Stony Brook University

Essays on Socioeconomic Disparities in Dental Health

A Dissertation Presented

by

Yanan Di

to

The Graduate School

in Partial fulfillment of the

Requirements

for the Degree of

Doctor of Philosophy

in

Economics

Stony Brook University

May 2008

Stony Brook University

The Graduate School

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Abstract of the Dissertation

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This dissertation examines the determinants of preventive dental care use and dental health outcomes, and it contributes to our understanding of forces behind the phenomenon of socioeconomic disparities in health. We explore the role of socioeconomic factors, dental health insurance and dental health preferences on the decision to use preventive dental care services. In addition, the impact of preventive care on dental outcomes is identified and quantified.

Access to quality care is a key suspect in explaining differences in outcomes, but measuring this access has not been easy. Insurance status is an obvious indicator of access to care. The dental health market is ideal for studying the role of access in producing efficient outcomes for a number of reasons: the ability to accurately measure access to care and the significant evidence base surrounding the benefits of preventive care, the wider disparities in quantity and quality of dental insurance coverage, as well as relatively high coinsurance rates in general.

Using data from the dental health market we study utilization patterns by socioeconomic status and access to care. We examine the role of socioeconomic factors, dental health insurance and dental health preferences on the decision to use preventive

dental care services. Estimated effects of dental health insurance are potentially biased by an adverse selection problem where the demand for services and insurance are simultaneous and driven by health need and preferences. We construct an indicator of preferences to directly purge the bias. We take into account heterogeneity in dental health preferences that may drive the propensity to insure, as well as the propensity to use dental health services (adverse selection). Using self-assessments from the National Health and Nutrition Examination Survey (NHANES), we construct indicators of preferences by taking advantage of the subjectivity incorporated in them. Using this survey we are able to test the factors of interest on the propensity to use preventive dental care, conditional on heterogeneous preferences. We find that dental insurance has a persistent effect in driving the behavior of investing in preventive dental care, even after controlling for dental care preferences. Frequency of preventive care visits are also influenced by socioeconomic status and dental insurance coverage, even after conditioning on dental preference and perceptions. Conditional on having positive visits, people of high socioeconomic status, with dental insurance, and with stronger dental health preferences, all significantly increase their frequency of care. While preferences and other factors explain some of the variation in utilization disparities, economic barriers, with lack of insurance in particular, do exist.

We also examine the determinants of dental health measured by dental caries by accounting for the endogeneity of routine dental care use. Routine dental visits decrease the probability of having caries. Therefore, preventive dental care indeed translates into better health outcomes measured by dental caries. We also identify and quantify the magnitude of the separate effects of racial differences in observed characteristics such as income, education, occupation, and health behaviors, taking into account of dental care use. We find that routine dental care utilization and income explain a large portion of racial disparities among whites, African-Americans, and Hispanics.

To my loving family

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Acknowledgments

Many people have helped me with this dissertation and throughout my time at Stony Brook. I am truly grateful for their help and support.

I would like to thank Debra Dwyer, my advisor, for her tremendous guidance and advice. She provided constant encouragement and support throughout my research. I would never have been able to complete this thesis without her help.

I am grateful for the members of my committee John Rizzo, and Mark Montgomery, for their advice and insightful comments. They were very supportive and helpful through the evolution of this thesis. I thank Hugo Ben´ıtez-Silva and Hongdao Meng for their valuable comments and suggestions.

I also thank the valuable suggestions of our group meeting members. I appreciate the useful comments from the participants of the Microeconomics Workshop in the Department of Economics, Stony Brook University.

Introduction

Dental health is an integral part of overall general health. For example, there are documented associations between coronary heart disease and oral health (Joshipura et al., 1996; Hsin-Chia Hung et al., 2004). According to the 2000 Surgeon General's report on oral health, although average levels of dental health have improved for Americans during the past five decades, profound disparities within the population persist. Unlike the general health market where there is a lot of uncertainty and a shortage of evidence based medicine, there are known positive payoffs to investments in preventive and maintenance care in the oral health care market (Gilbert and Litaker, 2007). Much of these disparities may be explained by differential utilization by socioeconomic status. Efforts were made to identify the reasons for the dental health utilization disparities so as to remove the barriers to access. However, the disparities remain. Some sex, income and racial or ethnic groups are disproportionately affected by dental diseases. Dental care utilization varies with sex and race or ethnicity, income and dental insurance which leads us to infer that access to preventive care is a driving force behind disparities. For example, Manski RJ et al. (2001) showed that the gap in use rates in terms of number of dental visits between

lower and higher-income people widened during the 20-year period from 1977 to 1996 in the United States.

Dental insurance coverage reduces the cost barrier and facilitates access to care. However, 108 million Americans are not covered by dental insurance, which is more than twice the number of people not covered by medical insurance. The wide disparity in dental health coverage makes this an ideal market to study for assessing efficiency and equity issues in health care delivery. Our sample size without coverage for preventive care is at least as large as those with coverage. Given the difference in cost between preventive and acute care, there may be significant efficiency costs to suboptimal levels of preventive utilization. This has policy relevance since publicly financed programs, such as Medicaid and Medicare, are very restrictive when it comes to dental care, especially preventive dental care. Medicare does not offer dental health coverage. Yet people with disabilities are among those who need dental care most. People with disabilities are found to have higher rates of poor oral hygiene and needs for periodontal disease treatment than the general population. Given the link to coronary heart disease from poor oral hygiene, coverage among Medicare recipients may prove cost-effective. For children with disabilities across different age groups, dental health care is reported by parents as one of the top needed services (Haveman et al. 1997). On the other hand, for the Medicaid program, less than half of the states provide comprehensive dental care for adults aged 21 and older. Most states only cover emergency treatment, or relief of pain and infection, and only a few states provide limited preventive coverage. Some states have no dental coverage at all. Therefore, many people in lower socioeconomic groups can only, at most, have access to acute care. Given the effectiveness and the cost-saving

nature of preventive dental care, these public policies that offer limited or no preventive dental coverage might be inefficient.

Although dental care demand is one component of overall health care demand, it possesses some special features that warrant separate analysis. For example, dental disease is relatively more predictable and easy to diagnose; patients could be more aware of the quality of service by learning from their past experiences; many prevention possibilities are available and they could actually hold off on treatment to save resources; dental disease is not typically considered an “emergency”, and untreated dental disease has a relatively less dramatic impact on people’s general health (Sintonen and Linosmaa, 2000). Although this argument is disputable, since severe dental pain and the impact on facial appearance could have greater impact on overall quality of life compared to many other diseases; for many people, dental care does not have the same intuitive quality of life implication that health care in general. They might downplay the importance of dental care despite the fact that teeth are a visible part of the body and have an important impact on overall well-being. So the discrepancy between actual health status and perceived threat to health might also be greater in this market. Given these special features, demand for dental care should be examined separately from the demand for medical care in general and provides a unique experiment for examining the role of access on behavior.

Demand for dental care involves both preventive care and curative care. Aside from self-care (brushing and flossing regularly, diet, etc.), professional preventive dental care includes routine check-ups and cleanings, which could prevent the development of dental diseases, enable early detection once diseases occur and consequently increase

efficiency by avoiding more expensive curative costs in the future. Use of diagnostic and preventive dental services has been increasing in recent years, and they make up a substantial share of all dental procedures provided (Eklund et al., 1997; Manski RJ et al. 2001, 2002). Having a preventive dental visit is found to be positively associated with higher socioeconomic status and related to other demographic factors as well (Goodman et al., 2005). Preventive dental care could prevent costly dental diseases relatively easily, yet the public programs do not cover enough preventive dental care. Those disparities in access are going to lead to disparities in diseases, which are costly later.

Preventive dental care not only saves us in terms of the more expensive dental health conditions, but could also have spillover effect into general health. According to the 2000 Surgeon General's report on oral health, preventive dental care can be helpful for the early detection of and intervention for other diseases, such as hypertension. AIDS, diabetes and some other systematic conditions could first be detected from oral signs and symptoms. Hence, preventive dental care is also an investment in the overall health.

To develop policies aimed at increasing access to, and the use of, preventive care, we need to study the determinants of utilization to incorporate the appropriate incentives into policies. Given the high cost of health insurance in this market (with higher coinsurance rates and limited coverage), and the low prevalence of employer-provided insurance, combined with a greater disutility for dental health care and a perceived lower gain to such an investment, the adverse selection problem in the dental health market may be significant. Studies examining the role of health insurance on utilization of preventive care may be biased by adverse selection given those who opt into dental insurance plans may be more likely to utilize. This could be because of a genetic predisposition toward

dental health problems and/or a greater propensity toward better dental hygiene (preferences). It is a well known fact that on average, people do not like visiting the dentist (See for example "Little Shop of Horrors"). Evidence of this is the growing number of dental shops offering stress management with routine care. Therefore controlling for the propensity to use based on preferences is key in modeling dental care utilization. We examine the role of socioeconomic factors and dental insurance status, as well as preferences for dental health services that may underlie the decisions regarding the cost and use of preventive dental care services. Identification of access to health care through insurance has been difficult primarily because of this potential for adverse selection which would exaggerate the insurance effect. One way to purge bias in the insurance effect is to directly control for preferences that drive both the propensity to use dental health services and to seek coverage for those services[2]. This preference parameter will control for heterogeneous dental preferences that may drive the propensity to insure as well as the propensity to use dental care services. We find that preference for dental care utilization is a significant predictor for the use of preventive care. After controlling for dental preferences, dental insurance, at the margin, will have a slightly smaller effect. Nevertheless, dental insurance has a persistent effect on preventive dental care utilization. Our results suggest that the decision to seek routine care is influenced by socioeconomic factors, dental insurance coverage, and dental preferences. This is all true for frequency of dentist visits as well. This has strong implications for policy given the lack of

[2] We prefer using this observed proxy of preferences over an IV approach for dealing with adverse selection since IV is only as good as instruments available, which are difficult to come by. Since we do not have instruments for insurance not correlated with preferences, but we do have preferences, we chose to purge in this way. Given our results are consistent with our priors, we believe this control for the omitted variable driving both insurance and the dependent variable works.

government intervention in the dental health care market. Moreover, having routine care visit significantly decreases the probability of dental caries. Therefore, preventive dental care is effective in promoting dental health. As for the racial disparities in dental health, we find that racial differences in routine care use explain a large component of disparities in dental caries among whites, African-Americans, and Hispanics.

Chapter 1

Health Disparities by Socioeconomic Status: What We Can Learn from the Dental Health Market?

1.1 Literature Review

1.1.1 Effects of Health Insurance and Income

Several empirical studies were conducted on the demand for dental care in the United States. Common findings are that higher income and lower prices lead to higher use of dental services. But their estimates on the magnitude of income and price elasticities of demand for dental care vary due to different measures of demand and

utilization, model specifications, estimation methods and data etc. Later studies examined the effect of dental insurance which is obviously important in adequately measuring consumer price. Insurance was found to increase the likelihood of obtaining dental care.

The estimated income elasticities varied in magnitude across different studies but for the most part reveal a relatively strong response to income. Using cross-sectional data, Anderson and Benham (1970) estimated a permanent income elasticity of 0.99, which is similar to the above 1.0 income elasticities observed by Upton and Silverman (1972). Anderson and Benham only used dental expenditures as the dependent variable. Upton and Silverman used number and type of dental visit variables, and they found that the fluoridation of public water supplies reduced the demand for dental services. But they ignored the price effect. Feldstein (1973) and Maurizi (1975) both used aggregate data in a simultaneous equation systems. In his time-series studies, Feldstein estimated the income elasticity to be 1.022 for per capita dental expenditure, and 1.71 for dental visits per thousand population. Maurizi found income elasticities to be 1.06. These two studies used two-stage least-squares analysis with endogenous price, but they fail to identify the demand curves, omitting socio-demographic and insurance variables [See Manning and Phelps for discussion, 1978]. Hu (1981) incorporates dental health insurance into a model of demand among low-income families and for this group finds stronger income elasticities than price elasticities – but the estimated elasticities were smaller than most other studies. Price was not accurately captured in the broad definition of health insurance used.

Responsiveness to price and income is also consistent with responsiveness to time costs which are also a factor in influencing the demand for dental care. Some studies have

found significant effects of time cost, for example waiting time had a significantly negative effect on the number of dental visits, and a marginal or non-significant negative effect on dental expenditures (Holtmann and Olsen,1976; Mueller and Monheit,1988; Sintonen and Maljanen,1995a). Another study by Grytten et al. (1990) found no significant effect of travel time on the probability of using dental services.

Estimated price elasticities to date have also varied considerably. Feldstein (1973) estimated the price elasticity to be –1.43. Maurizi's (1975) estimate was –1.76. However, as mentioned previously, their demand curves were under-identified and therefore the price elasticities were unreliable. Holtmann and Olsen (1976) found that the price elasticity was between –0.03 and –0.19, which was quite small but this may be a consequence of some estimation concerns. There was insufficient variation in price and the indicator of price is endogenous to utilization. They divided total out-of-pocket dental expenditures by total number of visits in a family to derive the price variable. This method not only made the price variable endogenous, but also omitted the quality difference by assuming that each visit cost the same price. Phelps and Newhouse (1974) attempted to estimate the effects of price on the demand for dental care using data from dental insurance plans. They had three separate estimates. Using variation in coinsurance rates, they found that the demand would be 30 percent higher at full coverage than with a 20 percent coinsurance rate. Their second estimate compared the demand before and after the implement of a dental insurance plan, and found demand was 96 percent higher with full coverage compared to no insurance coverage. Finally they compared the dental utilization of a local voluntary insurance plan with the U.S. population as a whole. Utilization rates were 80% higher for the insured group. Lack of controls for adverse

selection given voluntary participation, as well as for income and fluoridation levels in this analysis likely lead to exaggerated effects. In addition many of these studies were performed on older cohorts and may not be generalizeable today. What we have learned is that responsiveness to price, income, and time are not trivial and further analysis is warranted.

We can see that the preceding studies have shed light on the role of economic factors, but fall short of identifying the role of insurance. Manning and Phelps (1979) made efforts to correct these flaws. They estimated the income and price elasticities for different types of dental services separately, and they found that the elasticities varied across services and by type of person. For dental visits, the income elasticities ranged from 0.55 to 0.87 and the price elasticities were between –0.65 and –1.40. Based on these estimates, they projected that adults with full dental insurance would demand over twice as much dental care as uninsured adults, and over three times for children with full coverage. Income plays less of a role so that price is the driving force (contrary to the Hu (1981) findings). These projections for dental insurance were similar to the Phelps and Newhouse findings. However, there are several limitations in their study. First, individuals receiving free care or with partial dental insurance were excluded, so the influence of insurance on the demand for dental care cannot be generalized. Second, price variables were only available for three types of services and the other four services were assigned a weighted average of those available prices. Thus these price variables could be measured with error and lead to biased estimates. In addition, the tobit model they used may not be appropriate for count data like dental visits.

The studies mentioned above did not adequately analyze the effects of dental insurance on the demand for dental services. Dental insurance is a crucial factor that may partly reduce the price barrier among the insured, especially when cost is cited frequently as a barrier to receiving dental care. A robust finding is that dental coverage is positively related to the demand for dental services. If we believe the optimal quantity of services (preventive care in particular) is somewhere between what would be demanded at full price, and what would be demanded at a marginal cost of 0 – it is important to further explore the role of insurance in bringing us to efficient levels of demand.

