of the proposed treatments of a tooth with reversible pulpitis, 81.8% said they would consider DR (Table 2). (The respondents were informed that the cost of all procedures will be covered.) DR was significantly more often considered as a treatment option by insured rather than uninsured adults ($P = 0.009$). For RCT, less than half of the respondents were willing to consider the procedure as a treatment choice. Only 22.8% of the respondents were willing to consider tooth EXT.

The percentages of adults who ranked the best anchor (filling with full oral health) lower than the alternative treatment or the worst anchor (filling with pain and EXT) higher than the alternative treatment are presented in Table 3. When a subject ranked a filling with a 100% chance of ending up with the best anchor lower than the alternative treatment, it means that he or she chose the alternative treatment over a filling of the tooth with reversible pulpitis, which would result in full health for life. When a subject ranked a filling with a 0% chance of ending up with the best anchor as higher than the alternative treatment, it means that he or she chose a filling of a tooth with reversible pulpitis, even though the filling was certain to fail (severe and continuous pain) and the tooth was extracted on the same day. In these two cases, the unexpected rankings imply that the utility scale on which the SG question is based is not valid for these subjects. For DR with 95 and 75% success probabilities, 77.6 and 88.3% of adults ranked the an-

chors as expected, respectively. For RCT, 88.6% of the adults ranked the anchors as expected. For immediate tooth EXT, 86.0% of the adults ranked the anchors as expected (Table 3).

The following tables present data for subjects who ranked the anchors as expected. Table 4 presents the mean US by dental insurance status. No statistically significant differences in the average US were de-

Table 1. Characteristics of interviewed adults

	Total study population (N = 630)		No information on US (n = 4)		Invalid answers on US[a] (n = 9)		Individuals included in the analysis (N = 617)	
	n	% (SE)	n	% (SE)	n	% (SE)	n	% (SE)
Gender								
Male	261	48.7 (1.5)	2	57.5 (28.3)	4	46.1 (17.5)	255	48.7 (1.6)
Female	369	51.2 (1.5)	2	42.5 (28.3)	5	53.9 (17.5)	362	51.3 (1.6)
Age (mean)	630	40.5 (0.5)	4	49.5 (6.8)	9	33.9 (4.2)	617	40.5 (0.5)
Race/ethnicity								
Whites	397	65.7 (2.8)	3	77.8 (23.0)	6	65.2 (17.0)	388	65.6 (2.7)
African-Americans	166	23.9 (2.5)	1	22.1 (23.0)	3	34.8 (17.0)	162	23.7 (2.5)
Others	67	10.4 (1.7)	–	0	–	0	67	10.7 (1.7)
Education								
<12	86	12.9 (1.7)	–	0	2	22.9 (14.5)	84	12.9 (1.7)
12	124	19.0 (1.7)	3	72.9 (26.5)	4	42.3 (17.2)	117	18.2 (1.7)
>12	397	68.1 (2.3)	1	27.1 (26.5)	3	34.7 (17.0)	393	68.9 (2.3)
Income (in $1000)								
≥60	204	41.0 (2.8)	1	41.7 (34.4)	3	35.5 (17.4)	202	41.4 (2.8)
40–59	136	26.2 (2.5)	0	0	4	50.1 (18.5)	135	26.5 (2.5)
21–39	104	16.9 (1.9)	1	28.0 (28.6)	0	0	100	16.6 (1.9)
≤20	112	15.8 (1.8)	1	30.3 (30.1)	1	14.7 (13.3)	108	15.4 (1.8)
Insurance								
Yes	384	72.2 (2.2)	0	–[b]	4	47.3 (17.6)	380	72.6 (2.2)
No	236	27.8 (2.2)	0	–	5	52.7 (17.6)	231	27.4 (2.2)

[a] The answers of these individuals were considered invalid based on the fact that they gave the same answers for all utility and HTE SG questions.

[b] No data on dental insurance were provided by these participants.

