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Oral health, dental insurance and the demand for dental care in Australia

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This study uses data from the 2004-06 Australian National Survey of Adult Oral Health (NSAOH) and a simultaneous equation framework to investigate the interrelationships between dental health, private dental insurance and the use of dental services. The results show that dental health is influenced by social and demographic factors and health behaviours. In turn, these demographics and health behaviours affect the use of dental services, both through their impact on dental health and their influence on the decision to reduce the price of care through insurance. Our findings confirm that affordability is a major barrier to visiting the dentist for oral health maintenance and treatment. We find that if those who currently do not have private insurance were to be covered under the same circumstances as those who do, the probability of an individual visiting the dentist would increase from 43% to 66%. Also, those who do not currently have insurance tend to have lower income, worse oral health status and less education. Reducing the price of dental care by providing some form of insurance coverage would increase dental visits for those whose oral health is most affected by under-treatment.

JEL Classification: C3, D1, I1

Keywords: private health insurance, dental service utilisation, endogeneity, simultaneity, bivariate probit

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1 Introduction

Universal health insurance coverage is available to the vast majority of residents of wealthier countries, but those countries typically offer their citizens much more limited access to subsidised dental services, often severely restricted by age, health status or income (Paris et al., 2010). Yet dental caries, periodontal (gum) disease and tooth loss are common problems. To take just a few examples, over 40% of low income persons aged 20-64 years in the United States in 2005-08 had untreated dental caries, compared with only 16% of high income persons. In Australia, dental problems are ranked among the most frequently reported illness episodes. After adjusting for age and gender almost 40% of low income Australian adults had untreated decay in 2004-06 compared to 17.3% of high income adults, with a similar gradient for periodontal disease and even steeper gradient for inadequate dentition (Spencer and Harford, 2008). Dental services in most OECD countries are dominated by private provision with treatment averaging 5% of total health expenditure and 16% of private health expenditure across in 2009 (OECD, 2011).

In Australia, the health care system is characterized by a mix of public and private health service. While there is a universal public insurance scheme, known as Medicare, that funds free universal access to hospital treatment and subsidised out-of-hospital medical treatment, the dental health care system is dominated by private fee-for-service provision. According to the 2004-06 NSAOH, over 46% of Australians had some dental cover from private insurance[1] and around 10% were treated in the public sector on their last dental visit (NSAOH, 2006). Public sector provision is heavily means-tested and rationed by lengthy waiting lists, and is limited to emergency dental care and general dental treatment. Waiting times are significant, with the average exceeding two years in some states and up to five years in some locations. A main purpose of this study is to explain the current pattern of dental visits in Australia, and to simulate the impact of reductions in the price of services on visiting patterns for dental care. Affordability is generally not the only barrier to adequate dental care, but it is a significant one. Providing a level of subsidy that would reduce out of pocket costs is likely to improve visiting patterns and oral health, particularly for those without private insurance.

There is a substantial literature on the effect of insurance on the health service utili-

[1]Unlike many other OECD countries where health insurance is largely employer-funded and is considered a work-related benefit, responsibility for paying for dental services in Australia falls largely on the individual. Despite a large number of health funds, the insurance market is concentrated. Insurers generally offer two main types of coverage - hospital and ancillary - but many products differentiated by price, level of cover, etc are available in the Australian market. These ancillaries can cover a broad range of product and services such as dental including endodontic and orthodontic, optical, pharmaceuticals, physiotherapy, podiatry and psychology. Policies differ in terms of out-of-pocket payments and benefits covered. For further details on the Australian health insurance structure, see Colombo and Tapay (2003).

sation and a more limited literature on the factors that influence the demand for dental services (see, for example, Holtmann and Olsen Jr, 1976; Hay et al., 1982; Hopkins et al., 2013). A limitation of this literature is that it is often difficult to identify the effect of dental health on dental service use where causality runs in both directions. In particular the observed and unobserved characteristics of individuals that influence oral health are also likely to influence the demand for insurance and the demand for health services. This paper contributes to that literature by employing a system of simultaneous equations to model the determinants of dental health, dental insurance and dental service use. We specify a system of equations to estimate the demand for health, private health insurance, and dental service utilisation, accounting for those common unobserved characteristics of individuals that determine oral health, service use and the decision to purchase insurance. Importantly, we allow for the potential reverse causation between dental service utilisation and dental health, and we account for the potential endogeneity of private health insurance in dental health service utilisation. We use a particularly rich data source, the NSAOH 2004-06, which contains objective measures of oral health and dental health risk behaviours, that are not usually available in general health surveys (NSAOH, 2006). Given the complexity of our model we estimate it in two stages. In the first stage we estimate a reduced form of dental health, and in the second stage we estimate a bivariate probit using the full information maximum likelihood (FIML) method, with predicted values of latent health from the first stage. The other novelty in our study is that it uses the NSAOH, a particularly rich data source which contains objective measures of oral health and dental health risk behaviours.

The findings of this study indicate a positive effect of dental health on insurance purchase, consistent with the notion of advantageous selection (Dardanoni and Li Donni, 2012; De Meza and Webb, 2001), i.e. that individuals with better dental health are the ones most likely to purchase insurance. These results also show a negative effect of health risk behaviours on insurance purchase suggesting that risk aversion is an important element in the decision to purchase insurance. Individuals who are risk averse tend to engage in behaviours that minimise risk, such as taking out private insurance and having a higher rate of oral self-care. We find that having private dental insurance significantly increases dental service use, but we observe a negative relationship between oral health and service utilisation. While such effects have been interpreted as moral hazard in the literature, it would be inappropriate to draw strong conclusions; without an assessment of the nature and frequency of dental visits it is not possible to distinguish between the effect of *ex post* moral hazard on treatment and the effect of risk attitude on the demand for preventive services. Our study also finds evidence of some significant social disparities

in dental health outcomes and service utilisation.

2 Literature

In the broader literature of health care utilisation and private health insurance, studies have mostly ignored the simultaneous relationships between insurance, health and service utilisation. Some recent studies have modelled the endogeneity of insurance using Instrumental Variable (IV) and bivariate models (Harmon and Nolan, 2001; Savage and Wright, 2003; Koç, 2005; Hopkins et al., 2013). A few studies have explored the relationship between health and insurance in order to examine issues such as moral hazard and adverse selection - two commonly observed features of many insurance markets (Barrett and Conlon, 2003; Doiron et al., 2008) - however, no study has taken into account the simultaneous determination of health, health insurance, and health service utilisation.

There have been a small number of published empirical studies on the demand for dental services. Holtmann and Olsen Jr (1976) estimated a single linear regression model for dental visits using household-level survey data from New York and Pennsylvania. The results suggested a significant but low price elasticity of demand (-0.032 to -0.187) with a positive income elasticity. They found that the inclusion of interaction terms for taste variables (such as fear of the dentist by the head of household) had large effects on the results, and that the lowest income classes were the most sensitive to money and time prices. A later paper by Hay et al. (1982) used a similar theoretical structure to underpin a simultaneous equation model of latent dental health and the annual number of dental health visits by Blue Cross/Blue Shield employees in Greater New York. The estimated price elasticity of demand was negative and low (-0.2) with age negatively related to dental use. In contrast to the underlying theory, they failed to find any statistically significant relationship between the dental health status measures and contemporaneous dental service use in either direction.

A series of studies based on the RAND health insurance experiments in the US highlighted the role of insurance in dental service utilisation (Manning Jr and Phelps, 1979; Manning et al., 1985, 1987). In particular they showed that utilization of dental services increased significantly as cost-sharing declined, particularly as deductibles fell toward zero; enrollees in the free plan had 34% more visits than enrollees in the 95% coinsurance plan (Manning et al., 1985). Several studies recognised the two-part character of the decision-making process in medical services (Manning et al., 1987; Pohlmeier and Ulrich, 1995; Sintonen and Maljanen, 1995). Sintonen and Maljanen, for example, estimated a low but significant price elasticity of -0.069 using a sample of employees of Finnish

sickness funds; in the first stage they estimated the probability of reporting a visit to a dentist at least once every two years, while in the second stage self-reported gross expenditure was modelled for those who visited a dentist. Using a similar model, Mueller and Monheit (1988) studied the effects of insurance on demand by a standard population of white adults aged 16 to 64 years using the US National Medical Care Expenditure Survey; they found that imposing a generous first-dollar coverage - insurance with no deductible and a co-insurance not exceeding 10% - increases dental visits by 29%. In a two-step Heckman style model of utilisation and expenditure Grytten et al. (1996) used a sample of Norwegian military draftees, pseudo-randomised to access to a public dental care plan with a 75% subsidy by county of residence, to estimate the response of the demand for dental services to enrolment in the subsidy plan. They also estimated a single count variable equation for dental health (the number of decayed surfaces) on a wider sample and examined if the subsidy improved dental health. Surprisingly, they found that the public subsidy scheme had no effect on visits to the dentist, the amount of services used, and dental health.

