Effects of Overlapping Occupational Licenses On The Cost Of Dental Services
Evidence From Dental Insurance Claims

Allison Marier
Syracuse University
Center for Policy Research
426 Eggers Hall
Syracuse, NY 13244-1020
allison.marier@gmail.com

Coady Wing
Health Policy and Administration
University of Illinois at Chicago
1603 West Taylor
Chicago, IL 60612
coady.wing@gmail.com

Abstract
In the United States, occupational licensing regulations limit the scope of practice of dentists and dental hygienists. Only a dentist may legally perform most dental procedures; however, a smaller list of basic procedures may be provided by either a dentist or a dental hygienist. The specific list of services that may be provided by either type of worker varies across states and over time. We study the effects of these regulations on the market prices for basic dental services using a large database of dental insurance claims. Our main results suggest that the regulations increase prices by about 12% (p < .05). Related regulations increase utilization of dental services by about 3 to 3 percentage points.
Introduction

Occupational licensing has been an important institutional feature of the US health economy for a long time. The most basic economic concern is that licensing is a barrier to entry that restricts supply in ways that may drive up the wages and prices associated with medical care (Friedman and Kuznets, 1945). In one of the earliest applications of economic theory to health and health care, Arrow (1962) discussed the implications of physician licensing regulations. He was largely dismissive of proposals to allow free entry to medical professions. But – like many economists – Arrow suggested that a certification policy might be a preferable alternative. Interestingly, Arrow also pointed out that placing strict limitations on the right to perform specific types of work does more than simply restrict the supply of the regulated profession (physicians). It also reduces the supply of imperfect substitutes for existing services, which could be very costly in the long run (Arrow, 1962).

Arrow suggested that a system of graded licensing could reduce the pernicious effects of licensing while still maintaining a high standard of quality. Under graded regulations, people could be licensed to provide subsets of medical services. Arrow does not elaborate much on the proposal. But the logic of the idea is easy to understand. Graded licensing would create some overlap in the legal scope of practice of different occupational groups. The overlap would increase the degree of competition in health service markets and health care labor markets. It could encourage specialization, which could have advantages in terms of both cost and quality. In many situations the overlapping occupations might consist of people with different levels of general skill, and the overlap would allow workers to allocate their time to tasks that made the best use of their skills. These process make it likely that graded licensing policies seem like a
plausible way of mitigate the distortionary effects of all-or-nothing licensing while still maintain high standards of competence and quality.

In the 60 years since Arrow’s paper, occupational regulations have become much more pervasive in the United States. The fraction of workers covered by licensing regulations increased from about 5% in the 1950s to almost 29% in 2006 (Kleiner and Krueger, 2008). The health sector is particularly heavily regulated even by modern standards. Members of the conventional health service occupations – physicians, nurses, and dentists -- are universally required to hold licenses, of course. But over 76% of non-physician health workers also require a license to perform some aspect of their job (Kleiner and Park, 2010). One interesting development is that the “graded licensing” arrangements that Arrow envisioned are becoming more common. The market for dental services is a useful example.

In the United States, the provision of dental services is subject to occupational licensing regulations in every state. Only a dentist may legally perform most dental procedures. However, a smaller list of basic procedures may be provided by either a licensed dentist or a licensed dental hygienist. The specific list of services that may be provided by either type of worker varies across states and over time. Simple economic theory suggests that allowing hygienists and dentists to compete in the provision of a given service should put downward pressure on the prevailing price of the service. Partial deregulations that create regions of overlap between occupational groups do not represent the creation of perfectly competitive markets. But it is still quite plausible that variations in the scope of practice afforded to dental hygienists can affect the equilibrium price of dental services.¹

¹ This prediction seems plausible whether the regulations are framed as barrier to the entry of
There are wide disparities in dental health and utilization of basic dental services in the US (Mouradian et al, 2000). Regulations that limit the supply of dental services and that generate higher service prices may exacerbate these problems. And in a more general sense, occupational regulations that increase prices run counter to efforts to control rising health care costs in the United States. Given that the health services sector is subject to widespread occupational regulations, an analysis of the effects of regulation in dental markets may be informative about these larger issues as well.

In this paper, we study the effects of licensing regulations on the transaction prices of seven basic dental services: prophylaxis, fluoride treatment, local anesthesia, nitrous oxide, sealant application, amalgam restoration, and x-rays. These services are regulated differently across states and we use the variation across service categories, states, and time periods to estimate the effect of the licensing regulations on prevailing prices. Much of our analysis draws on data from a large database of private dental insurance claims. We extracted claims for the seven types of dental services listed above and used the billing and reimbursement information to construct estimates of the median transaction prices in state x year x service type cells. We linked the price data with regulatory information, and then estimated the effects of the regulations in generalized difference-in-differences (DID) and triple differences (DDD) regressions. We found that regulations that limit the right to provide basic dental services to licensed dentists increases the price of basic services by about 12% relative to a counterfactual market in which both dentists and dental hygienists are legally allowed to provide the service. We conducted additional analysis to rule out remaining threats the validity of our main results, and to understand how the regulations may affect some basic measure of utilization of dental services. The main results stand up to a variety of sensitivity analysis that probe key assumptions related to the method of
aggregating prices from the claims data, the correlation structure of the error distributions that is the basis for statistical inference, and the potential for unobserved confounding that occurs within and across geographical areas. And we found evidence that regulatory changes that give more freedom to hygienists led to increases in basic measure of dental service utilization. In particular, we found that when insurers are allowed to directly reimburse hygienists for their services, the proportion of people who utilized dental services within the past year increases by 3 to 4 percentage points.

Our main purpose in choosing to focus on seven specific dental services is that comparing prices in these markets can help us identify the causal effects of licensing regulations on equilibrium prices. The bulk of the paper is devoted to making such comparisons and to ruling out alternative interpretations of our basic findings. But the dental services we examine are important for at least three substantive reasons as well.

First, these seven services represent the “regulatory margin” for state governments considering changes in the regulatory status of dental hygienists. That is, state governments have shown a willingness to grant hygienists the authority to perform these tasks. But there is little evidence that states are willing to grant them authority to perform very many other services, perhaps because other services are considered too complicated or risky. The point is that our study is informative about policies that are “on the agenda” in various states. Our main results suggest that partial deregulations that grant more authority to hygienists are able to reduce the prevailing price of dental services.

Second, most dental care is basic dental care. The seven services we study represent a huge fraction of the dental services consumed in the United States each year. In the large database of
dental insurance claims that we used in our main analysis, there are over 770 million dental
claims spread almost evenly across three years (2005-2007). In each year, almost 40% of the
insurance claims involved one of the seven dental services that we are studying. The social costs
of a regulation that increases the price of these services by 12% are likely to be very large simply
because the services are widely consumed.

Third, the graded regulations in place for the provision of dental services could be useful model
for other parts of the health economy. For a variety of reasons, it seems unlikely that many
licensed occupations will converted to free-entry or even certified models. But the possibility of
increasing competition by expanding the scope of practice set of other occupational groups
presents another option that seems to move in the right direction. It seems easier – in a political
economy sense -- to extend the right to practice to a new occupational group than to de-license
already licensed groups. Our paper offers evidence that this model can help reduce the
distortionary price effects of conventional single-occupation licensing regimes.

