The Use of Administrative Databases to Assess Oral Health Care

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Abstract

Objective: *We examined the potential for research using administrative databases containing dentists' claims to identify both the type of health services research questions addressed and the strength of the evidence that is achieved in such studies.* ***Methods:*** *We searched Medline (1966 to March, 2003), retrieved additional reports from personal files, reviewed the literature cited in the relevant articles and conducted electronic searches on investigators' surnames. Information from relevant articles was abstracted into tables and the strength of the evidence for each was classified.* ***Results:*** *Thirty-eight studies met our inclusion criteria. Researchers have used administrative databases of dental records to examine provider practices, the longevity or consequences of dental interventions, the prevalence of dental conditions, and patient factors that determined care, and to establish quality assurance criteria or standards of care. The strongest designs were prospective or case-control (Level II-2).* ***Conclusion:*** *Studies analyzing administrative databases have the advantage of size and economy but are subject to several threats to their validity and are seldom population-based. The strongest designs occurred with investigation of the longevity or consequences of care. Several studies demonstrated the benefit of linking the service data to patient or provider characteristics. The study of dentists' claims data appears under exploited, especially in the area of identifying and recommending changes in dental health care policies.*

Key Words: health services research; dental insurance; dentists' practice patterns; dental records; health services needs and demands; dental audit.

Introduction

Traditionally, medical and dental records were maintained on paper in the form of individual patient charts. First generation databases were essentially used to replace the written copy with little more than electronic versions of the paper charts (1). However, in 1974, the US Department of Health, Education, and Welfare mandated that a uniform set of data be submitted to them, electronically, for all acute hospital discharges paid by Medicare and Medicaid. This requirement became a driving force in the development and spread of administrative databases in dentistry.

With access to the rich information in the province-wide databases maintained by the Canada's medical and hospital care programs, Canadian researchers have conducted extensive analyses of physicians' claims data. Such analyses have been used to: assess health policy (2,3); develop health status indicators (4); assess the urban/rural differences in access to care and utilization trends (5); measure the impact of technology change and health system reforms (6,7); assess outcomes of care (8,9); identify individual physicians' surgical workload (10); and document the variability in surgical rates (11,12). They have also been linked with surveys of representative samples of people to check on the accuracy of self-reported cases of disease (13) and to determine the costs of physicians' services to smokers (14).

Investigators (15) have claimed that administrative data offer advantages, namely that they:

- are generally longitudinal (data often span 10 years or more), based on clinical records which can be linked with other administrative data sets and/or over time to create a comprehensive representation of program use and client outcomes;
- are detailed and accurate measures of program status and outcomes;
- provide detailed information on the characteristics of participants, the services they have received, and the actions they have taken, which cannot be obtained in any other way;
- are extensive and relatively inexpensive source of information; and
- contain data about the same conditions or programs over a long period, making it easy to determine if recent changes are unusual.

Kaplan and Lillich (16) add that administrative databases:

- are readily available for timely analysis, retrieving needed information easily, which is critical for policy analyses;
- can be a major tool in evaluating the impact of policy analyses and conducting strategic planning;
- allow analysis of information about different patients and treatments, helping to create new research ideas; and;

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- offer "...benefits in the field of Health Services Research through the ordering of such a vast amount of information across so broad a spectrum...".

Disadvantages that occur with the use of administrative databases for research include (1,15):

- lack of agreement as to how items are coded;
- problems with accuracy and precision of data, such as:
  - basic information on patient characteristics, diagnoses and procedures and secondary procedures, may be miscoded;
  - data are generally available only for people who use services or access health care systems in the period of interest;
  - patients may be miscounted if they have multiple sites of residence or have undergone procedures out of province/state;
- patients are often incompletely characterized; key clinical data on processes and outcomes may be missing;
- identities and characteristics of providers may be inconsistently recorded; and
- outcomes of interest may not be captured e.g. symptom relief, quality of life, out-of-hospital events and level of satisfaction.

The full extent and utility of such studies in dentistry has not been reviewed, but their potential to address current questions in oral health care may have been under-exploited compared to their demonstrated utility in medical and hospital services research.

This paper sets out to examine the type of health services research questions addressed through the analysis of administrative databases in dentistry. A second purpose was to identify the research designs employed in such research and the strength of the evidence that is possible using such data sets.

Methods

We searched the electronic records of publications in Medline (1966 to March, 2003), using the broad categories of administrative databases, data set, database, computer programs, data collection, dentistry, dental research, educational research, outcomes, dental providers. The search was then narrowed to include articles related to insurance and claims, combinations such as dental claim, insurance claims, dental insurance, and medical insurance. Additional unpublished reports were retrieved from the first author's personal files collected up to 1987 for a previous research contract. The abstracts were read and those relevant to the review were selected and copied. The literature cited in these relevant articles was reviewed and appropriate publications retrieved. As a last step electronic searches on investigators surnames were conducted and again the articles were reviewed at the title and abstract stage. Information from relevant articles was abstracted into tables.