In a more recent study, Choi (2011) uses a difference-in-differences technique to compare the annual dental service use of low-income parents in states with and without adult Medicaid dental coverage. His findings suggested that adult Medicaid dental benefits increased the likelihood of a dental visit by up to 22% among low income people who typically experience the worst dental health. Another study by Hopkins et al. (2013) used the Australian National Health Survey data to explore the relationship between private dental health insurance and dental health service utilisation measured by time period since last dental consultation. Since ancillary insurance in Australia mostly covers both dental and optical services, they used information on whether the respondent or/and household member wore glasses or contact lenses in order to identify the insurance purchase decision. They found that individuals with insurance have more frequent dental consultations than those without insurance. Specifically, individuals who had an insurance policy were estimated to have around 30% higher chance of having visited a dentist in the previous 3 months. They were not, however, able to control directly for oral health and were limited to self-assessed general health to explain dental visits.

In most of the above studies, insurance status is either modelled as a random variable, or viewed as predetermined as a result of workplace policy or government provision, while dental health status is usually assumed to be an independent determinant of dental service use - what Sintonen and Maljanen term 'cautiously exogenous' (Sintonen and Maljanen, 1995) [page 459]. On the other hand, some studies have argued that insurance is potentially endogenous given that individuals who purchase private insurance are likely to

be those who anticipate, based on private information, a higher-than-average demand for dental care. Hopkins et al. (2013), for instance, found a significant bias in the estimated effect of insurance when the latter is treated as an exogenous variable as compared to when they accounted for its endogeneity. As far as we are aware, this paper is the first to estimate the demand for a health service within a framework that addresses the simultaneity and endogeneity issues associated with insurance purchase, health and service utilisation. In doing so we expect to produce more consistent estimates of the responsiveness of dental health service utilisation to changes in the price of insurance and the consequent change in dental health status.

3 Theoretical Framework

The canonical Grossman model (Grossman, 1972b,a) of the investment and consumption demand for the durable good dental health where individuals maximise intertemporal utility that is a function of the flow of health and the consumption of non-health commodities, suggests a typical formulation for the conditional demand for medical or dental services (Wagstaff, 1986; Pohlmeier and Ulrich, 1995):

$$LnD_t = \beta_0 + lnH_t + \beta_1 lnw_t - \beta_2 lnP_t^d + \beta_3 t + \beta_4 X + \beta_5 E + u_t \tag{1}$$

The utilisation of a particular type of dental health service, D, at age, t, is influenced by the latent variable, dental health status, H, the wage rate, w, representing the opportunity cost of time, a vector of dental health service prices, P^d, a vector of observed personal characteristics, X, that are associated with personal preferences for dental health, and the stock of knowledge, E, that both influences preferences and increases the productivity of investment in health.

In a human capital approach like this dental health is a choice variable because it is both a direct source of satisfaction and a determinant of income and wealth. The empirical strategy is to explain the two variables, dental service use and dental health, in terms of the set of exogenous factors that underpin Equation 1 and use insurance as the price of dental services, P^d. We use a rich set of observables and address simultaneity and endogeneity by specifying a system of equations.

4 Econometric Specification

Following the theoretical model described above, we specify the demand for dental care as follows:

$$Y_v^* = \mathbf{x}_v{}' \, \beta_v + \gamma_v^h Y_h^* + \gamma_v^i Y_i + \mu_v \tag{2}$$

where Y_v^* is the propensity to use dental services; Y_h^* is the latent measure of dental health; Y_i is the individual's observed insurance status; $\mathbf{x}_v$ is a vector of exogenous covariates; β_v is a vector of unknown coefficients; and μ_v is a vector of random error terms. Note here that latent health enters the demand equation because the underlying dental health of an individual is not directly measurable.

Estimating the effect of dental health in Equation 2 is complicated by two factors. First, the causation between dental health and visit to dentist may run in opposite direction with visit potentially influencing oral health. Regular check-ups, for instance, may have a positive impact on dental health. Second, the relationship between visit to dentist and dental health may be confounded by unobserved factors such as risk. A risk averse person will be more likely to have preventive routine check-ups and at the same time more likely to maintain good oral health. The endogeneity of dental health is therefore addressed by specifying an equation for an individual's underlying latent health as follows:

$$Y_h^* = \mathbf{x}_h{}' \, \beta_h + \gamma_h^v Y_v^* + \mu_h \tag{3}$$

where $\mathbf{x}_h$ is a vector of exogenous covariates; β_h is a vector of unknown coefficients; and μ_h is a vector of random error terms. Also note that the use of latent health instead of self-reported health status represents a way of purging measurement errors from self-reported dental health status (see, for example, Bound, 1991; Johnston et al., 2009).[2]

Given the institutional set-up discussed earlier, private dental insurance status is a key determinant of the decision to visit a dentist. At the same time, the insurance variable is potentially endogenous due to common unobservable factors affecting the decision to purchase insurance and the decision to visit a dentist. For instance, an unobserved characteristic, such as risk aversion, could influence both the demand for dental services and the decision to purchase private dental insurance cover. The endogeneity of insurance may also arise because of moral hazard and adverse selection (Koç, 2005; Savage and

[2]Specifically, if we assume $Y_h^* = Y_h^{**} + \epsilon_h$ and $Y_h^* = \mathbf{x}_h' \, \beta_h + \gamma_h^v Y_v^* + \nu_h$, ϵ_h the reporting error and ν_h a random variable orthogonal of Y_v^* and $\mathbf{x}_h$, then we can obtain Equation 3 by substituting $(\nu_h + \epsilon_h)$ with μ_h. See Bound (1991) and Bound et al. (1999) for more details.

Wright, 2003; Cardon and Hendel, 2001; Vera-Hernandez, 1999) such that individuals who purchase private insurance are likely to be those who anticipate, based on private information, a higher demand for dental service use. Ignoring such adverse selection may lead to an overestimation of its impact on the demand for health services. To address the potential endogeneity of insurance, we have entered insurance status in Equation 2. The dental insurance equation is specified as:

$$Y_i^* = \mathbf{x}_i' \, \beta_i + \gamma_i^h Y_h^* + \mu_i \tag{4}$$

Without loss of generality, Y_v^* and Y_i^* are mapped to some observable binary discrete variables Y_v and Y_i such that:

$$Y_j = \begin{cases} 1 & \text{if } Y_j^* > 0 \\ 0 & \text{if } Y_j^* \leq 0 \end{cases} \quad (j = v, i) \tag{5}$$

In particular, we have two states for each of the two latent variables. For the demand for dental service use, $Y_v = 1$ indicates that the individual visited a dentist, 0 otherwise while for insurance status, $Y_i = 1$ if the individual has a dental insurance, 0 otherwise. For dental health we observe four levels of self-assessed health varying from poor to excellent. The latent health Y_h^* is therefore translated into the observed variable Y_h by the following mapping:

$$Y_h = \begin{cases} 0 & \text{poor or fair} & \text{if } Y_h^* \leq \mu_1 \\ 1 & \text{good} & \text{if } \mu_1 < Y_h^* \leq \mu_2 \\ 2 & \text{very good} & \text{if } \mu_2 < Y_h^* \leq \mu_3 \\ 3 & \text{excellent} & \text{if } Y_h^* > \mu_3 \end{cases} \tag{6}$$

where the μ_i's are unknown threshold parameters.

Equations 2, 3, 4, 5 and 6 constitute a system of ordered and probit models which we estimate in two stages. Specifically, we estimate the reduced form equations of health and demand for dental service use in the first stage. Note, $\mathbf{x}_v$ and $\mathbf{x}_h$ may have some common variables, but for identification purposes each should contain at least one equation specific variable. Writing Equations 2 and 3 in their reduced forms results in:

$$Y_v^* = \mathbf{x}\pi_v + \varepsilon_v^* \tag{7}$$

$$Y_h^* = \mathbf{x}\pi_h + \varepsilon_h^* \tag{8}$$

where $\mathbf{x}$ is the set of all exogenous variables in $\mathbf{x}_v$, $\mathbf{x}_h$, and $\mathbf{x}_i$; π_v and π_h are the reduced-form coefficient parameters; and ε_v^* and ε_h^* are the error components.

Equations 7 and 8 are estimated using a probit model and an ordered probit model respectively, and the consistent estimates of π_v and π_h, denoted as $\hat{\pi}_v$ and $\hat{\pi}_h$, are used

to construct the predicted latent functions of health and demand for dental service use as follows:

$$\hat{Y}_v^* = \mathbf{x}\hat{\pi}_v \tag{9}$$

$$\hat{Y}_h^* = \mathbf{x}\hat{\pi}_h \tag{10}$$

In the second stage we replace $\hat{Y}_h^*$ in equations 2 and 4 and estimate the dental visit and insurance equations.[3] However, instead of estimating two univariate probits, here we estimate a bivariate probit model to account for the endogeneity of the insurance variable. Specifically,

$$\begin{aligned} Y_v^* &= \mathbf{x}_v{}' \, \beta_v + \gamma_v^h \hat{Y}_h^* + \gamma_v^i Y_i + \varepsilon_v \\ Y_i^* &= \mathbf{x}_i{}' \, \beta_i + \gamma_i^h \hat{Y}_h^* + \varepsilon_i \end{aligned} \tag{11}$$