**Background**

**Economic Models of Licensing** The economic theory of occupational licensing regulations
begins with the analysis of Friedman and Kuznets (1945) and Friedman (1962). In this line of
reasoning, licenses act as a barrier to entry that can restrict supply and increase wages and other
prices relative to a counterfactual competitive market. In this framework, licenses are pernicious
regulations that mostly function to secure economic rents for members of the licensed group. The
supply restriction model is an intuitive and useful starting point for the analysis of occupational licensing policy. But it does not incorporate the concerns about quality and information that are often used to justify occupational licensing regulations.

Other authors have shown that licenses can alleviate market failures in situations with information asymmetries. In particular, Akerlof (1970) shows that markets in which sellers have more information about the quality of a good than buyers can lead to a equilibrium in which only low quality goods are sold in the market. Leland (1979) applies this framework to the problem of entry into specific occupations and shows that licenses can improve welfare in some situations. Leland’s analysis focuses on the adverse selection of low quality workers into the regulated profession. Shapiro (1986) considers the role of licenses when service quality depends on effort so that moral hazard and not adverse selection is the main source of market failure. He models licensing regulations as a restriction on the inputs to the production function and shows that licensing restrictions can be welfare enhancing in some situations.

The three models discussed above provide useful insights into the ways in which occupational licensing regulations might affect labor and product markets. But to some extent the standard models do not seem to capture the “consumer protection” rhetoric that represents the most common defense occupational licensing regulations outside of economics. The popular justifications often hinge on claims about information and service quality. But usually the main concern in these debates does not seem to square with the idea that a ‘lemons problem’ or ‘moral hazard problem’ is reducing total surplus by limiting the extent of the market. Put differently, the fear does not seem to be that dental markets will collapse because people cannot tell dentists from quacks or because dentists will not make sufficient investments in dental-specific skills. Instead, the popular worry is that people will unwittingly receive low quality care and that the
low quality care will have longer term and perhaps irreversible consequences. Thus the popular argument against allowing “lower skill” providers – such as hygienists – to provide health services is that we may be exposing consumers to higher risk of receiving lower quality health care.

**Service Quality and Safety** Intuitive arguments about the way that licensing regulations ensure that people receive high quality services may be untrue in practice. For example, Kleiner and Kudrle (2000) note that in a classical information based model like the ones presented by Leland (1979) and Shapiro (1986) the effects of licensing regulations on prices and the distribution of service quality that is available can have off-setting effects on the average quality of services actually consumed in a market. The regulations can increase average quality consumed because higher quality services are available under the licensing regime. But the licenses can also reduce average quality consumed because they will increase prices and this may drive some consumers to reducing their consumption of health services.

The regulations we consider in this paper limit the scope of practice of dental hygienists and reduce the amount of competition faced by dentists in providing a particular set of services. Because they are product specific, these regulations do not seem to be mainly intended to combat an adverse selection problem in which low quality workers attempt to become dentists or dental hygienists. And they do not seem to be an effort to improve effort levels among dental care providers as suggested by a moral hazard model. It seems more plausible to think of these regulations as a kind of workplace/consumer safety regulation akin to restrictions on the use of toxic substances in factories or bans on the use of “unsafe” products (Kniesner and Leeth, 2004). In this respect, one important concern with regulations that grant more authority to occupations
that require less training is whether there really is a difference in safety or competence between the two groups.

To this end, Wetterhall et al (2010) evaluated the Alaska Dental Health Aide Initiative (ADHAI), which was designed to increase access to basic dental services by allowing lower skill aides to provide a range of basic dental procedures. The evaluation found that the quality of the services provided by the dental aides were indistinguishable from the quality of services provided by licensed dentists. Quality effects appear to be negligible for the services covered by the ADHAI, which are mostly the types of basic dental procedures that we are concerned with in this paper. In a similar study in a different context, Mundinger et al (2000) randomly assigned patients without a primary care provider to receive care from either a physician or a nurse practitioner. After six months there was no difference in overall health status or patient satisfaction and no difference in health service utilization between the two groups. These two random assignment evaluations suggest that proposals to expand the role of “lower skill” health care workers in the provision of a basic set of health services do not present large concerns about service quality.

**Benefits of Dental Services** Consumers benefit from dental care services in a variety of direct and indirect ways. Obviously people place value on resolving and preventing painful dental conditions. But there is evidence that dental care may have more subtle benefits as well. For example, Glied and Neidell (2010) find that exogenous exposure to fluoridated water during childhood increases the adult earnings of women by about 4%, with the strongest effects for women from low SES families. The argument here is mainly cosmetic. People with exogenously better looking teeth tend to earn more in the labor market. Hammermesh and Biddle (1994) study the wage effects of more general measures of physical beauty; they find substantial wage penalty for below average looks and a smaller wage premium for above average looks. These studies
suggest that expenditures on even purely cosmetic dentistry may have considerable value to a person’s economic wellbeing.

There is also a substantial literature suggesting that periodontitis (a chronic inflammatory dental disease) is related to cardiovascular disease. The evidence from these studies is complicated with some studies supporting a causal relationship and other suggesting that the connection is not causal. In a consensus report published in both the American Journal of Cardiology and the Journal of Periodontology, Friedewald et al (2009) discuss the conceptual mechanisms, which mainly involve the effects of chronic inflammation, that link the two health conditions. They review evidence from key individual studies and from several meta-analyses, and conclude that the available evidence suggests that untreated periodontitis does independently increase the risk cardiovascular disease. Cardiovascular disease is the leading cause of death for men and women in the United States and was responsible for 25% of all deaths in 2008 (Minino et al (2011). One estimate puts the total direct medical costs cardiovascular disease at $272.5 billion in 2010 alone, and these costs are expected to rise considerably over time (Heidenreich et al, 2011). Any ancillary benefits of dental care that served to reduce the burden of cardiovascular disease would be very valuable. Choi (2011) finds that Medicaid expansions, which lower the effective price of dental care to low income consumers, increase utilization rates. And so it is plausible that other interventions that increase the supply and lower prices could also change utilization rates in ways that might reduce disparities dental health and capture potential ancillary benefits related to cardiovascular health and labor market outcomes.

**Dental Service Markets** Total expenditures on dental services were about $105 billion in 2010 (CMS, 2011). Table 1 provides some simple information dentists, dental hygienists, and dental assistants, which are the three main occupational groups involved in the provision of dental
services. The wages of dentists are 2.3 times higher than the wages of hygienists and 4.7 times higher than the wages of dental assistants. Across the country, there are about 2 hygienists and 3 dental assistants for each dentist (OES, 2011). Annual salaries for the three groups combined comes to about $37 billion; which represents about 35% of total dental expenditures. The simple job descriptions reported in table 1 are from the O*Net, which is a database of information about the skills, duties, employment, and compensation characteristics of a large set of occupations in the United States. These simple descriptions suggest some potential overlap between the tasks performed by dentist and the tasks performed by dental hygienists. Both hygienists and dentists may perform basic examinations and provide various types of preventive care. The overlap occurs for tasks that are relatively high skill activities for hygienists and relative low skill activities for dentists. The actual degree of overlap depends on how licensing regulations constrain the activities of dental hygienists.

