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Comparing the Value of Three Main Diagnostic-Based Risk-Adjustment Systems (DBRAS)

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Note (1): After completion of analyses and initial reports of findings to Ontario and Quebec, Dr Berlinguet became a consultant for 3M-HIS in February 2005 and international medical director for 3M-Health Information Systems, August 26, 2005.

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Key Implications for Decision Makers

- Diagnostic-Based Risk-Adjustment Systems (DBRAS) are now widely used in the United States by healthcare payers and providers to identify the health status of individuals and predict their expenditures for the same year or the next year. That requires linking all diagnoses over a period of a year for an individual (from the same administrative databases input files as diagnosis related groups (DRG)) and generating one (for the categorical systems) or many groups (for the so-called dichotomous variables groupers) for each individual. These systems can be used for funding under a capitation arrangement, identifying high-cost patients for case management, monitoring health status of groups of enrolees, and planning and evaluating the health services.

- The lead researchers secured access to large development and validation samples from Ontario, Quebec, and Alberta. Evaluation licenses from three most relevant DBRAS were obtained, the ADG/ACG system from Johns Hopkins University, the HCC/ DCG system from DxCG Inc., and ACRG2/ CRG from 3M Inc. Data were processed successfully. All diagnoses coming from fee-for-service and hospital discharge summaries were used and pooled for each patient.

- The design involved measuring an expected cost and an observed cost for each individual of a validation sample for the same year (concurrent model) and for the following year (prospective model). Retrieving all expenditures from fee-for-service medical billings and/or acute hospital expenditures for inpatient services or ambulatory day surgeries is needed to calculate weights. Evaluation was done initially in all three provinces using socio-economic adjustments in addition to age and gender, and the three DBRAS systems were much better predictors of costs. Then our core comparative evaluation between DBRAS showed that the HCC/DCG system slightly outperformed the ACRG2/CRG model and more so, outperforms the ADG/ACG for cost prediction power for medical fee-for-service expenditures, hospital inpatient and ambulatory expenditures, and total cost. Some results varied much between provinces for same groupers.

- These systems are never used to predict individual expenses but rather to estimate expenses for groups of people with similar conditions. Predictive ratios (expected over observed costs) pool expenditures for many individuals. Hence, the prediction is much greater with groups of people. Still, we observe that these systems over-predict costs for the groups (here deciles: meaning all population sampled divided in 10 equal bins) in the lower-cost deciles, and under-predict for higher-cost deciles.

- Three main evaluation criteria were developed in January 2004 and used to rate each DBRAS grouper: 1) clinical and administrative value of categories; 2) discrimination and predictive value of categories; and 3) transparency, ease of use, and simplicity of resource weight calculation (see table 15 in the full report). All groupers are good and sound but decision makers shall select the one that fits their needs. Since then, clinical risk groups (CRGs) have been proposed in 2004 by the Quebec Ministry of Health for severity adjusting capitation payment of GPs; and the Calgary Health region has since acquired an operational license of CRGs.

Executive Summary

This research project was initiated in July 2000 when a group of public servants from five provinces west of New Brunswick met in Calgary to share funding mechanisms for acute healthcare and identify research priorities. Encounter groupers like Diagnostic Related Groups or the Canadian CMG (TM CIHI) have been used extensively to measure products of hospitals; a new type of groupers called Diagnostic-Based Risk-Adjustment Systems (DBRAS) were more widely used south of the border by healthcare payers and providers to identify health status of individuals, and predict their expenditures for the same year or the next year. That required linking together all diagnoses (and some interventions for at least one grouper) over a period of a year for an individual (from the same administrative data bases input files as DRG) and generating one (for the categorical systems) or more groups (for the so-called dichotomous variables groupers based on additive multiple linear regression models) for same individuals. It also involves retrieving all expenditures from fee-for-services medical billings and/or acute hospital expenditures for inpatient services or ambulatory day surgeries. These systems can be used for funding under a capitation arrangement, identifying high-cost patients for case management, monitoring health status of groups of enrolees over many years, and planning and evaluating the health services.

