NIPE Núcleo de Investigação em Políticas Económicas e Empresariais

#2
2025

WORKING PAPER

Kurt R. Brekke

Odd Rune Straume

Luigi Siciliani

"Public coverage of dental care: universal or targeted?"

https://nipe.eeg.uminho.pt/

«This paper is financed by National Funds of the FCT – Portuguese Foundation for Science and Technology within the project UID/03182, Centre for Research in Economics and Management/University of Minho»

Universidade do Minho
Escola de Economia, Gestão e Ciência Política

Public coverage of dental care: universal or targeted?*

Kurt R. Brekke† Odd Rune Straume‡ Luigi Siciliani§

January 2025

Abstract

This paper analyses the impact of public dental care coverage—universal versus targeted—on access, pricing, and public spending in a model with two competing dental practices and heterogeneous patient income groups. We evaluate two types of reimbursement schemes: fixed subsidies and cost sharing. Our findings show that public coverage improves access for low-income patients but increases producer prices due to reduced price elasticity of demand. Targeted coverage provides greater access at lower public cost compared to universal coverage, especially under cost-sharing schemes. With fixed subsidies, both schemes achieve similar access, but targeted coverage remains more cost-efficient. The policy that maximises utilitarian welfare is targeted coverage with a fixed subsidy, balancing improved access for low-income patients against higher prices for high-income patients. This trade-off highlights challenges in implementing targeted policies but provides insights for designing efficient and equitable public dental care systems.

Keywords: Dental care; Public coverage; Reimbursement schemes

JEL Classification: H51; I11; I18; L13

*Straume acknowledges financial support from National Funds of the FCT – Portuguese Foundation for Science and Technology within the project UIDB/03182/2020.

†Norwegian School of Economics (NHH), Department of Economics, Helleveien 30, 5045 Bergen, Norway; and Centre for Applied Research at NHH. E-mail: kurt.brekke@nhh.no

‡Department of Economics/NIPE, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal. E-mail: o.r.straume@eeg.uminho.pt

§Department of Economics and Related Studies, University of York, Heslington, York YO10 5DD, UK; E-mail: luigi.siciliani@york.ac.uk

1 Introduction

Access to affordable dental care is a critical component of overall health and well-being. Poor oral health can lead to significant physical, psychological, and financial burdens, affecting not only individuals but also the broader economy through lost productivity and increased healthcare costs (Peres et al., 2019).

Despite its importance, dental care is often treated as a secondary priority in health policy compared to general medical care, with many countries lacking comprehensive public coverage for dental services (Winkelmann et al., 2022).[1] As a result, financial barriers persist, particularly for low-income individuals, exacerbating health inequalities. In 2023, 6% of people who needed dental care in the European Union reported unmet needs because of affordability or accessibility issues according to the EU-SILC survey, but this proportion reached over 12% among low-income individuals (OECD, 2024). Affordability was the primary reason for unmet need because dental care in most instances must be paid out-of-pocket (Moran et al., 2024).

The dental care market presents unique economic and policy challenges. Unlike most other healthcare services, dental care often involves private (for-profit) providers operating in competitive markets where they freely can set prices of their services without any regulatory constraints.[2] Moreover, patient demand is sensitive to price changes, particularly among low-income groups, due to lack of coverage. This creates a clear need for policies that balance affordability with the financial sustainability of public programs. Understanding the dynamics of this market is crucial for designing effective interventions to improve access while minimising public expenditure.

The ongoing debate over universal versus targeted public coverage schemes underscores the need for rigorous economic analysis to guide policy decisions. Countries vary widely in how they organise public coverage for dental care. In the United States, public dental care coverage is primarily income-targeted through Medicaid at the state level and Medicare at the federal level. However, the extent of coverage varies significantly across states, ranging from minimal or no coverage to more comprehensive dental services.[3] In Europe, where universal coverage is generally more common, dental care policies exhibit surprisingly large variations. Some countries target coverage based on income (e.g., Italy and the United Kingdom), while

[1] At the global level, this is also recognised by the 2021 World Health Organization resolution on Oral Health, which urges countries to better integrate oral health into universal health coverage (Lamster, 2021).

[2] See, for example, Sintonen and Linnosmaa (2000) for an overview of the dental care market compared to health care more broadly.

[3] See, for instance, Buchmueller et al. (2016) for an overview of dental care coverage across states in the United States.

others provide broader universal coverage but limit it to specific age groups, such as children or the elderly.[4] A common feature across many countries is the lack of, or very limited, dental care coverage for the adult population. Similar to Medicaid in the US, the intensity of dental coverage in Europe varies widely, from minimal coverage (e.g., Norway and Denmark) to more extensive reimbursement of services (e.g., Germany and France).

A primary issue in the policy debate is how to expand public coverage effectively. Universal coverage can ensure broad access but may impose significant fiscal burdens, while targeted schemes efficiently allocate resources to those most in need but risk leaving higher-income groups with gaps in access. A secondary question is how to design reimbursement for dental care expenditures to balance incentives for cost containment with adequate coverage, ensuring affordability for low-income patients. This study examines these trade-offs by analysing how different coverage schemes affect market outcomes, including access to care, pricing, and expenditures. A key contribution is to incorporate dental practices' price responses to various coverage and reimbursement designs, thereby providing valuable insights for shaping effective and equitable dental care policies.

To do so, we develop a theoretical framework that considers a simplified market with two competing (for-profit) dental practices that are horizontally differentiated (à la Hotelling) and can freely set prices to attract patients. Patients differ in their willingness to pay for treatment due to income differences, where some patients have high incomes and can afford dental care at market prices, while others have lower incomes and may forgo treatment if the price is too high. The analysis compares two types of public coverage schemes: universal coverage, which provides financial support for all patients, and targeted coverage, which focuses solely on low-income patients. Within each scheme, two reimbursement mechanisms are considered: a fixed subsidy, where the payer covers a set amount of the treatment cost, and cost sharing, where a percentage of the treatment price is subsidised.

Based on this set up, we derive several important insights about the effects of public dental care coverage on access, pricing, and public spending. First, we find that public coverage schemes, whether universal or targeted, improve access to dental care for low-income patients by reducing their out-of-pocket costs and therefore making dental care more affordable. However, these schemes also reduce the price elasticity of demand, enabling dental practices to raise

[4] See, for example, Winckelmann et al. (2022) for a comprehensive overview of Europe and Allin et al. (2020) for selected European countries, and Australia, Canada and the US.

prices. This increase in producer prices partially offsets the benefits of reduced consumer prices, highlighting a trade-off between access and affordability.

Second, targeted coverage, which provides financial support only to low-income patients, achieves greater access at a lower cost compared to universal coverage. This is because targeted schemes focus resources on those most likely to forgo treatment due to financial constraints, reducing the overall burden on public funds. However, we show that targeted coverage implies an adverse spillover effect on high-income patients. By making demand less price elastic, the high-income patients now pay a higher price due to no coverage, implying winners and losers of such a policy scheme. Indeed, if the share of low-income patients is relatively small, targeted coverage might even increase the average consumer price for dental care, because of the adverse spillover effect on non-covered patients.

Third, the design of reimbursement mechanisms significantly influences the outcomes of public coverage. Under a fixed subsidy, both universal and targeted schemes improve access for low-income patients equally, but targeted coverage is more cost-efficient. Under cost-sharing schemes, targeted coverage achieves both higher access and lower producer prices than universal coverage, making it the preferred policy in such cases.

Fourth, from a welfare perspective, the study identifies targeted coverage with a fixed subsidy as the optimal policy. This design improves access for low-income patients while minimising public spending. However, since it results in higher prices for high-income patients, as explained above, this creates a trade-off that policymakers must consider. Specifically, the implementation of targeted coverage may face challenges, as it benefits low-income patients at the expense of high-income patients. Furthermore, the dental practices are better off profit-wise under universal coverage with cost sharing, which is opposite of the preference of the public payer. These trade-offs could affect public acceptance and political feasibility, underscoring the importance of balancing equity and efficiency in policy design.

Finally, in an extension to our main analysis we allow for dental practices to price discriminate according to the patients' coverage status.[5] When this is possible, the dental practices might charge higher prices to high-income (uncovered) patients and lower prices to low-income (covered) patients, thus widening the consumer price gap between the two groups. Lower prices

[5] In the main analysis, we implicitly assume that patients' income is not observable to dental practices, making price discrimination based on willingness to pay impossible. However, coverage status is arguably observable to dental practices, allowing for the possibility of charging different prices to covered (low-income) and uncovered (high-income) patients. This form of price discrimination is, of course, not possible under universal coverage.

for low-income patients increase their access to dental care (especially under a fixed subsidy), but result in a higher average consumer price. This is because the higher prices charged to high-income patients outweigh the reductions for low-income patients, creating a trade-off between access and affordability. These findings highlight the complex trade-offs involved in using targeted subsidies to improve equity in dental care access.

The rest of the paper is organised as follows. The next section situates our study within the existing literature. Section 3 introduces the theoretical model. Section 4 derives the equilibrium outcomes for the benchmark case with no public coverage for dental care. Section 5 examines the equilibrium outcomes under both universal and targeted coverage, encompassing fixed subsidy and cost-sharing schemes. Section 6 compares these outcomes and presents our main findings regarding their effects on pricing, access, and public spending. Section 7 conducts a welfare analysis and discusses the optimal policy. Section 8 extends the analysis by allowing dental practices to price discriminate under targeted coverage based on patients' coverage status. Section 9 concludes the paper. Finally, technical derivations and proofs of Propositions are provided in the appendices.

2 Related literature

There is a large and growing literature on expanding public coverage for healthcare. A large part of this literature is on expanding targeted coverage in the United States, focusing specifically on demand responses to specific changes in the Medicare or the Medicaid programs. A key finding is that more coverage leads to higher utilisation of healthcare services by the population that is targeted. For example, Finkelstein et al. (2012) report positive effects of increased coverage on the use of primary and preventive services from the Oregon Health Insurance Experiment. The seminal papers by Currie and Gruber (1996) and Card and Shore-Sheppard (2004), using quasi-experimental methods, find that the Medicaid expansions in the 1980s targeted at children increased their utilisation of health services. Card et al. (2008) find that utilisation increases when seniors become eligible for Medicare coverage at age 65.[6]

More recent studies have also focused on dental coverage in particular. For example, Decker and Lipton (2015) look at the effect of expanded Medicaid coverage on utilisation of dental

[6] These are just a few examples of studies on demand-side responses to increased coverage. See Buchmueller et al. (2005) for a review. There is also a related literature on health insurance coverage expansion in the context of low- and middle-income countries and its effect on access and financial protection (e.g., Limwattananon et al., 2015, for Thailand, Bernal et al., 2017, for Peru, and Bauhoff et al., 2011, for Georgia).

services and on health outcomes. Using state-level variation in dental coverage during 2000–2012, they report an increase in the likelihood of a recent dental visit, with the size of the effect increasing with Medicaid payment rates to dentists, and a reduction in the likelihood of untreated dental caries. A common feature of all these studies is that they use patients as the unit of observation, and provide no information on how providers respond to increased demand from expansion of coverage. Moreover, possible spillover effects from covered (insured) to uncovered (uninsured) patients are typically left out of these studies.[7]

The literature on *supply-side responses* to increased public coverage of healthcare is much smaller. The study by Buchmueller et al. (2016) is a notable exception. They investigate how changes in public health insurance coverage affect the behaviour of healthcare providers, focusing on dental services for adult Medicaid beneficiaries. By analysing variations in Medicaid dental coverage across states, they find that when Medicaid dental benefits for adults are expanded, more dentists participate in the Medicaid program, providing more services to publicly insured patients without reducing care for privately insured individuals.[8] Furthermore, dentists adapt to increased demand by employing more dental hygienists, who handle additional patient visits. The expansions lead to slightly longer patient wait times, especially in states with restrictive laws on the scope of practice for dental hygienists. Expanded Medicaid dental coverage increases dentists' income. Since Medicaid reimbursement rates are set by the states, and balanced billing is prohibited, the increase in dentists' income is due to higher patient volumes and more efficient use of resources.[9]

A related study is Baicker et al. (2023) who investigate pathways towards a universal coverage of healthcare in the US. Motivated by the large uninsured share of the population in the United States compared to other Western countries, they present two alternative approaches to expanding coverage: (i) the market failures approach that focuses on correcting inefficiencies by expanding Medicaid, increasing subsidies, simplifying enrollment, etc.; and (ii) the social floor approach that proposes a basic bundle of publicly financed health services to the whole population. The authors argue that the latter approach better aligns public spending with access

[7] See Lipton (2021) for a more recent study, and Huh (2021) on the effect of Medicaid on the relation of dentists in poor counties.

[8] Dentists have the choice to participate in Medicaid. However, many opt out due to the low reimbursement rates, administrative burdens, or the perception that Medicaid patients are more challenging to manage.

[9] Another paper on dental care and insurance markets is Grönqvist (2006), who investigates the role of information asymmetry in insurance markets. This study focuses on dropout decisions in a voluntary dental insurance scheme introduced by the National Dental Service in Sweden, and examines how insurers and policyholders update their information on risk and how these updates influence insurance renewal decisions.

to essential care, and combined with private top-up coverage it can also ensure innovation and flexibility for high-income individuals.