In this paper, we focus on a set of seven dental procedures: amalgam restoration, sealants, fluoride treatment, x-rays, cleaning, administration of nitrous oxide, and administration of local anesthesia. Dentists can legally perform these procedures throughout the country. Hygienists can perform some subset of these services in most states. But the precise list of procedures that hygienists are legally allowed to perform varies across states and over time. Figures 1 and 2 show the variation in these procedure specific regulations from 2001 to 2007. Figure 1 shows three procedures that hygienists usually are not allowed to perform. Close to 80% of states limit the right to perform amalgam restoration (fillings) to licensed dentists, so the overlap between the two professions with respect to this task is constrained in most states. Likewise, the majority of states do not allow hygienists to administer local anesthesia and only slightly more allow hygienists to administer Nitrous Oxide. In both cases, there is a downward trend: hygienists have
been acquiring greater authority to provide anesthetic drugs. Figure 2 shows the same type of plot for procedures that hygienists usually are allowed to perform. Almost all states allow hygienists to provide teeth cleaning (prophylaxis), fluoride treatment, and x-rays. And only around 18% the states do not allow hygienists to perform sealant applications. For these lower skill tasks, hygienists have made substantial in-roads, but the regulatory trend has been flat since 2003.

The wage and employment statistics in table 1 suggest that at prevailing wages, it would be considerably cheaper to employ hygienists to perform basic services than to employ dentists. Of course, the prevailing wages of dentists and hygienists are likely affected by the licensing regulations and the wages would probably change under a less regulated system. Kleiner and Park (2010) analyze the labor market effects of some of the same regulations that we consider in this paper. They find that the ability to practice independently of dentists increases the wages of dental hygienists by about 10% and decreases the wages of dentists by about 16%. One interpretation of these countervailing wage effects is that dentists have a degree of market power that is disrupted when hygienists have more authority to provide dental services. It seems plausible that at least some of these changes in the wage structure underlying the production of dental services could be passed on to consumers in the form of lower prices.

**Conceptual Framework**

A simple supply and demand framework provides an intuitive guide to the kinds of price effects that are the focus of this paper. Figure 1 depicts a hypothetical competitive market for a single dental service in which demand is downward sloping and supply is upward sloping. The line $S(p)$ shows the supply curve when both dentists and hygienists are eligible providers. The line $S(r)$
shows the supply curve when the set of providers is limited to dentists. With the demand curve held constant, the equilibrium price in this simple market is higher when only dentists are allowed to provide the service. The price effect of the regulation in this market is \( P(r) - P(p) \), which is the difference between the equilibrium prices that prevail under the two different regulations. The magnitude of the effect will vary with the size of the supply restriction and will also depend on the price elasticity of the demand and supply curves. Since these characteristics could reasonably vary across markets for different dental services in different geographical areas and different time periods it is likely that the effect of the regulation will vary across markets.

We do not intend the simple graph in figure 1 to be interpreted as a realistic model of the supply and demand for dental services in the United States. But we think it provides a useful guide to thinking about the ways that service specific regulations may affect prevailing prices, and to interpreting the results from quasi-experimental regression models. It also seems plausible that the implications of a simple supply shift explanation of regulatory price effects carry through reasonably well to more complicated situations. For example, consumer demand curves might be affected by insurance plan design and the premiums associated with those plans. And supply prices might be affected by bargaining and contracting between insurance companies and dental service providers. But it is difficult to come up with more complicated models in which regulations that exert a binding constraint on supply or on the use of lower cost inputs will not exert upward pressure on the prices charged by providers for their services. Thus we think it is a useful theoretical framework to keep in mind throughout the analysis.

**Quasi-Experimental Design**
With the supply and demand framework in mind we take a quasi-experimental approach to the empirical analysis the prices of dental services. To organize our thinking about the effect of the regulation and various sources of bias we adopt a potential outcomes notation that is common in the treatment effects literature. To this end, let \( Y(r)_{pst} \) and \( Y(p)_{pst} \) be a pair of potential outcomes that represent the equilibrium prices that would prevail in the market for product \( p \) in state \( s \) at time \( t \) under alternative regulatory regimes. Here, \( Y(r)_{pst} \) is the equilibrium price in the market if the market is regulated such that only dentists may provide the service. \( Y(p)_{pst} \) is the equilibrium price in the same market if the regulations permit either a dentist or a dental hygienist to perform the service. Thus \( r \) denotes the “regulated” price, and \( p \) denotes the “partially deregulated” price. The market specific effect of the regulation is \( \beta_{pst} = Y(r)_{pst} - Y(p)_{pst} \). We can never directly observe the market level effect of the regulation because only one of the two potential outcomes is actually observed; the other outcome is called the latent outcome or counterfactual outcome. Next, let \( R_{pst} = 1 \) if the market is subject to a ‘dentist only’ regulation and set to \( R_{pst} = 0 \) if both occupations are allowed perform the service. Then the observed price is \( Y_{pst} = Y(r)_{pst}R_{pst} + Y(p)_{pst}(1 - R_{pst}) \), which we can rewrite as \( Y_{pst} = Y(p)_{pst} + \beta_{pst}R_{pst} \).

Since we can’t directly estimate the market-specific impact most quasi-experimental empirical research focuses on average effects of the intervention. The average effect across all markets is \( E[\beta_{pst}] \) where the expectation is taken over each market in the population. Another common parameter this sometimes can be estimated under weaker assumptions is the average effect across those markets that are actually regulated, which is written \( E[\beta_{pst} | R_{pst} = 1] \). These average effects across markets constitute the focus of our empirical analysis.
If regulations were randomly assigned across a well-defined population of dental markets then a simple comparison of mean prices among regulated and partially deregulated markets would provide a credible estimate of the average effect of the regulations. In practice, regulations are not randomly assigned. Some dental services may be more likely to be regulated than others. Some geographical areas may be more open to partial deregulation than others. And regulatory changes may be more common in some time periods than other. If the differences in regulations that are in place across markets is systematically related to other factors that affect prices in those markets then simple comparisons of mean prices in groups of regulated and partially deregulated markets will yield biased estimates of the effect of the regulations.

These selection problems make it likely that \( E[Y(p)_{pst}|R_{pst} = 1] \neq E[Y(p)_{pst}|R_{pst} = 0] \) so that the regulated markets would have different average prices than the deregulated markets even in the absence of the regulations. It is useful to consider some more concrete reasons that regulated and partially deregulated dental service markets might have different equilibrium prices even in the absence of a regulatory treatment effect. We think that the three most important reasons involve differences in service complexity, differences in the demand for high quality dental services, and secular trends in dental service prices and regulations.