The lead researchers based in three provinces at the Calgary Health Region, Regie de l'Assurance Maladie du Québec, and the Ontario Ministry of Health and Long-Term Care secured access of large and representative development and validation samples from each province for the years 1997/1998 (only Quebec and Ontario), 1998/1999, and 1999/2000 (all three provinces). The clinical information of all those individuals was linked together and the medical fee-for-service and acute inpatient and ambulatory surgeries expenditures for the same year and the following year were linked and estimated. Evaluation licenses from three most relevant American providers of such DBRAS were obtained, namely the ADG/ACG system from Johns Hopkins University, the HCC/ DCG system from DxCG Inc., and ACRG2/ CRG from 3M Inc. Data were processed successfully. All diagnoses coming from fee-for-service (private offices, clinics, and emergency rooms) and from hospital discharge summaries were pooled for each patient. The number of invalid diagnoses was less than one percent in each province. Frequency distribution in each province and with American databases was comparable and reviewed by the developer of each system and proved valid.

Evaluation of predictive power of the best predictive models of the two dichotomous variables models (ADG and HCC) were done, while a least performing model (ACRG2) was selected for the CRG system (mutually exclusive categorical model) because the number of categories (maximum: 149) was a better match with the other two systems and that 16 sub-groups of age and gender cells were added to the explanatory models, which would have made the total number of possible combinations too high to have used the most detailed model encompassing a maximum of 1,075 cells.

The methods involved measuring an expected cost and an observed cost for each individual from a validation sample for the same year (concurrent model) and for the following year (prospective model). In order to identify an expected cost, estimation of expected costs was done prior to that with another independent random sample. The way the CRG weights were calculated was to average the costs for all individuals in the same ACRG2 group, severity level and age and gender

sub-group, much akin what is done for the encounter groupers DRG/CMG. Capping (truncation) of costs at the 99^{th} percentile was also done, and all analyses used both the raw expenditures and the truncated value for each of the specific buckets of medical fee-for-service expenditures, acute care hospital expenditures (inpatient and ambulatory surgeries), and total expenditures (sum of fee-for-service and hospital expenditures). For the dichotomous variables groupers ADG and HCC, because one individual may be described by one or many groups at the same time, multiple linear regression calculations were done to derive coefficients that were then added to obtain a final scoring weight and estimated cost. Once expected costs and observed costs were obtained for each individual, the next and final step to quantify predictive power of each system was to proceed with a simple linear regression model where the variable to be explained is the observed cost, either the raw cost or the truncated cost for same year expenditure or for the following year expenditures.

When all three systems were compared with using only age and gender 16 sub-groups as predictors, the explained variance (maximum of 1.00) for each and all individuals for the same year, Quebec total raw costs was only 0.04 for the age/gender adjusters while 0.43 for the best model CRG there, and 0.07 for the truncated costs in relation to 0.55 for the ACRG2/CRG model. As for explanation of the following year costs (prospective model), the comparable results were, for the age/gender adjuster, 0.07 in the untruncated (raw) costs model and 0.04 for the truncated model, while respectively 0.17 and 0.12 for the best performing DBRAS grouper in that test in Quebec, ACRG2/CRGs.

Evaluation was initially done in all three provinces of using socio-economic adjustments in addition to age and gender. Here again, using Ontario and ADG as examples in this report but the same magnitude of results in Quebec, while slightly higher in Alberta where an individual measure of SES is done (mean test), the explained variance was much lower using SES ecological (measured not on individuals but on geographic location) values and age/gender adjusters than using one DBRAS, here ADG. The results were 0.03 (truncation on costs) and 0.01 (no truncation of costs) versus 0.37 and 0.21 for the ADG concurrent total costs models, while the following results were produced for the prospective model (explanation of next year costs): 0.03 (truncation) and 0.01 (no truncation of costs) for the SES+ age/gender adjusters versus 0.14 and 0.16 for the ADG models with age+ gender adjustments.

Tables 10 and 11 (in the full report) summarize all results for all costs buckets for the three provinces tests. In general, the HCC/DCG system slightly outperformed the ACRG2/CRG model and more so, outperforms the ADG/ACG. Some results varied between provinces for same groupers. For example, one explanation for the relatively poorer performance of ACRG2/CRG models in Ontario and Alberta may be due to the distinction between principal and secondary diagnoses were not retained in the grouping process for these two provinces while it was done in Quebec. Another factor may have been the higher variability of expenditures in those two provinces, both for the medical fee-for-service and hospital costs: given that the explained variance from the regression is measured by squaring the differences between observed and expected, this may have had a larger impact on CRGs, especially because this classification only retains one mutually exclusive group per individual and not one or many as the dichotomous variables ones (in the ADG and HCC models). Finally, in Ontario and even more so in Alberta, more diagnoses were available for each patient given in Ontario for the medical billing up to two diagnoses could be documented, and in Alberta, diagnosis information from the emergency rooms and outpatients clinic hospital administrative systems were also available: this may have also favoured the two other groupers in relation to ACRG2/CRGs.