There is also a strand of literature that studies the design of insurance coverage in healthcare markets accounting for market power on the provider side. For example, Bardey et al. (2016) examine the optimal design of health insurance reimbursement policies in markets characterised by imperfect competition among medical product providers. It evaluates how insurers can use a combination of reimbursement instruments to balance affordability, access, and producer pricing while addressing ex post moral hazard. Cremer and Lozachmeur (2022) analyse the effects of different reimbursement schemes on market outcomes in a setting where a monopolistic provider sells a medical product and health insurers compete. They find that copayment schemes lead to lower producer prices and higher consumer welfare compared to coinsurance schemes, and that the monopolist sets higher prices under coinsurance because the reimbursement is proportional to the price, incentivising higher price levels.

Abstracting from competition in the insurance market, a few papers focuses on selective contracting and how providers respond to reimbursement schemes. For example, Barros and Martinez-Giralt (2002) examine how (public and private) healthcare providers respond to different reimbursement policies covering the interaction between in-plan and out-of-plan providers. In a set-up similar to ours, they allow providers to compete on prices and analyse their response to different reimbursement policies. However, they do not consider the choice of universal versus targeted coverage, nor the consequences on access for high- and low-income patients under different reimbursement schemes. This applies also to the other papers mentioned above.[10]

Our paper also differs from the strand of literature that examines competition among healthcare providers under different payment schemes.[11] In this body of work, providers are often non-profit or public entities, which may imply altruistic motives influencing service provision and responses to payment or reimbursement policies. Additionally, in most cases, prices for covered health services are typically fixed at the point of service delivery, either through regulation or pre-negotiation with insurers. As a result, competition usually occurs along non-price dimensions, with quality competition being the primary focus.[12]

As noted in the Introduction, dental care markets tend to differ significantly from medical care markets (e.g., Sintonen and Linnosmaa, 2000). In dental markets, prices are usually freely

[10] See Bardey and Rochet (2010) for a model of selective contracting in a two-sided market approach.
[11] See, for instance, the review of this literature by Gaynor and Town (2011).
[12] See, for example, Brekke et al. (2008, 2011).

set without regulatory constraints (even when patients are covered), and the vast majority of providers operate as for-profit entities. These characteristics are explicitly accounted for in our analysis, allowing us to explore how dental care providers respond to different choices of coverage and reimbursement schemes under a set of assumptions that matches the observed market characteristics in many countries. In the next section, we detail the analytical framework used in our study.

3 Model

Consider a market for dental care in which two competing dental practices (henceforth referred to as *dentists*) are located at opposite endpoints of a Hotelling line of length 1. A unit mass of potential patients are uniformly distributed on the same line, and each of them demands one treatment from the most preferred dentist as long as the total cost of attending this dentist does not exceed the patient's willingness to pay for the treatment. We can interpret the Hotelling line either as a geographical market or as a market with horizontal product differentiation along one particular dimension of the services offered by the two dental practices.

Let dentist 1 (2) be located at the left (right) endpoint of the line, and suppose that the cost of travelling along the line is $t > 0$ per unit of distance, and that the consumer price at dentist i is σ_i. The net utility of a patient located at $x \in [0, 1]$ is then given by

$$U = \begin{cases} \theta - \sigma_1 - tx & \text{if treated by dentist 1} \\ \theta - \sigma_2 - t(1-x) & \text{if treated by dentist 2} \\ 0 & \text{if remaining untreated} \end{cases}, \tag{1}$$

where θ represents patients' willingness to pay for dental treatment.

We assume that the patients differ in income, which in turn implies that they differ in their willingness to pay for dental treatment. More specifically, suppose that a share λ are low-income patients with a willingness to pay for treatment equal to θ_L, whereas the remaining share consists of high-income patients with a willingness to pay equal to θ_H. Thus, $\theta = \{\theta_H, \theta_L\}$, with $\theta_H > \theta_L$.[13] For simplicity, we assume that the shares of low- and high-income patients are constant along the Hotelling line.

We will also assume that the parameters of the model are such that, in each equilibrium

[13] In Appendix A we provide a technical justification for interpreting the utility parameter θ as reflecting income.

considered, the demand segment consisting of high-income patients is fully covered while the demand segment consisting of low-income patients is only partially covered. Thus, whereas all high-income patients choose to attend a dentist for treatment, some of the low-income patients will choose to abstain from treatment.[14] This implies that total demand for dental care is price elastic and allows us to analyse how different public coverage schemes affect *access* to dental care.

If each patient in the market makes a utility-maximising choice, demand for dentist i from *high-income patients* is given by

$$q_i^H = (1-\lambda)\left(\frac{1}{2} + \frac{\sigma_j - \sigma_i}{2t}\right), \quad i,j = 1,2, \quad i \neq j, \tag{2}$$

while demand from *low-income patients* is

$$q_i^L = \lambda\left(\frac{\theta_L - \sigma_i}{t}\right), \tag{3}$$

where q_i^L is derived under the assumption that the market for low-income patients is not fully covered (i.e., some low-income patients prefer not to demand dental care as the price exceeds their willingness to pay net of the transport costs).

The cost of dental treatment is assumed to be the same for both dentists and given by a constant marginal cost c, and we assume that the dentists are free to set the price of the treatment offered, and that they are both profit maximisers. We also assume that patient income is not observable to the dentists. In the absence of any public coverage scheme that reveals patients' income status, this implies that the dentists are not able to price discriminate between patients with different willingness to pay for treatment. Each dentist knows the distribution of high- and low-income patients in the market, and their respective willingness to pay for dental treatment, but cannot distinguish between a high-income and a low-income patient without further information. Denoting the producer price of dentist i by p_i, the dentists' profits are then given

$$\pi_i = (p_i - c)\left(q_i^H + q_i^L\right), \quad i = 1,2. \tag{4}$$

We will analyse three different scenarios regarding public coverage of dental care expenditures. We start out with the benchmark case of *no public coverage*, in which each patient pays

[14] In each case considered, we provide parameter conditions that ensure an equilibrium outcome in which the high-income segment is fully covered while the low-income segment is partially covered.

the full price charged by the treating dentist. We subsequently consider the cases in which public coverage is either *universal* or *targeted*. In the former case, the public payer covers part of the dental care expenditures of each patient in the market, whereas in the latter case, only low-income patients get parts of their expenditures covered.

With public coverage of dental care, the total costs for the public payer is given by the subsidy per patient times the number of patients covered in equilibrium. Let subscript U and T indicate equilibrium values under universal and targeted coverage, respectively. The public payer costs under these two coverage schemes, which we denote by γ_U and γ_T, respectively, are then given by

$$\gamma_U = \left(2\lambda q_U^L + 1 - \lambda\right)\left(p_U - \sigma_U\right) \tag{5}$$

and

$$\gamma_T = 2\lambda q_T^L \left(p_T - \sigma_T\right). \tag{6}$$

Finally, the equilibria derived in each scenario are those resulting from a static non-cooperative game in which the two dentists set prices simultaneously.

4 Benchmark: no public coverage

As a benchmark for comparison, consider the case of no public coverage of dental care expenditures, which implies that the consumer price at dentist i is equal to the producer price, denoted by p_i. In this case, demand from high- and low-income patients are found by setting $\sigma_i = p_i$ in (2) and (3), respectively. From (4), the first-order condition for the optimal price set by dentist i is given by

$$\frac{\partial \pi_i}{\partial p_i} = q_i^H + q_i^L + \left(p_i - c\right)\frac{\partial\left(q_i^H + q_i^L\right)}{\partial p_i} = 0, \tag{7}$$

which can be re-written in the form of a standard inverse elasticity pricing rule, given by

$$\frac{p_i - c}{p_i} = \frac{1}{\varepsilon_i}, \tag{8}$$

where

$$\varepsilon_i := -\frac{\partial\left(q_i^H + q_i^L\right)}{\partial p_i}\frac{p_i}{q_i^H + q_i^L} \tag{9}$$

is the *producer price elasticity of demand* facing dentist i.

In the symmetric Nash equilibrium, each dentist sets a price of

$$p_N = \frac{(1+\lambda)\,c + (1-\lambda)\,t + 2\lambda\theta_L}{1+3\lambda}, \tag{10}$$

which implies that the equilibrium consumer price is $\sigma_N = p_N$ and yields the following demand for each dentist from the low-demand segment:[15]

$$q_N^L = \lambda\frac{(1+\lambda)\,(\theta_L - c) + (1-\lambda)\,t}{(1+3\lambda)\,t}. \tag{11}$$

This equilibrium exists for a parameter space defined by

$$c + \frac{(1-\lambda)\,t}{1+\lambda} < \theta_L < c + \frac{(3+\lambda)\,t}{2\,(1+\lambda)}, \tag{12}$$

which is non-empty for all $\lambda \in (0,1)$.

5 Public coverage of dental care expenditures

Let us now assume that some of the patients' expenditures for dental care are being covered by a public payer. We will consider two different schemes for covering these expenditures: (i) a fixed subsidy scheme in which the public payer covers a fixed amount $s > 0$ that does not depend on the price of the treatment and (ii) a cost-sharing scheme in which the public payer covers a fixed share $\alpha \in (0,1)$ of the price charged to each patient. If we incorporate both payment schemes in a unified framework, the consumer price for a covered patient who is treated by dentist i is given by[16]

$$\sigma_i = \max\left\{(1-\alpha)\,p_i - s, 0\right\}. \tag{13}$$

As previously mentioned, we will compare two different cases regarding the extent of public coverage. In the case of *universal coverage*, all patients face a consumer price as given by (13). The alternative case is *targeted coverage*, in which the consumer price depends on the patient's income. In this case we assume that public coverage is targeted to low-income patients, implying that a low-income patient faces a consumer price as given by (13), whereas consumer and producer prices are equal for high-income patients (i.e., no coverage).

[15] Due to our assumption that the high-income segment is always covered, demand for each dentist from this segment is equal to $(1-\lambda)/2$ in any symmetric equilibrium.

[16] We implicitly assume that s is never set such that the consumer price is negative.

5.1 Universal coverage

By substituting the value of σ_i from (13) into (2)-(3), we obtain the demand from high- and low-income patients under universal coverage, which is given by, respectively,

$$q_i^H = (1-\lambda)\left(\frac{1}{2} + \frac{(1-\alpha)(p_j - p_i)}{2t}\right) \tag{14}$$

and

$$q_i^L = \lambda\left(\frac{\theta_L + s - (1-\alpha)p_i}{t}\right), \tag{15}$$

where $i, j = 1, 2$ and $i \neq j$. On general form, the first-order condition for the profit-maximising price of each dentist is still given by (8), but universal coverage changes each dentist's pricing incentives through changes in the producer price elasticity of demand.

There are potentially two different channels of influence. First, for given producer prices, universal coverage affects the total demand facing each dentist. More specifically, from (14)-(15) we see that, for given and equal producer prices ($p_i = p_j$), universal coverage increases demand from the low-income segment. This effect is qualitatively similar for a fixed subsidy ($s > 0$) and for cost sharing ($\alpha > 0$). All else equal, this makes demand less price elastic and therefore gives each dentist an incentive to set a higher price.

Second, universal coverage might also make demand less price responsive, but only if coverage is based on cost sharing. From (14)-(15) we see that $\left|\partial q_i^k / \partial p_i\right|$, $k = H, L$, is unaffected by s but is decreasing in α. Thus, while a fixed subsidy makes demand less price elastic through a positive demand effect only, cost sharing makes demand less price elastic because demand increases *and* becomes less price responsive. Again, this contributes to higher profit-maximising producer prices.

In the symmetric Nash equilibrium, the producer prices are given by

$$p_U = \left(\frac{1+\lambda}{1+3\lambda}\right)c + \frac{2\lambda(\theta_L + s) + (1-\lambda)t}{(1-\alpha)(1+3\lambda)}. \tag{16}$$

These prices yield the following market coverage (demand) in the low-income segment:

$$q_U^L = \lambda\frac{(1+\lambda)(\theta_L + s - (1-\alpha)c) - (1-\lambda)t}{(1+3\lambda)t}. \tag{17}$$

This equilibrium exists for a parameter set defined by

$$(1-\alpha)\,c - s + \left(\frac{1-\lambda}{1+\lambda}\right) t < \theta_L < (1-\alpha)\,c - s + \frac{(3+\lambda)}{2\,(1+\lambda)} t, \tag{18}$$

which is non-empty for all $\lambda \in (0,1)$ and $\alpha \in (0,1)$.

Under universal coverage, the consumer prices are equal for all patients and given by

$$\sigma_U = (1-\alpha)\,p_U - s, \tag{19}$$

and the total costs for the public payer are given by

$$\gamma_U = \left(2\lambda q_U^L + 1 - \lambda\right)(\alpha p_U + s)\,. \tag{20}$$

5.2 Targeted coverage

Consider now a targeted coverage scheme in which the public payer covers a share of the dental treatment expenditures only for low-income patients. This means that consumer prices depend on income status, such that the consumer price at dentist i for a low-income patient, denoted by σ_i^L, is given by (13), whereas the equivalent consumer price for a high-income patient is given by $\sigma_i^H = p_i$.

In this section we assume that the dentists continue to use uniform pricing also under a targeted coverage scheme. This assumption is relaxed in Section 7, where we explore the possibility that targeted coverage allows the dentists to price discriminate between low- and high-income patients based on coverage status.