**Service Complexity** Simple comparisons of regulated and unregulated dental service markets could be misleading if regulated dental services tend to be more complicated and difficult to perform than partially deregulated dental services. For example, it may be more common for states to partially deregulate the provision of prophylaxis (teeth cleaning) than amalgam restoration (fillings) because amalgam restoration may require more skill to perform than prophylaxis. Difference in service complexity across regulated and partially deregulated markets could explain any observed price differences even in the absence of a regulatory treatment effect.
**Demand For Dental Services** Another way to study the effects of regulations would be to compare prices for the same dental service across states with different regulations. This method would appear to avoid the problem of different service complexity mentioned above. However, cross-state comparisons could lead to biased estimates if there are differences in levels of demand for (high quality/safe) dental services across the states. Higher demand could drive up prices and could also provide support for occupational licensing regulations that are intended to promote high quality dental care. This relationship between demand for dental services and the demand for regulation could lead to higher prices in regulated markets even in the absence of a regulatory effect.

**Secular Trends** One final straightforward way to study the price effects of regulations is to compare prices for the same goods (perhaps even in the same state) before and after changes in the occupational regulations. Here the problem is that regulatory changes might be confounded with secular trends in the prices of dental services.

**Difference in Differences Models**

To cope with the sources of bias described above we estimate generalized difference in difference (DD) regression models (Wooldridge, 2011; Meyer, 1995). To understand how the standard model applies to our study, suppose that $\theta_p$ is a vector of observable and unobservable characteristics associated with product $p$, including measures of the complexity of providing the service. Similarly, let $\theta_s$ and $\theta_t$ be vectors of observable and unobservable characteristics of state $s$ and time period $t$, respectively. If we could perfectly observe the information contained in these three vectors and condition our analysis on them then it would be possible to credibly estimate the effect of the regulation using the prices observed in regulated and partially
deregulated markets. The identifying assumption in this ideal scenario is that

$$E[Y(0)_{pst} \mid R_{pst} = 1, \theta_p, \theta_s, \theta_t] = E[Y(0)_{pst} \mid \theta_p, \theta_s, \theta_t]$$

which simply means that counterfactual (partially deregulated) equilibrium prices are mean independent of regulatory status conditional on the values of $\theta_p, \theta_s, \text{and } \theta_t$.

In practice, we cannot observe the values of the product, state, and year characteristics directly. However, the panel structure of our data set allows us to account these unobserved characteristics by including a full set of product, state, and year fixed effects in a regression of prices on the regulation indicator. This assumption is the basis of the generalized DD regression model. The specific regression equation that we estimate is:

$$Y_{pst} = \beta R_{pst} + \theta_p + \theta_s + \theta_t + \varepsilon_{pst}$$

In the model, $\varepsilon_{pst}$ is an error term and $\beta = E[\beta_{pst} \mid R_{pst} = 1]$. In other words, the assumptions supporting the model are sufficient to identify the average treatment effect on the treated (Blundell and Dias, 2008).^2

**Triple Differenced Models**

The DD model provides unbiased estimates of the effect of the regulation under the assumption that counterfactual partially deregulated prices are mean independent of regulations conditional

---

^2 Under the additional assumption that $E[Y(1)_{pst} \mid R_{pst} = 1, \theta_p, \theta_s, \theta_t] = E[Y(1)_{pst} \mid R_{pst} = 0, \theta_p, \theta_s, \theta_t]$ the same effect parameter can be interpreted as the overall average treat effect of the regulations. Intuitively the addition of this second assumption rules out the possibility that regulated markets are selected with reference to their idiosyncratic response to the regulations. Blundell and Dias (2009) provide a helpful review of the identification conditions considered here.
on product, state and, year fixed effects. From a conceptual standpoint, the key remaining threats
to the internal validity of this generalized DD comparison stem from unobservable factors that
affect both prices and regulations and that are not differenced away by the product, state, and
year fixed effects. In our data the regulations vary across service categories, states, and years and
this means that we are able to estimate even more general versions of the model that allow for
unobservable confounders that vary at the state x year, year x product, and product x state level.

Some of these factors are easier to interpret than others. For instance, it is possible that state
specific temporal shocks could explain both prices and regulations. Likewise, product specific
time trends could arise if technological changes make it easier or cheaper to perform a particular
dental service and these changes also encourage partial deregulation of the associated dental
markets. It is more difficult to think of intuitive explanations for state x product category specific
unobservable variables that affect both prices and regulations. Nevertheless the data underlying
our analysis technically permit estimation of a generalized version of the DDD regression model:

\[ Y_{pst} = \beta R_{pst} + \theta_p + \theta_s + \theta_t + \delta_{ps} + \delta_{st} + \delta_{pt} + \epsilon_{pst}, \]

Here \( \delta_{ps}, \delta_{st}, \text{and} \ \delta_{pt} \) represent vectors of variables that vary at the product x state, state x time,
and product x time levels. The interpretation of the effect parameter \( \beta \) is the same as it is in the
simpler DD model but here the identification strategy is robust to a more elaborate class of
unobserved shocks that are correlated with both regulations and prices. In essence we have
expanded the conditioning set of variables that are in place to establish the conditional (mean)
independence condition.

Data
**Insurance Claims** The core of our analysis is based on a large database of private insurance claims maintained by Fair Health, Inc, which is a non-profit firm that provides independent estimates of the distribution of health services reimbursement rates across the United States. Estimates of price distributions from the database are widely used by insurance companies and providers to determine appropriate reimbursement rates for health services. The database consists of individual insurance claims provided by a large set of “contributing insurance companies” who operate in markets across the United States. Each contributing company agrees to submit a complete and unadulterated dataset of the insurance claims it processed over a calendar year.\(^3\) The number of contributing companies varies somewhat over time.

We use three years of the dental insurance claims database. There were 157 contributing companies in 2005, 137 in 2006, and 125 in 2007\(^4\). Once the claims data are received they are placed in a common format and pooled into a single very large database. The dental insurance module, which is the basis of this paper, includes insurance claims for approximately 250 million dental procedures each year. The data are de-identified to protect the confidentiality of patients and contributing companies.

The database contains various pieces of information for each claim. For our purposes the most important pieces of information are: the current dental terminology (CDT) code\(^5\) associated with

---

3 A contributor is an insurance organization that has made a contractual agreement to submit claims to the database; the structure of the insurance industry in the United States means that these companies may be affiliated with a larger parent company and so it may or may not be reasonable to think of each contributor as an independent company.

4 Changes in the number of contributing firms may reflect the consolidation of contributions made by multiple subsidiary companies but it is difficult to know for sure because the identity of the companies is masked in the database for confidentiality reasons.

5 Current Dental Terminology (CDT) codes are developed and maintained by the American Dental Association. Each CDT code is accompanied by a brief description of the procedure; CDT codes tend to be grouped by procedure.
the procedure that is the basis of the insurance claim; the zipcode of the location that the service was rendered; the amount of money billed by the provider for the service; and the amount of money reimbursed (allowed) by the insurance company for the service. We used the CDT codes to identify claims for services affected by the seven service specific regulations that are the topic of this paper.⁶ These 21 codes accounted for 39% of the approximately 750 million claims in the full dental insurance claims database.

