EVIDENCE REPORT

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Converge3

Integrating health, economic and equity evidence to inform policy

Evaluating the Cost Effectiveness of Dental Care Insurance for Low-Income Seniors and Social Assistance Recipients in Ontario: An Application of Microsimulation Modelling

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About this Report

Converge3 commissioned the Canadian Centre for Health Economics to conduct an economic evaluation of different models of dental care services for (1) seniors and (2) individuals on social assistance in Ontario. Converge3 receives funding from the Province of Ontario. The views expressed in this report are those of the authors and do not necessarily reflect those of Converge3 or the Province of Ontario.

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About Converge3

Converge3 is a policy research centre based in the Institute of Health Policy, Management and Evaluation at the University of Toronto that focuses on integrating health, economic and equity evidence to inform policy. The Centre is funded by the Province of Ontario and includes multiple partner organizations, including Li Ka Shing Knowledge Institute at St. Michael's Hospital, McMaster University, Ottawa Hospital Research Institute, ICES, Health Quality Ontario, Public Health Ontario, and the Ontario Ministry of Health.

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Executive Summary

Introduction

Expenses for dental care services are insured inconsistently across jurisdictions. In Ontario, the Ontario Health Insurance Plan (OHIP) insures some dental-surgical services performed in a hospital but not services provided in dental offices. Outside of OHIP, some Ontarians are eligible for some services through publicly funded dental programs, including people receiving social assistance.

A review of the literature suggests that there is evidence of an association between oral health and overall health. The degree to which the relationship is causal, however, has been a subject of debate. Thus, providing dental insurance to some or all of the population in Ontario may improve dental and, perhaps, overall health outcomes. A future dental insurance program will have to address questions of what services to cover and for what populations. From a policy perspective, analyzing the cost effectiveness of various dental insurance program options can inform decision making.

The purpose of this project was to develop a microsimulation model to evaluate the cost effectiveness of providing dental care insurance for various dental services and sub-populations in Ontario. This report aimed to answer two main policy questions:

1. What models of dental care services for seniors in Ontario will improve dental health and access to dental care while being cost effective?

2. What models of dental care services for individuals on social assistance in Ontario will improve dental health and access to dental care while being cost effective?

Approach

We performed a cost-utility analysis using a microsimulation model developed in R to estimate lifetime healthcare costs, quality-adjusted life years (QALYs), and incremental cost-effectiveness ratios of a variety of government-sponsored dental insurance schemes for two hypothetical cohorts: 1) seniors aged 65 and over; and 2) individuals on social assistance aged 18 years and over. All hypothetical scenarios are compared to the status quo in Ontario. We used a health care system (payer) perspective. We analyzed secondary data to estimate the effects of receiving dental care on heart disease, diabetes, and stroke outcomes. We developed a microsimulation model that extrapolated these effects to Ontarians and explores the effects of insurance, including variations in breadth (universal versus targeted populations), depth (how much is covered), and scope (dental services covered).

Results

The secondary data analysis suggested large protective effects of dental care for heart disease, diabetes, and stroke, with a particularly large effect for stroke (odds ratio = 0.717). At a willingness-to-pay threshold of $50,000 per QALY gained, coverage of a basic set of dental care services for seniors was cost effective if oral health was assumed to have a positive relationship with overall health but not otherwise. However, we did not investigate the possibility of copayments or reduced dental fees which may have had an impact on the cost effectiveness (with or without links between oral health and overall health). It would also be useful in future research to evaluate the cost effectiveness of dental coverage much earlier in life.

Coverage of basic dental services for Ontarians receiving social assistance was not cost effective under any of our assumptions. However, social assistance – and therefore, access to insured dental care services – is short-term and periodic for most participants., which may significantly limit the ability of dental care to have long-run effects. Similar to the model for seniors, we did not investigate the effects of copayments on cost or access.

A summary of the key analyses and results are shown below:

	Oral Health ICER	**Overall Health ICER**
Low income seniors population		
Basic	$141,987	$32,801
Comprehensive		$53,532
Major/elite		$87,143
Social Assistance population		
Basic		$172,407
Comprehensive		$385,580
Major/elite		$533,396

ICER=incremental cost effectiveness ratio

Discussion and conclusions

This report presented two key findings. The analysis showed a relationship between oral health and overall health, which will contribute to the growing body of literature examining the importance of dental care to public health. We found that those who visited the dentist were less likely to have diabetes, heart disease and stroke.

The economic evaluation showed that provision of dental insurance to targeted populations is unlikely to be cost effective, depending on the expected health gains resulting from dental care. There are other considerations in addition to cost effectiveness that may affect organization and provision of dental care in Ontario.

Contents

1. Introduction

Expenses for dental care services are covered inconsistently across public health care systems, with some jurisdictions offering some coverage and others offering none[1]. In the Province of Ontario, the Ontario Health Insurance Plan (OHIP) insures dental-surgical services that are medically necessary, performed in a hospital by a dentist or dental specialist, and listed under the Schedule of Benefits-Dental Services[2]. Dental services provided in dental offices are not insured under OHIP[2]. Outside of OHIP, Ontario offers some publicly funded dental programs[2]; this includes coverage for individuals on social assistance[3].

In 2015, a report prepared by Ottawa Public Health found that an increasing number of uninsured and under-insured patients were utilizing hospital emergency rooms for dental treatment[4]. One source estimated that preventable dental issues such as gum disease, infections and chronic pain lead to more than 60,000 emergency visits per year in Ontario, and that a significant portion of these visits were from seniors[5]. In addition to the treatment of these oral health conditions, there has been some evidence in the clinical literature regarding the possible link between oral health and other health outcomes such as cardiovascular disease and diabetes[6].

The Ontario government recently announced that it will be provide publicly funded dental care for low-income seniors[5]. To qualify, an individual needs to be over the age of 65 and have an income under $19,300 per annum for single individuals or $32,300 for couples. At the time of writing, the list of dental services to be provided to these seniors was not available. Moreover, there has been no mention as to whether these services may be extended to all seniors (i.e. universal coverage for everyone 65+) or if there may be partial funding with co-payments paid by patients associated with some services.

The introduction of dental insurance to some or all of the population in Ontario may serve to improve dental and potentially overall health outcomes. More specifically, the availability of dental insurance affects the probability of an individual visiting the dentist, which can prevent the development of poor oral health conditions. In addition, if the relationship between oral health and overall health is causal, then the introduction of dental insurance would also affect the likelihood of developing a range of diseases. The introduction of dental insurance, however, is not trivial, as it raises the questions of what services to cover and for what populations. From a policy point of view, knowing the cost-effectiveness of various dental insurance programs is important to ensure efficient use of government resources.

The purpose of this project is to develop a microsimulation model to evaluate the cost-effectiveness of policies relating to dental care insurance for various dental services and sub-populations in Ontario. This report aims to answer two main policy questions:

1. What models of dental care services for seniors in Ontario will improve dental health and access to dental care while being cost-effective?

2. What models of dental care services for individuals on social assistance in Ontario will improve dental health and access to dental care while being cost-effective?

For the first research question, we will investigate the cost-effectiveness of the proposed public dental care insurance for low income seniors (65 and over). For the second research question, we will investigate the cost-effectiveness of providing dental insurance to individuals on the Ontario Works (OW) and Ontario Disability Support Program (ODSP) programs for individuals 18 and over. These social assistance programs will be discussed in further detail throughout the report.

2. Literature Review on Dental Care and Health

Most studies to date have focused on the relationship between poor oral health, which is typically exemplified by periodontitis, and general health outcomes. For example, the relationship between periodontal disease and coronary heart disease (CHD) has been investigated extensively in the literature[7]. The results of these studies generally show that periodontal disease is associated with CHD. In 2012, the American Heart Association performed a review of the literature to date, and concluded that the evidence at the time supported an associative, but not a causal, relationship between periodontitis and atherosclerotic vascular disease[8]. In that review, the authors note that much of the evidence at the time came from observational studies, and that residual confounding could have biased the results. The American Dental Association agreed with the conclusions of this review[8]. Cullinian & Seymour[9] also acknowledge a lack of evidence in this area, but note that this lack of evidence does not necessarily imply that periodontitis is not a risk factor for cardiovascular disease. They go on to say that the evidence to support a causal relationship would likely require a long-term intervention study, which would be difficult to implement and may never be done.

Another health outcome is diabetes, although the nature of the underlying relationship between periodontitis and diabetes has not been resolved in the literature. Some sources suggest that periodontitis is both a risk factor and an outcome in relation to diabetes (i.e. a bidirectional relationship)[10]. Given the uncertainty, however, we do not assert that one direction is more likely to occur than another.

For the purposes of this report, it is important to note that we do not model the relationship between periodontitis and diabetes per se. Rather, we model the impact of the extension of publicly funded dental coverage on dental health and overall health as represented by three common chronic conditions (discussed more below). As it happens, the literature relating to the link between dental care and overall health is significantly smaller than that relating periodontitis to general health. Brown et al.[11] investigated the effect of dental care on cardiovascular disease outcomes using a cohort of married, middle-aged individuals in the United States. The outcome was an indicator for whether the individual experienced any of a heart attack, angina, congestive heart failure, death from heart attack, or stroke. The study found that dental care was associated with a reduction in CVD events of at least one third for females, but there was no statistically significant effect for males. This study, perhaps because it was published in the health economics literature, was not included in the American Heart Association literature review, and used an instrumental variables (IV) approach to address the issue of potential omitted variable bias (i.e. residual confounding). Sen et al.[12] also used cohort data from the Atherosclerosis Risk in Communities (ARIC) study, and found that regular dental care utilization was associated with a lower stroke risk (hazard ratio (HR) = 0.77) controlling for other risk factors (race, age, sex, body mass index, hypertension, diabetes, smoking, education, etc.). Sen et al.[12] did not test for the potential endogeneity of dental care in their study, which could have had implications for their results.

Although these studies make valuable contributions, they each suffer from potential limitations that are important to note. First, Brown et al.[11] used an aggregation of many cardiovascular outcomes, and so it is unclear if regular dental care has differential effects for the outcomes investigated and the analysis focused on married individuals only. Finally, to date, no study has investigated the potential relationship between dental visits and diabetes.

To summarize, a review of the literature to date suggests that there is evidence of an association between oral health and overall health. The degree to which the relationship is causal, however, has been a subject of debate, although studies such as Brown et al.[11] have attempted to address the limitations of the earlier literature. Given the limitations of the current literature, we estimate two versions of the model: one with and one without links between oral health and overall health. For the former model, we estimate transitional probabilities using econometric methods that are suited to dealing with issues of endogeneity using longitudinal data that is as representative of the general population as possible. While there may well be a link between oral health and other diseases, in this study, we focus on heart disease, diabetes and stroke which together constitute a significant burden of disease in the population and in which the links to oral health have been given attention in the extant literature.

3. Approach

We perform a cost-utility analysis using a microsimulation model to estimate lifetime healthcare costs, quality-adjusted life years (QALYs), and the Incremental Cost-Effectiveness Ratio (ICER) for hypothetical cohorts under a variety of dental insurance schemes. All hypothetical scenarios are compared to the status quo in Ontario, which is intended to capture the current distribution of dental insurance for either: 1) seniors aged 65 and over or 2) individuals on social assistance aged 18 years and over. For the purposes of this report, we take a health care system (payer) perspective.

We used R software to develop our microsimulation model, and acknowledge the use of the suggested code from Jalal et al.[13] and Krijkamp et al.[14]

4 Model Framework

4.1 Oral Health Model

The identification of health states for the model is complicated by the fact that there exists some doubt about the extent of a causal relationship between oral health and overall health in the literature. Given this uncertainty, we first start with a basic model that only contains oral health as a health state (ignoring death for the moment). This model is depicted in Figure 1 (please note all tables and figure are provided in an appendix).

Our definitions of "Good Oral Health", "Fair Oral Health", and "Poor Oral Health" can be found in Section 6 of this report. There are several things to note about the assumptions implied by Figure 1. First, as noted above, we make no assumptions about there being a causal relationship between oral health and overall health. We do assume, however, that health care utilization and health utility are affected by oral health, which together have an effect on QALYs and costs. This assumption is based on the conclusions of the Ottawa Public Health report described in the Introduction section of this report, and the effects are formally quantified in Section 6. Second, and related to the first point, we make no assumptions about the relationship between oral health and mortality. Finally, we allow individuals to freely transition between oral health states. By doing so, we allow individuals to recover from poor oral health, which can occur through many mechanisms including, but not limited to, dental treatment (either through a dentist at a dental office or in the emergency room at a hospital). These oral health transitional probabilities are quantified in Section 6 of this report.

4.2 Overall Health Model

In addition to oral health, our model also contains overall health states that have been linked to oral health issues in the literature. These health states are shown in Figure 2.

In this model, we allow individuals to transition from the diabetic state to heart disease given that diabetes is a risk factor for cardiovascular problems. We also allow for transitions from the diabetic and heart disease states to the stroke state given that diabetes and cardiovascular problems are risk factors for the development of a stroke (first event). It is important to note that "Heart disease" includes a very heterogeneous mix of heart related problems. In terms of the probability of developing "Heart Disease", we utilize a measure that captures coronary heart disease, angina, congestive heart failure, or other heart problems (see Section 5 for more details). For the measurement of health utilities and health care utilization, we utilize a broader question derived from the Canadian Community Health Survey (CCH) that asks whether the respondent has heart disease (see Section 6). For individuals who transitioned from one disease to another (i.e. from diabetes to stroke), these individuals are placed in the latter state, but the utilities and costs capture the "memory" of the individual's transition (i.e. individuals with stroke and diabetes would have a lower utility and incur higher health care costs than individuals with stroke alone).

We first assume that overall health is independent of oral health (Model 1). As a result, in the cost-effectiveness analysis, overall health does not differ between treatment and control, and the differences between costs and QALYs is attributable to changes in oral health alone through the availability of dental insurance. We then extend the model to allow for the possibility of dental care affecting other aspects of health (Model 2). Due to data limitations, we do not quantify the link between oral health and overall health, but rather, the relationship between dental care and overall health. The quantification of these probabilities is described in Section 5 of the report. The transitional probabilities from the healthy state to diabetic, heart disease, and stroke states in this model are affected by the use of dental care. Moreover, transitional probabilities amongst the poorer health states themselves (i.e. heart disease, diabetes, and stroke) are also affected by the use of dental care.

5. Dental Care and Overall Health

Given the debate in the literature as to the extent of a causal relation between oral health and overall health, we estimate these probabilities using longitudinal data and econometric methods that can account for endogeneity.

Endogeneity is defined as correlation of the explanatory variables and the error term[15]. The concept of "endogeneity" is therefore quite broad in the sense that it can arise from many different circumstances, including (but not limited to):

1. Omitted variable bias: The bias in an estimator that arises because a variable that is determinant of Y and is correlated with an included regressor has been omitted from the regression[15].

2. Simultaneous causality bias: When, in addition to the causal link of interest from X to Y, there is a causal link from Y to X[15].

When estimating the effect of oral health on overall health, endogeneity due to omitted variables (i.e. residual confounding) is the main source of endogeneity with which we are concerned. Endogeneity due to simultaneity may have been an issue for diabetes, but is less of a concern since we are investigating the effect of dental care on the probability of developing diabetes rather than oral health specifically. Regardless, the method of Instrumental Variables (IV) can be used to solve endogeneity due to omitted variable bias as well as simultaneous causality bias[16], which is what we utilize below.

The econometric approach is similar to that taken in Brown et al.[11] and adds additional waves of the data set used in Brown et al. that have since become available (described in more detail below). Our analysis differs in that we include unmarried and single individuals as well as those who are married. Moreover, we disaggregate heart disease and stroke which Brown et al. had combined, since there is the possibility for a differential effect of dental visits on these outcomes. We also add diabetes as an additional outcome variable.

5.1 Data

In order to quantify the effect of dental visits on health outcomes, we utilize data from the Health and Retirement Study (HRS, 2018), which is a longitudinal, nationally representative survey of men and women in the U.S. over 50 years old. The HRS is sponsored by the National Institute of Aging and is conducted by the Institute of Social Research at the University of Michigan. Initiated in 1992, HRS is a population-based survey designed to study the health and well-being of community-dwelling adults over 50 years old in the contiguous United States. The original HRS sample consisted of individuals born between 1931 and 1941, and came from a screening of housing units that were generated using a multi-stage, clustered area probability frame[17]. Of those identified this way, interviews were obtained from 12,652 respondents (out of 15,497 eligible), resulting in a response rate of 81.6%[17]. The HRS also includes the spouses or partners of respondents, who may be under the age of 50. The overall response rate was 81.4%. We use 8 waves of the HRS (waves 5 - 12) which corresponds to the period 2000-2014. Each wave occurs every two years. Response rates for follow-up waves for the entire sample was consistently high and over 80% for the years 2000 - 2014[18].

For the purpose of informing health policy decisions in Canadian contexts, it may have been preferable to use Canadian data for this analysis. Unfortunately, longitudinal survey data on dental visits and health outcomes that would allow for investigation of causal relations is limited in Canada. For example, some waves of the Canadian Community Health Survey contain detailed data on dental visits, but it is cross-sectional[19] and does not consistently include questions for each province about dental visits in each wave. The National Population Health Survey (NPHS) is longitudinal, but only contains information on dental visits in one of the survey cycles[20]. This said, since the focus of the analysis is on estimating the impact of dental care on the specified health outcomes and since Canadian dental care services are expected to be sufficiently comparable and to be at least on par with those provided in the U.S., we expect the estimated effects to be applicable to the Ontario population with similar socio-demographic characteristics.

One obvious difference between the US and Canadian populations may be the extent of publicly funded health care and dental care. It is important to note, however, that the models we estimate are based on the Grossman[21] model of health capital in the economics literature. In this model, insurance does not enter into health production directly. Instead, the effect of insurance on health is through health promoting activities such as dental visits. As a result, the health production function of individuals in Canada and the U.S. would both have similar inputs, and would both exclude insurance since its effect is through health promoting activities (i.e. dental care). The theoretical exclusion of insurance from the health production function is what allows us to use it as an instrument, which is described in more detail below. Brown et al.[11] also utilize a Grossman type framework for the relationship between dental visits and cardiovascular disease outcomes; more details can be found in that paper. Another point related to the above is that health care utilization is not a function of insurance alone. It is also a function of the health habits of the individual, marital status, socioeconomic status, etc. Thus, despite the differences in publicly funded insurance across the US and Canadian populations, we would expect similar patterns in the development of diseases such as heart disease, diabetes, and stroke across the life span. Moreover, the US Medicare system, which provides health insurance to individuals over the age of 65, does not include dental services[22], and so we do not expect to observe an increase in the probability of dental care utilization at this age. Nonetheless, to ensure comparability, we compare the predicted probabilities derived from our models with publicly available incidence (where available) of the same diseases in Canada.

As noted above, our study includes three outcome variables. The first is an indicator for whether the respondent was diagnosed with heart disease since the previous wave. Our measure of heart disease comes from a question in the HRS that asks if a doctor told the respondent they had coronary heart disease, angina, congestive heart failure, or other heart problems (ever or since the last wave, depending on whether it was the respondent's first interview). Unfortunately, the last category (other heart problems) cannot be broken up further in the data. The second outcome is an indicator for whether the respondent was diagnosed with diabetes which comes from the HRS question that asks if a doctor told the respondent they had diabetes or high blood sugar (ever or since the last wave). Similar to the heart disease question, we are unable to separate diabetes from high blood sugar from this question, and the definition of "high" would have been based on the doctor's assessment (i.e. it may mean impaired glucose tolerance/prediabetes). Finally, our third outcome is an indicator for whether the respondent experienced a stroke since the previous wave (first event). This does not include transient ischemic attacks, which is reported separately from the stroke variable in the HRS data.

Our main independent variable is a binary indicator for whether the respondent has visited a dentist for dental care including dentures since the previous wave. It is important to note that the wording of this question changed in the later years of the HRS. In waves 1-5 (years 1992 – 2000) the question asked whether the respondent has seen a dentist in the past year. In waves 6 onward (years 2002 – 2014), the question asks whether the respondent has seen a dentist within the past 2 years. To ensure temporal consistency, we only utilize dental utilization data from wave 6 onward, but utilize data from 2000 for the lagged health variables.

For the purposes of this study, we construct three sub-samples. The first consists of individuals who had never developed heart disease up to and including the 5th wave (n = 42,785 person-year observations). The second consists of individuals who had not developed diabetes up to and including the 5th wave (n = 45,218 person-year observations). Finally, the third consists of individuals who had never experienced a stroke up to and including the 5th wave (n = 51,528 person-year observations). We then construct indicators for whether the individuals developed the illness at any time in the later years of the survey, up until wave 12 (2014).

5.2 Methods

In general terms, we aim to estimate the following relationship for each of our three sub-samples:

$$D_{it} = \beta_0 + \beta_1 Dental_{i,t-1} + \beta_2 H_{i,t-1} + \beta_3 X_i + \beta_4 X_{it} + \epsilon_{it} (1)$$

where D is an indicator for whether the individual developed one of the three outcomes described above since the previous wave (i.e. one of heart disease, diabetes, or stroke, depending on the sample). The variable "Dental" is an indicator for whether the individual visited the dentist since the previous wave. The variable H contains health status characteristics in the previous wave, which includes smoking status (current, former, and never), high blood pressure (yes/no), self-assessed health (Excellent, Very Good, Good, Fair, and Poor), and depression (yes/no). The vector X_i contains a vector of time-invariant controls (race (white, black, and other race), education, Hispanic, sex) and the vector X_{it} contains a vector of time-varying controls (age and marital status) that is collected in each wave. These measures are self-reported.

To obtain an unbiased effect of dental visits on the probability of developing a poor health outcome (i.e. β_1) is not trivial given that there are a number of factors that both affect the probability of visiting a dentist and influence the probability of developing a poor health outcome. For example, individuals with poorer health habits are more likely to develop heart disease, diabetes, or to have a stroke, and are less likely to receive preventive dental care[11]. To mitigate these effects, we control for observed health characteristics such as smoking status and depression, which may reflect the health habits of the respondent. Despite this, there may still be unobserved factors related to both dental visits and the probability of developing a poor health outcome which we address by application of the IV approach[23]. This approach involves estimating 2 equations simultaneously-equation 1 (now 3) from above alongside equation (2):

$$Dental_{i,t-1} = \gamma_0 + \gamma_1 Insurance + \gamma_2 H_{i,t-1} + \gamma_3 X_i + \gamma_4 X_{it} + \mu_{it} (2)$$
$$D_{it} = \theta_0 + \theta_1 Dental_{i,t-1} + \theta_2 H_{i,t-1} + \theta_3 X_i + \theta_4 X_{it} + \omega_{it} (3)$$

Since both the outcome and endogenous variable (dental visits) are binary, we perform the IV estimation using a bivariate probit model to estimate equation (3)[23]. This approach is similar to a standard two-stage least squares approach, but is run recursively and can be used for IV analysis by allowing for correlation between the error terms in the two equations. Equation (2) is the treatment equation in that it models dental visits as a function of the instrument (described below) and all exogenous variables in the outcome equation (3). Equation (3) is the same outcome equation as equation (1), but with coefficients that control for the potential endogeneity of dental care.

