Developing Management Information from an Administrative Database of Dental Services: Identifying Factors that Influence Costs

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Abstract

Objective: *We describe service patterns and compare changes in program expenditures with the Consumer Price Index over eight years in a dental program with a controlled-fee schedule offered to Canadian First Nations and Inuit people.* ***Methods:*** *We obtained the computerized records of dental services for the period from 1994 to 2001. Each record identified the date and type of service, region and type of provider, age of the client and encrypted identifying information on clients, bands, and providers. We classified the individual services into related types (diagnostic, preventive, etc.). We aggregated the records by client and developed indices for the numbers of clients, mean numbers of services per client, cost per service, and prices.* ***Findings:*** *Over the 8 years, 16.0 million procedures, totaling $811.8 million, were provided to 538,034 different individuals, approximately 76% of the eligible population. Restorative procedures accounted for 36% of all expenditures followed by diagnostic (12.7%), preventive (12.2%), and orthodontic (8.9%) services. For much of the period, increases in program expenditures were exceeded by increases in the Consumer Price Index. This was consistent with fewer services per client, a less expensive mix of services, and relatively flat prices. However, in 2000 and 2001 higher prices and more clients resulted in increasing expenditures.* ***Conclusions:*** *Program expenditures were influenced by different factors over the study period. In the final two years, increasing expenditures were driven by price increases and increasing numbers of clients, but not by increasing numbers of services per client, nor a 'richer' mix of services.*

Key Words: dental records; utilization review; health services research; health services needs and demands; insurance, dental

Introduction

Canada's aboriginal people are made up of North American (First Nations) Indians, Metis and Inuit. Each group, and groups within each group, are characterized by unique cultural, language and geographic attributes. Indian Bands (traditional groups forming an administrative unit) have been allocated reserves in most provinces but there are no reserves in Newfoundland and Labrador or the Territories. Many First Nations people live off-reserve and in the Territories and increasingly in Saskatchewan, they make up a high proportion of the population.

Compared to other Canadians, First Nations groups have a much higher birth rate, 23.0 per 1000 population, twice that of other Canadians, and are younger, with 35% younger than 15 years old compared to 20% in the general Canadian population. Aboriginal Canadians have lower life expectancy than other Canadians, they have high prevalence of diabetes and among adolescent males, suicide and self injury are the leading causes of death. Aboriginal communities have high incidence of Early Childhood Caries (1) and children have much higher rates of dental caries (2).

Since signing treaties with First Nations in the late 19th Century, the Federal Government, through Health Canada, has provided health services, including dental services, for First Nations people. Over the years, as more dentists located in communities accessible to First Nations people, the dental program evolved from mostly direct service provision to eligibility to attend private practitioners. Originally, dentists invoiced the Regional Office of Health Canada for the services. In 1987, the program administration was both privatized and centralized. Since then, the program has operated much like a conventional dental insurance plan.

As part of the fiduciary role for the health of aboriginal people assumed by the Government of Canada, aboriginal people are eligible from birth for a range of health care services including dental services funded by the First Nations and Inuit Health Branch (FNIB) (3). In 2001, 706,000 were eligible for these programs. Covered services are defined for providers (~2000 denturists, who are a regulated health provession in all Canadian jurisdictions and 17,000 dentists) (4) in periodic mailings of fee schedules and program guidelines. Fees paid vary by jurisdiction. The federal government program managers set the fee schedule to approximate 90% of each provider's provincial professional association's previous year's fee guide. Providers directly invoice First Canadian Health, an administrative

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agency, which pays providers and maintains electronic records of the transactions. The price paid to providers for any one procedure is the lesser of what the provider invoices, or the set fee schedule in that jurisdiction.

About 60% of Canadians visit a dentist each year (5), but just over one-third (36% in 2001) (3) of First Nations people visit annually. Determinants of regular visiting have not been explored in First Nations populations, but formal education and economic status, which determine service utilization in the Candian population (5) are much lower in many Aboriginal families. In addition, distances to a dentist from a rural reserve would be greater than for those First Nations people living off-reserve in an urban area.