As mentioned above, the claims data contain two pieces of information on the transaction price of the service: the billed amount and the allowed amount. The billed amount is essentially the provider’s list price for the service. In many cases, insurance companies may negotiate discounted prices by offering membership in a network of preferred providers. In this paper, we focus on measures of prices that are based on the allowed amount. We removed claims from the samples with missing or corrupted information for the billed or allowed charge variable, and we also removed claims with very large prices that were likely data transcription errors – the charge has extra zeros or slipped decimal places. These steps affected a very small fraction of the cases.

Because the occupation regulations that are the focus of this paper vary at the state level we aggregated the claims data to the state level, which has become standard practice in applied research based on variation in state regulations and program characteristics (Angrist and Pischke, 2009; Bertrand, Duflo, and Mullainathan, 2004). The main outcome variable we use in our sample is the median allowed charged for a specific CDT procedure code within a given

---

⁶ Some of the covered procedures categories involve multiple CDT codes. For instance, patients may be billed for complete series X-rays, single film X-rays, panoramix X-rays, etc. We were interested in CDT codes for services the following classes of services: 1) prophylaxis, 2) fluoride treatment, 3) local anesthesia, 4) nitrous oxide, 5) sealant application, 6) amalgam restoration, and 7) x-rays. We compiled a list of CDT codes that fell into each of these seven categories and then selected these claims from the overall database. Specifically, we extracted claims for the following 21 CDT codes: D0240 D0250 D0260 D0272 D0274 D0276 D0274 D0340 D0350 D1110 D1120 D1203 D1204 D1351 D2140 D2150 D2160 D2161 D9210 D9211 D9212 D9215 D9230.
state and year. We use the state median as the estimate of a typical price because price distributions are sometimes skewed and the median provides a more robust measure of a typical price. Analysis based on mean prices in state x year x CDT code cells produces nearly identical results.

Table 2 reports across state averages of the median price in each of the seven product categories for the years 2005-2007. These are averages calculated from the aggregated data set and they give equal weight to each market. The prices vary somewhat across the seven service categories. Across states, the average price received by providers is about $113 for amalgam restoration (fillings), $55 for prophylaxis (teeth cleaning), $25 for fluoride treatment, and between $30 and $40 for X-rays, Sealant Restoration, Local Anesthesia, and Nitrous Oxide.

Dental Regulations The regulations we use to define a market as regulated or partially deregulated vary across states, years, and service categories. Some of the service categories are much more likely to be regulated than others; in fact, there is much more variation in regulatory status across markets and states than there is over time. We have regulatory data for the years 2001-2007 but we only have insurance claims data from 2005-2010. As discussed earlier in the paper, figures 1 and 2 plot the proportion of states in which only a dentist may perform a particular dental service over time. There was a deregulatory trend over 2000-2007 with hygienists gaining the right to provide more services. At least two important points become clear from figures 1 and 2. First, there is substantial variation in the regulatory status of specific dental services across states and there is also substantial variation in the regulatory status of different types of dental services. For good or ill the variation across states and product categories is an important source of variation in our analysis. Second, there is some variation in the regulatory
status of the different products over time but not much of this variation occurs during the 2005-2007 window for which we have insurance claims data.

Additional Data Sources Our main analysis is based on the insurance claims and regulatory data. But to assess the robustness of the results and examine some additional research questions, we also made use of two additional sources of information. We used a commercial database purchased from zip-codes.com to construct measures of the demographic, economic, and geographic information about each zipcode in the United States. The zipcodes.com data is compiled mainly from the United States Postal Service (USPS) and the US Census Bureau. The zip-code.com database includes the latitude and longitude of the centroid of each zipcode area. We used this information calculate the distance of each zipcode in each state to various state border using the Haversine formula.⁷

We also pooled data from the 2000-2006 Behavioral Risk Factor Surveillance Survey (BRFSS) to examine the effects of the regulations on the utilization of dental services. The BRFSS is a household survey that is conducted in each state under the supervision of the CDC. The survey instrument collects data on whether respondents have visited a dentist in the past year, past two years, and past five years. It also asks whether respondents have had their teeth cleaned in the past year or past two years. We created indicator variables to measure the use of dental services in the past year and two years and we used these measures to study the effects of the regulations on utilization. The BRFSS data and analysis are explained in more detail later in the paper.

Results

---

⁷ Thomas Holmes generously provides the state border coordinates data on his personal website.
**State Level Regressions** Table 3 reports estimates of the effect of the regulation from four different regression models. The dependent variable is the median price in the state x year x product category cell. Table 4 reports results from the same specifications but the dependent variable is the log of the median price in the state x product x year cell. Column 1 reports estimates from the generalized DD regression, which included a full set of state fixed effects, year fixed effects, and product category fixed effects. In the level effect model, the regression implies that the regulations increased prices by about $6.73. The log-linear model implies that the regulations increase prices by about 12%, which is consistent with the level price effect in dollar terms. An effect of ~12% is substantial, especially when one considers aggregate yearly consumption of basic dental services in a typical year. However, the idea that occupational regulations increase prices of basic dental service by about 12% does not seem implausible given the very large differences in the wages of dentists and dental hygienists. We estimated the standard error of the effect estimates using a Huber-White robust variance matrix that allowed for clustering at the state level. In both the level and log-linear models the effects were large enough to reject the null hypothesis that the regulations have no effect on prices at conventional levels of statistical significance (p<.05).

To account for the possibility of state specific temporal shocks that affect both regulations and prices, column 2 reports estimates of regulatory effects using models that include state x year fixed effects. Adding these state-year specific effects does not change the results in any meaningful way. Column 3 reports results from models that allow for both state x year and also time x product category fixed effects. These additional fixed effects are meant to capture any product specific technological changes that might explain a change in cost structure. Again the effects are nearly identical to the estimates in Models A and B and this is true whether the
outcome is in level form or log form. Finally, Column 4 reports estimates from a more saturated DDD model, which adds state by year, product by year, and state by product fixed effects to the standard DD model. In the level outcome model, the effect estimate falls from $6.80 to $2.67 and is no longer statistically significant. In the log-linear model the effect falls from 12% to 7% and remains statistically significant.

Adding state by product-specific fixed effects to the regression model dramatically reduces the amount of regulatory variation that can be used to estimate the model parameters. Figures 1 and 2 show that much of the variation in regulations comes from the fact that the states regulate a different list of products and much of this variation is removed by the state by product fixed effects. This is the main reason why the DDD specification yields a smaller and noisier effect estimate. Given the lack of variation in the full DDD specification it is sensible to ask whether a state by product specific fixed effect is a plausible source of confounding in our analysis. We find it difficult to come up with a plausible state by product specific shock that would explain both regulations and prices. Accordingly we interpret the results in tables 2 and 3 as evidence that the occupational regulations increase prices by about 12%.