The column headings on the tables were tailored to fit the nature of the articles. The strength of the evidence for each was classified according to the Canadian Task Force on Preventive Health Care (17).

Results

More than 500 articles were found within the initial search terms. Limiting the search to include articles related to insurance and claims, etc., provided 354 articles. The abstracts of all these were read and 35 articles were selected for copying and detailed review. At this stage, only 18 published articles containing dental research and administrative databases were kept for abstraction.

At the end of the initial search process, six additional articles (18-23), not identified in the electronic searches, were added from the first author's personal files. Searching the literature cited and on investigator's names identified an additional 15 articles.

Reports where electronic databases were established as part of the study (24) including the Rand Health Insurance Experiment (25,26), were not included in order to limit the review to examining the research potential of studies beginning with, or linked to, established administrative databases. Studies which used an electronic database to assemble the study group but which contained no further analysis of the database (27,28) were also excluded.

Thirty-eight articles were selected and 34 were abstracted into tables; the other 4 were of two types but are only described in order to meet the table limit for this publication.

The examination of provider practices was the most common type of study. These fell into four categories: a) general descriptive (22,29-33); b) comparing practices among types of providers (34-36); c) comparing service provision among those providing care under different forms of insurance (18,19,37); or d) as influenced by factors other than type of insurance (21,23,34,38-41). A second group of studies examined the consequences or longevity of dental care interventions (20,42-46) and one study (47) was found that used linked administrative databases to report on the prevalence of dental conditions. Nine studies (48-56) examined patient-based determinants of care and three studies (57-59) reported on the use of administrative databases for quality assurance or for establishing guidelines for care.

The six studies that were found to have described provider practices, in general, are shown in Table 1A. All of the studies are cross-sectional or repeated cross-sectional (Level III evidence). Hayden (22) illustrates the simplest form of this type of study – the frequency of the top 30 procedures provided over 3.9 yrs by a sub-set of dentists in 48 states. del Aguila et al. (33) provide additional analysis of some of the trends over two years and an analysis of the volume of care provided by general and specialist dentists. Eklund et al. (32) provide more detailed analysis of the costs of care and trends in the mean number of services per person provided over 3 to 5-year intervals to an insured group in Michigan. Grembowski et al. (30) used the information in the database of a homologous population to derive practice profiles (preventive, or treatment oriented, and low rate) among 200 dentists providing services to 23,000 teachers in the State of Washington.

Table 1A
Provider practices – general, descriptive

Authors/Date	*Population*	*Outcomes/Practices*	*Findings*	*Comments*
del Aguila MA, Anderson M, Porterfield D, Robertson PB. JADA 2002	620 293 patients in 1993 880 317 patients in 1999 Washington Dental Service Washington State 1993 and 1999 (2 yrs of data) Care in 1993	Multiple outcomes	Number of procedures: - 1993 - 4.3 million - 1999 - 5.8 million Pattern of care: - Single crowns ~ 21% of costs in both years. Higher expenditures for resin restorations in 1999. Providers: - > 80% of care provided by general dentists; trend to more specialists	Repeated cross-sectional descriptive study (III) Database information validated with a subset of patient charts
Eklund SA, Pittman JL, Smith RC JADA 1998	750 000 people Delta Dental Plan (fee for-service component) Michigan 1980-1995 (16 yrs of data)	Inflation adjusted (discounted) per patient expenditures (gross incomes of practices) by age-group and class of service	Discounted per patient expenditures changed very little over the 16 years despite shifts to higher expenditures in diagnostic and preventive services	Repeated cross-sectional descriptive study (III)
Hayden WJ. J Dent Edu 1997	636 703 patients; 3 861 039 services May 1990- April 1994 (3.9 yrs of data) 2778 dentists from 48 states in USA	Frequency of procedures	Top 30 procedures by frequency and total charges identified	Descriptive study (III)
Eklund SA, Pittman JL, Smith RC. JADA 1997	750 000 people Delta Dental Plan (fee for-service component) Michigan 1980-1995 (16 yrs of data)	Mean numbers of services by type per person per year for 1980 and for each 5 yrs afterwards	Results are presented in charts Mean numbers of services: - Examinations ~ 1 (1980) to ~1.5 (1995) - Restorations ~ 1.5-2 (1980) to 1 or fewer (1995) - Extractions fallen; - Endodontics, crowns in older patients, fixed bridges and periodontics rose	Repeated cross-sectional descriptive study (III) Newer procedures, such as implants and sealants, were not included in the analysis