Overall, the relevance of higher explained variance proportion has to be put in perspective. First, if one sees that there is a 0.50 explained variance for one system at the individual level, that roughly means that it is almost like tossing a coin to predict right amount of spent expenditures for same year; and 0.20 is that much lower to explain next year expenditures. Obviously, there is more than meets the eye, and that is why predictive ratios are so useful to consider (see Figure 15 in the full report): they pooled expenditures for many individuals and there the predictive power is much stronger. Indeed such systems are never used to predict on individual expenses but rather to estimate expenses for groups of people with similar conditions. The prediction is much greater, even if we see that these systems usually over-predict costs for the groups (here deciles: meaning all population sampled divided in 10 equal bins) in the lower-cost deciles, and under-predict for higher costs deciles. The exception here is that the regression models that contain negative coefficient artificially create negative costs here if such groups are not pruned from the models tested, which we did not do, in order to secure similar comparison with all same cases and no manipulation.

In the final analysis, the investigators went through a semi-structured consensus methodology (quasi Delphi) to come to three main evaluation criteria to rate each and all groupers: 1) clinical and administrative value of categories (face value/clinical relevance and level of granularity for epidemiological applications); 2) discrimination and predictive value of categories (accuracy and precision for cost prediction); and 3) convenient resource weighting (transparency, ease, and simplicity of calculation). Table 11 in the full report provides our collective rating for each DBRAS.

Criterion/Product	**Clinical Relevance**	**Resources Prediction**	**Convenient Resource Weighting**
ADG/ACG	+	+ +	+
DCG-HCC	+ +	+ + +	+
CRG	+ + +	+ +/+ + +	+ + +

The Calgary Health Region has since acquired an operational license of CRGs; and CRGs have been selected by the Quebec Ministry of Health for capitation payment of GPs.

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DBRAS and Examples Fom the Three Selected Ones

Diagnosis-based risk adjustment systems (DBRAS) classify enrolees or patients to identify individuals with one or many health status groups. This process requires taking into account diagnosis information from administrative files that describe inpatient or ambulatory encounters (mainly day procedures) from acute episodes of care in hospitals, diagnosis information from medical billing slips, and/or other diagnosis information coming from emergency rooms or hospital clinics. If no diagnosis information is available from the above sources, pharmaceutical information from pharmacy billings from drug reimbursement schemes are often used, even if they do not have the same discriminatory power as the diagnosis information.

Two types of DBRAS are available. The first one is called mutually exclusive categorical system and is akin to diagnosis related groups (DRG), as a patient/enrolee is categorized into only one group. The second kind of system, a so-called dichotomous variables or regression models system, has patients being described by one or many dichotomous variables (condition present or not) groups or categories.

Out of the three systems evaluated, the Version 1.2 of the clinical risk groups (CRG) System from 3M-HIS Inc. is of the first kind, namely categorical in nature with only mutually exclusive groups. The best performing models of the two other groupers evaluated and used for this project are the ADG Model of the A.C.G. System, Version 4.3, from Johns Hopkins University; and the Hierarchical Co-existing Conditions (HCC) Model, Version 5.1, DCG System from DxCG Inc. These last two are dichotomous in nature, the former enabling identification of one or many of 34 disease status for each individual, while the HCC/DCG model enables classifying one person with one to 118 dichotomous categories.

Only the CRG system utilizes a list of 28 non-discriminatory procedures (like heart transplant or kidney transplant) to add to the definition of health status. The CRG system has many levels of granularities; we used an intermediate one, the so-called ACRG2, which places one enrolee in only one of 149 aggregated groups (including severity levels) while the full system contains up to 1,075 groups (depending of the dataset at hand).

Tables 1 to 3 provide examples of each of these systems and their relative frequency distribution for one of the Ontario datasets used in this project.