Assuming that the error terms ε_v and ε_i jointly follow a bivariate normal distribution, that is $(\varepsilon_v, \varepsilon_i)' \sim BVN[0, \Sigma]$, the variance-covariance matrix Σ is given by

$$\Sigma = \begin{pmatrix} 1 & \rho_{vi} \\ \rho_{vi} & 1 \end{pmatrix},$$

where ρ_{ij} is the correlation coefficient between ε_v and ε_i. While many of the variables overlap in $\mathbf{x}_v$ and $\mathbf{x}_i$, they also contain a set of instruments in order to facilitate identification. For excluded instruments to be valid in an IV framework, variables excluded from one equation (used to instrument the right-hand side endogenous variable in that equation) should not be correlated with the variable of interest. Identification is also ensured through a highly non-linear specification. The bivariate probit specification with potentially non-zero off-diagonal elements in Σ allows for correlations across the disturbances of the two equations which embody unobserved characteristics of the same individuals. Note that the assumption of unit variance ensures the parameters can be identified separately from the variance of ε_v and ε_i (Greene, 2003). The system of equations are estimated on Stata. The adjusted standard errors of the second stage parameters are obtained using the bootstrap method with 1000 repetitions. The computation of marginal effects in this model is fairly complex given the endogenous structure of the model and the presence of common variables across the three equations. We therefore estimate them via numerical derivatives of the multivariate normal distribution functions with respect to the exogenous variables. Consider, for example, X^* that appears in all three equations. If we were to compute the marginal effect of X^* on say, visit to dentist, this would be comprised of a direct effect of X^* on visit to dentist and indirect effects through the insurance status and

[3]Note we can also estimate the impact of dental visit on dental health by replacing $\hat{Y}_v^*$ in the structural probit model in equation 3.

latent health variables given the latter enter the dental visit equation (see, Greene, 2003). Standard errors of the estimated marginal effects and treatment effects are computed using the delta method. Marginal effects are estimated on GAUSS 12. Since the joint and conditional probabilities are highly non-linear functions of $\mathbf{x}$, analytical solutions of marginal effects are difficult to obtain. Thus, the marginal effects are calculated using numerical gradients. The marginal effects of the explanatory variables are estimated at the respective means of the variables though in the case of the insurance variable, we decompose the results into the average treatment effect on those that have an insurance (the treated) and on those who don't (the untreated) to provide evidence of the potential impact of increasing insurance coverage. The standard errors of the marginal effects are then estimated using the delta method.

5 Data and Variable Specifications

The data set we use in this paper is the 2004-06 National Survey of Adult Oral Health (NSAOH) which contains more comprehensive information on participants' dental health statuses (NSAOH, 2006). A three-stage stratified clustered sampling design was used in the survey to randomly select from a target population of Australian residents aged 15 years or more. Specifically, the probability proportional to size (PPS) sampling method was used where size was defined as the number of households listed in the Electronic White Pages (EWP) in each postcode. Within each sampling household, one person was randomly selected by a computer algorithm. Participants with their original teeth were invited to undergo a standardised dental examination conducted by trained dentists in a local clinic, where levels of tooth loss, dental decay experience, tooth wear and signs of gum disease were recorded. Every effort was made to interview the target person although, in certain circumstances, the questions were answered by another adult in the form of a proxy interview. The survey also collected a wide range of self-reported information such as private health insurance arrangements, general health status, health risk behaviors, and socio-demographic characteristics through computer-assisted telephone interviews[4].

Two more surveys followed the NSAOH in 2008 and 2010 and were known as the National Dental Telephone Interview Surveys (NDTIS)(NDTIS, 2010). The NDTIS surveys were based on a two-stage stratified clustered sampling design that differed from the NSAOH in that no dental examination was conducted. For the 2008 NDTIS sample, the target population was residents aged 5 years or older, while for the 2010 NDTIS sample,

[4]See details in Slade et al. (2007)

residents aged 2 years and over were included[5]. We choose to restrict the study to the 2004-06 NSAOH data set which is more comprehensive and contains crucial information on dental health. Nonetheless, we present some trends in insurance participation and dental service utilisation over the three surveys in Table 1. We note a gradual increase in the percentage of individuals who had some dental insurance cover over the years from 48% in 2004-06 to 60% in 2008-10. The proportion of insurance holders among those who had access to public dental services increased from 29% to 37% over the same period. On the other hand, the proportion of insurance holders conditional on having access to public dental services increased gradually from 56% to 66%. With regard to dental service utilisation, the proportion of those who had made a recent visit (i.e in the year prior to the survey) remained constant at around 63% across all the survey years. Comparing utilisation rates among those who had insurance cover with those who did not, we find that having some level of dental insurance cover does have a significant impact on visits. Specifically, in 2004-06 around 72% of those who had dental insurance reported a recent trip to a dentist compared to 53% of those without cover.. These proportions remained more or less constant over the years. Likewise, the proportion of those without private cover but with access to public dental care who had made a recent visit to a dentist remained constant at around 52% across the years. Clearly, having private dental insurance makes an individual more likely to visit a dentist, while having nominal access to public dental services does not necessarily lead to an increase in dental service utilisation. This is consistent with a public system characterised by high eligibility thresholds and significant waiting times (see, for example, Hopkins and Kidd, 2012).

Table 1: Trends in Private Dental Insurance and Service Utilisation

	2004-06	2006-08	2008-10
Private insured	48.4%	56.0%	59.6%
Private insured|Access to public	28.8%	37.5%	37.3%
Private insured|No access to public	55.5%	62.7%	65.9%
Dental visit	62.5%	63.0%	63.3%
Dental visit|Privately insured	72.3%	71.5%	71.6%
Dental visit|Not privately insured	53.3%	52.2%	51.0%
Dental visit|Not privately insured, Access to public	51.3%	51.9%	51.7%

Very few studies in the literature have estimated an elasticity of demand for dental health insurance given the difficulty of obtaining information on insurance premium. The inclusion of such information is an important feature of our empirical analysis. In this paper, we construct individual-specific data for the price of insurance following Butler (1999), and use financial statements of insurance funds and other information published

[5]Details on these surveys are available in Stewart and Ellershaw (2012) and Brennan and Ellershaw (2012)

by the Private Health Insurance Administration Council (PHIAC), the body responsible for regulating the health insurance industry (PHIAC, 2007), to estimate a premium and an expected benefit which we then use to generate the age and gender-specific price of ancillary cover for every state. In particular, we estimate premiums at state level using premium revenue data for each insurer, benefits paid by type of policy (hospital vs ancillary), and the number of policies sold. An average administrative loading is first estimated for each state using the ratio of total premium revenue to total benefits. It is then multiplied by total benefits and divided by the number of single-equivalent policies to obtain an estimate of the premium for a single ancillary policy for each state.[6] Premiums for family policies are taken as double, and because of the community rating regulations, these premiums are assumed to be invariant with respect to age and sex for all individuals within a state. If Z is the premium for insurance and B the expected benefit, with an actuarially fair premium, $Z = B$ and $Z/B = 1$. The ratio of premium to expected benefit can be taken as the price of insurance, i.e. the price paid per dollar of expected benefits received. An estimate of price is therefore obtained by dividing the relevant estimated premium with benefits paid in each state. Because we have information on benefits paid by age group and gender, this allows us to estimate an age and gender-specific price for each state. This results in a significant amount of variation in the price data. We then assign this price to individuals based on their gender, age and the state in which they reside.

This study focuses on a sample of 11,231 Australian adults aged 15 and over, after dropping missing observations. All three dependent variables in our analysis (dental health status Y_h, dental insurance cover status Y_p, and dental visit Y_v) are dichotomous variables constructed using various survey questions. Questions related to dental health were as follows: *How would you rate your own dental health? Would you say that it is excellent, very good, good, fair or poor? Questions on dental insurance and utilisation were: Do you have private insurance cover for dental expenses? How many dental visits did you make in the last 12 months?* The dental health variable takes a value of 1 if the individual's self-assessed dental health was good to excellent, and 0 otherwise. The insurance variable represents the status of individuals who, at the time of the survey, held private insurance coverage for dental expenses. The dental visit variable takes a value of one if the individual had visited a dentist in the 12 months prior to the survey, and 0 if otherwise.

[6]Note we could only estimate a price for ancillary cover that includes a range of services other than dental; however, the majority of benefits paid is accounted by dental (44%) followed by chiropractic (14%), physiotherapy (13%) and optical account (10%), with negligible amount paid towards a range of other services. While we have information on benefits paid by types of cover, we do not have a further breakdown of paid benefits by age and gender or the number of policy holders by types of covers.

In terms of explanatory variables, common covariates in both the insurance and visit equations are demographic controls: age; gender; ethnicity; remoteness (with living in the capital city as the base category); whether the individual was born in Australia; whether a language other than English is spoken at home; whether the individual has attained educational qualifications beyond year 12; individual income (as one of eight bands, with the highest as the reference category); dwelling status (as one of four - rented, mortgages, and rent-free, with homeowners used as the reference category); state of residence (with New South Wales as the reference category); and smoking status (as one of three - current smoker and past smoker, with non-smoker used as the base category). We also controlled for whether the individual had any fear of seeing a dentist with four levels of fear: little, moderate and high (with no fear as the base category); and whether individual had access to public dental care.

In the insurance equation we also control for some prevention variables such as the regularity with which the individual flosses their teeth, with four levels - very often/often, sometimes, and hardly ever, with not at all as the base category. Individual habits regarding flossing and smoking can also be considered good proxies for unobserved characteristics such as risk attitudes and therefore help address endogeneity biases in our model. Like most studies in this literature, we do not include a structural model of the supply of dental services, incorporating instead the local density of dentists as a variable in the utilisation equation so as to capture the time-price of care and other supplier influences (Mueller and Monheit, 1988; Parkin and Yule, 1988; Hu, 1981). Information on dentist density, i.e the number of dentists per 100,000 population is obtained from the Dental Labour Force Collection and is then matched to the respective survey data by statistical division (Balasubramanian and Teusner, 2011).

