RESTRICTIONS ON DENTAL AUXILIARIES

An Economic Policy Analysis

by

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PREFACE

This report was prepared using simple conceptual and statistical models and readily available data. The report presents new evidence on the price and income effects of restrictions on the employment of dental auxiliaries. The report also surveys the extensive literature that compares the quality of dental service by auxiliaries to the quality of service by dentists. Finally, the report draws conclusions for public policy and presents some areas for future research.

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I. Introduction and Summary

Several states impose restrictions on dentists' employment of dental auxiliaries (hygienists and assistants). For example, some states limit the number of hygienists that a dentist may employ, or the duties that an auxiliary may perform. If these restrictions prevent dentists from using auxiliaries for tasks the auxiliaries are qualified to perform, then the restrictions may reduce the efficiency of production of dental services and increase the prices that consumers pay for them. To the extent that higher prices cause consumers to decrease their purchases of dental services, the result could be a reduction in dental health.

Put another way, a potential benefit of relaxing restrictions on the use of dental auxiliaries is the extension of services to consumers who do not currently receive them (General Accounting Office, 1980, chap. 2). A 1977 survey conducted by the National Center for Health Statistics found that half of the U.S. population had not visited a dentist in a year, over one-third had not visited a dentist in two years or longer, and approximately 20 million Americans had never visited a dentist (GAO, 1980, pp. 14-15). High cost, in terms of both price and time, is a major reason why many Americans do not obtain routine dental care.[1] To the extent that relaxing auxiliary use restrictions would increase efficiency and accessibility, and lower the cost of dental care, more U.S. consumers would obtain such care.

A potential cost of relaxing restrictions on the use of dental auxiliaries is a reduction in the quality of dental service. Auxiliaries receive less extensive training than dentists do, and might be less skilled in the tasks that dentists would delegate to them.

In this report we evaluate the effects on price and service quality of a relaxation of restrictions on dentists' use of auxiliaries. Our study examines restrictions on the number of hygienists that a dentist may employ and

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[1] Two other reasons cited are fear of pain and lack of awareness of the consequences of untreated dental disease.

restrictions on the functions that an auxiliary may perform. Our study does not examine restrictions on independent practice by auxiliaries. In other words, we do not examine the requirements that auxiliaries practice under the supervision of dentists.

To evaluate the impact of auxiliary use restrictions on price, we estimate the effects of the restrictions in 1970 and 1982, the years for which state-level price data are available. Because similar restrictions were present in both 1982 and 1985 (the most recent year for which information on restrictions is readily available), our 1982 estimates provide a reasonable approximation of current price effects of the restrictions. To evaluate the effects of auxiliary use restrictions on quality, we survey an extensive literature that compares the quality of service provided by dentists to that provided by dental auxiliaries.

Our findings provide evidence that, in both 1970 and 1982, restrictions on the use of dental auxiliaries raised the prices of several dental procedures and the average price of a dental visit. According to our estimates, the individual dental-procedure price increases ranged from six to thirty percent in 1970, and from nine to ten percent in 1982. Our estimated increase in the average price of a dental visit is eleven percent for 1970, and seven percent for 1982.

These price increases imposed substantial losses on consumers and on the U.S. economy. Our estimated loss to consumers exceeds $1 billion for 1970 and is approximately $700 million for 1982.[2] We estimate that the loss to the U.S. economy was more than $500 million in 1970, and more than $300 million in 1982. Because the number of states that imposed auxiliary use restrictions in 1982 is comparable to the number in 1985, our 1982 estimates provide a reasonable approximation of current losses due to the restrictions.

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[2] Our loss estimates are expressed in 1986 dollars.

Our survey of the quality literature finds substantial agreement that, for the dental procedures studied, the quality of service provided by auxiliaries is equal to that provided by dentists. These results suggest that the substitution of auxiliary time for dentist time, which the relaxation of restrictions would permit, would not reduce the quality of dental service.

Based on the results of this and previous studies, we conclude that relaxation of restrictions on the number of hygienists that a dentist may employ would benefit consumers by providing the same quality of service at a lower price. As a result, consumers and the U.S. economy would obtain substantial savings, and increased purchases of dental care by American consumers could improve their dental health.[3] We therefore recommend that states that restrict the number of hygienists per dentist give serious consideration to relaxing those restrictions. Because our study does not examine restrictions on independent practice by dental auxiliaries, we reach no conclusions on the costs or benefits of such restrictions.

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[3] Even if the relaxation of auxiliary use restrictions provided lower quality service at a lower price, consumers might prefer that price-quality combination to the current higher-price-higher-quality combination in restricted states.

II. Dental Auxiliaries: Training and Tasks

Dental auxiliaries can be divided into three groups: hygienists, assistants, and expanded-function dental auxiliaries (EFDAs).[4] These groups differ in terms of educational requirements and the tasks that each is allowed to perform. With few exceptions, dental auxiliaries work under the supervision of a dentist.[5]

A dental hygienist must complete a two-year post-secondary-school program of instruction at a technical school, community college, or university. Then the hygienist must pass a state's licensure examination to practice in that state. The hygienist's traditional primary functions are related to the prevention of oral disease: for example, performing prophylaxes (cleanings), taking radiographs (x-rays), and giving fluoride treatments.

Most dental assistants receive their training on the job. Increasing numbers of them, however, have obtained one or two years of instruction at a vocational-technical school or community college. Although assistants are not licensed by a state, those with formal education may take an examination to be certified by the American Dental Assistants Association.

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[4] In 1977 there were approximately 110,000 dentists, 30,000 dental hygienists, 140,000 dental assistants, and 10,000 EFDAs in the U.S. (Most of the information in this section is taken from GAO, 1980, pp. 2-5.)

[5] In California, Colorado, and Washington, state dental hygienist associations are proposing that hygienists be allowed to practice independently of dentists. For example, in California, dental hygienists with five years of experience would be allowed to establish their own offices and to provide traditional hygiene services under contract with a dentist. In Washington, "dental hygienist practitioners" with a B.A. from an accredited school and two years of supervised experience would be permitted to practice independently.

The assistant's primary function is to help the dentist by, for example, preparing materials and passing instruments while the dentist treats a patient.

An EFDA is a hygienist or assistant with additional formal schooling or on-the-job training, which enables the EFDA to perform functions beyond the traditional ones of a hygienist or assistant. The education and examination requirements to become an EFDA vary by state, as do the functions that an EFDA is permitted to perform. In some states, completing restorations (fillings) is one of the EFDA's expanded functions. To complete a restoration, the EFDA places filling material (such as amalgam, composite resin, or silicate cement) in a cavity drilled by the dentist, and shapes the material to reconstruct the original outline of the tooth.

III. The Nature of the Restrictions

State restrictions on the use of dental auxiliaries take two general forms: restrictions on the number of hygienists that a dentist may employ, and restrictions on the functions that an auxiliary may perform. In some states, different functions-restrictions apply to hygienists and assistants. In addition, some state laws or regulations specify the kind of supervision that a dentist must exercise over auxiliaries' performance of different functions. The required supervision ranges from general to direct, depending upon the function. General supervision allows the dentist to authorize and instruct the auxiliary to perform certain procedures, but does not require that the dentist be present. Direct supervision requires that the dentist be present while the auxiliary performs the assigned tasks (Johnson and Holz, 1973). In either case, the supervising dentist has ultimate responsibility for the auxiliary's work.

Several states specify the maximum number of dental hygienists that a dentist may employ.[6] Further, the number of states that impose such restrictions has increased since 1970. In that year, twelve states (plus the District of Columbia) restricted the number of hygienists that a dentist was permitted to employ, with the majority of these states limiting the number of hygienists per dentist to two. In 1982, sixteen states restricted the number of hygienists, with nine states limiting the number to two. By 1985, seventeen states had such restrictions.

Until the early 1970s, many states restricted dental hygienists to the "traditional" functions of prophylaxis, applying fluoride, taking radiographs, and charting existing dental conditions (Johnson and Bernstein, 1972). As the education levels of auxiliaries increased, however, states

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[6] States that restrict the number of dental hygienists generally allow a dentist to employ between one and three hygienists. One of these states, California, limits the number of auxiliaries to two.

began to permit dental auxiliaries to take on additional responsibilities. In 1968, only nine states permitted dental auxiliaries to perform expanded functions; by 1973, 44 states allowed for expanded functions by auxiliaries.

States characterize and define expanded functions in various ways, making it difficult to distinguish clearly between restrictive and permissive states. Most state provisions, however, fall into two general categories: (1) an "open provision" which permits the dentist to delegate any function within the competence of the auxiliary; and (2) a list of specifically permitted or prohibited auxiliary functions.

Examples of the expanded functions that some states did not permit dentists to delegate to auxiliaries in 1970 are: performing preliminary oral examinations, taking radiographs, giving fluoride treatments, and completing amalgam restorations. The first three restrictions may have applied solely to dental assistants, because many states considered the restricted functions to be traditional hygienist functions. By 1982, these restrictions were virtually nonexistent for both hygienists and assistants, leaving only the restriction on completing amalgam restorations.[7]

The restriction on completing amalgam restorations was one of the most widespread restrictions on auxiliaries in both 1970 and 1982. In 1970, only five states permitted auxiliaries to complete restorations. By 1982, ten states permitted hygienists to perform this function. Also in 1982, eight states allowed dental assistants to complete amalgam restorations.[8]

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[7]Johnson and Holz (1973, p.2) note that state laws and regulations are in some instances ambiguous regarding whether particular restrictions apply to hygienists, assistants, or all auxiliaries.

[8] Based on data for earlier years, these eight states appear to be a subset of the ten that allowed hygienists to perform this function.

In the next section we will describe how state regulation of dentist licensure is relevant to our examination of auxiliary use restrictions. All states license dentists, but states differ in their treatment of dentists licensed in other states. Some states require out-of-state licensees to take an examination, while other states recognize out-of-state licenses without an examination. In 1970, 32 states required an examination of the licensees of other states. In 1982, there were 33 non-recognition states.[9]

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[9] Other state regulations may affect the organization or behavior of the dental service firm. For example, some states limit the number of offices that a dentist may have or the amount of advertising that a dentist may do. Although these regulations are beyond the scope of this study, we will examine, in Section VIII, the possible bias that their omission could cause.

IV. Some Simple Conceptual Models

The empirical work in our study is based on some simple conceptual models in which dentists are both the suppliers of some input services and the owners who receive the residual net income of the dental service firm (see Feldstein, 1973, and Saving et al., 1978). Other input services are supplied by the owners of capital and by dental auxiliaries.[10] The owner-dentists are assumed to take the prices of dental output and of these inputs as given, and to attempt to maximize net income.[11] To do this, absent restrictions on the use of inputs, dentists combine inputs so as to minimize the cost of producing any chosen level of output.

Auxiliary use restrictions can prevent dentists from achieving the most efficient combination of inputs. For example, if the optimal ratio of hygienists to dentists is three to one, then a regulation limiting the actual ratio to two to one will force dentists to deviate from the optimum. The result will be a higher cost of producing dental services and thus higher service prices.

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[10] To simplify the discussion, we ignore other input suppliers such as secretaries, receptionists, bookkeepers, and laboratory technicians. According to 1982 ADA data, 78 percent of solo dentists employed no bookkeepers, and 94 percent employed no technicians.

[11] The purpose of such simplifying assumptions is to enable us to derive empirically testable hypotheses regarding the effects of auxiliary use restrictions. Other assumptions could be made. For example, we could assume that dentists maximize a utility function in which both net income and non-monetary variables--such as location, leisure, and the quality of service--are arguments. This would imply that a dentist would be willing to sacrifice some income to practice in a desirable location, to have more leisure time, or to provide high quality service. See Conrad and Sheldon (1982) for a discussion of a dentist-utility-maximization model developed by Boulier (1979).