**Robustness Checks and Further Analysis**

*Statistical Inference* Several authors have shown that nominal standard error estimates often are too small in DD regressions because of dependencies due to clustering and serial correlation that is amplified by the use of aggregate level regressors (Moulton, 1990; Bertrand, Duflo, and Mullainathan, 2004; Donald and Lang, 2007; Conley and Taber, 2011). Tables 3 and 4 report standard errors that were estimated using a Huber-White robust variance matrix that allowed for clustering at the state level. Technically, these standard errors are consistent with a sufficiently
large number of clusters and so the question is whether 51 clusters is enough to rely on the asymptotic approximation. An alternative interpretation suggests that the important source of clustering occurs at the product level. If product level clustering is central then with only 7 product groups it is unlikely that standard errors based on conventional formulas will provide a good basis for statistical inference.

To explore the robustness of our results to assumptions about the structure of the error distributions, which give rise to these concerns about the validity of the standard errors, we implemented a randomization test based on placebo laws. In the most basic implementation of the idea, we randomly selected a set of state x product x year cells, defined them as “pseudo regulated markets”, estimated the regression model using the placebo regulations instead of the real regulations, and stored the coefficient on the pseudo regulation. We repeated this process a 2000 times to build up a distribution of placebo effects. On average, these placebo laws should have no effect on prices because they are simply randomly chosen cells although some of the placebo’s will lead to large effects by chance. By comparing the regulatory effect produced by the actual regulations to the empirical distribution of effect estimates produced by the placebo laws we can understand the likelihood that our effect was observed by chance without appealing to the asymptotic sampling distribution of a given estimator. A version of this test led to inferences with the desired statistical properties in Bertrand et al (2004). Rosenbaum (2002, 2009) also argues that randomization tests have good properties in a variety of non-experimental settings. The test is does not require assumptions about clustering and serial correlation; instead it hinges on the assumption that the treatment variable is independent of the potential outcomes conditional on the covariates included in the model. Since we were already imposing this assumption, the placebo laws test seems to only weaken the assumptions underlying our analysis.
One conceptual problem that arises with implementing a placebo test is that the true “law generating process” is unknown. To assess the implications of these alternative law generating processes on the distribution of placebo outcomes, we computed randomization tests limited the placebo laws to arise within the same states as the real laws, within the same product groups as the real laws, and within the same years of the real laws. Note that in each case the placebos are permutations of the existing laws so that in the full sample the total number of laws stays fixed and the identification of the model does not fail for any particular arrangement of laws.

Figure 3 plots kernel density estimates of the placebo law effects. The distributions vary somewhat across the four different law generating processes; however they are approximately mean zero, which implies that the effect estimator is unbiased. The vertical line on the far right of figure 4 represents the effect estimate -- $6.80 -- that we actually observed in our data. Clearly it falls in the extreme tail of the distribution of placebo effects which makes it quite unlikely that the effect was observed due to chance. Based on the placebo law distribution the probability of observing an effect of $6.80 when the true effect is 0 is well below .05. Thus, the placebo laws tests casts some doubt on the possibility that our conclusions are invalid because of biased standard errors.

**MSA Level Regressions** To analyze the impact of regulations at a more local level we restricted the analysis to metropolitan statistical areas (MSAs) that cross state borders. Specifically, we aggregated the claims data to the MSA x state x product x year cells using only claims for dental services that were performed in geographical areas that were less than 20 miles from the state border. The identifying assumption in this model is that unobservable price trends on either side of the border are captured by MSA, year, and product fixed effects and do not bias the regulation
coefficient. To control for additional variation, product by MSA and year by MSA fixed effects are included, along with zipcode.com demographic control variables.

The results from regressions based on the level price are in table 5. Estimates based on log prices are in table 6. The estimates from the level price regressions imply that the regulations increase prices by about $3 within MSAs when the model accounts for product fixed effects, MSA fixed effects, and year fixed effects. These estimates are sufficient to reject the null of no effect at conventional levels of significance. The models based on log prices produce estimates that are very similar in magnitude to the level price estimates but they are noisily estimated and are not statistically different from zero.

In both the level and log models, the effects become quantitatively and statistically insignificant when product x MSA and MSA x year fixed effects are included in the model. As previously discussed, no convincing MSA-product shock story comes to mind that would explain both regulation and prices. Accordingly, our preferred estimate comes from the specification in column 3, which implies that the regulations increase price by about 3% within the same MSA. The MSA regressions provide a way of more directly controlling for unmeasured differences between regulated and unregulated geographic areas because the analysis is limited to more or less coherent economic zones that are bisected by a state border that marks a change in licensing regulations. The effects may be smaller at the local level because consumers may be able to escape higher prices in regulated areas by crossing the state border to purchase dental services. The finding that the regulatory effects persist even in these small areas that facilitate shopping around adds support to our state level analysis.
Utilization Effects Our analysis so far implies that allowing hygienists to provide more dental services reduces the prices of those services by a meaningful amount. A natural follow-up question is whether the price reductions also led to an increase in the use of dental services. To examine this question, we pooled data from waves of the Behavioral Risk Factor and Surveillance Survey (BRFSS) that collected measures of dental service utilization for people in all states. The BRFSS is a cross sectional telephone survey that is conducted by state health departments with technical support from the Centers for Disease Control. The survey consists of core components that are collected in all states and various modules and state-specific components.

In 2002, 2004, and 2006, the BRFSS asked respondents in all 50 states “how long has it been since you last visited a dentist or dental clinic for any reason?” And it also asked “how long has it been since you last had your teeth cleaned by a dentist or a dental hygienist?” We used these items to construct four dichotomous measures of dental utilization that indicated whether: the person had visited a dentist or dental clinic in the last 12 months, the person had visited a dentist or dental clinic in the last 24 months, the person had had his/her teeth cleaned by a dentist or hygienist in the last 12 months, and the person had his/her teeth cleaned by a dentist or hygienist in the last 24 months. Since these variable do not map directly to the multiple service specific licensing regulations, we were not able to estimate utilization models that exactly paralleled our price analysis. To make progress on the issue, we defined summary measures of the restrictiveness of the licensing environment for hygienists in each state and estimated models with the following form:

\[ Y_{ist} = R_{st} \beta + X_{ist} \gamma + \lambda_t + \alpha_s + \epsilon_{ist} \]
In the model, $Y_{ist}$ is one of the four measures of dental utilization, $X_{ist}$ is a vector of covariates including measures of age, age squared, race-ethnicity, gender, education, household size and composition, employment status, and bracketed income categories. We use $s$ to index states and $t$ to index years. $\lambda_t$ and $\alpha_s$ represent year and state fixed effects. $R_{st}$ is a summary measure of the regulatory status of state $s$ in year $t$. We examined three summary measures of the regulatory environment: the number of dental tasks that a hygienist may legally perform, an indicator set to 1 if an insurance company may reimburse a hygienist directly for her services, and an indicator set to 1 if the state Medicaid program may reimburse a hygienist directly for her services. These last to indicators are meant to capture a broader notion of the independent practice authority of dental hygienists. In each case, the coefficient on the regulatory variable, $\beta$ is the object of interest. We estimated the models using least squares regressions with robust standard errors that allowed for clustering at the state level (Angrist and Pichke, 2009).