We use dental insurance as an instrument for dental care, which should not have an effect on health outcomes except through its effect on dental care. This instrument was also proposed, but not used, by Brown et al.[11]. To qualify as an instrument, dental insurance must be correlated with dental care (instrument strength) and be unrelated to the health outcomes in the second stage equation (instrument validity). Instrument strength is testable via the first stage regression. Instrument validity is generally not testable unless there are more instruments than endogenous regressors[24]. Despite this, since the first stage is non-linear, we can perform a test of instrument validity through an auxiliary regression where the instrument is included in the second stage[25]. Statistical significance of the instrument implies that the validity criterion is not satisfied. Statistical insignificance of the instrument would offer support that it is valid, but would not prove it undeniably since the true error can never be observed.

The test for endogeneity is a test for the statistical significance of the correlation parameter of the errors from the two equations[26] (first and second IV stages). If this parameter is not statistically significant, then this suggests that dental visits are exogenous, and can therefore be estimated using a standard logit model (i.e. equation (1) alone).

We utilize clustered standard errors, with clustering at the individual level, to allow for correlation of the errors over time[27].

5.3 Results

5.3.1 Descriptive Statistics

Table 1 presents descriptive statistics from the first sub-sample on individuals developing heart disease, by use of dental care (mean of observations pooled across years). The data suggests that a higher proportion of individuals who did not go to the dentist develop heart disease at some point between waves 6 and 12. These estimates cannot be considered causal, however, as noted above we generally observe that individuals in better health are more likely to go to the dentist than those in poorer health, as measured by high blood pressure, self-rated health, diabetes, and depression.

Table 2 and Table 3 present the descriptive statistics from the second and third sub-samples on individuals developing diabetes and stroke, by use of dental care. The patterns we observe are similar to the heart disease case, as individuals who have not used dental care tend to be in poorer overall health as well.

5.3.2 Logit Regression Results

Table 4 presents the regression results (equation 1) for the heart disease model in the form of odds ratios. We can see from the table that individuals who receive dental care are less likely to develop heart disease by a factor of 13.1%. We also find that current and former smokers, poorer self-rated health status, high blood pressure, and diabetes have a significant impact on the risk of developing heart disease. The results of the model also suggest that blacks are at a lower risk of developing heart disease in reference to whites, which is consistent with the finding in Brown et al. using the same HRS data for married men[11] (N.B.: our analysis includes men and women together). We also observe that age is not significant in the heart disease model, which may be due to the way it is entered (i.e. as a quadratic term, which may result in collinearity issues). Despite this, it is likely that age still has an impact on the probability of developing heart disease since age is considered a risk factor for stroke.

Table 5 presents the regression results for the diabetes model. Similar to the heart disease model, we see that individuals who visited the dentist were 14.2% less likely to develop diabetes.

Table 6 presents the regression results for the stroke model. Similar to heart disease and diabetes, we observe that individuals receiving dental care were 28.3% less likely to have a stroke. We also observe the same effects for poorer health status on the probability of developing the outcome.

Given the potential for heterogeneous effects by sex, we perform auxiliary regressions where the variable 'dental care' is interacted with sex. The interaction term was not significant in any of the models, suggesting that the effect of dental care does not differ statistically by sex (see Table 7). As a result, we pooled the male and female observations and included a dummy variable to control for sex.

5.3.3 IV Results

We present the tests for endogeneity (see Table 8), including the point estimate for rho (i.e. the correlation parameter between the errors of the first and second equations) as well as the p-value for the estimate. We observe from Table 8 that the parameter is insignificant across all of the equations, which suggests that dental care is exogenous.

This result presupposes that our instrument is sufficiently correlated with the endogenous variable (dental visits) and uncorrelated with the error in the second stage equation. To demonstrate this, we present the first stage results for all three sub-sample models (see Table 9 - Table 11). We can see from these Tables that dental insurance is significantly associated with dental visits in all three models, thereby providing evidence for the sufficient strength of our instrument. In terms of instrument validity, we report the p-value on dental visits in the second stage auxiliary regression (Table 12). We observe that dental insurance is not statistically significant in any of the models, which suggests that our instrument is uncorrelated with the second stage equation error term.

5.4 Discussion of HRS Results

As discussed in our review of the literature, there exists some uncertainty with regards to the strength of the relationship between oral health and overall health. As a result of this uncertainty, we estimate regression models that estimate the effect of dental care on the development of heart disease, diabetes, and stroke controlling for observed risk factors. We also utilize longitudinal data as well as econometric methods that address potential endogeneity. The results of the model suggest large protective effects of dental care for heart disease, diabetes, and stroke, with a particularly large effect estimated for stroke (OR = 0.717). The stroke estimate is in line with the estimates from other studies such as Sen et al.'s adjusted HR estimate of 0.77 as well as the one third reduction in CVD events for married women which they estimated using an aggregation of stroke and heart diseases. It should be noted, however, that our model estimates an association between receiving dental care and receiving a diagnosis of a disease. We therefore assume that diagnosis equals onset, which is an important limitation since some diseases may be diagnosed later than the onset date. To ensure that our results are not entirely driven by the parameters we have estimated, we also perform sensitivity analysis using the confidence intervals of these parameters.

6. Model Inputs

6.1 Oral Health

In order to quantify the costs and QALYs associated with oral health, we need a measure that captures a variety of oral health issues (pain, infections, etc.) that is linkable to health care utilization and utility data. One possibility would be to use the loss of attachment (LOA) variable in the Canadian Health Measures Survey (CHMS), which has been considered the gold standard for measurement of periodontal disease[28]. Unfortunately, the CHMS does not contain measures of health care utilization such as hospital visits, and so we would be unable to quantify the effect of poor oral health on health care utilization.

An alternative to the CHMS is the Canadian Community Health Survey (CCHS). The 2013/14 CCHS contains measures of oral health for individuals residing in Ontario, as well as data on health utilization and health utility. Unfortunately, the CCHS does not contain the same LOA measure as the CHMS. This said, for the purposes of this model, an ideal measure of oral health would adequately represent both clinical and self-reported oral health. Both elements are important as they would be expected to have an impact on both costs and QALYs over an individual's lifetime. For example, the medical severity of the condition likely impacts the cost of treatment as well as the utility of the individual (particularly for severe conditions). Likewise, we would also expect an individual's self-perception of their oral health to affect their utilization of health care resources as well as their utility when in poorer oral health states.

For the purposes of this model, we utilize the self-reported oral health measure available in the 2013/14 CCHS. Self-reported oral health measures integrate subjective perceptions and objective observations into a unified summary measure[29]. In the CCHS, the question is worded as "In general, would you say the health of your teeth and mouth is"; respondents can respond with "Excellent", "Very Good", "Good", "Fair", and "Poor". These response options are identical to the 'global oral health rating' described in Thomson et al[29], who showed the validity of the measure for young and middle-aged adults.

For the purposes of the microsimulation model, we combine the "Excellent", "Very Good", & "Good" categories into one category (referred to as "Good Oral Health" hereafter), and keep "Fair Oral Health" and "Poor Oral Health" as distinct categories.

6.2 Utilities

The utilities for the health states in our model are calculated using the 2013/14 CCHS, which contain the Health Utilities Index Mark 3 instrument (HUI3). The HUI3 is one of the indirect methods for utility score assessment recommended by the Canadian Agency for Drugs and Technologies in Health (CADTH)[30], and combines a generic comprehensive health status classification system and a generic health-related quality of life (HRQoL) utility scoring system[31]. Utility scores were derived by Statistics Canada using the answers from individual responses to the HUI3 instrument questions[31].

Using ordinary least squares (OLS), we regress the health utility score on a set of indicators for sex, heart disease, diabetes, stroke, and oral health status. These results are presented in Table 13. We observe from this regression that all else being equal, being male is significantly associated with a higher health utility score. Not surprisingly we find that poor oral health and poor overall health are significantly associated with lower health utility scores. We also observe that fair oral health has about the same disutility as heart disease, and that poor oral health has a worse disutility than stroke. When interpreting the utility scores, it is important to note that the definitions in the CCHS may not perfectly overlap with the definitions in the HRS. For example, the HRS question on heart disease is much more detailed and lists a range of possible heart issues that the respondent may have. The CCHS, on the other hand, simply asks if the respondent has heart disease. Moreover, the stroke question asks if the respondent suffers from the effects of a stroke. This has important implications for the results. For example, the question on oral health is likely more reflective of the respondent's current health state (particularly if the respondent has had diabetes, heart disease, or stroke for years) and so may offer a higher dis-utility as respondents living with the disease for years may have had time to adjust to the poorer health state. Moreover, the estimates average over a range of severity of heart disease and stroke, which may have diluted the result.

Using the regression coefficients, we calculate utility scores for the health states in the model. These scores are presented in Table 14.

6.3 Health Care Costs

Given the reported link between poor oral health and emergency department visits in Ontario[5], our measure of health care costs are hospital costs.

In the 2013/14 CCHS, respondents are asked to provide the number of nights they spent as a patient in a hospital, nursing home, or convalescent home in the past 12 months. Unfortunately, the latter two (nursing home and convalescent home) could not be be separated from hospital days in the data. We estimate the following relationship between hospital days and the health states in our model:

$$hospdays = \beta_0 + \beta_1 good.oral + \beta_2 fair.oral + \beta_3 heart.disease + \beta_4 diabetes + \beta_5 stroke + \beta_6 X$$

Where poor oral health is the reference category, and X is a vector of controls (age, sex, income, and smoking status).

We estimate the above equation using a Poisson model, with standard errors bootstrapped to account for over-dispersion[27]. The results of this estimation are presented in Table 15. We observe from this table that oral health is significantly associated with hospital days, controlling for overall health measures, age, sex, income, etc. The results of this estimation are consistent with the notion that poor oral health leads to excess hospital days in Ontario.

Using the regression coefficients, we estimate predicted hospital days for the health states in our model (i.e by health state, oral health state, age, and sex). In order to translate these predicted hospital days into cost, we need an average of the per diem cost of a hospital visit in Ontario. According to Kralj & Kantarevic.[32], per-diem hospital costs in Ontario vary from about $900 per day in small community hospitals to almost $2,500 per day in specialty hospitals. For the purposes of the model, we use the middle of this range, or $1,700, and explore the lower and upper ranges in the sensitivity analysis.

6.4 Costs of Dental Care

6.4.1 Non-social assistance dental costs

Given the large variation in the scope of dental services covered across countries, we define a number of different dental plans that the Ontario Government may wish to pursue. The services contained within these plans are based on the framework in Farmer et al.[33] All dental cost data for the non-social assistance plans are obtained from The *2019 ODA* [Ontario Dental Association] *Suggested Fee Guide for General Practitioners*[34], and are presented below.

6.4.1.1 Basic/Core/Preventive

According to Farmer et al.[33] dental services included under basic/core/preventive include routine exams, routine x-rays, scaling, fillings, and tooth extractions. A subset of these costs are presented in Table 16 below.

For the purposes of the model, we assume that a routine visit would include an Examination & Diagnosis (recall) (which, according to the Fee Guide, includes the "examination of hard and soft tissues, including checking of occlusion and appliances, but not including specific test/analysis as for Complete Oral Examination"), Scaling (2 units of time or 30 minutes), Polishing (half unit of time), and 4 bite wing radiographs, thereby giving a cost of $219 per dental visit. This assumes that the Ontario government will cover one dental visit per year per individual. We also assume that every individual who visits the dentist incurs the above cost in each period. We believe this is a reasonable assumption as the above services are generally part of a routine dental exam in each year. Additional services such as fillings and tooth extraction would generally occur in addition to the routine yearly dental care if a dental problem is identified. These probabilities (i.e. the number of individuals who will require the service) are quantified in Section 6.5.7.

The cost of a filling can range between $156-$368, which depends on the number of surfaces (1 - 5(max) surfaces), whether or not the tooth is a molar, etc[34]. For the purposes of this report, we use the middle of this range, or $262, and explore the effects of the lower and upper ends in the sensitivity analysis.

The cost of a single tooth extraction is $160 for an uncomplicated case and $247 for a complicated case[34]. For the purposes of the model, we assume that the government will pay for a single tooth extraction in a single year (if one is required). We also use the middle of this range, or $203.50, and explore the effects of the lower and upper ends in the sensitivity analysis.

6.4.1.2 Comprehensive/Core+

According to Farmer et al.[33], Comprehensive/Core+ includes root canals and periodontal treatment. For the purposes of the model, we assume that these services would be covered in addition to the services in the basic/core/preventive scenario.

According to the 2019 ODA fee guide[34], the cost of a root canal procedure for an uncomplicated case (defined as "virtually straight canal penetrated by size #15 file") can range between $511 - $988 depending on the number of canals ($511 for one canal, $988 for four or more canals). This cost can increase further depending on: difficult access, exceptional anatomy, calcified canals, re-treatment, and continuing treatment (as defined in the 2019 ODA guide), to a maximum cost of $1192. For the purposes of this report, we use the middle of the range ($851.50) for the model (with sensitivity analysis for the lower and upper ranges).

Periodontal treatment refers to a wide array of gum treatment services that can be broadly defined as non-surgical and surgical procedures. Within these categories, costs vary depending on the type of oral disease, units of time involved, and type of surgical procedure (gingival curettage, gingivoplasty, gingivectomy, flap approach, etc.). The lowest cost periodontal service is $57 for non-surgical desensitization (one unit of time, or 15 minutes) and the highest cost is for periodontal surgery for grafts, osseous, autograft (including flap entry, closure, and donor site) at $1261. Given the uncertainty, we use the middle of this range ($659) and perform sensitivity analysis for the lower and upper values of the range.

6.4.1.3 Major/Elite

According to Farmer et al.[33], major/elite includes Major Fillings (which includes crowns and bridges) and Dentures. For the purposes of the model, we assume that these services would be covered in addition to the services in the basic/core/preventive and comprehensive/core+ scenarios.

The cost of a crown can range between $211-$802, which depends on the material used (metal, polymer glass, etc.), whether the crown is lab fabricated, whether a metal base is used, etc. For the purposes of the model, we use the middle of this range ($506.50) and explore the effects of the lower and upper ranges in the sensitivity analysis.

The cost of a bridge can range from $77-$489 depending on the amount of dentist time, the material used (cast metal, polymer glass, etc.), whether or not the service is a repair to existing bridge work, etc. Similar to crowns, we use the middle value for the cost of a bridge ($283) and explore the effects of the lower and upper values in the range in the sensitivity analysis.

The cost of denture services can range between $71-$1705 depending on whether the service is for complete or partial dentures, whether the dentures are for the maxillary or mandibular, whether the denture is being repaired, etc. Similar to the above cases, we use the middle of this range, or ($888), and then explore the effects of the lower and upper ranges in the sensitivity analysis.

6.4.2 Social assistance dental costs

The Ministry of Children, Community and Social Services (MCCSS) has its own fee guide for dental services for individuals on social assistance, which includes individuals 18+ on ODSP. A subset of the relevant fees from the MCCSS schedule is presented in Table 17.

To be consistent with the other cost data, we only collect data on general practitioners. The fees presented are all lower than the recommended fees presented earlier. Moreover, the MCCSS fee guide does not include bridges or denture services. For the purposes of the model, we assume that the cost of these services would not be incurred by the government in the control arm.

It is important to note that, at the time of writing, the MCCSS did not cover individuals on OW. Since these costs are incurred by municipalities, we assume that the Ontario Government does not incur any of the dental costs for individuals on OW in the control arm.

6.5 Probabilities

6.5.1 Oral health transitional probabilities

For the purposes of the model, it is important to recognize that oral health is a fluid state where individuals can transition back and forth from good to poor oral health. This process is a function of many factors, which includes, but is not limited to, age, dental care, sex, etc.

For example, a senior in poor health may visit an emergency department for oral care. Once treated, the individual may transition from poor to fair oral health.

The best way to estimate oral health transitional probabilities would be through the use of longitudinal data that contains consistently collected information on the oral health of participants. To the best of our knowledge, no such data set exists in Canada. We were also unable to find a publicly available longitudinal data set from another country that collected this information.

Given the lack of longitudinal data on oral health, we instead utilize a cross-sectional multistate model, following the approach of Van Den Hout[35] using data from the 2013/14 CCHS (waves pooled together), to estimate the transitional probabilities between oral health states. In addition to interval censoring, this approach is also designed for left-censoring, which is an important feature given that we are fitting the model for individuals 18 and over.

Following the notation in Van Den Hout, let t denote age minus 18 years and define oral health states "Good Oral Health", "Fair Oral Health", and "Poor Oral Health" as health states 1, 2, and 3. The hazard models for the transitions between oral health states is defined as:

$$q_{rs}(t) = exp(\beta_{rs} + \xi_{rs}t)$$

for (rs) ∈ {(1,2), (2,1), (2,3), (3,2)}. β_{rs} and ξ_{rs} are parameters to estimate. Estimation of the model parameters is by maximum likelihood.

Conditional on the row vector $p_{t-1} = (p_1(t-1), p_2(t-1), p_3(t-1))$ with observed proportions for the three states at t-1, the distribution of frequencies $Z_t = (Z_1(t), Z_2(t), Z_3(t))$ at t are assumed to be multinomially distributed; or:

$$Z_t | p_{t-1}, P(t-1,t), m_t \sim Multinomial(p_{t-1}P(t-1), m_t)$$

where P(t-1,t) is the 3x3 transition matrix for the 1-year interval (t-1,t) and m_t is the number of multinomial trials. Letting f denote the probability mass function of the multinomial distribution, and assuming independence across the years, the log-likelihood function can be written as:

$$L(\theta|data) = \sum_{t=1}^{T} l\,og(f(z_i | p_{t-1}, m_t, \theta))$$

where θ is a vector of model parameters and t is age (transformed). Following Van Den Hout. (2017), we use the general-purpose optimizer in R to maximize the log-likelihood function over the parameter space.

We fit the model for individuals aged 18-90 years of age. Since the approach requires single age prevalence, which is not available in the Public Use Microdata Files (PUMF), we obtain prevalence data from the master file CCHS. The data and model fit are presented in Figure 3

We can see from this figure that the model does well in capturing the general trends in self-assessed oral health. Despite this, we note that the model generally under predicts the prevalence of poor oral health, which can cause bias against the intervention. It is important to note, however, that the fit is conditional on the prevalence at age 18. For the seniors model, we use the prevalence at age 65 for the starting values for self-assessed oral health.

In addition to the model fit, we also present example transitional probability matrices from the model. For individuals aged 20, the one year transitional probabilities are:

	Good	Fair	Poor
Good	0.9807	0.0191	0.0002
Fair	0.1190	0.8629	0.0181
Poor	0.0076	0.1126	0.8798

And for individuals aged 50, the one year transitional probabilities are:

	Good	Fair	Poor
Good	0.9742	0.0254	0.0004
Fair	0.1498	0.8265	0.0237
Poor	0.0123	0.1396	0.8481

The results of the model suggest that the one year probability of transitioning from Good to Fair oral health is greater than the one year probability of transitioning from good to poor oral health, and that the risk of transitioning to poor oral health increases with age. These results are consistent with our expectations. It is important to note, however, that these probabilities are only a function of age. Our method of combining these probabilities with dental care use are described in Section 6.7.

6.5.2 Social assistance transitional probabilities

As described previously in the Introduction section, for the purposes of this report, there are two main social assistance programs that we are interested in modelling: OW and ODSP. The OW program provides income assistance for individuals and families in temporary financial need, and the ODSP program provides longer term income support for individuals with disabilities[36].

It is important to recognize that government insured dental care varies across these two programs. Under ODSP, the MCCSS provides a basic dental plan to recipients and their dependents, which is centrally administered. According to a recent Converge3 report[37], the current MCCSS schedule represents 30 cents on the dollar for a dental practice, and thus dentists would seem to be subsidizing the government plans. Under OW, dental benefits are a "discretionary health benefit" that is administered at the municipal level by OW administrators. According to the report, there is currently variation in program transparency (how readily available information is to clients and providers), policy and process elements (administrative approach to providing and paying client benefits), and program eligibility[37]. It is also the municipalities who are responsible for the payment of dental care.

For the purposes of the model, there are three different types of individuals we are interested in: those not on social assistance, those on OW, and those on ODSP. We also need to recognize how transitions across these three states varies across the lifetime. For example, individuals not on social assistance can experience a financial and/or disability shock at any age, and so there exists a one year probability of transitioning to these states, which will be non-zero from age 18 onward. Moreover, it is possible for individuals to transition from OW to ODSP, as individuals in need of "immediate financial assistance" are encouraged to apply to OW first[38] (and then apply to ODSP afterwards), which is likely due to the application time for ODSP. It is also possible for individuals to transition from ODSP to OW, as individuals on ODSP are required to undergo medical reviews to determine if they still meet the program's definition of "disability"[39]. If they no longer qualify for Income Support under ODSP, they can still apply to OW if they require financial assistance. Thus, we are interested in estimating the relationships presented in Figure 4.

In order to estimate these probabilities, we employ a cross-sectional multistate model (described in previous section) using data from the 2015/16 CCHS. In this survey, respondents are asked to identify the sources of their income in the previous year; one possible option is "Provincial or municipal social assistance or welfare". For individuals who responded "Yes" to this question, the survey asks a follow-up question on whether the amount included a supplement for people with disabilities. We first restricted the survey sample to individuals in Ontario, and then constructed a categorical variable that identified the social assistance states for the model. We coded individuals as "OW" if they received income from social assistance but with no funds for people with disabilities. Next, we coded individuals as "ODSP" if they received income from social assistance with funds for people with disabilities. All other individuals were coded as "No".

We estimate two models, one for each sex, to allow for the possibility of different social assistance trajectories by males and females. The models are estimated using individuals aged 18-90 years. As before, we use single age prevalence computed with the master file CCHS files.

The prevalence and model fit for males and females are presented in Figure 5 - Figure 6. The data from the CCHS are generally consistent with administrative data of individuals on social assistance in Ontario[36]. More specifically, we observe a higher proportion of individuals on OW and ODSP in the younger (less than 65) age groups. We also generally observe the highest proportions of individuals on OW at younger age groups (i.e 20 - 30 years of age). Beyond the age of 65, very few individuals are on social assistance. As noted in Kerr et al.[36], at age 65, individuals in Ontario become eligible from other forms of income support, and so the few seniors who are on social assistance are primarily newcomers who have not met residency requirements for these other income support programs.