One general remark that was made by clinicians and administrators during this project and that will be used as a final evaluation criteria to select "best DBRAS system" is the clinical relevance of the categories, which is less for the ADG/ACG system, more clinically relevant for the HCC/DCG system, and most from the CRG system (even if the example in Table 3 is at the ACRG2 level of granularity, which lumps many conditions that are discrete entities at finer level of granularity than ACRG1 and CRG).

ADG	Description	Percent
1	Time Limited: Minor	19.5%
2	Time Limited: Minor — Primary Infections	44.0%
3	Time Limited: Major	4.2%
4	Time Limited: Major — Primary Infections	4.6%
5	Allergies	5.2%
6	Asthma	5.7%
7	Likely to Recur: Discrete	24.0%
8	Likely to Recur: Discrete — Infections	16.3%
9	Likely to Recur: Progressive	2.3%
10	Chronic Medical: Stable	33.2%
11	Chronic Medical: Unstable	15.0%

Table 1: ACG/ ADG system (Johns Hopkins University) Ontario DBRAS Sample 1998-1999. Note: As ADG are non-mutually exclusive categories, total is more than 100 percent

Number	HCC Definition	Ontario (rate per 10,000)	U.S. commercial insured population (rate per 10,000)
001	HIV/AIDS	7	7
002	Septicemia/Shock	17	27
005	High-cost Cancers	31	14
008	Low-cost Cancers/Tumours	165	121

Table 2: DCG/HCC from DxCG Inc. Ontario 1998-1999

Number	ACRG 2 Definitions	Severity Level	%
100	Healthy	0	34.05%
230	Significant Acute — One excluding ENT MDC	0	1.53%
400	Multiple Minor Chronic Diseases	T	3.71%
520	Dominant or Moderate Chronic — Circulatory	1	14.35%
520	Dominant or Moderate Chronic — Circulatory	2	2.32%
520	Dominant or Moderate Chronic — Circulatory	3	0.58%
520	Dominant or Moderate Chronic — Circulatory	4	0.48%
520	Dominant or Moderate Chronic — Circulatory	5	0.07%
520	Dominant or Moderate Chronic — Circulatory	T	17.79%
630	Pair — Diabetes and Hypertension or a Minor Chronic Disease Level 2	T	0.92%
810	Metastatic, Dominant, or Complicated Malignancies	T	1.95%

Table 3: ACRG2. Examples of categories and severity levels. DBRAS Ontario sample. 65 yo+ 1998-1999. Note: T means Total

Using the CRG group Diabetes total counts and total (hospital + physician services costs) for Ontario in 1997-98, Figure 1 exemplifies the potential of DBRAS to identify the 253 individuals who have much higher costs than the rest of such individuals with only diabetes and no other chronic or major health condition in the Ontario sample used (sample of less than 18 percent of total population). Contrary to most other CRGs and for all ACRG2 tested in the three provinces minus a few exceptions, there is no clear monotonic increase between severity levels 1 and 3 here.