The results from the Rand Health Insurance Study (HIS) suggest that dental services are significantly more responsive to cost sharing than other out-patient health services and serve as motivation for the current study. Manning et al. (1986) used experimental data from the HIS, which does not suffer from the self-selection problem of non-experimental study. They found that insurance plans with lower coinsurance rates resulted in a higher use of dental services. Dental expenditures were found to increase by 46 percent when the coinsurance rate fell from 95 percent to 0 percent, and two-thirds of this increase is attributable to an increase in the likelihood of visiting a dentist during the year. The high-income group had more visits than the low-income group, but the latter had more expensive visits – which is consistent with our hypotheses that barriers to access are inefficient. So higher income groups have a greater propensity to use dental services. The response to cost sharing is greater for the lower-income groups. The use of preventive care, one of the common but less expensive services, increases significantly as income increases after controlling for insurance.

Using non-experimental data from the 1977 National medical Care Expenditure Survey, Mueller and Monheit (1988) analyzed a sample of white adults aged 16 to 64, and they found similar result as the RAND findings, i.e., the first-dollar coverage had the greatest impact on demand. They showed that insurance increased the likelihood of obtaining dental care as well as the per capita expenditure. In their study the insured tend to demand more expensive services, and the price is positively related to the number of visits and expenditures. Results also suggest that users receive basic dental services regardless of their insurance status. However, insurance has a direct effect on the use of more expensive dental care. Price could be endogenous. Their results were questionable since the out-of-pocket prices for the user was not observed, and sample selection is an issue not addressed. Moreover, the sample studied is a national representation of white prime-aged adults, and therefore not a representative sample of the entire American population.

There were also several empirical studies on the demand for dental care conducted in other countries, but robustness of results is lacking given similar concerns with data availability, measurement, and model specification. [Parkin and Yule (1988); Stoyanova (2001); Alvarez and Delgado (2002); Stoyanova (2003); Sintonen and Maljanen (1995); Nguyen and Hakkinen (2005); Bhatti et al. (2006)].

Hence, except for the Rand health insurance study (Manning et al. 1986) where the insurance status is randomly assigned in the experiment, most empirical studies using observational data failed to account for the adverse selection of dental insurance. As a consequence, their results might be subject to selection bias. Munkin and Trivedi (2007) attempted to correct this selection bias by accounting for the endogeneity of dental

insurance. Using Medical Expenditure Panel Survey (MEPS) data, they examined the effect of dental insurance on the demand for general dental services. Their sample included privately employed individuals aged 25 to 64 years old except for the self-employed. They show a positive incentives effect of dental insurance, and suggest that this might be due to the unobserved variable such as people with worse dental health could be more likely to be insured and use more dental services. In addition, income and age exhibit non-monotonic relationships with dental insurance status.

Therefore there is consensus for significant responsiveness to income, price and cost-sharing in demand for dental care, although the magnitudes are not robust and the verdict is still out over the role of insurance in improving efficiency in the dental health market.

1.1.2 The Demand for Preventive Care

The demand for preventive care both in the general health and the dental health market have been examined both in economic studies and in public health studies. Although they differ in disciplines and methods, the results are similar with few surprises.

Economic studies investigated utilization patterns of many types of preventive health care services. The individual is viewed as investing now to obtain future benefits, such as reduced risk of bad health outcomes and saved costs of possible curative care. Individuals choose quantities of preventive care based on expected health gains, avoided lost work-time and reduced future out-of-pocket health expenditures (Phelps,1978). Kenkel (1994) provided evidence on the responsiveness of the demand for preventive

care to changes in insurance coverage, age and schooling. Some other work examined the use of preventive care in the context of information (Hsieh and Lin, 1997), labor market behavior (Mullahy, 1999), myopic preferences (Byrne and Thompson, 2001), and across health states (Wu, 2003). Two studies included dental checkups as one form of preventive care. Perry and Rosen (2001) showed that there was no substantial differences on utilization of health care services between the self-employed and wage-earners, given the fact that the former group were less likely to be insured. Murasko (2003) examined the role of work characteristics to account for the time-costs of seeking preventive health services. An Australian study by Hopkins (2005) found that Australians with private insurance and high incomes have more frequent dental visits measured by the time period since the last dental consultation. Of course, adverse selection is an issue in this type of study.

Similar findings on the associations between socioeconomic status, insurance and preventive care utilization were discovered in the public health research as well. Using a 1994 probability sample of adults living in a three-county area that includes Detroit and its suburbs, Marilyn et al. (1999) found that being male, having lower income levels, not having a usual place for care and being anxious about receiving dental care were associated with infrequent dental checkups.

Using 1996 Medical Expenditure Panel Survey (MEPS), Goodman et al. (2005) found that the utilization of preventive care differed by age, gender, income etc. Older respondents, poorer respondents, nonwhite respondents, male respondents, respondents without dental insurance, respondents with lower education and respondents residing in a non-metropolitan area were less likely to report having had a preventive dental care visit.

The demand for dental preventive care depends on the production efficiency of that care, as is true in the demand for all health care services. But what is consistently found is the importance of preferences in consumer decision-making. Preferences are related to degree of risk aversion which varies by individual attributes. It is widely known that individuals tend to be less risk averse with their dental health than general health, and are likely to have greater disutility from the consumption of dental health services. Given the role of consumer sovereignty in the supply of various commodities, these differences in preferences between the health market and dental health market may explain the greater uninsurance rate in the latter. If our objectives are to improve national health at minimal cost, the consequences on the dental health market may be inefficient, even if they are utility maximizing.

1.1.3 Measurement Error in Dental Health Status: Potential Reporting Bias

A common concern in empirical analysis of the health market is measurement of the good – namely health. Whether it is a utilization study or an outcomes study – measurement of the stocks and flows of health are often important. Typically we must rely on subjective self assessments as indicators of health stock in survey data, which gave rise to a large literature on the reliability and validity of these indicators in terms of their propensity to accurately measure health. Fortunately many of the public datasets as well as experimental studies, in an attempt to address this concern, collect not only the subjective self-reports from patients, but objective diagnosis from physicians. This is

useful not only for addressing potential concerns in using subjective self-reports – but in identifying another typically unobserved attributes of individuals that might affect behavior. In other words, individual differences between self-assessments and physician diagnosis are not likely randomly distributed across the study sample, and carry information that may be valuable and typically unobserved but relevant to the analysis.

Several studies on dental health illustrate and analyze the determinants of self-reported (SROH) oral health, and compare them to a dentist's rating. The discrepancy between oral health measured by dentists and patients has been documented across many studies. Low or inconsistent associations were found between the two. Early studies found week associations between clinical measures of oral health and subjective indicators (Brunswick and Nikias, 1975; Giddon et al., 1976; Berkey et al., 1985; Drake et al., 1980). A normative standard expectation could also bias the self-reported dental health. Reisine and Bailit (1980) suggested that positive perceptions existed among those who had large numbers of missing teeth or poor periodontal health. Some other study (Atchison,1993) accounted for the functional measures, and compares the single-item ratings by dentists and patients among dentate elders. They still found striking differences between the two. Clinical characteristics drive dentists' ratings almost entirely, while subjective self-assessed characteristics play a bigger role in patients' ratings. Toothache, decayed teeth and worsening periodontal health are correlated with lower perceived dental heath reported by participants in the Rand Health Insurance Experiment (Gooch et al. 1989). For the elderly, a correlation between subjective measures of oral health and missing teeth has been found (Locker and Slade, 1994; Matthias et al, 1995). Another finding showed little association between satisfactions with teeth and number of teeth or

conditions of teeth among the elderly (Rosenoer and Sheiham, 1995).

Gilbert et al. (1998) explore the multidimensionality of oral health and they report that having oral disadvantage, speaking difficulty, self-reported oral disease and tissue damage, and having fewer teeth remaining were significantly associated with poorer SROH. Important factors that are positively associated with SROH include age and positive dental attitudes.[3] Gift et al (1998) show that perceptions of natural dentition are associated with clinical and self-defined treatment needs, perception of general health, dental disease indicators are significant factors associated with, but not with socioeconomic indicators.

Therefore, self-reported dental health is related to clinical measures, and the self-reported dental health could be a biased indicator of true health due to individual's self-felt need, own experience, expectation, attitude and other factors. While it is important to control for these other factors given their role in predicting utilization, it is difficult to interpret the results when self-assessments are used as indicators of health stock. In this study we aim to disentangle the role of preferences from the role of actual health in predicting the demand for preventive services.

We build on what we have learned to date in this extensive literature. Namely we agree that preventive dental care is a more efficient way to utilize resources. We know that access to such services is associated with income, insurance coverage, and price; and as well as socioeconomic and demographic factors. And we know that preferences matter in predicting self-assessments of dental health and the need for dental health services. The National Health and Nutrition Examination Survey (NHANES) provide extensive

[3] Attitudes include confidence in the effectiveness of dental care, weight on importance of investing in dental care, cynicism toward dentists, cost issues, etc.

information on socioeconomic factors, insurance, self-assessed dental health and dentists' examination results. With this dataset, we are able to tie together the literature by incorporating reporting biases in the self-reported compared to actual clinical dental health measures into the model for demand of preventive dental care. We take into account heterogeneity in dental health preferences by recognizing that self-assessed dental health could be biased by non-random heterogeneous preferences that also influence dental care utilization. For example, people who use dental services may have a different information set for forming health assessments and those individuals possesses non-random preferences for dental health. Thus we could separate the actual dental health and the unobserved heterogeneity in terms of preferences for utilization. This enables us to better assess the behavior preventive dental care, and test the factors driving the propensity of investing in preventive care.

We can examine the effect of socioeconomic status and dental insurance after controlling for dental preferences, which could otherwise make dental insurance endogenous. The policy implications are related to understanding behavior to implement measures to enhance preventive dental care utilization, and ultimately dental health status and lower dental health care spending. To succeed in meeting our objectives we need to understand the role of insurance, economics factors, and dental health preferences. If demand for preventive services is not responsive to price, but more driven by preferences, there is little policy could do by way of economic incentives and information and advocacy would be the best route. The consensus in the literature so far, does suggest that economic factors will be an important incentive in the decision to invest in one's dental health. But none have disentangles the confounding effects of preferences adequately.

1.2 Theoretical Framework

We build on the framework suggested by Sintonen and Maljanen (1995) for modeling the demand for dental care and incorporate dental preferences into the model. For this analysis we do not model the supply side of the market. Based on Grossman's (1972) theory, dental health depreciates over time. Individuals maximize their utility by preventing the depletion of their dental health using preventive dental services. The consumption of preventive dental care is to maintain and enhance good dental health and avoid future costs of curative care. Individual's utility depends on dental health and other commodities. The individual uses his own time and market goods and services to produce dental health to maximize utility. Dental health depreciates over time and making investments can increase the stock of dental health.

Grossman's (1972) model has been criticized for the unrealistic assumption that individuals choose health investments exogenously, and that levels of health stock are a choice. They assume that the exogenous health investments influence health with certainty. Zweifel and Breyer (1997) suggest that individuals make choices that influence transition probabilities between the healthy and sick states. Thus health is not a choice with certainty. Health inputs are state-dependent, which means health status is not only the consequence of the health production process but also acts as a stochastic input factor.

Compared to general health, the production of dental health possesses less uncertainty. In particular, preventive dental care has been proven to be very effective in terms of preventing the development of dental diseases, enabling early detections and

saving future curative costs. So the evidence base in this market may be sufficient to apply the Grossman framework under the assumption of certain gains to investments in preventive care.

Grossman (1972) acknowledges that demand for health is indirect in that it is acquired through investments in services that actually reduce utility. As stated earlier, this disutility may be greater in the dental health market – with more heterogeneity in preferences. In other words, it is important to incorporate dental preferences into this demand for dental health framework because some people might have greater disutility from a dentist visit than others. These people are less likely to invest in information, less likely to insure, and they will demand fewer preventive dental care visits.

Demand for dental health $D(H)$ depends on the price of dental health P_H, Income Y, the prices of other goods P_z, and the valuation of dental health, i.e. perceived benefits, V_H

$$D(H) = h(P_{H,}P_z, Y, V_H) \tag{1}$$

The partial derivative with respect to Y and V_H are all positive, and the partial derivative with respect to prices are negative.

The valuation of dental health V_H depends on a set of individual characteristics, such as education, age, race and gender, E. For example, more educated people are better informed about the importance of dental health. The valuation of dental health is presumably higher among higher educated individuals. The valuation of dental health also relates to an individual's preferences or attitudes toward dental health care, F. If they have positive beliefs in the effectiveness in preventive care, and do not have

disutility of going for preventive visit, the valuation will increase. Otherwise, if they have lower preferences for dental health and dental care, this decreases the valuation of dental health. Thus,

$$V_H = v(E, F) \tag{2}$$

Holding prices of other goods as constant, we could denote the demand for preventive dental care as:

$$D(d) = D(M, T, E, F, Y, H_0) \tag{3}$$

where M , represents the out-of-pocket price of preventive dental care, which relates to dental insurance coverage. Time costs, T , relate to occupation or work characteristics. H_0 stands for the stock of dental health. Y , represents income. Higher income and higher education are expected to increase the demand for preventive care. Dental insurance, which decreases the out-of-pocket price, should increase the demand too. Lower propensity to use or weaker preferences for preventive dental care utilization could decrease the demand for preventive dental care. Conditional on dental preferences, the effect of dental insurance is expected to decrease. But the magnitude of change is uncertain. Our hypothesis is that individuals with weaker dental preferences, greater disutility or distaste towards dental health care utilization are less likely to invest in information pertaining to dental health, including dental consultation and care, holding prices fixed. As a result, they will demand less preventive dental care, and may have less elastic demand, which may be “suboptimal”.

1.3 Empirical Models

We seek to estimate the following equation for the propensity to have a routine visit:

$$y_1^* = \gamma_0 + \gamma_1 X_1^{'} + \gamma_2 Ins + \gamma_3 FF + e \quad (4)$$

Where $y_1 = 1$ if $y_1^* > 0$, and $y_1 = 0$ otherwise where y^* measures propensity to invest in preventive care. *Ins* is the dental insurance variable. FF represents a dental preference variable: fear of going or "fearfactor". Those with a distaste for dental health services want to use fewer services than recommended. We treat FF as endogenous for a number of reasons. First, one's preferences for dental health services may be the consequence of utilization experience or could reflect *learning*. Individuals' preferences could be influenced by the past dental experiences they have, i.e., $FF=f(y_0)$. Second, given the construction of the FF indicator, it is also tied to underlying poor health. This could be okay for the purpose of purging adverse selection bias in the dental health insurance effect. But we also seek to identify the role of fear separately from health.[4] So treating the dental preference variable as endogenous we get:

$$FF^* = \sigma_0 + \theta_1 X_1^{'} + \theta_2 Z + \varepsilon_4 \quad (5)$$

where FF=1 if FF*>0, and FF=0, otherwise. *Z* is an instrumental variable.

We employ two techniques to identify effects of factors on the probability of having a routine visit: the first one is the maximum likelihood technique or two-stage method of moments. This technique is a probit model with a binary endogenous variable,

[4] More discussion on the construction of FF follows in the data section.

where the dependent variable, having a routine visit or not, is dichotomous, and the endogenous variable, dental preference, is also binary. The second technique is to estimate equations (4) and (5) jointly by a bivariate probit model, where $(e, \varepsilon_4) \sim N(0, \Omega)$. Ω denotes the correlation between the error terms of the two equations.[5]

Secondly, following the decision to go, those who decided to use routine dental care will choose the frequency of visits. We employ an ordered probit model to test the determinants of routine care frequency among those who choose to use preventive dental care.