One of the main advantages of the 2004-06 survey is that not only does it provide information on self-assessed health at four levels (poor or fair, good, very good and excellent) but it also has more objective clinical measures of oral health. In the broader health literature specific health conditions or diseases have often been used to account for endogeneity and measurement errors of self-reported health (Bound, 1991; Bound et al., 1999; Cai, 2009; Johnston et al., 2009). We therefore use the following objective measures of dental health to instrument self-reported dental health: toothache; discomfort, food avoidance; and sensitive teeth, each with four levels of regularity - very often/often, sometimes, and hardly ever, with never as the base category. We also control for whether the individual had: broken or chipped teeth; pain in the jaw, temple or face; sore gums or gum disease, in the year prior to the survey. We identify the insurance equation using a derived price of insurance described above and the dental visit equation is identified

using the local density of dentists. Table 2 in the appendix provides the definition and summary statistics of the variables used in the study.

6 Results

Table 3 reports the results of the three respective equations: dental health, dental visit, insurance participation estimated in two stages over the 2004-06 sample. The -0.87 correlation between the unobserved components of insurance and health service use ($p = 0.00$) indicates that private dental insurance participation is endogenous with respect to visits to the dentist. This endogeneity arises from common unobserved factors that impact on both the decision to purchase insurance and the decision to visit a dentist; a negative correlation here suggests that the unobserved factors have opposite effects on insurance participation and dental visit. It seems plausible, for example, that an individual who has a positive attitude towards health will be more likely to purchase dental health insurance. At the same time, someone who takes good care of their dental health is likely to have better dental health outcomes and consequently make fewer visits to the dentist for treatment. Controlling for the endogeneity of insurance reduces bias and increases the size of the estimated effect of insurance on dental service use.[7]

As mentioned above, we use a number of identifying instruments to address endogeneity. Specifically, we use the over-identification test for linear models to verify the validity of our instruments. Given the difficulty of testing the validity of instruments in non-linear models (see Davidson and MacKinnon, 1993), we conduct the test by estimating linear probability models instead of probit models. We apply the generalized method of moment (GMM) estimator to the dental utilisation and insurance equations to obtain the over-identification test statistics (i.e. the Hansen J statistics). Under the null hypothesis all instruments are valid, while the alternative hypothesis is that they are not. In particular, the Hansen J statistics for the overidentifying restrictions in the utilisation and insurance equations with respect to the health equation are 1.96 ($p = 0.3326$) and 2.78341 ($p = 0.2540$).[8] We then turn to the instrument in the insurance equation, that

[7] This is consistent with the the results found in Hopkins et al. (2013). They proxy dental utilisation by the time since last visit to the dentist. The estimated positive correlation coefficient between dental utilisation and insurance indicates that unobserved factors that increase insurance participation are positively correlated with the probability of seeing a dentist less frequently.

[8] As mentioned above, we follow the literature and use objective measures of dental health to instrument self-reported oral health. The dental utilisation equation, on the other hand, is instrumented using dentist density. It could be argued that the instruments in the health equation are potentially correlated with utilisation and insurance purchase. However, given we are estimating reduced form equations in the first stage, we believe that instruments in the dental health and utilisation equations are not crucial to identify the bivariate probit model.

is, the price of insurance. Unfortunately, the validity of this instrument cannot be tested using a similar approach given the model is just-identified. However, we can conduct a test of weak instruments in order to test the validity of the exclusion restriction (see Stock and Yogo, 2002). Essentially, if the first-stage estimations have a poor fit then the use of the weak instrument may result in significant inconsistencies in the IV estimates. We apply the test suggested by Stock and Yogo where the test statistic is the F-statistic with a null hypothesis that the instrument is weak against the alternative that it is strong. The F-statistic in the utilisation equation with respect to the insurance instrument is 53.78, which is larger than the critical value of 16.38, showing evidence that the price of insurance is a weak instrument.

Tables 4, 5 and 6 report the marginal effects of the control variables on the unconditional probabilities of oral health, private dental insurance and dental service use. Note that the marginal effects represent the absolute changes in the respective probabilities in response to a unit change in each individual explanatory variable. We start with the results of the dental health equation (Table 4). Males have a lower probability of having very good or excellent dental health than females. As expected, dental health deteriorates with age and we find a positive effect of education and income on dental health.[9] Compared to those with a total annual household income of more than 100K (income8), all income groups have poorer dental health. For instance, those in the lowest income group (income1) have 12.3 and 5.0 percentage points (pp) higher chances of reporting poor/fair and good dental health respectively but 12.6 and 4.7 pp lower probabilities of reporting very good and excellent dental health respectively. As expected, engaging in risky health behaviours such as smoking is also associated with poorer dental health. Poorer oral health is also associated with those patients who have a phobia of dentists. For example, those who report being moderately afraid or distressed to see a dentist are 13 pp less likely to have very good or excellent oral health. Lastly, our set of instruments - the objective measures of health - are all shown to be statistically significant. As we would expect, flossing is associated with better dental health, while those who frequently experience toothache, discomfort, food avoidance, sensitive teeth, face pain, gum sore, gum bleed and gum disease, or have chipped or broken teeth, are likely to have poorer dental health. We also estimated the structural health equation in order to estimate the effect of dental visit on oral health.[10] Our results show a positive association between visiting a dentist in the year and current oral health; in particular, those who visit a dentist have a 3 pp and 2.4 pp lower chance of reporting poor/fair and good dental health respectively,

[9]Note the reference category for income is the highest income group such that a negative sign would indicate a positive correlation of health with income.

[10]For brevity we do not present the results but they are available from the authors on request.

and a 3.6 pp and 1.8 pp higher likelihood of reporting very good and excellent dental health respectively.

We now turn to the marginal effects of the variables in the insurance equation (Table 5). Note that here the total effect of the exogenous variables comprise of a direct effect on insurance participation and an indirect effect through the endogenous latent health variable. For brevity, we focus on the total effects although it is worthwhile noting that the net positive effect of, say, the age variable, is comprised of a direct positive effect on the decision to purchase insurance offsetting the negative indirect effect of age via the dental health equation. For most variables, the direct effect on insurance dominates and the indirect effect on insurance take-up through oral health is small and insignificant. On the other hand, some variables such as gender and education only have a significant indirect effect. Overall, most of the explanatory variables have the expected signs. The decision to have private dental health insurance is positively related to age, being born in Australia, being a non-aboriginal, and the wealth variables such as owning a property and higher income. On the other hand, living in remote areas relative to capital cities, speaking a language other than English, and being a smoker or ex-smoker are associated with a lower probability of having dental insurance. For instance, those living in remote areas are 17 pp less likely, and a current smoker 13 pp less likely to have a dental insurance policy.

In terms of preventative measures, we find that frequency of flossing is associated with a higher probability of having private dental insurance, with those who floss more than seven times a week being nearly 17 pp more likely to purchase insurance. Flossing behaviours can also be regarded as risk factors associated with dental health. Since flossing improves oral health and reduces the demand for most dental services we might expect that those who floss regularly would be less likely to take out insurance. The evidence regarding these dental health risk factors such as flossing and smoking does not support this kind of adverse selection but rather the opposite - that individuals who take less risks with their health are the ones most likely to purchase insurance. Consistent with a number of empirical studies which have found evidence of advantageous selection in the insurance market (Dardanoni and Li Donni, 2012; Fang et al., 2008; De Meza and Webb, 2001), these results indicate that an important element in the decision to purchase insurance is simply risk aversion, with the more risk averse adopting less risky behaviours and taking out private dental health insurance. We find that even after correcting for the endogeneity of oral health, insurance is positively correlated with oral health. This reinforces our previous evidence on advantageous selection in health insurance. Note that if we treat oral health as exogenous, the effect is estimated to

be slightly higher at 3.1 pp against 2.7 pp when endogeneity is accounted for.[11] As expected, those who have access to public dental care have an 8 pp lower probability of having private dental insurance. The cost of insurance is potentially a determinant of the decision to purchase insurance. As expected, the price of insurance is negatively related to insurance participation. Specifically, a one-dollar increase in the price of insurance reduces the probability of an individual purchasing insurance by 2 pp. This translates into a price elasticity of participation of -0.28.[12]

Next we look at the marginal effects of factors on the decision to visit a dentist (Table 6). The total effects consist of the direct effect variables on the probability of seeing a dentist and indirect effects through their influences on the take-up of private insurance and oral health. Once again we focus on the total effects. In terms of the demographics, age, being of non-Aboriginal status, education, and wealth indicators such as higher income and owning a property are found to be positively associated with visiting a dentist, while living in remote areas and being a smoker is seen to reduce the probability of visiting a dentist. As expected, an individual with a fear of the dentist is found to be less likely to visit one, while episodes of toothache, discomfort, food avoidance, sensitive tooth, broken/chipped tooth, face pain, sore gums, bleeding gums and gum disease make the sufferer more likely to visit a dentist. It seems likely that those with poor oral health will be more likely to visit the dentist for treatment in that year than for prevention.[13] In a separate analysis where we model those who reported seeing a dentist for a check-up separately from those who reported visiting the dentist for treatment[14], we find that the results are not qualitatively different from our main results. In both models we estimate a negative relationship between oral health and visit to the dentist, with a much larger effect for those who reported seeing a dentist for treatment. We modelled separately those who reported seeing a dentist for a check-up, and those who saw a dentist for treatment. Having access to public dental care (largely as a consequence of lower private insurance cover) is associated with a decreased probability of an individual visiting a dentist. As expected, the geographical density of dental surgeries is also positively and significantly related with dental service utilisation.