Under targeted coverage, demand for dentist i from the high-income segment is the same as in the benchmark case of no coverage and given by (2) for $\sigma_i = p_i$, while demand from the low-income segment is the same as in the case of universal coverage and given by (15). From the first-order condition for the profit-maximising producer price, which on general form is still given by (8), it follows that targeted and universal coverage yield different pricing incentives only insofar as these two coverage schemes affect the producer price elasticity of demand differently. This is not the case under a fixed subsidy, since coverage in this case affects the price elasticity of demand only through a positive demand effect, and this effect comes only from the low-income segment, as is evident from (14)-(15).

On the other hand, if coverage is based on cost sharing, there is an additional effect caused

by less price-responsive demand, as previously explained. This effect is stronger under universal than under targeted coverage, since demand become less price responsive for all patients in the former regime but only for the low-income patients in the latter regime. Thus, if public coverage is based on cost sharing, demand is less price elastic (for given producer prices) under universal than under targeted coverage.

Profit-maximising price setting by each dentist yields the following prices in the symmetric Nash equilibrium:

$$p_T = \frac{(1 + (1 - 2\alpha)\,\lambda)\,c + 2\lambda\,(\theta_L + s) + (1 - \lambda)\,t}{1 + (3 - 4\alpha)\,\lambda}. \tag{21}$$

In this equilibrium, market coverage in the low-income segment is given by

$$q_T^L = \frac{(1 + (1 - 2\alpha)\,\lambda)\,(\theta_L + s - (1 - \alpha)\,c) - (1 - \alpha)\,(1 - \lambda)\,t}{(1 + (3 - 4\alpha)\,\lambda)\,t}, \tag{22}$$

and the equilibrium exists for a parameter set characterised by

$$(1 - \alpha)\,c - s + \frac{(1 - \alpha)\,(1 - \lambda)}{1 + (1 - 2\alpha)\,\lambda}t < \theta_L < (1 - \alpha)\,c - s + \frac{(3 + \lambda - 2\,(1 - s + \lambda)\,\alpha)}{2\,(1 + (1 - 2\alpha)\,\lambda)}t, \tag{23}$$

which is non-empty for all $\lambda \in (0, 1)$ and $\alpha \in (0, 1)$.

In this regime, the consumer price for a patient of type k, denoted by σ_T^k, is given by

$$\sigma_T^k = \begin{cases} p_T & if \quad k = H \\ (1 - \alpha)\,p_T - s & if \quad k = L \end{cases}, \tag{24}$$

whereas the *average* consumer price is given by[17]

$$\sigma_T^{av} = \frac{(1 - \lambda)\,p_T + 2\lambda q_T^L\,((1 - \alpha)\,p_T - s)}{1 - \lambda + 2\lambda q_T^L}, \tag{25}$$

and the total costs for the public payer are given by

$$\gamma_T = 2\lambda q_T^L\,(\alpha p_T + s)\,. \tag{26}$$

[17] The average consumer price is defined as a weighted average where the weights are given by the relative demand of low- and high-income (i.e., covered and uncovered) patients.

6 Universal versus targeted coverage

We are now ready to analyse how the choice of universal versus targeted coverage affects consumer prices, access to dental care and the total costs of the coverage scheme for the public payer and the patients. These variables are not only directly affected by the choice of coverage scheme, but also indirectly affected through the effect of the coverage scheme on the dentists' pricing incentives. Furthermore, and as indicated by our previous discussion of the dentists' pricing incentives, these effects might depend not only on whether coverage is universal or targeted, but also on the design of the reimbursement scheme, i.e., whether coverage is based on cost sharing or a fixed subsidy.

By the assumption of full market coverage in the high-income segment, the equilibrium demand of each dentist in this segment (q^H) is the same in all equilibria. On the other hand, the degree of market coverage in the low-income segment depends on the consumer prices, which in turn depend on the coverage scheme and on the equilibrium producer prices set by the dentists. We will therefore use the equilibrium demand of each dentist in the low-income segment (q^L) as a measure of *access* in the market for dental care; i.e., a higher value of q^L implies increased access to dental care.

In order to facilitate the analysis, we assume that the public payer offers only a fixed subsidy (i.e., $\alpha = 0$ and $s > 0$) or only a pure cost-sharing scheme (i.e, $\alpha > 0$ and $s = 0$). In the former case, the parameter set that allows for equilibrium existence in all relevant cases (under universal, targeted or no coverage) is defined by

$$c + \left(\frac{1-\lambda}{1+\lambda}\right) t < \theta_L < c - s + t, \tag{27}$$

and is non-empty if $s < 2\lambda t/(1+\lambda)$. In the latter case, the set of parameters values for which an equilibrium exists in all cases considered is given by

$$c + \left(\frac{1-\lambda}{1+\lambda}\right) t < \theta_L < (1-\alpha)\, c + \min\left\{\frac{(3+\lambda-2(1+\lambda)\alpha)}{2(1+(1-2\alpha)\lambda)}, 1\right\} t, \tag{28}$$

where

$$\frac{(3+\lambda-2(1+\lambda)\alpha)}{2(1+(1-2\alpha)\lambda)} > (<)\, 1 \text{ if } \alpha < (>)\, \frac{1}{2}. \tag{29}$$

We also make the following parameter restriction,

$$t \geq \underline{t} := \frac{(1+\lambda)\, c}{2\lambda}, \tag{30}$$

which implies that the parameter set given by (28) is non-empty for all $\alpha \in (0,1)$.

As previously alluded to, there are two different dimensions to the policy problem of designing a coverage scheme for dental care costs. One issue is whether coverage should be universal or targeted, and the other issue is whether the (universal or targeted) coverage scheme should be designed with cost sharing or with a fixed subsidy. Thus, there are four different types of coverage scheme. In order to facilitate the characterisation of these four types in terms of equilibrium outcomes, we start out by describing the effects of either universal or targeted coverage relative to the benchmark with no coverage:[18]

Proposition 1 *Compared to the benchmark with no coverage:*

(i) Universal coverage leads to higher producer prices, lower consumer prices for all patients, and increased access to dental care.

(ii) Targeted coverage leads to higher producer prices, lower (higher) consumer prices for low-income (high-income) patients, and increased access to dental care. The average consumer price goes up (down) if the share of low-income patients is sufficiently low (high).

The positive effect of (any type of) public coverage on producer prices is not surprising. As previously explained, public coverage makes demand less price elastic and therefore creates an incentive for the dentists to increase their prices. Furthermore, public coverage always leads to lower consumer prices for low-income patients, since the public subsidy more than outweighs the increase in producer prices for these patients. A direct implication of lower consumer prices in the low-income segment is that access to dental care improves. These effects of a public coverage scheme hold regardless of whether coverage is targeted or universal, and regardless of whether it is based on a fixed subsidy or on cost sharing.

On the other hand, the effect of public coverage on *consumer prices for high-income patients* depends crucially on whether such coverage is universal or targeted. Consumer prices are not only affected directly by the coverage scheme, but are also indirectly affected by the dentists' price responses. Absent such price responses, universal coverage reduces consumer prices for all patients whereas targeted coverage reduces consumer prices for low-income patients but has

[18] A formal proof is given in Appendix B.

no effect on high-income patients. However, when we take the dentists' price responses into account, the difference between these two coverage schemes becomes starker, particularly for high-income patients. Due to the positive effect on producer prices, targeted coverage actually *harms* high-income patients who have to pay higher prices.

Perhaps surprisingly, targeted coverage might even lead to an increase in the *average consumer price* compared with the benchmark case. This happens if the share of low-income patients is sufficiently small, such that price increases for high-income patients more than outweigh the subsidies given to low-income patients. These adverse effects of targeted coverage on the price paid by high-income patients, and potentially also on the average consumer price, are qualitatively the same regardless of whether the subsidy scheme is based on a fixed subsidy or on cost sharing.

Let us next turn to a direct comparison of universal versus targeted coverage, where the specific design of the subsidy scheme (cost-sharing versus fixed subsidy) turns out to play a crucial role:[19]

Proposition 2 *(i) With a fixed subsidy ($\alpha = 0$ and $s > 0$), consumer prices in the low-income segment, and thus access to dental care, are the same under targeted and universal coverage.*

(ii) With cost sharing ($\alpha > 0$ and $s = 0$), consumer prices in the low-income segment are lower, implying that access to dental care is higher, under targeted than under universal coverage.

(iii) Although access might be higher under targeted coverage, total public spending is always lower under targeted than under universal coverage.

Whether the coverage scheme is designed with cost sharing or with a fixed subsidy plays a crucial role for the effects of universal versus targeted coverage on the consumer price for *low-income* patients. With a fixed subsidy, targeted and universal coverage have identical effects on the producer price, and thus identical effects on the consumer price for low-income patients. The reason is that the fixed subsidy does not affect the price elasticity of demand in the high-income segment. Since the subsidy is the same regardless of which dentist a high-income patient chooses, it does not affect relative consumer prices and therefore does not affect the price elasticity of demand. Thus, since the subsidy only affects the price elasticity of demand in the low-income segment, it does not matter for the dentists' pricing incentives whether the subsidy is targeted

[19] A formal proof is given in Appendix B.

or not.

However, this is not the case if public coverage is based on cost sharing. In this case, the equilibrium producer price is now higher under universal than under targeted coverage. The reason is that cost sharing makes demand less price responsive, and thus less price elastic, in *both* segments. The total demand facing each dentist is therefore less price elastic if coverage is universal than if it is targeted, thus leading to higher prices under the former coverage scheme. Consequently, if coverage is based on cost sharing, low-income patients pay less under targeted than under universal coverage, all else equal.

The effect of universal versus targeted coverage on *access* to dental care follows directly from the effect on consumer prices in the low-income segment and therefore depends crucially on whether coverage is based on a fixed subsidy or on cost sharing. With a fixed subsidy, public coverage increases access by the same amount regardless of whether it is universal or targeted. On the other hand, if coverage is based on cost sharing, access is higher under targeted than under universal coverage.

For the public payer, the total cost of the coverage scheme (in terms of public spending) is always lower if coverage is targeted to the low-income segment. When coverage is based on a *fixed subsidy*, public spending does not depend on producer prices and access is the same under universal and targeted coverage, so the cost of the coverage scheme is unambiguously lower in the latter case. Under *cost sharing*, on the other hand, public spending depends not only on the number of covered patients but also on the price per treatment. Compared to universal coverage, targeted coverage has three effects that are relevant for the total costs of the public payer: (i) high-income patients are not covered, (ii) the producer price goes down, and (iii) a larger number of low-income patients seek treatment. Whereas the first two effects contribute to lower public spending, the third effect goes in the opposite direction. However, we are able to show (see the proof of Proposition 2 in Appendix B) that the first two effects always dominate. Thus, when public coverage is based on cost sharing, targeted coverage yields both higher access and a reduction in the total costs, compared with universal coverage.

Finally, it is worth noting that the dentists also benefit from public coverage of dental care costs, since it leads to both higher demand and higher producer prices in equilibrium, thus unambiguously yielding higher profits. Moreover, it is easily confirmed that equilibrium profits are negatively correlated with the price elasticity of demand, which implies that the profit-maximising coverage scheme is universal coverage with cost sharing.

7 Welfare and policy analysis

In this section we build on our analysis in the previous sections to derive some welfare and policy implications. We start out by summarising the effects of different coverage schemes on consumers' surplus, before deriving the welfare-optimal policy under a utilitarian approach.

7.1 Consumers' surplus

Consumers' surplus for low- and high-income patients is in equilibrium given by

$$CS^L = 2\lambda \int_0^{q_r^L} (\theta_L - \sigma_r - tx)\, dx, \tag{31}$$

and

$$CS^H = 2(1-\lambda) \int_0^{1/2} (\theta_H - \sigma_r - tx)\, dx, \tag{32}$$

respectively, where σ_r is the equilibrium consumer price and q_r^L is the equilibrium volume of low-income patients treated by each dentist in coverage regime $r = N, U, T$.

Under a *fixed subsidy*, and relative to no coverage, low-income patients benefit from targeted or universal coverage through lower consumer prices and improved access. For these patients, access and prices change by the same amount under targeted and universal coverage. High-income patients, on the other hand, always receive dental care regardless of coverage regime. Relative to no coverage, they pay a lower price under universal coverage but pay a *higher* price under targeted coverage. This is because targeted coverage makes demand less price elastic, which in turn increases the price charged by the dentists. Since the expenditures of high-income patients are not covered in a targeted coverage scheme, these patients face a higher consumer price due to the adverse effect of the coverage scheme on the dentists' pricing incentives.

Results differ to some extent under *cost sharing*. For low-income patients it is still the case that both targeted and universal coverage improve access and reduce consumer prices. But the increase in access for low-income patients is higher under targeted coverage than under universal coverage. Moreover, the consumer prices are lower under targeted coverage than under universal coverage, which suggests that low-income patients benefit more from targeted coverage both in terms of access and price. It is still the case that high-income patients pay a higher price under targeted coverage than under no coverage. Therefore, these patients are worse off from a policy that introduces targeted coverage, regardless of whether it is based on a fixed subsidy or on cost

sharing.

7.2 The first-best solution

We take a utilitarian approach and define welfare as the difference between the gross consumer surplus and dentists' costs. We take as given the existence of two dentists located at the end-points of the Hotelling line. The first-best solution, in which a utilitarian social planner allocates dental care to patients in a welfare-maximising way, must then necessarily be symmetric.