1.3.1 Measurement Error

We treat "true" dental health as latent and use a measurement error framework to incorporate two indicators for this latent variable. We observe dentist's diagnosis, and also the respondent's self-reported dental health, which we believe are both influenced by the underlying latent variable of dental health, albeit to different extents. People with similar true levels of dental health stock and conditions could report differently in a non-random way that depends on heterogeneous preferences or attitudes toward dental health. So self-assessed dental health could pick up more than "true" dental health. So while there may be a strong correlation between the self report and actual health, there is an additional component that is correlated with the dependent variable and other patient attributes that is reflected in that response – and we assume this component is a reflection of preferences. We try to back out this indicator of preferences by assuming that dentist's

[5] We use a recursive simultaneous bivariate probit model.

diagnosis is always the truth. There is information in the discrepancy between the two observed indicators, and we will use this information to gauge dental preferences.

Self-reported and dentist-assessed dental health are all related to the "true" but unobserved dental health η^*. Since we assume that dentist observe the "true" dental health, dentist's perception on the respondent's dental health D_d^* are based on dental examinations and indicate the respondent's "true" dental health status η^* as follows:

$$D_d^* = \eta^* \tag{5}$$

So we assume no measurement error. We observe dentist's diagnosis D_d which takes the value of 0 if the respondent has no significant need and dentist's recommendation is to continue routine dental care. It equals 1 if the respondent is diagnosed as having dental conditions that need further care.

$$D_d = \begin{cases} 1 & if \quad \eta^* \le 0 \\ 0 & if \quad \eta^* > 0 \end{cases}$$

The respondent's own assessment on his or her dental health, D_s^* captures some component of η^* as well as the respondent's dental preferences so that we have the following measurement error model: $D_s^* = \beta\eta^* + \varepsilon$ where β is close to 1 and ε captures preferences. One can think of a production function approach for a self-report as follows:

$$D_s^* = \alpha_1 X + B^* \tag{6}$$

Where X is a set of exogenous characteristics of individuals, including socioeconomic variables and the dental insurance coverage tied to the respondent's ability to pay. B^* is a latent variable, which denotes preferences for dental health that is the unobserved

propensity to use. It includes disutility of going to the dentist, such as anxiety towards dental care, tolerance for pain and confidence in treatment, expectations of gain from dental health investments, including the value of dental appearance, as well as the value or importance placed on dental health. We observe two results for the self-reported dental health:

$$D_s = \begin{cases} 1 & if \quad D^* \geq 0 \\ 0 & if \quad D^* < 0 \end{cases}$$

D_s equals 1 if the respondent reports having fair or poor dental health. Otherwise, 0 represents very good or good self-reported health.

The following table summarizes the potential states of reporting based on the discrepancy between the dentist's diagnosis and the respondent's self-reported dental health status.

		Dentist's Recommendation D_d	
		Need further care	Continue routine care
Self-reported D_s	Very good or good	Over-estimation	Agreement
	Fair or poor	Agreement	Under-estimation

Assuming there is information in the degree to which respondents mis-report their health, we tap into that information as indicative of something typically unobserved and possibly correlated with preferences for dental health services. We assume people who underestimate would like more care than the doctor's recommend. These under-estimators may have a greater propensity to use dental services than others, and they not suffer as much disutility from going to a dentist. Those who overestimate do not believe they need services despite dentists' recommendations otherwise. Consequently, we

assume that people who overestimate, at the margin, have a lower propensity to use dental services – possibly because of higher time costs or greater disutility from going. Those in agreement may be more homogeneous in their propensity to use services. But this is an empirical question. Clearly those in good health, who report they are in good health, must have a greater propensity to go. However, those who accurately report poor health could do so because they learned it from a dentist, or because they know they should go given symptoms but fail to go despite that. In other words, they have a strong distaste that leads them to stay in poor health, despite the fact that they know they should go. Given the ambiguity in what this indicator may be measuring, we use information collected on barriers to going to the dentist. Unfortunately the question is only asked on a smaller subsample in the data we use. We find a strong correlation between those who overestimate and those who accurately report poor health, and fear as a barrier to utilization. For this reason we set FF = 1 if respondents overestimate or accurately report poor health, and 0 otherwise. Since this is clearly tied to poor health, the indicator FF is picking up more than propensity to fear using a dentist and needs to be treated endogenously using this measurement error model.

1.3.2 The Adverse Selection Problem

Those with the greater propensity to use dental health services may also be those more likely to opt into insurance plans. Without a control for propensity to use the services, health insurance effects may be exaggerated given it will pick up this greater propensity to use which is the dependent variable. We use the information regarding

health status discrepancies to construct indicators of dental health care preferences to address the potential adverse selection problem. First, the individual will decide whether to seek routine dental care or not. Individuals' preferences could drive the propensity to insure as well as their dental care-seeking behavior. By controlling for dental preferences, we can get an unbiased estimate on the role of dental insurance in driving the behavior of investing in preventive dental care.

1.4 Data

We use the National Health and Nutrition Examination Survey (NHANES) which not only collects extensive information on demographics, socioeconomic factors and insurance, but rich health status data. The survey is unique in that it combines face to face interviews with physical examinations. The health examination is conducted in a Mobile Exam Center (MEC) for almost all participants. The current sample is comprised of two release cycles: 1999-2000, (interview sample size 9,965 and MEC examined sample size of 9,282) and 2001-2002 (interview sample size 11,029 and MEC examined sample size of 10,477). This dataset is suitable for our purpose because it contains both the self-reported conditions of dental health, dental care utilization patterns, and the objective measures of dental health status. We exclude from the sample any persons younger than 21 since those under 21 have different oral conditions and needs compared to adults, and may be tied to parent choices. Further, we exclude those who did not participate in the oral health examinations in the study.

To construct the utilization indicator for our dependent variable we use whether

the respondent had routine checkups/cleanings or not. This is constructed from the survey question "During the past 3 years, have you been to the dentist for routine check-ups or cleanings?" This is followed by another question, "During the past 3 years, how often have you gone to the dentist for routine check-ups or cleanings?" The potential responses are: 2 or more times a year, once a year, less than once a year, (whenever needed) no regular schedule[6]. In our analysis, we create a dichotomous indicator equal to 1 if the respondent uses routine care with a regular schedule. Respondents who had no routine care visit, or who visited on an irregular basis, are regarded as non-users since respondents who had no regular schedule could be those who went for a checkup only when problems occurred. They are less homogeneous in their utilization. We use the dichotomous indicator of use for our first model and frequency of routine dental care for our second model.

To test our hypotheses on the importance of health insurance (price) to promote health through utilization, we use a dichotomous indicator where dental insurance is set to 1 if the respondent reports having dental coverage[7]. We also use an indicator to represent those who do not know if they have coverage.

To control for adverse selection we control for dental health and propensity for mis-reporting (related to preferences). The self-assessed dental health has been scaled to

[6] The respondents were first asked for the main reason of the last dental visit. They could choose one of the following: 1= Went in on own for check-up, examination, or cleaning; 2= Was called in by the dentist for check-up, examination, or cleaning; 3= Something was wrong, bothering or hurting; 4= Went for treatment of a condition that dentist discovered; at earlier checkup or examination; 5= Other. Those people who chose 1 or 2 will be asked how often they have routine checkup or cleaning directly. Those people who chose 3, 4 or 5 will be probed to ask 1) whether they have routine checkup or not, if yes, 2) how often? Therefore, if they went last time for a problem, and they got a checkup, most likely they would not respond as having a routine checkup. So the two are not lumped together.

[7] Unfortunately we do not have information about specific coverage for preventive care. Most private plans, even the least comprehensive, provide preventive care coverage given expected savings from preventing acute care. For Medicaid, only a few states has limited coverage of preventive care.

4 levels: very good, good, fair or poor. This is compared to dentists' recommendations for care. The recommendation states the specific dental conditions detected and the action required. Four levels of recommendations are assigned: See a dentist immediately because oral lesions requiring emergent attention (e.g. abscess, oral cancer); See your dentist within the next two weeks due to oral pathology requiring follow-up (e.g. severe periodontal disease or cavities); See your dentist at the earliest convenience (usually a non-emergency condition exists); Or continue your regular routine care. We group the first two levels together and name it "urgent need" since relatively immediate care is required for both.[8] The FF indicator described in Section 4.1 then is constructed using these data. People who report themselves in very good or good dental health but are diagnosed as needing care fall into the "overestimation of health" category. Those who report having fair or poor dental health but do not have significant dental needs are regarded as underestimating their dental health. Those reporting accurately but in poor health are included in the indicator for FF=1.

We also are able to control for socioeconomic factors (income, education, occupation). The poverty income ratio (PIR) variable is used to measure family income levels. PIR takes into account the family size as well as the family's total income. PIR values below 1.00 are below the official poverty threshold and are coded as families with poor income. Occupations are grouped into three categories: white collar, service collar and blue collar. Among white collar and blue collar occupations, subgroups are divided according to the work characteristics to capture variations in time costs and time preferences (details shown in the Appendix). People who are currently not working are

[8] Also the sample size for the first category is very small.

characterized by their current status: unemployed, homemaker, student, retired, not working because of health reasons (including disabled) and not working because of other reasons. Demographic characteristics like race and marital status are also controlled for. People are divided into six age groups since age influences demand for preventive care according to the literature. The general health conditions are included as well. An indicator is created for respondents who were excluded from the periodontal and root decay assessment because of confounding medical conditions. An indicator of current smoking status is included as a control for risk aversion through risky behaviors in general as well as a risky factor for dental health in particular.

Dental health stock is measured by the number of missing teeth due to dental diseases. We create four dummy variables: with five or fewer teeth missing, with more than five teeth missing, with five or fewer teeth missing but replaced, and with more than five teeth missing but replaced. We use missing teeth as the health stock variable, because they are not simultaneously determined by routine utilization in the current period, and are therefore exogenous.

To identify the system of equations we need exclusion restrictions. Specifically we need an instrument that is correlated with preferences for health, but not with utilization. The instrumental variables we use for the bivariate probit model and the maximum likelihood technique are indicators of propensity to invest in health outside of medical services. We use an indicator that compares the activity in the last month with the last year, and an indicator for having been diagnosed with high blood pressure. The activity comparison indicator is constructed from the question “How does the amount of activity that you reported for the past 30 days compare with physical activity for the past

12 months?" The respondent chooses from one of the following choices: more active, less active, about the same, or do not know. Another indicator is being regularly active. Respondents with no less than 600 minutes of combined moderate or vigorous activity, and no less than 20 times in the last 30 days are considered as regularly active.[9] We construct a dummy variable that represents those who were regularly active or those who became physically more active for the past 30 days. Conceptually, the activity level is not related to routine dental care visit, but it represents people's expectation or attitude towards health. The respondents who care more about their health are more likely to increase their activity levels. Therefore it correlates with preferences for health, including dental health, which is fear factor in our case. People who are current smokers are more likely to be those who have unhealthy lifestyles and those who tend to be more risky and care less about their health, so they are positively correlated with lower propensity to use. Therefore this indicator correlates with "fear factor", but it is not directly related to routine dental care visits[10].

1.5 Results

Table 1.1.a presents evidence on reporting bias in self-assessed dental health. As expected, there is clearly a correlation between self-assessed dental health and dentist's diagnosis, but there is also significant variation. Roughly 9% of the overall sample is off

[9] Difined according to Kruger et al. (2007).

[10] Instruments pass tests of exogeneity and validity.

in an extreme way (report the extreme value of good or poor health but are told the opposite by the dentist). Over 10% of the overall sample has discrepancies. Among those who report their dental health to be good or very good, 31% would require further care according to dentists – which suggests a significant degree of overestimation.

Table 1.1.b shows characteristics of those more or less likely to mis-report. Compared to those in agreement with dentists, people who overestimate are more likely to be covered by dental insurance while those who underestimate are less likely to be covered – a correlation that is consistent with adverse selection. People who underestimate also have a lower rate of private insurance coverage, higher rate of Medicare coverage, and they tend to have lower income. So underestimation is associated with older age and cost barriers. They are less frequent users of routine care, and with a larger number of missing teeth due to dental diseases, which is also related to older age. They have poorer general health and lower education levels. The group with fear factor tends to be less active during the past 30 days compared to the past year, and they also have a higher proportion of current smokers than the groups with good dental health (either report correctly or underestimate). Fear factor is associated with being blue collar, Black or Hispanic, and being a current smoker.

We care about lack of insurance as a barrier to entry. Table 1.2 reports descriptive statistics by dental insurance coverage and utilization of routine care. Consistent with our priors, and in accordance with the literature, people with higher income and higher education are more likely to have routine dental care. For people holding white collar jobs, a higher percentage of them had routine dental visits. So having higher socioeconomic status does relate to a greater propensity for routine care. Blacks,

Hispanics and Mexican people are less likely to visit compared to whites. Males, smokers and those who have fair or poor general health conditions have a lower propensity for routine dental care. Moreover, access to dental health care, through insurance, makes a difference in choices made for preventive dental care. For the insured, those who had routine care are less likely to overestimate, while for the uninsured, it is those who had no routine care that are less likely to overestimate. Those who are insured and use have a greater propensity to use and report health accurately than those who insure and do not (revealed distaste for going). Those who are uninsured and had routine care are actually more likely to reveal a distaste for going given our assumption – but this is without controlling for health which is clearly tied to utilization and insurance. Clearly insurance, as an indicator of price or access, is going to increase utilization at the margin – 63% among the insured had routine care compared to only 39% among the uninsured. So that without controlling for other factors like health, simple descriptive analysis only motivates further investigation. The point from this table is that there are differences in reporting patterns based on propensity to use and propensity to insure. Which is precisely what we want to control for given our adverse selection concern.

Before moving onto multivariate analysis we look at the frequency of visits by insurance status and propensity to overestimate in Table 1.3. The majority of the insured have 2 or more visits per year, while only fewer than 10% visit less than once a year. Those who overestimate their dental health tend to visit less often for the insured – again an indicator of propensity to use. The uninsured appear to be split into two types: those who self-pay and are better able to afford to go (they are slightly better off than those who do not use regular visits among the insured), and those who face real financial

barriers. So the self-pay group may be more like the insured in that they choose self-insurance. As for the uninsured, those who visit at least twice a year are the least likely to overestimate (24%); while 33% of those who are not insured and go one time overestimate compared to only 26% for those who go less than once a year. Socioeconomic effects display similar patterns. Regardless of insurance status, higher income, higher education and white collar jobs still make a difference in visit frequency. The difference in visit frequency between the insured and uninsured is not as big as one might predict, but does exist. 61% of the insured have two or more visits per year, while 54% of the uninsured visit that often.

Table 1.4.a shows results from the univariate probit model. Column 1 presents results from the single probit model without the preference variable "fear factor". Dental insurance coverage proves to be a strong predictor of utilization of routine care; increasing the propensity to use this care by roughly 12%. Column 2 adds FF into the estimation to purge any upward bias on the effect of dental insurance stemming from a potential adverse selection problem. People who have a distaste for going to the dentist may opt out of an insurance plan, or not invest in insurance, so that they are also less likely to use dental services. So the dental insurance effect in column 1 could be exaggerated. One way to purge this bias is to control for the propensity to use dental health services, or preferences. Once we control for the preference variable FF, the marginal effect of dental insurance goes down slightly to 0.11, which suggests there may be some adverse selection problem, albeit small. The marginal effect of FF is even larger than the insurance effect – decreasing the propensity to use routine care by almost 18%. Column 3 adjusts for potential measurement error in the construction of FF. Given it is

tied to discrepancies in self reports of dental health (which may be tied to learning from using care), as well as health status, the effect of FF may be biased. By using factor analysis we capture the component of FF not tied to poor health (See Appendix for details). After purging potential measurement error bias the effect of preferences goes down to about 11%.