It is interesting to note some of the contrasting findings relating to the direct and

[11]The full set of results with oral health as an exogenous variable is not reported in the paper for brevity. They are however available from the authors on request.

[12]The elasticity shows the percentage change in the insurance participation probability in response to a unit change in the price.

[13]Note the breakdown of dental visit by type of visits is as follows: 2.8% reported check-up(s) only; 4.5% reported dental treatment(s) only; 55.5% reported check-up(s) and dental treatment(s).

[14]Note the two groups are not mutually exclusive. We also modelled sub-samples of those who visited the dentist for check-up only and for dental treatment only, however given the samples are small, the results are not reliable.

indirect effects across the same variables. For example, being a male is associated with a lower probability of visiting a dentist overall, but this a combination of the fact that males are less likely to have insurance, more likely to have poor oral health and less likely to visit the dentist independently of insurance or oral health status. Income and education also have opposing direct and indirect effects on the use of dental services. Being in the lowest income group has the direct effect of raising the likelihood of visiting a dentist by 21 pp, but this is offset by a 48-pp reduction as consequence of lower likelihood of being insured and a small positive effect from having poorer oral health. The net effect is that the lowest income group has a 27 pp lower probability than the highest income group of visiting a dentist in the year. Higher education, on the other hand, is associated with a higher probability of a dental visit. More specifically, an individual with year 12 qualifications or higher has a 3 pp higher probability of visiting a dentist in the year. This is a consequence of a higher direct effect on the probability of dental visit and a higher likelihood of having insurance, offset by a small effect from having better oral health.

After controlling for the effects of the socioeconomic, demographic and risk variables, and the impact of insurance, the effect of dental health is found to be negative, that is, good dental health is associated with a lower incidence of dental visits with a marginal effect of -5.1 pp.[15] On the other hand, we find a positive association between insurance and the probability of dental visit after controlling for observed socioeconomic, demographic and risk variables, and dental health status.

Given the policy importance of increasing the effectiveness of insurance subsidies on the use of dental services, we report the effects of having insurance not only for the sample as a whole but also for those who do not currently have insurance. Table 7 reports the treatment effect of dental insurance on the whole sample, on those who have insurance, and on the potential effect on those who do not, along with their standard errors. For instance, the average treatment effect of the treated (ATT), which is the average gain from the treatment of those who actually purchased insurance cover, is 66 pp while the average treatment effect of the untreated (ATU), the average gain from the treatment of those who did not purchase an insurance cover, is 43 pp. The average treatment effect of the insurance status on the probability of visiting a dentist is estimated to be somewhere between the two, at 56 pp.

[15]Note that if we estimate the model treating dental health and insurance as exogenous variables, the marginal effect of health is an increase of 5.5 pp on the probability of dental visit.

7 Conclusion

In this paper, we investigate the relationships between individuals' dental health, the decision to purchase private dental insurance, and dental service utilisation using the National Survey of Adult Oral Health, a unique data set containing comprehensive information on individuals' dental health and health service utilisation. One important contribution of our paper to the existing literature is the estimation of a comprehensive model that allows us to take into account the interrelationships between dental service utilisation, dental health status and private dental insurance. In particular we have been able to show more clearly the pathways of effect of behavioural and market influences on dental service use. For example, it is clear that while some health behaviours such as dental self-care reduce the demand for dental service use through an improvement in oral health, others such as smoking are associated with greater dental use largely because of their association with income and insurance status. Smokers are less likely to have insurance and less likely to go to the dentist but not as a direct result of their poor oral health. In general, our findings indicate a positive effect of dental health and a negative effect of health risk behaviours on insurance purchase, and therefore the absence of adverse selection. In other words, individuals with better dental health and healthier risk behaviours are the ones most likely to purchase insurance. These results imply that an important element in the decision to purchase insurance is simply risk aversion, with the more risk averse adopting less risky behaviours and taking out private insurance. With regard to dental service utilisation, we find that insurance status significantly increases dental service utilisation but we observe a negative relationship between oral health and visit to the dentist. While such effects have been interpreted as moral hazard in the literature, it is also consistent with the idea that more risk averse individuals purchase preventive services from dentists through routine check-ups and health maintenance. Without an assessment of the nature and frequency of dental visits we cannot distinguish between these two possibilities.

We find evidence of social inequality between the rich and the poor in each of our three main outcomes; oral health, dental insurance and dental service use. Those with lower incomes are less likely to report good to excellent oral health, however the main effect of income on dental service use is not through oral health, but because of the effect of income levels on an individual's decision to take out insurance; that is, the way income affects the affordability of dental services. Households earning more than *$100,000* per year are predicted to have a 27% higher probability of using dental services relative to households with yearly income less than *$12,000*. The highest income households are

also 54% more likely to be covered by some level of dental insurance. We also observe considerable disparities in dental health status with the richest households around 17% more likely to report very good to excellent dental health than the poorest households.

The results confirm that affordability is a major barrier to visiting the dentist for oral health maintenance and treatment. The predicted average percentage increase in visits to the dentist associated with the price reduction from having insurance is 56 pp. For those who do not currently have insurance, the predicted effect of insurance on visits is likely to be smaller. The results suggest that if those who currently do not have private insurance were to be covered under the same circumstances as those who do, they would increase their probability of visiting the dentist from 43% to 66%. Also, those who do not currently have insurance tend to have lower income, worse oral health, and less education. Reducing the price of dental services by providing some form of insurance coverage would increase dental visits for those whose oral health is most affected by undertreatment.

An obvious next step would be to model the role of providers as agents of the patient in influencing the number, type, and quality of services consumed as a simultaneous decision rather than as an independent sequential one with uncorrelated errors across equations. A system of equations like this would involve more complexity in terms of estimation and would be an ideal target for future research.

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8 Appendix

Table 2: Summary Statistics and Variable Definitions

Variable Name	Mean	SD	Description
Panel A: Health Insurance and Dentist Density			
phi	0.486	0.500	=1 if have private dental health insurance; =0 otherwise
public	0.264	0.441	=1 if eligible for public dental care; =0 otherwise
insuprice	6.910	2.196	Derived price of dental insurance
density	48.514	15.364	Dentists per 100,000 population, year 2006
Panel B: Dental Services Utilization			
visit	0.630	0.483	=1 if made any dental visit in last 12 months; =0 otherwise
Panel C: Dental Health Status			
Self-assessed dental health:			
dsah	2.381	0.901	Ordered variable, 1 to 4, self-rated dental health is fair or poor to excellent
dsahex	0.114	0.318	=1 for excellent; =0 otherwise
dsahvg	0.326	0.469	=1 for very good; =0 otherwise
dsahg	0.386	0.487	=1 for good; =0 otherwise
dsahfp	0.174	0.379	=1 for fair or poor; =0 otherwise
Toothache: frequency of toothache in the last 12 months			
toothache_of	0.050	0.218	=1 for very often or often; =0 otherwise
toothache_st	0.093	0.291	=1 for sometimes; =0 otherwise
toothache_hd	0.227	0.419	=1 for hardly ever; =0 otherwise
toothache_nv	0.629	0.483	=1 for never; =0 otherwise (reference category)
Discomfort: frequency of discomfort in the last 12 months			
discomf_of	0.132	0.339	=1 for very often or often; =0 otherwise
discomf_st	0.129	0.335	=1 for sometimes; =0 otherwise
discomf_hd	0.129	0.335	=1 for hardly ever; =0 otherwise
discomf_nv	0.610	0.488	=1 for never; =0 otherwise (reference category)
Food avoidance: frequency of food avoidance			
foodavoid_of	0.080	0.272	=1 for very often or often; =0 otherwise
foodavoid_st	0.093	0.290	=1 for sometimes; =0 otherwise
foodavoid_hd	0.110	0.314	=1 for hardly; =0 otherwise
foodavoid_nv	0.716	0.451	=1 for never; =0 otherwise (reference category)
Sensitive teeth: frequency of experiencing sensitive teeth in the last 12 months			
sensitive_of	0.110	0.313	=1 for very often or often; =0 otherwise
sensitive_st	0.195	0.396	=1 for sometimes; =0 otherwise
sensitive_hd	0.204	0.403	=1 for hardly ever; =0 otherwise
sensitive_nv	0.490	0.500	=1 for never; =0 otherwise (reference category)
broken	0.245	0.430	=1 if had broken/chipped tooth in last 12 months; =0 otherwise
gumsore	0.156	0.363	=1 if had sore gums in last 12 months; =0 otherwise
gumbleed	0.274	0.446	=1 if had bleeding gums in last 12 months; =0 otherwise
facepain	0.224	0.417	=1 if had pain in jaw/temple/face in last month; =0 otherwise
gumdisease	0.109	0.312	=1 if have gum disease; =0 otherwise
Panel D: Dental Health Related Behaviour/ Attitude towards dentist			
floss_nv	0.485	0.500	=1 if the freq. of flossing in last week is 0; =0 otherwise (reference category)
floss_st	0.284	0.451	=1 if the freq. of flossing in last week is 1-6; =0 otherwise
floss_dy	0.180	0.384	=1 if the freq. of flossing in last week is 7; =0 otherwise
floss_of	0.051	0.220	=1 if the freq. of flossing in last week is >7; =0 otherwise
Smoking status:			
smoker	0.183	0.386	=1 if currently smoke; =0 otherwise
exsmoker	0.296	0.457	=1 if used to smoke; =0 otherwise
nosmoker	0.521	0.500	=1 if never smoke; =0 otherwise (reference category)
Afraid or distressed of seeing dentist:			
afraid_nev	0.547	0.498	=1 for never; =0 otherwise (reference category)
afraid_lit	0.204	0.403	=1 for little; =0 otherwise
afraid_mod	0.131	0.338	=1 for moderate; =0 otherwise
afraid_ext	0.117	0.322	=1 for very or extreme; =0 otherwise