Imposing *ex ante* symmetry and letting q^H and q^L be, respectively, the number of high-income and low-income patients treated by each of the two dentists, social welfare is given by

$$W^{fb} = 2\lambda \left[\int_0^{q^H} (\theta_H - tx)\, dx - cq^H \right] + 2(1-\lambda) \left[\int_0^{q^L} (\theta_L - tx)\, dx - cq^L \right]. \tag{33}$$

It is easily confirmed that W^{fb} is maximised at

$$q^k = \min \left\{ \frac{\theta_k - c}{t}, \frac{1}{2} \right\}; \quad k = H, L. \tag{34}$$

Under the assumption that $\theta_L > c + t/2$, the first-best solution is that all patients receive dental care, i.e., $q^H = q^L = 1/2$.

7.3 The second-best solution

By comparing (34) with (3) for $\sigma_i = p_i$, it is easily verified that the equilibrium outcome in the benchmark case of no public coverage is characterised by suboptimally low access to dental care among low-income patients, for the entire set of parameters given by (12). This market failure is caused by imperfect competition, which enables the dentists to charge prices above marginal cost. Consequently, there is scope for a policy maker to improve access, and thereby increase welfare, by introducing a public coverage scheme. However, since it is costly to raise the funds needed for public coverage of dental care, the second-best solution trades off improved access against higher public spending.

We denote the opportunity cost of public funds by $\mu > 0$. Social welfare in the second-best scenario is then given by the sum of net consumer surplus (patient utility net of the consumer price) and the dentists' profits, net of the costs to the public payer weighted by the opportunity

cost of public funds, which simplifies to

$$W^{sb} = 2(1-\lambda)\left[\int_0^{1/2}(\theta_H - tx)\,dx - \frac{c}{2}\right] + 2\lambda\left[\int_0^{q_r^L}(\theta_L - tx)\,dx - cq_E^L\right] - \mu\gamma_r, \tag{35}$$

where q_r^L is the equilibrium number of low-income patients treated by each dentist and γ_r is the equilibrium public spending in coverage regime $r = U, T$.

The above mentioned policy trade-off can be illustrated by considering the welfare effect of introducing or increasing the fixed subsidy s under coverage scheme r, which is given by

$$\frac{\partial W^{sb}}{\partial s} = 2\lambda\left[\left(\theta_L - tq_r^L - c\right)\frac{\partial q_r^L}{\partial s} - \mu\left(q_r^L + s\frac{\partial q_r^L}{\partial s}\right)\right]. \tag{36}$$

The first term is positive given our assumption that $\theta_L > c + t/2$, while the second term is negative. Under a fixed subsidy scheme, access to dental care is higher under a public coverage scheme (either targeted or universal) relative to no coverage, but public coverage increases the deadweight loss from raising public funds. Welfare improves when the first effect dominates, which requires that the opportunity cost of public funds is sufficiently low. The same conclusion is reached if we instead consider the introduction of a cost-sharing scheme; again, public coverage is welfare improving if the opportunity cost of public funds is sufficiently low.

How is the above described welfare trade-off affected if coverage is targeted instead of universal? This question can be answered by drawing on some of the results presented in Proposition 2. If the public coverage scheme is based on a *fixed subsidy*, we know that access to dental care is the same under targeted and universal coverage for a given fixed subsidy, and we also know that public spending is lower under a targeted scheme. It follows immediately that, for any given value of s, welfare is higher under targeted than under universal coverage because the same increase in access can be achieved at a lower cost. The same conclusion holds if public coverage is based on *cost-sharing*. For any given value of α, we know from Proposition 2 that targeted coverage yields both higher access and lower public spending than universal coverage, so the welfare ranking of the two coverage schemes is unambiguous also in this case.

Given that targeted coverage is welfare superior to universal coverage, the remaining policy question is whether such a coverage scheme should be based on a fixed subsidy ($s > 0$ and $\alpha = 0$) or on cost sharing ($s = 0$ and $\alpha > 0$). In Appendix B (proof of Proposition 3 below) we show that, under targeted coverage, the same level of access can always be achieved at a lower cost with a fixed subsidy rather than cost sharing. The second-best solution can therefore be

characterised as follows:[20]

Proposition 3 *If the opportunity cost of public funds is sufficiently low, and if social welfare is utilitarian, the welfare-maximising policy is targeted coverage with a fixed subsidy. Compared with the benchmark case of no public coverage, this second-best solution benefits low-income patients but harms high-income patients.*

Given that public funds are costly to raise, the optimal policy is one that improves access in the most cost-efficient way, which in turn dictates that coverage should be targeted to the patient group with suboptimally low access. The reason why a fixed subsidy is preferable to cost sharing is related to the dentists' strategic price responses. If producer prices remained unchanged, the second-best level of access could be achieved either by a fixed subsidy or by cost sharing (or by a combination of the two) at exactly the same cost for the public payer.

However, the dentists' price responses to a public coverage scheme creates a cost inefficiency that increases the amount of spending required to achieve a certain level of access. All else equal, the stronger the producer prices respond to a public coverage scheme, the more costly is the scheme for the public payer. The key difference between a fixed subsidy and an equivalent degree of cost sharing is that the positive price response is smaller in the former case than in the latter. The reason is that a fixed subsidy affects the price elasticity of demand only through a positive demand effect, whereas cost sharing additionally makes demand less price responsive. Thus, a coverage scheme based on cost sharing is less cost-efficient because the effect of the subsidy on consumer prices (and thus access) is to a larger extent offset by higher producer prices.

Notice however that the optimal policy involves a conflict of interest between different patient groups. Whereas a universal coverage scheme would benefit all patients, targeted coverage benefits low-income patients while simultaneously harming high-income patients. Because of the strategic effect of public coverage on the dentists' pricing incentives, increased access for low-income patients is partly paid for by high-income patients in the form of higher prices of dental care. Because of this conflict of interest, the optimal policy of targeted coverage might be more difficult to implement in practice. For example, if the choice of public coverage scheme is the equilibrium outcome of a median voter model, the second-best solution would be implemented only if the median voter is a low-income patient. An additional complicating

[20] A formal proof is given in Appendix B.

factor is the conflict of interest between the dentists and the public payer. Since the dentists' profits are higher under universal coverage with cost sharing, implementation of the second-best solution might be precluded through political lobbying by the dental industry.

We have established that the second-best solution is targeted coverage with a fixed subsidy. The final step in the welfare analysis is to determine the optimal level of such a subsidy. From (36), second-best welfare is maximised when the following first-order condition holds:

$$\left(\theta_L - tq_T^L - c\right)\frac{\partial q_T^L}{\partial s} - \mu\left(q_T^L + s\frac{\partial q_T^L}{\partial s}\right) = 0. \tag{37}$$

The second-order condition always holds, since

$$\frac{\partial^2 W^{sb}}{\partial s^2} = -2\lambda\left[t\left(\frac{\partial q_T^L}{\partial s}\right)^2 + 2\mu\frac{\partial q_T^L}{\partial s}\right] < 0, \tag{38}$$

which confirms that the solution to (37) is indeed a maximum. It might be instructive to re-write (37) and express the optimal subsidy, denoted by s^*, on implicit form as

$$s^* = \frac{\left(\theta_L - tq_T^L - c\right)}{\mu} - \frac{q_T^L}{\partial q_T^L/\partial s}. \tag{39}$$

Intuitively, the optimal subsidy increases with the marginal benefit from access and the demand responsiveness to the subsidy, and it decreases with the opportunity cost of public funds and the number of recipients of the subsidy. Using (22), the closed-form solution for the optimal subsidy is

$$s^* = \frac{(1+\lambda)\left((1-\lambda)\,t + 2\lambda\left(\theta_L - c\right)\right) - \mu\left(1+3\lambda\right)\left((1+\lambda)\left(\theta_L - c\right) - (1-\lambda)\,t\right)}{(1+\lambda)\left(1+\lambda+2\left(1+3\lambda\right)\mu\right)}, \tag{40}$$

and it follows that

$$s^* > 0 \text{ if } \mu < \frac{(1+\lambda)\left((1-\lambda)\,t + 2\lambda\left(\theta_L - c\right)\right)}{\left(1+3\lambda\right)\left((1+\lambda)\left(\theta_L - c\right) - (1-\lambda)\,t\right)}. \tag{41}$$

This confirms that the optimal subsidy is positive whenever the opportunity cost of public funds is sufficiently low.

8 Price discrimination based on coverage status

Our main analysis relies on the implicit assumption that patients' income is observable to the public payer but not to the dentists, so that the dentists are not directly able to price discriminate between patients with different willingness to pay for treatment (which is by assumption correlated with income). However, if public coverage is made contingent on patients' income, as in a targeted coverage scheme, then the coverage status of a patient potentially gives the dentists a signal about income status that allows them to price discriminate based on willingness to pay.[21] In this penultimate Section of our paper we will therefore extend our analysis to consider some implications of this possibility.

Under targeted coverage with price discrimination, the demand from the high-income segment is given by (2) for $\sigma_i = p_i$, whereas demand from the low-income segment is given by (15). If we allow each dentist to set different treatment prices for the two types of patients, the prices in the symmetric Nash equilibrium will be given by

$$p_T^H = c + t \tag{42}$$

and

$$p_T^L = \frac{c}{2} + \frac{\theta_L + s}{2\left(1-\alpha\right)}. \tag{43}$$

The resulting market coverage in the low-income segment, denoted by $\widehat{q}_T^L$, is given by

$$\widehat{q}_T^L = \frac{\theta_L + s - \left(1-\alpha\right)c}{2t}. \tag{44}$$

This equilibrium exists for a parameter set given by

$$\left(1-\alpha\right)c - s < \theta_L < \left(1-\alpha\right)c - s + t, \tag{45}$$

which does not depend on λ (since equilibrium prices do not depend on λ) and is non-empty for all $\alpha \in (0,1)$.

Under targeted coverage with price discrimination, the patient-specific and average consumer

[21] A patient's coverage status would be observable to the dentist if the patient pays the consumer price and the dentist is subsequently reimbursed by the public payer, in which case the patient would have to document eligibility for a lower consumer price to the dentist. An alternative scenario, in which a patient's coverage status would not (necessarily) be observable to the dentist, is that the patient pays the producer price and is subsequently reimbursed by the public payer.

prices, denoted by $\widehat{\sigma}_T^k$ and $\widehat{\sigma}_T^{av}$, respectively, are given by

$$\widehat{\sigma}_T^k = \begin{cases} p_T^H & if \quad k = H \\ (1-\alpha)\, p_T^L - s & if \quad k = L \end{cases} \tag{46}$$

and

$$\widehat{\sigma}_T^{av} = \frac{(1-\lambda)\, p_T^H + 2\lambda \widehat{q}_T^L \left((1-\alpha)\, p_T^H - s\right)}{1 - \lambda + 2\lambda \widehat{q}_T^L}. \tag{47}$$

As it turns out, the effects of price discrimination on producer and consumer prices under cost sharing will depend on whether the cost sharing rate α is below or above a threshold level given by

$$\overline{\alpha} := 1 - \left(\frac{\theta_L}{c + 2t}\right). \tag{48}$$

For values of θ_L that satisfy (28), $\overline{\alpha}$ lies strictly between 1/2 and 1. The next Proposition summarises the main effects of price discrimination under a targeted coverage scheme:[22]

Proposition 4 *(i) Consider a targeted coverage scheme that is based on either a fixed subsidy or on cost sharing with $\alpha < \overline{\alpha}$. Compared with uniform pricing, price discrimination then leads to higher (lower) producer prices and therefore higher (lower) consumer prices for high-income (low-income) patients, a higher average consumer price, and increased access to dental care.*

(ii) Consider instead a targeted coverage scheme that is based on cost sharing with $\alpha > \overline{\alpha}$. Compared with uniform pricing, price discrimination then leads to higher (lower) producer prices for low-income (high-income) patients and therefore a smaller consumer price difference between the two patient types, a lower average consumer price, and reduced access to dental care.

Under a fixed subsidy, if targeted coverage allows the dentists to price discriminate based on coverage status, they will set a higher price for (uncovered) high-income patients than for (covered) low-income patients. The reason is that the location of the indifferent patient is more sensitive to price changes in the latter segment, which makes demand from low-income patients more price elastic than demand from high-income patients.[23] Although the subsidy in itself makes demand less price-elastic in the low-income segment, as previously explained in our main analysis, the demand from low-income patients remains more price elastic than the demand

[22] A formal proof is given in Appendix B.

[23] Setting $\alpha = 0$ and comparing (15) with (2) for $\sigma_i = p_i$, we see that a marginal price change by one of the dentists moves the location of the indifferent patient by a distance $1/t$ in the low-income segment but only by a distance $1/2t$ in the high-income segment.

from high-income patients under uniform pricing, implying that the latter group of patients will be charged a higher price if the dentists are able to price discriminate.

These producer price effects imply that price discrimination *reinforces* the difference in consumer prices between high- and low-income patients under targeted coverage. On the one hand, this leads to increased access because low-income patients pay less for dental care. On the other hand, the average consumer price is higher if the dentists price discriminate than if they charge uniform prices. In other words, price discrimination harms high-income patients more than it benefits low-income patients. Thus, increased access for low-income patients comes at the expense of higher consumer expenditures overall.