The effects of other important factors driving the use of preventive care are as expected. People with poorer accumulated dental health stock or overall health, lower education, and lower income are less likely to have a routine visit. Being male, and blue collar also reduces the probability of using routine care. One interesting finding is that there is no independent race effect once we control for FF, which suggests that preferences are tied to culture and race.

"Fear factor" is subject to measurement error because it captures fear, poor heath (as a flow indicator rather than stock), as well as the learning experiences from past utilization. As a consequence utilization and FF may be simultaneously determined. In other words, there could be some offsetting effects that bias the effect of "fear factor", and treating them simultaneously may be an alternative method for purging the bias. In Table 1.4.b we perform a bivariate probit analysis to gauge the effect of "fear" separate from health effects[11] . Being regularly active (physically) or becoming more active, and being a current smoker are used as instrumental variables[12].

[11]We also use another technique: maximum likelihood techniques or two-stage method of moments. These two techniques produce the same results. The maximum likelihood estimation of endogenous binary variable approach is implemented in the statistical package Stata using the add-on Gllamm (Generalized Linear Latent And Mixed Models - Rabe-Hesketh, Pickles, and Skrondal 2002) and Ssm routines (Maximum likelihood estimation of endogenous switching and sample selection models for binary, count, and ordinal variables - Miranda A., and Rabe-Hesketh S. 2006)

[12] They passed the weak instrument test (F-stat=18.53). An overidentification test has been performed:

As mentioned earlier, the construction of FF results in three components of the indicator that would drive the utilization outcome – with effects that have opposing signs. At the margin those who currently report poor dental health are more likely to self-select into being insured, and they have a higher propensity to seek routine care. They have the most to gain from insurance and utilization. Since those who are "fearful" according to our indicator are all in poor health, the effect of FF would be underestimated since the positive effect of poor health on utilization would offset the negative effect of being fearful. Since FF is correlated with propensity to mis-report, which is negatively tied to experience with dental health utilization, the effect of FF as an indicator of disutility for preventive care could be exaggerated. Given rho is positive and significant (rho=0.562), we know that the former effect outweighs the latter. Poor health is clearly a big part of FF and positively associated with utilization. After controlling for this simultaneity, the marginal effect of "fear" goes up significantly to -0.496. This is a big jump compared to the univariate probit model, where there is no control for current health which is clearly endogenous. The strong tie between current dental health and FF was affecting the effect of preferences in the univariate model. Therefore, dental preference, namely the distaste of going to the dentist, has a significant effect on one's decision of not using routine care services.[13] However the effect of insurance remains relatively robust with a significant marginal effect of 0.10.

P-value =0.268. So the instruments are not directly determinants of routine visit.

[13] Using factor analysis should have also purged the effect of poor health so that we might have expected the effect to go up in that model (Column 3 Table 4a). Given factor analysis is a data reduction technique, and the expected tie between fear and current health, we may purge too much. In other words, attenuation bias from measurement error may be the consequence of keeping a small component of the indicators for constructing FF.

Those who exercise regularly are less likely to fear, while those who smoke tend to have a higher propensity to be fearful. Being male, Black, Mexican and Hispanics are positively correlated with "fear factor". Those with lower income, lower education, poorer dental health stock, fair or poor overall health have a higher probability of having the "fear factor".

Besides the propensity to use preventive care, we are also interested in the frequency of use. We restrict our sample to those who have a positive number of visits and try to examine the determinants of routine visit frequency[14]. Table 1.5 shows the ordered probit results for visit frequency. Among users of preventive care, there is a significant difference between those who visit more than once a year and all others. Both preferences and dental health insurance have a significant impact on these choices as expected. The FF significantly discourages frequent use whereas insurance plays a less significant role in how often one goes for routine care. 63% of those who had routine care have insurance compared to less than 50% in the whole sample. So there is less variation in insurance status among those who use.

Socioeconomic factors continue to be significant predictors for visit frequency. People with high income and more than high school education are significantly more likely to visit twice or more per year. Being male, Black, Mexican or Hispanic are significantly associated with fewer routine dental visits. Occupation becomes an insignificant predictor for visit frequency, indicating that once the decision for seeking care has been made, the time cost is no longer a concern. People of the younger age

[14] We test the ordered probit model with sample selection and using the method of generalized linear latent and mixed models, but the log likelihood test of rho is insignificant. So no evidence of sample selection bias is found. Therefore we report the result without sample selection only.

groups tend to visit less often. Those who are covered by dental insurance are significantly more likely to visit more frequently. Having five teeth missing due to dental diseases, or missing but replaced, is a significant predictor for infrequent routine visit.

Finally, to purge the simultaneity problem with our indicator of FF, we use a biprobit model, where being current smoker, poor or fair overall health, and the exclusion conditions serves as the instrument[15]. We compare frequent users (greater than once a year) to those who visit once a year or less. Once again, Table 1.6 shows that after we control for simultaneity, the negative effect of "fear factor" on the probability of more frequent visit becomes stronger (marginal effect changes from -0.124 to -0.397). The effect of insurance remains robust with a slight increase in the propensity to be a frequent user if one is insured.

1.6 Conclusions and Policy Implications

Higher socioeconomic status and improved access through dental insurance coverage are known to be positively associated with preventive dental care visits. However, estimated effects of dental health insurance are potentially biased by an adverse selection problem where the demand for services and insurance are simultaneous and driven by health need and preferences. Purging potential bias from endogeneous insurance has always been a challenge given the difficulty in identifying adequate instruments (that are not tied to health status and utilization directly). What has always

[15] They passed the weak instrument test (F-stat=12.87). An overidentification test has been performed: P-value =0.753, so the instruments are not directly determinants of routine visit.

been missing is a clean indicator of underlying preferences that drive one's "propensity to use dental health services" independent of current health. In this study, rather than using a weak instrumental variables approach (Heckman, 1995), we construct an indicator of preferences to directly purge the bias. We also perform sensitivity analysis by allowing for various types of measurement error in our preference indicators. Regardless of how we measure preferences, whether we include them or not, and allowing for simultaneity between utilization and preferences tied to current health – the effect of insurance remains robust. Dental health insurance increases the propensity to use routine care by between 10 and 12%. In other words, lack of health insurance is a barrier to preventive care and ultimately efficient delivery in the dental health market. These effects are likely an underestimate given the amount of variation in the quality of coverage (for preventive care visits in particular) which is unobserved in our data.

Another robust finding in our work is a clearly significant effect of disutility from dental health services that also serves as a barrier to efficient outcomes in the dental health market. While the effect of this fear factor is not robust in magnitude (ranging from 11% - 50% less likely to use), it is robust in sign and significance. While there is little policy can do to change preferences, education and advocacy for preventive care might be effective. One would assume there would be more fear associated with treatment of neglected conditions than routine care.

Frequency of preventive care visits are also influenced by socioeconomic status, dental insurance coverage, and dental preferences. Conditional on having positive visits, people of high socioeconomic status, with dental insurance, and with stronger dental health preferences, are all significantly increase the frequency of care. This implies that

dental insurance improves access for all despite of preferences for utilization. However, dental preferences, i.e. to avoid the disutility associated with dental care, and the lower propensity to use dental services, leads to less than optimal utilization from the health maximization perspective.

A clear policy implication would be in facilitating access to preventive dental care, to achieve cost-effectiveness in the delivery of dental health services, given the significant impact of dental insurance to access. We could start with the publicly financed programs to improve coverage for preventive care. People respond to incentives that would lower overall costs. If the publicly financed programs offer more dental insurance coverage for preventive care, recipients will seek more preventive care, so dental health could be promoted and the more costly curative care could be saved. Given the size of the Medicare program in particular, expanding coverage to preventive care could set a precedent for improving efficiency in the dental health market in general.

Table 1.1.a Frequency of self-perceived oral health, given dentists' recommendations

	Self-reported dental health			
Dentists' diagnosis	Feel very good (N=1729)	Feel good (N=2909)	Feel fair (N=2002)	Feel poor (N=1050)
Continue routine care (N=3357)	69.21%	53.02%	31.90%	14.88%
Need to see dentists (N=4333)	30.79%	47.98%	68.10%	85.12%

Table1.1.b Characteristics of Respondents, by discrepancy between self-reported dental health and dentist's diagnosis[16]

	Full Sample (N=7690) %	Over-estimation (N=2033) %	Accurate-poor (N=2300) %	Accurate-good (N=2605) %	Under-estimation (N=752) %	Fear Factor (N=4333) %
Dental insurance	53.69	54.72	42.06	60.95	51.81	48.51
Private insurance	68.78	69.16	52.18	80.00	65.39	60.88
Medicare	17.08	13.84	14.48	19.54	23.26	14.16
Medicaid	5.16	5.81	8.55	2.49	5.26	7.15
Routine care	57.03	57.64	28.32	75.47	55.98	43.29
Missing teeth N<=5	31.39	35.08	44.72	19.55	34.27	39.81
Missing teeth N>5	8.80	6.17	21.69	1.88	10.36	13.75
Missing replaced <=5	10.91	10.34	9.71	11.52	13.34	10.03
Missing replaced >5	16.93	12.37	16.59	17.30	29.62	14.44
Socioeconomic status						
Poor income	12.82	13.00	21.45	6.72	14.78	17.10
Low income	18.89	18.16	28.99	12.77	19.19	23.46
Middle income	26.97	29.90	24.83	26.55	26.03	27.44
High income	34.56	31.69	17.66	47.67	33.56	24.84
Missing income	6.76	7.26	7.07	6.29	6.44	7.17
Less than HS	20.61	20.12	34.27	11.37	24.12	27.00
High school	25.33	26.41	30.39	20.94	26.8	28.37
More than HS	54.06	53.47	35.34	67.69	49.09	44.64
White collar	38.08	37.71	24.49	48.88	30.39	31.27
Health professional	2.08	1.70	0.75	3.58	0.42	1.24
Other professional	18.07	16.49	9.11	25.34	16.36	12.90
Sales occupation	11.51	12.22	9.51	12.94	8.74	10.90
Technician/assistant	6.42	7.30	5.12	7.02	4.88	6.23
Service collar	8.71	9.00	11.66	6.61	8.63	10.31
Blue collar	13.59	21.07	27.43	10.65	15.41	18.39
Farm and agri	1.62	2.04	2.57	0.89	0.88	2.30
Transportation	2.88	3.23	3.78	2.23	2.15	3.50
Other blue collar	13.59	15.80	21.08	7.53	12.38	18.39
White	73.33	67.02	62.27	84.54	74.13	64.73
Black	9.98	13.39	14.31	5.34	7.93	13.84
Mexican	6.43	6.48	10.94	3.42	6.61	8.66
Hispanic	6.74	8.95	8.75	3.92	6.87	8.86
Other race	3.52	4.16	3.73	2.78	4.45	3.92
Male	47.81	54.80	52.96	40.84	43.00	53.93
Married	60.59	58.92	54.50	65.62	60.74	56.78
Poor/fair general health	16.55	12.43	30.01	8.97	23.89	20.99
Current smoker	23.69	27.39	39.16	15.69	22.22	31.25
Regularly active	37.63	47.66	38.05	56.25	46.42	32.58

[16] Weighted means reported in all descriptive tables.

Table 1.2 Characteristics of Respondents by Dental Insurance and Routine Care Use

		Insured		Uninsured	
	Total (N=7690) %	Had routine care (N=2398) %	No routine care (N=1432) %	Had routine care (N=1438) %	No routine care (N=2214) %
Fear Factor	51.88	37.42	67.47	42.82	69.86
Overestimation	26.53	26.46	28.26	27.17	24.94
Accurate (Poor)	25.35	10.97	39.21	15.65	44.92
Accurate (good)	39.12	54.26	23.08	47.32	20.98
Underestimation	8.99	8.32	9.45	9.86	9.16
Socioeconomic status					
Poor income	12.82	4.86	17.56	9.10	23.36
Low income	18.89	9.45	18.07	17.18	34.72
Middle income	26.97	26.22	32.57	28.73	23.51
High income	34.56	54.28	25.05	37.23	10.86
Missing income	6.76	5.19	6.76	7.76	7.55
Less than HS	20.61	8.19	29.80	13.26	37.67
High school	25.33	20.13	30.00	22.80	31.78
More than HS	54.06	71.68	40.20	63.94	30.55
White collar	38.08	56.13	32.00	35.42	18.64
Health professional	2.08	4.01	0.97	1.65	0.35
Other professional	18.07	29.76	12.60	15.45	6.81
Sales occupation	11.51	15.50	13.30	9.91	5.85
Technician/ assistant	6.42	6.86	5.13	8.40	5.63
Service collar	8.71	6.62	10.34	9.50	10.12
Blue collar	18.09	14.38	24.00	11.71	24.59
Farm and agricultural	1.62	0.62	1.28	2.39	2.80
Transportation	2.88	3.06	4.28	1.54	2.72
Other blue collar	13.59	10.70	18.43	7.77	19.07
White	73.33	79.11	64.05	79.67	66.12
Black	9.98	7.80	18.61	5.73	10.62
Mexican	6.43	4.20	6.09	5.23	10.91
Hispanic	6.74	5.16	7.91	5.95	8.73
Other race	3.52	3.73	3.33	3.43	3.61
Male	47.81	45.30	51.38	43.49	52.30
Married	60.59	70.60	58.33	60.14	49.60
Poor/fair general health	16.55	8.61	22.85	13.37	25.98
Current smoker	23.69	15.91	28.57	17.94	36.17
Regularly active	37.63	46.92	31.35	39.87	26.43

Notes: we include those who do not know their dental insurance coverage in the full sample, but they are not analyzed separately to compare with those with and without insurance.