Figure 1

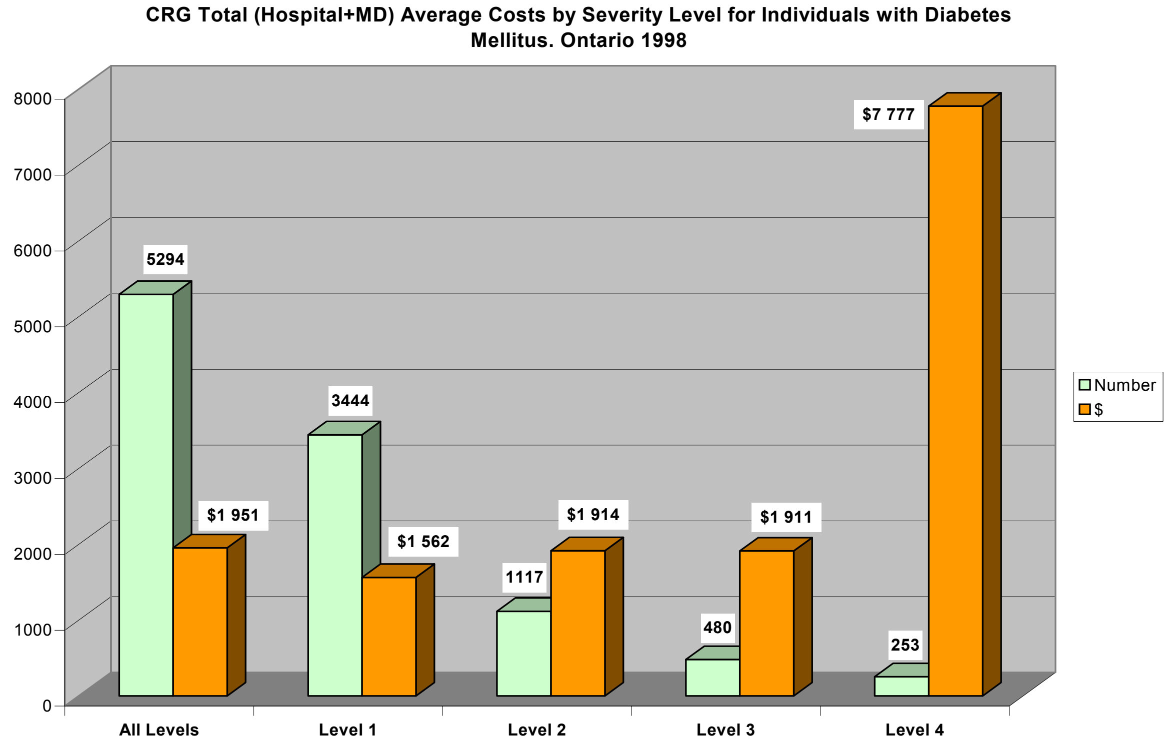


Figure 2 shows the effect of age on percentage distribution by each of the mutually exclusive ACRG3 health status for all Quebec RAMQ enrolees (7.3 million) using only medical fee-for-service diagnosis information. Notice the relative increase of health status after 85 years old due to the death of younger, sicker enrolees, which is an interesting finding. This phenomenon was observed for all three provinces using our sample diagnoses information from all sources, medical billing and hospital separations forms.

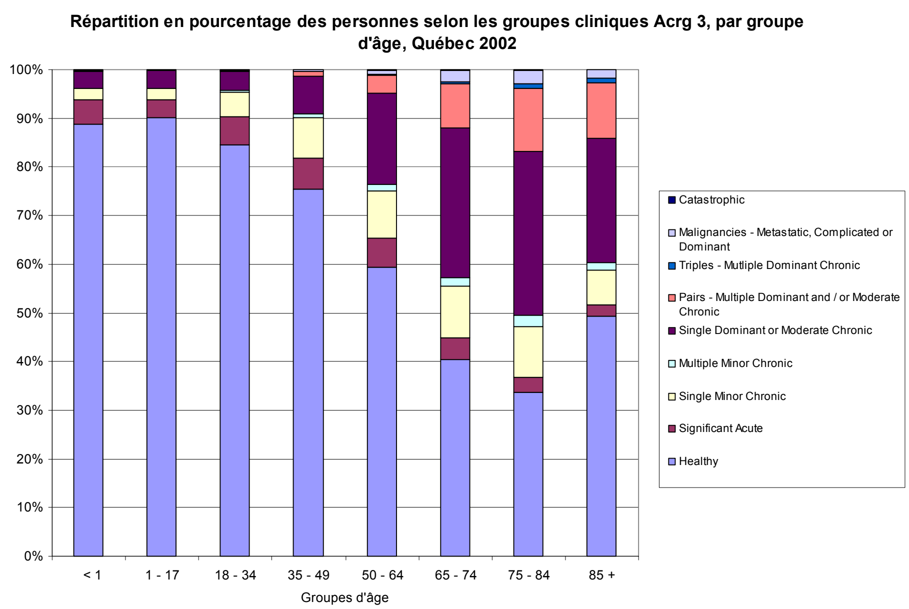


Figure 2: Percentage distribution by age groups and ACRG 3, Québec 2002

Design and Methods

The general design selected is represented in Table 4. Clinical information was pooled for each individual sampled in each of the first year of either the development or validation set. Then the costs (medical services; acute hospital care costs; total costs) for each individual were retrieved either for the same year (concurrent model) or for the following year (prospective model), and this for both the independent and randomly selected development and validation samples.