In terms of the cross-sectional multistate model, we observe that the model generally does quite well in tracking the underlying evolution of social assistance in Ontario. For males aged 20, the one year transitional probabilities are:

	No	OW	ODSP
No	0.9797	0.0201	0.0002
OW	0.1410	0.8402	0.0188
ODSP	0.0108	0.1318	0.8575

For males aged 30, the one year transitional probabilities are:

	No	OW	ODSP
No	0.9758	0.0239	0.0003
OW	0.2372	0.7418	0.0210
ODSP	0.0318	0.2086	0.7596

And for males aged 70, the one year transitional probabilities are:

	No	OW	ODSP
No	0.9765	0.0230	0.0005
OW	0.9189	0.0768	0.0044
ODSP	0.7634	0.1746	0.0620

The results suggest that:

1. The probability of transitioning from "No" to "ODSP" increases with age, but starts to decrease around the age 65 point (latter result not shown, but available upon request)
2. As age increases, OW becomes more "temporary" and males are more likely to switch off in the next year
3. After age 65, individuals in any type of social assistance are likely to switch off in the next year.
4. Individuals on ODSP are more likely to stay in this program in the next year than individuals on OW, with the exception of individuals over the age of 65

For females aged 20, the one year transitional probabilities are:

	No	OW	ODSP
No	0.9717	0.0279	0.0004
OW	0.2574	0.7184	0.0242
ODSP	0.0380	0.2235	0.7385

For females aged 30, the one year transitional probabilities are:

	No	OW	ODSP
No	0.9708	0.0287	0.0005
OW	0.3811	0.5963	0.0226
ODSP	0.0882	0.2996	0.6123

And for females aged 70, the one year transitional probabilities are:

	No	OW	ODSP
No	0.9830	0.0168	0.0003
OW	0.9502	0.0476	0.0021
ODSP	0.8442	0.1209	0.0349

The results suggest that:

1. The probability of transitioning from "No" to "OW" increases during child bearing years (20-30 years old)
2. As age increases, OW becomes more "temporary" and females are more likely to switch off in the next year
3. After age 65, individuals in any type of social assistance are likely to switch off in the next year.
4. Individuals on ODSP are more likely to stay in this program in the next year than individuals on OW, with the exception of individuals over the age of 65

These results are consistent with the general patterns found in Kerr et al.[36], as well as our own expectations based on the nature of the program.

6.5.3 Dental insurance transitional probabilities

For the purposes of the model, it is important to recognize that the probability of having dental insurance likely decreases with age due to factors such as retirement, employment shocks, etc. For individuals on social assistance, we assume that these individuals are covered under the government dental insurance plans via OW and ODSP. For individuals not on social assistance, we need to know the probability of having dental insurance as a function of age and sex. We are therefore interested in estimating the relationship in Figure 7, where individuals having employment or private dental coverage are considered to have dental insurance, otherwise individuals are considered to have no dental insurance.

Using the 2013/14 CCHS data from the master file, we restricted the sample to individuals who reported receiving no income from social assistance, and calculated the single age prevalence of having insurance by sex. We then used the cross-sectional multistate model to give us yearly transitional probabilities for each sex. The prevalence and model fit by sex for individuals aged 22-90 is presented in Figure 8-Figure 9.

We observe from these Figures that the proportion of individuals with dental insurance generally increases until the mid-fifties, and then starts to decline. We also observe that both the male and female models fit the data reasonably well. It is important to note, however, that this fit is conditional on the prevalence at age 22. We found that model fit based on prevalence at age 18 led to model misfit in the younger age groups - especially an overestimation of individuals having dental insurance and an underestimate of individuals without. Since we are taking a lifetime perspective, we use the prevalence of dental insurance at age 22 as the prevalence of dental insurance of individuals aged 18.

6.5.4 Probability of developing a chronic disease

The probability of developing the various diseases in the model are derived from the regression analysis presented in Section 5 of this report. The estimated probabilities for developing heart disease are presented in Figure 10 and Figure 11 below. For both males and females, we observe that individuals who do not receive regular dental care and have diabetes are at the highest risk of developing heart disease. In contrast, individuals with regular dental care and no diabetes are at the lowest risk of developing heart disease.

The estimated probabilities for developing diabetes are presented in Figure 12 and Figure 13 below, by use of dental care. We observe that the probability of developing diabetes plateaus in the mid-sixties, and then starts to decline in older ages. This trend is also observed in Canada, where almost half of the incident cases in 2008/09 where between 45-64 years old[40]. We observe from the Figures that the greatest effect of dental care occurs approximately in the 45-64 age range.

Finally, we present the estimated probabilities of developing a stroke by sex (Figure 14 and Figure 15). In general, we observe that individuals with heart disease, diabetes, and no dental care are at the highest risk of developing a stroke. In contrast, individuals with no heart disease, no diabetes, and regular dental care are at the lowest risk.

6.5.5 Probability of death, conditional on health state

We estimated these probabilities by combining life table data from the Statistics Canada Life Table (2014-2016), disease prevalence data from Ontario, and the effect of these chronic conditions on all-cause mortality. The disease prevalence was estimated using the 2013/14 CCHS, and are presented in Table 18 - Table 23. The mortality ratios used in this study are obtained from Preis et al.[41] for Diabetes, Bronnum-Hansen et al.[42] for Stroke, and the Public Health Agency of Canada[43] for Heart Disease. These ratios are presented in Table 24.

6.5.6 Probability of dental care use

It is important to note that individuals with dental insurance may not necessarily visit the dentist every year. The probability of visiting the dentist is associated with many factors including sex, age, income, etc.

In order to quantify the probability of visiting the dentist as a function of insurance and other factors, we make use of the 2013/14 CCHS. For the purposes of this report, we combine employment and private insurance into one category. In a separate regression, we estimated the impact of insurance on dental visits with employment and private insurance as separate categories, and found no statistically significant difference between the two coefficients (p-value = 0.1001) The results of the regression model are presented in Table 25. Using the regression coefficients, we estimated the predicted probability of going to the dentist by age and sex. In the intervention arm, we assume that individuals who qualify for public dental insurance face the employment/private probability of going to the dentist.

6.5.7 Probability of receiving dental care services

Major dental services such as fillings and tooth extractions occur on a case-by-case basis when the individual requires the treatment.

In the 2013/14 CCHS, respondents who visited the dentist in the past year were asked if they had any teeth removed by a dentist. We regress this indicator on age and sex to obtain the probability of having a tooth extracted for individuals 18+. These probabilities are presented in Table 26. The data suggests that the probability of getting a tooth extracted is highest in the lowest and highest age groups. For younger individuals, the higher probability is likely due to wisdom tooth extraction.

Unfortunately, tooth extraction was the only dental service available in the 2013/14 CCHS. In order to quantify the probability of receiving other dental services, we utilize data from a dental supplement to the 2008 HRS. This supplement was administered to under 10% (1246 of 14970) of the 2008 HRS respondents and asked detailed questions regarding their dental utilization (see Manski el al.[44] for more details). Using the questions from the survey, we calculated the probability of getting various dental services by age and sex (see Figure 16 - Figure 21). With the exception of bridge work and dentures, we see that the probability of receiving these dental treatments falls with age.

6.6 Baseline characteristics

6.6.1 Dental care for low-income seniors

Given that the target population for the seniors is individuals aged 65+, our model follows a hypothetical cohort where everyone starts at the age of 65. As a result of this restriction, we require data on individuals aged 65 as starting values for the model. These data are taken from the 2013/14 CCHS, and are described in more detail below.

6.6.1.1 Income groups

In order to determine the cost-effectiveness of this policy intervention (i.e. public dental care for low income seniors), we need to know the number of individuals in Ontario who would qualify. To determine this, we use data from the 2013/14 CCHS, which contains information on marital status and income from all sources. For the purposes of this report, we consider an individual as coupled if their martial status is “Married” or “Common-law”, and single if their marital status is “Widowed”, “Divorced”, “Separated”, and “Single”. We compute these frequencies for individuals aged 65, which are presented in Figure 22 below.

The data suggest that the majority of seniors who are 65 years of age and qualify for free dental care (i.e. single < $19,300 & couple < $32,300) have no dental insurance. For couples earning >= $32,300, we observe that the majority have employment insurance, although a non-trivial proportion do not have insurance. Finally, for single individuals earning >= $19,300, we observe that the majority do not have insurance, although a non-trivial proportion do have employment insurance.

6.6.1.2 Oral health status

Given that the population consists of individuals who are 65 years old, it would be unreasonable to assume that everyone starts with good oral health. We therefore compute the distribution of oral health status using 2013/14 data CCHS for individuals aged 65, which is presented in Figure 23 below.

We observe from the above Figure that, although the majority of respondents report having good oral health, approximately 20% report having fair and poor oral health.

6.6.1.3 Overall health status

In addition to oral health, it is likely that many seniors would not be in perfect health at age 65. As a result, we compute the distribution of health status at age 65 using 2013/14 CCHS, which is presented in Figure 24 below.

We observe from the Figure that the majority of individuals at age 65 are “Healthy”, which we define as individuals without heart disease, diabetes, or a history of stroke. In terms of the poorer health states, diabetes (alone) has the highest prevalence, followed by heart disease and stroke. A relatively low proportion of individuals have multiple diseases, with some individuals having both heart disease and diabetes, and an even smaller proportion having heart disease, diabetes, and stroke. For the purposes of the model, individuals having both heart disease and diabetes are put in the “Heart Disease” state since diabetes is a risk factor for heart disease. This said, the “memory” of diabetes is preserved, which affects the costs and QALYs associated with individual. Similarly, individuals who have heart disease, diabetes, and stroke are put in the “Stroke” disease state since heart disease and diabetes are risk factors for having a stroke. Similar to the above, the “memory” of having heart disease and diabetes is preserved in the model.

6.6.2 Social assistance

For the social assistance model, an important point to consider is the level of analysis that should be performed. Burry et al.[37] showed that there exists variation in the type of dental services available at the municipal level in Ontario for individuals on OW, which may suggest an analysis at this level. We attempted to model this by estimating the probability of dentist visits as a function of health region (proxy for municipality in the 2013/14 CCHS) and controls, and found that health region was jointly insignificant. It is important to note, however, that we were unable to distinguish between individuals on OW and ODSP in the

2013/14 CCHS; the latter having their dental coverage through the MCCSS. Moreover, both OW and ODSP typically reimburse dentists using the MCCSS fee schedule, which is generally lower than the suggested fees from the ODA[37]. This would suggest that the issue of dental access for individuals on Social Assistance is a Provincial one rather than a municipal one, and so the analysis would need to be performed at the Provincial level.

For starting values, we assume that everyone is “Healthy” at age 18 (i.e. no heart disease, diabetes, or stroke) and use the distribution of oral health for individuals aged 18 from the 2013/14 CCHS master file.

6.7 Effect of Dental Care on Oral Health

To estimate the impact of dental care on oral health, we utilize data from the 2013/14 CCHS. For the purposes of this report, we are interested in the following relationship:

$$OralHealth = \beta_0 + \beta_1 DentalCare + \beta_2 X + \epsilon$$

Where oral health is the three level categorical variable described previously (good, fair, and poor), dental is an indicator for whether the respondent visited the dentist in the past year, and X is a vector of controls (age, sex, education, and income). We estimate the above using a multinomial logit.

We present the relative risk ratios estimated in Table 26 (full results available upon request). These ratios are combined with dental utilization and the oral health transitional probabilities estimated in Section 6.5.1 to obtain oral health transitional probabilities that are conditional on dental use.

6.8 Discounting

All future costs and QALYs were discounted at a rate of 1.5%, as recommended in the 2017 CADTH guidelines[30]. We also conduct sensitivity analysis where we explore the effects of a 0% and 6% discount rate.

7. Microsimulation Results

We now present the results of the microsimulation. For all models, we used 100,000 simulated individuals. The model was run with yearly cycles until the death of the entire cohort. Costs and QALYs were calculated based on the health states of the individuals. We did not sample costs and QALYs, but include one-way sensitivity analysis for all models. In all tables, ’*’ denotes Monte Carlo Standard Error (MCSE), and “LE” denotes Life Expectancy (based on a starting age of 65 for seniors and 18 for social assistance recipients).

7.1 Low Income Seniors

7.1.1 Basic/Core/Preventive

We first present the case where there is no link between oral health and the development of chronic illnesses. To calculate these probabilities, we use the regression coefficients estimated in Section 5, but hold the dental care variable constant at its mean.

In our first scenario, we calculate the cost-effectiveness of introducing basic/core/preventive dental coverage for low-income seniors (as defined by the Ontario government), which is presented in Table 28. Individuals requiring additional care (i.e. those contained within comprehensive/core or major/elite) are not included in costs (since they are not incurred by the payer). We present undiscounted and discounted results.

We observe that the intervention is not cost effective using a threshold of $50,000. Given the uncertainty in many of the model parameters, we also performed a one-way sensitivity analysis for the various uncertain costs described previously, which is presented in Figure 25. The results suggest that the lack of cost-effectiveness is not driven by any one parameter, as the lower bounds are all greater than $50,000.

In our next scenario, we allow for a relationship between oral health and overall health. This is presented in Table 29. In this case, the intervention would be considered to be cost-effectiveness, as both ICERs are below the threshold of $50,000 per QALY. It is worth noting that the incremental costs are lower and the incremental QALYs are higher in this scenario.

Given the uncertainty in costs and effects of dental care, we also perform a one-way sensitivity analysis for this scenario, which is presented in Figure 26. We observe that the ICER is most sensitive to the effect of oral care on stroke, followed by the discount rate. Despite the sensitivity, the upper bounds do not exceed $50,000 for any of the parameters.

7.1.2 Comprehensive/Core+

In our next scenario, we add the dental services from comprehensive/core+ into the model. Since the model using oral health only was not cost effective, we only repeat this exercise for the model that allows linkages between oral health and overall health. These results are presented in Table 30.

At a cost-effectiveness threshold of $50,000 per QALY, this intervention may also be cost-effective, as the undiscounted ICER is less than $50,000. We also perform a sensitivity analysis, which is presented in Figure 27.

In this case, many of the upper bounds exceed $50,000, and so we are less certain about the cost-effectiveness of this intervention.

7.1.3 Major/Elite

In our next scenario, we add the dental services from major/elite into the model. Similar to the above scenario, we only repeat this exercise for the model that allows linkages between oral health and overall health. The results are presented in Table 31.

In this case, both the discounted and undiscounted ICERs are above $50,000, which would suggest that the intervention is not cost-effective.

We also perform a sensitivity analysis, which is presented in Figure 28. In this case, the lower bounds do not reach $50,000 for any of the parameters, which suggests that this intervention is likely not cost-effective at the $50,000 threshold.

7.2 Social Assistance Model

We now present results from the social assistance model. Similar to the low-income seniors, the model using oral health only (i.e. no links to poorer health states) was not cost-effective. For the purposes of this report, we omit these results and focus on the model with links between oral health and overall health.

7.2.1 Basic/Core/Preventive

We first start with the model offering basic/core/preventive dental services, which is presented in Table 32. We observe that the intervention is not cost-effective, as both ICERs are above $50,000.

We also perform a one-way sensitivity analysis (full results available upon request). In this case, the lower bounds do not reach $50,000 for any of the parameters, which suggests that this intervention is likely not cost-effective at the $50,000 threshold.

7.2.2 Comprehensive/Core+

In our next scenario, we add the dental services from comprehensive/core+ into the model; these results are presented in Table 33. Similar to the previous case, both ICERs are greater than $50,000, which suggests that the intervention is not cost-effective. We omit the sensitivity analysis for this case, but it is available upon request.

7.2.3 Major/Elite

In our next scenario, we add the dental services from major/elite into the model; these results are presented in Table 34. Similar to the previous cases, both ICERs are greater than $50,000, which suggests that the intervention is not cost-effective.

8. Limitations

This study is subject to a number of limitations that are worth noting. In terms of our HRS analysis, we do not observe the type of dental care received during the visit. We recognize, however, that some procedures are preventive while others are restorative, and that different procedures may have different impacts on health outcomes. In general, however, we assume that dental visits improve oral health, and would therefore expect to see protective effects of regular dental care on health outcomes. Second, the HRS does not contain measures of particular aspects or types of oral health conditions such as periodontal disease. The literature to date suggests a link between periodontal disease and outcomes such as diabetes, so it would have been useful to include this in the regression had it been available. It is important to note, however, that we do control for self-assessed health status, which may pick up the effects of poor oral health as well. Despite this, future studies with more detailed data on oral health may wish to investigate the potential pathways linking particular oral health conditions to other health conditions. Third, our measure of heart disease in the HRS is unable to distinguish "heart attack, coronary heart disease, angina, and congestive heart failure" from "other heart problems". The latter may have had different mechanisms than the former; unfortunately, it is hard to say what effect this would have had on the results. Fourth, and related to the above point, we are unable to distinguish diabetes from high blood sugar in the HRS. Fifth, our HRS results may have been subject to an ascertainment bias as we do not control for the frequency of physician visits. This additional analysis could not be completed within the timelines of this project, but will be investigated in a future analysis. Finally, the probability of getting a stroke in the younger age groups was likely overestimated using the HRS data, as the quadratic function decreases in the younger age groups and then increases in the older age groups. This partly explains why life expectancy in the social assistance model is lower than one would expect. This would have caused bias towards the intervention in the social assistance model, as more individuals would have been subject to stroke (and thus the protective effects of dental care) than what would normally be the case. Given that none of the social assistance models were cost-effective, this limitation did not appear to materially impact the main findings of the report.

In terms of the model, our quantification of the relationship between groups of dental services (i.e. comprehensive/core+ versus basic/core/preventive) and outcomes is somewhat limited in the sense that adding dental services (root canals, bridges, etc.) to basic/core/preventive only affect costs, not QALYs (these dental services are performed conditional upon going to the dentist). Unfortunately, we were unable to use the HRS to determine the impact of different bundles of dental services on outcomes such as health utilities. It is difficult to perform sensitivity analysis for this (in addition to exploring the lower and upper ranges of the estimates) as we do not observe the types of treatments individuals receive when they go to the dentist, and so the effect of dental care on health outcomes is an average of the effects of various dental care services (cleaning, gum treatment, denture services, etc.). Thus, it is unclear if the effect we estimate is an over or under estimate for the various bundles of dental care services described in Farmer et al.[33]. That said, evidence from Manski & Brown.[45] suggests that 75% of adults aged 65 and over in the U.S. who visited the dentist in the past year received preventive services (cleaning, fluoride, or sealant). Brown et al.[11] suggest that it is these preventive services that are expected to be associated with an improved cardiovascular risk profile. Since we assume that the above preventive services are included in all groups of services, it may be reasonable to use the same effect across the different configurations of dental services. Future research may wish to explore this further. Another limitation relating to modelling is that we do not perform probabilistic sensitivity analysis (PSA) for any of the models. Given the uncertainty in the number of parameters, it would have been preferable to perform a PSA for each of the models. Unfortunately, this analysis could not be completed within the timelines of the project. This will be investigated in a future analysis.

Another important limitation is that, according to the results of the model, the dental insurance policy interventions are not cost effective unless the links between oral health and overall health are incorporated. This is an important point to acknowledge given the uncertainty in the literature and paucity of causal estimates in the literature at this time as to the strength of any causal relation between oral health and overall health. We attempted to address this gap by estimating the relationships between dental care and overall health using longitudinal data and econometric techniques for causal inference using a dataset that is as representative of the general population as possible. Despite this, more research on the relationship between dental care and overall health, potentially using different data than what was used in this study, is required.

In terms of health care utilization, we use a measure of hospital days that includes days spent in a nursing home, or convalescent home. It is unclear of the bias in this case, as we may have over or under estimated the effect of poor oral health on hospital days depending on the relationship between poor oral health and nursing/convalescent home days. The 2015/16 CCHS contains a hospital days specific question, but does not collect dental care data for individuals in Ontario. It does, however, collect dental data on individuals in Newfoundland, Alberta, and Nunavut. Given that dental care is likely covered similarly across provinces, the effect of poor oral health on hospital visits may be similar. Thus, as a sensitivity analysis, we could re-estimate the hospital days regression using the 2015/16 CCHS data. This could not be done within the timelines of the project, but will investigated in a future analysis.

Finally, there is also the issue that dental services for those on social assistance is reimbursed at a fraction of the rate that dentist charge privately insured patients which may mean that while those on social assistance may technically qualify for some care, it does not necessarily mean that they were supplied with that care. In our model, we assumed that if individuals were eligible for such services that they did not experience difficulties gaining access. This assumption will be investigated in more detail in future research.

9. Conclusions

We develop a microsimulation model to evaluate the cost-effectiveness of potential government sponsored dental insurance schemes in Ontario. The model is built flexibly to allow for variations in breadth (universal versus targeted populations), depth (how much is covered), and scope (dental services covered). We illustrate the use of the model through the proposed dental care policy for low income seniors as well as a hypothetical policy for individuals on social assistance in Ontario.

We found that coverage of a basic set of dental care services for seniors was cost-effective if oral health was assumed to have a positive relationship with overall health but not otherwise. It is important to note, however, that we did not investigate the possibility of copayments or reduced dental fees which may have had an impact on the cost effectiveness (with or without links between oral health and overall health). It would also be useful in future research to evaluate the cost-effectiveness of dental coverage much earlier in life.

We found that coverage of basic dental services for those on social assistance was not cost effective under any of our assumptions. The nature of the social assistance programs is for most participants, short-term and periodic meaning that their access to covered dental care services is thus also likely to be short-term and periodic which may significantly limit the ability of dental care to have had any long run or significant lasting effects. Similar to the model for seniors, some form of copayment or reduced dental fees may be helpful, but would need to be done in a way that does not reduce the probability of individuals visiting the dentist.

In addition to Ontario specific interventions, the model can be expanded to evaluate the cost-effectiveness of potential dental care policy interventions in other jurisdictions as well.

References

1. Paris V, Devaux M, Wei L. Health systems institutional characteristics. 2010;(50). Available from: https://www.oecd-ilibrary.org/content/paper/5kmfxfq9qbnr-en

2. Ontario Ministry of Health and Long-Term Care. Ontario health insurance plan annual report. Toronto: Ministry of Health; Long-Term Care, Health Services Branch; 2013.

3. Singhal S, Mamdani M, Mitchell A, Tenenbaum H, Lebovic G, Quiñonez C. Dental treatment and employment outcomes among social assistance recipients in ontario, canada. Health Policy. 2016;120(10):1202–8.

4. Ottawa Public Health. Update on dental health services in ottawa [Internet]. 2015. Available from: http://s3.documentcloud.org/documents/2509652/update-on-dental-health-services-in-ottawa.pdf

5. The Canadian Press. Free dental care for low-income seniors to be announced in budget. CBC Radio Canada [Internet]. 2019 Apr 9; Available from: https://www.cbc.ca/news/canada/toronto/ontario-budget-health-politics-free-dental-care-1.5090396

6. Pfeffer A. Uninsured dental patients end up in ottawa emergency rooms, report says. CBC Radio Canada [Internet]. 2015 Nov 9; Available from: https://www.cbc.ca/news/canada/ottawa/dental-emergency-report-1.3308355

7. Humphrey LL, Fu R, Buckley DI, Freeman M, Helfand M. Periodontal disease and coronary heart disease incidence: A systematic review and meta-analysis. Journal of general internal medicine. 2008;23(12):2079.

8. Lockhart PB, Bolger AF, Papapanou PN, Osinbowale O, Trevisan M, Levison ME, et al. Periodontal disease and atherosclerotic vascular disease: Does the evidence support an independent association? A scientific statement from the american heart association. Circulation. 2012;125(20):2520–44.

9. Cullinan MP, Seymour GJ. Periodontal disease and systemic illness: Will the evidence ever be enough? Periodontology 2000. 2013;62(1):271–86.

10. Chang P-C, Lim LP. Interrelationships of periodontitis and diabetes: A review of the current literature. Journal of Dental Sciences. 2012;7(3):272–82.

11. Brown TT, Dela Cruz E, Brown SS. The effect of dental care on cardiovascular disease outcomes: An application of instrumental variables in the presence of heterogeneity and self-selection. Health economics. 2011;20(10):1241–56.

12. Sen S, Giamberardino LD, Moss K, Morelli T, Rosamond WD, Gottesman RF, et al. Periodontal disease, regular dental care use, and incident ischemic stroke. Stroke. 2018;49(2):355–62.