Table 1A - Continued
Provider practices – general, descriptive

Authors/Date	*Population*	*Outcomes/Practices*	*Findings*	*Comments*
Grembowski D, Milgrom P, Fiset L. J Public Health Dent 1990	23,153 teachers and their dependents with up to 10 years of previous insurance served by 200 dentists Washington Dental Service Washington 1984-85 (2 yrs of data)	Practice profiles based on diagnostic, preventive, restorative and periodontic procedures	Three profiles identified: 1) Preventive oriented 2) Treatment oriented 3) Low rate	Descriptive study (III) Extreme variation in dentists' profiles given the homologous insured population
Bailit H, Clive J. Medical Care 1981	Claims data from 227 gp dentists Northeast USA 1976 1 years data	Practice profiles derived from 16 service categories Practice profile adjusted by indirect methods according to the entire reference group Service provision fitted to probability models	Variation in practice pattern considerable Important to adjust individual dentists rates to identify patterns Four types of practice pattern identified Age of patient an important predictor of variation Patterns stable over time	Descriptive study (III) with sophisticated adjustment techniques.

Table 1B summarizes the information from the three studies that sought to identify differences in practices between: dentists and denturists (60); general practitioners, public health dentists and pediatric specialists (35); and dental students and dentists (36). While two studies are cross-sectional in design, one employs a retrospective design (Level II-2 evidence), all studies suffer threats to their validity given that the patients visiting one or another practitioner type may have substantially different needs or expectations of care. In the Lewis & Thompson study (34) the potential for extra-billing by only one group of providers adds a further confounder.

Not shown in a table are three studies (18,19,37) that examined the differences in care provided under fee-for-service and capitation insured plans. While this is Level II-2 evidence, the fact that there was no control for prior needs and the choice of the plan was made by the patients and providers, limits the confidence in any conclusions that the service patterns occurred because of the method of payment. Further, the studies were all of one-year duration, which would seem to be a short a period to draw firm conclusions. The strength of the findings lies in their size, all together about 34 000 patient-years of care.

Seven studies, shown in Table 1C, examined the influence of factors, other than payment method or provider type, on provider practices. Porter et al. (23) showed that fee bundling for diagnostic and preventive services was not effective in reducing dentists' billings on recall visits. Ismail et al. (40) examined the factors that influenced the provision of restorations; the factors were derived from a previous epidemiological survey of the children's oral health. Robison et al. (41) linked their service data to an earlier assessment of health status and showed that non-sealant provision was associated with the highest need children. Lewis and Thompson (34) found that higher service levels were associated with the later cohorts covered in the province-wide program for seniors in Alberta, Canada. Grembowski et al. (38) showed that variation in service rates was common among dentists and was influenced by practice size and urban location, patient exposure to fluoridated water and to non-price competitive factors. Linking the database findings to the dentists' self-reports on factors that were important in decision making, Grembowski et al. (39) found that dentists' reports of patient factors explained less than 30% of the service

variation. Simard et al. (21) showed that service provision of endodontic services, crowns and general anesthetics was sensitive to fee reductions of 50% in the crown and endodontic fees. These seven studies were conducted using both retrospective and prospective (Level II-2 evidence) as well as cross-sectional (Level III) designs.

Table 2 provides information on six studies that examined the consequences or longevity of interventions. Bogacki et al. (46) compared 5-year and 7-year survival rates of resin and amalgam restorations and Eklund et al. (44) found no effect on the subsequent restoration rate of children previously treated with professionally applied topical fluorides (PATF). Caplan and Weintraub (43) linked their administrative data with information taken from the patient charts to examine factors associated with the loss of root-canal filled teeth. Three studies examined the consequences of providing sealants; Kuthy et al. (42) and Weintraub et al. (45) examined the effect of sealant provision on later interventions or costs and Whyte et al. (20) examined the survival of sealants as measured by a clinical screening 2-5 years after the original placement. Five of these studies compared outcomes in terms of subsequent services between two cohorts (Level II-2 evidence) whereas Whyte et al. (20) reported on the survival of sealants (single cohort - Level III) as determined from follow-up screening reports.