		97/98	98/99	99/00
Developmental Cycle	Concurrent	😐$		
	Prospective	😐	$	
Validation cycle	Concurrent		😐$	
	Prospective		😐	$

😐 : Clinical Information
$: Resource Information

Table 4: Overall design of research project

Two randomly selected independent sample sizes of 25 percent of all Quebec inhabitants aged one to 65, and 50 percent of those aged younger than one year old and 65 years and older were retained for the development sample and the validation sample. For the development sample, 2,311,594 individuals were selected. The study retained all their medical diagnoses from all medical billings (fee-for-services) and from all acute hospital discharges (inpatient and ambulatory day surgeries and admission stays) for the years 1998-99 and 1999-2000. The same was done for each individual in a validation sample of 2,330,837 enrolees for the years 1998-99 and 1999-2000.

In Ontario, the samples encompassed 12.5 percent of all people aged one to 65 years old and 25 percent of those aged younger than one year old and older than 65 years. The Ontario development sample contains 1,875,991 individuals, and the validation sample contains 1,924,042. Direct fee-for-service medical costs from the Ontario Health Insurance Plan were obtained and added for each year. CMGs and NAHCRI (T.M. CIHI) were used and weights were calculated using the Ontario weight sets provided by the Ministry of Health.

In Alberta, due to access problems resolved only in 2004, a randomly selected sample of 25 percent of the overall population was retained and split in two — 303,375 for the development sample; and 302,648 for the validation sample — for the years 1998/1999 and 1999/2000. Hence no individual aged younger than one year old was present in the second year of both development and validation samples.

Individuals dying were included in the analyses of the concurrent models but excluded if they died the first year for the prospective models. Partial enrolment due to migration or dying was not accounted for given the nature of the public funding systems. A special effort was made in Quebec to identify most of the newborns historically registered under their mother's identifier at birth, and the retrieval rate was close to 95 percent.

The number of records (pooled information over each year) without any diagnosis for the Quebec validation sample was 28.4 percent for the sampled individuals aged one to 64 and 16.4 percent for those aged 65 and older. For the same Ontario sample, the corresponding numbers were 31.6 percent for those aged 0 to 64 and 13.7 percent for those 65 years of age and older.

The average number of diagnoses (when there was at least one per enrolee) was 3.8 diagnoses for those in Quebec aged one to 64, and 5.6 for those 65 years and older. The respective numbers for Ontario were 6.9 and 8.5, possibly due to the ability to have two diagnoses per fee-for-service OHIP slip. Similar average numbers of diagnoses per enrolee were obtained in Alberta; these also included those administratively coded from emergency rooms and clinics. Fee-for-service diagnoses were not retained from inpatient and ambulatory location because discharge summary information was available for similar encounters.

In Quebec, 1.9 percent of the diagnosis codes were invalid for the sampled individuals aged younger than one year. The invalid rates were three percent for those aged one to 64 and 3.7 percent for those aged 65 and older. Most of these invalid codes were ICD-9 code V 999.0, mainly used for diagnostic interventions when only symptoms are present. In Ontario, less than one percent of codes were invalid, as that code had already been removed. In Alberta the percentage of rejected codes was also less than one percent.

The costs of acute care do not include capital costs for the acute care institutions; ambulatory drug costs; outpatient rehabilitation services, long-term care; or homecare. The individuals who incurred no cost in a given year were left out of the concurrent models analyses but were retained for the prospective models analyses.

To illustrate this, the following average costs (and standard deviations) were initially observed for the first years of each the concurrent and prospective samples in Ontario: TOTAL COSTS (MD+HOSP.) Concurrent Model: $774 (S.D. $379); TOTAL COSTS: Prospective Model: $607 (S.D. $627).

As Figure 3 illustrates for Quebec medical and hospital costs, the distribution of costs is skewed to the left. Another example from Ontario shows that the median individual 1998-99 OHIP cost in our sample is $98, while at the 75th percentile it is $283, at the 95th percentile it is $1,135, and at the 99th percentile it is $2,751. For the same year and cost bucket in Ontario, the lower seven deciles of costs have averages costs below $300, while the eight is at $401, the ninth at $653, and the tenth is at $1,855.