13. Jalal H, Pechlivanoglou P, Krijkamp E, Alarid-Escudero F, Enns E, Hunink MM. An overview of r in health decision sciences. Medical Decision Making. 2017;37(7):735–46.

14. Krijkamp EM, Alarid-Escudero F, Enns EA, Jalal HJ, Hunink MM, Pechlivanoglou P. Microsimulation modeling for health decision sciences using r: A tutorial. Medical Decision Making. 2018;38(3):400–22.

15. Stock JH, Watson MW. Introduction to econometrics. Pearson/Addison Wesley; 2007.

16. Wooldridge JM. Econometric analysis of cross section and panel data. MIT press; 2010.

17. Health and Retirement Study. Sample sizes and response rates [Internet]. 2011. Available from: http://hrsonline.isr.umich.edu/sitedocs/sampleresponse.pdf

18. Health and Retirement Study. Sample sizes and response rates [Internet]. 2017. Available from: https://hrs.isr.umich.edu/sites/default/files/biblio/ResponseRates_2017.pdf

19. Beland Y. Canadian community health survey – methodological overview. Health Reports [Internet]. 2002 Mar;13(3):9–14. Available from: http://myaccess.library.utoronto.ca/login?url=https://search-proquest-com.myaccess.library.utoronto.ca/docview/207491408?accountid=14771

20. Statistics Canada. NPHS content, household component, cycles 1 to 9 [Internet]. 2017. Available from: http://www.statcan.gc.ca/eng/statistical-programs/document/3225_D3_T9_V4-eng.pdf

21. Grossman M. On the concept of health capital and the demand for health. Journal of Political economy. 1972;80(2):223–55.

22. U.S. Centers for Medicare & Medicaid Services. Dental services [Internet]. No date. Available from: https://www.medicare.gov/coverage/dental-services

23. Angrist JD, Pischke J-S. Mostly harmless econometrics: An empiricist's companion. Princeton university press; 2008.

24. Cameron AC, Trivedi PK. Microeconometrics using stata. Vol. 2. Stata press College Station, TX; 2010.

25. Roodman D, Morduch J. The impact of microcredit on the poor in bangladesh: Revisiting the evidence. Journal of Development Studies. 2014;50(4):583–604.

26. Knapp LG, Seaks TG. A hausman test for a dummy variable in probit. Applied Economics Letters. 1998;5(5):321–3.

27. Allison PD. Fixed effects regression models. Vol. 160. SAGE publications; 2009.

28. Health Canada. Report on the findings of the oral health component of the canadian health measures survey; 2007-2009 [Internet]. 2010. Available from: http://publications.gc.ca/collections/collection_2010/sc-hc/H34-221-2010-eng.pdf

29. Thomson W, Mejia G, Broadbent J, Poulton R. Construct validity of locker's global oral health item. Journal of dental research. 2012;91(11):1038–42.

30. Canadian Agency for Drugs and Technologies in Health. Guidelines for the economic evaluation of health technologies: Canada. 4th ed. CADTH; 2017.

31. Guertin J, Humphries B, Feeny D, Tarride J. Health utilities index mark 3 scores for major chronic conditions: Population norms for canada based on the 2013 and 2014 canadian community health survey. Health reports. 2018;29(11):12.

32. Kralj B, Kantarevic J. Primary care model enrolment and hospital length of stay in ontario: Patient rostering associated with reduced length of stay, significant health system savings. Ontario Medical Review. 2012;79(8):16–9.

33. Farmer J, Allin S, Quinonez C, Peckham A, Marchildon G. Dental care coverage for older adults in seven jurisdictions: Progress report. Rapid Review. 2019;(14).

34. Ontario Dental Association. ODA suggested fee guide for general practitioners. Toronto: Economics of Practice Committee, Ontario Dental Association; 2019.

35. Van Den Hout A. Multi-state survival models for interval-censored data. Chapman; Hall/CRC; 2016.

36. Kerr D, Smith-Carrier T, Wang J, Tam D, Kwok SM. Population aging and the ontario disability support program (odsp). Canadian Journal of Disability Studies. 2017;6(4):33–55.

37. Burry A, Cohen T, Quinonez C. A review of dental care services for adults in receipt of social assistance in ontario. 2019; Available from: https://converge3.ca/publication/evidence-dental-for-adults-on-social-assistance

38. Ontario Ministry of Children, Community and Social Services. Applying for odsp income support. 2018; Available from: https://www.mcss.gov.on.ca/en/mcss/programs/social/odsp/income_support/IS_Application.aspx

39. Ontario Ministry of Children, Community and Social Services. Disability/health eligibility: About medical reviews. 2018; Available from: https://www.mcss.gov.on.ca/en/mcss/programs/social/odsp/income_support/odsp_medical.aspx

40. Canada PHA of. Diabetes in canada: Facts and figures from a public health perspective. Government of Canada. 2011;27–50.

41. Preis SR, Hwang S-J, Coady S, Michael J. Pencina, D'AgostinoSr RB, Savage PJ, et al. Trends in all-cause and cardiovascular disease mortality among women and men with and without diabetes mellitus in the framingham heart study, 1950 to 2005. Circulation. 2009;119:1728–35.

42. Brønnum-Hansen H, Davidsen M, Thorvaldsen P. Long-term survival and causes of death after stroke. Stroke. 2001;32(9):2131–6.

43. Public Health Agency of Canada. Report from the canadian chronic diseasesurveillance system: Heart disease in canada, 2018. 2018.

44. Manski RJ, Hyde JS, Chen H, Moeller JF. Differences among older adults in the types of dental services used in the united states. INQUIRY: The Journal of Health Care Organization, Provision, and Financing. 2016;53:0046958016652523.

45. Manski R, Brown Jr E. Medical expenditure panel survey (meps) chartbook no. 17: Dental use, expenses, private dental coverage, and changes, 1996 and 2004. Rockville (MD): Agency for Healthcare Research and Quality (US). 2007;

