**Unequal Access and Socioeconomic Gradients in Perceived Oral Health: Evidence from an Emerging Country**[1]

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**Abstract**

This paper studies the socioeconomic disparities in self-perceived oral-health among Chilean adults. Data are from an in-depth survey that includes detailed questions on oral health, dental care, and socioeconomic status for a sample of people in Santiago, Chile in 2011, complemented with nationally representative surveys to check for selection bias. Oral health outcomes consist of a self-diagnosed need for a prosthesis in the national data, and the Oral Health Impact Profile (OHIP) and its distinct questions in the in-depth survey. Education, income and affiliation to the public health insurance system indicate socioeconomic background. The results imply a clear socioeconomic gradient that is steep at both ends of the income distribution, but constant in mid-income levels. This gradient is more evident in the psychological and social dimensions than in the physical limitation dimensions of OHIP. The findings are consistent with inequities in the access to oral health services due to insufficient provision in the public sector and costly solutions in the private sector.

**Keywords:** Chile, health-related quality of life, socioeconomic gradients, inequality.

## Introduction

Oral health disorders impact daily living and quality of life in multiple dimensions (Allen, 2003; Gift et al., 1992). Bad oral health is associated to functional limitations, pain and self-esteem (Slade et al., 2005; Sanders et al., 2006a), as well as to a number of general health conditions (Lamster et al., 2008). Other less studied dimensions such as labor market opportunities also relate to oral health (Glied and Neidell, 2010).

The literature is not only interested in the objective oral conditions, but also in the way individuals perceive that they translate into their lives (Lee et al., 2013). For example, a bad oral condition might lead to eating difficulties with a negative impact on nutritional intake (Walls et al., 2000; Ritchie et al., 2002); it might translate into functional limitations due to discomfort, restricting activities like work

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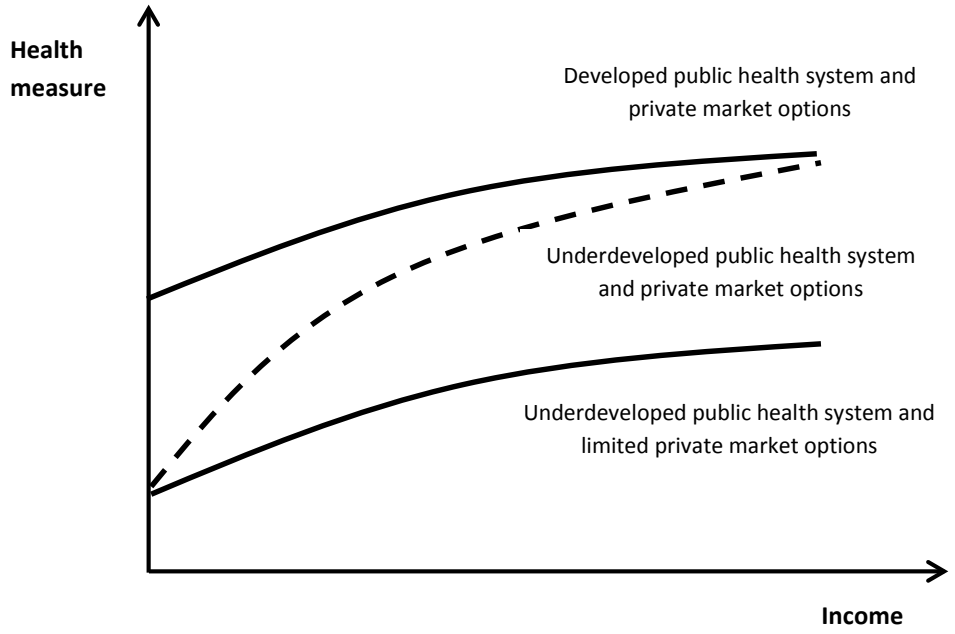
or study (Reisine, 1985); and it might translate into reduced social interactions due to shame because of missing teeth or chronic bad breath (Jones et al., 2003; McKeown, 2003).

This paper aims to study the existence of a socioeconomic gradient in self-perceived oral health (SPOH) among Chilean adults. We emphasize the role of socioeconomic background since much of the observed variability has been related to factors like education and income (Locker, 2009). Specifically, we examine the independent contribution of socioeconomic factors in explaining SPOH and its distinct dimensions, after adjusting for objective oral health and other determinants.

There may be different reasons why the socioeconomic gradient varies across countries. We hypothesize that the shape of this gradient depends on the inter-play between public and private provision. Figure 1 illustrates this idea. A country with a less developed health system and scarce privately provided options (i.e., if accessible, of bad quality, or if of good quality, too expensive for the large majority) should show a socioeconomic gradient that is relatively flat at levels that could be considered unsatisfactory for large portions of the population. In contrast, a less developed public system combined with high quality privately provided services should originate a steeper gradient, whereas a developed public system (combined or not with private markets) should also originate a flat gradient but at higher levels of health outcomes.

**Figure 1**
**Health related socioeconomic gradient for different health systems**




Most of the studies on oral-health gradients have been conducted in developed countries. In these contexts, the literature consistently finds a significant socioeconomic gradient. For instance, Sanders

et al. (2006a and 2006b), Wamala et al. (2006), Sabbah et al. (2007) and Locker (2009) find steep gradients in oral-health among adults in Australia, Sweden, the US and Canada, respectively. Interestingly, in one of the few studies for developing countries, Gabardo et al. (2015) find no association between oral-health perceptions and income among adults in Brazil.

These results are consistent with the hypothesis we illustrate in Figure 1. As the literature for developed countries argues, the gradient is explained mainly by differences in access to dental care, either publicly or privately provided. In fact, even though most developed countries have strong public health care sectors, the private sector also plays a very important role in the provision and even the finance of dental care (Neumann and Quiñonez, 2014). Brazil may be closer to the case in which the public sector is weak and private options are not sufficiently available for most of the population.

Along these lines, the case of Chile is interesting: the public provision of oral health services is quite limited as it mainly offers primary services to pregnant women, 6 year old children and 60 year old adults covered by public health insurance, as well as basic outpatient emergency services (Superintendencia de Salud, 2014). The limited public provision of services addressing complex problems is combined with an active private sector that offers heterogeneous prices and quality. On average, the cost of a removable dental prosthesis at private clinics in one of the most populated municipalities in Santiago, Maipú, nears 340 dollars. Moreover, participants in the in-depth survey that we use as the main data source for this study, paid on average about 600 dollars in additional dental services that were needed when acquiring prostheses. These facts have two implications: (i) individuals actually spend money in the private sector, and (ii) these are costly services considering that on average household's monthly income among this population nears 1,200 dollars according to the 2011 *Caracterización Socioeconómica Nacional* survey (CASEN) conducted by Chile's Ministry of Social Development.