During the period under study, particular features of the program included payment for dental services provided to First Nations and Inuit people across Canada; no co-payments, deductibles or dollar limits; payment for relatively comprehensive care, including orthodontics; some limitations on frequency for provision of dentures and some major restorative care; and use of dentist-consultants to predetermine treatment plans exceeding $800 and some endodontic and major restorative services.

Clients were eligible, under an associated program, for reimbursement of long-distance travel costs for themselves and an accompanying adult, where necessary, if they had to travel outside of their own community to obtain emergency or specialists' care.

The current study forms part of a larger project aimed at the evaluation of the existing program and for the planning and development of policies to support the efficient use of program resources.

Evans has presented a framework for the determinants of health care expenditures (6). Under this framework, total expenditures under a health care program can be disaggregated into separate elements: the average expenditure per service (made up of the price per service and the relative 'mix' of expensive and less expensive services), the average number of services per client and the total number of clients using the program. The framework emphasizes the need to consider all elements when analyzing health care expenditures. To illustrate, suppose a Ministry of Health, interested in controlling total health care expenditures, decided to freeze a program's fee schedule. Total expenditures would continue to rise if providers increased the number of services per client, provided a 'richer' mix of services, or served more clients. Effective control of program expenditures can only be achieved if policy makers can manage all determinants of expenditure.

Information available under the universal health insurance programs of provincial ministries of health has been used by Canadian-based researchers to assess health policy; develop health status indicators (7); assess the urban/rural differences in access to care and utilization trends (8); measure the impact of technology change and health system reforms (9, 10); assess outcomes of care (11, 12); identify individual physicians' surgical workload (13); and document the variability in surgical rates (14, 15). In addition, these data have also been linked with surveys of representative samples of people to check on the accuracy of self-reported cases of disease (16) and to determine the costs of physicians' services to smokers (17).

Although dental insurance administrative databases have been used to examine provider practices (18), the consequences or longevity of care (19), prevalence of oral conditions (20), patient-based determinants of care (21), and to screen for quality of care (22), none was found that expressly set out to use administrative data to identify potential management policies.

We set out to describe trends in dental services utilization, namely to: identify frequency of use by clients; determine the frequency and distribution of the services for this population between and within the major categories of diagnostic, preventive, restorative, periodontal etc. services by service year; and identify the factors that influenced the trends in costs over the eight years of the database.

The purpose of this paper is to use the Evans' determinants of expenditure framework to analyze the pattern of expenditures observed in the NHIB program over the period 1994-2001. Specifically we considered the following: 1. Did real expenditures in the program increase (i.e., did increases in expenditures exceed the rate of inflation?) 2. Were the prices of services paid to dentists under the program increased in line with inflation? 3. Did services per client change in ways that 'compensated' for any change in the price per service after allowing for inflation?

Using Evans' model, given that prices for services were constrained by reference to provincial fee guides, and that eligibility was relatively constant over the limited time-period, only affected by births and deaths within the group, we hypothesized that, if there were trends in program costs, they would be driven by changes in the number and mix of services provided.

Methods

All patient, provider, and band identifiers were encrypted and the analysis was given expedited approval for ethics at the University of Toronto. The service utilization data were obtained on CDROM from Health Canada for each of 8 years, from 1994 to 2001. Each record contained 13 items including the service code, the tooth number, tooth surface, date of service, patient identification numbers (encrypted), band number (encrypted), date of birth, sex, provider identification number (encrypted), region of provider, type of provider (denturist, dentist - whether general practitioner or specialist type), the amount paid and the laboratory fee paid.

First Nations people remain members of their band no matter where they obtain care and Health Canada accounts for expenditures to the regions based on the use by members of the bands in that region. In order to compare our findings on regional expenditures with those of the

Department's, we obtained additional information on the region of the band for each encrypted patient number.