Table 1.3 Descriptive Statistics by dental insurance and checkup frequency among those with positive routine dental visits

	Total	Insured			Uninsured		
	N=3900 %	>=2 (N=1460) %	=1 (N=716) %	<1 (N=222) %	>=2 (N=779) %	=1 (N=503) %	<1 (N=156) %
Fear Factor	39.38	30.52	45.95	59.69	35.42	50.63	57.80
Overestimation	26.80	22.70	31.37	37.71	23.78	33.31	26.50
Accurate (Poor)	12.58	7.82	14.59	21.98	11.64	17.32	31.29
Accurate (good)	51.79	61.31	45.42	31.85	55.07	39.08	31.81
Underestimation	8.83	8.17	8.63	8.45	9.51	10.29	10.40
Socioeconomic Status							
Poor income	6.43	3.36	7.84	6.06	5.94	13.08	13.57
Low income	12.13	7.07	14.59	10.06	14.40	20.75	21.00
Middle income	27.04	24.44	27.59	34.68	29.71	25.47	33.27
High income	48.25	60.89	43.31	41.85	42.62	31.39	26.77
Missing income	6.15	4.23	6.67	7.35	7.33	9.31	5.39
Less than HS	9.99	6.40	11.77	9.58	9.71	17.15	20.00
High school	20.84	19.33	21.68	20.98	20.76	24.83	27.26
More than HS	69.18	74.27	66.55	69.44	69.53	58.01	52.74
White collar	49.01	60.25	45.57	60.42	37.03	35.69	26.37
Health professional	3.21	3.71	4.12	5.80	1.71	2.12	0.00
Other professional	24.89	33.27	22.62	27.42	16.91	12.42	16.88
Sales occupation	13.64	16.30	12.53	19.26	9.70	11.83	5.37
Technician/ assistant	7.27	6.96	6.31	7.94	8.71	9.31	4.13
Service collar	7.62	4.90	10.98	4.95	8.20	10.83	12.27
Blue collar	13.41	13.06	15.90	19.00	9.44	12.31	21.58
Farm and agricultural	1.21	0.54	0.99	0.00	2.06	1.86	5.67
Transportation	2.51	2.65	3.25	5.35	0.91	1.66	4.45
Other blue collar	9.69	9.87	11.66	13.65	6.47	8.79	11.47
White	79.31	83.80	70.52	72.89	84.67	72.28	75.78
Black	7.07	6.38	9.76	11.78	4.85	6.48	8.03
Mexican	4.57	3.75	4.43	6.73	2.88	8.01	9.07
Hispanic	5.49	2.70	9.97	7.45	4.76	8.47	4.69
Other	3.57	3.38	5.32	1.15	2.85	4.77	2.44
Male	44.71	44.64	41.75	61.42	41.94	42.17	55.32
Married	66.53	73.43	66.01	64.99	63.55	58.71	46.87
Poor or fair general health	10.27	7.20	11.36	9.99	12.06	14.56	16.60
Current smoker	16.63	14.51	17.12	22.12	15.15	17.94	32.27
Regularly active	44.64	48.78	47.40	31.98	42.32	35.54	40.02

Table 1.4.a The probability of having routine preventive care in the dental health market

	Model 1 without fearfac		Model 2 with fearfac		Model 3 with factor analysis	
	Coef./Std.err.	Marginal	Coef. /Std.err.	Marginal	Coef. /Std.err.	Marginal
Fear Factor	----	----	-0.448 (0.036)***	-0.177	---	--
Factor Analysis	----	----	----		-0.285 (0.019)***	-0.114
Dental insurance	0.297 (0.049)***	0.118	0.285 (0.050)***	0.113	0.282 (0.050)***	0.112
Private Insurance	0.339 (0.043)***	0.135	0.330 (0.043)***	0.131	0.319 (0.044)***	0.127
Medicare	0.135 (0.064)**	0.054	0.122 (0.065)*	0.049	0.120 (0.065)*	0.048
Medicaid	0.011 (0.072)	0.004	0.024 (0.073)	0.009	0.022 (0.073)	0.009
Missing teeth N<=5	0.034 (0.038)	0.014	0.128 (0.039)***	0.051	0.178 (0.039)***	0.071
Missing teeth N>5	-0.339 (0.059)***	-0.134	-0.213 (0.060)***	-0.085	-0.115 (0.061)*	-0.046
Missing replaced <=5	0.388 (0.056)***	0.152	0.365 (0.057)***	0.143	0.375 (0.057)***	0.146
Missing replaced >5	-0.485 (0.051)***	-0.191	-0.522 (0.051)***	-0.205	-0.490 (0.051)***	-0.193
Dental Ins*Black	-0.176 (0.089)**	-0.070	-0.177 (0.089)**	-0.070	-0.171 (0.090)*	-0.068
Dental Ins*Mexican	0.078 (0.083)	0.031	0.067 (0.084)	0.027	0.066 (0.085)	0.026
Dental Ins*Hispanic	-0.015 (0.145)	-0.006	-0.018 (0.146)	-0.007	-0.000 (0.147)	-0.000
Dental Ins*Other race	0.247 (0.204)	0.097	0.214 (0.208)	0.084	0.203 (0.208)	0.080
Low income	0.134 (0.054)**	0.053	0.125 (0.054)**	0.050	0.117 (0.055)**	0.047
Middle income	0.332 (0.057)***	0.131	0.307 (0.057)***	0.121	0.291 (0.057)***	0.115
High income	0.673 (0.062)***	0.259	0.622 (0.063)***	0.240	0.603 (0.063)***	0.233
Missing income	0.287 (0.070)***	0.113	0.261 (0.070)***	0.103	0.244 (0.071)***	0.096
High school	0.251 (0.046)***	0.100	0.249 (0.047)***	0.099	0.245 (0.047)***	0.097
More than high school	0.562 (0.045)***	0.221	0.541 (0.045)***	0.213	0.531 (0.045)***	0.209
Age 21-29	-0.179 (0.094)*	-0.071	-0.151 (0.094)	-0.060	-0.122 (0.095)	-0.049
Age 30-39	-0.066 (0.091)	-0.026	-0.021 (0.092)	-0.008	0.003 (0.092)	0.001
Age 40-49	0.061 (0.089)	0.024	0.094 (0.090)	0.037	0.113 (0.090)	0.045
Age 50-59	0.024 (0.087)	0.010	0.058 (0.088)	0.023	0.084 (0.088)	0.033
Age 60-69	0.088 (0.066)	0.035	0.108 (0.066)*	0.043	0.117 (0.066)*	0.047
Male	-0.195 (0.036)***	-0.078	-0.148 (0.037)***	-0.059	-0.146 (0.037)***	-0.058
Married	0.044 (0.036)	0.018	0.037 (0.036)	0.015	0.040 (0.036)	0.016
Black	-0.143 (0.070)**	-0.057	-0.089 (0.070)	-0.036	-0.091 (0.071)	-0.036
Mexican	-0.099 (0.062)	-0.040	-0.063 (0.063)	-0.025	-0.033 (0.063)	-0.013
Hispanic	0.038 (0.104)	0.015	0.065 (0.105)	0.026	0.065 (0.106)	0.026
Other race	-0.154 (0.147)	-0.061	-0.130 (0.149)	-0.052	-0.099 (0.149)	-0.040
Current smoker	-0.242 (0.041)***	-0.096	-0.261 (0.042)***	-0.104	-0.252 (0.042)***	-0.100
Exclude conditions	-0.086 (0.043)**	-0.034	-0.117 (0.044)***	-0.047	-0.119 (0.044)***	-0.047
Fair or poor health	-0.209 (0.043)***	-0.083	-0.183 (0.043)***	-0.073	-0.136 (0.044)***	-0.054
Insurance not known	-0.113 (0.104)	-0.045	-0.130 (0.105)	-0.052	-0.139 (0.105)	-0.055
White collar						
Health Professional	0.152 (0.162)	0.060	0.127 (0.164)	0.051	0.096 (0.166)	0.038
Other professional	0.075 (0.072)	0.030	0.042 (0.073)	0.017	0.033 (0.074)	0.013
Sales occupation	-0.030 (0.073)	-0.012	-0.026 (0.074)	-0.010	-0.028 (0.074)	-0.011
Technicians	0.008 (0.087)	0.003	0.013 (0.088)	0.005	0.005 (0.088)	0.002
Blue collar						
Agricultural	-0.123 (0.126)	-0.049	-0.103 (0.126)	-0.041	-0.129 (0.127)	-0.052
Transportation	-0.087 (0.109)	-0.035	-0.102 (0.110)	-0.041	-0.106 (0.111)	-0.042
Other blue collar	-0.208 (0.069)***	-0.083	-0.183 (0.069)***	-0.073	-0.184 (0.070)***	-0.073
Unemployed	0.172 (0.117)	0.068	0.174 (0.119)	0.069	0.192 (0.119)	0.076
Homemaker	-0.011 (0.075)	-0.005	-0.012 (0.076)	-0.005	-0.012 (0.076)	-0.005
Student	0.402 (0.185)**	0.155	0.431 (0.188)**	0.166	0.427 (0.189)**	0.164
Retired	0.059 (0.078)	0.024	0.035 (0.079)	0.014	0.018 (0.079)	0.007
Not working health reasons	-0.091 (0.081)	-0.036	-0.104 (0.082)	-0.042	-0.115 (0.082)	-0.046
Not working other reasons	-0.008 (0.118)	-0.003	-0.001 (0.118)	-0.000	0.002 (0.119)	0.001
_Cons	-0.629 (0.119)***		-0.411 (0.121)***		-0.701 (0.120)***	

Observations (N): 7690 * p<0.10, ** p<0.05, *** p<0.01

Notes: 1) the excluded variables are: poor income, less than high school, age 70 and over, single, divorced and widowed, white, good, very good and excellent general health, service collars. 2) Exclude conditions are recorded in the Appendix. 3) Income is measured with poverty income ratio (PIR), which accounts for both the family income and the family size.

Table 1.4.b The probability of having routine preventive care in the dental health market (Maximum likelihood estimation with endogenous variable)

	Bivariate Probit Model					
	Routine			**Fear factor**		
	Coef./ std. err.		Marginal	Coef.	Std err	
Dental insurance	**0.251**	**(0.036)*** **	**0.100**	--	-	--
Private Insurance	0.305	(0.040)***	0.121	--	--	--
Medicare	0.117	(0.059)**	0.047	--	--	--
Medicaid	0.029	(0.066)	0.012	--	--	--
Missing teeth N<=5	0.298	(0.044)***	0.118	0.594	(0.036)***	0.224
Missing teeth N>5	0.054	(0.073)	0.022	0.847	(0.059)***	0.289
Missing replaced <=5	0.270	(0.056)***	0.106	-0.182	(0.051)***	-0.072
Missing replaced >5	-0.570	(0.049)***	-0.222	-0.246	(0.049)***	-0.097
Low income	0.105	(0.052)**	0.042	-0.092	(0.052)*	-0.036
Middle income	0.214	(0.058)***	0.085	-0.264	(0.053)***	-0.104
High income	0.419	(0.072)***	0.165	-0.508	(0.056)***	-0.200
Missing income	0.176	(0.069)**	0.070	-0.245	(0.068)***	-0.097
High school	0.214	(0.045)***	0.085	-0.072	(0.046)	-0.028
More than high school	0.424	(0.051)***	0.168	-0.244	(0.044)***	-0.095
Age 21-29	-0.064	(0.092)	-0.025	0.407	(0.065)***	0.153
Age 30-39	0.057	(0.089)	0.023	0.433	(0.062)***	0.162
Age 40-49	0.130	(0.084)	0.052	0.311	(0.059)***	0.118
Age 50-59	0.125	(0.083)	0.050	0.352	(0.058)***	0.133
Age 60-69	0.138	(0.062)**	0.055	0.181	(0.054)***	0.070
Male	-0.050	(0.039)	-0.020	0.328	(0.031)***	0.128
Married	0.048	(0.033)	0.019	--	--	
Black	-0.043	(0.050)	-0.017	0.377	(0.044)***	0.142
Mexican	0.093	(0.046)**	0.037	0.315	(0.044)***	0.120
Hispanic	0.139	(0.072)*	0.055	0.210	(0.073)***	0.080
Other race	0.066	(0.099)	0.026	0.207	(0.096)**	0.079
Exclude conditions	-0.165	(0.042)***	-0.066	-0.191	(0.041)***	-0.075
Fair or poor overall health	-0.115	(0.043)***	-0.046	0.169	(0.042)***	0.066
Insurance not known	-0.105	(0.096)	-0.042	--	--	--
White collar						
Health Professional	0.110	(0.149)	0.044	--	--	--
Other professional	0.033	(0.067)	0.013	--	--	--
Sales occupation	-0.038	(0.067)	-0.015	--	--	--
Technicians and assistants	-0.001	(0.080)	-0.000	--	--	--
Blue collar						
Farm and agricultural	-0.103	(0.116)	-0.041	--	--	--
Transportation	-0.087	(0.100)	-0.035	--	--	--
Other blue collar	-0.169	(0.063)***	-0.067	--	--	--
Unemployed	0.141	(0.109)	0.056	--	--	--
Homemaker	-0.017	(0.069)	-0.007	--	--	--
Student	0.387	(0.171)**	0.150	--	--	--
Retired	0.015	(0.071)	0.006	--	--	--
Not working for health reasons	-0.108	(0.075)	-0.043	--	--	--
Not working for other reasons	-0.027	(0.109)	-0.011	--	--	--
Fear Factor	**-1.346**	**(0.126)*** **	**-0.496**	--	--	--
Smoking	--	--	--	**0.297**	**(0.039)*** **	**0.113**
Regularly Active	--	--	--	**-0.158**	**(0.032)*** **	**-0.062**
_cons	-0.010	(0.128)	--	-0.251	(0.075)***	--
Rho= 0.562 (0.083)						
Wald test of rho=0: chi2(1) = 21.536 Prob > chi2 = 0.000						

Observations (N): 7690 p<0.10, ** p<0.05, *** p<0.01

Table 1.5 Ordered probit results for routine dental visit frequency among those with positive routine visits

	2 or more times per year (N=2264)		Once a year (N=1246)		Less than once a year (N=390)	
	Mar.eff../Std.err.		Mar.eff./Std.err.		Mar.eff./Std.err.	
Fear Factor	-0.112	(0.016)***	0.066	(0.009)***	0.047	(0.007)***
Dental insurance	0.040	(0.018)**	-0.024	(0.011)**	-0.016	(0.008)**
Private health insurance	0.040	(0.022)*	-0.023	(0.013)*	-0.017	(0.010)*
Medicare	-0.030	(0.033)	0.018	(0.019)	0.012	(0.014)
Medicaid	0.037	(0.042)	-0.023	(0.026)	-0.014	(0.015)
Missing teeth N<=5	0.012	(0.018)	-0.007	(0.011)	-0.005	(0.007)
Missing teeth N>5	-0.062	(0.033)*	0.035	(0.017)**	0.027	(0.016)*
Missing replaced <=5	0.001	(0.023)	-0.001	(0.014)	-0.000	(0.009)
Missing replaced >5	-0.071	(0.027)***	0.040	(0.014)***	0.031	(0.013)**
Low income	-0.009	(0.032)	0.005	(0.019)	0.003	(0.013)
Middle income	0.025	(0.032)	-0.015	(0.019)	-0.010	(0.012)
High income	0.088	(0.033)***	-0.053	(0.020)***	-0.035	(0.013)***
Missing income	0.020	(0.039)	-0.012	(0.024)	-0.008	(0.015)
High school	0.019	(0.025)	-0.011	(0.015)	-0.007	(0.010)
More than high school	0.042	(0.024)*	-0.025	(0.014)*	-0.017	(0.010)*
Age 21-29	-0.177	(0.047)***	0.090	(0.020)***	0.087	(0.028)***
Age 30-39	-0.150	(0.045)***	0.080	(0.021)***	0.070	(0.024)***
Age 40-49	-0.096	(0.044)**	0.053	(0.023)**	0.043	(0.022)**
Age 50-59	-0.071	(0.043)	0.040	(0.023)*	0.031	(0.020)
Age 60-69	-0.031	(0.034)	0.018	(0.019)	0.013	(0.014)
Male	-0.049	(0.017)***	0.029	(0.010)***	0.020	(0.007)***
Married	0.017	(0.017)	-0.010	(0.010)	-0.007	(0.007)
Black	-0.059	(0.024)**	0.034	(0.013)***	0.025	(0.011)**
Mexican	-0.052	(0.023)**	0.030	(0.013)**	0.022	(0.010)**
Hispanic	-0.099	(0.037)***	0.053	(0.018)***	0.046	(0.019)**
Other race	-0.048	(0.046)	0.027	(0.025)	0.021	(0.021)
Current smoker	-0.018	(0.022)	0.010	(0.013)	0.007	(0.009)
Exclude conditions	0.019	(0.021)	-0.012	(0.013)	-0.008	(0.008)
Fair or poor overall health	-0.022	(0.024)	0.013	(0.014)	0.009	(0.010)
Insurance not known	-0.127	(0.058)**	0.065	(0.025)***	0.062	(0.034)*
White collar						
Health professional	-0.051	(0.058)	0.029	(0.031)	0.022	(0.027)
Other professional	0.024	(0.032)	-0.014	(0.019)	-0.009	(0.012)
Sales occupation	0.007	(0.034)	-0.004	(0.020)	-0.003	(0.013)
Technician/ Assistant	0.024	(0.040)	-0.015	(0.025)	-0.009	(0.015)
Blue collar						
Farm and agricultural	-0.003	(0.068)	0.002	(0.040)	0.001	(0.028)
Transportation	-0.050	(0.055)	0.028	(0.029)	0.022	(0.026)
Other blue collar	0.003	(0.035)	-0.002	(0.021)	-0.001	(0.014)
Unemployed	-0.068	(0.058)	0.038	(0.030)	0.030	(0.028)
Homemaker	-0.013	(0.037)	0.008	(0.022)	0.006	(0.016)
Student	0.039	(0.075)	-0.024	(0.048)	-0.015	(0.027)
Retired	0.050	(0.038)	-0.031	(0.024)	-0.019	(0.014)
Not working for health reasons	-0.015	(0.045)	0.009	(0.026)	0.006	(0.019)
Not working for other reasons	0.054	(0.058)	-0.034	(0.038)	-0.020	(0.020)