Then, consistent with the hypothesis in Figure 1, this combination of insufficient publicly provided services and heterogeneous and costly services offered by an active private sector, makes it especially interesting to study the Chilean socioeconomic gradient in SPOH. The objectives of this study are thus, first, to assess whether socio-economic status accounts for differences in oral health perceptions in the adult Chilean population, and second, to assess the shape of the gradient.

## Methods

### *Samples*

Our main data source is an in-depth survey that gathers information on oral health, dental care, and socioeconomic status of the subjects. This survey was taken as the baseline survey of a randomized control trial (RCT) set up to evaluate the impact of the free provision of removable dental prostheses (results of the RCT are in Gallego at al., in progress). In February of 2011, 1413 residents of the Greater Santiago area responded announcements published in mass media and applied for the program. Eligibility was restricted to individuals affiliated to the public healthcare system, whose ages ranged

between 18 and 60 years. To participate, they first had to apply by phone or by registering in a website. Then they were appointed to a dental revision and to a baseline survey at a Pontificia Universidad Católica Campus. The study was approved by the Human Ethics and Research Committee of the Economics Department of the University. We use data from the registration form and the baseline survey.

Each subject received an extensive dental revision following protocols designed by the WHO (1997). Qualified dentists applied the instruments using homogeneous criteria. The data include information on the status of each tooth (healthy, caries, lost, etc.) as well as on conditions such as periodontal disease, gingivitis and occlusion problems. The survey also collected clinical information on individual oral health status, self-perceived oral health, self-esteem, and socioeconomic and demographic characteristics.

To measure the experience of oral health impairments, each patient answered a Spanish translation of the 14 questions version of the Oral Health Impact Profile (OHIP-14) developed by Slade (1997). This instrument collects information on seven dimensions: Functional Limitations, Physical Pain, Psychological Discomfort, Physical Disability, Psychological Disability, Social Disability, and Handicap. Questions are answered on a Likert scale basis. Scores range between 0 and 56; a higher score indicates a worse perceived oral health-related quality of life.

To measure self-esteem, we used a Spanish version of the Rosenberg Score Test (Rosenberg, 1965), translated by Subsecretaría de Previsión Social (2006). This instrument consists of 10 questions related to individual assessment about personal characteristics answered on a Likert scale basis. Scores range between 10 and 40; a higher measure indicates a higher global self-esteem.

The survey also gathered data on age, gender, marital status, number and age of children, employment, education and income. It also included variables associated to oral health behavior, such as frequency of daily tooth brushing and time since the last dental appointment.

This dataset is complemented with data from a national representative health survey (*Encuesta Nacional de Salud*, hereafter ENS) carried out in 2010 by the Ministry of Health (2010a) which includes questions about oral health and prostheses use. It is also complemented with data from the representative household survey CASEN collected in 2011 which includes vast socioeconomic information that we use to correct for potential sample selection issues (Ministry of Social Development, 2011).

*Statistical analysis*

We use regression methods to estimate socioeconomic gradients in perceived oral health. In particular, we estimate a regression of the form:

$$y_1 = x_1\beta_1 + x_2\beta_2 + u_1 \quad (1)$$

where $y_1$ is a dental health measure, $x_1$ is a vector of socioeconomic variables, $x_2$ is a vector of control variables (including other relevant characteristics such as age, gender, and household demographics, among others) and $u_1$ is an error term. We are interested in estimating $\beta_1$.

We mainly use two variables as proxies of socioeconomic status: income and public or private health insurance affiliation. We also use educational attainment as a complementary measure. The use of affiliation to different types of health insurance is an addition to the previous literature that estimates socioeconomic gradients and is closely related to the institutional details of the Chilean health system (Sapelli and Vial, 2003). In Chile, individuals make mandatory contributions to health insurance, choosing between public insurance (from the Fondo Nacional de Salud, FONASA) and private insurance (from one of the Instituciones de Salud Previsional, ISAPREs). Within the public system (FONASA), affiliated individuals are distributed from letters A (the most vulnerable) to D (the least vulnerable) based on their income and number of dependents. These categories differ on benefits and copayments. The services provided by the private sector (ISAPREs) are relatively more expensive and only the highest income households take this option. For instance, in the CASEN 2011 survey just 13% of the population was affiliated to an ISAPRE and about 85% of those affiliated to an ISAPRE belonged to the top two income quintiles.

We first estimate equation (1) using the ENS sample and self-reported prosthetic need as the dependent variable. When using the in-depth survey sample we face the challenge that the individuals participating in the study may represent a self-selected sample and, therefore, it may not be representative of the complete relevant population. Although this sample should come close to the population that has a high latent demand for dental care (and, therefore, should come close to the public policy target population), we are concerned that due to selection issues, we cannot estimate a socioeconomic gradient (i.e., $\beta_1$) that is meaningful. It is worth noting that we are not concerned *per se* by not having a representative sample of the population but by the fact that a self-selected sample may lead to biased estimates of $\beta_1$ (Wooldridge, 2010).

In order to deal with this problem we use a two-step procedure (Heckman, 1979). The idea behind this procedure is that a non-representative sample leads to biased estimates if sample selection is the result of unobservable characteristics associated with both participation in the sample and outcomes. The fact that individuals had to first apply and then travel to fill the in-depth survey in order to participate in the RCT program makes it plausible that unobserved characteristics are at place.

To correct for this potential bias, we first estimate an equation that models the participation in the sample:

$$y_2 = 1[x_3\beta_3 + v_2 > 0] \qquad (2)$$

where $y_2$ is an indicator variable denoting whether an individual is observed (i.e., is in the in-depth sample), $x_3$ is a set of variables that affect the participation decision and $v_2$ is an error term. Assuming that the error terms $(u_1, v_2)$ are independent of $x$, and that $v_2$ follows a Normal distribution, the

estimation of the participation equation using a probit model produces an estimate of the inverse of the Mills ratio (IMR). It can be shown that under these assumptions, if one estimates equation (1) including the IMR as a control variable, the parameter estimates are consistent (Heckman, 1979; Wooldridge, 2010).

We estimate equation (2) by combining the baseline survey with a representative sample from the 2011 CASEN survey, comprising individuals who comply with the eligibility criteria to participate in of the RCT program. We use the CASEN survey and not the ENS because of its richer information on households' characteristics. In order to insure identification, we need to include in $x_3$ some variables that are excluded from the estimation of equation (1). We use variables related with proximity to the information sources about the program and with the cost of traveling to the University campus as excluded variables when estimating the participation equation.