One study, not shown in a table, examined the prevalence of oral conditions. Fedele et al. (47) examined the distribution of oral cancer (OC) sites among patients with OC discharged

Table 1B
Provider practices by types of providers

Authors/Date	*Population*	*Provider*	*Comparator*	*Outcomes*	*Comments*
Leggott JP, Robertson PB, del Aguila M, Swift JJ, Porterfield D, Phillips S. J Dent Edu 2002	9488 University of Washington (UW) patients 880 317 Washington Dental Service (WDS) patients of general dental practitioners Delta Dental Plan and Prodata Systems Washington State 1990 (1 yr of data)	Dental students (UW)	Community dental practitioners (WDS)	Relative distribution of service-types: - no significant differences in the between UW and MDS providers Patient age and gender also similar between providers	Descriptive study (III) Limitations: - Mentors of UW students also WDS providers; - Patient cost-sharing and fee-for-service may influence (constrain) choice of care for both delivery models limiting real differences
Cooke MR, Farrington FH, Huie M, Meadows SL. Amer Academy of Pediatric Dent 2001	747 dentists providing dental care to Medicaid patients younger than 21 yrs during 1995-5 in Virginia USA 2 yrs of data	General practitioner dentists (GPDs)	Public health dentists (PHDs) Pediatric dentists (PDs)	GPDs provided more diagnostic procedures GPDs and PDs provided fewer preventive services than GPDs	Descriptive study (III)
Lewis DW, Thompson GW, Folkins A. J Prosth Dent 1995	260,000 persons, age > 64yr 6 million records of care Extended Health Dental Plan, Alberta, Canada 1978-92 (14yr of data)	Dentists	Denturists	Replacement rate of dentures: - 48% replaced between 5th and 6th year after insertion - Denturist ~ 21% (patients did not have to pay extra-billing fee) - Dentist ~ 7% (patients could be extra-billed)	Retrospective two-cohort study (II-2) Replacement rate initially followed frequency (5yr) allowed by the terms of the plan but no second peak (at 10 yrs) noted Could not control for effects of extra-billing

Table 1C
Provider practices according to factors other than provider type or type of insurance

Authors/Date	*Population*	*Outcomes/Practices*	*Findings*	*Comments*
Porter J, Coyte P, Barnsley J, Croxford R. Health Services Research 1999	4455 employees at four Ontario Canada hospitals with recall visit procedures Liberty Health Plan 1987-1990 Five years of data	Real (inflation adjusted) expenditures per patient on all services provided at recall visits following 'bundling' of diagnostic and preventive services into packages that were priced lower than the same services 'a la carte'	Real expenditures fell by 0.3% in the first year but increased by 4.8% by the last year. Increases were mainly due to additional charges for periodontal and restorative services provided to regular users.	Repeated cross sectional (III) Longitudinal nature of the data used to examine dentists' response to a cost containment measure. 37% of the variation explained by the regression model
Ismail A, Brodeur JM, Gagnon P, Payette M, Picard D, Hamalian T, Olivier M. J Public Health Dent 1997	911 surveyed children with dental plan claims within 3 and 6 mo. of the survey examination Quebec Children's Dental Plan Quebec 1990 and 1991	Restorations provided to pits and fissures of first permanent molar teeth with caries status independently assessed no more than 6 months earlier	Cavitated lesion strong predictor of restoration OR>4.1 Proportion of sound or non-cavitated surfaces receiving restorations = 73%-81% Higher restorative profile of dentist also predicted restoration	Prospective study (II-2) of factors predicting restoration Service data linked to prior epidemiology survey
Robison VA, Rozier RG, Weintraub JA, Koch GG. J Dent Res 1997	390 children who had a claim after 1986-87 state-wide survey 71 children with and 319 without sealants Medicaid clients North Carolina 1987-1992 (6 yr of data)	Non-sealant provision vs sealant provision	Non–sealant provision associated with: - high untreated caries scores (OR = 2.63, 95% CI = 1.3-5.0) - high untreated caries scores and epidemiologicly defined need for sealant (OR= 4.55, 95% CI= 1.5-14.3) Sealants provided to a minority of clients Preventive care (sealants) not provided to those identified as most in need in the prior survey	Retrospective case-control design (II-2) Cases defined as non-sealant recipients Administrative data-base linked to epidemiologic survey results Clinical status of child not known at the exact time the dentist made the decision to seal or not
Lewis DW, Thompson GW. Am J Public Health 1995	17 816 subjects, initially aged 65-69, followed for 6 yr starting in 1978/79 27 474 subjects initially aged 65-69, followed for 6 yr starting in 1985/86 Extended Health Dental Plan Alberta, Canada 1978-1986 (15 yr of data)	Mean number of visits Expenditures per patient by denturists and dentists Distribution of expenditures by type of care Continuity of annual use	Later cohort had: - 24% more visits - 33% higher expenditures; - Fewer denture services and more periodontal services; - 55% had use in 5 or 6 years vs 42% in the early cohort	Retrospective cohort study (II-2)

Table 1C - Continued
Provider practices according to factors other than provider type or type of insurance