Observations (N): 3900 p<0.10, ** p<0.05, *** p<0.01

Notes: the routine dental visit frequencies from high to low are: twice or more per year (coded as 0), once per year (coded as 1) and less than 0

Table 1.6 Results for routine dental visit frequency among those with positive routine visits (twice or more per year is regarded as frequent visit)

	Probit Model		**Bivariate Probit Model**			
			Frequent Visit		**Fear Factor**	
	Mar. Eff	Std. Err.	Mar. Eff	Std. Err.	Mar. Eff	Std. Err.
Dental insurance	0.047	(0.019)**	0.044	(0.047)**	--	--
Private Insurance	0.048	(0.024)**	0.042	(0.058)*	--	--
Medicare	-0.030	(0.034)	-0.028	(0.081)	--	--
Medicaid	0.018	(0.047)	0.019	(0.114)	--	--
Missing teeth N<=5	0.004	(0.019)	0.056	(0.073)**	0.190	(0.049)***
Missing teeth N>5	-0.079	(0.036)**	0.003	(0.127)	0.265	(0.093)***
Missing replaced <=5	-0.012	(0.024)	-0.013	(0.061)	-0.015	(0.062)
Missing replaced >5	-0.093	(0.029)***	-0.057	(0.083)*	0.097	(0.073)***
Low income	-0.017	(0.036)	-0.030	(0.091)	-0.055	(0.094)
Middle income	0.041	(0.035)	0.010	(0.095)	-0.113	(0.089)***
High income	0.098	(0.036)***	0.042	(0.112)	-0.180	(0.090)***
Missing income	0.024	(0.042)	-0.005	(0.112)	-0.109	(0.111)***
High school	0.020	(0.027)	0.013	(0.069)	-0.012	(0.072)
More than high school	0.065	(0.026)**	0.034	(0.074)	-0.083	(0.066)***
Age 21-29	-0.230	(0.044)***	-0.176	(0.133)***	0.094	(0.093)**
Age 30-39	-0.211	(0.043)***	-0.153	(0.130)***	0.116	(0.087)***
Age 40-49	-0.139	(0.042)***	-0.093	(0.118)**	0.085	(0.083)***
Age 50-59	-0.122	(0.042)***	-0.074	(0.118)	0.110	(0.082)***
Age 60-69	-0.062	(0.034)*	-0.034	(0.091)	0.066	(0.078)**
Male	-0.027	(0.017)	0.009	(0.057)	0.129	(0.043)***
Married	0.005	(0.018)	0.004	(0.044)	--	--
Black	-0.069	(0.026)***	-0.025	(0.081)	0.147	(0.065)***
Mexican	-0.069	(0.025)***	-0.036	(0.072)	0.107	(0.062)***
Hispanic	-0.167	(0.041)***	-0.132	(0.113)***	0.088	(0.105)**
Other race	-0.101	(0.050)**	-0.079	(0.125)	0.064	(0.129)
Exclude conditions	--	--	--	--	-0.097	(0.058)***
Fair or poor overall health	--	--	--	--	0.059	(0.062)**
Insurance not known	-0.142	(0.066)**	-0.115	(0.168)*	--	--
Fear Factor	**-0.124**	**(0.017)*** **	**-0.397**	**(0.293)*** **	--	--
Smoking	--	--	--	--	0.102	(0.062)***
_cons				(0.163)***	--	(0.122)***
			Rho= 0.464 (0.192)			
			Likelihood-ratio test of rho=0: chi2(1) = 4.19648			
			Prob > chi2 = 0.0405			

Observations : N=3900 p<0.10, ** p<0.05, *** p<0.01

Chapter 2

The Effects of Socioeconomic Status and Routine Dental Care on Dental health

2.1 Literature Review

Dental health is an integral part of overall health status. Dental health disparities persist within the population (Surgeon General's report on oral health, 2000). For instance, the proportion of untreated decayed teeth is higher among the poor. Much of these disparities may be explained by differential utilization by socioeconomic status. One common dental disease, dental caries, is proved to be associated with socioeconomic and behavioral factors (Berset et al., 1996; Chen and Hunter, 1996; Cohen and Bryant, 1984; Grytten et al., 1996; Peterson, 2005; Thomson et al., 2004). Moreover, dental

caries are significantly affected by health behaviors and dental care utilization. Most studies examine the determinants of dental caries are social and epidemiologic. For the few economic studies, dental care utilization, especially preventive dental care utilization is not accounted for. The effects of dental health stock and individual characteristics are not fully examined even if dental care use is included as one of the independent variables.

One recent study by Nguyen et al (2008) examine both the direct and indirect effects of lifestyle, health behavior, and socioeconomic status on dental caries, taking into account of dental care use. They find that health behaviors such as smoking increases the probability of having caries, and dental care utilization, regular dental visits and teeth-brushing reduce caries. They use the longitudinal study of the Northen Finland 1966 Birth Cohort with respondents of young adults. The longitudinal data provides socioeconomic status and health behaviors variables at the birth and youth time, but dental health outcomes and dental care utilization variables are not available at the longitudinal basis. The endogeneity of routine dental visits are not accounted for, and there is no dental insurance variable. In addition, the dental caries variable in the data is self-reported, which could be biased due to knowledge, past experiences, and observation.

In this paper, we examine the effects of routine dental care use on the probability of having dental caries, while accounting for the endogeneity of routine visits. We quantify the impact of routine care on dental health outcomes measured by dental caries. This dental health condition is reported by the dentist, and every respondent remained in our sample received the oral examination in the survey.

Previous studies have documented evidence of racial and ethnic differences in untreated dental caries in the United States (Kaste et al., 1996; Winn et al., 1996; Vargas

et al. 1998;). US Surgeon General's report on oral health also reports that adult non-Hispanic blacks and Mexican Americans have higher proportions of untreated decayed teeth than their non-Hispanic white counterparts, regardless of poverty status. The report points out the needs for actions to reduce the differences. Most studies focus on identifying disease patterns by race and ethnic groups, while only a few explore the pathways through which the disparities can be narrowed. Reid et al. (2004) examine the impact of material and behavioral factors on racial and ethnic disparities in untreated dental caries. They conclude that material factors such as income, education, dental insurance status, etc. contribute more to the disparities. Therefore improving material factors will be more effective in racial disparity reduction compared to addressing behavioral factors such as smoking, marital status, and obesity. No previous study employs the decomposition technique to identify what portion of the racial differences are resulted from observed factors, and what portion of the differences can be attributed to unobserved factors or heterogeneity across racial and ethnic groups.

This study aims to gauge the magnitude of the separate effects of racial differences in observed characteristics such as income, education, occupation, and health behaviors, taking into account of dental care use. We examine which factors contribute more to racial disparities so as to design policies to reduce the barriers and thus the disparities.

2.2 Theoretical Framework

Based on Grossman's (1972) theory, dental health depreciates over time. Individuals maximize their utility by preventing the depletion of their dental health using preventive dental services. The consumption of preventive dental care is to maintain and enhance good dental health and avoid future costs of curative care. Individual's utility depends on dental health and other commodities. The individual uses his own time and market goods and services to produce dental health to maximize utility. Dental health depreciates over time and making investments can increase the stock of dental health. The individual chooses dental and general health behaviors which could affect his or her dental health. Preventive and curative dental care could fix and prevent dental problems. Therefore they can reduce current disutility, and also increase future utility by adding to the dental health stock.

Grossman's (1972) model has been criticized for the unrealistic assumption that individuals choose health investments exogenously, and that levels of health stock are a choice. They assume that the exogenous health investments influence health with certainty. Zweifel and Breyer (1997) suggest that individuals make choices that influence transition probabilities between the healthy and sick states. Thus health is not a choice with certainty. Health inputs are state-dependent, which means health status is not only the consequence of the health production process but also acts as a stochastic input factor.

Compared to general health, the production of dental health possesses less uncertainty. In particular, preventive dental care has been proven to be very effective in terms of preventing the development of dental diseases, enabling early detections and

saving future curative costs. So the evidence base in this market may be sufficient to apply the Grossman framework under the assumption of certain gains to investments in preventive care. We build on the framework suggested by Sintonen and Maljanen (1995) for modeling the demand for dental care. For this analysis we do not model the supply side of the market.

Routine dental care use reduces the probability of developing caries and helps the early detection of caries. Curative care could reduce caries, but people whose last visit were curative care might be those who use routine care less often, and are more prone to have caries due to health behaviors, dental health stock, and past utilization patterns. Health behaviors such as smoking and drinking may increase caries risks.

2.3 Empirical Models

2.3.1 Regression Model

We employ a recursive bivariate probit model to capture two sequential events: dental health and routine dental care use. We allow for the impact of routine care use on dental health, but we do not account for the effect of dental health on dental care utilization.

Let y_1 be a binary endogenous dummy variable (y_1 =1 if use routine dental care, 0 otherwise). The dental health equation is given by:

$$h_1^* = \beta' X_1 + \gamma y_1 + e \qquad (7)$$

where h_1^* >0 (h_1 =1) and h_1^* <0 (h_1 =0) indicate that the respondent has dental caries or

otherwise, respectively. X_1 is a vector of exogenous variables that affect dental health.

The routine dental care utilization equation is given by:

$$y_1^* = \alpha' X_2 + \varepsilon \tag{8}$$

where y_1^*>0 (y_1=1) and y_1^*<0 (y_1=0) indicate that the respondent has routine visit or not, respectively. X_2 is a vector of exogenous variables including socioeconomic variables, insurance status, and dental health stock.

We estimate equations (1) and (2) jointly by the recursive bivariate probit model, where $(e, \varepsilon_4) \sim N(0, \Omega)$. Ω denotes the correlation between the error terms of the two equations (Greene, 2003; Maddala, 1983). Unobserved factors contained in the random error terms, such as individuals' past dental experiences, dental behavior, valuation and past conditions of dental health, as well as supply side characteristics, could affect dental health and routine care use simultaneously. This two-equation equation specification for two dichotomous variables can be consistently estimated by Full-Information Maximum Likelihood (FIML) methods.

2.3.2 Decomposition Method

To disentangle the sources of observed racial differences in dental health, the typical approach is to use the Blinder-Oaxaca technique, first developed by Oaxaca (1973) and Blinder (1973). However, this method is not directly applicable to our nonlinear model. We follow the method suggested by Fairlie (2005) to decompose the racial disparities applied to equation (1).

First, we compute the total difference in dental health between a white and nonwhite respondent. Then we examine what portion of this difference is explained by observed socioeconomic variables once the nonwhite respondent is "given" the white characteristics. Let $\bar{H}^j$ denote the average probability of the binary dental health status for race j. Let F denote the cumulative normal distribution function for the probit. Thus, for a nonlinear equation $Y = F(X\hat{\beta})$, The decomposition may be written as:

$$\bar{H}^W - \bar{H}^B = [\sum_{i=1}^{N^W} \frac{F(X_i^w \hat{\beta}^W)}{N^W} - \sum_{i=1}^{N^B} \frac{F(X_i^B \hat{\beta}^W)}{N^B}] + [\sum_{i=1}^{N^B} \frac{F(X_i^B \hat{\beta}^W)}{N^B} - \sum_{i=1}^{N^B} \frac{F(XB_i^w \hat{\beta}^B)}{N^B}] \quad (9)$$

where N_j is the sample size for race j.

The first term in brackets represents the portion of racial differences that is due to observed population characteristics, and the second term is the portion due to differences in parameter estimates (unmeasurable or unobserved endowments) in different racial groups. As most previous studies, this "unexplained" portion of the racial differences is not our focus since it has been difficult to interpret the results (Jones 1983, Cain 1986, and Oaxaca and Ransom 1997)

2.4 Data

Our data are from the National Health and Nutrition Examination Survey (NHANES) which not only collects extensive information on demographics, socioeconomic factors and insurance, but rich health status data. The survey is unique in that it combines face to face interviews with physical examinations. The health

examination is conducted in a Mobile Exam Center (MEC) for almost all participants. The current sample is comprised of two release cycles: 1999-2000, (interview sample size 9,965 and MEC examined sample size of 9,282) and 2001-2002 (interview sample size 11,029 and MEC examined sample size of 10,477). This dataset is suitable for our purpose because it contains both the self-reported conditions of dental health, dental care utilization patterns, and the objective measures of dental health status. We exclude from the sample any persons younger than 21 since those under 21 have different oral conditions and needs compared to adults, and may be tied to parent choices. Further, we exclude those who did not participate in the oral health examinations in the study.

The dependent variable in the dental health equation, dental caries, measures the presence of untreated caries when the oral health examination was performed. The variable is constructed from dentist's diagnosed untreated caries/restorative needs (yes/no). The dependent variable in the routine care utilization equation measures whether the respondent had routine checkups/cleanings or not. This is constructed from the survey question "During the past 3 years, have you been to the dentist for routine check-ups or cleanings?" This is followed by another question, "During the past 3 years, how often have you gone to the dentist for routine check-ups or cleanings?" The potential responses are: 2 or more times a year, once a year, less than once a year, (whenever needed) no regular schedule[17]. In our analysis, we create a dichotomous indicator equal to

[17] The respondents were first asked for the main reason of the last dental visit. They could choose one of the following: 1= Went in on own for check-up, examination, or cleaning; 2= Was called in by the dentist for check-up, examination, or cleaning; 3= Something was wrong, bothering or hurting; 4= Went for treatment of a condition that dentist discovered; at earlier checkup or examination; 5= Other. Those people who chose 1 or 2 will be asked how often they have routine checkup or cleaning directly. Those people who chose 3, 4 or 5 will be probed to ask 1) whether they have routine checkup or not, if yes, 2) how often? Therefore, if they went last time for a problem, and they got a checkup, most likely they would not respond as having a routine checkup. So the two are not lumped together.

1 if the respondent uses routine care with a regular schedule. Respondents who had no routine care visit, or who visited on an irregular basis, are regarded as non-users since respondents who had no regular schedule could be those who went for a checkup only when problems occurred. They are less homogeneous in their utilization.

Curative dental care is a dichotomous variable measured by having the last visit as treatment care during the past 3 years: either "Something was wrong, bothering or hurting" or "Went for treatment of a condition that dentist discovered at earlier checkup or examination".

To test our hypotheses on the importance of health insurance (price) to promote health through utilization, we use a dichotomous indicator where dental insurance is set to 1 if the respondent reports having dental coverage[18]. We also use an indicator to represent those who do not know if they have coverage.