Continued on next page

Table 2 – continued from previous page

Variable Name	Mean	SD	Description
Panel E: Demographic Characteristics			
male	0.408	0.492	=1 if male; =0 otherwise
age	47.690	16.295	age in years
non_ATSI	0.985	0.122	=1 if not aboriginal or torres strait islander origin; =0 otherwise
Yr12above	0.638	0.481	=1 if the highest year level of qualification is year 12 or above; =0 otherwise
AU	0.774	0.418	=1 if born in Australia; =0 otherwise
othlang	0.098	0.297	=1 if language other than English spoken at home; =0 otherwise
Remoteness:			
reg_city	0.588	0.492	=1 if lives in major city; =0 otherwise (reference category)
reg_inner	0.213	0.409	=1 if lives in inner regional area (ABS ARIA remoteness code = 1); =0 otherwise
reg_outer	0.143	0.350	=1 if lives in outer regional area (ABS ARIA remoteness code = 2); =0 otherwise
reg_remote	0.056	0.230	=1 if lives in (very) remote area (ABS ARIA remoteness code = 3/4); =0 otherwise
Household yearly income			
income1	0.054	0.226	=1 if less than $12k; =0 otherwise
income2	0.123	0.329	=1 if $12-<20k; =0 otherwise
income3	0.111	0.315	=1 if $20-<30k; =0 otherwise
income4	0.115	0.318	=1 if $30-<40k; =0 otherwise
income5	0.195	0.396	=1 if $40-<60k; =0 otherwise
income6	0.151	0.358	=1 if $60-<80k; =0 otherwise
income7	0.106	0.308	=1 if $80-<100k; =0 otherwise
income8	0.145	0.352	=1 if $\geq$ $100k; =0 otherwise (reference category)
Current dwelling status			
dwell_rent	0.184	0.387	=1 if current dwelling: rented accommodation; =0 otherwise
dwell_mort	0.337	0.473	=1 if current dwelling: mortgage; =0 otherwise
dwell_own	0.456	0.498	=1 if current dwelling: owned outright; =0 otherwise
dwell_oth	0.023	0.151	=1 if current dwelling: rent-free accommodation / other; =0 otherwise (reference category)
State of residence:			
NSW	0.262	0.439	=1 if NSW; =0 otherwise (reference category)
VIC	0.180	0.384	=1 if VIC; =0 otherwise
QLD	0.148	0.355	=1 if QLD; =0 otherwise
SA	0.092	0.289	=1 if SA; =0 otherwise
WA	0.092	0.290	=1 if WA; =0 otherwise
TAS	0.071	0.256	=1 if TAS; =0 otherwise
ACT	0.075	0.264	=1 if ACT; =0 otherwise
NT	0.081	0.273	=1 if NT; =0 otherwise

Table 3: Estimated Coefficients

	First stage Ordered Probit: Self-reported Dental Health		Second stage Bivariate Probit: Private Dental Health Insurance[a]		Dental Visit[a]	
health[b]			0.070	[0.021]***	-0.134	[0.019]***
phi					1.687	[0.031]***
density	-0.001	[0.001]			0.003	[0.001]**
insuprice	-0.006	[0.010]	-0.052	[0.011]***		
public	0.016	[0.034]	-0.205	[0.041]***	0.060	[0.037]*
male	-0.223	[0.029]***	-0.010	[0.034]	-0.112	[0.025]***
age	-0.008	[0.001]***	0.005	[0.001]***	0.001	[0.001]
non_ATSI	0.156	[0.089]*	0.356	[0.116]***	-0.063	[0.091]
reg_inner	-0.064	[0.038]*	-0.262	[0.036]***	0.116	[0.039]***
reg_outer	-0.040	[0.052]	-0.369	[0.046]***	0.185	[0.053]***
reg_remote	-0.096	[0.079]	-0.430	[0.078]***	0.146	[0.085]*
AU	0.024	[0.028]	0.145	[0.033]***	-0.078	[0.030]***
othlang	-0.131	[0.040]***	-0.120	[0.046]***	0.077	[0.042]*
Yr12above	0.083	[0.023]***	0.037	[0.027]	0.037	[0.025]
income1	-0.484	[0.064]***	-1.349	[0.080]***	0.404	[0.074]***
income2	-0.394	[0.052]***	-1.261	[0.066]***	0.417	[0.061]***
income3	-0.308	[0.048]***	-0.998	[0.060]***	0.394	[0.056]***
income4	-0.262	[0.043]***	-0.785	[0.053]***	0.308	[0.049]***
income5	-0.187	[0.037]***	-0.678	[0.044]***	0.253	[0.041]***
income6	-0.154	[0.038]***	-0.456	[0.047]***	0.131	[0.043]***
income7	-0.042	[0.042]	-0.203	[0.051]***	0.045	[0.045]
dwell_rent	-0.070	[0.033]**	-0.455	[0.041]***	0.113	[0.036]***
dwell_mort	-0.065	[0.027]**	-0.151	[0.032]***	-0.035	[0.028]
dwell_other	-0.067	[0.072]	-0.164	[0.092]*	0.045	[0.082]
VIC	0.078	[0.032]**	-0.272	[0.039]***	0.200	[0.035]***
QLD	-0.107	[0.035]***	0.004	[0.041]	-0.018	[0.038]
SA	-0.079	[0.041]*	0.332	[0.048]***	-0.162	[0.043]***
WA	-0.066	[0.042]	0.407	[0.050]***	-0.134	[0.044]***
TAS	-0.089	[0.048]*	0.475	[0.056]***	-0.345	[0.054]***
ACT	-0.122	[0.045]***	-0.253	[0.055]***	0.205	[0.047]***
NT	-0.049	[0.062]	0.378	[0.073]***	-0.274	[0.066]***
smoker	-0.260	[0.030]***	-0.318	[0.037]***	0.026	[0.033]
exsmoker	-0.079	[0.024]***	-0.077	[0.029]***	0.038	[0.027]
afraid_lit	-0.175	[0.027]***	0.088	[0.034]**	-0.128	[0.030]***
afraid_mod	-0.361	[0.033]***	0.013	[0.041]	-0.252	[0.037]***
afraid_ext	-0.400	[0.036]***	0.008	[0.044]	-0.363	[0.040]***
floss_of	0.234	[0.049]***	0.425	[0.050]***		
floss_dy	0.228	[0.030]***	0.378	[0.030]***		
floss_st	0.160	[0.025]***	0.258	[0.024]***		
toothache_of	-0.319	[0.056]***				
toothache_st	-0.375	[0.040]***				
toothache_hd	-0.200	[0.027]***				
discom_of	-0.774	[0.037]***				
discom_st	-0.506	[0.033]***				
discom_hd	-0.265	[0.032]***				
foodavoid_of	-0.434	[0.047]***				
foodavoid_st	-0.293	[0.040]***				
foodavoid_hd	-0.094	[0.035]***				
sensitive_of	-0.191	[0.040]***				
sensitive_st	-0.179	[0.030]***				
sensitive_hd	-0.039	[0.028]				
broken	-0.185	[0.026]***				
facepain	-0.107	[0.027]***				
gumsore	-0.152	[0.033]***				
gumbleed	-0.201	[0.026]***				
gumdisease	-0.625	[0.039]***				
constant			0.513	[0.187]***	-0.944	[0.132]***
μ_1	-2.565	[0.168]***				
μ_2	-1.171	[0.167]***				
μ_3	0.074	[0.167]				
ρ					-0.867[0.021]***	
Log likelihood						

Standard errors are in parentheses; [a] bootstrapped standard errors. *, ** and *** denote significance at 10%, 5% and 1% respectively.
[b] In the second stage health refers to predicted health from the first stage reduced form estimation.