Figures

Figure 1: Microsimulation Framework: Oral Health States

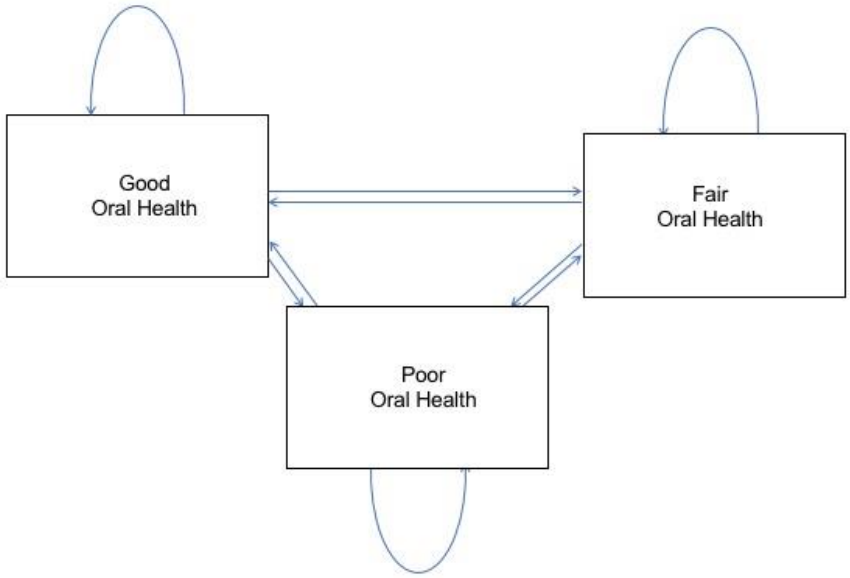


Figure 2: Microsimulation Framework: Overall Health States

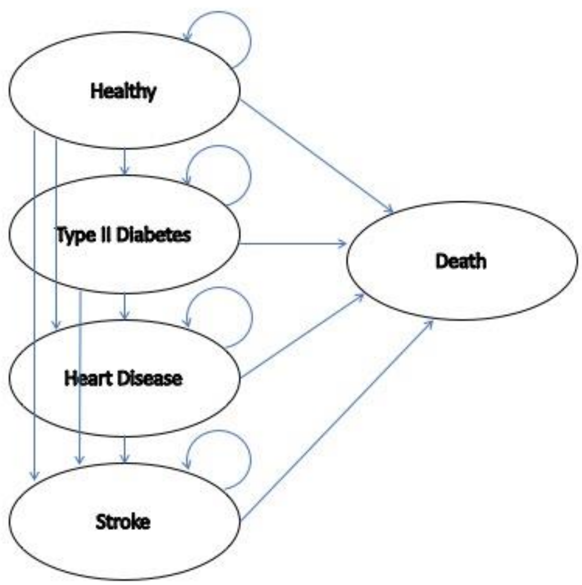


Figure 3: Oral Health Prevalence and Model Fit

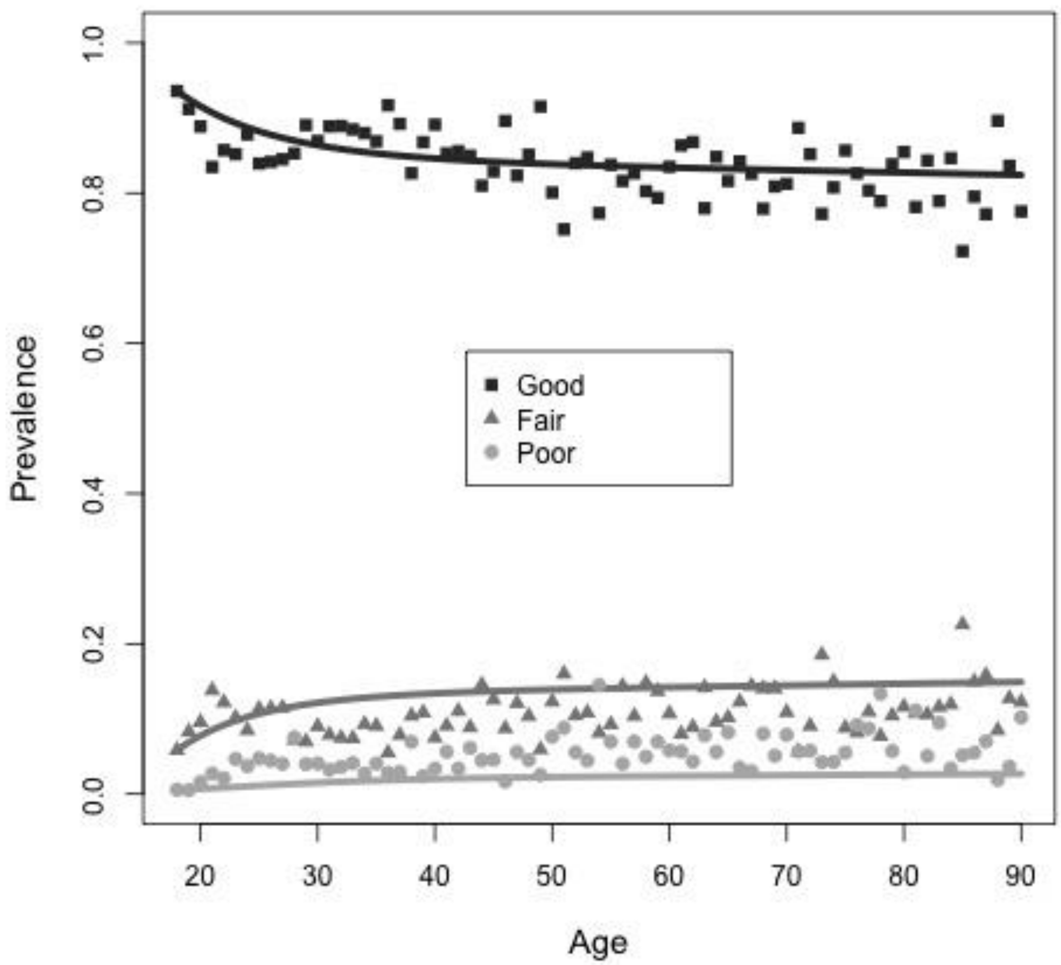


Figure 4: Microsimulation Framework: Social Assistance States

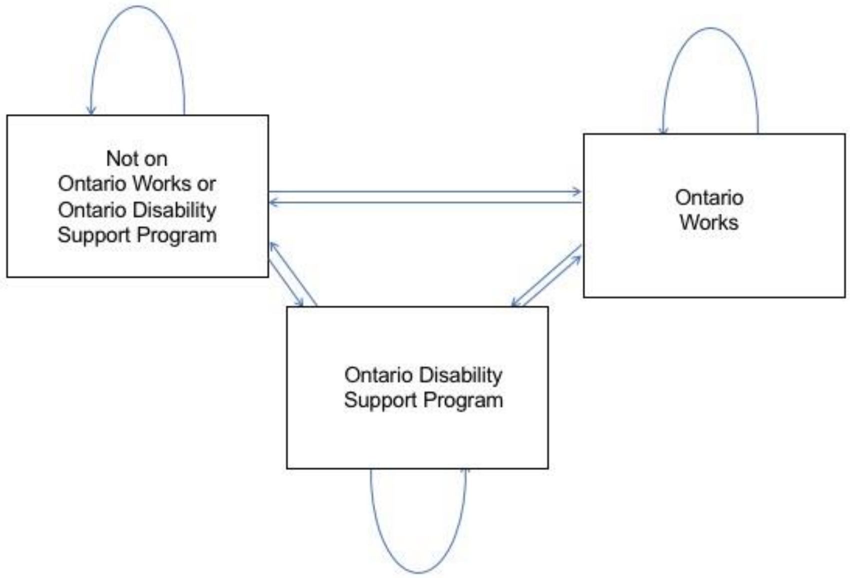


Figure 5: Social Assistance Prevalence and Model Fit, Males

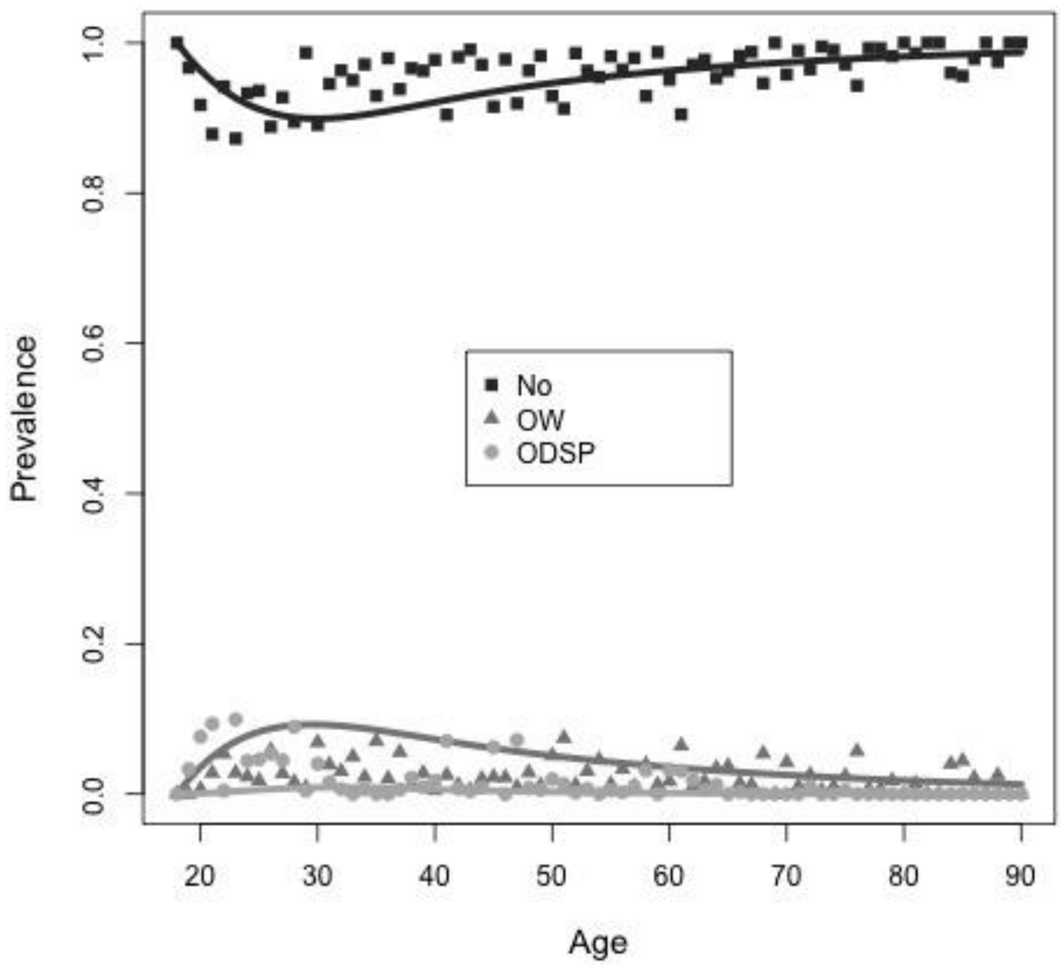


Figure 6: Social Assistance Prevalence and Model Fit, Females

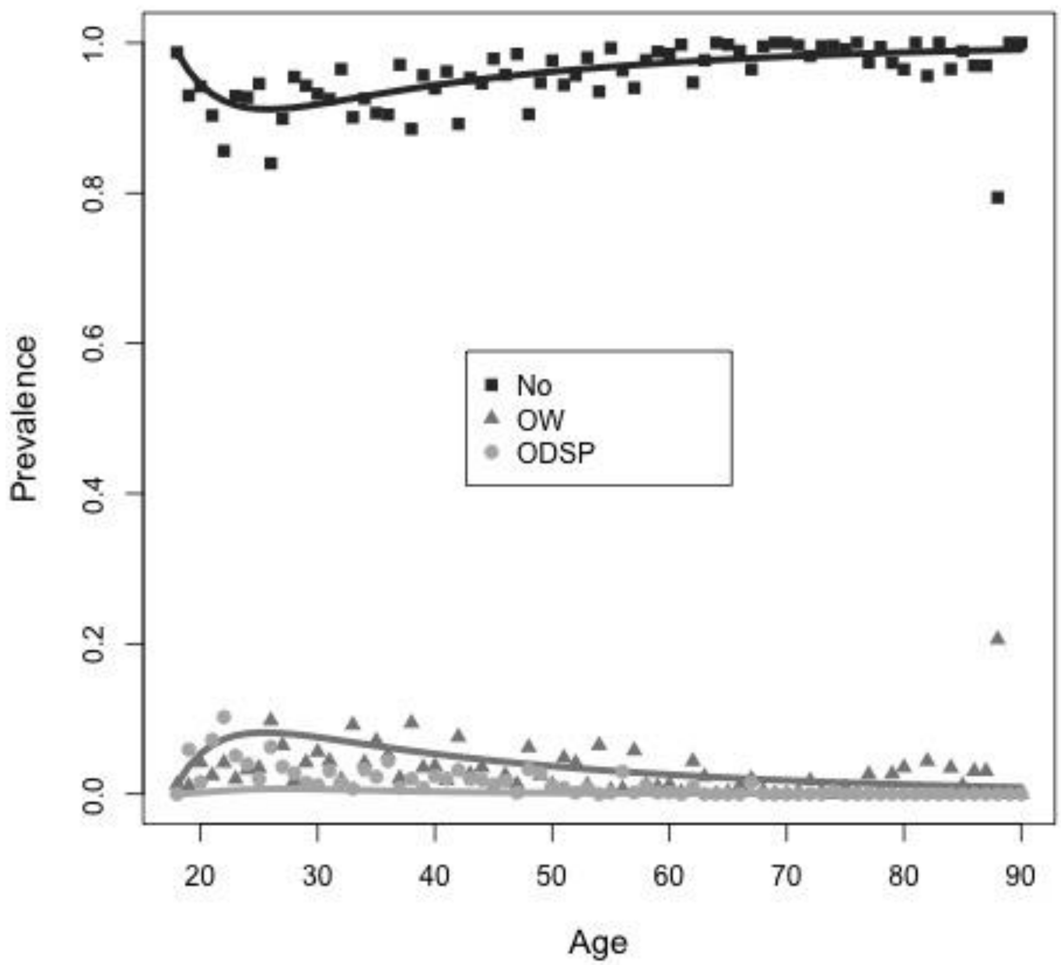


Figure 7: Microsimulation Framework: Insurance States

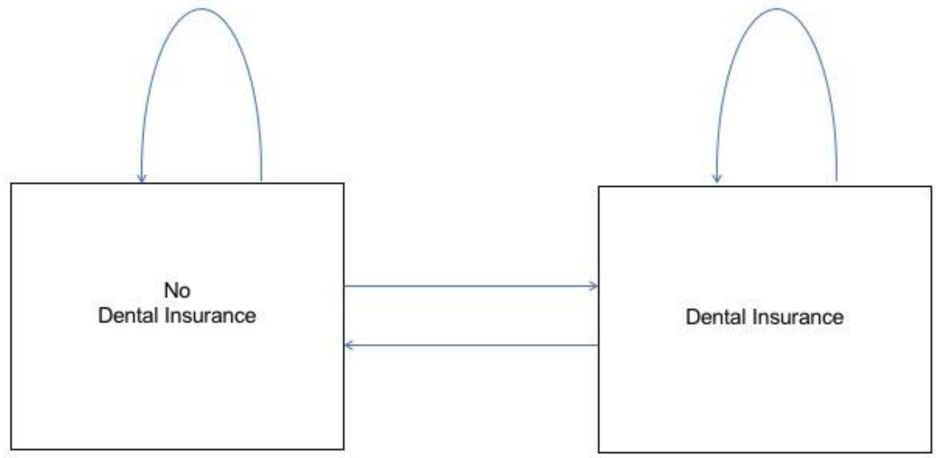


Figure 8: Insurance Prevalence and Model Fit, Males

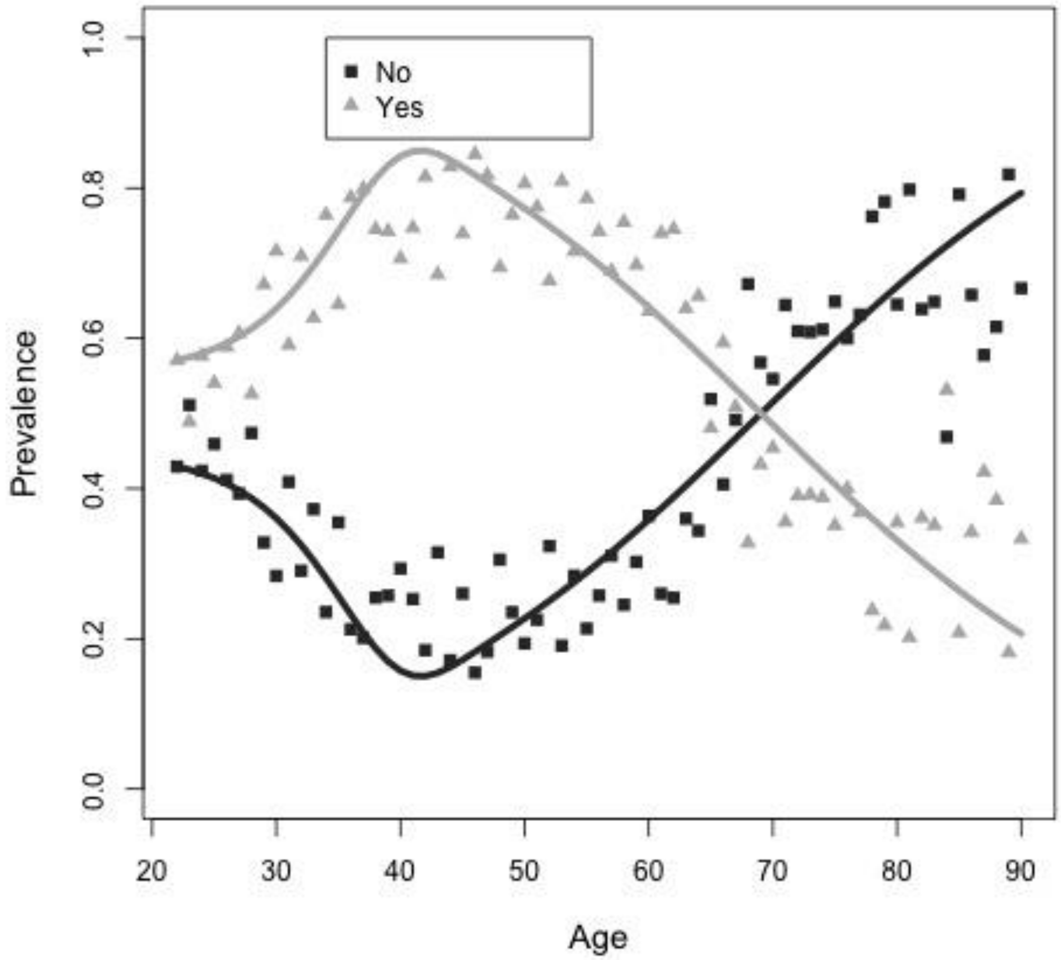


Figure 9: Insurance Prevalence and Model Fit, Females

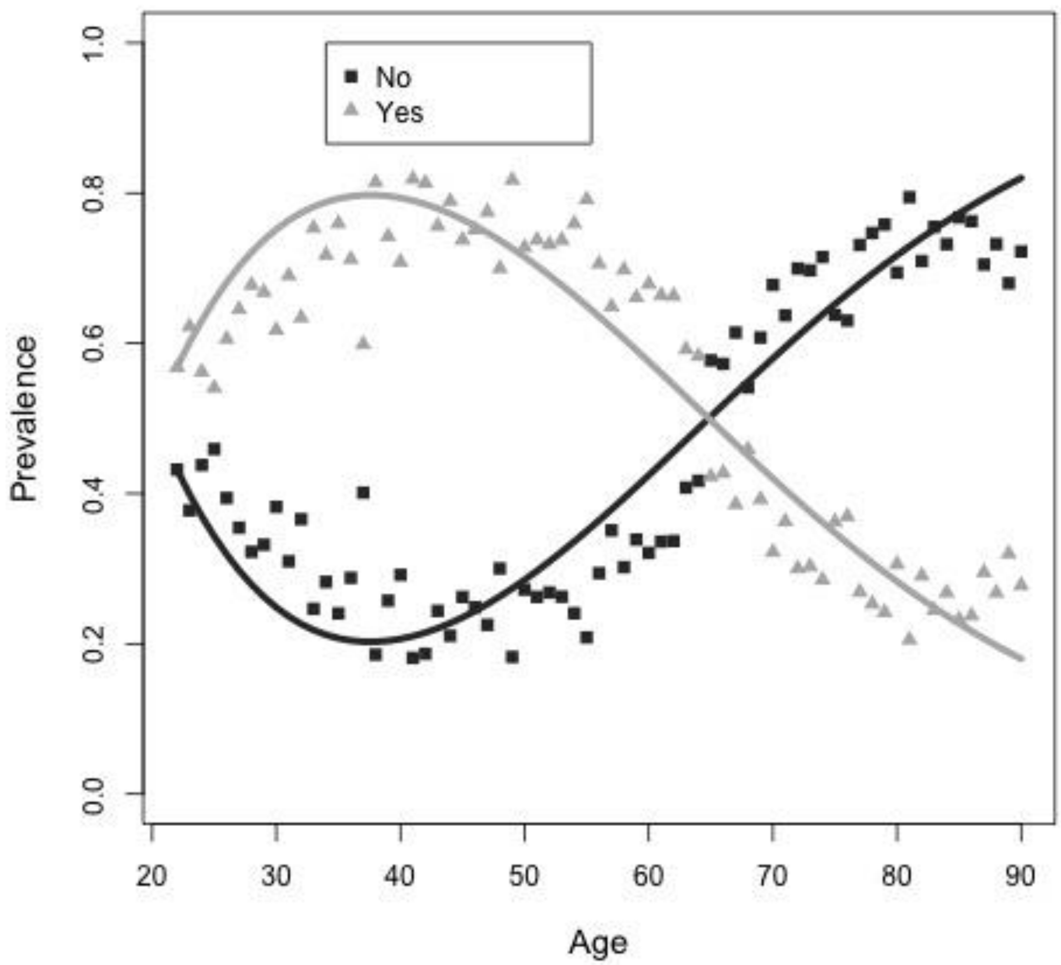


Figure 10: Probability of developing heart disease, males

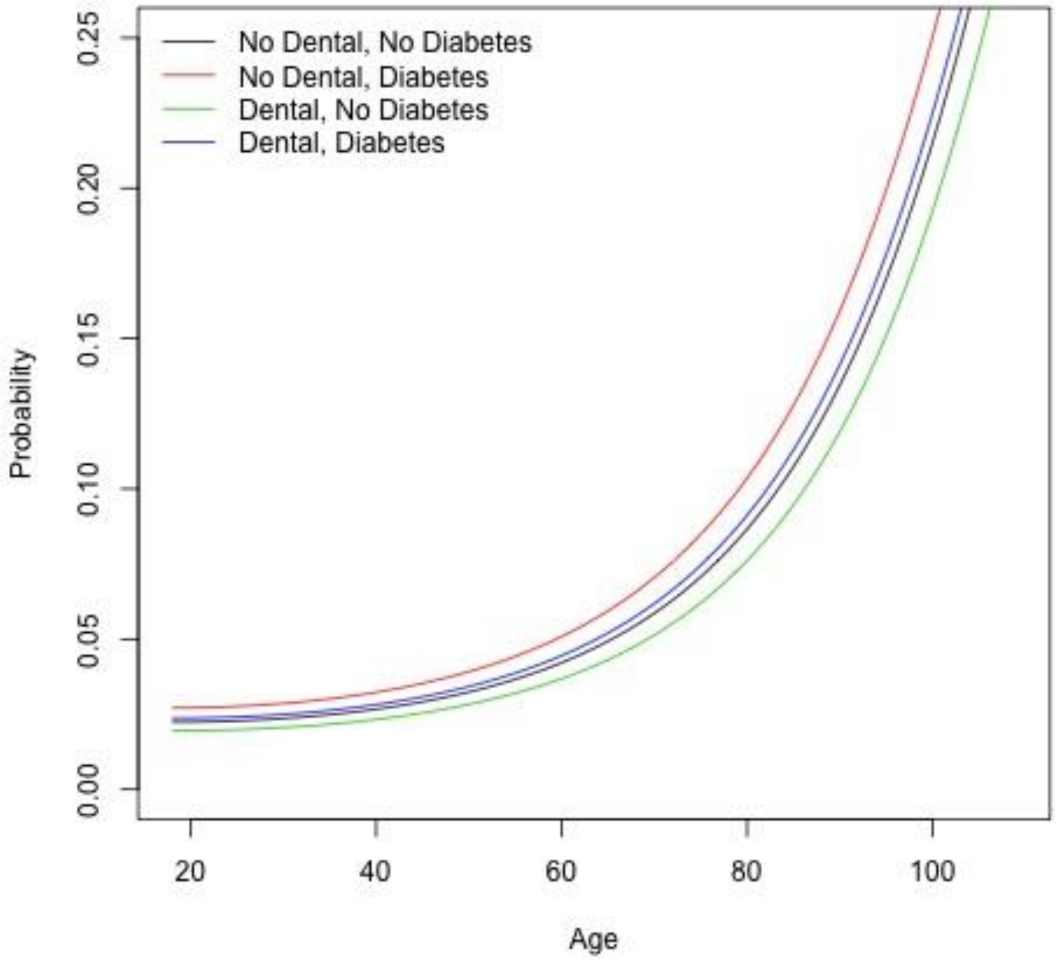


Figure 11: Probability of developing heart disease, females

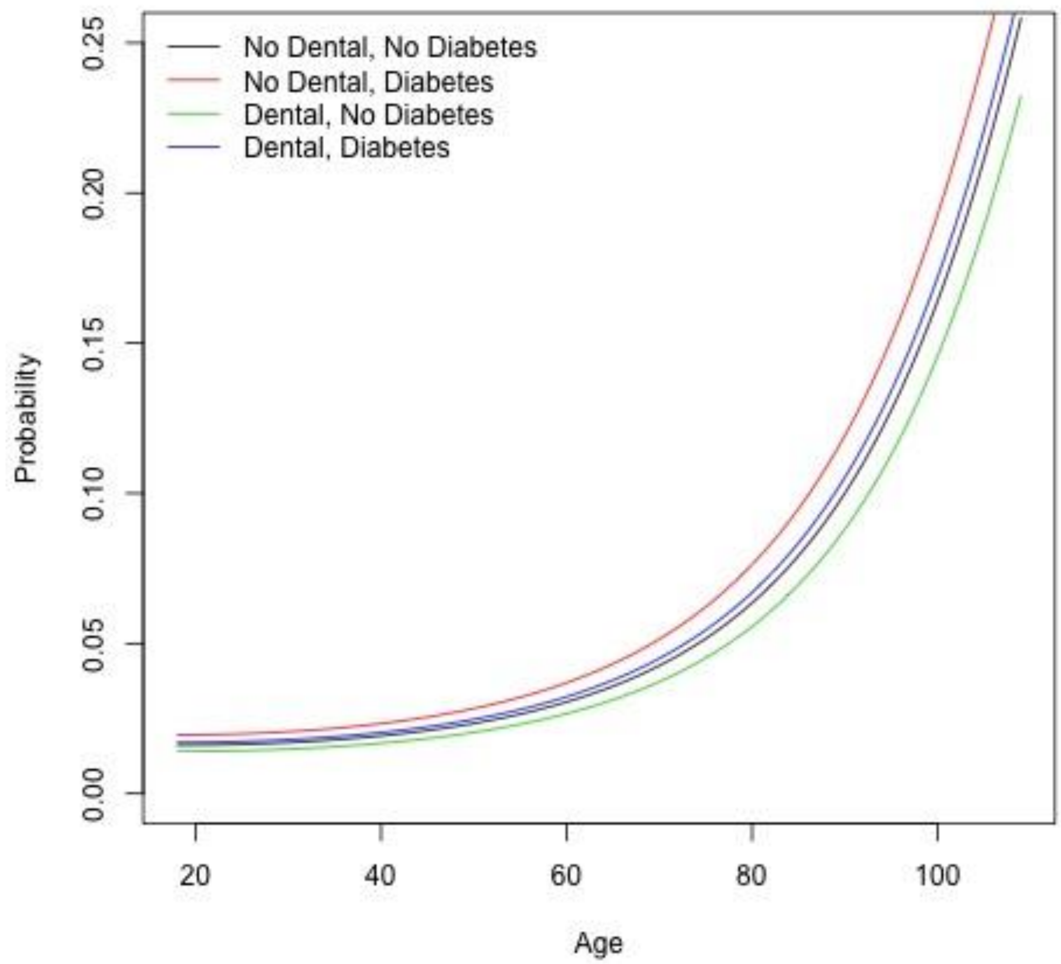


Figure 12: Probability of developing diabetes, males

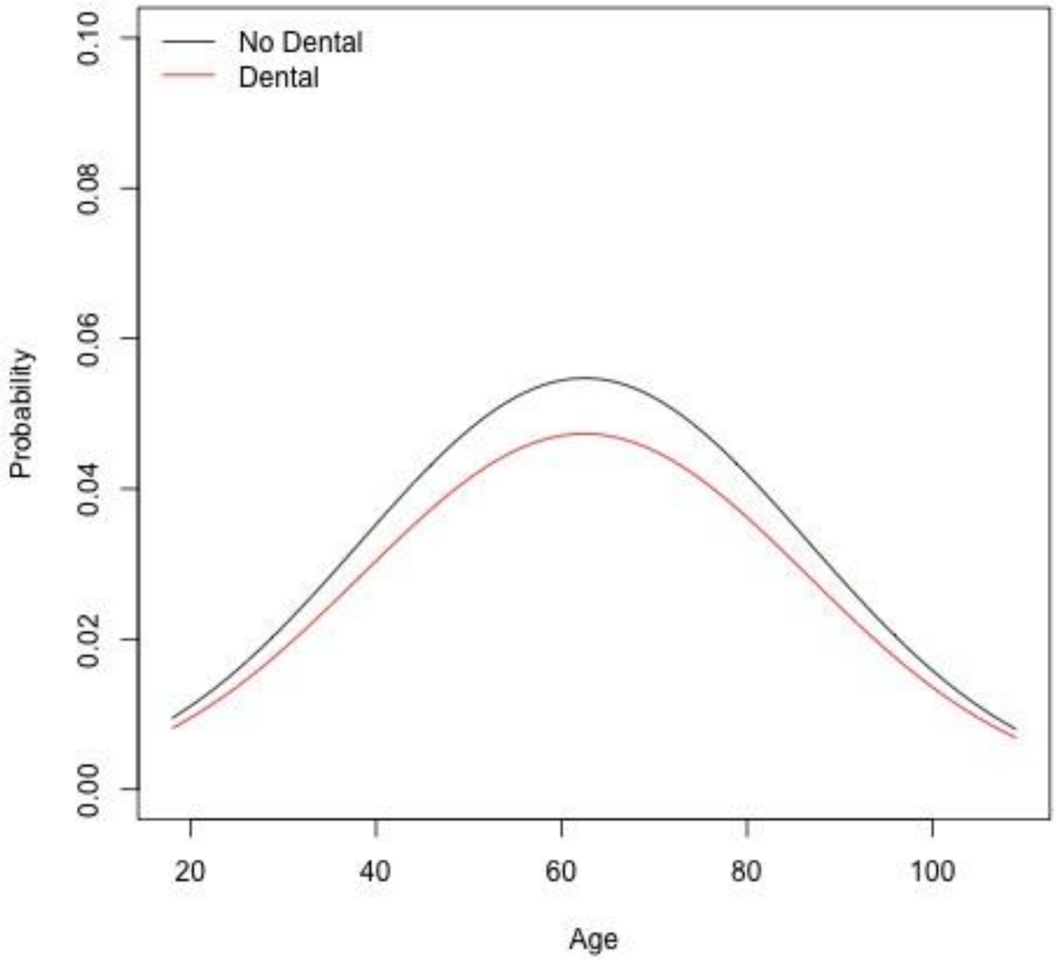


Figure 13: Probability of developing diabetes, females

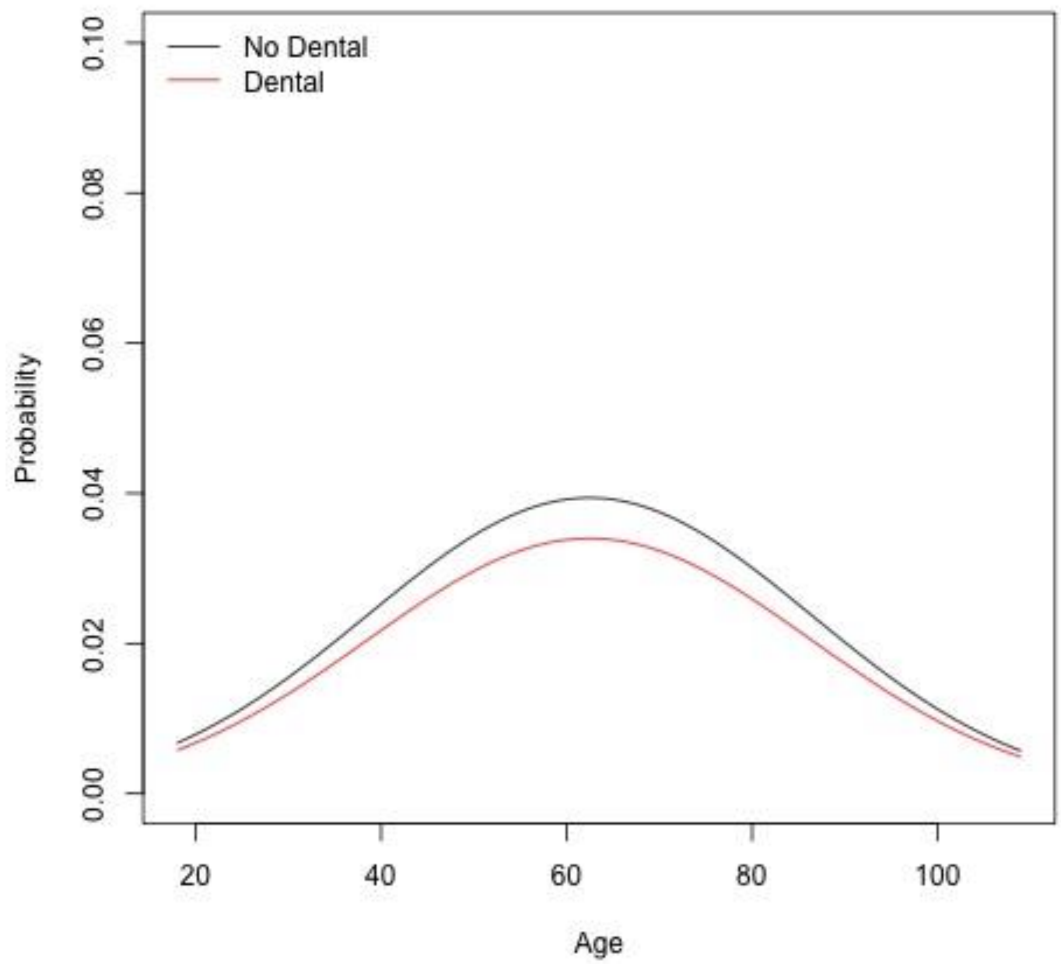


Figure 14: Probability of developing a stroke, males

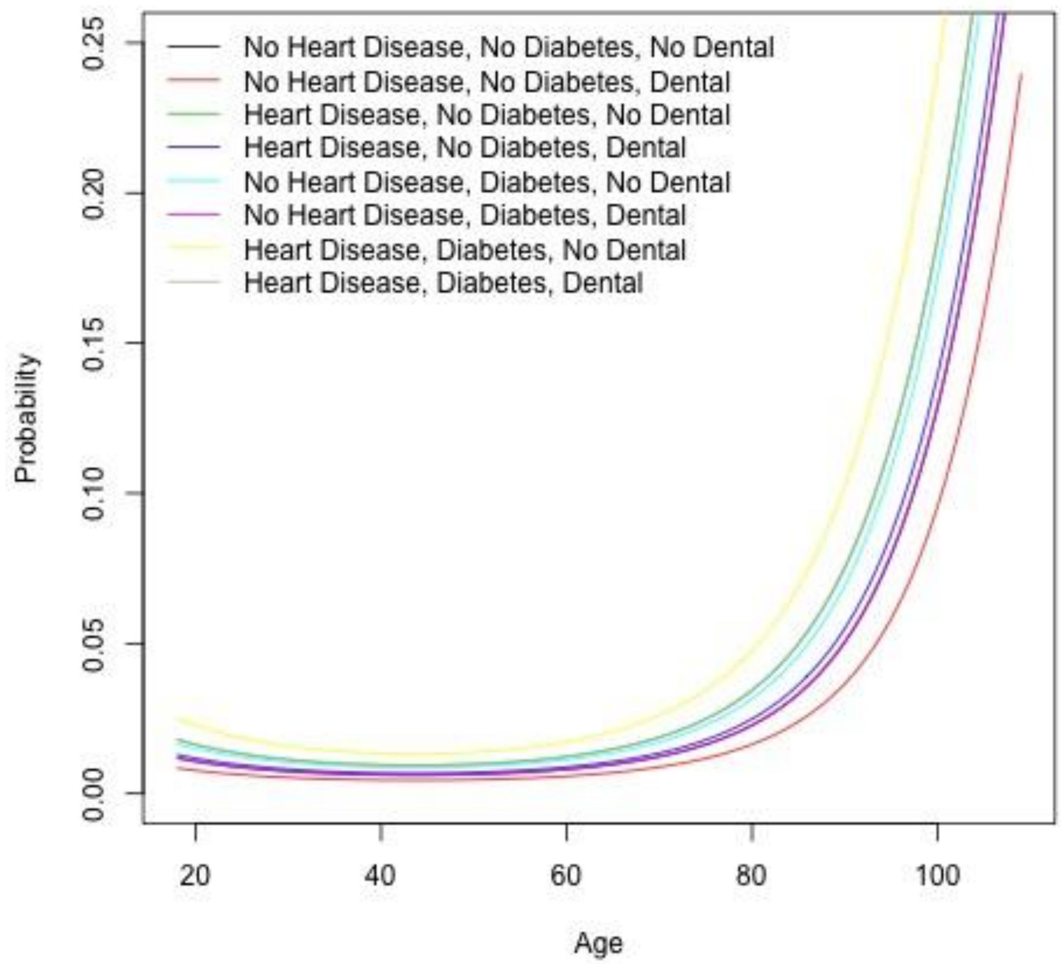


Figure 15: Probability of developing a stroke, females

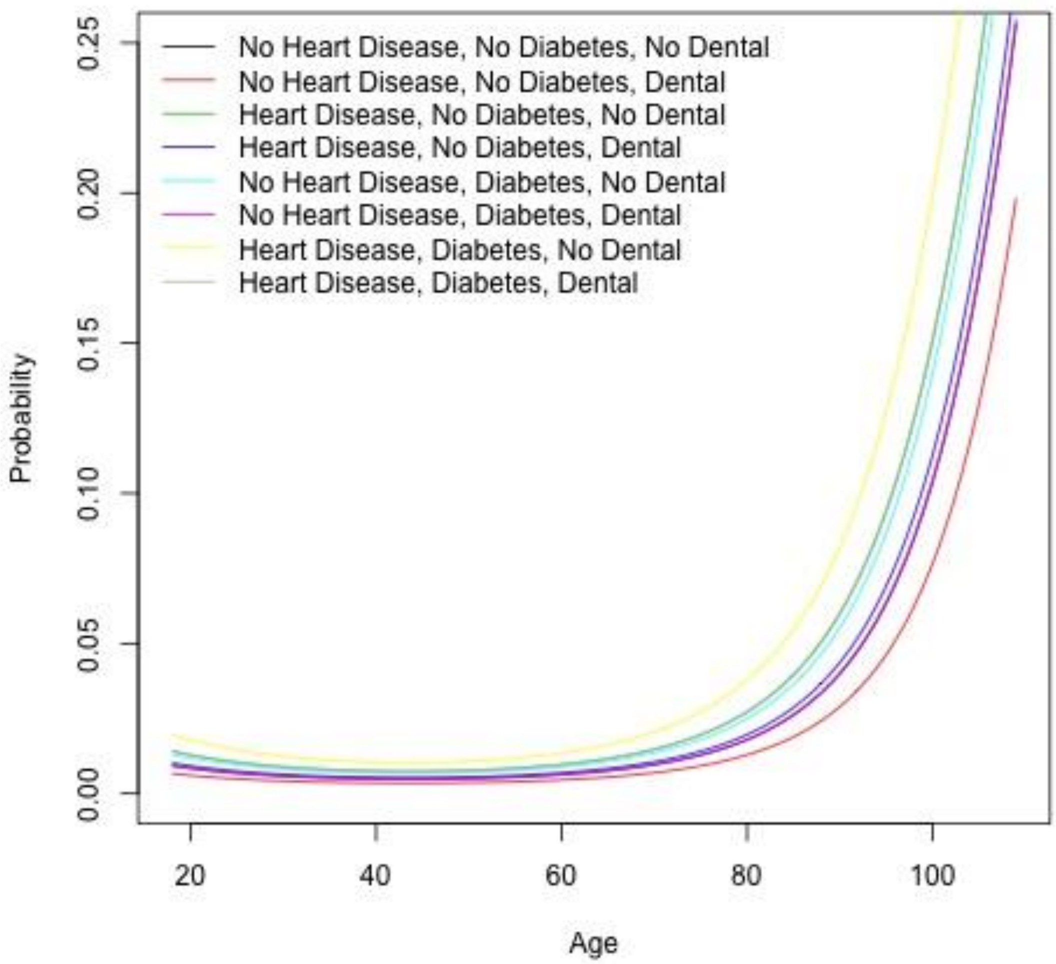


Figure 16: Probability of getting a filling, by sex

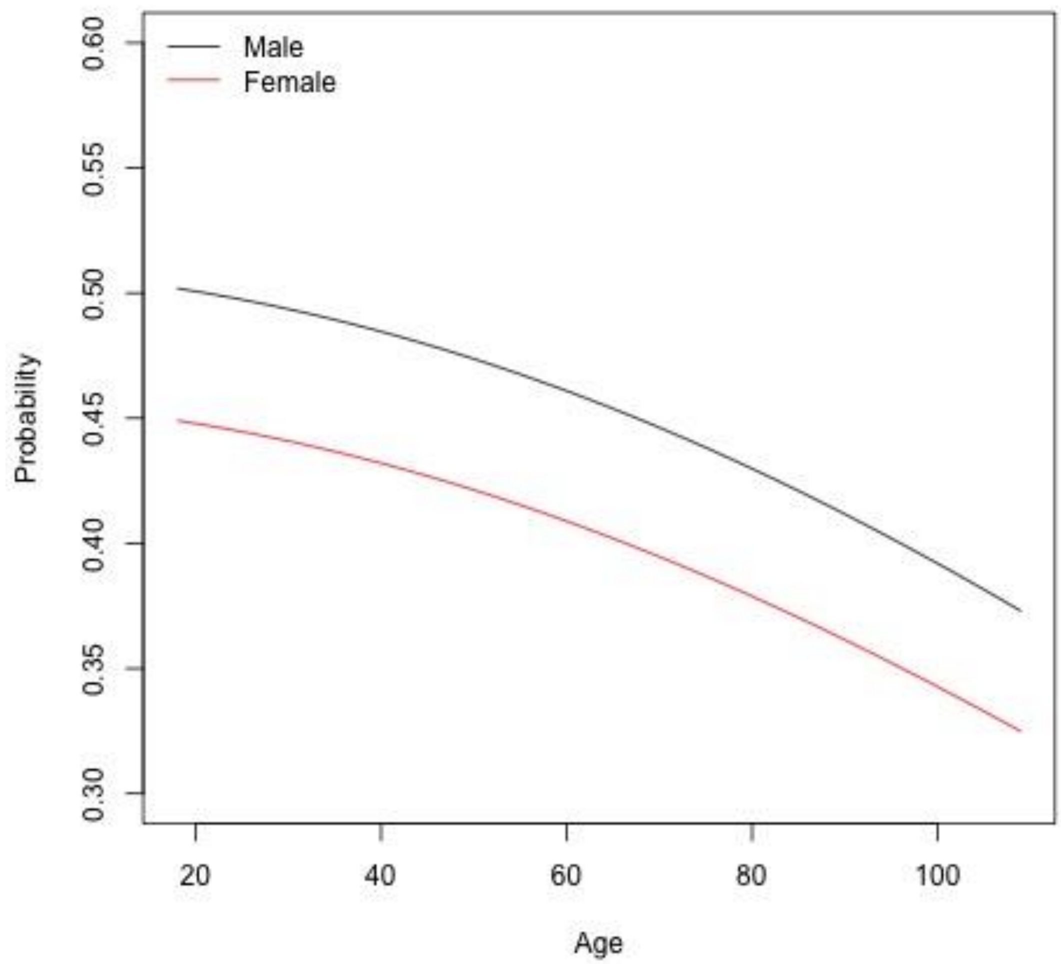


Figure 17: Probability of getting a root canal, by sex

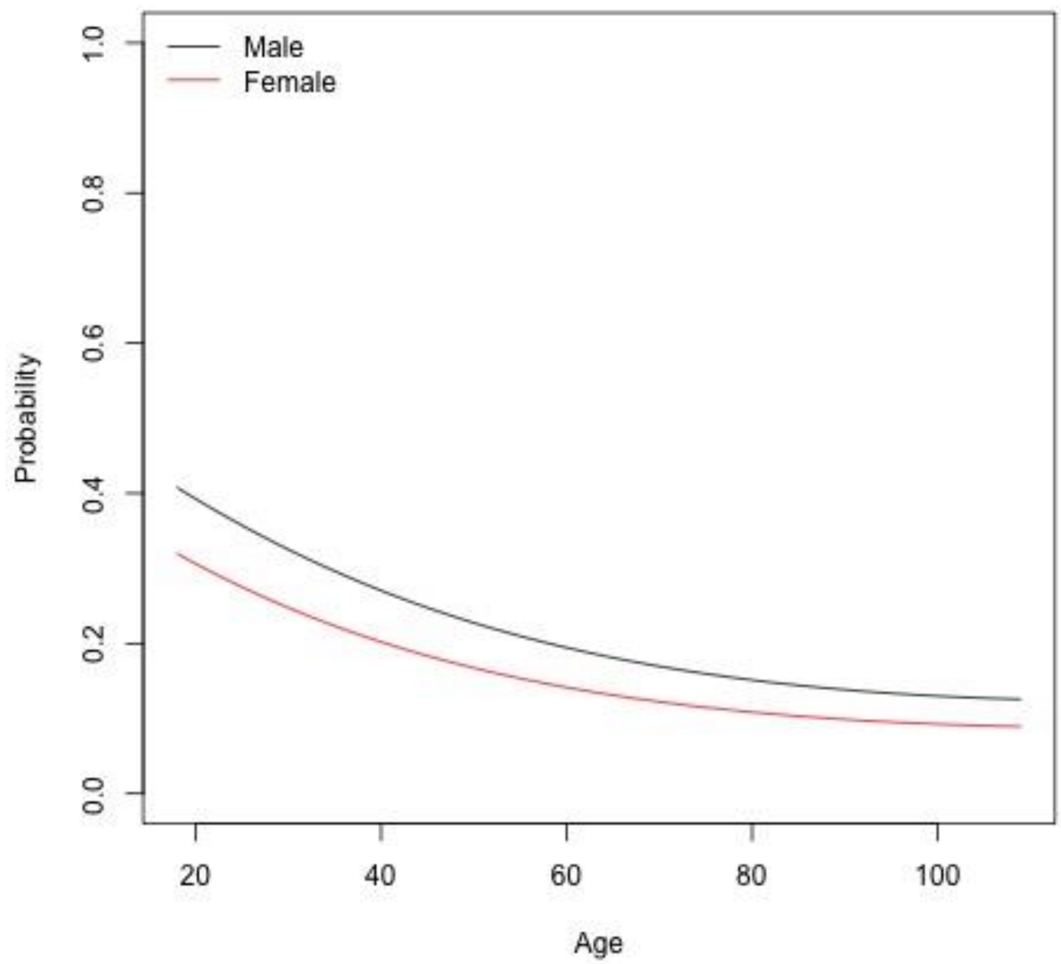


Figure 18: Probability of getting gum treatment, by sex

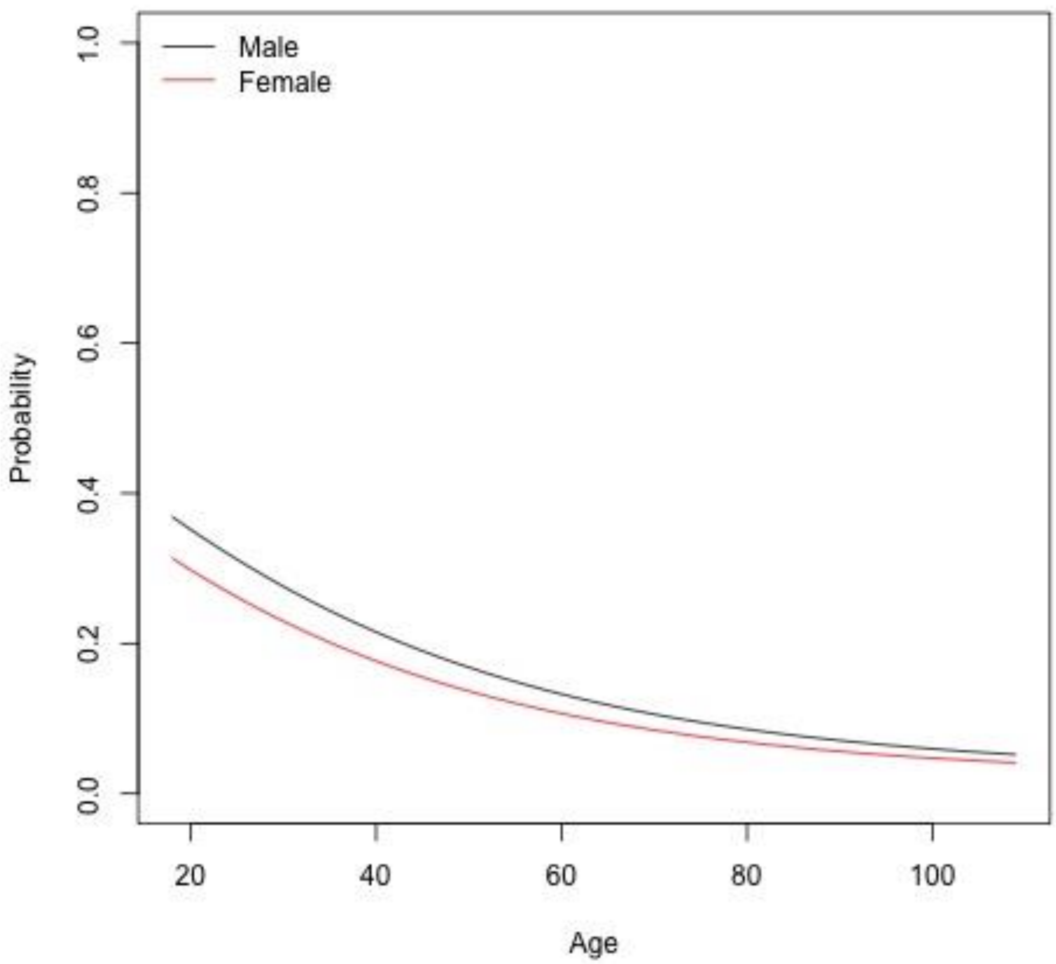


Figure 19: Probability of getting a crown, by sex

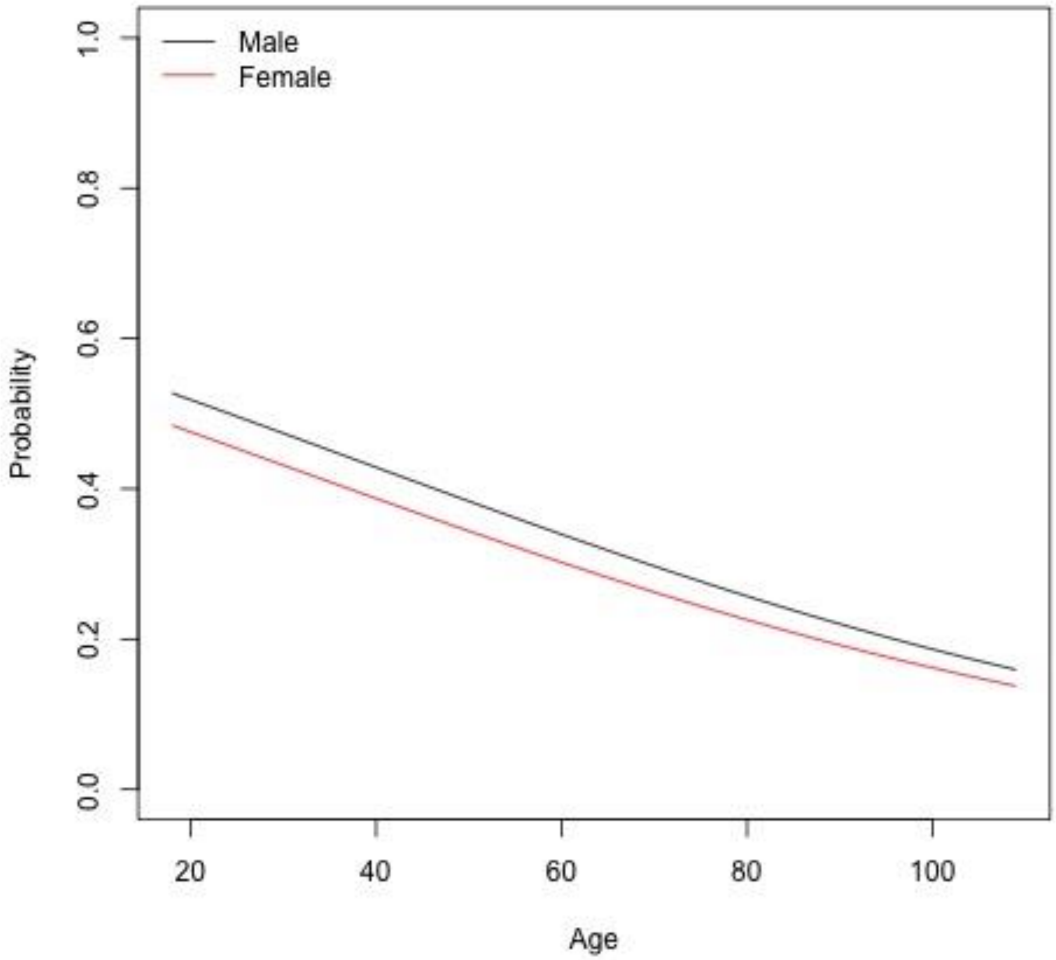


Figure 20: Probability of getting a bridge, by sex

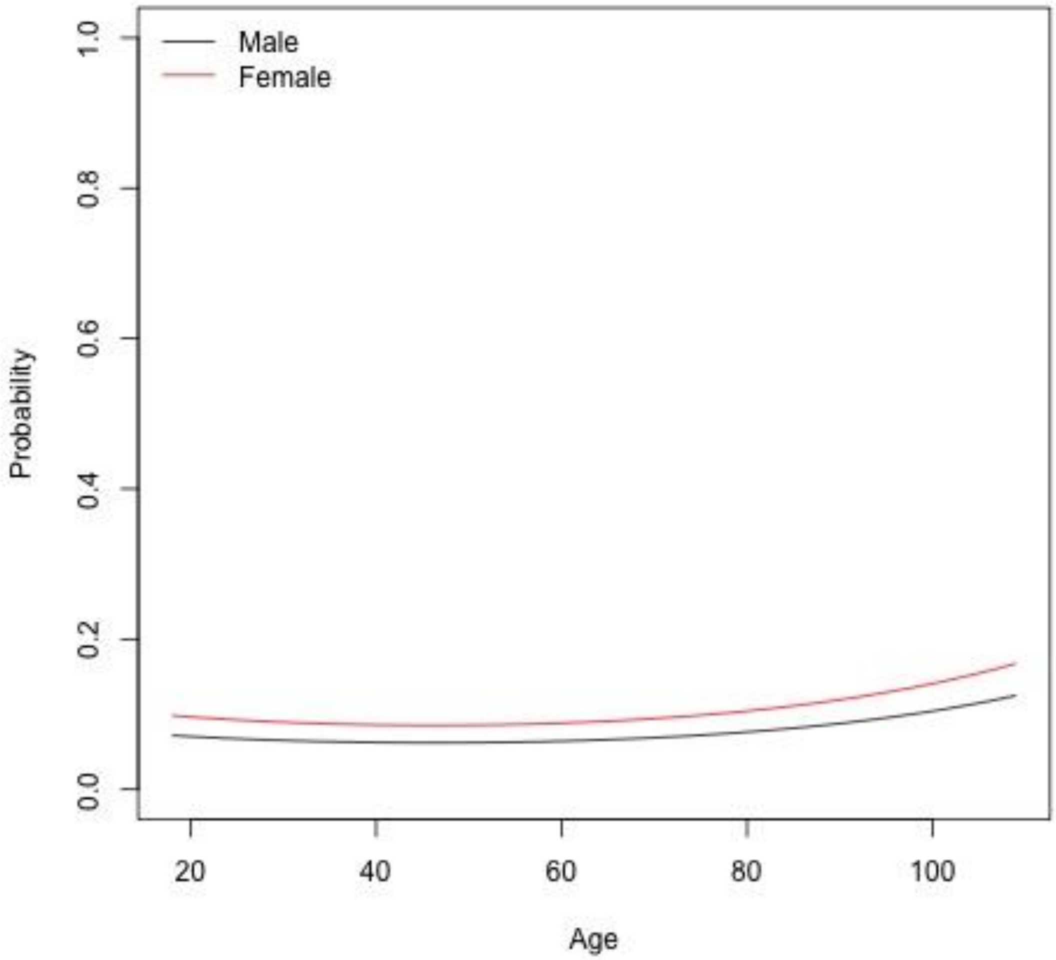


Figure 21: Probability of getting denture treatment, by sex

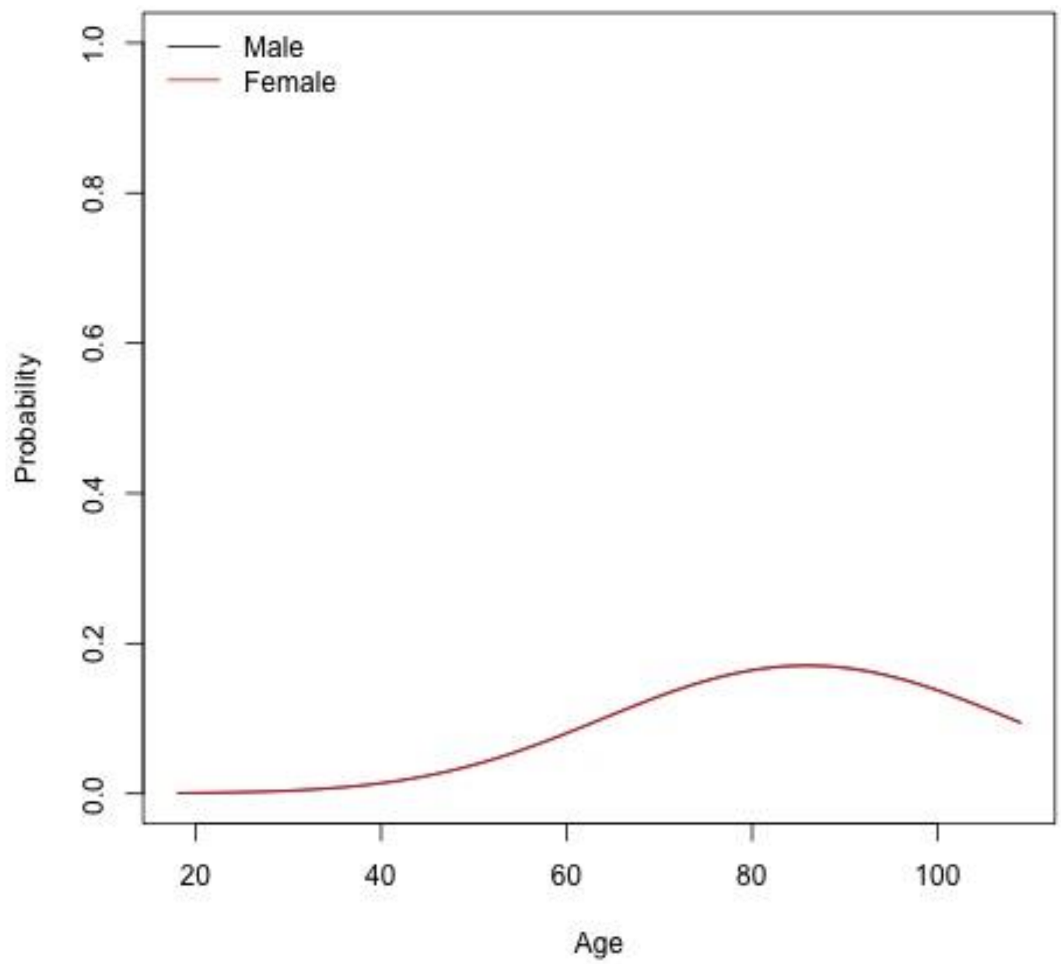


Figure 22: Distribution of dental insurance type by Income Group

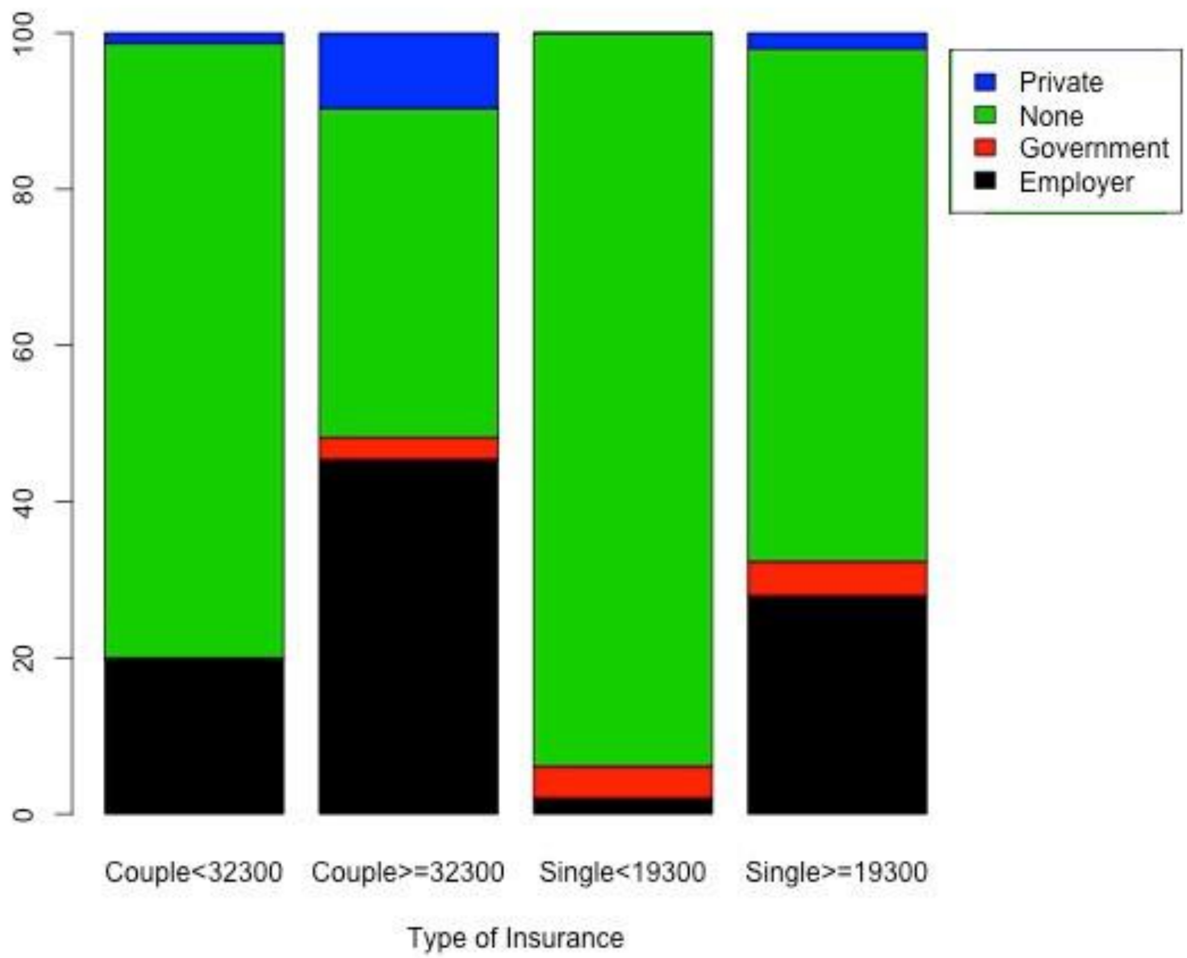


Figure 23: Initial Oral Health Status

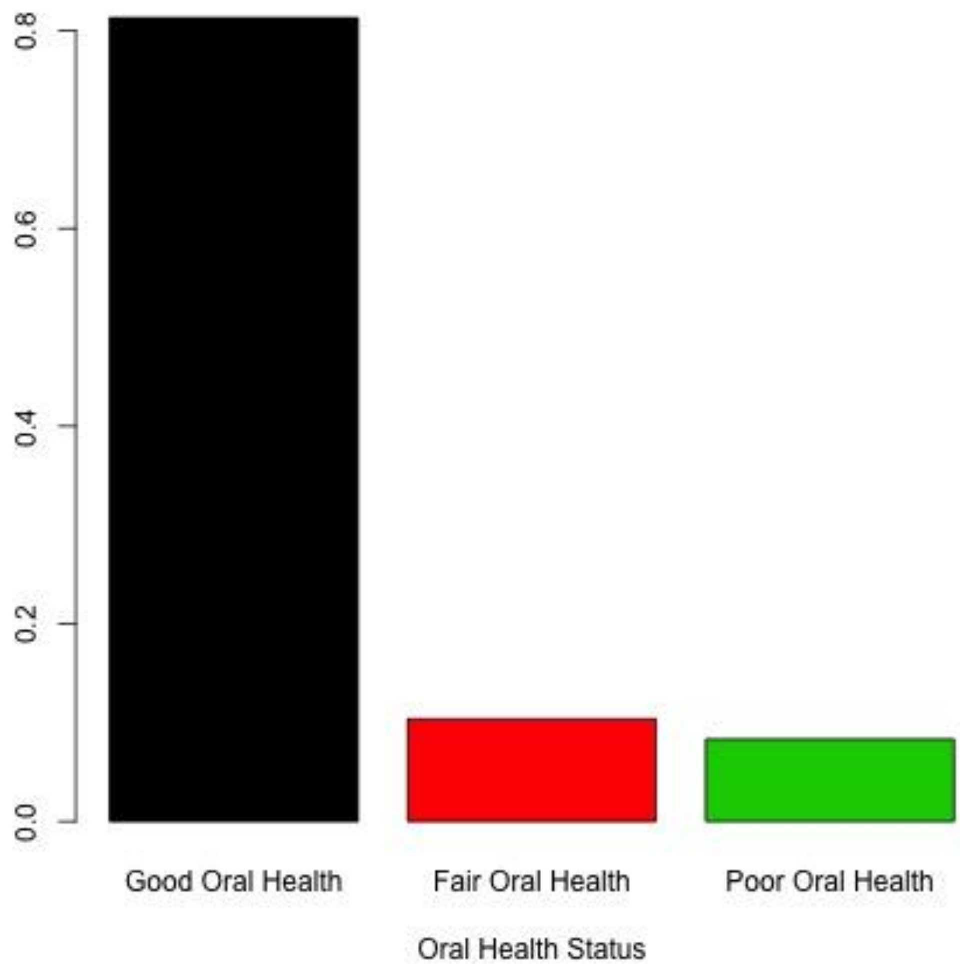


Figure 24: Initial Overall Health Status

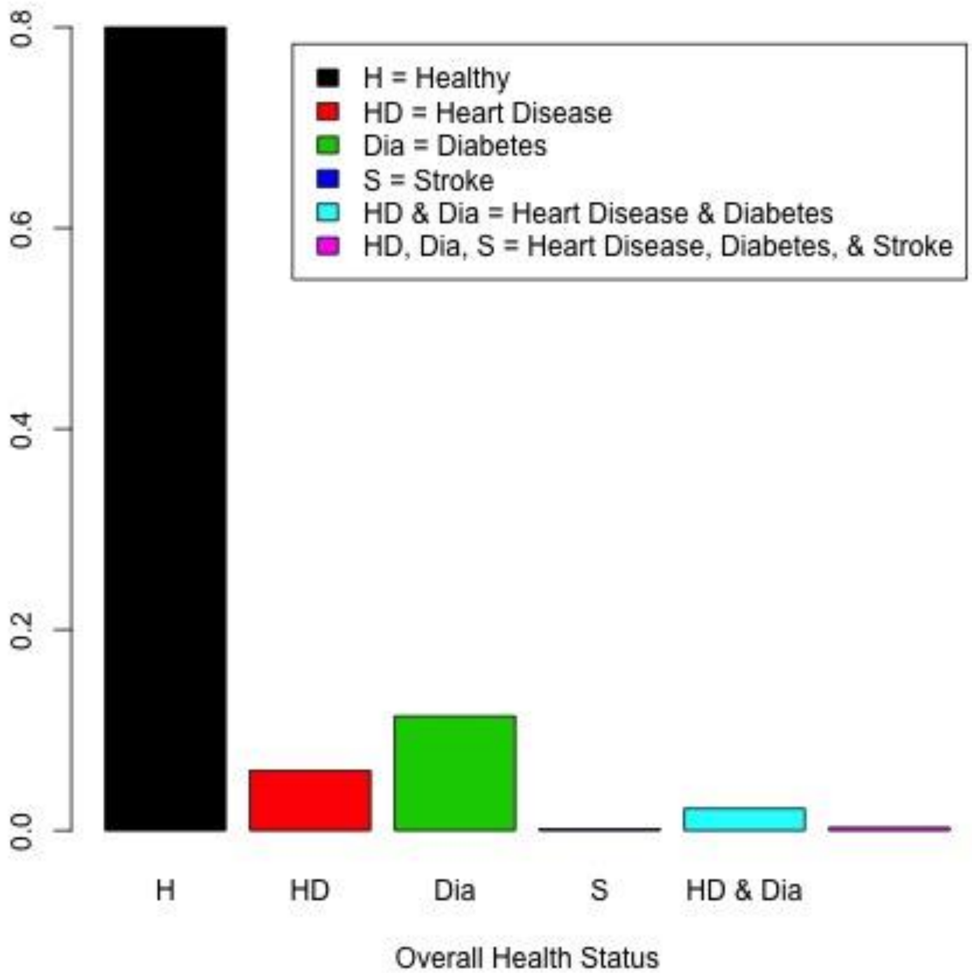


Figure 25: Basic Coverage for Low Income Seniors, Oral Health Only