In addition to raising the cost of production and the price that consumers pay for dental services, auxiliary use restrictions can raise dentists' incomes. Salop, Scheffman, and Schwartz (1984) have shown that, under certain conditions, regulation of an industry will increase market price more than average cost. As a result, sellers' economic rents will increase.[12]

Higher dental service prices and dentists' incomes due to auxiliary use restrictions follow from three conceptual models of the dental service firm. In the remainder of this section, we discuss these models.[13]

In our first model, we assume that dental firms produce a single output, patient-visits. All firms are assumed to use the same technology, which combines the services of dentists, auxiliaries, and capital. Some of each of these input services is required to produce output. We further assume that if all firms in a particular location expand production, additional capital and auxiliary services can be hired at their prevailing prices. By contrast, we assume that additional dentist services are supplied only at a higher wage.

Both incumbent dentists and new-entrant dentists supply additional services only at a higher wage. An expansion of services by incumbent dentists increases the marginal value of sacrificed leisure because the incumbents must work longer hours. A higher wage is needed to induce these dentists to give up more leisure. Potential new entrants consist of

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[12] Economic rent is a payment to an input supplier in excess of the minimum income that would retain his input supply in its present use.

[13] Saving et al. (1978) develop a model in which consumer demand for dental services is influenced not only by price but also by the time required to obtain those services. In the discussion that follows, we reach similar conclusions without the time assumption.

dental school graduates[14] and dentists located outside the area of expanding dentist services. Those potential entrants with strong preferences for the expanding area enter at a relatively low wage compared to the wage needed to attract the potential entrants with strong preferences for other areas.

Regulation could contribute to the upward slope of the dentist-service supply function in some states.[15] Entry into dentist service markets appears to be impeded in states that do not recognize out-of-state dentists' licenses (see Holen, 1965; and Benham, Maurizi, and Reder, 1968). Because of the costs imposed by these states' examination requirements, a higher wage appears to be needed to induce entry by out-of-state dentists.[16]

Under these assumptions, an increase in consumer demand for patient-visits leads to a substitution of dental auxiliary and capital services for the input services supplied by dentists. As consumers' education and income rise, the demand for dental services increases, causing an increase in production. This raises the wage of dentists relative to the

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[14] According to Department of Health and Human Services' estimates based on ADA data, there were 5,337 dental school graduates in 1984 compared to 137,950 active dentists.

[15] See Feldstein (1977) and Fraundorf (1984) for histories of attempts by the ADA, its predecessor organizations, and state dental societies to restrict entry into dentistry.

[16] A policy of non-recognition in some states will affect dentists' incomes in other states. For example, if dentists' average income is relatively low in state A, the non-recognition policies of other states will impede the exit of dentists from A. As a result, dentists' average income in A could remain relatively low. To simplify the discussion, we disregard such effects.

prices of the other inputs. As a result, dentists as owners find it more efficient to produce with additional auxiliary and capital services relative to dentist services. Nevertheless, the cost of an additional patient-visit rises as production expands.

Assuming no offsetting cost reduction, the rising wage of dentists results in an upward-sloping market supply of patient-visits (S), as depicted in Figure 1. At low levels of production, the dentists' wage is relatively low, and a relatively low output price covers firms' costs including a normal return on capital. At higher levels of production, the increased dentists' wage raises costs, and a higher output price is needed to cover costs including a normal return.[17]

The market demand for patient-visits is shown in Figure 1 by curve D. Other things equal, we expect consumers to buy more patient-visits when the price falls. As a result, market demand has a negative slope (see Hu, 1981).

Given market supply S and market demand D, the equilibrium price of a patient-visit is P, and the number of patient-visits purchased is Q. Because of the upward-sloping supply of patient-visits, dentists earn rents equal to area PEA at this equilibrium.

To the extent that auxiliary use restrictions are effective, they prevent owner-dentists from minimizing costs by substituting auxiliary services for dentist services as production is expanded. As a result, the cost of patient-visits is higher at every level of output. Moreover,

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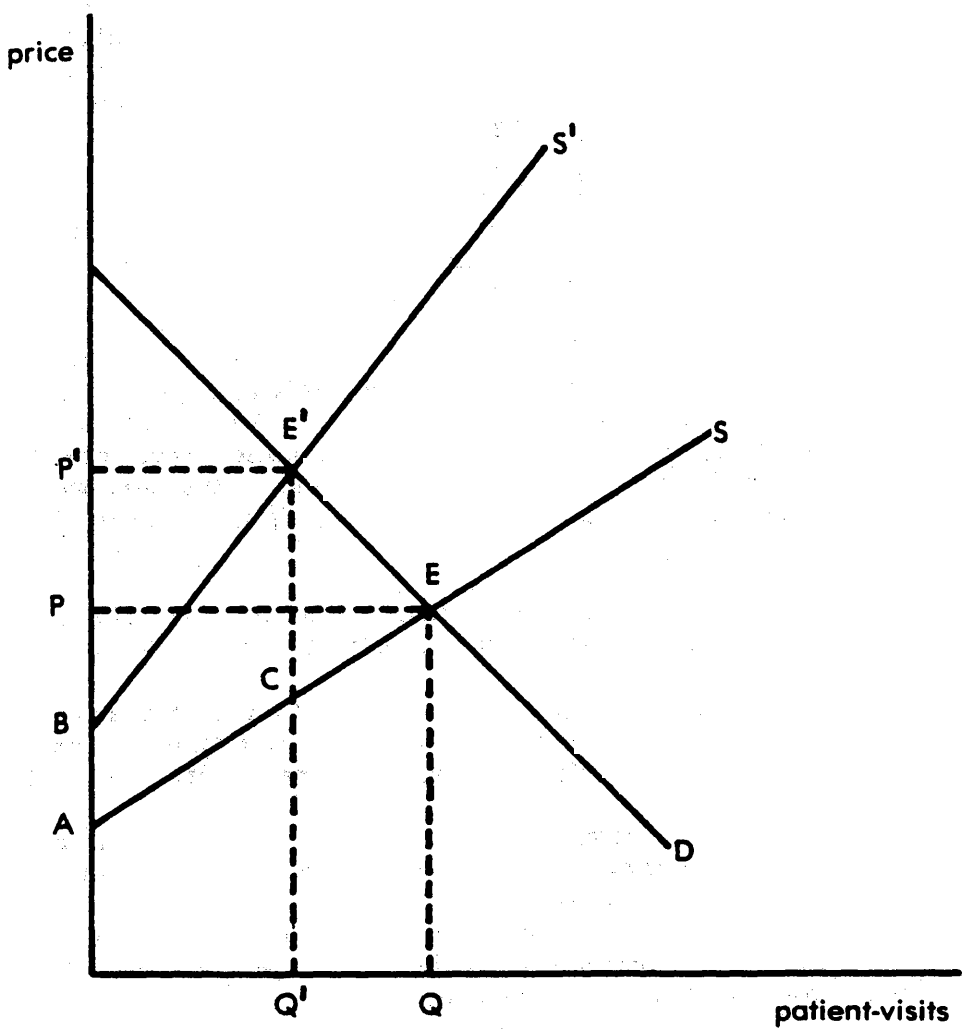
[17] Scheffman and Appelbaum (1982) suggest another reason why the market supply of patient-visits could be upward-sloping: variation in dentists' ability and productivity. For example, dentists differ in skill in performing dental procedures and in ability to manage the activities of dental auxiliaries. Given such differences, some dental firms will have higher costs than others, and the market supply of patient-visits will slope upward.

Figure 1

Supply and Demand for Patient-Visits



because regulation forces the actual auxiliary/dentist ratio to deviate farther from the cost-minimizing ratio as production expands, the cost of a patient-visit is increased more at high production levels than at low levels.[18]

The effects of auxiliary use restrictions are depicted in Figure 1 by a shift and rotation of market supply up and to the left. The market supply of patient-visits in a restricted state is shown by S', and market equilibrium is at E'. The price of a patient-visit rises to P', and the quantity of patient-visits purchased falls to Q'. The cost of the auxiliary use restriction to consumers is equal to area P'E'EP in lost consumer surplus.[19] Dentists now earn rents equal to area P'E'B which, under certain conditions (see Salop, Scheffman, and Schwartz, 1984), will be larger than area PEA, the rents earned by dentists in unrestricted markets.[20] The U.S. economy suffers a loss equal to area BE'EA. This loss is a sum of two areas: BE'CA, the additional resources needed to produce Q' patient-visits; and E'EC, the dentist rent and consumer surplus lost due to the reduction in patient-visits from Q to Q'.

In our second conceptual model, we retain all but two of the assumptions of our first model. We relax the assumption of a single output and the assumption that some of each input is needed to produce output. Instead, we assume that the dental service firm produces multiple

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[18] In Section IX, we will examine the possible effects of auxiliary use restrictions on the quality of dental services.

[19] Consumer surplus is the amount that a consumer would be willing to pay for a commodity in excess of the market price rather than doing without the commodity.

[20] Figure 1 depicts the rents earned by dentists as a group with and without auxiliary use restrictions. Because the restrictions will change the number of dentists, we cannot use Figure 1 to show the effect on rent per dentist. Nevertheless, under certain conditions, rent per dentist will increase due to auxiliary use restrictions.

outputs, such as oral examinations, prophylaxes (cleanings), radiographs (x-rays), and amalgam restorations (fillings). It is assumed that some of these outputs (for example, the taking of x-rays) can be provided by either dentists or auxiliaries without the other group's input.[21]

Under the input-supply assumptions of our first model, the supply of x-rays by dentists differs from the supply of x-rays by auxiliaries. Assuming that the supply of dentist services is upward sloping, the supply of x-rays by dentists is also upward sloping. By contrast, assuming that the supply of auxiliaries is horizontal (more auxiliaries can be employed at the prevailing wage), the supply of x-rays by auxiliaries is also horizontal.

The market for x-rays under these assumptions is depicted in Figure 2. The horizontal supply of x-rays by auxiliaries is S_a; the upward-sloping supply of x-rays by dentists is S_d. The market demand for x-rays is D. Absent auxiliary use restrictions, auxiliaries supply all x-rays in the market. Equilibrium is at E with quantity Q sold at price P. Because S_a is horizontal, no economic rents are earned. By contrast, if regulation prevents auxiliaries from supplying x-rays, then dentists provide a smaller quantity of x-rays, Q', at a higher price, P'. At the new equilibrium, E', on the dentists' supply of x-rays, S_d, dentists earn rents equal to area P'E'A. Consumer surplus falls by an amount equal to area P'E'EP. The U.S. economy suffers a loss equal to area AE'EP. This loss is a sum of two areas: AE'BP, the additional resources needed to produce Q' x-rays; and E'EB, the lost consumer surplus due to the reduction in the number of x-rays from Q to Q'.

Our third model restores our first model's assumption of a single output, patient-visits, but relaxes the assumption that all dental service firms use the same technology.