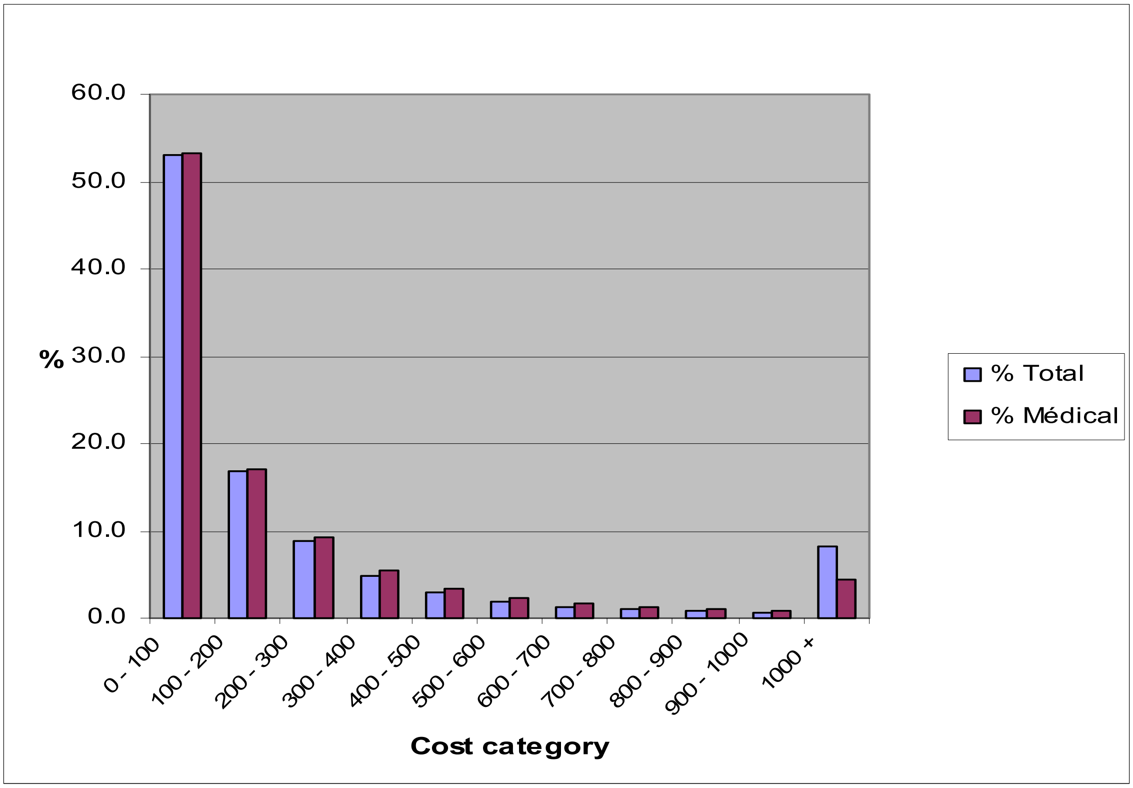


Figure 3: % Distribution of Medical Costs and total in $. Quebec 1998

Outliers were isolated for statistical purposes even if we considered that untrimmed costs represent the reality and must be accounted for. Given the limitations of the regression models and that the variances tests mostly square the difference between the observed and the expected values, we proceeded to keep all enrolees. However, we also tested capping/truncating their expenses at the 99th percentile value of respective cost buckets, which retained more than 96 percent of the total costs in each province for each sample and test.

Table 5 shows how the three provinces compare in total provincial health expenditures that go beyond acute care. Alberta ranks first for age/sex standardized expenditures, and Quebec and Ontario are respectively 8th and 9th among Canadian provinces.

	Quebec	Ontario	Alberta
$ Non-Standardized	1,681	1,767	2,040
$ Standardized (*)	1,703	1,820	2,311
$ Rank (Stand.)	8	9	1
$ Rank (Non-Stand.)(*)	9	8	3

(*) *Age-gender indirect standardization using Canadian population as reference*
Source Alberta Health & Wellness 2000

Table 5: Provincial Health Expenditures (Acute Care) in $ 1999-2000

Table 6 indicates the average costs observed in the various statistical analyses for each province. As the ambulatory costs available in Alberta could not distinguish ambulatory surgeries (requiring operating room), it was decided to drop that component from the Alberta analyses to be more comparable with the other provinces. However, Alberta's diagnosis information from emergency rooms, hospital clinics, and ambulatory surgeries are retained, as the available datasets could not identify the source of such diagnosis information.