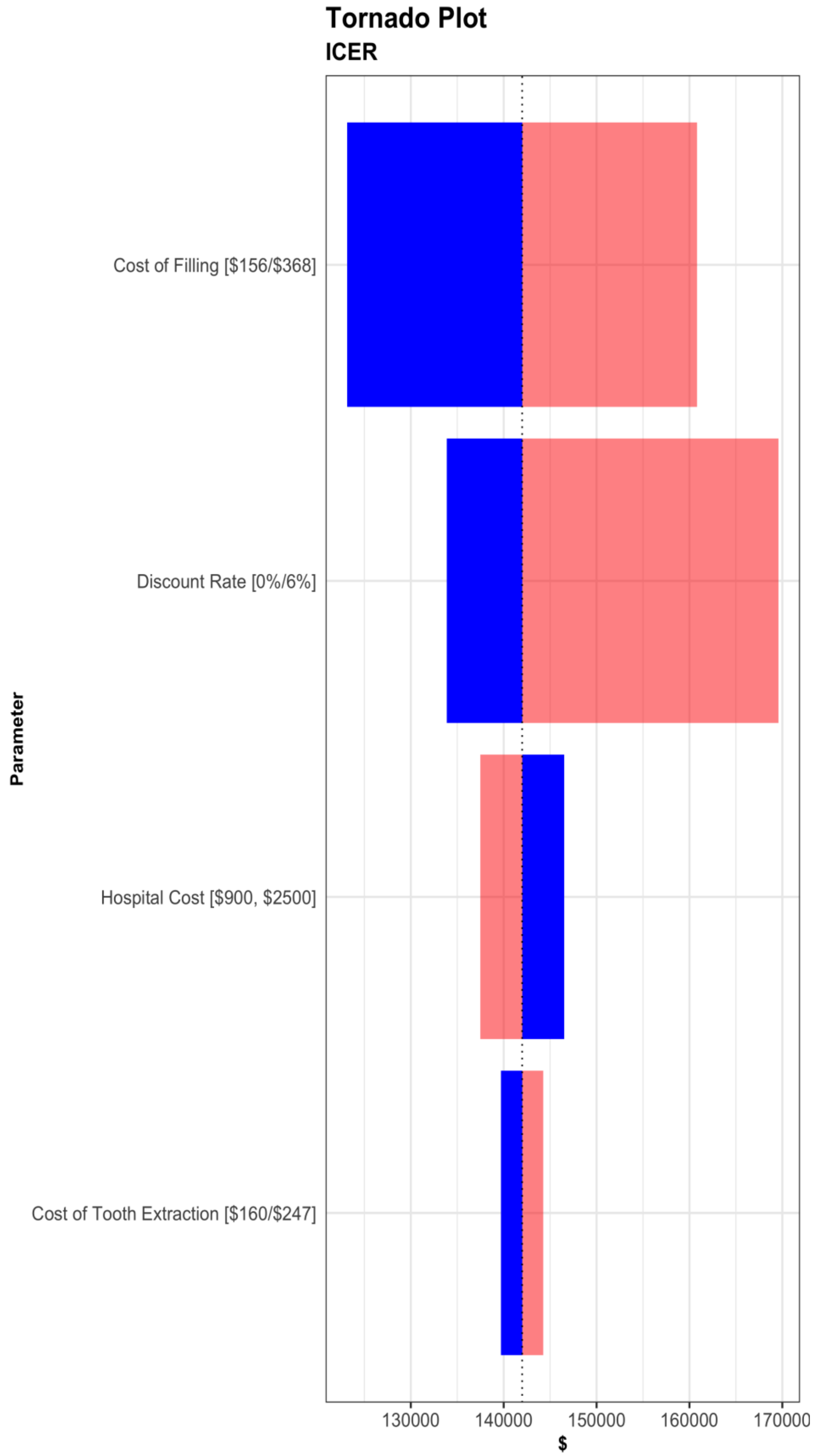


Figure 26: Basic Coverage for Low Income Seniors, Oral & Overall Health

Figure 27: Comprehensive/Core+ for Low Income Seniors, Oral & Overall Health

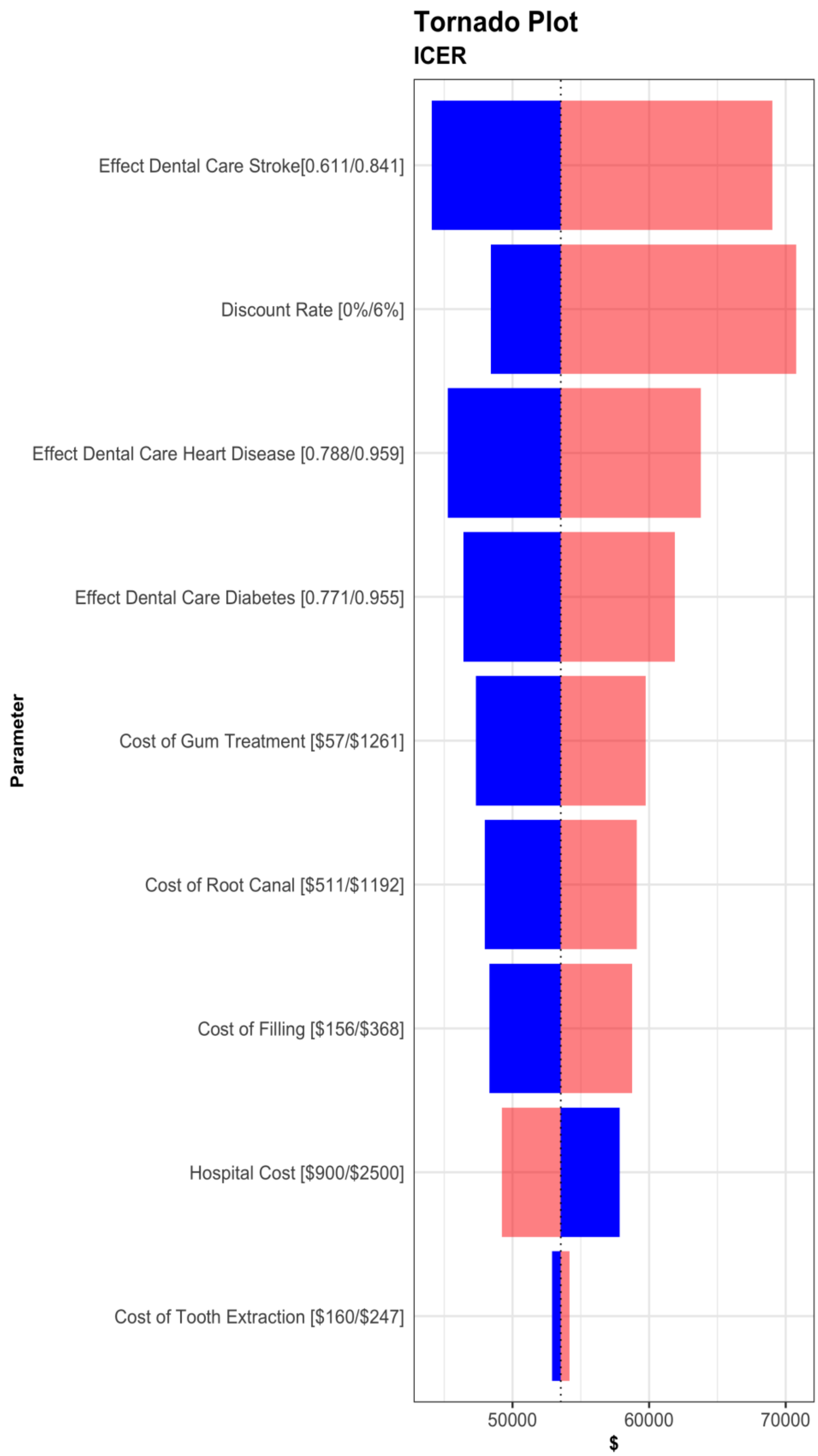
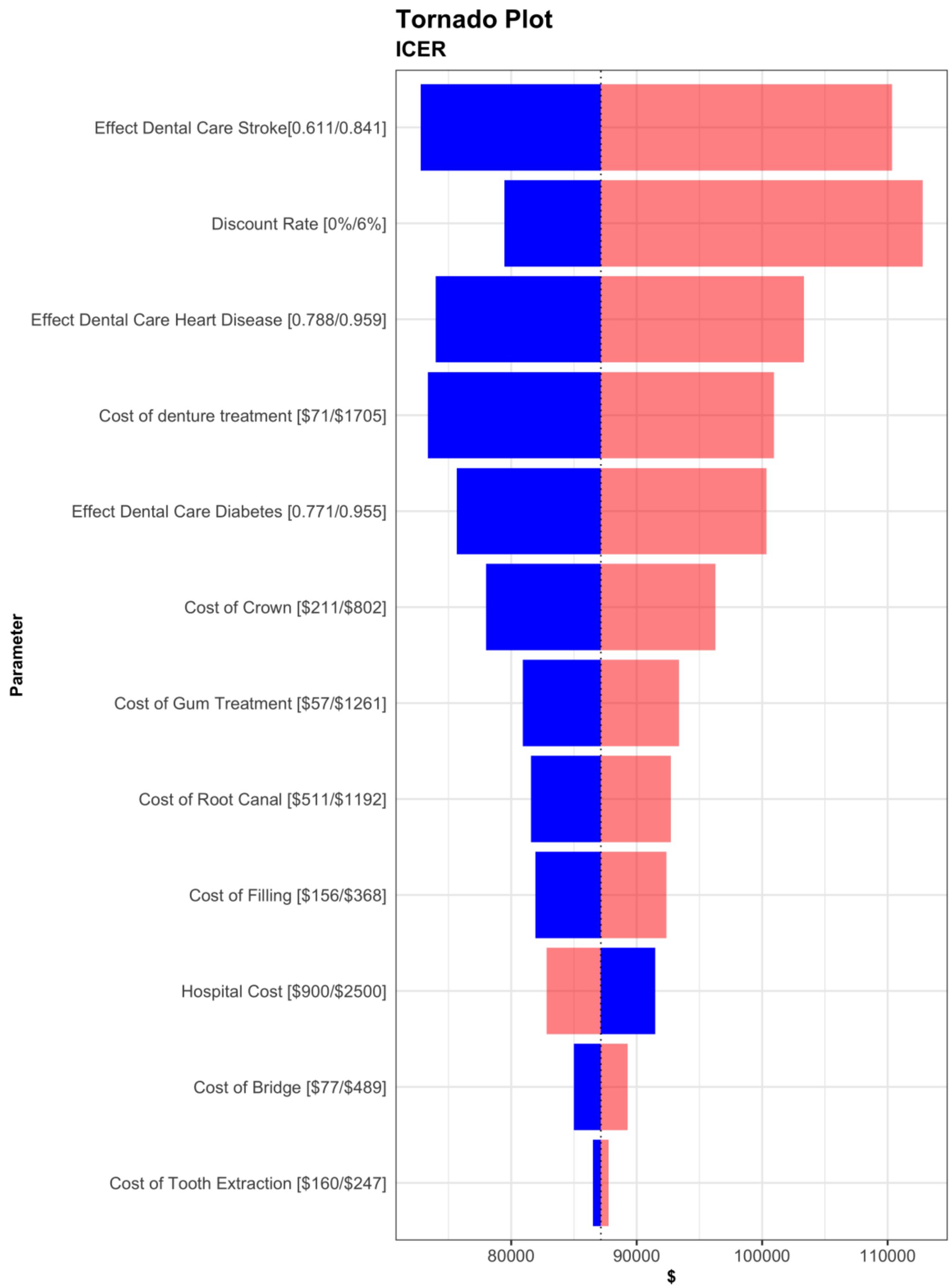


Figure 28: Major/Elite for Low Income Seniors, Oral & Overall Health



Tables

Table 1: Heart Disease Data Descriptive Statistics: Total Pooled Across Waves

	No Dental Use		Dental Use	
	Mean or Proportion	Group Size or [(SD)]	Mean or Proportion	Group Size or [(SD)]
Heart Disease	0.064	857	0.047	1383
Age	69.909	(9)	68.908	(9)
Female	0.645	8708	0.674	19753
Race				
White	0.748	10087	0.878	25716
Black	0.199	2684	0.092	2689
Other Race	0.053	721	0.030	888
Hispanic	0.129	1739	0.060	1763
Education				
Less than high school	0.330	4459	0.104	3046
GED	0.063	853	0.035	1012
High school graduate	0.350	4718	0.323	9453
Some College and Above	0.257	3462	0.539	15782
Married	0.536	7225	0.685	20075
Lagged Health Indicators				
Smoking Status				
Never smoker	0.398	5374	0.491	14374
Former smoker	0.413	5575	0.425	12447
Current smoker	0.188	2543	0.084	2472
Self-assessed Health				
Excellent	0.095	1287	0.170	4975
Very Good	0.290	3908	0.408	11953
Good	0.346	4668	0.301	8829
Fair	0.213	2878	0.100	2933
Poor	0.056	751	0.021	603
High blood pressure	0.583	7870	0.503	14721
Diabetes	0.211	2846	0.137	4024
Depressed	0.221	2987	0.140	4091
Instrument				
Dental Insurance	0.251	3389	0.460	13476
N		13492		29293

Table 2: Diabetes Data Descriptive Statistics: Total Pooled Across Waves

	No Dental Use		Dental Use	
	Mean or Proportion	Group Size or [(SD)]	Mean or Proportion	Group Size or [(SD)]
Diabetes	0.051	714	0.036	1127
Age	70.402	(9)	69.486	(9)
Female	0.634	8847	0.653	20427
Race				
White	0.771	10757	0.895	27985
Black	0.185	2585	0.078	2424
Other Race	0.044	616	0.027	851
Hispanic	0.105	1466	0.049	1542
Education				
Less than high school	0.312	4351	0.097	3044
GED	0.065	903	0.036	1139
High school graduate	0.357	4978	0.316	9884
Some College and Above	0.267	3726	0.550	17193
Married	0.538	7503	0.684	21379
Lagged Health Indicators				
Smoking Status				
Never smoker	0.384	5364	0.480	15002
Former smoker	0.423	5910	0.436	13633
Current smoker	0.192	2684	0.084	2625
Self-assessed Health				
Excellent	0.095	1327	0.165	5154
Very Good	0.289	4040	0.409	12798
Good	0.343	4794	0.300	9377
Fair	0.215	3000	0.102	3175
Poor	0.057	797	0.024	756