Authors/Date	*Population*	*Outcomes/Practices*	*Findings*	*Comments*
Grembowski D, Milgrom P, Fiset L. Soc Sci Med 1991	23 153 patients enrolled in the Washington Educators Association dental plan Washington USA 1984 -1985 2yrs of data	Service rates for substitute services: - Crown vs amalgam or crown build-up - RCT vs extraction - Bridge vs partial denture Results linked to survey of dentists' self-reports of technical and patient factors that they felt important in clinical decision making Practice structure, environment and dentists beliefs also measured in survey	Regression analysis explained less than 30% of variation in the service provisions Patient factors reported as significant in many decisions Technical factors (periodontal status, potential for tooth damage) not consistently important Structures environment and beliefs, not consistent factors in decision making	Descriptive study (III)
Grembowski D, Milgrom P, Fiset L. J Public Health Dent 1990	23,153 teachers and their dependents with up to 10 years of previous insurance served by 200 dentists Washington Dental Service Washington 1984-85 (2yrs of data)	Service rates of dentists	Large variation was found in the rates of provision of dental services Dentists who had the highest or lowest rate for one service usually had the opposite rate for other services Other determinants included practice characterisitics (size, urban location) patient exposure to fluoridated water and non-price competition	Descriptive study (III) Treatment data linked to mailed survey of dentists to obtain practice characteristics Not possible to detect cost-effectiveness of high expenditure practices
Simard PL, Brodeur J-M, Gringas F, Saucier A, Demers M. J Public Health Policy 1988	432 272 children in 1981 and 454 511 children in 1983 from the Quebec Children's Dental Care Program	Service rates for crowns, pulpectomies and pulpotomies and general anaesthetics following a fee reduction of 50% for the procedures	Restorative and endodontic procedures fell 59% and general anaesthetics fell 40%	Repeated cross-sectional descriptive study (III)

from a 172 Veteran's Affairs hospitals and whether the OC patients differed, by age or race, from all patients discharged from the same institutions. The Veterans Affairs database contains ICD-9-CM codes and individual records that can be linked to databases containing socio-demographic data (age and race).

We show the nine studies that reported patient-based determinants of care in Table 3. In the most recent, Boehmer et al. (56) found that, in Veterans Affairs patients, obtaining a root canal therapy, as opposed to an extraction, was associated with race. Three studies used the longitudinal properties of the data to assess the influence of previous restorative care (54), fluoridation (52) and patient health status (53) on the receipt of restorative services. The balance of the studies (48-51,55,56) treated the data as if it were assembled at one point in time, and therefore we scored them as cross-sectional (Level III). The stronger of these (49-51) examined the association between factors obtained from linked surveys of families or patients and used the service data as outcomes. With the concurrent links to service provider characteristics (53), some of these studies overlap with those reported in Table 1C.

Table 4 displays the three studies that used administrative databases as a tool in assuring quality or establishing standards of practice. In the most recent article, Rocky (59) reported on the use of the administrative databases to identify unusual practice patterns, the process serving as a screening tool for the further investigation of providers. Earlier articles showed that establishing 'tracer' sets could rule out 90% of the patient population and still identify 50% of the problem practices (57). Cohen (58) used an administrative database to develop 43 guidelines that might identify providers for further review.

Discussion

We set out to examine the potential for research using administrative databases containing dentists' claims. We found that these types of studies had been carried out to examine questions on: provider practices, the longevity or consequences of dental interventions, the prevalence of dental conditions, patient factors that determined care, and to establish quality assurance criteria or standards of care.

With their advantages of reflecting real-life experience, inexpensive data collection, numbers of patient years, and longitudinal nature, electronically maintained administrative databases of oral health care are ripe for analysis of oral health service provision. Since they are often established as the basis of dentists' claims submission or claims review, databases have inherent validity, given that they have met tests for financial audit purposes.

However, there are limits to the validity of findings derived from dental administrative databases (1,15). Coding errors, not corrected or eliminated in the data-cleaning process, should be random and not bias the findings. Nonetheless, there are several sources of potential bias. For example, given the limits to coverage in all plans, the findings may be biased by the potential for patients to obtain care outside the insurance plan. Especially for more affluent populations, additional services (such as orthodontic care) could be an important component of total care and the database would understate the actual care they received. In addition, and except for staff models of HMOs, insured patients may not represent the entire client group of any one dentist and the services may not be representative of that provider's pattern of practice and so may limit the use of the database for quality assurance purposes. Since, in most cases, the data do not describe the care that the non-insured population receives the findings are not population-based.

We found the strength of these studies difficult to classify. Even though they may have had several years of claims, some investigators analyzed the database as if it were cross-sectional data. The more informative of these studies treat the service data as outcomes and examine the influence of determinants, obtained from concurrent surveys of patients or providers. The strongest studies use all of the above, plus sophisticated modeling techniques. Other investigators have used the temporal properties of a database that contains several years of service records. However, even there, some are repeated cross-sectional analyses (Level III) where the authors describe the trends in care from year to year. Others assemble a single cohort of patients within the database, to describe the natural history or longevity of a service by identifying subsequent treatment of that patient or tooth. In one case, actual health outcomes, rather than service provision, were determined by findings from a separate screening examination (20).