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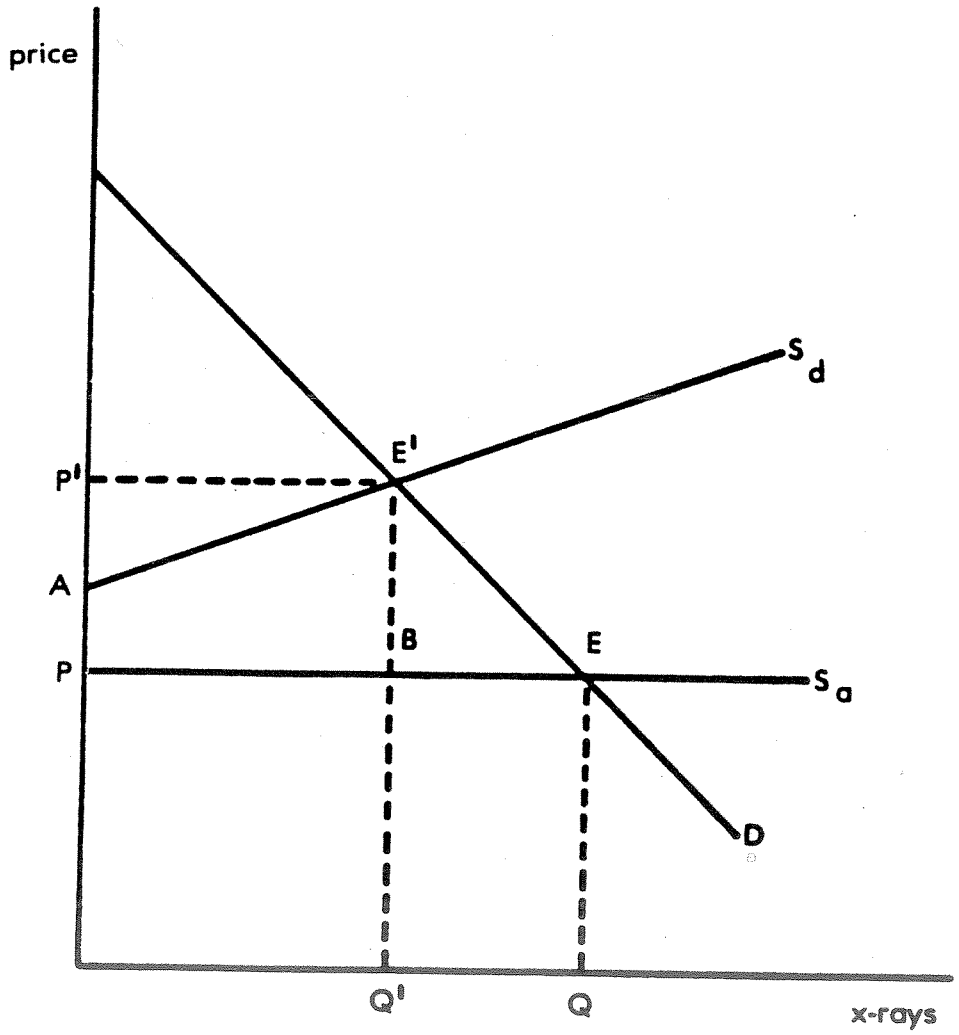
[21] Outputs that must be produced with a combination of dentist and auxiliary inputs can be analyzed using our first model.

Figure 2

Supply and Demand for X-Rays



Instead we assume that some firms (type a) use a high level of auxiliary inputs relative to dentist inputs, while other firms (type b) use few or no auxiliary inputs. This difference in input ratio can be assumed to result from differences in the ability of owner-dentists to manage the activities of auxiliaries (see Scheffman and Appelbaum, 1982).[22]

Although the supply function of each group of firms is upward sloping, the type-b supply function is steeper. Because type-b firms use dentist inputs more intensively, costs rise more rapidly when production expansion drives up the dentists' wage. As a result, a higher price of patient-visits is needed at every output to cover costs including a normal return.

Figure 3 depicts a market in which type-a and type-b firms compete. Panel 3.1 shows the supply of patient-visits

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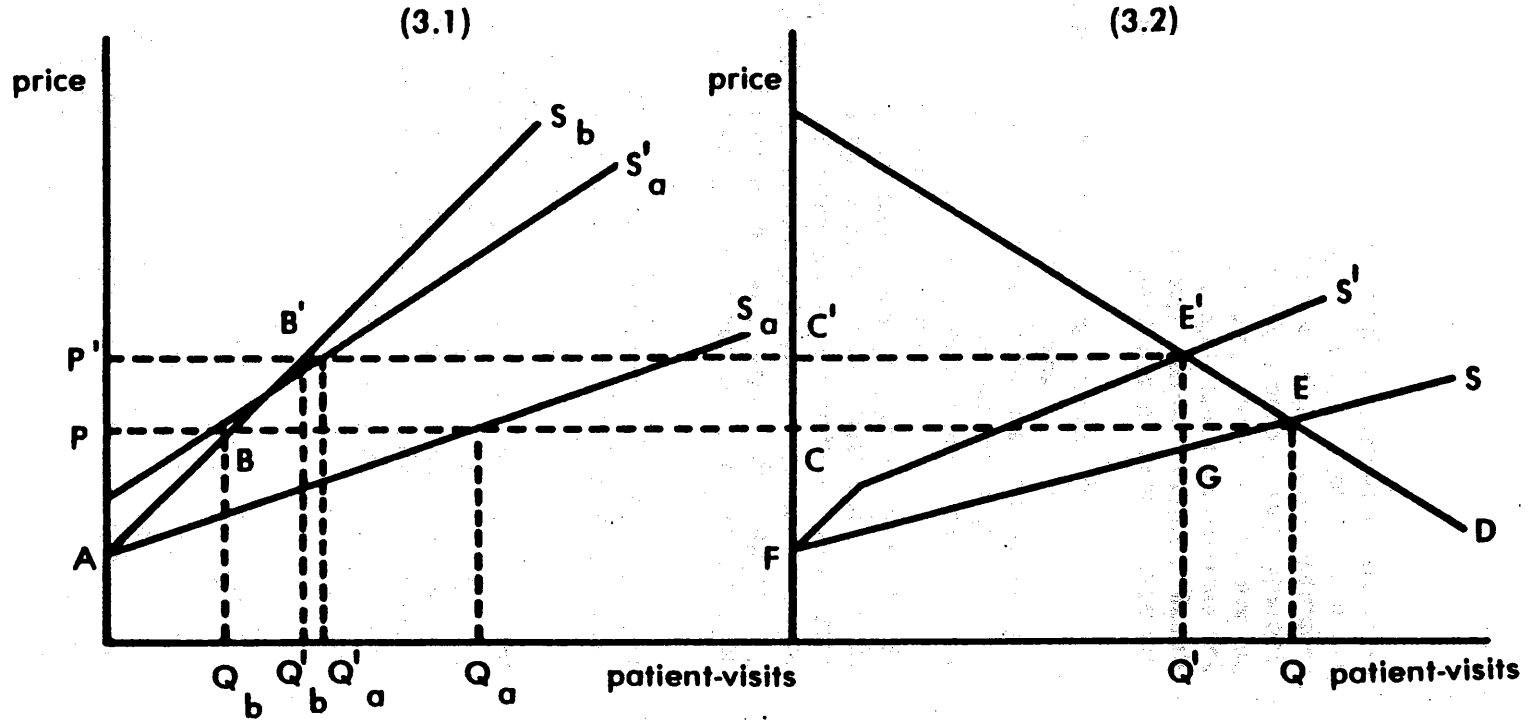
[22] Dental firms can be classified as solo practices or group practices. According to 1982 ADA data, almost 75 percent of privately practicing dentists worked as solo practitioners. Group practices with two dentists accounted for 16 percent of privately practicing dentists, and practices with three or more dentists accounted for the remaining nine percent of privately practicing dentists.

Solo practices tend to resemble our type-b firms. For 1981, ADA data indicate that 54 percent of solo dentists employed no dental hygienists, and 35 percent employed one hygienist. In that same year, 55 percent of solo dentists employed one dental assistant, and 23 percent employed two assistants.

Although we lack data on auxiliary use by group practices, ADA data for independent dentists (which include group practitioners) suggest that groups employ more auxiliaries per dentist than do solo dentists. In addition, greater use of auxiliaries by groups is asserted by Conrad and Sheldon (1982) and is implicit in Kushman et al.'s (1978) argument that group practice permits more efficient use of auxiliaries. In sum, group practices are more likely to resemble our type-a firms than are solo practices.

Figure 3

Supply and Demand for Patient-Visits by Type-a and Type-b Firms



by type-a firms, S_a, and the supply by type-b firms, S_b. Panel 3.2 shows the market supply S, which is the sum of S_a and S_b, and the market demand D. Equilibrium is at E, with price equal to P and quantity sold equal to Q. Type-b firms sell quantity Q_b and earn rents equal to area PBA. The remainder of Q, Q_a, is sold by type-a firms.

Next, assume that auxiliary use restrictions are imposed and that they affect only type-a firms.[23] The increased costs of type-a firms are represented by a shift and rotation of the type-a supply curve to S'_a. This causes the market supply to move to S'. At the new equilibrium, E', there is a higher price, P', and a lower quantity sold, Q'. The quantity sold by type-a firms falls to Q'_a. By contrast, the quantity sold by type-b firms rises to Q'_b, and the rents earned by type-b firms rise to P'B'A. As indicated in the discussion of our first model, the rents earned by type-a firms rise under certain conditions. Consumer surplus is reduced by C'E'EC. The U.S. economy suffers a loss equal to area FE'E. This loss is a sum to two areas: FE'G, the additional resources needed to produce Q' patient-visits; and E'EG, the dentist rent and consumer surplus lost due to the reduction in the number of patient-visits from Q to Q'.

In this section, we have presented three simple conceptual models which predict that auxiliary use restrictions will increase dental service prices and can increase the rents earned by at least some dental service firms. After reviewing the literature on auxiliary use restrictions in the next section, we will develop a simple econometric model to estimate the price and income effects of these restrictions. Using our econometric results, we will estimate the losses that the restrictions impose on consumers and on the U.S. economy.

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[23] Our results would follow from the weaker assumption that auxiliary use restrictions have a larger effect on type-a firms than on type-b firms. However, the exposition would be more complicated. Because type-a firms are more auxiliary-intensive, restrictions do have a larger effect on them than on type-b firms.

V. Previous Empirical Studies

Previous studies have estimated the effects of auxiliary use restrictions.[24] DeVany et al. (1982) estimated the marginal product of dentists relative to the marginal products of hygienists and assistants respectively. The authors found that restrictions on the number of hygienists employed per dentist lower the marginal product of dentists relative to that of hygienists. Restrictions on the functions that auxiliaries are permitted to perform reduce the marginal product of dentists relative to that of dental assistants. These results are consistent with the hypothesis that auxiliary use restrictions cause dental firms to deviate from optimal input proportions, using more dentist inputs relative to auxiliary inputs. The authors concluded that, as a result, auxiliary use restrictions raise dental service costs, and may increase the fees charged for those services.

The DeVany et al. paper summarizes a more extensive analysis by Saving et al. (1978), which found that dental services are produced in restrictive states using more dentist time, less auxiliary time, and less capital than in permissive states. The authors defined as permissive those states that allow the completing of amalgam restorations to be delegated to an auxiliary. Saving et al. argued that this expanded function proxies a large set of functions that are legally delegable. Using 1977 data, the authors showed that in permissive states, 70-96 percent of dental assistant functions and 89-100 percent of dental hygienist functions were legally delegable. By contrast, with some exceptions, the restrictive states did not allow more than 17 percent of the functions to

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[24] Other studies found that hiring more auxiliaries and delegating expanded functions to them increases the potential productivity of dental firms (for example, see McBride, 1975, and Lipscomb and Scheffler, 1975). For a discussion of these studies see Saving et al. (1978).

be delegated to dental assistants, or more than 42 percent to be delegated to dental hygienists.[25]

Saving et al. hypothesized that if expanded-function dental auxiliaries were being utilized in permissive states, then output per dentist and dental firm size would be larger, and fees for amalgam restorations would be lower. The study's empirical results, however, do not support these hypotheses. The authors suggested three possible explanations for these negative results: 1) it was not profitable to utilize EFDAs in permissive states, 2) auxiliary function restrictions were not enforced in restrictive states, or 3) the introduction of EFDAs was profitable in permissive states, but a long lag was required.

Conrad and Sheldon (1982) examined auxiliary use restrictions, employing a model similar to one developed by Shepard (1978)[26]. The authors' reduced-form price equation contains regulatory restrictions on: recognition of dentists licensed in other states, advertising, auxiliary functions, the number of offices per dentist, and the number of hygienists per dentist. Both an average price of a dental visit and individual dental service prices were used. For a sample of states, the authors found that restrictions on the recognition of out-of-state dentists had a significant positive effect on the average price and on the price of single extractions.