High blood pressure	0.573	7995	0.492	15376
Depressed	0.229	3198	0.141	4414
Instrument				
Dental Insurance	0.250	3491	0.448	14020
N		13958		31260

Table 3: Stroke Data Descriptive Statistics: Total Pooled Across Waves

	No Dental Use		Dental Use	
	Mean or Proportion	Group Size or [(SD)]	Mean or Proportion	Group Size or [(SD)]
Stroke	0.021	342	0.011	399
Age	70.501	(9)	69.485	(9)
Female	0.631	10515	0.647	22551
Race				
White	0.756	12597	0.881	30706
Black	0.194	3240	0.089	3087
Other Race	0.050	834	0.031	1064
Hispanic	0.123	2045	0.057	1990
Education				
Less than highschool	0.330	5500	0.105	3656
GED	0.065	1082	0.036	1268
High school graduate	0.346	5773	0.318	11081
Some College and Above	0.259	4316	0.541	18852
Married	0.537	8952	0.685	23860
Lagged Health Indicators				
Smoking Status				
Never smoker	0.387	6454	0.484	16867
Former smoker	0.439	7320	0.437	15249
Current smoker	0.174	2897	0.079	2741
Self-assessed Health				
Excellent	0.082	1370	0.151	5246
Very Good	0.269	4486	0.391	13637
Good	0.345	5754	0.317	11061
Fair	0.236	3939	0.116	4042
Poor	0.067	1122	0.025	871
High blood pressure	0.617	10282	0.523	18225
Heart Disease	0.246	4101	0.197	6877
Diabetes	0.233	3884	0.153	5333
Depressed	0.235	3917	0.145	5060
Instrument				
Dental Insurance	0.251	4182	0.452	15756
N		16671		34857

Table 4: Heart Disease Regression Model

	OR	SE	95% CI		P.value	Sig
Constant	0.013	1.012	0.002	0.092	0.000	***
Dental Care	0.869	0.050	0.788	0.959	0.005	**
Age	0.987	0.028	0.934	1.042	0.637	
Age Squared	1.000	0.000	1.000	1.001	0.056	
Female	0.715	0.049	0.650	0.787	0.000	***
White (ref)	-	-	-	-	-	-
Black	0.678	0.075	0.585	0.786	0.000	***
Other Race	0.956	0.130	0.741	1.233	0.728	
Hispanic	0.645	0.098	0.533	0.781	0.000	***
GED	1.174	0.117	0.933	1.476	0.172	
Less than high school (ref)	-	-	-	-	-	-
High school graduate	1.116	0.069	0.975	1.277	0.111	
Some College and Above	1.134	0.070	0.988	1.301	0.074	
Married	0.907	0.049	0.824	1.000	0.050	*
Never Smoker (ref)	-	-	-	-	-	-
Former smoker	1.211	0.050	1.099	1.334	0.000	***
Current smoker	1.345	0.077	1.157	1.563	0.000	***
Excellent Health (ref)	-	-	-	-	-	-
Very Good	1.489	0.091	1.246	1.779	0.000	***
Good	2.007	0.091	1.679	2.399	0.000	***
Fair	2.534	0.101	2.078	3.090	0.000	***
Poor	4.025	0.127	3.137	5.163	0.000	***
High blood pressure	1.350	0.048	1.228	1.484	0.000	***
Diabetes	1.218	0.057	1.090	1.361	0.001	***
Depressed	1.165	0.059	1.038	1.307	0.009	**

Time fixed effects included.