Using the CTFPHC classification system (17), the strongest design we found was prospective or case-control, Level II-2. The investigation of the longevity or consequences of care (Table 2) consistently had stronger designs (Level II-2). The three reports on the pattern of care according to type of insurance also had designs (Level II-2) but could not control for selection bias on the part of both patients and providers.

The strongest of the longitudinal studies compare the outcomes of alternate treatments by assembling two cohorts and following them forward in the database until the patient/tooth is (re-) treated or not – see Table 2. The classification of these studies is somewhat complex given that the start of the investigation occurs after the data have been collected, so we have termed these retrospective two-cohort studies (II-2). Only two studies (41,43) employed a case-control design (II-2). The Caplan study (43) was a modified case-control design in that they followed one cohort of those who had been treated with root canal therapy until the result could be classified as a case or non-case and then looked backward into the patient characteristics to determine what might have influenced the outcome. The three insurance studies (not shown in a table) and three reports that began with the collection of base-line data and then obtained the subsequent ser-

Table 2
Consequences or longevity of interventions

Authors/Date	*Population*	*Intervention*	*Control*	*Outcomes*	*Critical Appraisal Comments*
Bogacki RE, Hunt RJ, del Aguila M, Smith WR. Operative Dent 2002.	300 753 adult patients with either amalgam or resin restoration Washington Dental Service Washington State USA 1993-2000 (9.5 yr of data)	Resin in posterior teeth	Amalgam in posterior teeth	Survival of restoration Probability of 5-yr survival with the same dentist: - amalgam = 0.94 - resin = 0.93 Probability of 7-yr survival with: - same dentist = 0.92 - diff. dentist = 0.60 16.4% greater chance of resin failure than amalgam (on a very low rate of failure)	Retrospective two-cohort study (II-2) All restorations followed for at least 6 months - many right-censored Lack of control such as what and how the material was used and, when the restoration was considered a failure
Weintraub JA, Stearns SC, Rozier RG, Huang CC. Am J Public Health 2001	15 438 children 61 752 first permanent molars 279 680 tooth-yrs North Carolina Medicaid child clients 1985-92 (8yr of data)	Sealants	No sealant	For children with sealed relative to those with no sealed teeth: - decreased likelihood of later restorations - decreased expenditures Effect greatest on high-risk children and up to 3 yr after placement	Retrospective two-cohort observational study (II-2); Potential bias towards underestimating effect of sealants due to selection of low-risk clients Not possible to identify sealants lost with time
Eklund SA, Pittman JL, Heller KE. J PublicHealth Dent 2000	15 190 children and 1556 dentists Delta Dental Plan Michigan 1990-97 (8 yr of data)	Professionally Applied Topical Fluorides (PATF)	No PATF	Number of interproximal surfaces restored Increase with: - younger children - dentists tendency to provide restorations - provision of sealants PATF had no effect on subsequent restoration rate	Retrospective two-cohort study (II-2) Regression analysis used to control for other variables $R^2 = 0.13$
Caplan DJ, Weintraub J J Public Health Dent 1997	Members of Kaiser Permanente Dental Care Program (144,000 clients), Oregon USA who received a root canal treatment in 1987 or 1988. 8 yrs of data.	CASES 96 root canal filled teeth (RCFT) lost by December 31, 1994 Factors associated for tooth loss abstracted from patient charts	CONTROLS 120 root canal filled teeth still retained by December 31, 1994	Median period for loss = 3 yr. RCFT loss associated with fewer proximal contacts (with adjacent teeth), older patients, facial trauma, missing teeth and higher plaque scores	Retrospective case-control study (II-2)

Table 2 - Continued
Consequences or longevity of interventions

Authors/Date	*Population*	*Intervention*	*Control*	*Outcomes*	*Critical Appraisal Comments*
Kuthy AR, Branch LG, Clive JM. J Dent Educ 1990	1 350 000 children aged 5-15 yr Private insurance carrier data Most from Washington, California and Alaska 1986-89 (3.3 yr of data)	Sealants - 419 children	No Sealant – 419 children matched by age and sex from database	Provision of one or more posterior tooth restorations: - to ~ 20% of both groups Total costs: - Sealant Grp = $532.7 - No sealant Grp = $385.4 Survival of posterior tooth surfaces vs receipt of posterior filling: - OR = 1.5 among sealed group	Retrospective two-cohort observational study (II-2) Threats to validity: - lack of tooth and surface specific information renders restoration provision and survival analysis ecological - fluoridation status, type of insurance, number of providers treating each child, not known but assumed similar due to matching
Whyte RJ, Leake JL, Howley TP. J Public Health Dent 1987;47(4):177-181.	4 525 children aged 5-15 with 11,237 sealants on first permanent molars Saskatchewan Dental Plan Saskatchewan, Canada Sept 1981- Mar 1984 2.5 yrs of data	Sealants on first permanent molars	No control group Health status assessed through independent survey and findings linked to service data	Follow-up care for two years. 90% Sealant present and sound in both years 5% Sealant resealed and sound 2% Sealant sound then resealed. 0.1% Sealant resealed and resealed again 3% All other outcomes	Retrospective single cohort study (III) linked to detailed screening data Sealant success ~ 97% over 2 yrs was higher in low caries group (97.8%) vs high caries group (95.9%) Chisq. p<.001