We also are able to control for socioeconomic factors (income, education, occupation). The poverty income ratio (PIR) variable is used to measure family income levels. PIR takes into account the family size as well as the family's total income. PIR values below 1.00 are below the official poverty threshold and are coded as families with poor income. Occupations are grouped into three categories: white collar, service collar and blue collar. Among white collar and blue collar occupations, subgroups are divided according to the work characteristics to capture variations in time costs and time preferences. People who are currently not working are characterized by their current status: unemployed, homemaker, student, retired, not working because of health reasons

[18] Unfortunately we do not have information about specific coverage for preventive care. Most private plans, even the least comprehensive, provide preventive care coverage given expected savings from preventing acute care. For Medicaid, only a few states have limited coverage of preventive care.

(including disabled) and not working because of other reasons. Demographic characteristics like race and marital status are also controlled for. People are divided into six age groups since age influences demand for preventive care according to the literature. The general health conditions are included as well. An indicator is created for respondents who were excluded from the periodontal and root decay assessment because of confounding medical conditions. Indicators of current smoking and drinking status are included as a control for risk aversion through risky behaviors in general as well as a risky factor for dental health in particular.

Dental health stock is measured by the number of missing teeth due to dental diseases. We include two dummy variables: with five or fewer teeth missing, and with more than five teeth missing. We use missing teeth as the health stock variable, because they are not simultaneously determined by routine utilization in the current period, and are therefore exogenous.

2.5 Results

Table 2.1 shows characteristics of the full sample, and of the insured and the uninsured groups, separately. Roughly half (54%) of the respondents are covered by dental insurance. People who are uninsured are more likely to have dental caries and missing teeth, and they have fewer routine visits and more curative care visits. They are relatively older, with poorer general health, and are more likely to be current smokers. Compared with the insured, the uninsured is a group of lower socioeconomic status in terms of income, education, and occupation.

Racial differences among white, African-American, and Hispanic in the observed factors are shown in table 2.2. Compared with other racial and ethnic groups, whites have a higher probability of having routine visits and they have a lower probability of having curative care visits. They have better dental health status, better dental health stock in terms of missing teeth, and better overall health. A higher percentage of whites have higher levels of income and education.

We care about lack of insurance as a barrier to entry and thus may lead to poorer dental health outcomes. Table 2.3.a presents descriptive statistics by dental insurance coverage, utilization of routine care, and presence of dental caries. 71% of those who have caries had no routine visit, while only 35% of those who do not have caries had no routine visit. Among the insured, the percentage of those had routine visit and without caries is higher (75%). In contrast, a higher percentage of the uninsured had no routine visit and ended up with dental caries (78%). Table 2.3.b shows descriptive statistics by utilization of routine care, presence of dental caries and race. 68% of whites had routine visit and no caries, and this percentage is much higher than the African-Americans and Hispanics.

Table 2.4 presents results from the univariate probit model. Routine visit decreases the propensity to have dental caries by 15%. The effects of other important factors contributing to the probability of having caries are as expected. People with poorer accumulated dental health stock and more curative visit are more likely to have caries. Being male and current smoker also increases the probability of having caries. African-Americans and Hispanics are more likely to have caries, while being older, white collar, and with higher levels of income and education reduce the probability of caries.

Table 2.5 reports the recursive bivariate probit results. Since unobserved factors contained in the random error terms, such as individuals' past dental experiences, dental behavior, valuation and past conditions of dental health, as well as supply side characteristics, could affect dental health and routine care use simultaneously, estimates of the effect of routine care use could be biased in the simple probit model. Utilization is clearly tied to health, and poor health outcomes might increase utilization. While routine visits should reduce caries, those who have caries may have developed a greater propensity to use, which offsets the negative effect of routine care. By controlling for propensity to use preventive care independent of health, we expect a larger effect of routine visits. After controlling for this simultaneity, the marginal effect of routine care goes up significantly by 11%. Therefore having a routine visit could lower the probability of the occurrence of caries by 26%. Being male, African-American, and Hispanic are significantly associated with having caries. Those who have more missing teeth are more likely to have caries. The effects of socioeconomic factors such as income and education on dental caries work through routine care utilization, while working professionals within white collar are less likely to have caries.

Table 2.6.a reports estimates of the nonlinear decomposition technique for the white/African-American differences in the probability of having dental caries. The individual contributions from racial differences in dental care, age, gender, income, education, dental health stock, health behavior, general health status, and occupation are reported. The difference between white and African-American dental caries probability is -0.2226. The observed population characteristics could explain half of the total differences. The largest factor explaining this racial disparity in the occurrence of dental

caries is routine visit. Lower levels of routine visit among African-Americans account for -0.0339 (15.23%) of the white/African-American differences in the probability of having dental caries. The higher prevalence of missing teeth among African-Americans accounts for -0.0339 (15.23%) of the racial differences. Younger age and lower income of African-Americans also explain a large portion of the differences (8.72% and 5.10%, respectively).

Table 2.6.b shows the decomposition results for white/Hispanic differences. The largest factor explaining this racial disparity in the occurrence of dental caries is still routine visit. Fewer routine visits among Hispanics account for -0.303 (19.14%) of the white/Hispanic differences in the probability of having dental caries. Younger age of Hispanics explains 15.98% of the differences. Lower levels of income and education also significantly contribute to the racial differences (9.27% and 8.15%, respectively). The decompositions suggest that differences in all of the included observed characteristics explain 70.6% of the white/Hispanic differences in the probability of dental caries occurrence.

2.6 Conclusions

This study examines the determinants of dental health measured by dental caries by accounting for the endogeneity of routine dental care use. Having routine care visit significantly decreases the probability of dental caries. Therefore, preventive dental care is effective in promoting dental health. We find no significant direct association of income and education with dental caries. These socioeconomic factors seem to play an

important role in reducing dental caries via its indirect effect through dental care use. Policy alternatives aimed at reducing disparities in dental caries would be effective if they remove the barriers to preventive dental care utilization.

As for the racial disparities in dental health, we find that observed characteristics explain a large component of disparities. To reduce racial differences in dental caries among whites, African-Americans, and Hispanics, policies should facilitate the use of routine care. Lower levels of income among African-Americans and Hispanics also contribute to the racial differences. Education is also an important factor accounting for differences in the probability of having caries among whites and Hispanics. This suggests that policies aimed at increasing Hispanics' general education seem to be able to reduce white/Hispanic disparities in caries. Alternatively, since knowledge and attitudes of dental health and dental care are associated with education, interventions that could change knowledge and attitudes can also reduce racial disparities.

Table 2.1 Summary Statistics: by insurance status

Variables	Full Sample (N=7690)		Insured (N=3830)		Uninsured (N=3651)	
	Mean	Std.	Mean	Std	Mean	Std.
Dental Caries	0.22	0.01	0.17	0.01	0.27	0.01
Routine Visit	0.57	0.02	0.69	0.01	0.44	0.02
Age	46.82	0.37	44.89	0.39	49.01	0.58
Male	0.48	0.01	0.47	0.01	0.48	0.01
Poor income	0.13	0.01	0.09	0.01	0.17	0.02
Low income	0.19	0.01	0.12	0.01	0.27	0.01
Mid income	0.27	0.01	0.28	0.01	0.26	0.01
High income	0.35	0.02	0.45	0.02	0.22	0.02
Miss income	0.07	0.01	0.06	0.01	0.08	0.01
Edu: <high school	0.21	0.01	0.15	0.01	0.27	0.01
Edu: high school	0.25	0.01	0.23	0.01	0.28	0.01
Edu: >high school	0.54	0.02	0.62	0.02	0.45	0.02
Married	0.61	0.01	0.67	0.01	0.54	0.02
Whites	0.73	0.02	0.74	0.02	0.72	0.02
African-American	0.10	0.01	0.11	0.01	0.08	0.01
Hispanics	0.13	0.02	0.11	0.02	0.16	0.03
Other race	0.04	0.00	0.04	0.01	0.04	0.01
Dental insurance	0.54	0.01	1.00	0.00	0.00	0.00
Private insurance	0.69	0.01	0.89	0.01	0.45	0.02
Medicare	0.17	0.01	0.10	0.01	0.26	0.01
Medicaid	0.05	0.00	0.07	0.01	0.03	0.01
Ins_not know	0.02	0.00	0.00	0.00	0.00	0.00
Current Smoker	0.24	0.01	0.20	0.01	0.28	0.01
Drinking	0.29	0.02	0.30	0.02	0.28	0.02
Exclude cond.	0.18	0.01	0.16	0.01	0.20	0.01
Poor/fair health	0.17	0.01	0.13	0.01	0.20	0.01
Curative care	0.28	0.01	0.27	0.01	0.31	0.01
Missing teeth N<=5	0.31	0.01	0.29	0.01	0.34	0.01
Missing teeth N>5	0.09	0.01	0.07	0.01	0.11	0.01
Health professional	0.02	0.00	0.03	0.01	0.01	0.00
Other professional	0.18	0.01	0.24	0.01	0.11	0.01
Sales occupation	0.12	0.01	0.15	0.01	0.08	0.01
Technicians and assistan	0.06	0.00	0.06	0.01	0.07	0.01
Service collar	0.09	0.00	0.08	0.01	0.10	0.01
Farm and agricultural	0.02	0.00	0.01	0.00	0.03	0.00
Transportation	0.03	0.00	0.03	0.00	0.02	0.00
Other blue collar	0.14	0.01	0.13	0.01	0.14	0.01
Unemployed	0.02	0.00	0.01	0.00	0.03	0.00
Homemaker	0.08	0.01	0.07	0.01	0.09	0.01
Student	0.01	0.00	0.01	0.00	0.01	0.00
Retired	0.16	0.01	0.09	0.01	0.23	0.01
Not work health reason	0.07	0.01	0.06	0.01	0.07	0.01
Not work other reason	0.02	0.00	0.01	0.00	0.03	0.00

Table 2.2 Summary Statistics: by race

Variables	White (N=3954) Mean	African American Mean (N=1427)	Hispanic (N=2115) Mean
Dental Caries	0.17	0.41	0.33
Routine Visit	0.62	0.40	0.44
Age	48.26	44.25	41.34
Male	0.49	0.45	0.47
Poor income	0.09	0.23	0.25
Low income	0.17	0.23	0.29
Mid income	0.28	0.26	0.24
High income	0.41	0.19	0.14
Miss income	0.06	0.09	0.08
Edu: <high school	0.14	0.35	0.44
Edu: high school	0.27	0.23	0.20
Edu: >high school	0.59	0.42	0.36
Married	0.65	0.36	0.57
Dental insurance	0.54	0.60	0.44
Private insurance	0.74	0.59	0.49
Medicare	0.19	0.14	0.08
Medicaid	0.04	0.09	0.10
Ins_not know	0.02	0.02	0.02
Current Smoker	0.23	0.27	0.23
Drinking	0.32	0.22	0.24
Exclude cond.	0.20	0.17	0.11
Poor/fair health	0.14	0.24	0.25
Curative care	0.27	0.34	0.32
Missing teeth N<=5	0.29	0.41	0.40
Missing teeth N>5	0.08	0.17	0.08
Health professional	0.02	0.01	0.01
Other professional	0.21	0.12	0.09
Sales occupation	0.12	0.11	0.12
Technicians and assistants	0.07	0.05	0.05
Service collar	0.07	0.16	0.14
Farm and agricultural	0.01	0.01	0.03
Transportation	0.03	0.04	0.04
Other blue collar	0.13	0.13	0.19
Unemployed	0.02	0.04	0.03
Homemaker	0.07	0.06	0.12
Student	0.01	0.01	0.02
Retired	0.18	0.11	0.06
Not work health reason	0.06	0.12	0.07
Not work other reason	0.02	0.03	0.03

Table 2.3.a Dental caries and routine visits: frequency distributions by insurance status

	Full Sample (N=7690)		**Insured (N=3830)**		**Uninsured (N=3651)**	
	No Caries (%)	**Caries (%)**	**No Caries (%)**	**Caries (%)**	**No Caries (%)**	**Caries (%)**
No Routine	35.11	71.22	25.32	61.20	47.89	78.27
Routine	64.89	28.78	74.68	38.80	52.11	21.73

Table 2.3.b Dental caries and routine visits: frequency distributions by race

	Whites (N=3954)		**African-Americans (N=1427)**		**Hispanics (N=2115)**	
	No Caries (%)	**Caries (%)**	**No Caries (%)**	**Caries (%)**	**No Caries (%)**	**Caries (%)**
No Routine	31.53	70.99	49.34	74.34	49.54	70.64
Routine	68.47	29.01	50.66	25.66	50.46	29.36

Table 2.4 The probability of having dental caries (univariate probit results)

	Probit Model		
	Coef.	**Std.err.**	**Marginal**
Curative visit	0.229	(0.037)***	0.068
Routine visit	-0.529	(0.038)***	-0.151
Missing teeth N<=5	0.701	(0.039)***	0.216
Missing teeth N>5	0.954	(0.056)***	0.334
Low income	-0.099	(0.052)*	-0.027
Middle income	-0.11	(0.056)**	-0.031
High income	-0.264	(0.064)***	-0.071
Missing income	-0.138	(0.072)*	-0.037
High school	-0.021	-0.048	-0.006
More than high school	-0.152	(0.048)***	-0.043
Age 21-29	0.849	(0.085)***	0.287
Age 30-39	0.644	(0.084)***	0.211
Age 40-49	0.453	(0.083)***	0.144
Age 50-59	0.368	(0.083)***	0.116
Age 60-69	0.142	(0.069)**	0.042
Male	0.187	(0.040)***	0.054
Married	-0.058	-0.038	-0.016
Black	0.372	(0.047)***	0.115
Hispanic	0.184	(0.045)***	0.054
Other race	0.074	-0.11	0.022
Current smoker	0.119	(0.043)***	0.035
Drinking	0.012	-0.043	0.003
Exclude conditions	0.014	-0.047	0.004
Fair or poor overall health	0.071	-0.044	0.02
White collar			
Health professional	-0.222	-0.195	-0.057
Other professional	-0.291	(0.082)***	-0.076
Sales occupation	-0.025	-0.078	-0.007
Technicians and Assistants	-0.097	-0.094	-0.027
Blue collar			
Farm and agricultural	0.118	-0.122	0.035
Transportation	0.013	-0.114	0.004
Other blue collar	0.072	-0.07	0.021
Unemployed	-0.157	-0.121	-0.042
Homemaker	0.12	-0.077	0.035
Student	-0.189	-0.209	-0.05
Retired	-0.051	-0.084	-0.014
Not working for health reasons	-0.087	-0.08	-0.024
Not working for other reasons	0.038	-0.119	0.011
_cons	-1.34	(0.107)***	

Observations (N): 7690 p<0.10, ** p<0.05, *** p<0.01

Table 2.5 Estimation results from the recursive probit models for dental caries and routine visits