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[25] Arizona, Delaware, and Montana are the exceptions. Although classified as restrictive states because they do not permit dentists to delegate the finishing of amalgam restorations, they do permit delegation of up to 52 percent of expanded functions to dental assistants and up to 68 percent of such functions to dental hygienists.

[26] Shepard assessed the impact of licensing practices on the price of a dental visit and on the net income of dentists in 1970. The author found that, other things equal, price was 15 percent higher in states that impeded entry by out-of-state dentists. Dentists' net income was 12 percent higher in restrictive states.

the average price and on the price of single extractions. Restrictions on the number of hygienists per dentist had a significant positive effect on the price of prophylaxes. For a sample of SMSAs, restrictions on the number of hygienists and on the number of offices had significant positive effects on the average price and on the prices of prophylaxes, single extractions, and one-surface restorations. As future research, Conrad and Sheldon suggested the use of variables that represent restrictions on individual functions, instead of the summary measure that the authors used.

In sum, previous studies have presented some evidence that auxiliary use restrictions 1) distort the combination of inputs in the production of dental services, 2) raise costs, and 3) lead to higher service prices. The studies contain other evidence, however, that such restrictions have no significant effect on dental service production. These mixed findings suggest the need for more examination of the restrictions.

In the sections that follow, we will extend past work to develop a simple econometric model of auxiliary use restrictions. We will then use both 1970 and 1982 data to estimate the price and income effects of the restrictions, and the resulting losses to consumers and to the U.S. economy.

VI. A Simple Econometric Model

Building on the studies discussed in the preceding section, we estimate reduced-form price and net-income-of-dentist equations at the state level. For the price variable in our model, we use either the average price of a dental visit or the price of an individual dental service. Some individual prices are the fees for oral examinations, radiographs, prophylaxes, fluoride treatments, extractions, and amalgam restorations.

We define four expanded-functions variables which take on a value of one where a state prevents dental auxiliaries, either hygienists or assistants, from performing the following functions: preliminary oral examinations, radiographs, fluoride treatments, and amalgam restorations. These functions were chosen because each can be associated with a particular dental-service fee. In 1970 there were some restrictive states and some permissive states for each of these expanded functions. Hence, all four restrictions are included in the 1970 equations. By 1982 the first three restrictions were virtually nonexistent for both hygienists and assistants. Thus, only the restriction on completing amalgam restorations was included in the 1982 equations.

We use our model to test the hypotheses that restrictions on the number of hygienists and on the functions of auxiliaries raise dental service prices and dentists' net income. In addition to some control variables that influence the supply and demand for dental services, we include a variable to take into account the effect of dentist licensure restrictions. Assuming a linear form, the two equations of our model can be written as follows:

$$\begin{aligned} PRICE = {} & a_0 + a_1\,LIMNUM + a_2\,LIMFUN + a_3\,RECOG \\ & + a_4\,SCHOOL + a_5\,FLUORID + a_6\,INCP + a_7\,AGE \\ & + a_8\,URBAN + u \end{aligned}$$

$$\begin{aligned} INCD = {} & b_0 + b_1\,LIMNUM + b_2\,LIMFUN + b_3\,RECOG \\ & + b_4\,SCHOOL + b_5\,FLUORID + b_6\,INCP + b_7\,AGE \\ & + b_8\,URBAN + e \end{aligned}$$

All variables are defined at the state level. The price and income variables are deflated.[27]

The dependent variables are defined as follows:

PRICE = a dental service price in dollars

INCD = average net income of dentists in thousands of dollars per year

The explanatory variables are defined as follows:

LIMNUM = 1 in states that restrict the number of hygienists per dentist[28]
= 0 otherwise

LIMFUN = a vector of restrictions, as defined in dental practice acts or regulations, on the delegation of functions to auxilaries, with the following elements:

LIMEXAM = 1 in states that do not permit auxiliaries to perform oral exams
= 0 otherwise

LIMRAD = 1 in states that do not permit auxiliaries to take radiographs
= 0 otherwise

LIMFLUOR = 1 in states that do not permit auxiliaries to give fluoride treatments
= 0 otherwise

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[27] See Section VII for a discussion of the deflators that we used and for the sources of the data. The interested reader is referred to those sources for detailed definitions.

[28] One of these states, California, limits the number of auxiliaries per dentist to two.

LIMAMAL = 1 in states that do not permit auxiliaries to complete amalgam restorations
= 0 otherwise

RECOG = 1 in states that recognize dentists' licenses of another state
= 0 otherwise

SCHOOL = ratio of number of dental schools to population in thousands

FLUORID = fraction of population drinking fluoridated water

INCP = average per capita income in thousands of dollars per year

AGE = ratio of young population to total population[29]

URBAN = ratio of population living in urbanized areas to total population[30]

Predicted signs of regression coefficients and brief explanations for these predictions are as follows:

LIMNUM and LIMFUN: We expect that these restrictions will raise the cost of production of dental services and

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[29] Due to a difference in the way readily available data are tabulated, we use either population under 21 or population under 24 for the numerator of this ratio. See Section VII for more details.

[30] For a detailed definition of urban population, see U.S. Bureau of the Census, Census of Population, 1980, Appendix A.

therefore the price. These restrictions may also increase the average income of dentists.[31]

RECOG: We expect that recognition of out-of-state licenses will facilitate entry into dental services markets. This will expand the supply of dental services, tending to reduce price and dentists' average income.

SCHOOL: We expect that a higher ratio of instate dental schools to state population will facilitate entry into dental service markets, tending to lower prices and dentists' incomes.

FLUORID: Previous studies (see, for example, Hu, 1981) have found that fluoridation reduces the demand for dental services. This will tend to reduce dental service prices and dentists' incomes.

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[31] With regard to the price effects of auxiliary use restrictions, we adopt what appears to be the most general hypothesis, namely that such a restriction will increase the prices of all dental services, but that the effect will be strongest on the price of the service that is directly limited. For example, we hypothesize that a restriction preventing auxiliaries from completing amalgam restorations will also affect the prices of oral examinations, radiographs, prophylaxes, fluoride treatments, and extractions, but that the restriction will have the strongest effect on the price of amalgam restorations.

Saving et al. (1978) adopted a similar hypothesis. The authors argued that if using an auxiliary in place of a dentist is economically efficient, then legislation allowing the auxiliary to perform a function will lower the price of that function. The dentist can then reallocate his time to other dental services, but because his labor will be spread across many other services, the effect on the prices of these services will be smaller.

INCP: We expect that consumers with higher incomes will demand more dental services. Given an upward sloping supply of dental services, an increase in demand will raise price and tend to increase dentists' incomes.

AGE: Previous studies (see, for example, Hu, 1981) have found that the demand for dental services for children is greater than the demand for dental services for adults. Where children are a relatively large fraction of the population, we expect dental service prices and dentists' income to be higher.

URBAN: We expect input prices (for example, land) to be higher in urbanized areas. This will tend to increase the cost of production and the price of dental services, and will reduce dentists' incomes, other things equal.

VII. The Data

Because no consistent, multiyear data set is readily available, we develop state-level price data from two different sources, one for 1970 and another for 1982. American Dental Association price data for the 1970 estimations are available from the ADA's 1970 Dental Fee Survey and from Shepard (1978). The 1970 Dental Fee Survey reports fees for individual dental services. Shepard constructed an average price of a dental visit by weighting twelve of the ADA fees by the frequency with which each service is performed; the weights are provided by Poetsch and Moen (1969).[32] We examine some of the services that Shepard included in his study, but we put greater emphasis on relatively auxiliary-intensive services.[33]

Although no ADA price data are available at the state level for later years, 1982 data on expenditures and number of charges by dental service are available at the zip code level from Health Insurance Association of America, Prevailing Dental Healthcare Charges. For each dental service, we aggregated these data to the state level and divided total expenditures by the total number of charges to

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[32] The services included in Shepard's average are periodic oral exam, complete series of x-rays, dental prophylaxis, simple tooth removal, root canal extirpation and filling, amalgam filling (one surface), amalgam filling (two surfaces), gold inlay (two surfaces), cast gold crown, bridge (two units), acrylic-base denture, and denture repair.

[33] The ten services that we examine for 1970 are periodic oral examination (excluding radiograph), complete series of bitewing radiographs, dental prophylaxis, topical application of stannous fluoride (one treatment excluding prophylaxis), simple removal of tooth (with local anesthesia and including routine postoperative care), extirpation of pulp and filling of one root canal (excluding restoration), amalgam filling for one-surface cavity, amalgam filling for two-surface cavity, gold inlay for two-surface cavity, and cast gold crown (all cast).

obtain the average price of the service. We then constructed an average price of a dental visit by weighting thirteen of these individual dental-service prices by the services' respective shares of the total number of charges for all thirteen services.[34] The services included in our 1982 average differ from our 1970 services and from the services included in Shepard's 1970 average.[35] The differences are due to variation in the availability and aggregation of the reported prices.[36]

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[34] Our 1982 average price is deflated by 1980 Bureau of Labor Statistics budget data for an intermediate income, four-person family. A similar deflator was used by Conrad and Sheldon (1982). By contrast, Shepard's 1970 average price is deflated by the 1970 BLS Consumer Price Index. Conrad and Sheldon concluded that this and other differences between their data and Shepard's did not lead to a large difference in the estimated effect of reciprocal licensing of out-of-state dentists.

[35] The services that we include in our 1982 average are periodic oral examination, bitewings (two films), prophylaxis (adults), prophylaxis (children), topical application of stannous fluoride (one including prophylaxis), amalgam (one surface, deciduous), amalgam (two surfaces, deciduous), amalgam (one surface, permanent), amalgam (two surfaces, permanent), inlay (gold, two surfaces), gold full cast crown, root canal therapy (one excluding restoration, traditional), and extraction (single tooth).

[36] Two of Shepard's twelve procedures--bridge and denture--were not included in our 1982 average because HIAA data on expenditures and number of charges were not available for all states, and because these procedures appear to use small quantities of auxiliary inputs. In addition, because the HIAA data disaggregate prophylaxes into adult's and children's services, and amalgam fillings into those for deciduous and permanent teeth, we included the disaggregated service prices in our 1982 average price.

The values of the restrictions variables are presented in Tables 1 and 2. The auxiliary-use restrictions variables are defined taking into account both laws and regulations. Restrictions on the number of hygienists are reported by DeVany et al. (1982). The restrictions on auxiliary functions are reported in the ADA Survey of Practice Act Provisions for Expanded Functions, 1972. For 1982, limits on the number of hygienists and restrictions on hygienist functions are reported in the American Dental Hygienists' Association's Legislative Action Package, Comparative Overview of 51 Practice Acts. Restrictions on the recognition of out-of-state dentists' licenses are presented in Johnson and Bernstein (1972) and in "Licensure by Credentials," (1985).

State-level data for the remaining variables were obtained from several sources. Net income of dentists by state for 1970 is reported in the ADA's 1971 Survey of Dental Practice. The number of dental schools is available from the ADA's Annual Report on Dental Education, various issues. Urbanization, income per capita, population, and age variables are available from the Statistical Abstract.[37] The percentage of the population drinking fluoridated water is reported in the Fluoridation Census, 1970 and 1980.

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[37] Due to a change in the way readily available data are tabulated, a difference exists between the 1970 and 1982 definitions of the AGE variable. In 1970, AGE is the fraction of the population under 21; in 1982, it is the fraction under 24.