Data cleaning involved: 1. recoding the sex variable to provide a standard coding (1,2 vs M,F) for all provinces; 2. replacing blank or missing tooth-numbers with '00' as a 'legitimate' tooth-number if the service was a whole-mouth service such as an examination or a scaling procedure, and dropping the remaining 11,137 records with blank, missing, or illegitimate tooth numbers; 3. dropping records of procedures where refunds of fees were made to Health Canada for that procedure, plus dropping all records of refunds to ensure the file contained the services that had been validated by the financial audit process; 4. recoding all service codes to the 2001 CDA Uniform System of Coding and List of Services (23) plus those orthodontic codes used exclusively by the NIHB and then dropping all records with invalid service codes. 5. disaggregating the components of recall 'packaged services' (e.g., examination and tooth polishing) and assigning each to its appropriate service category. The fee paid for the packaged service was compared to the sum of the single items where they had been charged separately. Then the fees for the items in the package were allocated as that percent of the items separately.

We then aggregated the service utilization data into person-based records. For each person we: 1. organized related procedure codes into sub-categories of procedures (e.g., examinations) and then consolidated the sub-categories into one file for each of the ten major service categories (diagnostic, preventive, restorative, etc.). In general, the procedure codes were counted as one service for each procedure code (e.g., one examination, one denture). In the cases of radiographs, scaling and general anaesthetics, these were quantified according to numbers (e.g., bitewings counted as two radiographs) or time-units of 15 minutes. In this report we use the term services to include numbers of radiographs and time-units of scaling and general anesthetic administration; 2. identified each service, by category and calendar year of delivery; 3. derived a master client-level file containing all patient identifiers, band numbers, services by type and year, and paid amounts. Last, we validated the accuracy of these procedures by comparing the total numbers of service units in the service level master file with those in the client-level master file.

TABLE 1
Percent of estimated eligible population receiving one or more services in the NIHB Dental Program in 2001 and 1994-2001

Age	Population[29] of First Nations and Inuit people in Canada 2001 (000s)	Percent of 2001 population with a service in 2001	Percent of 2001 population with at least one service during 1994-2001
0-4	59.7	21.5	27.2
5-9	80.1	45.6	76.6
10-14	76.1	47.7	86.1
15-19	66.2	39.2	85.6
20-39	235.7	35.7	82.7
40-59	136.7	34.2	80.2
60 and older	51.5	20.1	64.8
All	706.3	35.8	76.2

For the analysis of the data, age was assigned as the age at the end of the study, so that children under age eight were not alive for all years of the study period. We derived the age-specific numbers of clients with one or more services in each of the eight years and calculated the utilization for each year and for the full eight years using population estimates for First Nations and Inuit people in 2001. While this assumes a constant size and age distribution in each region over the eight years, the estimates of First Nations people in any one year are not so precise, so that year- to-year comparisons with the estimates would be more valid.

Having compiled information for the services provided in each of ten categories, we computed the age-specific probability of a client receiving a service, and the mean number of services per client over the eight-year study period. We also derived information on the number of services per client and the paid amount per service for each year and derived indices by expressing the data for each year in relation to base year (1996) values which were set to 100. Following the approach of Evans (6), we disaggregated expenditures over time into components of prices, numbers of clients and services per client. To examine price changes while controlling for any change in the mix of services, we established a 'standard basket' of the 95 most common procedures provided in 1996 and created an index of price change using 1996 as the base (100). From our initial review of the data, 1996 appeared to be the first year where the services were relatively stable and these 95 procedures made up 90% of all services.

Findings

The initial files contained 12.9 million service records covering $827.6 million in expenditures. Data cleaning resulted in 12.8 million records with $811.8 million of expenditures. Following the 'unbundling' of the packaged services, adjustments for actual counts of radiographs and units of scaling and aggregating by patient, these $811.8 millions were made up of 16.0 million services provided to 538 034 different clients. In all, the database includes information on 1.9 million patient-years of services.