The above described effects of price discrimination are qualitatively similar if coverage is instead based on cost sharing, but only if the share of the price covered by the public payer is sufficiently low; more precisely, if $\alpha < \overline{\alpha}$, where $\overline{\alpha}$ is given by (48). However, in contrast to the case of a fixed subsidy, the producer price might be higher for low-income than for high-income patients under cost sharing. The reason is that cost sharing makes demand less price responsive, and the magnitude of this effect is increasing in the degree of cost sharing.

A sufficiently high value of α makes demand less price elastic in the low-income segment, implying that a price discriminating dentist will set a higher price for low-income patients than for high-income patients under targeted coverage. This happens in our model if $\alpha > \overline{\alpha}$. In this case, price discrimination *dampens* the consumer price difference between the two patient types, which leads to lower access but also a reduction in the average consumer price. Thus, the trade-off between higher access and lower consumer prices remains the same as under a fixed subsidy, regardless of the value of α, since price discrimination will either increase or reduce both access and the average consumer price.

9 Concluding remarks

Oral health is a key element of overall health and contributes to well-being (Peres et al., 2019). Yet, coverage of dental care services remains limited across many countries. Across European countries, many individuals report unmet need for dental care mostly due to affordability reasons. The lack of adequate access to dental care has also a pronounced socioeconomic gradient, with individuals with lower income reporting higher unmet need due to lack of affordable dental care (Moran et al., 2024). A key issue at the forefront of the policy debate is how to address the

gap in access to dental care. In this study, we have investigated different policy options that relate to the introduction or expansion of public coverage and its impact on coverage, pricing and public spending. We obtain several main policy implications.

First, we show that public coverage through a subsidy or cost sharing is welfare improving by increasing access of low-income individuals as long as the opportunity cost of public funds is sufficiently low. This is in line with policy efforts to include dental care as part of statutory coverage though such coverage can be limited (e.g., in Italy, Norway or Spain), partial (e.g., in Belgium and France) or comprehensive depending on the country. For example, in the case of partial coverage, cost sharing can vary between 25% and 80% (Winkelmann et al., 2022).

Second, we show that targeting low-income individuals is generally preferable to a universal scheme. This is because both targeted and universal coverage improve access to dental care, but universal coverage has a higher burden on public funds. This is in line with some countries, such as Australia, Canada, Cyprus, Italy and the United Kingdom, who target the poor or very poor (Allin et al., 2020; Winkelmann et al., 2022).

Third, a fixed subsidy is generally better than cost sharing. Although both reimbursement schemes improve coverage, the latter scheme makes it more costly for the public payer to achieve a given level of coverage. The reason is that demand is less price elastic under cost sharing, which implies that the direct effect of the reimbursement scheme on consumer prices is to a larger extent offset by higher producer prices.

Fourth, under targeted coverage, the price paid by high-income patients increases relative to no coverage. This implies that high-income patients tend to be worse off following the introduction of targeted coverage. They obtain similar coverage relative to the setting with no coverage but end up paying a higher price. Instead, low-income patients benefit both from higher coverage and lower prices. In terms of political acceptability, this creates a tension between high- and low-income individuals. This is not the case under a universal scheme as high-income individuals benefit from lower consumer prices, while low-income individuals benefit from both better coverage and lower prices.

Private dental care providers are always better off with public coverage, either targeted or universal, because such coverage increases both producer prices and volume, thus unambiguously yielding higher profits. Under a fixed subsidy, providers would also be indifferent between universal and targeted coverage because price and coverage, and therefore profits, remain the same. This further emphasises that it is mainly the loss of high-income individuals that may be

an obstacle towards implementing a targeted scheme. However, if the base of low-income voters is sufficiently large, this may be less of a concern. One additional complexity of a targeted scheme, though, is that it requires the development of explicit and verifiable eligibility rules, which add to the administrative burden of the scheme.

Finally, another potential obstacle to implementing targeted coverage is related to the distributional implications of its funding. If a targeted coverage scheme is funded through general taxation, high-income individuals may resist paying additional taxes to support expanding dental coverage from which they do not directly benefit. Clarke and Cutler (2024) suggest income-contingent loans as an alternative, tying repayment to individuals' income levels. This approach could expand access to dental care while limiting immediate government expenditure. However, such loans still involve a subsidy for low-income individuals who may repay little or nothing, shifting some financial burden back to taxpayers. While our study focuses on the market effects of coverage, the fiscal implications of these schemes warrant future research.

Appendix A: Interpretation of the utility function

Suppose that patients have identical ordinal preferences and differ only in income. Let y_i be the income of patient i and let $\widetilde{p}$ be the total expenditures (consumer price plus transportation costs) of a dental treatment. The utility of patient i, expressed as utility of net income, is assumed to be given by $\widetilde{u}_i = f\left(y_i - \widetilde{p}\right)$, where f is increasing and concave. Suppose that $\widetilde{p}$ is small relative to y_i (implying that expenditures of dental care constitute a small fraction of the total income). In this case, the utility function can be approximated by a first-order Taylor expansion around $\widetilde{p} = 0$, yielding

$$\begin{aligned} \widetilde{u}_i &\simeq f\left(y_i\right) + f'\left(y_i\right)\left[y_i - \widetilde{p} - y_i\right] \\ &= f'\left(y_i\right)\left[\frac{f\left(y_i\right)}{f'\left(y_i\right)} - \widetilde{p}\right], \end{aligned} \tag{A1}$$

which, by a monotonic transformation $u_i := \frac{\widetilde{u}_i}{f'(y_i)}$, is equivalent to the utility function in (1) for $\theta_i := \frac{f(y_i)}{f'(y_i)}$ and $\widetilde{p}$ equal to the consumer price σ plus transportation costs. Since f is concave, $y_i > y_j$ implies $\theta_i > \theta_j$, i.e., richer patients have a higher willingness-to-pay for dental care.

Appendix B: Proofs

Proof of Proposition 1

(i): A comparison of (10) and (16) yields

$$p_U - p_N = \frac{2\lambda\left(s+\theta\alpha\right)+\left(1-\lambda\right)\alpha t}{\left(1-\alpha\right)\left(1+3\lambda\right)} > 0, \tag{B1}$$

while a comparison of (10) and (19) yields

$$\sigma_N - \sigma_U = \frac{1+\lambda}{1+3\lambda}\left(s+\alpha c\right) > 0. \tag{B2}$$

That universal coverage yields higher access than no coverage follows directly from (B2).

(ii): A comparison of (10) and (21) yields

$$p_T - p_N = 2\lambda\frac{\left(1+3\lambda\right)s+\alpha\left(1-\lambda\right)\left(c+2t\right)+4\alpha\lambda\theta_L}{\left(1+3\lambda\right)\left(1+\left(3-4\alpha\right)\lambda\right)} > 0, \tag{B3}$$

which also implies that targeted coverage leads to higher consumer prices for high-income patients, since $\sigma_T^H = p^T$. Regarding the effect of targeted coverage on consumer prices for low-income patients, consider first the case of a fixed subsidy ($\alpha = 0$). From (19) and (24) it is easily verified that $\sigma_U = \sigma_T^L$ for $\alpha = 0$. It then follows from (B2) that targeted coverage with a fixed subsidy leads to a lower consumer price for low-income patients. Consider next the case of cost sharing ($s = 0$). From (19) and (24) we derive

$$\sigma_U\big|_{s=0} - \sigma_T^L\big|_{s=0} = \frac{\alpha\left(1-\lambda\right)\varphi}{\left(1+3\lambda\right)\left(1+3\lambda-4\alpha\lambda\right)}, \tag{B4}$$

where

$$\varphi := \left(1-\lambda\right)t + 2\lambda\left(\theta_L - \left(1-\alpha\right)c\right). \tag{B5}$$

The sign of (B4) is given by the sign of φ, which is monotonically increasing in θ_L. Evaluating φ at the lower bound of θ_L, given by (28), yields

$$\lim_{\theta_L \to c+\frac{1-\lambda}{1+\lambda}t} \varphi = 2\alpha\lambda c + \left(\frac{1-\lambda}{1+\lambda}\right)\left(1+3\lambda\right)t > 0. \tag{B6}$$

Due to monotonicity, this implies that $\varphi > 0$, and thus $\sigma_U\big|_{s=0} > \sigma_T^L\big|_{s=0}$, for all values of θ_L

defined by the equilibrium existence condition (28). It then follows from (B2) that targeted coverage with a fixed subsidy also leads to a lower consumer price for low-income patients. The result that targeted coverage leads to increased access follows directly from the above derived results on the consumer prices of low-income patients.

Regarding the effect of targeted coverage on the average consumer price, consider first the case of a fixed subsidy ($\alpha = 0$). From (10) and (25) we derive

$$\sigma_T^{av}|_{\alpha=0} - \sigma_N|_{\alpha=0} = \frac{2\lambda s\Delta}{(1+\lambda)(1+3\lambda)((1-\lambda)t + 2\lambda(\theta_L + s - c))}, \tag{B7}$$

where

$$\Delta := 2t(1+2\lambda)(1-\lambda) - (1+\lambda)^2(\theta_L + s - c). \tag{B8}$$

The sign of (B8) is given by the sign of Δ, which is monotonically decreasing in θ_L. Evaluating Δ at the upper bound of θ_L yields

$$\lim_{\theta_L \to c-s+t} \Delta = t\left(1 - 5\lambda^2\right), \tag{B9}$$

which is positive if λ is sufficiently low. In that case, it follows from the monotonicity of Δ that $\Delta > 0$ for all θ_L. Thus, $\sigma_T^{av}|_{\alpha=0} > \sigma_N|_{\alpha=0}$ if λ is sufficiently low.

Consider next the case of cost sharing ($s = 0$). From (10) and (25) we derive

$$\sigma_T^{av}|_{s=0} - \sigma_N|_{s=0} = \frac{2\alpha\lambda\upsilon}{(1+3\lambda)(1+3\lambda-4\alpha\lambda)(1+\lambda-2\alpha\lambda)\omega}, \tag{B10}$$

where

$$\begin{aligned} \upsilon \;:\; &= t(1-\lambda)\left[\begin{array}{c} c(3+\lambda-2\alpha(1+\lambda))(1+\lambda-2\alpha\lambda) \\ +\theta_L\left(6\lambda+11\lambda^2-16\alpha\lambda^2-1\right)+t(1-\lambda)(3+5\lambda-\alpha(1+7\lambda)) \end{array}\right] \\ &\quad -(1+\lambda-2\alpha\lambda)(\theta_L-(1-\alpha)c)\left(c\left(1+5\lambda^2\right)+2\lambda((1-\alpha(1+3\lambda))c+(1-\lambda)\theta_L)\right). \end{aligned} \tag{B11}$$

The sign of (B10) is determined by the sign of υ. Notice first that

$$\frac{\partial^2 \upsilon}{\partial(\theta_L)^2} = -4\lambda(1-\lambda)(1+\lambda-2\alpha\lambda) < 0, \tag{B12}$$

implying that υ is globally concave in θ_L. Evaluating υ at the lower bound of θ_L yields

$$\lim_{\theta_L \to c + \frac{1-\lambda}{1+\lambda} t} \upsilon = \frac{(1+3\lambda)\,\rho}{(1+\lambda)^2}, \tag{B13}$$

where

$$\begin{aligned} \rho \;\; : \;\; & = (1+3\lambda)\left((1-\lambda)\,t\right)^2 \left(2\,(1+\lambda) - \alpha\,(1+3\lambda)\right) - \alpha\left((1+\lambda)\,(1+\lambda-2\alpha\lambda)\,c\right)^2 \\ & -ct\,(1-\lambda)\,(1+\lambda)\left(2\alpha\left((1+\lambda)^2 - 2\alpha\lambda\,(1-\lambda)\right) - (1+\lambda)\,(1+3\lambda)\right). \end{aligned} \tag{B14}$$

From (B14) we derive

$$\frac{\partial \rho}{\partial t} = (1-\lambda)\,\Lambda, \tag{B15}$$

where

$$\begin{aligned} \Lambda \;\; : \;\; & = 2\,(1-\lambda)\,(1+3\lambda)\left(2\,(1+\lambda) - \alpha\,(1+3\lambda)\right) t \\ & + c\,(1+\lambda)\left((1+\lambda)\,(1+3\lambda) - 2\alpha\left(2\,(1-\alpha)\,\lambda + (1+2\alpha)\,\lambda^2 + 1\right)\right). \end{aligned} \tag{B16}$$

It is straightforward to see that Λ is monotonically increasing in t. Evaluating Λ at the lower bound of t yields

$$\lim_{t \to \underline{t}} \Lambda = \frac{(1+\lambda)\,c}{\lambda} \begin{pmatrix} (2-\lambda)\,(1+3\lambda)\,(1+\lambda) \\ -\alpha\left(1 + 7\lambda\left(1+\lambda-\lambda^2\right) - 4\lambda^2\,(1-\lambda)\,\alpha\right) \end{pmatrix}. \tag{B17}$$