Table 2. Willingness to consider treatment procedures for a tooth with reversible pulpitis

		Individuals according to dental insurance status		
	All individuals (N = 617) % (SE)	Insured (n = 380) % (SE)	Uninsured (n = 231) % (SE)	P-value[a]
Filling	85.5 (1.5)	87.0 (1.7)	81.9 (3.0)	0.1448
DR (75 or 95%)	81.8 (1.8)	84.9 (1.9)	74.4 (3.6)	0.0090
RCT (95%)	46.7 (2.3)	48.9 (2.9)	41.0 (3.4)	0.0780
Immediate EXT	22.8 (2.1)	20.9 (2.4)	27.5 (3.7)	0.1269

[a] P-value for the comparison between insured and uninsured individuals.

Table 3. Percentage of respondents by ranking of the best[a] and worst[b] anchors

	All individuals	Individuals according to anchor choice pattern	
Treatment	(N = 617; mean (SE))	Expected n (%)	Unexpected n (%)
RCT (95%)	75.6 (1.1)	542 (88.6)	75 (11.4)
DR95%	86.2 (0.7)	466 (77.6)	151 (22.4)
DR75%	72.5 (0.7)	538 (88.3)	79 (11.7)
Immediate EXT	31.3 (1.3)	522 (86.0)	95 (14.0)

[a] Filling a tooth that develops no pain for the rest of the life.

[b] Filling a tooth that develops severe and continuous pain immediately after placement of the filling and is extracted on the same day when it was filled.

Table 4. Mean of US of adults who correctly ranked the best and worst anchors

		Insurance status		
Treatment	Mean (SE)	Insured mean (SE)	Uninsured mean (SE)	*P*-value[a]
RCT (95%)	77.4 (1.0)	77.1 (1.1)	78.0 (1.7)	0.6464
DR95%	85.6 (0.8)	85.4 (0.9)	86.2 (1.2)	0.5861
DR75%	72.1 (0.6)	72.2 (0.7)	71.6 (1.2)	0.6329
EXT	30.0 (1.3)	28.9 (1.5)	32.6 (2.0)	0.1490

[a] *P*-value from *t*-tests comparing the mean US of insured and uninsured individuals.

Table 5. Mean US for DR with 75 or 95% success probability by educational and dental insurance status

	Mean US (DR75%[a]; *N* = 519)		Mean US (DR95%[a]; *N* = 447)		
	n	Mean (SE)	*n*	Mean (SE)	*P*-value[c]
Education (years)					
<12	67	70.0 (2.4)	50	87.4 (2.5)	<0.0001
12	98	72.2 (1.3)	82	83.5 (1.9)	<0.0001
>12	354	72.3 (0.7)	315	86.7 (0.9)	<0.0001
P-value[b]	–	0.6447	–	0.3794	–

[a] DR75% or DR95%: Treatment with DR that is 75 or 95% successful in treating a tooth with reversible pulpitis.
[b] *P*-values from ANOVA for comparison of means among educational levels.
[c] *P*-values from paired *t*-tests for comparison of the mean US for each educational level.

tected between insured and uninsured adults. Previous dental experiences, before accounting for confounding variables, did not influence the US of DR (results are presented for 75% success; a similar finding was observed for DR with 95% success).

The mean US of the treatments were not significantly influenced by the educational level of the respondents (Table 5). DR was highly preferred (has highest US) among adults with different educational backgrounds, especially when the procedure is 95% successful in treating the affected tooth (Table 5).

In a linear multiple regression analysis, the US for DR75% was higher for adults between 30 and 50-year-olds, relative to the scores of younger adults. Also, adults who have had a tooth filled assigned lower US than adults with no previous experience with fillings (Table 6). Factors such as gender, race, education, income, insurance status, experiences with EXTs or root canal treatment, regularity of dental visits, quality of life, and quality of oral health were not significantly associated with US. There was, however, a significant interaction between race and dental insurance. African-Americans with no dental insurance had significantly higher US for DR (75%) than other adults ($P < 0.05$). Similarly, African-American males had significantly higher US than other adults. All the factors included in the models explained only about 6% of the variation in the US for DR75%.