TABLE 1
State Restrictions, 1970

States	RECOG	LIMNUM	LIMEXAM	LIMRAD	LIMFLUOR	LIMAMAL
Alabama	0	0	1	1	1	1
Alaska	1	0	1	1	1	1
Arizona	0	0	1	1	1	1
Arkansas	0	0	1	0	1	1
California	0	1	1	1	1	1
Colorado	0	0	1	1	1	1
Connecticut	0	0	0	0	0	1
Delaware	0	0	1	0	1	1
D.C.	0	1	1	1	1	1
Florida	0	1	1	0	1	1
Georgia	0	0	0	0	1	1
Hawaii	0	0	1	1	1	1
Idaho	0	0	0	0	0	1
Illinois	1	1	1	1	1	1
Indiana	1	0	1	1	1	1
Iowa	1	0	0	0	0	1
Kansas	1	0	1	1	1	1
Kentucky	1	1	0	0	0	0
Louisiana	0	0	0	0	0	1
Maine	0	0	0	0	0	0
Maryland	0	0	1	0	0	1
Massachusetts	1	0	1	1	1	1
Michigan	0	0	1	0	1	1
Minnesota	0	0	0	0	0	1
Mississippi	1	0	1	0	0	1
Missouri	1	0	1	0	0	1
Montana	0	0	1	1	1	1
Nebraska	1	0	0	0	1	1
Nevada	0	0	1	1	1	1
N. Hampshire	1	0	1	0	0	1
N. Jersey	0	0	1	1	1	1
N. Mexico	0	1	1	1	1	1

N. York	1	0	0	0	1	1
N. Carolina	0	1	0	0	0	1
N. Dakota	1	0	1	0	1	1
Ohio	1	1	1	0	1	1
Oklahoma	1	1	1	0	0	1
Oregon	0	1	0	0	0	0
Pennsylvania	1	0	1	0	0	0
Rhode Island	1	0	1	1	1	1
S. Carolina	0	0	0	0	0	1
S. Dakota	1	0	1	0	0	1
Tennessee	0	0	0	0	0	1
Texas	0	1	0	0	0	1
Utah	0	0	1	1	1	1
Vermont	0	0	1	1	1	1
Virginia	0	1	1	1	1	1
Washington	0	1	0	0	0	0
W. Virginia	1	0	1	1	1	1
Wisconsin	0	0	1	1	1	1
Wyoming	0	0	1	0	0	1
Total	19	13	35	21	29	46

RECOG = 1 in states that recognise other states' dentists' licenses.

LIMNUM = 1 in states that restrict the number of hygienists per dentist.

LIMEXAM = 1 in states that do not permit auxiliaries to perform preliminary oral examinations.

LIMRAD = 1 in states that do not permit auxiliaries to take and expose radiographs.

LIMFLUOR = 1 in states that do not permit auxiliaries to apply fluoride.

LIMAMAL = 1 in states that do not permit auxiliaries to complete amalgam restorations.

TABLE 2.

State Restrictions, 1982*

States	RECOG	LIMNUM	LIMAMAL
Alabama	0	0	1
Alaska	0	0	0
Arizona	0	1	1
Arkansas	1	0	1
California	0	1	1
Colorado	0	1	0
Connecticut	0	0	1
Delaware	0	0	1
D.C.	0	0	1
Florida	0	1	1
Georgia	0	0	1
Hawaii	0	0	1
Idaho	0	0	1
Illinois	0	1	1
Indiana	1	0	0
Iowa	1	0	1
Kansas	1	0	1
Kentucky	0	1	0
Louisiana	0	0	1
Maine	1	0	1
Maryland	1	0	1
Massachusetts	1	0	1
Michigan	1	0	1
Minnesota	1	0	1
Mississippi	0	0	0
Missouri	1	0	1
Montana	0	1	1
Nebraska	1	0	1
Nevada	0	0	1
N. Hampshire	1	0	1
N. Jersey	0	0	1
N. Mexico	0	1	1
N. York	1	0	1
N. Carolina	0	1	1
N. Dakota	0	0	1
Ohio	0	1	0

Oklahoma	1	1	1
Oregon	0	1	1
Pennsylvania	1	0	0
Rhode Island	1	0	1
S. Carolina	0	0	1
S. Dakota	0	0	1
Tennessee	1	0	1
Texas	0	1	1
Utah	0	1	1
Vermont	1	0	0
Virginia	0	1	1
Washington	0	1	0
W. Virginia	0	0	1
Wisconsin	0	0	1
Wyoming	0	0	0
Total	18	16	41

RECOG = 1 in states that recognize other states' dentists' licenses.

LIMNUM = 1 in states that restrict the number of hygienists per dentist.

LIMAMAL = 1 in states that do not permit auxiliaries to complete amalgam restorations.

*Restrictions on performing oral exams, taking radiographs, and applying fluoride were virtually nonexistent by 1982.

VIII. Estimation Results

Our price equations were estimated by the ordinary-least-squares technique (OLS) for 1970 and 1982. Because data are not available for later years, the dentist income equation was estimated by OLS only for 1970. The results are summarized in Tables 3 and 4 and discussed in the accompanying text (see also the more detailed tables in the Appendix). [38]

A. 1970 Estimation Results

1. Price of a dental visit

The average 1970 price of a dental visit is higher in states that restrict the number of hygienists per dentist, or that do not permit auxiliaries to complete amalgam restorations. In states that restrict the number of hygienists per dentist, the average price is five percent higher than the mean 1970 average price. In states that do not permit auxiliaries to complete amalgam restorations, the average price is six percent higher than the mean.[39]

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[38] In general, in both the text and tables, we report results that are statistically significant at a conventional level, the five percent level.

[39] States that recognize dental licenses from other states have average prices that are four percent lower than the mean price. This result is consistent with our prediction that non-recognition impedes entry, and with the findings of previous studies (see Shepard, 1978, and Conrad and Sheldon, 1982).

The signs of several other significant coefficients are consistent with predictions. The positive coefficient of the urbanization variable is consistent with the hypothesis that urban areas have higher factor prices. The positive per capita income coefficient supports the proposition that high income increases the demand for dental services. The negative fluoridation coefficient is consistent with the

(continued...)

TABLE 3.

Summary of Percentage Effects of Auxiliary Use Restriction, 1970

Dependent Variable	Restriction				
	LIMNUM	LIMEXAM	LIMRAD	LIMFLUOR	LIMAMAL
Price of...					
Patient Visit	5	n.s.*	n.s.	n.s.	6
Oral Exam	11	n.s.	n.s.	n.s.	19
Radiograph	n.s.	n.s.	n.s.	n.s.	8
Prophylaxis	11	n.s.	n.s.	n.s.	n.s.
Fluoride Treatment	7	n.s.	n.s.	n.s.	n.s.
Extraction	5	n.s.	n.s.	n.s.	7
Root Canal	7	n.s.	n.s.	n.s.	11
Amalgam Restoration (1 surface)	9	n.s.	n.s.	n.s.	n.s.
Amalgam Restoration (2 surfaces)	6	n.s.	n.s.	n.s.	n.s.
Gold Inlay	n.s.	n.s.	n.s.	n.s.	n.s.
Gold Crown	n.s.	n.s.	n.s.	n.s.	n.s.
Dentists' Income	6	n.s.	n.s.	n.s.	10

* n.s. = not significant at five percent level.

Allowing auxiliaries to perform radiographs, fluoride treatments, or preliminary oral exams has no significant effect on the average price. As we explained in Section III, these restrictions may have appled solely to dental assistants; hygienists have traditionally been able to perform these functions. To the extent that hygienists can substitute for assistants, these restrictions will have smaller impacts on costs and prices. Our results are consistent with the proposition that hygienists are a good substitute for assistants in the performance of these functions.

Auxiliary use restrictions could be correlated with other restrictions on dental practice, such as restrictions on advertising by dentists and on the number of offices that a dentist may operate. If such correlation existed, then our auxiliary-use-restrictions results would be biased. To test this possibility, we estimated a model that includes restrictions on advertising and on the number of offices per dentist. The coefficients of these added restrictions are insignificant. In addition, the coefficients of the auxiliary use restrictions are essentially unchanged. Based on these findings, we conclude that our auxiliary-use-restrictions results are not biased by the omission of other dental-practice restrictions.[40]

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[39](...continued)
hypothesis that fluoridation decreases the demand for dental services. Our fluoridation result is also consistent with the findings of several earlier studies (see for example, Shepard, 1978, and Hu, 1981). Finally the significant coefficients of the two demand variables (per capita income and fluoridation) provide support for our hypothesis that the supply of dental services is upward sloping.

The SCHOOL and AGE variables' coefficients are not significant. A similar result was obtained using the ratio of new dental graduates to population in place of the ratio of dental schools to population.

[40]The estimation of this expanded model should not be viewed as a definitive test of hypotheses regarding the (continued...)

2. Individual service prices

Individual price equations were also estimated to isolate the dental services whose prices were affected by auxiliary restrictions in 1970. Several coefficients have the expected signs.

Limiting the number of hygienists per dentist raises the prices of seven of the ten procedures studied. These seven are: oral exam, prophylaxis, fluoride treatment, extraction, root canal therapy, and one- and two-surface amalgam restorations. The price increases for these seven procedures range from five to eleven percent.

The prices of four of the ten procedures are significantly higher in states that do not allow auxiliaries to complete amalgam restorations. These four procedures are: oral exam, radiograph, extraction, and root canal therapy. The price increases for these four procedures range from seven to nineteen percent. These results are inconsistent with the hypothesis that the restriction on completing amalgam restorations will raise the price of a restoration more than the prices of other dental services.

Consistent with our average price results, the remaining auxiliary-use restrictions do not have significant positive coefficients. As suggested above, these restrictions may limit the use only of dental assistants. Hence, our individual service results tend to provide added support for

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[40](...continued)
impact of restrictions on either advertising by dentists or the number of offices per dentist. The data for these restrictions were selected primarily because of their ready availability in Conrad and Sheldon (1982). The data do suggest that there was little interstate variation in advertising restrictions in 1970 (Conrad and Sheldon, 1982, pp. 53-54). A definitive test of hypotheses regarding advertising and number-of-office restrictions would require more careful selection of data, and is beyond the scope of this study.

the proposition that hygienists are good substitutes for assistants.[41]

In sum, our 1970 price-equation results provide evidence that auxiliary restrictions increase the prices of some dental procedures and the average price of a dental visit. These findings are consistent with the hypothesis that the restrictions force dentists to adopt input combinations that increase the costs of dental service firms.

3. Net Income of Dentists

Having estimated the effect of auxiliary use restrictions on price, we now test the hypothesis that they increase the net income of dentists, a possibility suggested by Salop, Scheffman, and Schwartz (1984). For 1970, we find that dentists' net income is higher in states that restrict the number of hygienists per dentist or that do not allow auxiliaries to complete amalgam restorations. Where hygienists' numbers are limited, the net income of dentists is six percent higher than the mean net income of dentists. Where auxiliaries are not permitted to complete amalgam restorations, dentists' income is ten percent higher than the mean.

It is of interest to note that the income-raising amalgam-restoration restriction has persisted over time. In 40 of the 45 states for which we have complete data, auxiliaries were not permitted to finish amalgam restorations in 1970, and 38 of 47 such states did not allow dentists to delegate this function in 1982. By contrast, the other

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[41] Recognition of out-of-state dentists' licenses lowers the price of two of the ten procedures. These decreases range from five to six percent. With the exception of the SCHOOL variable (whose coefficient is never significant), the coefficients of the other explanatory variables are significant in some of the price equations.

auxiliary-use restrictions were virtually non-existent in 1982.[42]

B. 1982 Estimation Results

It is important to recall that the restrictions on oral exams, radiographs, and fluoride treatments were virtually nonexistent for both hygienists and assistants in 1982. As a result, only the restriction on completing amalgam restorations is included in the 1982 equations. As we explained in Section V, this restriction is correlated with a large number of restrictions on the functions that could be delegated to auxiliaries, which were omitted from our 1970 equations. Between 1970 and 1982, it appears that the states relaxed many of these omitted restrictions. As a result, the amalgam restoration restriction probably represents significantly fewer such restrictions in the 1982 equations.

1. Price of a dental visit

Consistent with our findings for 1970, the restriction on the number of hygienists per dentist has a significant positive effect on the 1982 average price of a dental visit.