Table 3
Patient-based determinants of care

Authors/Date	*Population*	*Outcomes/Practices*	*Findings*	*Comments*
Boehmer U, Nancy R, Berlowtiz DR, Christiansen CL, Lewis E, Jones JA. Am J Public Health 2002	15,102 out-patients Department of Veterans Affairs USA 1997/8 (1 yr of data)	Probability of having Root Canal Therapy (RCT) vs an Extraction among racial groups Purpose of the study was to test source of reporting of racial data on health service findings	ORs of obtaining RCT vs Extraction = - Asians 1.83 - Blacks 0.53 - Hispanic 0.74 - Multiple (whites) 0.8	Descriptive study (III) Many subjects with unknown race/ethnicity Estimates of effect varied by source of information on race
Dasanayake AP, Li Y, Philip S, et al. Pediatric Dent 2001	~870 000 Medicaid eligible children aged 5-9 and 11- 14 yrs receiving care from 1990 -1997 Service data base linked to eligibility database 8 yrs of data	Receipt of a sealant	22% of continuously eligible children received one or more sealants Higher for females and whites	Descriptive study (III)

Table 3 - Continued
Patient-based determinants of care

Authors/Date	*Population*	*Outcomes/Practices*	*Findings*	*Comments*
Heller KE, Eklund SA, Pittman J, Ismail AA. Pediatric Dent 2000	9886 children aged 0-8 yr Delta Dental Plan of Michigan Michigan USA 1990-1998 (9 yr of data)	Probability of tooth treatment in the permanent dentition	Permanent tooth restoration most strongly predicted by previous treatment of primary posterior teeth among children 0-3 yrs (LR+ = 2.15)	Retrospective cohort study (II-2)
Grembowski D, et al. Medical Care, 1997	10,628 adults Washington State employees aged 20-34. From fluoridated and non-fluoridated communities 955 had base-line interviews and examinations and subsequent care obtained for 2 years from insurance database	Probability of receipt of restoration and mean number of restorations Findings linked to lifetime exposure to fluoride and status of tooth/restoration obtained by interview and examination at base-line	Specificity values of predictors usually higher than sensitivity values Exposure to fluoride reduced the initial caries prevalence and DFT counts but had little effect on subsequent restoration rates. Dentists restoration replacement decisions inconsistent with quality assessment at baseline Higher restoration rates in fluoridated site influenced by high concentration of dentists	Prospective study (II-2) of care provided over the two years following the interview.
Grembowski D, Fiset L, Milgrom P, Forrester K, Spadafora, A. J Public Health Dent, 1997 Grembowski D,	681 employees and spouses of Washington State followed for two years after an initial interview and oral health assessment. Dentists charactistics obtained in census survey of dentists. Treatment claims data obtained from insurer 2 yrs of data 985 children, aged 9-14,	Overtreatment = restoration of teeth with no decay or with satisfactory fillings Undertreatment = non restoration of teeth with decay or with unsatisfactory fillings Probability of receipt	>39% of adults had overtreament Overtreatment associated with more fillings at baseline, and dentists who were younger , with busy practices, advertised, charged higher fees, had solo practice, less continuing education 16% of adults had undertreatment Undertreatment associated with fewer decayed teeth or more missing surfaces or with dentists who believed in sharing info with patients, had a busy practice, or reported not placing restorations when there was radiographic evidence of caries	Prospective study (II-2) of care provided over the two years following the interview. Database findings on the care linked to both employee health status survey and provider survey results Descriptive study (III)