Discussion

This paper presents data on a large population-based study of utilities of dental interventions. The study is unique in that it attempts to determine the valuation of a new and promising technology that the National Institute for Dental and Craniofacial Research (NIDCR) has invested funds to develop. When this project was designed, the NIDCR plans for research submitted to the US Congress called for a significant investment in studies of tissue regeneration to promote oral and maxillofacial health (14). It was also envisioned that the potential regeneration of dentin, bone, and other oral tissues could lead to a revolution in dental care, which would surpass the one that followed the development of anesthesia and restorative materials in the 19th and 20th centuries.

The potential success of biomimetics in improving the oral health of Americans, however, will be determined by whether the technology will lead to an improvement in the well being of Americans, as measured by reduced inconvenience of pain and discomfort, time lost from work and family life, and improved quality of life. It is imperative for the dental research community to consider the total and tangible impact of any new technology on societal health and wealth. DR, as the results of this study show, has a high utility, especially among Americans between

Table 6. Multiple linear regression coefficients of for US for DR with 75% success probability

	No interaction (N = 538) β (SE)	Interaction #1 (N = 538) β (SE)	Interaction #2 (N = 538) β (SE)
Gender (ref: female)			
Male	0.97 (1.2)	0.8 (1.2)	−0.5 (1.2)
Age (ref. ≤ 30)			
30–50	**4.3 (1.8)** [a]	**4.4 (1.8)** [a]	**4.2 (1.9)** [a]
≥50	1.8 (2.5)	1.8 (2.4)	1.7 (2.5)
Race (ref. = others)			
African-American	−1.7 (2.0)	−3.5 (2.0)	−5.0 (2.2)
Education (ref. ≥ 12 grade)			
<12	−0.06 (2.9)	−0.9 (3.0)	−0.7 (2.9)
12	−0.21 (1.8)	−4.0 (1.8)	−1.0 (1.9)
Annual income[b] (ref. ≥ 60)			
40–59	1.3 (1.3)	−3.6 (2.8)	−2.8 (2.7)
21–39	−2.5 (2.2)	−0.4 (1.7)	−0.5 (1.7)
<20	−4.8 (2.3)	2.0 (1.3)	2.0 (1.3)
Dental insurance (ref. = yes)			
No	1.25 (1.4)	−0.2 (1.7)	0.9 (1.4)
Ever had a tooth extracted (ref. = no)			
Yes	0.4 (1.7)	0.4 (1.4)	0.3 (1.4)
Have regular dental visits (ref. = no)			
Yes	0.4 (1.7)	0.4 (1.7)	0.3 (1.7)
Ever had a root canal filling (ref. = no)			
Yes	0.4 (1.5)	0.4 (1.4)	0.4 (1.4)
Ever had a tooth filled (ref. = no)			
Yes	−4.7 (2.2)	−4.1 (2.1)	−4.2 (2.3)
Perceived oral health status (ref. = poor to fair)			
Good-to-excellent	−0.4 (1.6)	−0.5 (1.6)	−0.5 (1.6)
SF-36 (physical)	−0.06 (0.07)	−0.05 (0.07)	−0.07 (0.07)
SF-36 (mental)	−0.01 (0.07)	0.0 (0.07)	0.0 (0.07)
Insurance–race (ref. = insured or uninsured, others)			
Uninsured African-Americans	–	**7.0 (3.4)**	–
Race–gender (ref. = others, males or females)			
African-American males	–	–	7.0 (2.9)
R^2	0.05	0.06	0.06

[a] Regression coefficients in bold are significant ($P < 0.05$).

[b] Income expressed in 1,000.00 dollars.

the age of 30 and 50 years, who have relatively lower needs for restorative care (15).