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[42] For example, comparing the 1970 sample of states for which we have complete data to the 1982 sample, the number of states that restricted the taking of x-rays declined from 18 to zero. In 1982, only the District of Columbia imposed this restriction, and only on dental assistants.

The net income of dentists is influenced significantly by two other variables: recognition of out-of-state licensees and per capita income. Dentists in recognition states have net incomes that are seven percent below the mean. This result is consistent with the hypothesis that non-recognition impedes entry by out-of-state dentists. In addition, dentists' incomes are higher in states with high per capita incomes. This is consistent with the predicted effect of per capital income on the demand for dental services. The remaining auxiliary-use restrictions and the SCHOOL, AGE, and URBAN variables have insignificant coefficients.

TABLE 4.

Summary of Percentage Effects of Auxiliary Use Restrictions, 1982

Dependent Variable	Restriction	
	LIMNUM	LIMAMAL
Price of...		
Patient Visit	7	.s.*
Oral Exam	n.s.	.s.
Radiograph	n.s.	n.s.
Prophylaxis (Adults)	10	.s.
Prophylaxis (Children)	n.s.	.s.
Fluoride Treatment	n.s.	.s.
Amalgam Restoration (1 surface, deciduous)	n.s.	.s.
Amalgam Restoration (2 surfaces, deciduous)	9	.s.
Amalgam Restoration (1 surface, permanent)	10	n.s.
Amalgam Restoration (2 surfaces permanent)	10	n.s.

TABLE 4.--Continued

Dependent Variable	Restriction	
	LIMNUM	LIMAMAL
Gold Inlay	10	n.s.
Gold Crown	n.s.	n.s.
Root Canal	n.s.	n.s.
Extraction	n.s.	n.s.

* n.s. = not significant at five percent level.

Price is seven percent higher in states that impose this restriction than the mean price of a dental visit. By contrast, the amalgam restoration restriction does not have a significant positive effect on average price in 1982.[43]

2. Individual service prices

In states that restrict the number of hygienists per dentist, the prices of five of our thirteen procedures are higher than in states that do not impose these restrictions. These five procedures are: adult prophylaxis, amalgam restoration (two surface, deciduous), amalgam restorations (one and two surface, permanent), and two-surface gold inlay. The price increases range from nine to ten percent, evaluated at the mean price for each procedure.[44]

In some states, limits on the number of hygienists appear to be reinforced by other restrictions that prevent dental assistants from performing traditional hygienist functions. For example, in 1982, 32 states did not permit dental assistants to clean and polish teeth. In states that also limited the number of hygienists, dentists could not substitute assistants for hygienists to provide prophylaxes.

Restricting auxiliaries from completing amalgam restorations has no significant effect on any of the 1982

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[43] Similarly, recognition of out-of-state dentists' licenses does not have a significant price-reducing effect in 1982. However, income per capita and the percentage of the population drinking fluoridated water do have significant effects on price. The coefficients of these two demand variables have the same signs as in the 1970 equations: positive for per capita income and negative for the percentage of the population drinking fluoridated water. The SCHOOL, AGE, and URBAN variables do not have significant effects on average price.

[44] In the 1982 individual-price equations, recognition of out-of-state dentists' licenses lowers the price only of oral examinations.

individual prices that were examined. These results contrast with the four significant amalgam-restoration coefficients for 1970. Perhaps the simplest explanation for this contrast, as suggested by Saving et al. (1978), is that the amalgam restoration restriction is a proxy for a large set of auxiliary function restrictions, and that most of the other members of that set were eliminated in the interim.

Alternatively, the finding that the restriction on amalgam restorations does not raise prices in 1982 may be the result of differences in the price data. ADA survey data were used for 1970, but HIAA insurance data were used for 1982. An uncertainty associated with the use of insurance data is whether a patient with insurance tends to pay higher prices than one with no insurance. In addition, to the extent that there is heterogeneity within a procedure category, and insurance coverage is selective, a price based on insurance data will differ from a price based on data that more broadly represent the range of services within the procedure category. As a result, any bias present in the 1982 insurance data may be greater than any bias in the ADA data.

Despite the different data sets used, however, our empirical results for 1970 and 1982 provide evidence that auxiliary use restrictions raise the prices of several dental procedures and the average price of a dental visit. Such price increases could impose substantial losses on consumers and on the U.S. economy. In the remainder of this section, we estimate these losses.

C. Loss Estimates

Using our regression results, we can estimate the losses that auxiliary use restrictions imposed on consumers and on the U.S. economy in 1970 and 1982. The losses are depicted

in Figure 4, which is similar to Figure 1. Both figures are drawn based on the assumptions of our first model.[45]

1. Consumer surplus loss

Auxiliary use restrictions reduce consumer surplus by an amount equal to area P'E'EP in Figure 4. To estimate this loss, we derived an algebraic expression for area P'E'EP in terms of the percentage change in the price of a patient-visit due to the restrictions, total expenditure on patient-visits, and the price elasticity of demand for patient-visits.[46] Values of these variables were obtained using our estimated regression coefficients, estimates that we made of expenditures,[47] and estimates of demand elasticity

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[45] This model assumes that dental firms produce a single output, patient-visits. The model is discussed in Section IV; the results of estimating the model are presented in Tables A-1 and A-13.

[46] Assuming a non-unitary constant-elasticity demand function to simplify the mathematics, it can be shown using the integral calculus that the loss in consumer surplus is equal to the following expression.

$$[E/(1-e)][1-p)^{(1-e)}]$$

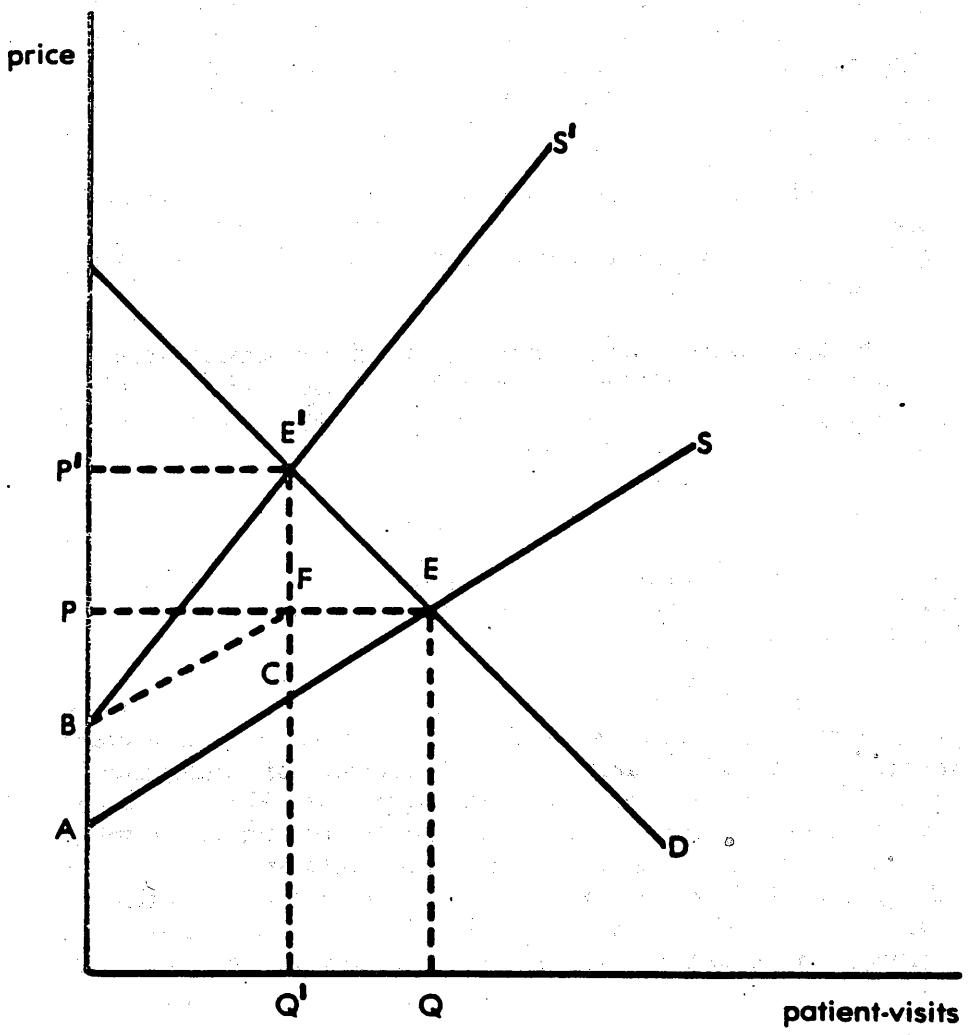
where E=total expenditure, e=elasticity of demand, and p=percentage decrease in price due to the relaxation of auxiliary use restrictions.

[47] For 1970, we estimated expenditure per dentist by state from ADA data on mean gross income of independent dentists. Lacking data on the number of independent dentists by state, we used an aggregate U.S. ratio of independent to active civilian dentists to convert the number of active civilian dentists in each state (obtained from HHS data) to an estimate of the number of independent dentists in the state. We then multiplied our number-of-dentists estimate by mean gross income to obtain estimated dental

(continued...)

Figure 4

Supply and Demand for Patient-Visits



that we obtained from the literature.[48] Using different values of the elasticity, we constructed a range of loss estimates.[49]

For the year 1970, we estimate that restrictions on the number of hygienists per dentist reduced consumer surplus by $280-290 million in the 12 states that imposed such restrictions. We also estimate that restrictions on finishing amalgam restorations reduced consumer surplus by $790-840 million in the 40 states that imposed such restrictions. In total, we estimate that auxiliary use restrictions imposed a loss of $1.07-1.13 billion on consumers during the year 1970.[50]

For the year 1982, we estimate that restrictions on the number of hygienists per dentist reduced consumer surplus by $680-710 million in the 16 states that imposed such restrictions. Because we observed no significant effect of restrictions on the finishing of amalgam restorations for 1982, $680-710 million is also our estimate of the total loss imposed on consumers by auxiliary use restrictions in that year.

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[47](...continued)
expenditures by state. For 1982, Health Care Financing Administration data on dental expenditures by state are presented in Levit (1985, pp. 44-45).

[48] The range of demand elasticity estimates obtained in previous studies (0.03 to 1.76) was found in Hu (1981).

[49] Because we estimated the percentage change in the price of a patient-visit using the restricted price as the base (P' in Figure 4), our loss estimates vary positively with the elasticity of demand.

[50] Our loss estimates are expressed in 1986 dollars for purposes of comparison. Estimates of the total loss may differ from the sum of the individual loss estimates due to rounding errors.

2. Loss to the U.S. economy

Auxiliary use restrictions cost the U.S. economy an amount equal to area BE'EA in Figure 4.[51] Lacking estimates of the effects of the restrictions on the supply curve for patient-visits, we cannot obtain a direct estimate of this loss. We can, however, estimate the loss indirectly using its relationship to the consumer surplus loss. A conservative lower-bound estimate of the loss to the U.S. economy is one-half of the loss in consumer surplus.[52] For 1970, we estimate that auxiliary use restrictions imposed a loss of $540-560 million on the U.S. economy. For 1982, our estimate of this loss is $340-360 million.[53]

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[51] The loss to the U.S. economy will be smaller than the loss to consumers if the restrictions transfer income from consumers to dentists.

[52] In Figure 4, it can be seen that area BE'EF is smaller than the loss to the U.S. economy, area BE'EA. To compare area BE'EF to the loss in consumer surplus, area P'E'EP, we can subtract the area common to both, E'EF. What remains is rectangle P'E'FP and triangle BE'F. It follows from elementary geometry that the area of BE'F is one-half of the area of P'E'FP. Hence, one-half the consumer surplus loss is a conservative lower-bound estimate of the loss to the U.S. economy.

[53] The comparability of these numbers to the consumer surplus loss estimates may be affected by rounding errors.