It can easily be verified that the expression in (B17) is positive for all $\lambda \in (0,1)$ and $\alpha \in (0,1)$. Due to the monotonicity of Λ in t, it follows that $\Lambda > 0$ and thus $\partial\rho/\partial t > 0$. Evaluating ρ at the lower bound of t yields

$$\lim_{t \to \underline{t}} \rho = \frac{(1+\lambda)^2\,c^2}{4\lambda^2}\tau, \tag{B18}$$

where

$$\tau := 2\,(1-\lambda)\,(1+3\lambda)\,(1+\lambda) - \alpha \begin{pmatrix} 8\lambda + 6\lambda^2 - 8\lambda^3 + 9\lambda^4 \\ +1 - 8\alpha\lambda^2\left(1 + 3\lambda^2 - 2\alpha\lambda^2\right) \end{pmatrix}. \tag{B19}$$

It is fairly straightforward to verify that $\tau > 0$, implying that $\rho > 0$ at the lower bound of t, if λ is not very high. In that case, the previously established monotonicity of ρ in t implies

that $\rho > 0$ for all permissible parameter values, implying that $\upsilon > 0$ at the lower bound of θ_L. Furthermore, evaluating υ at the upper bound of θ_L yields

$$\lim_{\theta_L \to (1-\alpha)c+t} \upsilon = t\vartheta, \tag{B20}$$

where

$$\begin{aligned} \vartheta \quad : \quad & = t\left(1-\lambda\right)\left(1+\lambda\right)\left(2+4\lambda-\alpha\left(1+5\lambda\right)\right) \\ & +c\left(1+\lambda\left(3-4\alpha\right)\right)\left(1-5\lambda^2-\alpha\left(1+2\lambda-7\lambda^2\right)\right). \end{aligned} \tag{B21}$$

It is evident that ϑ is monotonically increasing in t. Evaluating ϑ at the lower bound of t, given by (30), yields

$$\lim_{t \to \underline{t}} \vartheta = \frac{c\left(1+3\lambda\right)}{2\lambda}\varrho. \tag{B22}$$

where

$$\begin{aligned} \varrho \quad : \quad & = 2\left(1+2\lambda\right)^2 - 8\alpha\lambda\left(1-\lambda^2-\alpha\lambda\right) - 16\left(1-\alpha\right)\left(1+\alpha\right)\lambda^3 \\ & - \left(\alpha + 34\lambda^4 + 56\alpha^2\lambda^4 + 22\alpha\lambda^2 - 87\alpha\lambda^4\right). \end{aligned} \tag{B23}$$

It is fairly straightforward to verify that $\varrho > 0$, and thus $\vartheta > 0$, if λ is sufficiently small. In that case, the monotonicity of ϑ in t implies that $\vartheta > 0$ for all permissible parameter values, which in turn implies that $\upsilon > 0$ also at the upper bound of θ_L. Thus, if λ is sufficiently small, $\upsilon > 0$ at the lower and upper bounds of θ_L, and the concavity of υ in θ_L then ensures that $\upsilon > 0$, implying that $\sigma_T^{av}|_{s=0} > \sigma_N|_{s=0}$, for all values of θ_L satisfying the equilibrium existence condition given by (28).

Proof of Proposition 2

(i) From (19) and (24), it is straightforward to verify that $\sigma_U = \sigma_T^L$ for $\alpha = 0$. The implications for access follow directly.

(ii) The fact that $\sigma_U > \sigma_T^L$ for $s = 0$ was established in the proof of Proposition 1; see (B8). The implications for access follow directly.

(iii) Consider first the case of $\alpha = 0$. In this case, γ_U and γ_T do not depend directly on producer prices and are determined only by the number of covered patients. Since $q_T^L\big|_{\alpha=0} =$

$q_U^L\big|_{\alpha=0}$, it must necessarily be the case that $\gamma_U\big|_{\alpha=0} > \gamma_T\big|_{\alpha=0}$.

Consider next the case of $s = 0$. From (20) and (26) we derive

$$\gamma_U\big|_{s=0} > \gamma_T\big|_{s=0} = \frac{\alpha\,(1-\lambda)\left[t\digamma - 4\alpha\lambda^2\left(\theta_L - (1-\alpha)\,c\right)\Upsilon\right]}{t\,(1+3\lambda)^2\,(1-\alpha)\,(1+3\lambda-4\alpha\lambda)^2}, \tag{B24}$$

where

$$\digamma := \Xi + (1-\lambda)\,t\left(\left(1+3\lambda\right)^3 + 2\lambda\left(\alpha\left(1+14\lambda+17\lambda^2\right) - 2\left(3+5\lambda\right)\left(1+3\lambda\right)\right)\alpha\right), \tag{B25}$$

$$\begin{aligned}\Xi \;\;:\;\; &= c\,(1-\alpha)\left(\left(1+\lambda\right)\left(1+3\lambda\right)^3 - 4\alpha\lambda\left(6\lambda+7\lambda^2+3\right)\left(1+3\lambda-2\alpha\lambda\right)\right)\\ &+2\lambda\left(\left(1+3\lambda\right)^3 + \alpha\left(32\alpha\left(1+\lambda\right)\lambda^2 - \left(1+3\lambda\right)\left(14\lambda+19\lambda^2-1\right)\right)\right)\theta_L\end{aligned} \tag{B26}$$

and

$$\Upsilon := 2\,(1-\alpha)\left(\left(1+\lambda\right)\left(1+3\lambda\right) - \lambda\left(3+5\lambda\right)\alpha\right)c - (1-\lambda)\left(1+3\lambda-2\alpha\lambda\right)\theta_L. \tag{B27}$$

The sign of (B24) is given by the sign of the bracketed expression in the numerator, which we denote by

$$\Omega := t\digamma - 4\alpha\lambda^2\left(\theta_L - (1-\alpha)\,c\right)\Upsilon. \tag{B28}$$

From (B28) we derive

$$\frac{\partial^3\Omega}{\partial\alpha^3} = 48c\lambda^2\left(\left(1+10\lambda+13\lambda^2-4\lambda\left(3+5\lambda\right)\alpha\right)c - 4\lambda\left(1+\lambda\right)\theta_L - \left(3+6\lambda+7\lambda^2\right)t\right). \tag{B29}$$

It is easy to verify that (B29) is monotonically decreasing in α. Evaluating the expression at the lower bound of α yields

$$\lim_{\alpha\to 0}\left(\frac{\partial^3\Omega}{\partial\alpha^3}\right) = 48c\lambda^2\left(\left(1+10\lambda+13\lambda^2\right)c - \left(3+6\lambda+7\lambda^2\right)t - 4\lambda\left(1+\lambda\right)\theta_L\right), \tag{B30}$$

which is monotonically decreasing in θ_L. Evaluating (B30) at the lower bound of θ_L yields

$$\lim_{\theta_L\to c+\frac{1-\lambda}{1+\lambda}t}\left(\lim_{\alpha\to 0}\left(\frac{\partial^3\Omega}{\partial\alpha^3}\right)\right) = 48c\lambda^2\left(1+3\lambda\right)\left(\left(1+3\lambda\right)c - \left(3+\lambda\right)t\right) < 0. \tag{B31}$$

It follows that $\partial^3\Omega/\partial\alpha^3$ is negative for all $\alpha \in (0,1)$, which means that $\partial^2\Omega/\partial\alpha^2$ is monotonically decreasing in α. From (B28) we derive

$$\frac{\partial^2\Omega}{\partial\alpha^2} = -4\lambda\beta, \tag{B32}$$

where

$$\begin{aligned}\beta \quad : \quad &= 4\lambda\left(2+11\lambda+11\lambda^2\right)c^2 - 2\lambda\left(\left(3+18\lambda+11\lambda^2\right)c - 2\lambda\left(1-\lambda\right)\theta_L\right)\theta_L \\ &+12c\lambda\left(4\lambda\left(1+\lambda\right)\theta_L + \left(3+6\lambda+7\lambda^2\right)t - \left(1+10\lambda+13\lambda^2-2\lambda\left(3+5\lambda\right)\alpha\right)c\right) \\ &-\left(2\left(1+5\lambda\right)\left(3+6\lambda+7\lambda^2\right)c + \left(1-\lambda\right)\left(1+14\lambda+17\lambda^2\right)t + 32\lambda^2\left(1+\lambda\right)\theta_L\right)t.\end{aligned} \tag{B33}$$

If follows from (B32) that $\partial^2\Omega/\partial\alpha^2$ and β have opposite signs, and since $\partial^2\Omega/\partial\alpha^2$ is monotonically decreasing in α, it also follows from (A38) that β is monotonically increasing in α. Evaluating β at the upper bound of α yields

$$\lim_{\alpha\to 1}\beta = -\begin{pmatrix} 4\lambda\left(1+2\lambda\right)\left(1-\lambda\right)c^2 \\ +\left(1-\lambda\right)\left(2\left(3+6\lambda+7\lambda^2\right)c + \left(1+14\lambda+17\lambda^2\right)t\right)t \\ +2\lambda\left(\left(3-6\lambda-13\lambda^2\right)c + 16\lambda\left(1+\lambda\right)t - 2\lambda\left(1-\lambda\right)\theta_L\right)\theta_L \end{pmatrix}. \tag{B34}$$

From (B34) we derive

$$\frac{\partial}{\partial\theta_L}\left(\lim_{\alpha\to 1}\beta\right) = -2\lambda\kappa, \tag{B35}$$

where

$$\kappa := \left(3-6\lambda-13\lambda^2\right)c + 16\lambda\left(1+\lambda\right)t - 4\lambda\left(1-\lambda\right)\theta_L. \tag{B36}$$

(B35) has the opposite sign of κ, which is monotonically decreasing in θ_L. Evaluating κ at the relevant upper bound of θ_L yields

$$\lim_{\theta_L\to\frac{(3+\lambda-2(1+\lambda))}{2(1-\lambda)}t}\kappa = 2\lambda\left(9\lambda+7\right)t + \left(3-6\lambda-13\lambda^2\right)c, \tag{B37}$$

which is monotonically increasing in t and positive since

$$\lim_{t\to\underline{t}}\left(2t\lambda\left(7+9\lambda\right) + \left(3-6\lambda-13\lambda^2\right)c\right) = 2c\left(5+5\lambda-2\lambda^2\right) > 0. \tag{B38}$$

Thus, $\kappa > 0$, which implies that the sign of (B35) is negative, which in turn means that $\lim_{\alpha\to 1}\beta$

is monotonically decreasing in θ_L. Evaluating this expression at the lower bound of θ_L yields

$$\lim_{\theta_L \to c + \frac{1-\lambda}{1+\lambda} t} \left(\lim_{\alpha \to 1} \beta \right) = - \frac{\Theta}{(1+\lambda)^2}, \tag{B39}$$

where

$$\begin{aligned} \Theta \quad : \quad & = t\,(1+3\lambda) \left(2\,(1+\lambda) \left(3+7\lambda^2+6\lambda^3\right) c + (1-\lambda)\,(1+3\lambda) \left(1+10\lambda+5\lambda^2\right) t\right) \\ & -2\lambda \left(6\lambda+15\lambda^2-5\right) (1+\lambda)^2\, c^2. \end{aligned} \tag{B40}$$

(B39) has the opposite sign of Θ, which is monotonically increasing in t. Evaluating Θ at the lower bound of t yields

$$\lim_{t \to \underline{t}} \Theta = \frac{(1+\lambda)^2\, c^2}{4\lambda^2} \left(1+27\lambda+94\lambda^2+114\lambda^3-15\lambda^4-93\lambda^5\right) > 0, \tag{B41}$$

which means that $\Theta > 0$, which in turn implies that $\lim_{\alpha \to 1} \beta < 0$, which, due to the monotonicity of β in α, implies that $\beta < 0$. From (B32) it then follows that $\partial^2 \Omega / \partial \alpha^2 > 0$ for all $\alpha \in (0,1)$. Thus, $\partial \Omega / \partial \alpha$ is monotonically increasing in α. Evaluating $\partial \Omega / \partial \alpha$ at the upper bound of α yields[24]

$$\lim_{\alpha \to 1} \frac{\partial \Omega}{\partial \alpha} = -\,(1-\lambda)\,\delta, \tag{B42}$$

where

$$\begin{aligned} \delta \quad : \quad & = (1-\lambda)\,(1+\lambda)\,(8\lambda t + (1-\lambda)\,c)\,t \\ & -2\lambda \left(2\lambda\,(3+5\lambda)\,c + 2\lambda\,(1-\lambda)\,\theta_L - \left(10\lambda+7\lambda^2-1\right) t\right) \theta_L. \end{aligned} \tag{B43}$$

From (B43) we derive

$$\frac{\partial \delta}{\partial \theta_L} = 2\lambda \left(t \left(10\lambda+7\lambda^2-1\right) - 2c\lambda\,(5\lambda+3) - 4\lambda\,(1-\lambda)\,\theta_L\right) \tag{B44}$$

The sign of $\partial \delta / \partial \theta_L$ is given by the sign of an expression that is monotonically decreasing in θ_L. Evaluated at the relevant upper bound of θ_L, we have

$$\lim_{\theta_L \to \frac{(3+\lambda-2(1+\lambda))t}{2(1-\lambda)}} \left(\frac{\partial \delta}{\partial \theta_L} \right) = (1+\lambda)\,(9\lambda-1)\,t - 2\lambda\,(3+5\lambda)\,c. \tag{B45}$$

[24] The expression for $\partial \Omega / \partial \alpha$ is highly involved and thus not reported.