Table 4: Health Equation: Marginal Effects

	Self-reported Dental Health Status							
	Poor or Fair		Good		Very Good		Excellent	
density	0.000	[0.000]	0.000	[0.000]	0.000	[0.000]	0.000	[0.000]
insuprice	0.001	[0.002]	0.001	[0.002]	-0.002	[0.002]	-0.001	[0.001]
public	-0.003	[0.007]	-0.003	[0.006]	0.004	[0.009]	0.002	[0.005]
male	0.046	[0.006]***	0.040	[0.005]***	-0.057	[0.007]***	-0.029	[0.004]***
age	0.002	[0.000]***	0.002	[0.000]***	-0.002	[0.000]***	-0.001	[0.000]***
non_ATSI	-0.035	[0.021]	-0.025	[0.012]**	0.041	[0.023]*	0.019	[0.009]**
reg_inner	0.013	[0.008]	0.011	[0.007]*	-0.016	[0.010]*	-0.008	[0.005]*
reg_outer	0.008	[0.011]	0.007	[0.009]	-0.010	[0.013]	-0.005	[0.007]
reg_remote	0.020	[0.018]	0.016	[0.012]	-0.025	[0.021]	-0.012	[0.009]
AU	-0.005	[0.006]	-0.004	[0.005]	0.006	[0.007]	0.003	[0.004]
othlang	0.028	[0.009]***	0.022	[0.006]***	-0.034	[0.011]***	-0.016	[0.005]***
Yr12above	-0.017	[0.005]***	-0.015	[0.004]***	0.021	[0.006]***	0.011	[0.003]***
income1	0.123	[0.020]***	0.050	[0.002]***	-0.126	[0.016]***	-0.047	[0.004]***
income2	0.094	[0.014]***	0.051	[0.004]***	-0.103	[0.014]***	-0.042	[0.005]***
income3	0.071	[0.012]***	0.044	[0.005]***	-0.080	[0.013]***	-0.035	[0.004]***
income4	0.060	[0.011]***	0.039	[0.005]***	-0.068	[0.011]***	-0.030	[0.004]***
income5	0.041	[0.008]***	0.031	[0.005]***	-0.048	[0.010]***	-0.023	[0.004]***
income6	0.033	[0.009]***	0.026	[0.006]***	-0.040	[0.010]***	-0.019	[0.004]***
income7	0.009	[0.009]	0.008	[0.007]	-0.011	[0.011]	-0.006	[0.005]
dwell_rent	0.014	[0.007]**	0.012	[0.006]**	-0.018	[0.008]**	-0.009	[0.004]**
dwell_mort	0.013	[0.006]**	0.012	[0.005]**	-0.017	[0.007]**	-0.009	[0.003]**
dwell_other	0.014	[0.016]	0.012	[0.012]	-0.017	[0.019]	-0.009	[0.009]
VIC	-0.015	[0.006]**	-0.015	[0.007]**	0.020	[0.008]**	0.011	[0.005]**
QLD	0.023	[0.008]***	0.018	[0.006]***	-0.028	[0.009]***	-0.014	[0.004]***
SA	0.017	[0.009]*	0.014	[0.007]**	-0.020	[0.011]*	-0.010	[0.005]**
WA	0.014	[0.009]	0.012	[0.007]	-0.017	[0.011]	-0.008	[0.005]
TAS	0.019	[0.011]*	0.015	[0.008]**	-0.023	[0.013]*	-0.011	[0.006]*
ACT	0.026	[0.010]**	0.021	[0.007]***	-0.032	[0.012]***	-0.015	[0.005]***
NT	0.010	[0.013]	0.009	[0.011]	-0.013	[0.016]	-0.006	[0.008]
smoker	0.058	[0.007]***	0.041	[0.004]***	-0.068	[0.008]***	-0.031	[0.003]***
exsmoker	0.016	[0.005]***	0.014	[0.004]***	-0.020	[0.006]***	-0.010	[0.003]***
afraid_lit	0.038	[0.006]***	0.029	[0.004]***	-0.045	[0.007]***	-0.022	[0.003]***
afraid_mod	0.085	[0.009]***	0.049	[0.003]***	-0.094	[0.009]***	-0.040	[0.003]***
afraid_ext	0.096	[0.010]***	0.052	[0.003]***	-0.105	[0.009]***	-0.043	[0.003]***
floss_of	-0.042	[0.008]***	-0.050	[0.012]***	0.056	[0.011]***	0.036	[0.009]***
floss_dy	-0.042	[0.005]***	-0.047	[0.007]***	0.056	[0.007]***	0.034	[0.005]***
floss_st	-0.031	[0.005]***	-0.031	[0.005]***	0.040	[0.006]***	0.023	[0.004]***
toothache_of	0.076	[0.015]***	0.042	[0.005]***	-0.084	[0.015]***	-0.035	[0.005]***
toothache_st	0.090	[0.011]***	0.048	[0.003]***	-0.098	[0.011]***	-0.040	[0.003]***
toothache_hd	0.043	[0.006]***	0.033	[0.004]***	-0.052	[0.007]***	-0.025	[0.003]***
discom_of	0.209	[0.012]***	0.057	[0.004]***	-0.196	[0.009]***	-0.069	[0.003]***
discom_st	0.126	[0.010]***	0.058	[0.003]***	-0.132	[0.009]***	-0.052	[0.003]***
discom_hd	0.060	[0.008]***	0.040	[0.004]***	-0.069	[0.009]***	-0.031	[0.003]***
foodavoid_of	0.107	[0.014]***	0.051	[0.003]***	-0.113	[0.012]***	-0.044	[0.004]***
foodavoid_st	0.068	[0.010]***	0.042	[0.004]***	-0.077	[0.011]***	-0.033	[0.004]***
foodavoid_hd	0.020	[0.008]**	0.016	[0.006]***	-0.024	[0.009]***	-0.012	[0.004]***
sensitive_of	0.042	[0.010]***	0.030	[0.005]***	-0.050	[0.011]***	-0.023	[0.004]***
sensitive_st	0.039	[0.007]***	0.030	[0.004]***	-0.046	[0.008]***	-0.022	[0.003]***
sensitive_hd	0.008	[0.006]	0.007	[0.005]	-0.010	[0.007]	-0.005	[0.004]
broken	0.040	[0.006]***	0.031	[0.004]***	-0.048	[0.007]***	-0.023	[0.003]***
facepain	0.022	[0.006]***	0.019	[0.004]***	-0.027	[0.007]***	-0.014	[0.003]***
gumsore	0.033	[0.008]***	0.025	[0.005]***	-0.039	[0.009]***	-0.019	[0.004]***
gumbleed	0.043	[0.006]***	0.034	[0.004]***	-0.052	[0.007]***	-0.025	[0.003]***
gumdisease	0.163	[0.012]***	0.057	[0.003]***	-0.161	[0.010]***	-0.059	[0.003]***

Standard errors are in parentheses; *, ** and *** denote significance at 10%, 5% and 1% respectively.

Table 5: Insurance Equation: Marginal Effects

	Private Dental Health Insurance					
	Direct effect		Indirect effect through health)		Total effect	
health[a]	0.02778	[0.008]***				
density			0.00000	[0.000]	0.00000	[0.000]
insuprice	-0.02090	[0.004]***	-0.00002	[0.000]	-0.02092	[0.004]***
public	-0.08174	[0.016]***	0.00007	[0.000]	-0.08167	[0.016]***
male	-0.00418	[0.013]	-0.00092	[0.000]**	-0.00510	[0.013]
age	0.00190	[0.001]***	-0.00003	[0.000]***	0.00187	[0.001]***
non_ATSI	0.14197	[0.045]***	0.00065	[0.001]	0.14262	[0.045]***
reg_inner	-0.10428	[0.014]***	-0.00026	[0.000]	-0.10455	[0.014]***
reg_outer	-0.14720	[0.017]***	-0.00017	[0.000]	-0.14737	[0.018]***
reg_remote	-0.17118	[0.030]***	-0.00040	[0.001]	-0.17158	[0.030]***
AU	0.05784	[0.013]***	0.00010	[0.000]	0.05794	[0.013]***
othlang	-0.04771	[0.019]**	-0.00054	[0.001]	-0.04826	[0.019]***
Yr12above	0.01461	[0.011]	0.00034	[0.000]**	0.01496	[0.011]
income1	-0.53758	[0.033]***	-0.00201	[0.001]	-0.53958	[0.033]***
income2	-0.50230	[0.026]***	-0.00163	[0.001]**	-0.50393	[0.026]***
income3	-0.39770	[0.023]***	-0.00127	[0.001]*	-0.39897	[0.023]***
income4	-0.31268	[0.021]***	-0.00108	[0.001]	-0.31376	[0.021]***
income5	-0.27000	[0.018]***	-0.00078	[0.000]*	-0.27078	[0.018]***
income6	-0.18162	[0.019]***	-0.00064	[0.000]	-0.18226	[0.019]***
income7	-0.08085	[0.020]***	-0.00017	[0.000]	-0.08102	[0.020]***
dwell_rent	-0.18119	[0.016]***	-0.00029	[0.000]	-0.18147	[0.016]***
dwell_mort	-0.06020	[0.013]***	-0.00027	[0.000]*	-0.06047	[0.013]***
dwell_other	-0.06549	[0.036]*	-0.00028	[0.002]	-0.06577	[0.036]*
VIC	-0.10838	[0.015]***	0.00032	[0.000]	-0.10806	[0.015]***
QLD	0.00171	[0.016]	-0.00044	[0.000]	0.00127	[0.016]
SA	0.13241	[0.019]***	-0.00033	[0.000]	0.13208	[0.019]***
WA	0.16209	[0.020]***	-0.00027	[0.001]	0.16182	[0.020]***
TAS	0.18908	[0.022]***	-0.00037	[0.001]	0.18871	[0.022]***
ACT	-0.10098	[0.021]***	-0.00051	[0.000]	-0.10148	[0.021]***
NT	0.15077	[0.029]***	-0.00020	[0.000]	0.15057	[0.029]***
smoker	-0.12662	[0.015]***	-0.00108	[0.000]**	-0.12770	[0.015]***
exsmoker	-0.03085	[0.012]***	-0.00033	[0.000]	-0.03118	[0.012]***
afraid_lit	0.03489	[0.013]***	-0.00072	[0.000]*	0.03417	[0.013]***
afraid_mod	0.00512	[0.016]	-0.00150	[0.001]**	0.00362	[0.016]
afraid_ext	0.00325	[0.018]	-0.00166	[0.001]**	0.00159	[0.018]
floss_of	0.16954	[0.020]***	0.00097	[0.001]	0.17051	[0.020]***
floss_dy	0.15067	[0.012]***	0.00095	[0.000]**	0.15162	[0.012]***
floss_st	0.10286	[0.010]***	0.00066	[0.000]**	0.10352	[0.010]***
toothache_of			-0.00132	[0.001]*	-0.00132	[0.001]*
toothache_st			-0.00155	[0.001]**	-0.00155	[0.001]**
toothache_hd			-0.00083	[0.000]**	-0.00083	[0.000]**
discom_of			-0.00320	[0.001]**	-0.00320	[0.001]**
discom_st			-0.00210	[0.001]**	-0.00210	[0.001]***
discom_hd			-0.00110	[0.001]**	-0.00110	[0.001]**
foodavoid_of			-0.00180	[0.001]**	-0.00180	[0.001]**
foodavoid_st			-0.00121	[0.001]*	-0.00121	[0.001]*
foodavoid_hd			-0.00039	[0.000]	-0.00039	[0.000]
sensitive_of			-0.00079	[0.000]**	-0.00079	[0.000]**
sensitive_st			-0.00074	[0.000]**	-0.00074	[0.000]**
sensitive_hd			-0.00016	[0.000]	-0.00016	[0.000]
broken			-0.00077	[0.000]**	-0.00077	[0.000]**
facepain			-0.00044	[0.000]*	-0.00044	[0.000]*
gumsore			-0.00063	[0.000]	-0.00063	[0.000]
gumbleed			-0.00083	[0.000]**	-0.00083	[0.000]**
gumdisease			-0.00259	[0.001]**	-0.00259	[0.001]**