IX. Restrictions and the Quality of Service

When considering the potential benefits and costs of relaxing state restrictions on the employment of dental auxiliaries, one must examine the potential effects on the quality of service in addition to the effect on price. Within our empirical framework, we can estimate only the price effect. We draw on the existing literature to determine the expected effects of a relaxation of the restrictions on the quality of dental service.

Scheffman and Appelbaum (1982) present a model of a dental firm that produces its output of services subject to input quality regulation, such as restrictions on the functions that are delegable to auxiliaries. The quality of service is determined by the quality of the inputs, and by the amount of time that the dentist devotes to each patient. As a result, output quality does not necessarily increase when regulation requires an increase in input quality. Rather, output quality could increase, remain constant, or decrease, depending on how the dentist adjusts the time spent with the patient in response to the mandated increase in input quality. Thus, the effect on service quality of the delegation of functions to auxiliaries is an empirical question.

This question is addressed in an extensive literature that documents experiments in public health, university, military, and private dental practices. These studies are almost unanimous in finding that quality is not decreased when expanded functions are delegated to auxiliaries who have been trained in those functions (see Kaplan, 1980; McBride, 1975; General Accounting Office, 1980; Hammons and Jamison, 1967; and Sisty and Henderson, 1974).

Most of the studies compare the technical quality of a single procedure performed by a trained EFDA to the quality when performed by a dental student or dentist. For example, when such tasks as placing rubber dams, taking preliminary impressions, and placing and finishing restorations were examined, there was no statistically significant difference in quality between procedures performed by an auxiliary and those performed by a dental student (Kaplan, 1980;

Rosenblum, 1971). In addition, there is evidence that dental auxiliaries with minimum training can perform prophylactic (cleaning) procedures as well as dental students can (Pelton et al., 1972). There is similar evidence for restorations. All 16 studies surveyed by the General Accounting Office (1980, p. 24) that addressed the quality issue concluded that restorations completed by EFDAs were equal in quality to those completed by control groups of practicing dentists or dental students.[54]

To our knowledge, only one study (Bergner et al., 1983) has found a significant difference in quality between the performance of hygienists and that of dentists. Using a sample of 17 private dental offices in Washington state, the authors found that dentists had a lower frequency of unsatisfactory composite restorations than hygienists had. For amalgam restorations and bitewing radiographs, however, the performance differences between dentists and hygienists were not significant.

A comprehensive study of expanded functions was undertaken at the Forsyth Dental Center in Boston. This study examines dental hygienists' performance of restorative dental procedures (Lobene, 1974; Hankin, 1977). Advanced-skills hygienists were allowed to perform the entire restorative procedure, including administering anesthesia to the patient, cutting the cavities, and placing and carving the restorations. Lobene argues that properly educated dental hygienists can perform restorations at a required quality level.

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[54] The extent of supervision of the EFDA by a dentist, if any, is not discussed in these studies. However, other studies (see Freed et al., 1985 and American Dental Hygienists' Association, 1982) focus on the degree of supervision that dentists currently exercise over dental auxiliaries. These studies present evidence that hygienists have been given a substantial amount of independence in the taking of medical histories and in deciding whether a patient should be referred to the dentist for further treatment.

Evidence from Canada confirms that the quality of care in the dentist's office does not suffer when an expanded function is delegated to an auxiliary. Scheffman and Appelbaum (1982) present empirical results from two studies conducted in Saskatchewan and Ontario, which compare the quality of dental services provided by auxiliaries to that provided by dentists. The quality of amalgam restorations and stainless steel crowns did not differ between the two providers.

In sum, the literature on quality supports the proposition that dental auxiliaries can perform traditional and some expanded functions at the same level of quality as the dentist. This evidence suggests that the relaxation of restrictions on auxiliary use would not reduce the quality of dental care.[55]

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[55] Non-recognition of dentists licensed out-of-state may influence the quality of dentists within a state. Holen's (1978) unpublished paper presents evidence that states with relatively strict licensing standards, and no reciprocal licensing agreements with other states, have lower dentist malpractice insurance premiums. Holen's results are also consistent with the hypothesis that licensing restrictions increase dental service prices, suggesting a possible trade-off between higher prices and higher quality.

Ohio has changed from a recognition state to a non-recognition state because of disciplinary problems under the former system. Nine of 142 dentists licensed by credentials over the period 1974 to 1984 had their dental licenses revoked for felony convictions. However, the executive director of the Ohio State Dental Board attributes the disciplinary problems to a lack of communication between state dental boards rather than to the recognition system itself ("Licensure by Credentials," 1985).

X. Policy Implications

From the findings of this study, we conclude that states that now restrict the number of hygienists per dentist should consider relaxing their restrictions. The evidence in this report is consistent with the hypothesis that if these restrictions were relaxed, consumers would pay lower prices for several dental procedures and a lower average price for a dental visit. These lower prices would provide hundreds of millions of dollars in savings annually to consumers and to the U.S. economy.

Previous studies have concluded that, at lower prices, consumers would buy more dental services and that, as a result, dental health would improve. These conclusions are reinforced by evidence from the extensive quality literature, which shows that dental auxiliaries can perform some expanded functions as well as dentists can. This evidence suggests that the employment of additional hygienists by dentists would not reduce the quality of dental services.

With regard to the remaining restrictions on auxiliary functions, our results do not offer any unequivocal implications for public policy. On the one hand, policy changes may already have eliminated most of these restrictions and rendered the remaining ones ineffectual. On the other hand, improved models and data may be needed to isolate these restrictions' effects. More research is called for, and, in the next section, we will describe some possible directions for this research.

XI. Future Research

The findings presented in this report should be viewed as a step toward a better understanding of restrictions on dental auxiliaries. Additional research is needed to examine some unanswered questions regarding these restrictions, and to evaluate other dental regulations. This research can be focused in several directions.

It would be useful to know more about the production process in the dental service firm. We have tested the hypothesis that a restriction on the use of an auxiliary for a particular service will affect the cost of all services. Other hypotheses are possible, however, and more work would help discriminate among them.

Improved knowledge of optimal auxiliary utilization in large dental firms would allow more accurate estimation of the differential impact of auxiliary restrictions on large commercial practices compared to solo practices. Such estimation would require less aggregated data than are currently available.

Data on the quantity of dental services would permit structural supply and demand equations to be estimated. Such estimation would separate the possible effects of regulations on demand, such as increased waiting time, from the effects on supply, such as decreased efficiency.

The quantity data would have to be less aggregated than the state-level data used in this report: perhaps SMSA-level or individual-firm-level data. Such data could also be used to study regulatory restrictions on advertising and on the number of offices that a dentist may operate. Together with auxiliary use restrictions, these regulations may discourage the delivery of dental services by large commercial practices. Because all these restrictions are likely to have stronger effects where entry is impeded, future work could examine possible interactions between the restrictions and non-recognition of out-of-state licenses.

With regard to the restriction on the finishing of amalgam restorations, we observed significant effects for 1970 but not for 1982. Further research might uncover the reason for this change. Such research would probably require a consistent set of price data over several years. In addition, because regulations vary over time (for example, between 1970 and 1982, 15 states changed their policies regarding recognition), further research would benefit from a model in which regulation is endogenous. The model should probably also include a dental insurance variable, because of the rapid increase in coverage since the early 1970s. This would require disaggregated data on insurance coverage, which are not currently available.

Much work remains to be done on the possible effects of regulation on the quality of dental services. One direction that appears promising is to examine further the relationship between dental malpractice premiums and auxiliary use restrictions.

APPENDIX

TABLE A-1.

Estimation Results for Average Price Equation, 1970

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.64	0.21	2.98*
LIMEXAM	-0.01	0.29	-0.02
LIMRAD	-0.04	0.30	-0.13
LIMFLUOR	-0.17	0.31	-0.56
LIMAMAL	0.82	0.33	2.50*
RECOG	-0.55	0.22	-2.52*
SCHOOL	-0.14	0.45	-0.31
FLUORID	-1.55	0.43	-3.60*
INCP	1.48	0.32	4.59*
AGE	-1.95	5.89	-0.33
URBAN	1.88	1.05	1.80*
Intercept	7.56	2.81	2.69
$R^2 = 0.75$			
F = 13.31			
n = 45			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-2.

Estimation Results for Oral Exam Price Equation, 1970

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.39	0.17	2.32*
LIMEXAM	0.11	0.23	0.49
LIMRAD	-0.02	0.23	-0.07
LIMFLUOR	-0.23	0.24	-0.97
LIMAMAL	0.68	0.26	2.66*
RECOG	-0.07	0.17	-0.43
SCHOOL	-1.44	3.50	-0.41
FLUORID	-1.01	0.34	-3.00*
INCP	0.32	0.25	1.28
AGE	0.25	4.61	0.05
URBAN	0.75	0.82	0.92
Intercept	1.85	2.20	0.84
$R^2 = 0.33$			
F = 2.97			
n = 45			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-3.

Estimation Results for Radiograph Price Equation, 1970

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.19	0.17	1.13
LIMEXAM	-0.36	0.23	-1.58
LIMRAD	0.21	0.23	0.90
LIMFLUOR	-0.17	0.24	-0.69
LIMAMAL	0.45	0.26	1.76*
RECOG	0.10	0.17	0.58
SCHOOL	-0.55	0.35	-1.58
FLUORID	-0.70	0.34	-2.07*
INCP	-0.29	0.25	-1.16
AGE	-8.27	4.62	-1.79
URBAN	1.97	0.82	2.41*
Intercept	9.05	1.81	3.95
$R^2 = 0.23$			
$F = 2.20$			
$n = 45$			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-4.

Estimation Results for Prophylaxis Price Equation, 1970

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.92	0.26	3.51*
LIMEXAM	0.06	0.36	0.18
LIMRAD	0.16	0.37	0.45
LIMFLUOR	-0.20	0.38	-0.52
LIMAMAL	0.29	0.40	0.71
RECOG	-0.50	0.27	-1.86*
SCHOOL	0.03	0.55	0.06
FLUORID	-1.45	0.53	-2.72*
INCP	0.93	0.40	2.33*
AGE	12.84	7.26	1.77*
URBAN	1.59	1.29	1.23
Intercept	-0.86	3.47	-0.25
$R^2 = 0.53$			
F = 5.44			
n = 45			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-5.

Estimation Results for Fluoride Price Equation, 1970

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.41	0.23	1.73*
LIMEXAM	-0.12	0.34	-0.35
LIMRAD	0.24	0.35	0.69
LIMFLUOR	-0.10	0.36	-0.29
LIMAMAL	0.47	0.38	1.23
RECOG	-0.16	0.26	-0.62
SCHOOL	0.63	0.52	1.21
FLUORID	-0.95	0.50	-1.88*
INCP	0.50	0.38	1.32
AGE	-4.59	6.89	-0.67
URBAN	0.32	1.22	0.26
Intercept	6.02	3.29	1.83
$R^2 = 0.14$			
F = 1.68			
n = 45			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-6.

Estimation Results for Extraction Price Equation, 1970

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.33	0.16	2.06*
LIMEXAM	-0.11	0.22	-0.52
LIMRAD	-0.04	0.22	-0.18
LIMFLUOR	0.07	0.22	0.29
LIMAMAL	0.54	0.24	2.26*
RECOG	-0.38	0.16	-2.33*
SCHOOL	-0.10	0.34	-0.30
FLUORID	-1.43	0.33	-4.38*
INCP	1.31	0.25	5.25*
AGE	4.57	4.37	1.05
URBAN	2.57	0.81	3.17*
Intercept	-0.20	2.09	-0.01
$R^2 = 0.84$			
F = 21.86			
n = 44			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-7.