The results are in table 7. The first panel shows estimates of the effects of allowing hygienists to perform more tasks on the probability that a person uses dental services. The models include state and year fixed effects as well as a vector of covariates so that the estimated effects come from within state variation in the number of allowed tasks between 2002, 2004, and 2006. The estimates are quantitatively small and are not precisely estimated. We find no evidence that increasing the number of tasks affects dental service utilization.

The story is somewhat different when reimbursement restrictions are used to measure the economic independence of dental hygienists. The second panel in table 7 shows that the allowing insurance companies to directly reimburse a dental hygienist increases the probability that a person has received dental care in the last 12 months by about 2.8 percentage points ($p = .055$). There is no effect on utilization in the past 2 years, this makes sense because the model is
identified using within state regulatory change and so a prevalence within a 2 year window should because the new regulations should not have effected behavior in earlier time periods. The reimbursement policy increases the probability that a person has had his/her teeth cleaned in the last 12 months by 4.3 percentage points (p = .004). This larger effect also makes sense because teeth cleaning is represents one of the central services provided by dental hygienists. Regulatory effects on teeth cleaning in the last two years are effectively zero. The estimates based on Medicaid reimbursement policies, presented in the third panel, tell a similar story. Allowing Medicaid to reimburse hygienists directly increases one year utilization rates by about 2.5 percentage points (p = .007). There is no effect on two year utilization rates. One year teeth cleaning rates increase by 3.7 percentage points (p = .001) and there is no effect on two year teeth cleaning rates.

**Conclusions**

In this paper, we studied an example of graded licensing that arises because of service-specific limitations on the scope of practice of dental hygienists. We found that the prevailing prices of basic dental services were 12% higher when the service could only be provided by a dentist rather than by either a dentist or a dental hygienist. The shift from a dentist only to a dentist or hygienist policy obviously does represent a movement towards a free entry model. But for practical purposes, allowing this type of overlap in occupational authorities may accomplish substantial reductions in the allocative inefficiencies associated with licensing. We also found evidence that utilization of dental services is 3 to 4 percentage points higher when hygienists can be reimbursed directly for their services, and this too seems like an important gain given well-documented disparities in dental health and access to dental care.
In most instances, the costs and benefits of licensing are difficult to assess empirically because licenses almost by definition make it hard to construct reasonable comparison groups that can be used to estimate what key health and economic outcomes would look like under alternative policies. Cross state comparisons are the most common way to proceed (Kleiner, 2000, 2006), but these methods make it difficult to separate the effects of licensing changes from state-specific trends in the demand and supply for the affected services. And in a broader sense, most of the licensing literature examines the effects of licensing on wages rather than on the prices that prevail in related product markets.

Our paper makes some progress on both of these limitations. By focusing on service-specific regulations, we were able to compare the effects of regulations within the same state by comparing prices in different product markets that should share similar underlying demand conditions. And by studying prices rather than wages, our analysis gave a different perspective on the way that licensing restrictions affect consumers.

Another contribution of our paper comes from the analysis of graded licensing regulations. The bulk of the literature tends to frame the discussion in terms of a licensed regime vs a free-entry or certification regime. We agree that in many situations, free-entry or certification represent superior alternatives to conventional licensing regulations. But there are very few examples of occupations that have been deregulated in these ways in the United States (Kleiner, 2006). The graded licensing approach that was discussed in Arrow (1963) may permit an alternative approach to regulatory reform that can reduce the economic disadvantages of licensing without overtly deregulating an incumbent occupational group.
References


Conley, T. G., & Taber, C. R. (2011). Inference with "Difference in Differences“ with a Small Number of Policy Changes,


Friedman, M. With the assistance of rose friedman. 1962. Capitalism and Freedom,


Table 1: Basic characteristics of key occupational groups involved in the production of dental services

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Employment</th>
<th>Average Hourly Wage</th>
<th>Education</th>
<th>Basic Job Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dentist</td>
<td>90,950</td>
<td>77.76</td>
<td>Doctoral or Professional Degree</td>
<td>Examine, diagnose, and treat diseases, injuries and malformations of teeth and gums. May treat diseases of nerve, pulp, and other dental tissues affecting hygiene and retention of teeth. May fit dental appliances or provide preventive care.</td>
</tr>
<tr>
<td>Dental Hygienist</td>
<td>184,110</td>
<td>33.54</td>
<td>Associate Degree or Bachelor's Degree</td>
<td>Clean teeth and examine oral areas, head, and neck for signs of disease. May educate patients on oral hygiene, take and develop x-rays, apply fluoride or sealants</td>
</tr>
<tr>
<td>Dental Assistant</td>
<td>296,810</td>
<td>16.70</td>
<td>Some College (No Degree)</td>
<td>Assist dentist, set up equipment, prepare patients for treatment, keep records.</td>
</tr>
</tbody>
</table>

Notes: Employment and average wage estimates are from the May 2011 Occupational Employment Statistics report. Educational information and simple job descriptions are from the O*Net database, which is maintained by the Bureau of Labor Statistics.
Table 2: Average transaction prices by service type and year across all state markets.

<table>
<thead>
<tr>
<th>Dental Service</th>
<th>Statistic</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prophylaxis (Cleaning)</td>
<td>Mean</td>
<td>52.16</td>
<td>54.2</td>
<td>57.06</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>12.74</td>
<td>12.96</td>
<td>13.9</td>
</tr>
<tr>
<td>Fluoride Treatment</td>
<td>Mean</td>
<td>24.85</td>
<td>25.9</td>
<td>24.97</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>5.76</td>
<td>5.8</td>
<td>4.52</td>
</tr>
<tr>
<td>Amalgam Restoration</td>
<td>Mean</td>
<td>108.94</td>
<td>113.33</td>
<td>121.15</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>31.94</td>
<td>34.23</td>
<td>36.21</td>
</tr>
<tr>
<td>X-Ray</td>
<td>Mean</td>
<td>34.57</td>
<td>35.86</td>
<td>37.97</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>19.03</td>
<td>20.27</td>
<td>21.12</td>
</tr>
<tr>
<td>Sealant Application</td>
<td>Mean</td>
<td>34.09</td>
<td>35.86</td>
<td>37.97</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>5.42</td>
<td>5.73</td>
<td>6.16</td>
</tr>
<tr>
<td>Anesthesia</td>
<td>Mean</td>
<td>33.81</td>
<td>31.3</td>
<td>30.8</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>70.92</td>
<td>32.34</td>
<td>23.04</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>Mean</td>
<td>35.51</td>
<td>37.65</td>
<td>40.77</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>8.23</td>
<td>9.29</td>
<td>11.56</td>
</tr>
</tbody>
</table>