This expression is monotonically increasing in t if $\lambda > \frac{1}{9}$. Evaluating (B45) at the lower bound of t yields

$$\lim_{t \to \underline{t}} \left(\lim_{\theta_L \to \frac{(3+\lambda-2(1+\lambda))t}{2(1+(1-2)\lambda)}} \frac{\partial \delta}{\partial \theta_L} \right) = \frac{c}{2\lambda} \left(5\lambda^2 + 7\lambda - 11\lambda^3 - 1 \right), \tag{B46}$$

which is positive if $\lambda > \frac{1}{11}\left(2\sqrt{5} - 3\right) \approx 0.133\,83$. Thus, unless λ is very low, δ is monotonically increasing in θ_L. Evaluating δ at the lower bound of θ_L yields

$$\lim_{\theta_L \to c + \frac{1-\lambda}{1+\lambda} t} \delta = \frac{\Gamma}{(1+\lambda)^2}, \tag{B47}$$

where

$$\begin{aligned} \Gamma \quad : \quad & = t\,(1+3\lambda)\left(2t\lambda\,(1-\lambda)\,(3+\lambda)\,(1+3\lambda) + c\,(1+\lambda)\left(11\lambda^2 + 9\lambda^3 + 1 - 5\lambda\right)\right) \\ & \quad -16\lambda^2\,(1+\lambda)^3\,c^2. \end{aligned} \tag{B48}$$

The sign of (B47) is given by the sign of Γ, which is monotonically increasing in t. Evaluating Γ at the lower bound of t yields

$$\lim_{t \to \underline{t}} \Gamma = c^2\,(1-\lambda)\left(2 + 7\lambda + 7\lambda^2\right)\frac{(1+\lambda)^3}{\lambda} > 0, \tag{B49}$$

which implies that $\Gamma > 0$, which in turn means that $\delta > 0$ and therefore that $\partial\Omega/\partial\alpha < 0$ for all $\alpha \in (0,1)$ when $\lambda > \frac{1}{11}\left(2\sqrt{5} - 3\right)$. Alternatively, if λ is sufficiently low, δ is monotonically decreasing in θ_L. In this case, δ is still positive for all parameter values if $\delta > 0$ when evaluated at the relevant upper bound of θ_L. From (B43) we derive

$$\lim_{\theta_L \to \frac{(3+\lambda-2(1+\lambda))t}{2(1-\lambda)}} \delta = t\left(\lambda\,(7+9\lambda)\,t - \left(\lambda + 7\lambda^2 + 9\lambda^3 - 1\right)c\right). \tag{B50}$$

This expression is monotonically increasing in t. Evaluating (B50) at the lower bound of t yields

$$\lim_{t \to \underline{t}} \left(\lim_{\theta_L \to \frac{(3+\lambda-2(1+\lambda))t}{2(1-\lambda)}} \delta \right) = \frac{c}{2}\,(1-\lambda)\left(9 + 23\lambda + 18\lambda^2\right) > 0. \tag{B51}$$

Thus, $\delta > 0$ for all $\alpha \in (0,1)$. It follows that Ω is monotonically decreasing in α. Finally,

evaluating Ω at the upper bound of α yields

$$\lim_{\alpha \to 1} \Omega = (1-\lambda)(1+\lambda)(2\lambda\theta_L + (1-\lambda)t)^2 > 0, \tag{B52}$$

which means that $\Omega > 0$, and thus that $\gamma_U|_{s=0} > \gamma_T|_{s=0}$, for all $\alpha \in (0,1)$.

Proof of Proposition 3

For a given value of s or α, targeted coverage is welfare-superior to universal coverage since access is weakly higher and total spending is strictly lower under targeted coverage (cf. Proposition 2). Thus, the second-best solution has targeted coverage. To find the most cost-efficient form of subsidy (fixed subsidy or cost sharing) under targeted coverage, we choose pairs of values of s and α such that access is the same, and then compare under which regime ($s > 0$ and $\alpha = 0$, or $s = 0$ and $\alpha > 0$) public spending is lower. Access for low-income patients is the same under both regimes if the consumer price is the same, i.e.,

$$q_T^L\big|_{\alpha=0} = q_T^L\big|_{s=0} \text{ if } p_T|_{\alpha=0} - s = (1-\alpha)\, p_T|_{s=0}\,. \tag{B53}$$

Under a fixed subsidy, the cost of public funds is

$$\gamma_T|_{\alpha=0} = 2\lambda s\; q_T^L\big|_{\alpha=0}\,, \tag{B54}$$

while under cost sharing it is

$$\gamma_T|_{s=0} = 2\lambda\; q_T^L\big|_{\alpha=0} (\alpha\; p_T|_{s=0})\,. \tag{B55}$$

Given that by assumption access is the same, public spending is higher under cost sharing when $\alpha\, p_T|_{s=0} > s$. By re-writing the condition in (B53) as

$$s - \alpha\, p_T|_{s=0} = p_T|_{\alpha=0} - p_T|_{s=0}\,, \tag{B56}$$

it follows that public spending is higher under cost sharing if $p_T|_{s=0} > p_T|_{\alpha=0}$. Recall that

$$p_T|_{\alpha=0} = \frac{(1+\lambda)\,c + 2\lambda\,(\theta_L + s) + (1-\lambda)\,t}{1+3\lambda}. \tag{B57}$$

By solving (B56) for s and substituting into (B57) we obtain

$$p_T|_{\alpha=0} = \frac{(1+\lambda)\,c + 2\lambda\,(\theta_L - (1-\alpha)\,p_T|_{s=0}) + (1-\lambda)\,t}{1+\lambda} \tag{B58}$$

It follows that $p_T|_{s=0} > p_T|_{\alpha=0}$ if

$$p_T|_{s=0} > \frac{(1+\lambda)\,c + 2\lambda\,(\theta_L - (1-\alpha)\,p_T|_{s=0}) + (1-\lambda)\,t}{1+\lambda}. \tag{B59}$$

By solving the inequality in (B59) for $p_T|_{s=0}$, we have that $p_T|_{s=0} > p_T|_{\alpha=0}$ if

$$p_T|_{s=0} > \frac{(1+\lambda)\,c + 2\lambda\theta_L + (1-\lambda)\,t}{1+(3-2\alpha)\,\lambda}. \tag{B60}$$

Using

$$p_T|_{s=0} = \frac{(1+(1-2\alpha)\,\lambda)\,c + 2\lambda\theta_L + (1-\lambda)t}{1+(3-4\alpha)\,\lambda}, \tag{B61}$$

we have that $p_T|_{s=0} > p_T|_{\alpha=0}$ if

$$\frac{(1+(1-2\alpha)\,\lambda)\,c + 2\lambda\theta_L + (1-\lambda)t}{1+(3-4\alpha)\,\lambda} > \frac{(1+\lambda)\,c + 2\lambda\theta_L + (1-\lambda)\,t}{1+(3-2\alpha)\,\lambda}. \tag{B62}$$

The inequality holds if

$$2\alpha\lambda[2\lambda(\theta_L - c(1-\alpha)) + (1-\lambda)t] > 0, \tag{B63}$$

which is always true given our assumption $\theta_L > c + t/2$. Therefore, we can conclude that $p_T|_{s=0} > p_T|_{\alpha=0}$ and therefore $\alpha\,p_T|_{s=0} > s$, implying that public spending is higher under cost sharing than under a fixed subsidy that yields an identical improvement in access.

Proof of Proposition 4

(i)+(ii): Consider first the case of $\alpha = 0$. From (21) and (42) we derive

$$\widehat{p}_T^H\big|_{\alpha=0} - p_T|_{\alpha=0} = \frac{2\lambda}{1+3\lambda}\,(2t + c - s - \theta_L)\,, \tag{B64}$$

and from (21) and (43) we derive

$$p_T|_{\alpha=0} - \widehat{p}_T^L\big|_{\alpha=0} = \frac{1-\lambda}{2\,(1+3\lambda)}\,(2t + c - s - \theta_L)\,. \tag{B65}$$

Both (B64) and (B65) are clearly positive for all values of θ_L that satisfy the equilibrium existence condition (27). This immediately implies that $\widehat{\sigma}_T^H\Big|_{\alpha=0} > \sigma_T^H\big|_{\alpha=0}$ and $\sigma_T^L\big|_{\alpha=0} > \widehat{\sigma}_T^L\Big|_{\alpha=0}$, which in turn implies that $\widehat{q}_T^L\big|_{\alpha=0} > q_T^L\big|_{\alpha=0}$. From (25) and (47) we derive

$$(\widehat{\sigma}_T^{av} - \sigma_T^{av})|_{\alpha=0} = \frac{\lambda(1-\lambda)(2t+c-s-\theta_L)\Phi}{2(1+\lambda)(1+3\lambda)((1-\lambda)t+2\lambda(\theta_L+s-c))((1-\lambda)t+\lambda(\theta_L+s-c))}, \tag{B66}$$

where

$$\begin{aligned}\Phi \quad : \quad &= 2\lambda(1+\lambda)(2(c-s)-\theta_L)\theta_L - 2\lambda(c-s)^2(1+\lambda) \\ &+st(3+5\lambda)(3\lambda-1)+t(1+\lambda)(4t(1-\lambda)+(9\lambda-1)(\theta_L-c)).\end{aligned} \tag{B67}$$

The sign of (B66) is given by the sign of Φ. Notice first that

$$\frac{\partial^2\Phi}{\partial(\theta_L)^2} = -4\lambda(\lambda+1) < 0, \tag{B68}$$

which implies that Φ is globally concave in θ_L. By evaluating Φ at the upper and lower bounds of the interval of θ_L that is required for equilibrium existence (cf. (27)), we obtain

$$\lim_{\theta_L \to c+\frac{1-\lambda}{1+\lambda}t} \Phi = \frac{\left((1-\lambda)(1+3\lambda)(3+5\lambda)t+(1+\lambda)\left(19\lambda^2-3\right)s\right)t - 2s^2\lambda(1+\lambda)^2}{1+\lambda} \tag{B69}$$

and

$$\lim_{\theta_L \to c-s+t} \Phi = t\left(3t(1+\lambda)^2 - 2(1+3\lambda)(1-\lambda)s\right). \tag{B70}$$

It is easily verified that both (B69) and (B70) are strictly positive for all $t > \underline{t}$. Since $\Phi > 0$ at the lower and upper bound of θ_L, the concavity of Φ ensures that $\Phi > 0$ also for all values of θ_L between the lower and upper bounds. Thus, $\widehat{\sigma}_T^{av} > \sigma_T^{av}$ for $\alpha = 0$.

Consider next the case of $s = 0$. From (21) and (42) we derive

$$p_T^H\big|_{s=0} - p_T|_{s=0} = 2\lambda\frac{(1-\alpha)(c+2t)-\theta_L}{1+3\lambda-4\alpha\lambda} > (<)\,0 \text{ if } \alpha < (>)\,\overline{\alpha}, \tag{B71}$$

and from (21) and (43) we derive

$$p_T|_{s=0} - p_T^L\big|_{s=0} = (1-\lambda)\frac{(1-\alpha)(c+2t)-\theta_L}{2(1-\alpha)(1+3\lambda-4\alpha\lambda)} > (<)\,0 \text{ if } \alpha < (>)\,\overline{\alpha}, \tag{B72}$$

where $\overline{\alpha}$ is given by (48). This immediately implies that $\widehat{\sigma}_T^H\Big|_{s=0} > (<)\, \sigma_T^H|_{s=0}$ and $\sigma_T^L|_{s=0} > (<)\, \widehat{\sigma}_T^L\Big|_{s=0}$ if $\alpha < (>)\, \overline{\alpha}$, which in turn implies that $\widehat{q}_T^L|_{s=0} > (<)\, q_T^L|_{s=0}$ if $\alpha < (>)\, \overline{\alpha}$. It is still the case that $\widehat{\sigma}_T^H\Big|_{s=0} > \widehat{\sigma}_T^L\Big|_{s=0}$ for all $\alpha \in (0,1)$, since

$$\widehat{\sigma}_T^H\Big|_{s=0} - \widehat{\sigma}_T^L\Big|_{s=0} = \frac{(1+\alpha)\, c + 2t - \theta_L}{2} > 0, \tag{B73}$$

where the positive sign of (B73) is determined by invoking the equilibrium existence condition given by (45). Finally, from (25) and (47) we derive

$$\widehat{\sigma}_T^{av}|_{s=0} - \sigma_T^{av}|_{s=0} = \frac{\lambda\,(1-\lambda)\,((1-\alpha)\,(2t+c) - \theta_L)\,\chi}{2\,(1+3\lambda-4\alpha\lambda)\,(1+\lambda-2\alpha\lambda)\,((1-\lambda)\,t + \lambda\,(\theta_L - (1-\alpha)\,c))\,\omega}. \tag{B74}$$