Another challenge for the dental community is the need to document the impact of investment in research on the oral health of Americans. The old paradigms of basic research conducted to elucidate new knowledge is still interesting and thought provoking; however, without a focused translational and clinical research program, potential new developments will remain in the laboratory. The US Public Health Service (USPHS) has defined oral health objectives for the nation. Relevant to this project is the year 2010 goal that calls for an "increase in the proportion of adults who have never had a permanent tooth extracted because of dental caries or periodontal disease." For 35–44-year-old Americans, the target is set at 31% – a decrease from 42% in 1988–94. Moreover, we contend that easy-to-apply dentin regenerative materials would help to save millions of teeth extracted all over the world where endodontic care is not available.

This study answered the question whether DR will be preferred and considered valuable to a group of Americans. DR was found to be preferred more often than RCT when both are hypothesized to have similarly high success rates. When DR was less successful than RCT, the average US was slightly lower than RCT. It is interesting to note that this study found a

small minority of adults (about 11%) who reported that DR or RCT is preferred to a filling that is certain to succeed in relieving the pain and maintain a functional tooth for life.

While this study was based on a model that incorporated all potential determinants of utility and choice of dental treatment, the model was not able to explain the variation in the US. The US of DR had relatively narrow variances (or low coefficients of variation). Two-thirds of the US for DR with 75% success were between 55 and 89. This condensation of scores limited the effectiveness of the regression model to identify factors explaining variation in US. It should be noted, however, that during the SG estimations, the respondents were informed that the treatments will be provided to them at no cost. This condition was added to ensure that all respondents, regardless of insurance status, will focus only on the benefits and risks associated with each treatment rather than on whether they can afford the treatment, hence, equalizing the influence of cost on preferences of insured and uninsured respondents.

The process of decision making depends on cognitive as well as affective evaluations of the risks and benefits associated with an intervention (16, 17). The presentations used in this study to describe the different treatment options and their consequences had an affect on the interviewees. These affects may have generated feelings regarding the likes and dislikes toward each treatment. The risk-as-feelings hypothesis has been proposed to explain decisions that cannot be accounted for by the standard expected utility theory (16, 17). It predicts that emotional reactions to risk associated with an event or intervention do not only follow a cognitive process. Emotional or affective reactions can drive behaviors and decisions. Individuals may react to the prospect of risk at two levels: first, they evaluate the risk cognitively, and second, they react to it emotionally. This study was not designed to test this hypothesis. The question of how and why individuals choose a treatment requires further investigation. The major practical application of this new research area is to explain why utilities of dental intervention differ among individuals and how best to market new dental technologies. Developing new products should consider how people would feel about the risks and benefits associated with the product.

Findings of this study should be considered by researchers and manufacturing companies when developing new DR products. For example, in the bivariate analysis, some previous dental experiences (RCT) did not influence the US, while in the regression analysis, adults who have had a filling gave a US that was, on average, 4.7 points lower than those who never had a filling. In the regression model, age was a significant factor, with adults in the middle age range (30–50 years) giving higher mean US than others. The regression analysis also identified an interaction between insurance and race with African-Americans giving higher scores than other insured or uninsured adults. African-American males also gave higher scores than others. These findings are interesting. However, it is important to note that similar trends were found when the WTP data were analyzed (18), where African-American insured that adults offered to pay two times higher increase in insurance premium than other adults to cover DR with 75% success rate.

While we can describe the findings of this new research area, explanation is hampered by a lack of a theoretical explanatory model of how individuals make decisions. For example, young American adults have significantly lower restorative needs for care than older adults (15); but they gave higher US for DR than others. The emphasis of this group of Americans on new and improved products may provide an explanation. As far as the finding that African-American males had higher average US for DR than other adults, the magnitude of the difference after adjusting for the roles of primary factors in the interaction is relatively small (around 3 points). Further research will be needed to explain why African-American males valued DR so highly.

This population-based study found that DR is highly preferred compared with other treatments of reversible pulpitis by the majority of Americans who participated in this study. This paper also raises some important questions on how decisions are made by the public at large. The effective impact of information may play a major role in shaping health decisions, even more so than simply the cognitive consideration of consequences associated with an intervention.

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