Note: We estimated the median allowed charge from insurance claims within state x year x service code cells. The table reports the average and standard deviation of these cell medians across all of the states in the sample. Each cell receives equal weight in the calculation.
Table 3: Effects of licensing regulations on the cell median prices.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulation Effect</td>
<td>6.73</td>
<td>6.76</td>
<td>6.8</td>
<td>6.8</td>
<td>2.67</td>
</tr>
<tr>
<td>SE</td>
<td>2.74</td>
<td>2.46</td>
<td>2.51</td>
<td>2.53</td>
<td>1.94</td>
</tr>
<tr>
<td>p</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.08</td>
</tr>
<tr>
<td>Covariates</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Product Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State x Year Fixed Effects</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Product x Year Fixed Effects</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Product x State Fixed Effects</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>R squared</td>
<td>0.643</td>
<td>0.643</td>
<td>0.645</td>
<td>0.651</td>
<td>0.703</td>
</tr>
<tr>
<td>N</td>
<td>2979</td>
<td>2979</td>
<td>2979</td>
<td>2979</td>
<td>2979</td>
</tr>
</tbody>
</table>

Note: Standard errors are calculated using a Huber-White Robust variance matrix that allows for clustering at the state level.
Table 4: Effects of licensing regulations on the log of cell median prices.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulation Effect</td>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
<td>0.07</td>
</tr>
<tr>
<td>SE</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>p</td>
<td>p&lt;.01</td>
<td>p&lt;.01</td>
<td>p&lt;.01</td>
<td>p&lt;.01</td>
<td>p&lt;.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Covariates</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State x Year Fixed Effects</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Product x Year Fixed Effects</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Product x State Fixed Effects</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

R squared: 0.645 0.646 0.650 0.651 0.695
N: 2979 2979 2979 2979 2979

Note: Standard errors are calculated using a Huber-White Robust variance matrix that allows for clustering at the state level.
Table 5: Effects of licensing on the price of dental services within MSA x Year x Service Type cells.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulation Effect</td>
<td>3.53</td>
<td>3.53</td>
<td>3.48</td>
<td>0.32</td>
<td>0.31</td>
</tr>
<tr>
<td>SE</td>
<td>1.35</td>
<td>1.17</td>
<td>1.16</td>
<td>1.62</td>
<td>1.64</td>
</tr>
<tr>
<td>p</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>Covariates</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Product Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MSA Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Product x Year Fixed Effects</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Product x MSA Fixed Effects</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MSA x Year Fixed Effects</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

| R squared                  | 0.742| 0.745| 0.747| 0.769| 0.771|
| N                          | 3741 | 3483 | 3483 | 3483 | 3483 |

Note: Standard errors are calculated using a Huber-White Robust variance matrix that allows for clustering at the state level.
<table>
<thead>
<tr>
<th>Statistic</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulation Effect</td>
<td>0.027</td>
<td>0.033</td>
<td>0.033</td>
<td>-0.008</td>
<td>-0.008</td>
</tr>
<tr>
<td>SE</td>
<td>0.022</td>
<td>0.021</td>
<td>0.022</td>
<td>0.03</td>
<td>0.031</td>
</tr>
<tr>
<td>p</td>
<td>0.23</td>
<td>0.14</td>
<td>0.14</td>
<td>0.80</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Covariates
- No
- Yes

Product Fixed Effects
- Yes

MSA Fixed Effects
- Yes

Year Fixed Effects
- Yes

Product x Year Fixed Effects
- No
- No
- Yes
- Yes

Product x MSA Fixed Effects
- No
- No
- No
- Yes

MSA x Year Fixed Effects
- No
- No
- No
- Yes

R squared | 0.706 | 0.709 | 0.710 | 0.737 | 0.739 |
N         | 3741  | 3483  | 3483  | 3483  | 3483  |

Note: Standard errors are calculated using a Huber-White Robust variance matrix that allows for clustering at the state level.
Table 7: Effects of hygienist licensing restrictions on utilization of dental services.

<table>
<thead>
<tr>
<th>Regulation</th>
<th>Statistic</th>
<th>Dental Visit In Last 12 Months</th>
<th>Dental Visit In Last 24 Months</th>
<th>Teeth Cleaned In Last 12 Months</th>
<th>Teeth Cleaned In Last 24 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Tasks Hygienists Are Allowed to Perform</td>
<td>Coefficient</td>
<td>-0.006</td>
<td>0.003</td>
<td>-0.013</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>0.012</td>
<td>0.006</td>
<td>0.014</td>
<td>0.012</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.593</td>
<td>0.685</td>
<td>0.351</td>
<td>0.697</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>91169</td>
<td>91169</td>
<td>83086</td>
<td>83086</td>
</tr>
<tr>
<td>Insurance Companies May Reimburse Hygienists</td>
<td>Coefficient</td>
<td>0.028</td>
<td>0.001</td>
<td>0.043</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>0.014</td>
<td>0.012</td>
<td>0.014</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.055</td>
<td>0.927</td>
<td>0.004</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>91169</td>
<td>91169</td>
<td>83086</td>
<td>83086</td>
</tr>
<tr>
<td>Medicaid May Reimburse Hygienists</td>
<td>Coefficient</td>
<td>0.025</td>
<td>0.007</td>
<td>0.037</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>0.009</td>
<td>0.013</td>
<td>0.01</td>
<td>0.011</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.007</td>
<td>0.58</td>
<td>0.001</td>
<td>0.179</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>91169</td>
<td>91169</td>
<td>83086</td>
<td>83086</td>
</tr>
</tbody>
</table>

Regressions were estimated using OLS regressions. Standard errors are calculated using a Huber-White Robust variance matrix that allows for clustering at the state level. State and Year Fixed Effects were included in all models, so that regulation effects are identified using within state variation in licensing regulations. The models also controlled for Models also include controls for age, age squared, race-ethnicity, gender, education, household size and composition, employment status, and bracketed income categories.
Figure 1: A simple depiction of supply and demand for services under alternative licensing policies.
Figure 2: The figure shows the proportion of states in the US that do not allow hygienists to independently perform three particular types of dental services. The services in this graph -- Amalgam Restoration, Local Anesthesia, and Nitrous Oxide -- are relatively highly regulated in the sense that few states allow hygienists to perform these tasks. The lines trend downwards somewhat over time, indicating that hygienists have acquired greater practice authority. But most of the variation comes from across state variation in service specific regulations.
Figure 3: The figure shows the proportion of states in the US that do not allow hygienists to independently perform three particular types of dental services. The services in this graph – Prophylaxis (cleaning), Fluoride Treatment, X-Rays, and Sealant Application – are relatively lightly regulated in the sense that most states do allow hygienists to perform these tasks. The lines trend downwards from 2001 to 2003, but have been constant since then. Overall, most of the variation comes from across state variation in service specific regulations.
Figure 4: The graph shows a kernel density plot of the distribution of 2000 placebo estimates of the effects of the regulation on cell level prices. The different lines show the distributions that arise from different law generating procedures. Each regression allowed for state, year, and product fixed effects. The estimate observed in the actual data is indicated by the vertical red line at about $6.80. The graph shows that an estimate as large as $6.80 is extremely unlikely to have arisen by chance. The placebo law distribution provides a way to conduct statistical inference under less restrictive assumptions than standard methods such as cluster-robust standard errors.