**Results**

*Descriptive statistics*

Tables 1 and 2 contain summary statistics for the ENS and in-depth surveys respectively. There are two main differences between these samples. On the one hand, the ENS is a national representative sample of individuals aged 15 or more. In contrast, the in-depth survey sample eligibility was restricted to residents of the Greater Santiago who were 18 to 60 years old and were affiliated to the public health insurance system. On the other hand, the in-depth survey sample represents individuals who self-selected into applying for the RCT program.

The first set of columns in Table 1 provides statistics for the full ENS survey, whereas the second set restricts the sample according to the in-depth survey eligibility conditions. Individuals in the full ENS survey are slightly older and more likely to be male and to be a household head than those in the restricted ENS sample. They are also less likely to have completed high school and to be employed. The incidence of dental prosthetic need is lower in the restricted sample as 28% (*versus* 35%) of respondents indicate using or needing a dental prosthesis, a fact consistent with the exclusion of older adults in the restricted sample.

Compared to the restricted ENS sample, most of the in-depth survey sample is composed of female participants (53% *versus* 72%). The individuals in the in-depth survey sample are also less likely to be married or living with a partner, and more likely to be heads of household. The in-depth survey participants and ENS respondents have achieved on average similar education levels and have similar employment rates.

The fraction of respondents in the ENS using and/or needing a dental prosthesis sharply contrasts with the fraction of individuals participating in the in-depth survey who are diagnosed with prosthetic needs (28% in the restricted ENS *versus* 75% in the in-depth survey). The latter is consistent with the large share of the in-depth survey participants who self-rate their oral health as bad or regular (98%).

**Table 1**

**Descriptive statistics of the ENS sample**

| | Full Sample | | | Restricted Sample[e] | | |
|---|---|---|---|---|---|---|
| | Mean | St.Dev. | N | Mean | St.Dev. | N |
| Age | 41.6 | 17.7 | 5269 | 37.7 | 12.6 | 471 |
| Gender (1 if male) | 0.49 | 0.50 | 5269 | 0.47 | 0.50 | 471 |
| Married or living with partner | 0.55 | 0.50 | 5269 | 0.56 | 0.50 | 471 |
| Number of household members | 4.11 | 1.83 | 5269 | 4.47 | 1.81 | 471 |
| Head of household | 0.42 | 0.49 | 5269 | 0.38 | 0.49 | 471 |
| Education[a] | | | | | | |
| *Middle education or less* | 0.31 | 0.46 | 5269 | 0.21 | 0.41 | 471 |
| *Incomplete high school education* | 0.16 | 0.37 | 5269 | 0.14 | 0.35 | 471 |
| *Complete high school education* | 0.29 | 0.45 | 5269 | 0.44 | 0.50 | 471 |
| *Tertiary education* | 0.24 | 0.43 | 5269 | 0.21 | 0.41 | 471 |
| Employed | 0.52 | 0.50 | 5269 | 0.65 | 0.48 | 471 |
| Household monthly income (thousand CLP[b]) | 360.0 | 287.3 | 5032 | 367.5 | 253.8 | 422 |
| Health Insurance | | | | | | |
| *Public Insurance A (most vulnerable)* | 0.26 | 0.44 | 5269 | 0.25 | 0.44 | 471 |
| *Public Insurance B* | 0.25 | 0.43 | 5269 | 0.28 | 0.45 | 471 |
| *Public Insurance C* | 0.09 | 0.29 | 5269 | 0.15 | 0.36 | 471 |
| *Public Insurance D (least vulnerable)* | 0.08 | 0.27 | 5269 | 0.11 | 0.32 | 471 |
| *Public Insurance unknown letter* | 0.11 | 0.31 | 5269 | 0.20 | 0.40 | 471 |
| *Private Insurance (ISAPRE)* | 0.12 | 0.33 | 5269 | 0.00 | 0.00 | 471 |
| *Other health insurance*[c] | 0.10 | 0.17 | 5269 | 0.00 | 0.00 | 471 |
| Oral health and behavior | | | | | | |
| *Dental visit within past year* | 0.44 | 0.50 | 5266 | 0.41 | 0.49 | 471 |
| *Prosthesis need (self-diagnosis)*[d] | 0.35 | 0.48 | 5172 | 0.28 | 0.45 | 460 |

Data weighted using sampling weights.

a. Estimated on the basis of the number of completed years of education.

b. The average exchange rate over the sampling period was 510 Chilean pesos per dollar according to the Central Bank of Chile.

c. Other responses are “No insurance”, “Do not know”, “Armed Forces’ system”, and “Other private”.

d. Individuals who either report using or needing a dental prosthesis.

e. Respondents aged 18 to 60, residents of the Greater Santiago and covered by the public health system.

**Table 2**

**Descriptive statistics of the in-depth survey**

| | Mean | St.Dev. | N |
|---|---|---|---|
| Age | 42.4 | 10.4 | 1413 |
| Gender (1 if male) | 0.28 | 0.45 | 1413 |
| Married or living with partner | 0.50 | 0.50 | 1394 |
| Number of household members | 4.31 | 1.75 | 1413 |
| Number of children under 5 in household | 0.21 | 0.47 | 1413 |
| Number of children between 5 and 18 | 0.91 | 1.03 | 1413 |
| Head of household | 0.70 | 0.46 | 1413 |
| Education | | | |
| *Middle education or less* | 0.17 | 0.38 | 1394 |
| *Incomplete high school education* | 0.19 | 0.39 | 1394 |
| *Complete high school education* | 0.45 | 0.50 | 1394 |
| *Higher education* | 0.20 | 0.40 | 1394 |
| Employed | | | |
| *Full time* | 0.47 | 0.50 | 1413 |
| *Part time* | 0.20 | 0.40 | 1413 |
| Household monthly income (th. CLP[a]) | 285.5 | 376.1 | 1413 |
| Health Insurance | | | |
| *Public Insurance A (most vulnerable)* | 0.29 | 0.46 | 1413 |
| *Public Insurance B* | 0.30 | 0.46 | 1413 |
| *Public Insurance C* | 0.26 | 0.44 | 1413 |
| *Public Insurance D (least vulnerable)* | 0.14 | 0.34 | 1413 |
| *Public Insurance unknown category* | 0.01 | 0.12 | 1413 |
| Oral health and behavior | | | |
| *At least one missing tooth* | 0.92 | 0.26 | 1413 |
| *Total number of missing teeth* | 8.35 | 6.53 | 1413 |
| *Number of frontal missing teeth* | 1.12 | 2.12 | 1413 |
| *Upper prosthetic need* | 0.75 | 0.43 | 1413 |
| *Lower prosthetic need* | 0.74 | 0.44 | 1413 |
| *At least one caries (treated or untreated)* | 0.98 | 1.44 | 1413 |
| *Number of untreated caries* | 2.74 | 3.07 | 1413 |
| *Occlusion problems* | 0.81 | 0.40 | 1413 |
| *Reported daily tooth brushing frequency* | 2.76 | 0.87 | 1413 |
| *Dental visit within past year* | 0.32 | 0.47 | 1413 |
| *OHIP-14 score* | 33.29 | 12.05 | 1413 |
| *Bad or regular self-rated oral health* | 0.98 | 1.42 | 1413 |
| Rosenberg self-esteem scale | 27.94 | 4.42 | 1413 |
| Distance to subway (kms.) | 6.38 | 13.56 | 1413 |
| Travel time to campus (minutes) | 22.27 | 13.73 | 1413 |