Table 3 - Continued
Patient-based determinants of care

Authors/Date	*Population*	*Outcomes/Practices*	*Findings*	*Comments*
Milgrom P Medical Care, 1988	from families insured under the Washington State employees plan 1982-1985 Four years of data	of restorative services and mean number of diagnostic, preventive and restorations Expenditures on dental care Findings linked to lifetime exposure and other factors obtained from base-line mailed questionnaire to parents	Exposure to fluoridation increased diagnostic, and preventive services Probability of restorations increased by supply of dentists but number of restorations among those getting at least one was reduced by fluoridation. Overall, children in markets with fewer dentists get fewer restorations independent of fluoridation status	Links service data with base-line assessment of need factors and fluoride exposure
Conrad D, Grembowski D, Milgrom P Health Services Research, 1987	Adults aged 20-34 from sample of 4173 families from the 1.2 million people insured under four types of plans with Pennsylvania Blue Cross in 1980 1 yr of data Mailed questionnaire to obtain family socio-demographic characteristics	Elasticities of: Probability of any use Expenditures among users Elasticities of: Probability of any use Probability of orthodontic use	Probability of use increases with older subscribers but younger spouses. Probability of use decreases with length of coverage Expenditures increase with education and decrease with duration of coverage	Descriptive study (III) Links socio-demographic data on the family with electronic records of use of dental services
Grembowski D, Conrad D, Milgrom P Health Services Research, 1987	Children in 2.9% sample of 1.2 million people insured under four types of plans with Pennsylvania Blue Cross in 1980 1 yr of data Sample mailed a questionnaire to obtain family socio-demographic characteristics	Expenditures among users Expenditures - all children	Increasing child age most important factor in increasing use. Age, cost sharing, and parent education predicts orthodontic use Increases in expenditures determined by age of child and length of coverage.	Descriptive study (III) Links socio-demographic data on the family with electronic records of use of dental services
Grembowski D, Conrad D, Milgrom P Am J Public Health, 1985	Sample of 8760 adults and 4209 children from the 1.2 million people insured under four types of plans with Pennsylvania Blue Cross in 1980 1 yr of data	Utilization by age-group; utilization defined as percent of of insureds filing at least one claim in 1980	Utilization (54%) higher than US Population (41%)	Descriptive study (III). Findings not controlled by income, education or other known determinants of utilization

Table 4
Establishing Quality Assurance / Standards of Practice Criteria

Authors/Date	*Population*	*Outcomes/Practices*	*Findings*	*Comments*
Rocky BN. J Canad Dent Assoc. 1988;54(11)817-819.	Provincial population Third party carriers of dental insurance British Columbia, Canada	Individual dentists' profile of procedures provided. Multiple outcome measures: - number of services per patient - number of any one service provided per patient - costs per service item rendered - cost per patient - per cent of patients receiving any particular service	Those dentists with frequencies beyond two standard deviations of the mean of those provided by dentists, with similar urban/rural location, and specialty, are investigated further Findings used to identify unusual provider profiles for quality assurance/ discipline purposes.	Multiple designs from cohort, by dentist, (II-2) to repeated cross-sectional (III)
Cohen J. Amer Fund for Dental Health & WK Kellogg Foundation, 1980	20,915 Delta Plan clients in Missouri 1974 to 1979 5yrs of data	PACE protocol guidelines for initiating reviews of dentists practices developed from professionally derived clinical guidelines and the pattern of practices revealed in the database	43 guidelines	Descriptive study (III) Policy development using health services data Guidelines not tested
DeVincenci RG, Ryge G. Calif Dent Assoc J. 1979	>100 000 claims from 1212 southern California dentists between 1971-1976	Dentists with patterns of practice that exceeded 'repeat ratios' established for 'tracer' services or combinations of services.' 645 patients of 'good' and 'bad' dentists, identified by the tracers, then examined to validate method	Using one specific tracer set as a screening tool could pick up 50% of the problem practices	Descriptive study (III) Well conducted but the establishment of the limits for repeat ratios established empirically.

vices from the database (40,52,53) were prospective in design and provide Level II-2 evidence.

The studies on patient, provider and market factors that influence care (Tables 1B, 1C, & 3) demonstrate that the pattern of care is consistent within, but highly variable between, dentists (29,30). The strong influence of provider and market factors (38,39,52,53) within the one insured group seems to be inconsistent with appropriate care.

One potential to improve such studies would be to include information on patient needs within the database. Where needs have been assessed in an epidemiological survey, investigators have noted that a high degree of the subsequent care is not consistent with the prior-determined health or need status (40,41,51). The inclusion of diagnostic codes (61) in administrative databases could allow for the analysis of the appropriateness and effectiveness (with subsequent diagnoses) of care.

In comparison to the studies on physician claims, the study of dentists' claims data appears under exploited especially in the areas of assessing changes in health policy and the impact of technology change. This may be the result of the limited nature of dental insurance schemes in that they are not universal and often lag the development of new technologies in their coverage. The finding that the provision of dental care is more variable than the estimate of need appears to have had little impact on public policy in dental care. This is in contrast to the study of medical care provision in Canada where high rates of variation identified in the analysis of the claims data, have been reduced by the issuance of guidelines and surveillance of surgical practices (62).

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