Let us first establish the sign of χ. Notice that

$$\frac{\partial^2 \chi}{\partial\,(\theta_L)^2} = -4\lambda\,(1+\lambda-2\alpha\lambda) < 0, \tag{B75}$$

which implies that χ is globally concave in θ_L. Evaluating χ at the lower bound of θ_L, given by (28), yields

$$\lim_{\theta_L \to c + \frac{1-\lambda}{1+\lambda} t} \chi = \frac{\zeta}{(1+\lambda)^2}, \tag{B76}$$

where

$$\begin{aligned} \zeta \;\; : \;\; & = t^2\,(1+3\lambda)\,(1-\lambda)\left((1+\lambda)\,(3+5\lambda) - 2\alpha\left(1+3\lambda+4\lambda^2\right)\right) \\ & -c\alpha t\,(1+\lambda)\left((1+\lambda)\left(3-19\lambda^2\right) - 2\alpha\lambda\,(3+5\lambda)\,(1-3\lambda)\right) \\ & -2\lambda\,(\alpha c\,(1+\lambda))^2\,(1+\lambda\,(1-2\alpha)), \end{aligned} \tag{B77}$$

and where

$$\frac{\partial^2 \zeta}{\partial t^2} = 2\,(1-\lambda)\,(1+3\lambda)\left((1+\lambda)\,(3+5\lambda) - 2\alpha\left(1+3\lambda+4\lambda^2\right)\right) > 0, \tag{B78}$$

implying that ζ is globally convex in t. Evaluating ζ at the lower bound of t, given by (30), yields

$$\lim_{t \to \frac{(1+\lambda)c\alpha}{2\lambda}} \zeta = \left(\frac{c\alpha}{2\lambda}\right)^2 (1+\lambda)^3\left(3+5\lambda+\lambda^2+15\lambda^3 - 2\alpha\,(1+5\lambda)\left(1-\lambda+2\lambda^2\right)\right) > 0. \tag{B79}$$

Given that $\zeta > 0$ at the lower bound of t, the convexity of ζ implies that $\zeta > 0$ for all values of t that are compatible with equilibrium existence, which in turn implies that $\chi > 0$ at the lower bound of θ_L. Evaluating χ at the upper bound of θ_L yields

$$\lim_{\theta_L \to (1-\alpha)c+t} \chi = t\varpi, \tag{B80}$$

where

$$\varpi := t\,(1+\lambda)\,(3\,(1+\lambda) - 2\alpha\,(1+2\lambda)) - 2c\alpha\,(1-\lambda)\,(1+3\lambda-4\alpha\lambda)\,. \tag{B81}$$

The sign of (B80) is given by the sign of ϖ, which is monotonically increasing in t. Evaluating ϖ at the lower bound of t yields

$$\lim_{t \to \frac{(1+\lambda)c\alpha}{2\lambda}} \varpi = \frac{\alpha c}{2\lambda}\left(3 + 5\lambda + \lambda^2 + 15\lambda^3 - 2\alpha - 8\alpha\lambda + 6\alpha\lambda^2 - 20\alpha\lambda^3\right) > 0, \tag{B82}$$

which, due to the monotonicity of ϖ in t, implies that $\chi > 0$ at the lower bound of θ_L for all values of t satisfying (30). Since $\chi > 0$ both at the lower and upper bound of θ_L, the concavity of χ in θ_L implies that $\chi > 0$ also for all values of θ_L between the lower and upper bounds. This implies in turn that the sign of (B74) is determined by the sign of $(1-\alpha)\,(2t+c) - \theta_L$, which is positive (negative) for $\alpha < (>)\,\overline{\alpha}$.

References

[1] Allin, S., Farmer, J., Quinonezc, C., Peckham, A., Marchildon, G., Panteli, D., Henschke, C., Fattore, G., Lamloum, D., Holden A.C.L., Rice, T., 2020. Do health systems cover the mouth? Comparing dental care coverage for older adults in eight jurisdictions. Health Policy, 124, 998–1007.

[2] Baicker, K., Chandra, A., Shepard, M., 2023. Achieving universal health insurance coverage in the United States: Addressing market failures or providing a social floor? Journal of Economic Perspectives, 37, 99–122.

[3] Bardey, D., Cremer, H., Lozachmeur, J-M., 2016. The design of insurance coverage for medical products under imperfect competition. Journal of Public Economics, 137, 28–37.

[4] Bardey, D., Rochet, J.C., 2010. Competition among health plans: a two-sided market approach. Journal of Economics & Management Strategy, 19, 435–451.

[5] Barros, P.P, Martinez-Giralt, X., 2002. Public and private provision of health care. Journal of Economics & Management Strategy, 11, 109–133.

[6] Bauhoff, S., Hotchkiss, D.R., Smith, O., 2011. The impact of medical insurance for the poor in Georgia: a regression discontinuity approach. Health Economics, 20, 1362–1378.

[7] Bernal, N., Carpio, M.A., Klein, T.J., 2017. The effects of access to health insurance: evidence from a regression discontinuity design in Peru. Journal of Public Economics, 154, 122–136.

[8] Brekke, K.R., Siciliani, L., Straume, O.R., 2008. Competition and waiting times in hospital markets. Journal of Public Economics, 92, 1607–1628.

[9] Brekke, K.R., Siciliani, L., Straume, O.R., 2011. Hospital competition and quality with regulated prices. Scandinavian Journal of Economics, 113, 444–469.

[10] Buchmueller, T.C., Grumbach, K., Kronick, R., Kahn, J.G., 2005. The effect of health insurance on medical care utilization and implications for insurance expansion: a review of the literature. Medical Care Research and Review, 62, 3–30.

[11] Buchmueller, T., Miller, S., Vujicic, M., 2016. How do providers respond to changes in public health insurance coverage? Evidence from adult Medicaid dental benefits. American Economic Journal: Economic Policy, 8, 70–102.

[12] Card, D., Dobkin, C., Maestas, N., 2008. The impact of nearly universal insurance coverage on health care: Evidence from Medicare. American Economic Review, 98, 2242–2258.

[13] Card, D., Shore-Sheppard, L.D., 2004. Using discontinuous eligibility rules to the effects of the federal Medicaid expansions on low-income children. Review of Economics and Statistics, 86, 752–766.

[14] Clarke, P., Cutler, H., 2024. A proposal to extend universal insurance to dental care in Australia. Australian Economic Journal, 57, 168–173.

[15] Cremer, H., Lozachmeur, J.-M., 2022. Coinsurance vs. copayments: reimbursement rules for a monopolistic medical product with competitive health insurers. Journal of Health Economics, 84, 102642.

[16] Currie, J., Gruber, J., 1996. Health insurance eligibility, utilization of medical care, and child health. Quarterly Journal of Economics, 111, 431–466.

[17] Decker, S.L., Lipton, B.J., 2015. Do Medicaid benefit expansions have teeth? The effect of Medicaid adult dental coverage on the use of dental services and oral health. Journal of Health Economics, 44, 211–225.

[18] Finkelstein, A., Taubman, S., Wright, B., Bernstein, M., Gruber, J., Newhouse, J.P., Allen, H., Baicker, K., Oregon Health Study Group, 2012. The Oregon health insurance experiment: evidence from the first year. Quarterly Journal of Economics, 127, 1057–1106.

[19] Gaynor, M., Town, R.J., 2011. Competition in Health Care Markets. In: Pauly M., McGuire T., Barros P.P. (Eds.), Handbook of Health Economics, North-Holland, Chapter 9, 499–637.

[20] Grönqvist, E., 2006. Information updating and insurance dropout: evidence from dental insurance. In: Chiappori, P.-A., Gollier, C. (Eds.), Competitive Failures in Insurance Markets, The MIT Press, 135–156.

[21] Huh, J., 2021. Medicaid and provider supply. Journal of Public Economics, 200, 104430.

[22] Lamster, I.B., 2021. The 2021 WHO resolution on oral health. International Dental Journal, 71, 279–280.

[23] Limwattananon, S., Neelsen, S., O'Donnell, O., Prakongsai, P., Tangcharoensathien, V., Van Doorslaer, E. and Vongmongkol, V., 2015. Universal coverage with supply-side reform: the impact on medical expenditure risk and utilization in Thailand. Journal of Public Economics, 121, 79–94.

[24] Lipton, B.J., 2021. Adult Medicaid benefit generosity and receipt of recommended health services among low-income children: the spillover effects of Medicaid adult dental coverage expansions. Journal of Health Economics, 75, 102404.

[25] Moran, V., Riganti, A., Siciliani, L. 2024. Performance comparison and socioeconomic inequalities in unmet need for medical treatment and dental care in the European Union. Recent Developments in Health Econometrics, CEA Vol. 297, chapter 3.

[26] OECD, 2024. Health at a Glance: Europe 2024. State of the Health in the EU cycle. OECD/European Union.

[27] Peres, M.A., Macpherson, L.M., Weyant, R.J., Daly, B., Venturelli, R., Mathur, M.R., Listl, S., Celeste, R.K., Guarnizo-Herrea, C.C., Kearns, C., Benzian, H., 2019. Oral diseases: a global public health challenge. The Lancet, 394, 249–260.

[28] Sintonen, H., Linnosmaa, I., 2000. Economics of dental services. In: Culyer, A.J., Newhouse, J.P., (Eds.), Handbook of Health Economics, 1B, Chapter 24, 1251–1296.

[29] Winkelmann, J., van Ginneken, E., Gomez Rossi, J., 2022. Oral health care in Europe: financing, access and provision. European Journal of Public Health, 32, 129–372.

Most Recent Working Paper

NIPE WP 2/2025	Brekke, K. R., Straume, O. R., & Siciliani, L. Public coverage of dental care: universal or targeted?, 2025
NIPE WP 1/2025	Brekke, K. R., Dalen, D. M., & **Straume, O. R.** Competition matters: uniform vs. indication-based pricing of pharmaceuticals, 2025
NIPE WP 1/2024	**Amado, C.**, Garrón, I., & Veiga, H. On the relationship of country geopolitical risk on energy inflation. Universidade do Minho, 2024
NIPE WP 14/2023	Engberg, E., Görg, H., Lodefalk, M., Javed, F., Längkvist, M., **Monteiro, N.,** Nordås, H., Pulito, G., Schroeder, S., Tang, A. AI Unboxed and Jobs: A Novel Measure and Firm-Level Evidence from Three Countries, 2023
NIPE WP 13/2023	**Susana Campos-Martins** and **Amado, C.**, Modelling causality in nonstationary variances with an application to carbon markets, 2023
NIPE WP 12/2023	Brekke, K. R., Dalen, D. M., and **Straume, O. R.** , Taking the competitor´s pill: when combination therapies enter pharmaceutical markets, 2023
NIPE WP 11/2023	**Cátia Cerqueira**, **Alexandre, F.**, and **Portela, M.**, Digitalization: the edge of first movers, 2023
NIPE WP 10/2023	Brekke, K. R., **Straume, O. R.**, and Sørgard, L., Trade, renewable energy, and market power in power markets, 2023
NIPE WP 9/2023	**António Pedro Coelho** and **Loureiro, G.**, Do Earnouts Create the Right Incentives?: Earnings Management Around Earnout-Based Acquisitions, 2023
NIPE WP 8/2023	**Fernando Alexandre**, Ferreira, D., Mendonça, S. and **Portela, M**. The elusive impact of R&D grants on firm productivity, 2023
NIPE WP 7/2023	Cirulli, V., Marini, G., Marini, M. A., and **Straume, O. R.,** Do Hospital Mergers Reduce Waiting Times? Theory and Evidence from the English NHS, 2023
NIPE WP 6/2023	**Rosa-Branca Esteves** and **Francisco Carballo-Cruz**, Can data openness unlock competition when an incumbent has exclusive data access for personalized pricing?, 2023
NIPE WP 5/2023	**Natália P. Monteiro** and **Odd Rune Straume**, Management, performance and pay, 2023
NIPE WP 4/2023	**Cristiana Gião** and **Rita Sousa**, Desenvolvimento de uma Matriz de Contabilidade Social para a análise do efeito das alterações climáticas no turismo, 2023
NIPE WP 3/2023	**Rosa-Branca Esteves** and Shuai, J., Behavior-Based Price Discrimination with a General Demand, 2023
NIPE WP 2/2023	**Rosa-Branca Esteves**, and Pasquier, N., Marketplace's incentives to promote a personalized pricing device: Does it pay-off to boost consumer disloyalty?, 2023
NIPE WP 1/2023	**João Cerejeira**, **Rita Sousa**, Bernardo, C. and Bento-Gonçalves, A., Do wildfires burn tourism intentions? The case of Portugal, 2023
NIPE WP 12/2022	**Luís Sá** and **Odd Rune Straume**, Hospital competition when patients learn through experience, 2022
NIPE WP 11/2022	**Cristina Amado**. Outlier Robust Specification of Multiplicative Time-Varying Volatility Models, 2022
NIPE WP 10/2022	Gabrielsen, T. S., Johansen, B. O. and **Odd Rune Straume**. Merger control in retail markets with national pricing, 2022
NIPE WP 09/2022	Liao, R. C. and **Gilberto Loureiro** and Taboada, A. G. Gender Quotas and Bank Risk, 2022
NIPE WP 08/2022	Hussain, T. and **Gilberto Loureiro**. Portability of Firm Corporate Governance in Mergers and Acquisitions, 2022
NIPE WP 07/2022	**Rosa-Branca Esteves**, Ghandour, Z., and **Odd Rune Straume**, Quality discrimination in healthcare markets, 2022
NIPE WP 06/2022	**Rosa-Branca Esteves**, The welfare effects of group and personalized pricing in markets with multi-unit buyers with a decreasing disutility cost in consumption, 2022
NIPE WP 05/2022	Kurt R. Brekke, Dag Morten Dalen and **Odd Rune Straume**, The price of cost-effectiveness thresholds, 2022
NIPE WP 04/2022	Pedro Luis Silva, **Carla Sá**, Ricardo Biscaia and Pedro N. Teixeira, High school and exam scores: Does their predictive validity for academic performance vary with programme selectivity?, 2022