a. The average exchange rate in February 2011 –the sampling period-- was 476 Chilean pesos per dollar according to the Central Bank of Chile. We use the maximum between the reported household income and the individual's reported labor income.

Sample selection probably explains this discrepancy as the respondents of the in-depth survey are people applying to a program offering free dental care services including prostheses. A socioeconomic gradient in oral health might also matter -at least compared to the full ENS sample-, as only individuals covered by the public healthcare system are eligible to participate in the in-depth survey. If high income and affiliation to the private system are correlated with better oral health, then prosthetic need should be lower in the ENS sample.

The difference in the incidence of prosthetic needs might also be related to an underestimation of oral health status among the ENS respondents who provided a self-diagnosis of their condition. In contrast, the in-depth survey respondents were clinically examined. Thus ENS respondents may not be fully aware of their dental health needs. Other studies report a similar gap between actual and self-perceived oral health status (Moura et al., 2014; Schützhold et al., 2014).

The summary statistics also provide information on the measures of material resources we use to estimate socioeconomic gradients. Respondents of the in-depth survey report much lower income than individuals in the restricted-ENS sample despite having similar educational attainment and employment rates. We are concerned that household income may be underreported in the in-depth survey, and thus we use health care affiliation indicator variables as proxies for material resources in our regression analysis below. In terms of affiliation to public or private health insurance programs, individuals in the restricted ENS sample are more likely to be affiliated to letters A and B than the respondents of the in-depth survey.

The descriptive statistics also provide information on dental visit patterns. In the full ENS sample, 44% of individuals visited a dentist within the past year compared to 41% and 32% in the restricted ENS and the in-depth survey samples respectively.

Table 2 also provides information on self-rated and clinically assessed oral health. In the sample, 98% of respondents have experienced dental caries and 92% have lost at least one tooth. According to the Ministry of Health (2010b), the respective prevalence rates among adults in Chile are 99% and between 80% and 99% depending on age. Finally, Table 2 reports a mean self-esteem indicator equal to 27.9, a level somewhat lower than the average of 32.5 reported by Rojas-Barahona et al. (2009) in a validation study for Chilean adults.

*Gradients in the national context*

Table 3 shows regressions estimating the socioeconomic gradient in self-diagnosed prosthetic need using the complete ENS. We use the two measures of material resources: public or private healthcare system affiliation (FONASA A to D or ISAPRE) and household per capita income divided in quintiles. We use two measures because we are concerned that income may be underreported in our baseline sample, particularly among relatively high income individuals. Thus, in our analysis of SPOH below we include categories of public system affiliation (letters A to D) as a proxy for per capita income. We also include educational attainment as a measure of long term income.

**Table 3**

**ENS results on self-diagnosed prosthetic need**

| | *Needs and/or uses dental prosthesis* | | | |
|---|---|---|---|---|
| | Coeff. | p-value | Coeff. | p-value |
| Health Insurance (base: *Public Insurance A, most vulnerable*) | | | | |
| *Public Insurance B* | -0.066 | 0.034 | | |
| *Public Insurance C* | 0.000 | 0.996 | | |
| *Public Insurance D (least vulnerable)* | -0.104 | 0.041 | | |
| *Private Insurance (ISAPRE)* | -0.205 | 0.000 | | |
| Household per capita income quintile (base: *Quintile I, lowest income*) | | | | |
| *Quintile II* | | | -0.051 | 0.185 |
| *Quintile III* | | | -0.080 | 0.054 |
| *Quintile IV* | | | -0.049 | 0.298 |
| *Quintile V (highest income)* | | | -0.182 | 0.000 |
| Education level (base: *Middle or less*) | | | | |
| *Incomplete high school* | -0.061 | 0.049 | -0.066 | 0.034 |
| *Complete high school* | -0.117 | 0.000 | -0.115 | 0.001 |
| *Higher education* | -0.146 | 0.000 | -0.147 | 0.003 |
| Observations | 5172 | | 4942 | |
| Pseudo $R^2$ | 0.319 | | 0.307 | |

The dependent variable is a dummy variable indicating whether the individual reports using and/or needing a dental prosthesis. Health insurance, income quintile and educational attainment variables are indicator variables. The remainder categories of health insurance as well as age, gender, marital status, and head of household and employment status are included but not reported. Marginal effects of a probit regression model with robust standard errors are reported. Data weighted using the ENS sampling weights.

Table 3 shows a socioeconomic gradient in self-reported prosthetic need. The gradient is steep at the lowest income level, becomes relatively flat at mid-income and turns steeper as the highest income category is reached. This pattern holds for both the estimations using income quintiles and healthcare system affiliation. We cannot reject the hypothesis that the coefficients associated to quintiles II to IV are the same as well as those associated to the public insurance B to D dummies (Chi-squared tests' p-values equal to 0.69 and 0.19 respectively).

Educational attainment is also related to prosthetic need even after adjusting for material resources. The probability of prosthesis need is reduced relative to the base by near 7, 12 and 15 percentage points as higher education levels are reached. Other studies have also found an independent effect of schooling on oral health (Borrell et al., 2004; Sabbah et al., 2007; Finlayson et al., 2010) perhaps due to transitory income shocks that may be better captured by income variables and to health-related behavioral differences across educational groups.