The age-specific populations and percent with one or more services for the entire study period (1994 to 2001) and for 2001 are shown in Table 1. Just more than one third of the population received a service in 2001 and over three quarters received at least

TABLE 2
Distribution of services and expenditures 1994-2001 by service category

Service Category	Percent of time/ service units (n = 16,039,587)	Percent of amount paid (n = $811,845,849)	Mean number paid per client* (n = 538,034)
Diagnostic	37.1	12.7	11.0
Preventive	25.8	12.2	7.7
Restorative	21.1	35.8	6.3
Endodontic	1.8	5.8	0.5
Periodontic	2.1	2.8	0.6
Removable prosthetic	1.5	12.1	0.4
Fixed prosthetic	0.1	0.3	0.03
Surgical	6.0	6.8	1.8
Orthodontic	1.7	8.9	0.5
Adjunctive	2.9	2.4	0.9

*Total mean number = 29.8 services (may not add due to rounding)

FIGURE 1
Mean number of time/service units per client 1994-2001

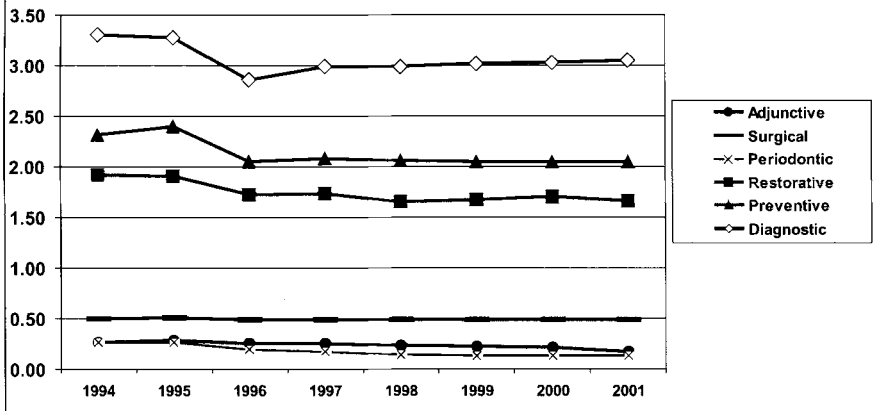
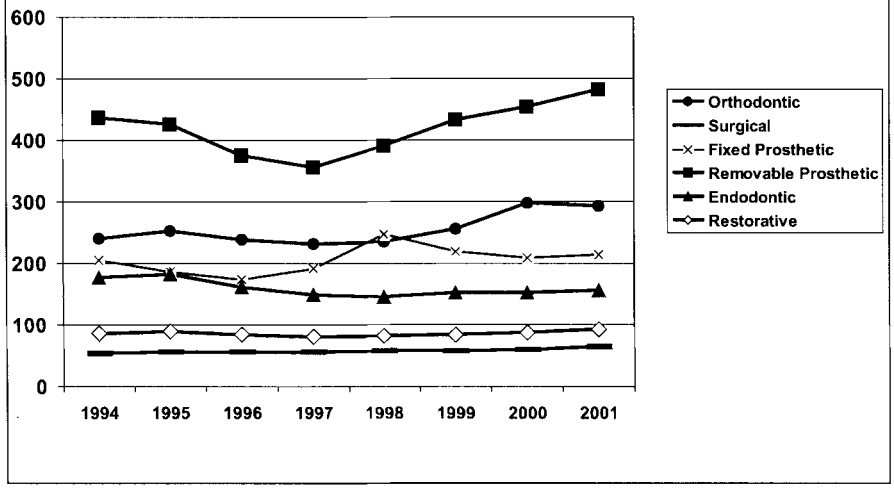


FIGURE 2
Cost per time/service unit by service category 1994 - 2001



one service at some time during the study period. In 2001, utilization was highest for the 10-14-year-olds followed by the 5-9-year-olds. While not shown in the table, highest utilization occurred in Alberta where over 87% of the First Nations and Inuit people had one or more services paid for by this program. The regions with the lowest utilization were Ontario and Manitoba.

Table 2 shows, by service category, the distribution of services and total expenditures and the mean number of services per client. Over the eight-year period, the mean number of services per client was 29.8. Diagnostic and preventive services made up almost two-thirds of all services but constituted less than one quarter of the total expenditures. In contrast, restorations represented 21% of services but nearly 36% of the amounts paid. The share of expenditures on removable prosthetic and orthodontic services far exceeded their share of total services.