[a] Predicted health from the first stage reduced form estimation. Standard errors are in parentheses. *, ** and *** denote significance at 10%, 5% and 1% respectively.

Table 6: Utilisation Equation: Marginal Effects

	Dental Visit							
	Direct effect		Indirect effect (through insurance)		Indirect effect (through health)		Total effect	
health[a]	-0.05138	[0.007]***						
density	0.00129	[0.001]**			0.00000	[0.000]	0.00130	[0.001]**
insuprice			-0.01879	[0.004]***	0.00004	[0.000]	-0.01875	[0.004]***
public	0.03087	[0.019]	-0.07351	[0.017]***	-0.00010	[0.000]	-0.04274	[0.017]**
male	-0.05736	[0.013]***	-0.00376	[0.012]	0.00146	[0.001]***	-0.05966	[0.013]***
age	0.00028	[0.000]	0.00171	[0.001]***	0.00005	[0.000]***	0.00205	[0.001]***
non_ATSI	-0.03209	[0.048]	0.12768	[0.042]***	-0.00102	[0.001]	0.09456	[0.045]**
reg_inner	0.05961	[0.021]***	-0.09378	[0.017]***	0.00042	[0.000]	-0.03375	[0.019]*
reg_outer	0.09482	[0.028]***	-0.13238	[0.022]***	0.00026	[0.000]	-0.03730	[0.025]
reg_remote	0.07472	[0.044]*	-0.15395	[0.032]***	0.00063	[0.001]	-0.07860	[0.039]**
AU	-0.04018	[0.016]**	0.05202	[0.013]***	-0.00016	[0.000]	0.01168	[0.014]
othlang	0.03955	[0.022]*	-0.04291	[0.018]**	0.00086	[0.001]*	-0.00250	[0.020]
Yr12above	0.01887	[0.013]	0.01314	[0.010]	-0.00054	[0.000]**	0.03147	[0.011]***
income1	0.20706	[0.045]***	-0.48344	[0.063]***	0.00317	[0.001]**	-0.27321	[0.042]***
income2	0.21377	[0.040]***	-0.45172	[0.057]***	0.00258	[0.001]***	-0.23537	[0.035]***
income3	0.20196	[0.036]***	-0.35765	[0.047]***	0.00202	[0.001]**	-0.15368	[0.029]***
income4	0.15806	[0.030]***	-0.28119	[0.037]***	0.00172	[0.001]**	-0.12142	[0.025]***
income5	0.12971	[0.026]***	-0.24282	[0.032]***	0.00123	[0.000]***	-0.11188	[0.022]***
income6	0.06706	[0.024]***	-0.16333	[0.025]***	0.00101	[0.000]**	-0.09527	[0.021]***
income7	0.02308	[0.024]	-0.07271	[0.020]***	0.00028	[0.001]	-0.04935	[0.021]**
dwell_rent	0.05793	[0.020]***	-0.16294	[0.024]***	0.00046	[0.000]	-0.10456	[0.019]***
dwell_mort	-0.01798	[0.015]	-0.05414	[0.013]***	0.00043	[0.000]*	-0.07169	[0.014]***
dwell_other	0.02296	[0.042]	-0.05890	[0.033]*	0.00044	[0.002]	-0.03550	[0.035]
VIC	0.10279	[0.020]***	-0.09747	[0.018]***	-0.00051	[0.000]	0.00481	[0.016]
QLD	-0.00936	[0.019]	0.00154	[0.014]	0.00070	[0.000]	-0.00712	[0.017]
SA	-0.08313	[0.024]***	0.11908	[0.022]***	0.00052	[0.001]	0.03647	[0.021]*
WA	-0.06872	[0.024]***	0.14577	[0.024]***	0.00043	[0.001]	0.07748	[0.022]***
TAS	-0.17708	[0.032]***	0.17004	[0.028]***	0.00059	[0.001]	-0.00646	[0.023]
ACT	0.10522	[0.027]***	-0.09081	[0.022]***	0.00080	[0.001]	0.01522	[0.022]
NT	-0.14059	[0.036]***	0.13559	[0.030]***	0.00032	[0.001]	-0.00468	[0.030]
smoker	0.01348	[0.017]	-0.11387	[0.019]***	0.00171	[0.001]***	-0.09868	[0.018]***
exsmoker	0.01941	[0.014]	-0.02775	[0.011]**	0.00052	[0.000]**	-0.00782	[0.012]
afraid_lit	-0.06556	[0.016]***	0.03138	[0.013]**	0.00114	[0.000]***	-0.03303	[0.014]**
afraid_mod	-0.12943	[0.021]***	0.00461	[0.015]	0.00237	[0.001]***	-0.12246	[0.018]***
afraid_ext	-0.18622	[0.025]***	0.00292	[0.017]	0.00262	[0.001]***	-0.18067	[0.021]***
floss_of			0.15247	[0.028]***	-0.00153	[0.001]	0.15094	[0.028]***
floss_dy			0.13550	[0.021]***	-0.00150	[0.001]***	0.13401	[0.021]***
floss_st			0.09250	[0.015]***	-0.00105	[0.000]**	0.09146	[0.015]***
toothache_of					0.00209	[0.001]*	0.00209	[0.001]*
toothache_st					0.00246	[0.001]***	0.00246	[0.001]***
toothache_hd					0.00131	[0.000]***	0.00131	[0.000]***
discom_of					0.00507	[0.002]***	0.00507	[0.002]***
discom_st					0.00332	[0.001]***	0.00332	[0.001]***
discom_hd					0.00173	[0.001]***	0.00173	[0.001]***
foodavoid_of					0.00284	[0.001]***	0.00284	[0.001]***
foodavoid_st					0.00192	[0.001]**	0.00192	[0.001]**
foodavoid_hd					0.00062	[0.000]	0.00062	[0.000]
sensitive_of					0.00125	[0.001]**	0.00125	[0.001]**
sensitive_st					0.00117	[0.000]**	0.00117	[0.000]**
sensitive_hd					0.00025	[0.000]	0.00025	[0.000]
broken					0.00121	[0.000]***	0.00121	[0.000]***
facepain					0.00070	[0.000]**	0.00070	[0.000]**
gumsore					0.00100	[0.000]**	0.00100	[0.000]**
gumbleed					0.00132	[0.000]***	0.00132	[0.000]***
gumdisease					0.00410	[0.001]***	0.00410	[0.001]***

[a] Predicted health from the first stage reduced form estimation.

Standard errors are in parentheses; *, ** and *** denote significance at 10%, 5% and 1% respectively.

Table 7: Treatment Fffects of Insurance

	Treatment effect	
Average Treatment Effect (ATE)	0.562	[0.008]***
Average Treatment Effect on the Treated (ATET)	0.661	[0.015]***
Average Treatment Effect on the Un-treated (ATEUT)	0.426	[0.023]***

Standard errors are in parentheses; *** denote significance at 1%.