*In-depth survey sample: gradient in self-perceived oral health*

While the ENS allows us to describe the complete socioeconomic gradient for self-reported prosthetic need, the data on SPOH excludes individuals not in the public system, as eligibility to participate in the in-depth survey is restricted to individuals affiliated to FONASA. If patterns for SPOH are the same as for self-reported prosthetic need, we should find no significant improvements in SPOH with income in the observed subpopulation, except for the lowest income category.

We estimate the SPOH equation using both a simple OLS procedure and the Heckman two-stage procedure described above. In the first case, we do not correct for potential biases related to self-selection of the individuals into participation in the in-depth survey. In the second case, we estimate equation (1) adding the IMR as a control variable in order to correct for potential biases related to self-selection. Table A.1 in the appendix presents the estimates of the participation equation along with a detailed discussion.

Table 4 presents our benchmark estimates of the determinants of SPOH. We start with a comparison between the OLS and two-stage procedures. The fact that the estimated coefficient on the IMR is marginally significant in the Heckman two-stage procedure implies that the error terms in equations (1) and (2) are (weakly) correlated and that therefore the OLS estimates may be inconsistent due to selection bias. However, the facts that the IMR is only marginally significant and that most of the OLS and Heckman two-stage estimates are qualitatively similar suggest that this bias may be important just for some of the estimated parameters.

The estimated gradient in the sample selection corrected panel of Table 4 is consistent with the estimates using the population-wide ENS: SPOH is worse among individuals in the lowest income group and relatively constant at higher income levels within the public insurance system. We cannot reject the hypothesis that the coefficients associated to the FONASA variables B to D are the same (Chi-squared test p-value equal to 0.88). The effect of moving from FONASA A to higher levels is large and significant, and equivalent to about 0.26 standard deviations of SPOH (evaluated at the FONASA B coefficient in the two-step procedure).

Each category of education presents statistically significant improvements in SPOH in Table 4, with an effect of moving from one category to the next of about 0.2 standard deviations of SPOH (evaluated at the Heckman procedure estimates). This confirms the findings in Table 3 that the impact of education goes beyond the impact through income.

The estimation results also suggest that self-perceived oral health is worse among women, and is negatively correlated with age and with the presence of children under 5 years of age in the household. The latter effect probably occurs because of time and money consuming activities related to childcare, which in turn suggests that this group could be an especially important target of oral health policies.

**Table 4**

**Self-perceived oral health regression results**

| | OLS | | Heckman Two-step | |
|---|---|---|---|---|
| | Coef. | p-value | Coef. | p-value |
| Gender (1 if male) | -3.991 | 0.000 | -2.433 | 0.042 |
| Age (*base: 18-30*) | | | | |
| *31-40* | 3.912 | 0.001 | 2.807 | 0.029 |
| *41-50* | 5.970 | 0.000 | 4.622 | 0.001 |
| *51-61* | 7.219 | 0.000 | 6.429 | 0.000 |
| Head of household | 1.522 | 0.038 | -1.506 | 0.456 |
| Married/partner | -0.364 | 0.609 | -0.186 | 0.784 |
| Children under 5 | 2.273 | 0.001 | 2.974 | 0.000 |
| Children aged 5-18 | 0.253 | 0.327 | 0.498 | 0.161 |
| Education (*base: Middle or less*) | | | | |
| *Incomplete high school* | -1.184 | 0.217 | -2.162 | 0.069 |
| *Complete high school* | -3.455 | 0.001 | -4.749 | 0.000 |
| *Higher Education* | -6.031 | 0.000 | -7.206 | 0.000 |
| Employed full time | 0.211 | 0.739 | 1.420 | 0.196 |
| Employed part time | -1.018 | 0.251 | -1.425 | 0.124 |
| Healthcare system (*base: Public Insurance A, most vulnerable*) | | | | |
| *Public Insurance B* | -2.493 | 0.002 | -3.166 | 0.001 |
| *Public Insurance C* | -2.164 | 0.039 | -3.640 | 0.004 |
| *Public Insurance D (least vulnerable)* | -2.382 | 0.006 | -3.475 | 0.007 |
| *Public Insurance unknown category* | -2.131 | 0.172 | 3.431 | 0.771 |
| Inv. Mills ratio (IMR) | | | -4.249 | 0.105 |
| Constant | 32.623 | 0.000 | 42.15 | 0.000 |
| Observations | 1,394 | | 1,394 | |
| R-squared | 0.138 | | | |

The dependent variable is OHIP-14 score. All independent variables are indicator variables. The first set reports OLS estimates without correction for sample selection. The next set corrects for sample selection using a two-step estimator. Clustered standard errors at the municipality of residence level are reported.
Inv. Mills ratio (IMR) is the sample selection correction variable. After estimating the participation equation (Table A.1), for each observation in the in-depth survey sample we compute $\hat{\lambda}=\phi(x_3\,\widehat{\beta_3})/\Phi(x_3\,\widehat{\beta_3})$, where $\phi$ is the density of the Normal Distribution and $\Phi$ is its cumulative.

We present estimates of the effects of the determinants of SPOH including controls for measures of the actual oral health condition in Table 5. The Table shows that oral health impairments are important determinants of SPOH. Malocclusion, frontal missing teeth, a large number of caries and missing teeth due to caries all worsen SPOH independently in the range of 0.11 to 0.43 standard deviations of SPOH.

Interestingly, the socioeconomic and educational gradients are attenuated once oral health status is controlled for. In the case of FONASA affiliation, we estimate relevant differences in SPOH between

the less favored group and the rest. Importantly, and analogous to our previous estimates, while all FONASA categories are significantly better than the lowest one, there is no statistically significant difference among them (with a p-value equal to 0.59).

Age categories are not statistically significant in the second stage in Table 5, suggesting that the observed correlation between SPOH and age is due to a decay in actual oral health status over time.