Little is known about the mix of services in this or other populations, since 'insured' groups with such a comprehensive list of service coverage and no deductibles or co-payment requirements are rare. Table 3 shows the percent of clients receiving one or more services (the probability of service) and mean number of services by age group and service category over the whole eight years. The probability of service use is highest for diagnostic services, followed by preventive, restorative and oral and maxillofacial surgery. For all services combined (last row) mean service use peaked for the 15 to 19-year-olds at 37.1 services and then fell for older groups to about half (18.7) of the peak for those 60+ yrs. Preventive, restorative and oral surgical services followed that pattern, as did orthodontics, but for the latter, over a narrower age range. Both adjunctive (mostly sedation/general anesthetic) and endodontic services peaked among 5 to 9-year-olds but then had a second peak among the 20 to 39-year-olds. Periodontal, removable and fixed prosthetics increased with increasing age in both the probability of use and in the mean numbers received.

TABLE 3
Percent of clients receiving services (mean number received) by age and service category - 1994-2001

Service Category	Age 0-4	Age 5-9	Age 10-14	Age 15-19	Age 20-39	Age 40-59	Age 60+	All Clients
Diagnostic	96.6 (2.6)	98.0 (6.9)	98.9 (12.5)	99.0 (13.5)	98.7 (12.6)	94.5 (11.2)	85.2 (6.2)	96.9 (11.0)
Preventive	60.4 (1.3)	86.6 (5.2)	92.1 (10.9)	91.4 (11.2)	85.6 (7.7)	73.7 (7.3)	43.7 (4.3)	81.3 (7.7)
Restorative	52.4 (4.1)	74.1 (6.4)	82.4 (7.1)	82.3 (6.9)	80.5 (6.8)	70.9 (5.8)	38.7 (3.0)	74.8 (6.3)
Endodontic	27.9 (0.9)	38.4 (1.2)	28.9 (0.6)	16.3 (0.3)	26.4 (0.5)	24.7 (0.4)	11.4 (0.2)	25.8 (0.5)
Periodontic	1.0 (0.0)	2.1 (0.0)	3.7 (0.1)	8.3 (0.2)	25.5 (0.8)	30.4 (1.4)	16.6 (0.8)	18.1 (0.6)
Removable Prosthetic	0.0 (0.0)	0.0 (0.0)	0.3 (0.0)	0.8 (0.0)	9.9 (0.2)	42.9 (1.1)	69.9 (2.1)	16.8 (0.4)
Fixed Prosthetic	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.1 (0.0)	1.1 (0.0)	2.2 (0.1)	1.0 (0.0)	0.9 (0.3)
OMF Surgery	35.8 (1.4)	48.7 (1.9)	58.4 (2.1)	50.3 (1.6)	55.0 (1.8)	45.9 (1.7)	39.7 (1.8)	50.8 (1.8)
Orthodontic	0.0 (0.0)	0.7 (0.0)	10.0 (0.6)	21.9 (2.7)	4.1 (0.4)	0.0 (0.0)	0.0 (0.0)	5.1 (0.5)
Adjunctive	14.0 (0.8)	25.2 (1.7)	19.9 (1.2)	13.4 (0.7)	19.6 (0.9)	16.0 (0.5)	13.5 (0.3)	18.3 (0.9)
All Services	100.0 (11.2)	100.0 (23.0)	100.0 (35.2)	100.00 (37.1)	100.0 (31.6)	100.0 (29.5)	100.0 (18.7)	100.0 (29.8)

TABLE 4
Indices of factors contributing to the changes in total expenditure 1994-2001 (1996=100)