*, **, & *** denote significance at the 5%, 1%, and 0.1% levels, respectively.

Table 5: Diabetes Regression Model

	OR	SE	95% CI		P.value	Sig
Constant	0.001	1.218	0.000	0.009	0.000	***
Dental Care	0.858	0.055	0.771	0.955	0.005	**
Age	1.120	0.035	1.047	1.200	0.001	**
Age Squared	0.999	0.000	0.999	1.000	0.000	***
Female	0.709	0.054	0.638	0.787	0.000	***
White (ref)	-	-	-	-	-	-
Black	1.225	0.074	1.060	1.415	0.006	**
Other Race	1.268	0.124	0.994	1.617	0.056	
Hispanic	1.399	0.091	1.171	1.672	0.000	***
Less than high school (ref)	-	-	-	-	-	-
GED	1.100	0.120	0.870	1.391	0.427	
High school graduate	0.949	0.073	0.822	1.096	0.480	
Some College and Above	0.872	0.076	0.751	1.013	0.072	
Married	0.939	0.055	0.844	1.045	0.249	
Never Smoker (ref)	-	-	-	-	-	-
Former smoker	1.003	0.055	0.901	1.117	0.953	
Current smoker	0.854	0.086	0.722	1.010	0.066	
Excellent Health (ref)	-	-	-	-	-	-
Very Good	1.352	0.095	1.123	1.629	0.001	**
Good	1.553	0.097	1.283	1.878	0.000	***
Fair	1.876	0.110	1.513	2.326	0.000	***
Poor	2.326	0.140	1.769	3.059	0.000	***
High blood pressure	1.998	0.056	1.791	2.228	0.000	***
Depressed	1.164	0.065	1.024	1.324	0.020	*

Time fixed effects included.

*, **, & *** denote significance at the 5%, 1%, and 0.1% levels, respectively.

Table 6: Stroke Regression Model

	OR	SE	95% CI		P.value	Sig
Constant	0.023	1.859	0.001	0.866	0.042	*
Dental Care	0.717	0.081	0.611	0.841	0.000	***
Female	0.784	0.086	0.662	0.928	0.005	**
Age	0.917	0.050	0.832	1.011	0.081	
Age Squared	1.001	0.000	1.000	1.002	0.003	**
White (ref)	-	-	-	-	-	-
Black	1.001	0.116	0.797	1.256	0.993	
Other Race	0.992	0.212	0.654	1.505	0.971	
Hispanic	0.875	0.158	0.642	1.193	0.399	
Less than high school (ref)	-	-	-	-	-	-
GED	0.974	0.201	0.656	1.445	0.895	
High school graduate	1.209	0.112	0.970	1.507	0.092	
Some College and Above	1.191	0.116	0.949	1.496	0.131	
Married	0.875	0.088	0.735	1.040	0.130	
Never smoker (ref)	-	-	-	-	-	-
Former smoker	1.120	0.086	0.946	1.327	0.189	
Current smoker	1.611	0.130	1.248	2.080	0.000	***
Excellent Health (ref)	-	-	-	-	-	-
Very Good	1.207	0.167	0.870	1.675	0.259	
Good	1.372	0.169	0.984	1.912	0.062	
Fair	1.782	0.182	1.248	2.544	0.001	**
Poor	2.477	0.217	1.620	3.787	0.000	***
High blood pressure	1.374	0.088	1.157	1.633	0.000	***
Heart Disease	1.532	0.085	1.297	1.809	0.000	***
Diabetes	1.406	0.087	1.186	1.667	0.000	***
Depressed	1.299	0.098	1.072	1.574	0.008	**

Time fixed effects included.

*, **, & *** denote significance at the 5%, 1%, and 0.1% levels, respectively.

Table 7: Test for heterogeneity of sex

	Heart Disease	Diabetes	Stroke
P-value on Interaction Term	0.216	0.37	0.66

Table 8: Tests for endogeneity of dental visits

	Rho	P-value
Heart Disease	0.025	0.715
Diabetes	-0.113	0.185
Stroke	0.042	0.682

Table 9: First stage IV results, Heart Disease Model

	Beta	SE	Sig
Constant	-1.576	0.450	***
Dental Insurance	0.509	0.022	***
Age	0.043	0.013	***
Age Squared	0.000	0.000	***
Female	0.190	0.027	***
Black	-0.425	0.037	***
White (ref)	-	-	-
Other Race	-0.186	0.061	**
Hispanic	-0.155	0.046	***
Less than high school (ref)	-	-	-
GED	0.176	0.063	**
High school graduate	0.444	0.036	***
Some College and Above	0.848	0.037	***
Married	0.239	0.025	***
Never smoker (ref)	-	-	-
Former smoker	-0.112	0.027	***
Current smoker	-0.522	0.039	***
Excellent health (ref)	-	-	-
Very Good	-0.055	0.029	
Good	-0.192	0.032	***
Fair	-0.353	0.039	***
Poor	-0.420	0.056	***
High blood pressure	-0.048	0.024	*
Diabetes	-0.121	0.031	***
Depressed	-0.033	0.025	

Time fixed effects included.

*, **, & *** denote significance at the 5%, 1%, and 0.1% levels, respectively.

Table 10: First stage IV results, Diabetes Model

	Beta	SE	Sig
Constant	-1.336	0.441	**
Dental Insurance	0.497	0.022	***
Age	0.037	0.012	**
Age Squared	0.000	0.000	**
Female	0.167	0.027	***
White (ref)	-	-	-
Black	-0.496	0.037	***
Other Race	-0.143	0.065	*
Hispanic	-0.190	0.048	***
Less than high school (ref)	-	-	-
GED	0.202	0.061	***
High school graduate	0.429	0.036	***
Some College and Above	0.848	0.037	***
Married	0.219	0.025	***
Never smoker (ref)	-	-	-
Former smoker	-0.120	0.027	***
Current smoker	-0.538	0.038	***
Excellent health (ref)	-	-	-
Very Good	-0.043	0.029	
Good	-0.185	0.032	***
Fair	-0.365	0.037	***
Poor	-0.344	0.054	***
High blood pressure	-0.074	0.023	**
Depressed	-0.052	0.024	*

Time fixed effects included.

*, **, & *** denote significance at the 5%, 1%, and 0.1% levels, respectively.

Table 11: First stage IV results, Stroke Model

	Beta	SE	Sig
Constant	-1.291	0.428	**
Dental Insurance	0.498	0.021	***
Age	0.035	0.012	**
Age Squared	0.000	0.000	**
Female	0.152	0.025	***
White (ref)	-	-	-
Black	-0.432	0.034	***
Other Race	-0.143	0.057	*
Hispanic	-0.176	0.042	***
Less than high school (ref)	-	-	-
GED	0.193	0.057	***
High school graduate	0.438	0.033	***
Some College and Above	0.848	0.034	***
Married	0.229	0.023	***
Never smoker (ref)	-	-	-
Former smoker	-0.137	0.025	***
Current smoker	-0.546	0.036	***
Excellent health (ref)	-	-	-
Very Good	-0.045	0.028	
Good	-0.167	0.031	***
Fair	-0.333	0.036	***
Poor	-0.379	0.050	***
High blood pressure	-0.072	0.022	**
Heart Disease	-0.057	0.026	*
Diabetes	-0.119	0.027	***
Depressed	-0.042	0.022	

Time fixed effects included.

*, **, & *** denote significance at the 5%, 1%, and 0.1% levels, respectively.

Table 12: Test for instrument validity, all models

	Heart Disease	Diabetes	Stroke
P-value on Dental Insurance	0.34	0.323	0.508

Table 13: Health Utility Regression Results

	Coefficient	Standard Error	95% CI		P-value	Sig
Constant	0.866	0.001	0.863	0.869	0.000	***
Male	0.031	0.002	0.027	0.035	0.000	***
Diabetic	-0.078	0.005	-0.087	-0.069	0.000	***
Stroke	-0.188	0.013	-0.215	-0.162	0.000	***
Heart Disease	-0.094	0.005	-0.104	-0.083	0.000	***
Good Oral Health (ref)	-	-	-	-	-	-
Fair Oral Health	-0.099	0.004	-0.107	-0.091	0.000	***
Poor Oral Health	-0.202	0.008	-0.217	-0.188	0.000	***

*, **, & *** denote significance at the 5%, 1%, and 0.1% levels, respectively.

Table 14: Utility Values for Health States

	Male - Good Oral Health	Female - Good Oral Health	Male - Fair Oral Health	Female - Fair Oral Health	Male - Poor Oral Health	Female - Poor Oral Health
Overall	0.881	0.782	0.679	0.850	0.751	0.648
Heart Disease	0.803	0.772	0.705	0.674	0.601	0.570
Diabetes	0.819	0.788	0.720	0.689	0.617	0.586
Stroke	0.709	0.678	0.610	0.579	0.507	0.476
Heart Disease & Diabetes	0.725	0.694	0.626	0.595	0.523	0.492
Stroke & Heart Disease	0.615	0.584	0.516	0.485	0.413	0.382
Stroke & Diabetes	0.630	0.599	0.532	0.501	0.428	0.397
Stroke, Heart Disease, & Diabetes	0.537	0.506	0.438	0.407	0.334	0.303

Table 15: Hospital Days Regression Model

	Coefficient	Standard Error	Sig
Constant	-1.051	0.179	***
18-19 (ref)	-	-	-
20-24	0.260	0.236	
25-29	0.527	0.207	*
30-34	0.707	0.191	***
35-39	0.289	0.222	
40-44	0.555	0.218	*
45-49	0.414	0.223	
50-54	0.780	0.207	***
55-59	0.707	0.192	***
60-64	0.766	0.188	***
65-69	0.960	0.186	***
70-74	0.948	0.194	***
75-79	1.195	0.194	***
80+	1.642	0.187	***
Income < $20,000 (ref)	-	-	-
Income $20,000-$39,999	-0.199	0.078	*
Income $40,000-$59,999	-0.342	0.089	***
Income $60,000-$79,999	-0.604	0.133	***
Income $80,000+	-0.727	0.139	***
Income Missing	-0.239	0.099	*
Never Smoker (ref)	-	-	-
Current Smoker	0.209	0.088	*
Former Smoker	0.163	0.069	*
Male	-0.120	0.060	*
Diabetes	0.540	0.073	***
Stroke	1.166	0.108	***
Heart Disease	0.769	0.073	***
Poor Oral Health (ref)	-	-	-
Fair Oral Health	-0.516	0.125	***
Good Oral Health	-0.603	0.101	***

*, **, & *** denote significance at the 5%, 1%, and 0.1% levels, respectively.

Table 16: Fees for Selected Dental Services, Ontario

	Fee ($)
Examination and Diagnosis (recall)	33
Scaling, 2 units of time (30 minutes)	114
Polishing, half unit of time (7.5 minutes)	25
Radiographs, Bitewing (4 images)	47

Table 17: MCCSS Fees for Selected Dental Services, Ontario

	Fee ($)
Examination and Diagnosis (recall)	19
Scaling, 2 units of time (30 minutes)	76.02
Polishing, half unit of time (7.5 minutes)	12.67
Radiographs, Bitewing (capped at 2 images)	16.33
Filling	44.34-123.66
Tooth Extraction	38.01-88.69
Root Canal	53.39-570.13
Periodontal treatment	38.01-380.08
Crown	354.74-443.43
Bridge	0
Denture Services	0

Table 18: Heart Disease Prevalence, Male

	No (%)	Yes (%)
18-19	99.61	0.39
20-24	99.43	0.57
25-29	99.36	0.64
30-34	99.43	0.57
35-39	99.25	0.75
40-44	98.47	1.53
45-49	97.70	2.30
50-54	94.73	5.27
55-59	93.04	6.96
60-64	89.13	10.87
65-69	85.00	15.00
70-74	80.77	19.23
75-79	75.02	24.98
80+	73.70	26.30

Table 19: Heart Disease Prevalence, Female

	No (%)	Yes (%)
18-19	99.84	0.16
20-24	99.28	0.72
25-29	99.03	0.97
30-34	99.45	0.55
35-39	99.20	0.80
40-44	98.57	1.43
45-49	98.27	1.73
50-54	96.92	3.08
55-59	95.91	4.09
60-64	94.59	5.41
65-69	92.36	7.64
70-74	88.43	11.57
75-79	83.58	16.42
80+	77.72	22.28

Table 20: Diabetes Prevalence, Male

	No (%)	Yes (%)
18-19	99.29	0.71
20-24	99.55	0.45
25-29	99.23	0.77
30-34	98.52	1.48
35-39	98.35	1.65
40-44	96.17	3.83
45-49	93.41	6.59
50-54	90.67	9.33
55-59	89.54	10.46
60-64	85.23	14.77
65-69	81.94	18.06
70-74	75.79	24.21
75-79	76.49	23.51
80+	82.15	17.85

Table 21: Diabetes Prevalence, Female

	No (%)	Yes (%)
18-19	99.38	0.62
20-24	99.46	0.54
25-29	99.14	0.86
30-34	98.46	1.54
35-39	97.67	2.33
40-44	96.79	3.21
45-49	96.89	3.11
50-54	93.57	6.43
55-59	92.09	7.91
60-64	88.26	11.74
65-69	86.78	13.22
70-74	83.92	16.08
75-79	81.58	18.42
80+	84.15	15.85

Table 22: Stroke Prevalence, Male

	No (%)	Yes (%)
18-19	99.94	0.06
20-24	99.97	0.03
25-29	99.94	0.06
30-34	99.89	0.11
35-39	99.82	0.18
40-44	99.60	0.40
45-49	99.22	0.78
50-54	99.41	0.59
55-59	98.81	1.19
60-64	97.64	2.36
65-69	97.54	2.46
70-74	95.70	4.30
75-79	95.13	4.87
80+	94.12	5.88

Table 23: Stroke Prevalence, Female

	No (%)	Yes (%)
18-19	99.70	0.30
20-24	99.93	0.07
25-29	99.88	0.12
30-34	99.87	0.13
35-39	99.74	0.26
40-44	99.77	0.23
45-49	99.01	0.99
50-54	98.99	1.01
55-59	98.78	1.22
60-64	98.09	1.91
65-69	98.19	1.81
70-74	97.61	2.39
75-79	96.76	3.24
80+	93.42	6.58

Table 24: Mortality Ratios

Source	Disease	Age Group	Male	Female
Preis et al.	Diabetes	45-74	1.81	2.29
Bronnum-Hansen et al.	Stroke	>=25	2.58	2.85
Public Health Agency of Canada	Ischemic Heart Disease	20-39	10.9	17.6
		40-54	4.3	5.8
		55-64	2.7	3.7
		65-74	2.4	2.9
		75-84	1.9	2.2
		85pls	1.7	1.7

Table 25: Dental Care Regression Model

	OR	SE	Sig
Constant	0.576	0.104	***
Income < $20,000 (ref)	-	-	-
Income $20,000-$39,999	1.228	0.035	***
Income $40,000-$59,999	1.706	0.042	***
Income $60,000-$79,999	2.015	0.055	***
Income $80,000+	2.843	0.057	***
Income (Missing)	1.517	0.040	***
Less than high school (ref)	-	-	-
High School Graduate	1.644	0.039	***
Some Post Secondary	1.816	0.068	***
Post Secondary	2.312	0.036	***
Poor Oral Health (ref)	-	-	-
Fair Oral Health	1.449	0.062	***
Good Oral Health	2.574	0.053	***
18-19 (ref)	-	-	-
20-24	0.533	0.096	***
25-29	0.336	0.097	***
30-34	0.342	0.099	***
35-39	0.373	0.099	***
40-44	0.399	0.099	***
45-49	0.396	0.100	***
50-54	0.511	0.096	***
55-59	0.546	0.094	***
60-64	0.579	0.093	***
65-69	0.610	0.092	***
70-74	0.553	0.094	***
75-79	0.552	0.096	***
80+	0.448	0.094	***
Male	0.630	0.026	***
No Insurance (ref)	-	-	-
Government Insurance	2.335	0.052	***
Employment/Private	3.028	0.028	***

*, **, & *** denote significance at the 5%, 1%, and 0.1% levels, respectively.

Table 26: Probability of getting a tooth extracted, by sex

	Male	Female
18-19	0.165	0.137
20-24	0.128	0.106
25-29	0.130	0.107
30-34	0.095	0.078
35-39	0.069	0.056
40-44	0.080	0.066
45-49	0.104	0.085
50-54	0.127	0.105
55-59	0.129	0.107
60-64	0.122	0.100
65-69	0.119	0.098
70-74	0.128	0.105
75-79	0.152	0.126
80+	0.138	0.114

Table 27: Effect of dental care on oral health

	Pr(Good = 1)	Pr(Fair = 1)	Pr(Poor = 1)
Good (Ref)	NA	0.533	0.350
Fair (Ref)	1.875	NA	0.656
Poor (Ref)	2.858	1.525	NA

Table 28: Basic Dental Coverage for Low Income Seniors, Oral Health Only

	Costs	*	QALYs	*	LE	Incremental Costs	*	QALYs Gained	*	LE Gained	ICER
Discount Rate = 0%											
No Treatment	50,355	165	14.038	0.021	18.325						
Treatment	51,265	166	14.045	0.021	18.325	910	8	0.007	0	0	133,870
Discount Rate = 1.5%											
No Treatment	40,236	125	12.104	0.016	18.325						
Treatment	41,016	126	12.11	0.016	18.325	780	6	0.005	0	0	141,987

Table 29: Basic Dental Coverage for Low Income Seniors, Oral and Overall Health

	Costs	*	QALYs	*	LE	Incremental Costs	*	QALYs Gained	*	LE Gained	ICER
Discount Rate = 0%											
No Treatment	50,382	165	14.046	0.021	18.33						
Treatment	51,130	165	14.072	0.021	18.341	748	19	0.025	0.001	0.011	29,508
Discount Rate = 1.5%											
No Treatment	40,244	125	12.111	0.016	18.33						
Treatment	40,896	125	12.131	0.016	18.341	652	15	0.02	0.001	0.011	32,801

Table 30: Comprehensive/Core+ Dental Coverage for Low Income Seniors, Oral and Overall Health

	Costs	*	QALYs	*	LE	Incremental Costs	*	QALYs Gained	*	LE Gained	ICER
Discount Rate = 0%											
No Treatment	50,382	165	14.046	0.021	18.33						
Treatment	51,609	166	14.072	0.021	18.341	1227	20	0.025	0.001	0.011	48,406
Discount Rate = 1.5%											
No Treatment	40,244	125	12.111	0.016	18.33						
Treatment	41,308	126	12.131	0.016	18.341	1064	16	0.02	0.001	0.011	53,532

Table 31: Major/Elite Dental Coverage for Low Income Seniors, Oral and Overall Health

	Costs	*	QALYs	*	LE	Incremental Costs	*	QALYs Gained	*	LE Gained	ICER
Discount Rate = 0%											
No Treatment	50,382	165	14.046	0.021	18.33						
Treatment	52,396	167	14.072	0.021	18.341	2014	24	0.025	0.001	0.011	79,468
Discount Rate = 1.5%											
No Treatment	40,244	125	12.111	0.016	18.33						
Treatment	41,976	127	12.131	0.016	18.341	1733	19	0.02	0.001	0.011	87,143

Table 32: Basic Dental Coverage for Social Assistance Recipients, Oral and Overall Health

	Costs	*	QALYs	*	LE	Incremental Costs	*	QALYs Gained	*	LE Gained	ICER
Discount Rate = 0%											
No Treatment	111,086	297	45.512	0.039	57.658						
Treatment	111,772	297	45.517	0.039	57.658	686	10	0.005	0.001	0.001	142,457
Discount Rate = 1.5%											
No Treatment	58,785	141	30.902	0.021	57.658						
Treatment	59,283	141	30.905	0.021	57.658	498	5	0.003	0	0.001	172,407

Table 33: Comprehensive/Core+ Dental Coverage for Social Assistance Recipients, Oral and Overall Health

	Costs	*	QALYs	*	LE	Incremental Costs	*	QALYs Gained	*	LE Gained	ICER
Discount Rate = 0%											
No Treatment	111,086	297	45.512	0.039	57.658						
Treatment	112,581	297	45.517	0.039	57.658	1494	12	0.005	0.001	0.001	310,319
Discount Rate = 1.5%											
No Treatment	58,785	141	30.902	0.021	57.658						
Treatment	59,899	141	30.905	0.021	57.658	1115	7	0.003	0	0.001	385,580

Table 34: Major/Elite Dental Coverage for Social Assistance Recipients, Oral and Overall Health

	Costs	*	QALYs	*	LE	Incremental Costs	*	QALYs Gained	*	LE Gained	ICER
Discount Rate = 0%											
No Treatment	111,086	297	45.512	0.039	57.658						
Treatment	113,172	298	45.517	0.039	57.658	2086	13	0.005	0.001	0.001	433,154
Discount Rate = 1.5%											
No Treatment	58,785	141	30.902	0.021	57.658						
Treatment	60,327	141	30.905	0.021	57.658	1542	8	0.003	0	0.001	533,396

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