**Table 5**

**Self-perceived oral health regression results, controlling for oral health condition**

| | OLS | | Heckman Two-step | |
|---|---|---|---|---|
| | Coef. | p-value | Coef. | p-value |
| Gender (1=male) | -4.348 | 0.000 | -2.977 | 0.009 |
| Age (*base: 18-30*) | | | | |
| *31-40* | 1.734 | 0.162 | 0.762 | 0.538 |
| *41-50* | 2.036 | 0.045 | 0.854 | 0.526 |
| *51-61* | 1.681 | 0.221 | 0.991 | 0.437 |
| Head of household | 1.586 | 0.024 | -1.079 | 0.573 |
| Married/partner | -0.208 | 0.735 | -0.052 | 0.936 |
| Children under 5 | 2.352 | 0.001 | 2.967 | 0.000 |
| Children aged 5-18 | 0.343 | 0.125 | 0.559 | 0.097 |
| Education (*base: Middle or less*) | | | | |
| *Incomplete high school* | 0.132 | 0.905 | -0.730 | 0.519 |
| *Complete high school* | -1.506 | 0.144 | -2.650 | 0.022 |
| *Higher Education* | -3.196 | 0.008 | -4.237 | 0.001 |
| Employed full time | 0.055 | 0.934 | 1.121 | 0.283 |
| Employed part time | -0.613 | 0.479 | -0.973 | 0.267 |
| Public health system (*base: Public Insurance A, most vulnerable*) | | | | |
| *Public Insurance B* | -1.945 | 0.005 | -2.539 | 0.004 |
| *Public Insurance C* | -1.661 | 0.081 | -2.960 | 0.014 |
| *Public Insurance D* | -0.965 | 0.237 | -1.930 | 0.115 |
| *Public Insurance unknown category* | 0.641 | 0.692 | 5.534 | 0.620 |
| Any frontal missing teeth | 4.760 | 0.000 | 4.721 | 0.000 |
| Caries (*base: <6*) | | | | |
| *6-11* | 1.760 | 0.017 | 1.784 | 0.036 |
| *12 or more* | 7.131 | 0.000 | 7.032 | 0.001 |
| Teeth lost by caries | | | | |
| *6-11* | 3.448 | 0.000 | 3.445 | 0.000 |
| *12 or more* | 5.151 | 0.000 | 5.171 | 0.000 |
| Malocclusion | 1.265 | 0.088 | 1.291 | 0.078 |
| Inv. Mills ratio (IMR) | | | -3.782 | 0.131 |
| Observations | 1,394 | | 1,394 | |
| R-squared | 0.226 | | | |

See Table 4 for details.

Our findings support the hypothesis that biological factors such as tooth loss are associated to SPOH. However, our results also show that there are other factors at play. A central finding is that there is a non-linear socioeconomic gradient in SPOH, with OHIP-14 scores that improve discretely when individuals overcome the lowest income level. We also find an educational gradient in SPOH even after controlling for income.

*Gradients in selected SPOH dimensions*

Socioeconomic indicators could impact differently the distinct dimensions of SPOH. We now explore the existence of socioeconomic gradients in eight selected SPOH questions scores. We focus on functional limitations and on psychological and social interaction impairments. We present the results in Table 6 where we include controls for objective oral health conditions as in Table 5, and estimate using the Heckman two step procedure.

We find no statistically significant correlation between the functional limitations and physical pain scores and FONASA categories, education or children at home. Trouble pronouncing words might be associated with specific missing teeth, a phenomenon that may not be correlated with income or with children at home. In turn, the absence of a socioeconomic gradient for physical pain could be expected because tooth extraction is offered by the public system.

We find a steep educational gradient for all the other selected questions. FONASA categories are also generally associated with specific scores, with a threshold effect that separates the lowest public health insurance group from the remainder of the population. The presence of children under five years of age is also generally significant.

Oral health impairment variables are also significant. Some have larger impacts on specific questions. For example, frontal missing teeth, an impairment that is very different from caries or malocclusion in its social significance, has a larger impact on life satisfaction and on being embarrassed.

In sum, after controlling for oral health indicators, the psychological and social dimensions, more than the physical limitation dimensions, seem to be responsible for the OHIP-14 gradients. Being embarrassed, irritable with others and feeling that life is less satisfying all show significant correlations with educational attainment and income measures. In these cases, we again find that while individuals affiliated to FONASA B to D categories are significantly better than those affiliated to FONASA A, their estimated coefficients are not statistically different between them (p-values equal to 0.47, 0.50 and 0.12, respectively).

**Table 6**

**Determinants of SPOH. Selected questions**

| | *Functional limitations* | | | | *Physical pain* | | *Physical disability* | |
|---|---|---|---|---|---|---|---|---|
| | *Sense of taste affected* | | *Trouble pronouncing words* | | *Painful aching* | | *Interrupted meals* | |
| | Coef. | p-value | Coef. | p-value | Coef. | p-value | Coef. | p-value |
| Education (base: *Middle or less*) | | | | | | | | |
| *Incomplete high school* | 0.037 | 0.776 | 0.041 | 0.759 | 0.052 | 0.635 | -0.228 | 0.082 |
| *Complete high school* | 0.002 | 0.985 | -0.001 | 0.996 | 0.136 | 0.229 | -0.422 | 0.002 |
| *Higher education* | -0.148 | 0.315 | -0.125 | 0.397 | 0.143 | 0.247 | -0.448 | 0.002 |
| Public health system (base: *Public Insurance A, most vulnerable*) | | | | | | | | |
| *Public Insurance B* | 0.012 | 0.909 | -0.237 | 0.022 | -0.142 | 0.100 | -0.192 | 0.061 |
| *Public Insurance C* | 0.157 | 0.261 | 0.043 | 0.759 | -0.061 | 0.601 | -0.309 | 0.026 |
| *Public Insurance D* | 0.085 | 0.551 | -0.031 | 0.830 | -0.002 | 0.985 | -0.124 | 0.379 |
| *Public Insurance unknown categ* | -0.114 | 0.929 | -1.936 | 0.140 | -0.385 | 0.725 | 1.498 | 0.241 |
| Children under 5 | 0.008 | 0.931 | -0.019 | 0.829 | 0.067 | 0.367 | 0.347 | 0.000 |
| Children aged 5-18 | -0.040 | 0.309 | -0.008 | 0.846 | -0.016 | 0.622 | 0.064 | 0.100 |
| Any frontal missing teeth | 0.215 | 0.017 | 0.649 | 0.000 | 0.013 | 0.870 | 0.288 | 0.001 |
| Caries (base: <6) | | | | | | | | |
| *6-11* | 0.203 | 0.038 | 0.108 | 0.276 | 0.164 | 0.048 | 0.100 | 0.304 |
| *12 or more* | 0.109 | 0.639 | 0.300 | 0.206 | 0.307 | 0.120 | 0.325 | 0.159 |
| Teeth lost by caries | | | | | | | | |
| *6-11* | 0.059 | 0.494 | 0.223 | 0.011 | 0.021 | 0.773 | 0.256 | 0.003 |
| *12 or more* | 0.256 | 0.027 | 0.449 | 0.000 | 0.098 | 0.316 | 0.586 | 0.000 |
| Malocclusion | -0.086 | 0.308 | 0.196 | 0.022 | 0.074 | 0.301 | 0.028 | 0.737 |
| Inv. Mills ratio (IMR) | 0.526 | 0.070 | 0.315 | 0.282 | 0.323 | 0.186 | -0.601 | 0.038 |
| Constant | 1.844 | 0.005 | 1.597 | 0.017 | 2.782 | 0.000 | 4.109 | 0.000 |
| Observations | 1,394 | | 1,394 | | 1,394 | | 1,394 | |