Year	Number of Clients		Number of Services per Client		Time/Service Units		Price of "Standard Basket"	Total Annual Expenditure		CPI All Items*
		Index		Index	Mean Cost per Unit	Index	Index		Index	
1994	223,825	92.8	9.02	112.3	$51.03	100.8	99.0	$103,055,812	105.1	96.3
1995	243,222	100.8	9.14	113.7	$53.90	106.5	102.0	$119,814,005	122.2	98.4
1996	241,197	100.0	8.03	100.0	$50.60	100.0	100.0	$98,056,810	100.0	100.0
1997	241,329	100.1	8.17	101.7	$48.75	96.3	101.0	$96,093,388	98.0	101.6
1998	244,476	101.4	7.98	99.4	$48.27	95.4	102.0	$94,218,720	96.1	102.5
1999	244,754	101.5	8.00	99.5	$48.75	96.3	102.0	$95,433,714	97.3	104.3
2000	248,403	103.0	7.99	99.4	$50.34	99.5	104.0	$99,915,645	101.9	107.1
2001	252,905	104.9	7.88	98.1	$52.79	104.3	112.9	$105,257,756	107.3	109.9

Note: The index is created by dividing the number for the year by that for 1996.

Figure 1 tracks the mean number of services per client over time for the six most frequent categories of service. As seen, the mean numbers of diagnostic, preventive, and restorative services fell in 1996, but then became virtually constant over the years 1997-2001. While surgical services remained relatively constant, periodontal services fell steadily, from 0.27 per person in 1994 to 0.13 in 2001 and adjunctive from 0.27 to 0.17. The mean number of services of the other five categories stayed relatively constant at 0.2 per person or less.

Over the eight years, mean cost per service for all categories increased from $51.03 to $52.79. Figure 2 displays the trends in costs per unit of service for the six categories with the greatest variation. The costs per service varied within a narrow range for the four categories not shown with adjunctive, diagnostic and periodontal services ending $6.00, $1.20 and $0.50 higher respectively and preventive services ending $3.00 lower than in 1994. For those shown in the figure, only the mean costs for endodontic services ended lower (by $21.80) than in 1994; mean costs for surgical, restorative and fixed prosthetic service both rose and fell ending at $10.00, $6.60, and $3.50 higher than in 1994. However, costs per unit for both removable prosthetic and orthodontic services increased dramatically, particularly over the last four years. By 2001, the mean amount paid per service category ranged from $18.20 for diagnostic services to $482.50 for removable prosthetics.

Table 4 provides the numbers of clients, mean number of services per client and expenditure per service together with an index score for each of these variables and the price index calculated for the 'standard basket' of 95 services and the Consumer Price Index (CPI) in relation to their 1996 values. In principle we would have preferred to choose the first year of the study period, 1994, as the baseline for these calculations. However, because of fluctuating numbers of clients over the 1994-1995 period, we elected to use as the reference year 1996, when

the client numbers had become more stable. Hence the value of all variables was set at 100 for 1996 and values of each variable for other years were expressed as a percentage of the 1996 value.

So, for example, the CPI in 1995 and 2001 was 96.3% and 109.9% of the 1996 value respectively. In other words, between 1996 and 2001 the CPI increased by almost 10%. Total expenditures fell from the peak of 122.2% (of the 1996 value) to 96.1% in 1998, and then rose to 107.3% by 2001. Thus, between 1996 and 2001 expenditures increased by less than the rate of inflation. On the other hand, the number of clients rose steadily, by almost 5% between 1996 and 2001. Given the rise in the numbers of clients, the fall in the expenditures from 1995 to 1996 was explained by decreases in both the number of services per client and the cost per service between these years. However, the further decline in the expenditure index between 1996 and 1998 appears to have been the result of a reduction in mean costs per service of 4.6%, since the number of services per client remained almost constant. The 2000-2001 rise in total expenditures was driven by a combination of increases in the numbers of clients and price per service tempered by the continuing fall in the number of services per client.

Examination of the price index based on the 'standard basket' of services shows relatively stable prices from 1994 to 1999 – the index varies between 99% and 102% of the 1996 value – but shows an accelerating increase thereafter. In the face of the steep increase in prices in 2001, providers must have provided a less expensive mix of services in that year compared to 2000, given that the mean cost per service rose by considerably less (from 99.5% of the 1996 value to 104.3% of that value). Indeed it appears that a less costly mix of services had been provided every year between 1995 and 2001, as during that interval, the price index of the standard basket exceeded the mean cost per service index.