Estimation Results for Root Canal Price Equation, 1970

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	3.61	1.97	1.83*
LIMEXAM	-1.69	2.69	-0.63
LIMRAD	-1.32	2.74	-0.48
LIMFLUOR	1.08	2.83	0.38
LIMAMAL	6.31	3.02	2.09*
RECOG	-2.66	2.04	-1.31
SCHOOL	-3.13	4.14	-0.76
FLUORID	-6.40	3.98	-1.61
INCP	0.85	2.98	0.29
AGE	-49.54	54.52	-0.91
URBAN	9.14	9.69	0.94
Intercept	64.84	26.02	2.49
$R^2 = 0.18$			
F = 1.87			
n = 45			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-8.

Estimation Results for Amalgam Restoration (one surface)
Price Equation, 1970

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.57	0.19	2.95*
LIMEXAM	-0.01	0.26	-0.02
LIMRAD	-0.03	0.27	-0.10
LIMFLUOR	0.14	0.28	0.50
LIMAMAL	0.46	0.30	1.56
RECOG	-0.16	0.20	-0.79
SCHOOL	0.33	0.41	0.80
FLUORID	-1.04	0.39	-2.66*
INCP	0.13	0.29	0.43
AGE	3.16	5.35	0.59
URBAN	2.18	0.95	2.29*
Intercept	3.12	2.55	1.22
$R^2 = 0.42$			
$F = 3.86$			
$n = 45$			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-9.

Estimation Results for Amalgam Restoration (two surface)
Price Equation, 1970

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.60	0.26	2.35*
LIMEXAM	-0.36	0.35	-1.03
LIMRAD	0.07	0.35	0.19
LIMFLUOR	0.06	0.37	0.17
LIMAMAL	0.61	0.39	1.57
RECOG	-0.23	0.26	-0.87
SCHOOL	0.01	0.54	0.03
FLUORID	-1.06	0.52	-2.06*
INCP	0.70	0.39	1.82*
AGE	3.56	7.05	0.50
URBAN	3.07	1.25	2.45*
Intercept	4.53	3.37	1.34
$R^2 = 0.53$			
F = 5.44			
n = 45			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-10

Estimation Results for Gold Inlay Price Equation, 1970

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	2.01	1.57	1.27
LIMEXAM	-1.06	2.14	-0.49
LIMRAD	-0.99	2.18	-0.46
LIMFLUOR	1.28	2.25	0.57
LIMAMAL	1.56	2.40	0.65
RECOG	-1.94	1.62	-1.20
SCHOOL	-5.68	3.29	-1.72
FLUORID	-4.26	3.17	-1.34
INCP	3.32	2.37	1.40
AGE	-45.82	43.34	-1.06
URBAN	5.90	7.70	0.77
Intercept	55.82	20.69	2.70
$R^2 = 0.29$			
F = 2.64			
n = 45			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-11.

Estimation Results for Gold Crown Price Equation, 1970

Explanatory Variable	Coefficient	Standard Error	t-ratio
.IMNUM	-0.97	3.19	-0.31
.IMEXAM	1.18	4.35	0.27
.IMRAD	-0.39	4.43	-0.09
.IMFLUOR	-0.55	4.58	-0.12
.IMAMAL	0.97	4.89	0.20
RECOG	-3.16	3.29	-0.96
SCHOOL	-4.38	6.70	-0.65
FLUORID	-1.22	6.44	-0.19
INCP	11.15	4.82	2.31*
AGE	-91.41	88.11	-1.03
URBAN	-4.95	15.65	-0.32
Intercept	80.07	42.06	1.90
$R^2 = 0.19$			
F = 1.92			
n = 45			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-12.

Estimation Results for Net Income of Dentists Equation, 1970

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	1.62	0.91	1.78*
LIMEXAM	0.54	1.24	0.43
LIMRAD	-0.98	1.26	-0.78
LIMFLUOR	0.62	1.31	0.47
LIMAMAL	2.45	1.39	1.76*
RECOG	-1.76	0.94	-1.88*
SCHOOL	0.41	1.91	0.21
FLUORID	-0.82	1.84	-0.44
INCP	2.76	1.37	2.01*
AGE	-13.33	25.12	-0.53
URBAN	-0.62	4.46	-0.14
Intercept	20.46	11.99	1.71
$R^2 = 0.24$			
F = 2.24			
n = 45			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-13.

Estimation Results for Average Price Equation, 1982

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.67	0.31	2.16*
LIMAMAL	-0.10	0.32	-0.30
RECOG	-0.33	0.31	-1.04
SCHOOL	-0.02	0.56	-0.04
FLUORID	-1.54	0.61	-2.55*
INCP	1.00	0.32	3.17*
AGE	3.74	6.21	0.60
URBAN	0.39	1.12	0.35
Intercept	3.67	3.44	1.07
$R^2 = 0.42$			
F = 5.24			
n = 47			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-14.

Estimation Results for Oral Exam Price Equation, 1982

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.01	0.17	0.04
LIMAMAL	-0.16	0.17	-0.94
RECOG	-0.34	0.17	-2.04*
SCHOOL	0.003	0.30	0.01
FLUORID	-0.32	0.32	-0.98
INCP	0.23	0.17	1.39
AGE	-1.73	3.31	-0.52
URBAN	0.97	0.60	1.62
Intercept	3.21	1.81	1.77
$R^2 = 0.24$			
F = 2.89			
n* = 48			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-15.

Estimation Results for Radiograph Price Equation, 1982

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.30	0.20	1.52
LIMAMAL	-0.04	0.20	-0.18
RECOG	0.08	0.20	0.43
SCHOOL	-0.17	0.35	-0.49
FLUORID	-0.37	0.38	-0.96
INCP	0.47	0.20	2.36*
AGE	3.87	3.90	0.99
URBAN	-0.25	0.70	-0.35
Intercept	0.43	2.13	0.20
$R^2 = 0.08$			
F = 1.48			
n = 48			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-16.

Estimation Results for Adult Prophylaxis Price Equation, 1982

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.96	0.38	2.56*
LIMAMAL	-0.03	0.39	-0.08
RECOG	-0.42	0.37	-1.13
SCHOOL	0.02	0.67	0.03
FLUORID	-2.36	0.73	-3.22*
INCP	0.88	0.38	2.31*
AGE	1.52	7.46	0.20
URBAN	0.98	1.35	0.73
Intercept	4.66	4.09	1.14
$R^2 = 0.46$			
F = 5.94			
n = 48			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-17.

Estimation Results for Children's Prophylaxis
Price Equation, 1982

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.48	0.30	1.59
LIMAMAL	-0.07	0.31	-0.21
RECOG	-0.36	0.30	-1.19
SCHOOL	0.10	0.54	0.18
FLUORID	-1.44	0.59	-2.45*
INCP	0.27	0.30	0.88
AGE	-0.85	5.99	-0.14
URBAN	0.83	1.08	0.77
Intercept	5.64	3.28	1.72
$R^2 = 0.24$			
F = 2.84			
n = 48			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-18.

Estimation Results for Fluoride Price Equation, 1982

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.76	0.58	1.31
LIMAMAL	-0.07	0.60	-0.11
RECOG	0.05	0.58	0.09
SCHOOL	-1.06	1.04	-1.02
FLUORID	-1.07	1.13	-0.95
INCP	0.59	0.59	1.01
AGE	3.46	11.55	0.30
URBAN	1.79	2.08	0.86
Intercept	4.21	6.33	0.67
$R^2 = 0.06$			
F = 1.38			
n = 48			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-19.

Estimation Results for Amalgam Restoration (one surface-deciduous) Price Equation, 1982

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.70	0.44	1.59
LIMAMAL	-0.09	0.46	-0.21
RECOG	-0.49	0.44	-1.12
SCHOOL	0.71	0.80	0.89
FLUORID	-1.59	0.86	-1.84*
INCP	1.22	0.45	2.73*
AGE	14.11	8.81	1.60
URBAN	-0.92	1.59	-0.58
Intercept	-1.63	4.82	-0.34
$R^2 = 0.27$			
F = 3.13			
n = 48			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-20.

Estimation Results for Amalgam Restoration (two surface-deciduous) Price Equation, 1982

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	1.12	0.49	2.25*
LIMAMAL	-0.19	0.51	-0.38
RECOG	-0.66	0.49	-1.34
SCHOOL	0.42	0.89	0.47
FLUORID	-1.76	0.96	-1.83*
INCP	1.68	0.50	3.35*
AGE	10.96	9.84	1.11
URBAN	-1.39	1.78	-0.78
Intercept	1.71	5.39	0.32
$R^2 = 0.37$			
F = 4.52			
n = 48			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-21.

Estimation Results for Amalgam Restoration (one surface-permanent) Price Equation, 1982

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.97	0.49	2.00*
LIMAMAL	-0.20	0.50	-0.39
RECOG	-0.48	0.48	-0.98
SCHOOL	0.71	0.87	0.81
FLUORID	-2.12	0.95	-2.24*
INCP	1.57	0.49	3.19*
AGE	19.89	9.66	2.06*
URBAN	-1.14	1.74	-0.65
Intercept	-4.39	5.29	-0.83
$R^2 = 0.35$			
F = 4.23			
n = 48			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-22.

Estimation Results for Amalgam Restoration (two surface-permanent) Price Equation, 1982

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	1.41	0.54	2.60*
LIMAMAL	0.04	0.56	0.07
RECOG	-0.42	0.54	-0.78
SCHOOL	0.69	0.98	0.71
FLUORID	-2.32	1.06	-2.20*
INCP	2.30	0.55	4.18*
AGE	21.40	10.80	1.98*
URBAN	-1.93	1.95	-0.99
Intercept	-4.16	5.91	-0.70
$R^2 = 0.44$			
F = 5.58			
n = 48			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-23.

Estimation Results for Gold Inlay Price Equation, 1982

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	9.51	5.42	1.75*
LIMAMAL	3.20	5.63	0.57
RECOG	2.68	5.47	0.49
SCHOOL	5.19	9.87	0.53
FLUORID	-13.78	10.58	-1.30
INCP	11.95	5.54	2.16*
AGE	43.26	108.67	0.40
URBAN	9.95	19.56	0.51
Intercept	11.02	60.13	0.18
$R^2 = 0.17$			
F = 2.17			
n = 47			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-24.

Estimation Results for Gold Crown Price Equation, 1982

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	-0.39	4.07	-0.10
LIMAMAL	-2.44	4.21	-0.58
RECOG	-1.68	4.05	-0.41
SCHOOL	-10.18	7.31	-1.39
FLUORID	-1.81	7.92	-0.23
INCP	9.43	4.11	2.29*
AGE	-86.78	80.83	-1.07
URBAN	12.96	14.59	0.89
Intercept	118.02	44.26	2.67
$R^2 = 0.23$			
F = 2.73			
n = 48			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-25.

Estimation Results for Root Canal Price Equation, 1982

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.26	2.50	0.10
LIMAMAL	-0.66	2.59	-0.26
RECOG	-3.12	2.49	-1.25
SCHOOL	0.89	4.49	0.20
FLUORID	1.86	4.87	0.38
INCP	4.23	2.53	1.67
AGE	-47.39	49.71	-0.95
URBAN	19.72	8.97	2.20*
Intercept	54.17	27.22	1.99
$R^2 = 0.31$			
$F = 3.58$			
$n = 48$			

* Significantly different from zero with the predicted sign at the five percent level or higher.

TABLE A-26.

Estimation Results for Extraction Price Equation, 1982

Explanatory Variable	Coefficient	Standard Error	t-ratio
LIMNUM	0.40	0.32	1.26
LIMAMAL	-0.25	0.33	-0.76
RECOG	-0.29	0.32	-0.93
SCHOOL	-0.01	0.57	-0.02
FLUORID	-1.66	0.62	-2.67*
INCP	1.52	0.32	4.72*
AGE	-0.74	6.33	-0.12
URBAN	2.75	1.14	2.41*
Intercept	1.81	3.47	0.52
$R^2 = 0.64$			
F = 11.33			
n = 48			

* Significantly different from zero with the predicted sign at the five percent level or higher.

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