**Table 6 (cont.)**

| | *Social disability* | | | | *Psychological disability* | | *Handicap* | |
|---|---|---|---|---|---|---|---|---|
| | *Irritable with others* | | *Difficulties doing jobs* | | *Being embarrassed* | | *Life less satisfying* | |
| | Coef. | p-value | Coef. | p-value | Coef. | p-value | Coef. | p-value |
| Education (base: *Middle or less*) | | | | | | | | |
| *Incomplete high school* | -0.077 | 0.579 | -0.134 | 0.366 | -0.037 | 0.749 | -0.037 | 0.784 |
| *Complete high school* | -0.309 | 0.029 | -0.322 | 0.034 | -0.183 | 0.118 | -0.343 | 0.014 |
| *Higher education* | -0.450 | 0.004 | -0.451 | 0.007 | -0.319 | 0.013 | -0.568 | 0.000 |
| Public health system (base: *Public Insurance A, most vulnerable*) | | | | | | | | |
| *Public Insurance B* | -0.233 | 0.032 | -0.347 | 0.003 | -0.164 | 0.068 | -0.147 | 0.168 |
| *Public Insurance C* | -0.266 | 0.072 | -0.435 | 0.006 | -0.245 | 0.044 | -0.356 | 0.014 |
| *Public Insurance D* | -0.125 | 0.403 | -0.318 | 0.047 | -0.282 | 0.023 | -0.161 | 0.274 |
| *Public Insurance unknown categ* | 1.204 | 0.381 | 0.801 | 0.576 | 0.535 | 0.634 | 0.429 | 0.744 |
| Children under 5 | 0.226 | 0.016 | 0.311 | 0.002 | 0.241 | 0.002 | 0.326 | 0.000 |
| Children aged 5-18 | 0.050 | 0.224 | 0.102 | 0.021 | 0.075 | 0.029 | 0.078 | 0.055 |
| Any frontal missing teeth | 0.290 | 0.003 | 0.254 | 0.012 | 0.378 | 0.000 | 0.506 | 0.000 |
| Caries (base: <6) | | | | | | | | |
| *6-11* | 0.074 | 0.481 | 0.094 | 0.388 | 0.205 | 0.026 | 0.123 | 0.218 |
| *12 or more* | 0.293 | 0.240 | 0.730 | 0.005 | 0.621 | 0.002 | 0.807 | 0.001 |
| Teeth lost by caries | | | | | | | | |
| *6-11* | 0.203 | 0.028 | 0.249 | 0.010 | 0.430 | 0.000 | 0.334 | 0.000 |
| *12 or more* | 0.392 | 0.001 | 0.433 | 0.001 | 0.440 | 0.000 | 0.397 | 0.000 |
| Malocclusion | 0.112 | 0.216 | 0.092 | 0.328 | 0.240 | 0.001 | 0.075 | 0.384 |
| Inverse Mills ratio (IMR) | -0.342 | 0.265 | -0.761 | 0.022 | -0.438 | 0.084 | -0.747 | 0.013 |
| Constant | 3.511 | 0.000 | 4.363 | 0.000 | 4.485 | 0.000 | 4.548 | 0.000 |
| Observations | 1,394 | | 1,388 | | 1,394 | | 1,393 | |

The dependent variables are OHIP-14 subcategories' scores. All independent variables are indicator variables .Regressions include all variables listed in Table 5; we report those related to socioeconomic status, children in the household and objective oral health. We correct for sample selection using Heckman's two-step estimator.

## Discussion

This study investigated the association between oral health self-perception and socioeconomic background among Chilean adults. Two data sets were used: a national representative sample and an in-depth survey sample from the baseline survey of a RCT set up to evaluate the impact of the provision of dental care services to low income individuals.

The latter sample, although not representative of the general population, should come close to the public policy target. One relevant advantage of the in-depth survey sample is its rich information on clinically assessed oral health, self-perceived oral health, self-esteem, socioeconomic background and demographic variables. The estimation results should be representative of those eligible for the program as we corrected for self-selection. Moreover, we show that correcting for the self-selected nature of the sample does not seem to affect the estimates of the effects of socioeconomic background on self-perceived oral health.

Using the national sample, we found socioeconomic gradients in self-reported dental prosthetic need when using educational attainment and household income measures. Estimated income gradients are steep at the lowest category, flat at mid-income and again steep at levels that coincide with the richest quintile of households.

The estimated patterns for SPOH using the in-depth survey sample are very similar considering that the sample does not include households at the upper end of the income distribution. When healthcare system affiliation is used as a proxy for income, individuals at the lowest level report poorer self-perceived oral health conditions. But while all other income categories are significantly better than the lowest one, there is no statistical difference between them.

Finally, the analysis of specific SPOH scores suggests that the psychological and social dimensions, more than the physical limitation dimensions, are responsible for the socioeconomic gradient in the OHIP-14 score.

The analysis thus confirms the existence of a socioeconomic gradient in SPOH which we mainly attribute to access inequalities to preventive dental services and to relatively complex oral health treatments like implants or prostheses. Socially disadvantaged households face access barriers to dental health care in Chile given the limited public provision of services and the costly and heterogeneous privately provided solutions. These barriers prevent even those with higher incomes within the public health system to improve their SPOH.

The estimated stepwise gradient differs in shape from the flat one found for Brazil (Gabardo et al., 2015) and the nearly linear ones found for developed countries (Sanders et al., 2006a and 2006b; Wamala et al., 2006; Locker, 2009).

The literature has linked socioeconomic status and health through factors other than a material resources channel: status-related patterns of health behavior, and psychological factors like psychosocial threats that lead to stress and that are unequally distributed in society (Sisson, 2007). These factors could also be influencing our results as they may operate simultaneously.

To determine whether psychological and psychosocial resources explain the relationship between socioeconomic status and oral health, some authors have included variables such as self-esteem in multivariate models of self-perceived oral health (Sanders and Spencer, 2005a and 2005b; Locker, 2009; Finlayson et al., 2010; Gabardo et al., 2015). In general, they find that psychosocial variables have explanatory power in oral-health regressions and that their inclusion reduces the strength of the

socioeconomic gradient. These results have been interpreted as evidence favoring a role for psychosocial factors in explaining oral-health disparities. However, other authors have suggested that self-esteem and life satisfaction can be explained by self-rated oral health; i.e., that causality may run in the opposite direction (Locker et al., 2002; Benyamini et al., 2004).