Discussion

Using administrative data based on utilization records of clients of the First Nations and Inuit Health Branch of Health Canada, we have developed age-specific profiles of care for this population. We have conducted an analysis of the service profiles and the changes over eight years. From this we have developed information on the 'demand' side of the determinants of the total expenditures. For the years 1994 to 2000, we did not find evidence to support our hypothesis that in the face of constrained prices, the mix of services would become 'richer' as compensation. Rather we found the opposite, namely, that total expenditures in the program at first came to, and were then maintained below, the rate of inflation apparently by means of: limited price increases; at first fewer and then constant number of services per client; and a continuing trend towards a less expensive mix of services.

During this period, expenditures increased by less than the rate of inflation in spite of a slight increase in the numbers of patients. This finding is inconsistent with the experience of some private dental insurance schemes in which cost increases have been reported to greatly exceed past rates of inflation (24) and continue to do so (25).

What accounts for this lower-than-expected rate of increase? Precise details of program administrative initiatives are vague. We understand that some service frequency limitations were introduced in 1995 and a predetermination pilot study began in one province in 1996 and was fully implemented across the country in 1997. Consistent with these changes, we observed dramatic falls in the numbers of services per client between 1996 and 2000 and in the mean cost per service from 1996 until 1999. In 2000 and 2001, total expenditures rose when the number of clients increased somewhat and that the prices paid per service increased dramatically.

While we cannot entirely explain the findings, their validity is strengthened by the comprehensive nature of the data set. The study material includes all the services paid out on a fee-for-service basis and over 1.9 million patient-years of care. Given the full extent of services covered, the proportion of First Nations and Inuit people needing and willing to pay for additional or alternative care outside the program is likely to be very small.

However, the database does not contain all services for all First Nation and Inuit people in Canada as Health Canada operates two other models of primary dental care for those First Nations and Inuit people living in communities not served by private dentists. The proportion of people who normally obtain care from the two other models and also receive services in the fee-for-service model is unknown, but is believed to be limited to those who have to be evacuated from remote communities for specialist care. In a typical year, about 93% of the dental expenditures on behalf of First Nations and Inuit people occur in the fee-for-service model studied here (26).

Comparing our findings with other studies is difficult since the other studies are relatively few in number, perhaps because such information on dental plans is deemed proprietary, or because they have been conducted on very different populations and for purposes different than examining factors influencing costs. In addition few, or probably no, private plans have such extensive first-dollar coverage and where clients can have travel costs paid. However, Grembowski *et al* (18) have found that employees of a Washington school district, received 6.4 services over two years (3.2 per year) with diagnostic and preventive services making up 63% and restorative care making up 28%. Among a cohort of Alberta elderly, diagnostic and preventive services made up 49.7% and restorative care 20.6% of all services (27). In this study, First Nations and Inuit clients received 29.8 services over 8 years (3.7 per year) with diagnostic and preventive services constituting 62.9% and restorative care making up 21.1% of the ser-

vices. Orthodontic services were not listed in these other two studies and we found they made up 1.7% of services units but nearly 9% of costs.

In comparison to these other studies, one might have expected a relatively greater provision of restorative procedures for First Nations and Inuit clients arising from the evidence of higher disease incidence and lower utilization of services (allowing needs to accumulate) in this population. Unfortunately, any analysis of the link between needs and services is not possible because we lack an independent estimate of health or need for the services. While other authors (21, 28, 29) have been able to explore these relationships using linked data on epidemiological needs, such data were not available for our population. In addition, no other diagnostic information or codes (30) are collected and retained in the database.

We have demonstrated the factors driving the trends in costs from the 'demand' side using the client as the basis of the analysis. Further analysis of the database could examine the extent to which the fees changed and, if they did not, why did providers provide a cheaper mix of services? These might emerge from an examination of provider characteristics that others have noted strongly influence the provision of care. Finally linking these service data to measures of health status would enable an examination of the influence of health needs on the expenditures.

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