	Bivariate Probit Model					
	Dental Caries			Routine Visit		
	Coef.	Std.err.	Marginal	Coef.	Std.err.	Marginal
Curative visit	0.224	(0.036)***	0.067	--	--	--
Routine visit	-0.92	(0.155)***	-0.263	--	--	--
Dental insurance	--	--	--	0.288	(0.037)***	0.115
Private insurance	--	--	--	0.366	(0.042)***	0.145
Medicare	--	--	--	0.127	(0.062)**	0.051
Medicaid	--	--	--	0.007	-0.07	0.003
Missing teeth N<=5	0.71	(0.039)***	0.221	0.165	(0.035)***	0.066
Missing teeth N>5	0.912	(0.060)***	0.319	-0.185	(0.055)***	-0.074
Low income	-0.073	-0.053	-0.021	0.15	(0.054)***	0.060
Middle income	-0.035	-0.063	-0.010	0.363	(0.056)***	0.143
High income	-0.131	-0.083	-0.037	0.733	(0.061)***	0.281
Missing income	-0.084	-0.074	-0.023	0.325	(0.069)***	0.127
High school	0.022	-0.051	0.006	0.267	(0.045)***	0.106
More than high school	-0.055	-0.062	-0.016	0.631	(0.044)***	0.247
Age 21-29	0.827	(0.085)***	0.280	-0.026	-0.086	-0.011
Age 30-39	0.636	(0.084)***	0.209	0.062	-0.084	0.025
Age 40-49	0.466	(0.082)***	0.149	0.169	(0.083)**	0.067
Age 50-59	0.373	(0.082)***	0.119	0.076	-0.084	0.03
Age 60-69	0.15	(0.068)**	0.045	0.093	-0.064	0.037
Male	0.156	(0.042)***	0.045	-0.204	(0.035)***	-0.081
Married	-0.039	-0.038	-0.011	0.082	(0.035)**	0.033
Black	0.335	(0.050)***	0.104	-0.279	(0.046)***	-0.111
Hispanic	0.178	(0.045)***	0.053	0.016	-0.042	0.007
Other race	0.063	-0.11	0.019	-0.055	-0.101	-0.022
Current smoker	0.113	(0.042)***	0.033			
Drinking	0.011	-0.043	0.003			
Exclude conditions	0.002	-0.047	0.001	-0.092	(0.042)**	-0.037
Fair or poor gen. healt	0.038	-0.046	0.011	-0.244	(0.042)***	-0.097
Insurance not know	--	--	--	-0.141	-0.102	-0.056
White collar						
Health professional	-0.187	-0.193	-0.05	0.195	-0.159	0.077
Other professional	-0.26	(0.082)***	-0.069	0.132	(0.071)*	0.053
Sales occupation	-0.012	-0.078	-0.003	-0.018	-0.072	-0.007
Technicians and Ass	-0.094	-0.093	-0.026	0.001	-0.086	0
Blue collar						
Farm and agricultura	0.097	-0.122	0.029	-0.094	-0.124	-0.038
Transportation	0.009	-0.113	0.003	-0.075	-0.108	-0.03
Other blue collar	0.047	-0.07	0.014	-0.213	(0.068)***	-0.085
Unemployed	-0.146	-0.12	-0.04	0.175	-0.116	0.069
Homemaker	0.112	-0.077	0.033	0.003	-0.074	0.001
Student	-0.126	-0.209	-0.035	0.426	(0.184)**	0.164
Retired	-0.036	-0.083	-0.01	0.066	-0.077	0.026
Not work for health reasc	-0.095	-0.08	-0.026	-0.082	-0.08	-0.033
Not work for other reasor	0.03	-0.118	0.009	-0.016	-0.117	-0.006
_cons	-1.223	(0.119)***		-0.994	(0.108)***	

Observations: N=7690 * p<0.10, ** p<0.05, *** p<0.01
Rho=0.245 (0.096)
Likelihood-ratio test of rho=0: chi2(1) = 5.899 Prob > chi2 = 0.015

Table 2.6.a Decomposition of White/African-American differences in dental caries

	Coef.	Std. Err.
White: dental caries rate	0.1698	--
African-American: dental caries rate	0.3924	--
White/ African-American differences	**-0.2226**	--
Contributions from racial differences in:		
Routine visit	-0.0339	0.0031
Curative care	-0.0045	0.0010
Age	-0.0194	0.0042
Male	0.0007	0.0002
Income	-0.0113	0.0031
Education	-0.0054	0.0027
Missing teeth	-0.0327	0.0024
Current smoker	-0.0013	0.0006
Drinking	0.0004	0.0005
Exclude conditions	0.0007	0.0010
Fair/poor general health	-0.0019	0.0016
Occupation	-0.0024	0.0035
All included variables	**-0.1104**	--
% total explained	**49.6%**	--

Table 2.6.b Decomposition of White /Hispanics differences in dental caries

	Coef.	Std. Err.
White: dental caries rate	0.1698	--
Hispanic: dental caries rate	0.3281	--
White/ Hispanic differences	**-0.1583**	--
Contributions from racial differences in:		
Routine visit	-0.0303	0.0027
Curative care	-0.0039	0.0008
Age	-0.0253	0.0041
Male	0.0007	0.0002
Income	-0.0147	0.0038
Education	-0.0129	0.0053
Missing teeth	-0.0092	0.0013
Current smoker	0.0020	0.0007
Drinking	-0.0007	0.0009
Exclude conditions	-0.0001	0.0017
Fair/poor general health	-0.0029	0.0025
Occupation	-0.0141	0.0044
All included variables	-0.1117	--
% total explained	**70.6%**	--

Appendix

Factor Analysis Results

Table A1. Factor Loadings from Factor Analysis

	Factor 1	Factor 2	Factor 3
Overestimated	0.27	0.93	-0.26
Underestimated	0.05	0.05	1.00
Accurate Poor	0.70	-0.68	-0.21
Accurate Good	-0.95	-0.24	-0.18

Factor 1 captures propensity to be in poor health since both Over-estimators and Accurate poor types are told they need care by a dentist. This factor may also capture another feature common to these two types of participants – in a random subsample these two types were the most likely to report a fear of going that keeps them from using the dentist. While not significant, there is some component in those who underestimate that has a positive commonality with factor 1 that may capture the propensity to not go as well since those who don't go are more likely to be inaccurate in their assessments. So factor 1 captures a combination of preferences for dental care, or low propensity to use, and poor health. Both of which would drive the propensity to insure. Factor 2 may

capture the propensity to use independent of health. It is mainly the component of the propensity to overestimate that is not tied to health (see correlations with health in Appendix A2 below). Those who overestimate may feel overly confident given their greater propensity to be insured. Factor 3 is uniquely the underestimators who tend to be an older cohort effect.

Table A2 Correlations Between Factors and Health, Investments in Health, And propensity to Be Insured

	Factor 1	Factor 2	Factor 3
Health Indicators			
Decay	0.50	-0.10	-0.21
Oral Pain	0.19	-0.10	-0.01
Missing Teeth	0.23	-0.13	0.01
Demographic			
Elderly	0.03	-0.03	0.04
Retired	-0.12	0.02	0.06
Investments in Health			
Exercise	-0.11	0.03	-0.02
Health Insurance			
Private Insurance	-0.22	0.08	-0.02
Medicare	-0.08	-0.01	0.07

The Preference Variable Fear Factor

Table A3 (Using NHANES 03-04) Comparison among overestimators, underestimators, and consistent estimators with respect to "past year need dental care but couldn't get it".

Question: "During the past 12 months was there a time when you needed dental care but could not get it at that time?" which is followed by "What were the reasons that you could not get the dental care needed?"

	N	OE N=1065	UE N=382	Accurate (good) N=1001	Accurate (poor) N=1694
Unfulfilled need	**N=930**	16.02%	6.99%	6.13%	70.86%
Could not afford cost	N=680	13.09%	6.76%	4.26%	75.88%
Not want to spend the money	N=90	18.89%	2.22%	6.67%	72.22%
Insurance not cover procedures	N=174	18.39%	9.77%	6.90%	64.94%
Office not convenient	N=85	17.65%	11.76%	7.06%	63.53%
Fear	N=73	16.44%	4.11%	2.74%	76.71%
Too busy	N=113	22.12%	8.85%	9.73%	59.29%
Problem will go away	N=35	17.14%	2.86%	5.71%	74.29%
Other reason	N=93	19.35%	9.68%	8.60%	62.37%

Observations: N=4142

	N	OE N=1065	UE N=382	Accurate (good) N=1001	Accurate (poor) N=1694
Unfulfilled need	**N=930**	**13.99%**	**17.02%**	**5.69%**	**38.90%**
Could not afford cost	N=680	8.36%	12.04%	2.90%	30.46%
Not want to spend the money	N=90	1.60%	0.52%	0.60%	3.84%
Insurance not cover procedures	N=174	3.00%	4.45%	1.20%	6.67%
Office not convenient	N=85	1.41%	2.62%	0.60%	3.19%
Fear	N=73	1.13%	0.79%	0.20%	3.31%
Too busy	N=113	2.35%	2.62%	1.10%	3.96%
Problem will go away	N=35	0.56%	0.26%	0.20%	1.53%
Other reason	N=93	1.69%	2.36%	0.80%	3.42%

Observations: N=4142

Occupation Categories

Occupations are grouped into three major categories: white-collar, blue-collar and service collar. Each category is subdivided into several groups according to the job characteristics.

White collar:

1. Health professionals: health diagnosing, assessing and treating occupations

2. Other professionals: Engineers, architects and scientists; teachers; Writers, artists, entertainers, and athletes; Other professional specialty occupations; Executive, administrators, and managers; Management related occupations.

3. Supervisors and proprietors, sales occupations; Sales representatives, finance, business, & commodities ex. Retail; Sales workers, retail and personal services

4. Technicians and related support occupations: Secretaries, stenographers, and typists; Information clerks; Records processing occupations; Material recording, scheduling, and distributing clerks; Miscellaneous administrative support occupations

Blue collar

1. Farm operators, managers, and supervisors; Farm and nursery workers; Related agricultural, forestry, and fishing occupations

2. Transportation: Motor vehicle operators; Other transportation and material moving occupations

3. Other blue collars: Textile, apparel, and furnishings machine operators; Machine operators, assorted materials; Fabricators, assemblers, inspectors, and samplers;

Construction laborers; Laborers, except construction; Freight, stock, and material movers, hand; Other helpers, equipment cleaners, hand packagers and laborers

Vehicle and mobile equipment mechanics and repairers; Other mechanics and repairers, Construction trades; Extractive and precision production occupations

Service collar:

Private household occupation;

Protective service occupations;

Waiters and waitresses; Cooks; Miscellaneous food preparation and service occupations; Health service occupations; Cleaning and building service occupations; Personal service occupations.

The Medical Exclusion Conditions

Variable: Exclusion

Respondents with the following medical conditions was excluded from the periodontal and root caries assessment: must always take antibiotics (e.g. penicillin) before dental check up or care; heart problems (specifically, congenital heart murmurs, heart valve problems, congenital heart disease, or bacterial endocarditis); rheumatic fever; kidney disease requiring renal dialysis; hemophilia; pacemaker or automatic defibrillator or artificial material in the heart veins or arteries.

NHANES Guidelines for Dental Referral

Level 1 Emergency dental condition: In the opinion of the examiner, a dental or oral condition exists which may require immediate services for the relief of symptoms and stabilization of the condition. Such conditions include but are not limited to: severe tooth pain, hemorrhage of the oral tissues, acute infectious processes of the oral cavity, traumatic injury to the teeth and surrounding tissues, unusual swelling of the face, gums, or other oral tissue, or oral conditions that obstruct the airway.

Level 2 Urgent dental condition: In the opinion of the examiner, a dental or oral lesion or condition exists for which the SP should seek medical/dental services within a few week period for diagnosis, relief of symptoms and/or stabilization of the condition, counseling

about the condition or other appropriate followup. Such conditions may include but are not limited to: tooth fracture, oral lesion or condition visible to the examiner or SP, lost restoration, chronic pain, or other condition that is unlikely to resolve without professional intervention.

Level 3 Earliest convenience: In the opinion of the examiner, a need for oral hygiene services or nonemergency conditions exist which should be addressed prior to the next scheduled visit. Such nonemergency conditions may include incipient/early caries lesions or mild gingivitis.

Level 4 Continue regular care: Applies when none of the above conditions exist.

Appendix Tables for Dental Health

Table B1 Descriptive statistics by dental insurance and routine visit for dental health

		Insured		Not insured	
	Total (N=7771) %	Had routine care (N=2404) %	No routine care (N=1441) %	Had routine care (N=1445) %	No routine care (N=2269) %
Filled and missing teeth					
Filled teeth N<=5	31.37	35.47	24.40	40.56	24.11
Filled teeth N>5	4.29	5.78	1.52	7.61	1.79
Root restoration	5.91	6.38	4.52	8.94	3.90
Missing teeth N<=5	31.33	28.28	31.08	36.51	32.78
Missing teeth N>5	8.83	4.20	12.54	6.43	14.67
Missing replaced <=5	10.87	13.87	4.69	17.21	6.30
Missing replaced >5	16.91	7.46	23.86	12.70	27.84
Miss for other reason	9.31	12.72	8.31	9.16	5.45
Replaced (other reason)	4.22	4.66	3.81	6.22	2.38
Edentulous	7.76	0.81	14.35	1.66	16.63
Current condtions					
Painful teeth	22.52	21.40	26.65	18.66	25.54
Decay	21.86	9.80	33.46	13.51	38.17
Gum	26.57	17.61	36.07	19.27	38.40
Hygiene	35.10	23.25	45.32	28.44	50.55
Soft tissue	0.35	0.21	0.22	0.38	0.64
Other fiding	3.41	2.43	3.91	2.98	4.92
Limit food	5.15	3.14	6.81	2.81	8.56
Dentist's recommend					
Urgent	4.80	0.98	6.20	1.75	11.70
Needcare	47.24	36.51	61.23	41.07	58.39
Normalcare	47.96	62.50	32.57	57.18	29.91

Notes: The number of teeth surface restorations is grouped into 2 categories: 1-5 restorations, and more than 5 restorations. Number of missing teeth due to dental disease, due to other reasons, and being replaced are grouped in the same way. Current dental conditions includes if they have dental pain, limited food due to dental problems, and diagnosed conditions such as decayed teeth, periodontal disease, gingival needs, soft tissue condition and other findings.

Table B2 Descriptive statistics by dental insurance and checkup frequency for dental health

	Total	Insured			Not insured		
	N=3913 %	>=2 (N=1463) %	=1 (N=719) %	<1 (N=222) %	>=2 (N=781) %	=1 (N=507) %	<1 (N=157) %
Filled & Missing							
Filled <=5	37.02	37.88	31.72	30.22	44.11	35.75	36.65
Filled>5	6.32	6.37	5.21	3.39	9.10	6.80	2.40
Root restoration	7.23	7.33	5.30	3.02	9.90	8.85	4..28
Missteeth<=5	31.01	27.56	28.63	32.35	37.44	37.24	29.59
Missteeth>5	4.91	3.45	6.03	3.74	5.33	6.97	10.45
Missrep<=5	14.95	14.63	14.37	6.77	20.49	13.38	11.84
Missrep>5	9.21	6.25	9.47	9.77	12.13	13.78	12.45
Missother	11.51	13.54	10.60	13.59	11.01	6.57	7.33
Otherrep	5.20	4.71	4.48	4.85	7.40	5.21	3.18
Edentulous	1.09	0.16	1.69	2.70	0.87	2.11	4.32
Dental Condition							
Painful teeth	20.04	19.72	23.38	27.10	15.31	23.16	22.43
Decay	11.00	6.94	13.52	18.41	8.77	17.90	24.75
Gum	18.28	13.99	21.45	31.35	19.00	18.98	21.52
Hygiene	25.11	18.07	30.13	38.35	21.09	35.32	45.68
Soft tissue	0.26	0.25	0.00	0.58	0.25	0.00	2.08
Other fiding	2.58	1.89	2.20	7.08	1.71	3.86	6.87
Limit food	3.03	2.10	4.86	5.02	2.41	3.54	2.68
Dentist Rec							
Urgent	1.33	0.58	1.62	1.86	1.07	2.04	4.36
Needcare	38.10	30.02	44.41	57.84	34.37	48.54	53.27
Normalcare	60.56	69.40	53.97	40.31	64.56	49.43	42.36

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