In the in-depth survey sample, the simple correlation of the OHIP-14 as well as of each of its questions with the Rosenberg measure of self-esteem is negative and strong, so better levels of SPOH are associated with higher self-esteem. However, as both OHIP-14 and self-esteem are outcome variables, important concerns arise regarding a regression analysis which treats one of these variables as exogenous to the other, preventing us from performing such statistical approximation. Still, we cannot rule out the hypothesis that there is a role for psychological factors in explaining the gradients.

Similarly, it is plausible that oral-health inequalities and behavior impact each other (López et al., 2006; Sabbah et al., 2009). To avoid reverse causality problems, we have not included current behavioral variables in our models. Yet, there is a correlation between education and the frequency of dental care visits in both samples, but no correlation between education and dental self-care behavior such as tooth brushing frequency in the in-depth survey sample. If education serves partly as a proxy for long-term income, then this result is consistent with the hypothesis of unequal access to oral health services more than of health-related behavioral differences. A similar result was found by Sanders et al. (2006b).

We do control for actual oral health conditions which in partly are determined by lifetime oral health behavior. Socioeconomic gradients are attenuated after adjusting for oral disease variables, although income remains a significant and relevant predictor of perceived oral-health status.

Finally, there may also be a concern on whether part of the observed gradient is related to the effects of health on income as health affects the ability to work and to generate earnings. However, the kind of impairments we analyze in this study, such as tooth loss, are conditions that usually take a long time to reach their final stages (Tonetti et al., 2000).

Thus, if the causality runs from oral-health status to income, then life course socioeconomic status, more than present status, should be identified as a main determinant of SPOH. We have included educational attainment as a measure of long term earnings ability. We find an independent correlation between SPOH and this measure of lifetime earnings, and between SPOH and current income measures.

**Conclusion**

This study contributes to the scarce evidence on SPOH and socioeconomic status for developing countries. It also highlights the shape of this relationship in a context of unequal access to oral health services due to a combination of insufficient provision in the public sector and costly and heterogeneous solutions in the private sector.

This study analyzes the case of Chile, a country that will probably make the transition to the group of developed countries in the next few decades. Thus access inequalities could be even more pronounced in poorer countries affecting the socioeconomic gradient. For instance, access barriers could extend even to basic oral-health services and not only to relatively complex procedures. If so, SPOH dimensions like those related to experiencing pain could –unlike in the Chilean case– show socioeconomic gradients.

The appropriate policy interventions to reduce the observed inequities depend on the factors that explain the gradient. This study emphasizes inequity of access but the relevance of the several channels that link socioeconomic background with dental health should be more clearly assessed. Given the potential reverse causality problems, we cannot rule out the role of other aspects in explaining the variation in self-perceived oral-health along the income distribution, in particular, psychosocial factors. In this line, two follow-ups of the participants in the in-depth survey assess both self-esteem and oral health related quality of life after the provision of removable dental prostheses, allowing us to study the effects of improvements in actual oral health status on both SPOH and the Rosenberg scores (Gallego et al., in progress).

**Appendix 1: Determinants of participation in the In-depth survey sample**

Table A.1 reports the determinants of the probability of participating in the in-depth survey sample. The Table shows that most of the covariates are statistically significant. Consistent with the summary statistics, participation in the in-depth survey sample is more likely among women and heads of household. Education and income (using FONASA levels as proxies) are also positively related to survey participation.

We also find that participation is negatively correlated with the presence of children in the household, with a likelihood of participation 2.4 and 0.8 percentage points lower if there are children of pre-school age and children aged 5 to 18 in the household, respectively. Full employment is also negatively correlated with participation. Possibly caring for small children and working full time reduce the likelihood of program awareness and application as they are time consuming activities.

Variables excluded from the second stage (distance to the subway and travel time to campus) are significant and with the expected signs. The first variable indicates whether there is a subway station within a two kilometer radius from the population centroid of the municipality where the subject lives. It is expected to capture location amenities and access to information about the program since an important diffusion mechanism was a newspaper delivered in the Santiago's subway system. It may also capture other unobservable characteristics that may be correlated with residential location choices. In turn, travel time to campus, measured from the municipality population centroid, serves as a proxy for transportation costs. We assume travels during low traffic daytime since individuals could choose their preferred time within a week to visit the University.

We find that individuals who live in municipalities with close access to subway stations are 2.1 percentage points more likely to participate in the in-depth survey. We also find that those in the third tercile of travel time to campus –who take 37 minutes or more– are 3.5 percentage points less likely to participate than those in the first tercile – who take less than 20 minutes.

**Table A.1**

**Marginal effects for the probability of participating in the in-depth survey**

| | Participation Equation | |
|---|---|---|
| | Coeff. | p-value |
| Gender (1 if male) | -0.054 | 0.000 |
| Age (*base: 18-30*) | | |
| *31-40* | 0.045 | 0.000 |
| *41-50* | 0.054 | 0.000 |
| *51-61* | 0.028 | 0.000 |
| Head of household | 0.132 | 0.000 |
| Married/partner | -0.008 | 0.102 |
| Children under 5 years of age | -0.024 | 0.000 |
| Children aged 5-18 | -0.008 | 0.001 |
| Education (*base: middle or less*) | | |
| *Incomplete high school* | 0.034 | 0.000 |
| *Complete high school* | 0.043 | 0.000 |
| *Higher education* | 0.044 | 0.000 |
| Employed full time | -0.047 | 0.000 |
| Employed part time | 0.015 | 0.092 |
| Healthcare system (*base: Public Insurance A, most vulnerable*) | | |
| *Public Insurance B* | 0.024 | 0.000 |
| *Public Insurance C* | 0.064 | 0.000 |
| *Public Insurance D (least vulnerable)* | 0.047 | 0.000 |
| *Public Insurance unknown category* | -0.073 | 0.000 |
| Distance to subway (1 if less than 2km) | 0.021 | 0.035 |
| Travel time to campus (*base: Tercile 1*) | | |
| *Tercile 2* | -0.004 | 0.666 |
| *Tercile 3* | -0.035 | 0.011 |
| Observations | 13,006 | |
| Pseudo $R^2$ | 0.181 | |

The dependent variable is a dummy variable indicating whether the individual is in the in-depth survey sample. All variables are indicator variables. We report marginal effects of a probit model and clustered standard errors at the municipality of residence level.

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