Cost/person	QUEBEC	ONTARIO	ALBERTA
Medical costs	$266	$288	$300
Hospital costs	$433	$456	$383
Hospital ambulatory sector	$31 (*)	$49 (*)	$242 (**)
TOTAL	**$720**	**$793**	$683 (***)

(*): Only day procedures (**): Includes emergency visits and clinics
(***): Note: w/o hospital ambulatory expenses: only for comparative purposes with other provinces

Table 6: Average acute care costs per person in provincial samples.1998-1999

In order to verify the quality of at least one of DBRAS and calibrate it with existing indicators of need for the funding formula for acute care hospitals in Ontario, Table 7 presents the ranked correlation for close to 130 hospital catchment areas. Figure 4 shows the resulting graphic using HCC/DCG weighted indicator and standardized mortality ratios for the same ecological units in Ontario, 1997/1998

Variable	Correlation
% low income	0.4
% rural	0.56
% aboriginal	0.42
Standardized mortality ratio	0.61
Age-adjusted utilization rate	0.73

Table 7: Correlation of DCG-HCC Risk Indices with Common Regional Needs Indicators. Ontario 1997-1998

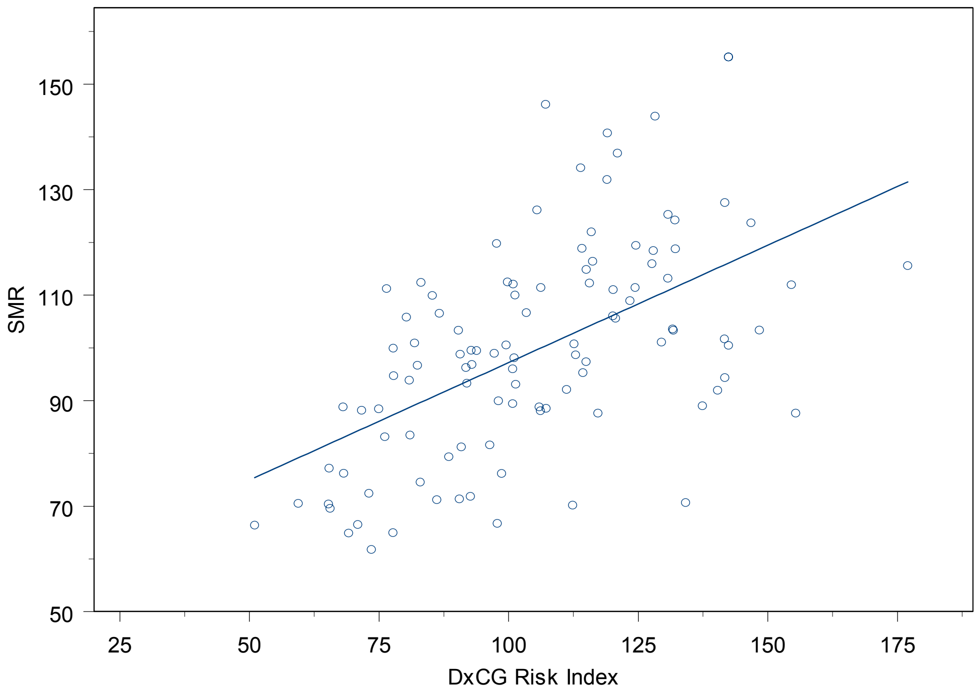


Figure 4: DCG-HCC Regional Needs Index vs. Mortality (SMR). Ontario. 1997/1998

The following bullets distinguish the variable to be explained and explanatory variables in the main results to produce inferential analysis and predictive power (R^2) that are contained in Figures 5 to 14. The costs weights are calculated to a method akin to DRG/CMGs (T.M. CIHI) for the categorical system CRG. However, for the dichotomous variables models ADG (ACG System) and HCC (DCG Systems), Table 8 somehow explains how we arrive at regression coefficients from a multiple linear regression model that are then added when more than one group is present for an individual to obtain a final score and cost weight.

Dependent Variable to be explained	=	Observed costs
Independent Variable to explain	=	Predicted costs by each DBRAS
Other variables to test	=	Age (eight groups) Gender Socio-economic status

Step 1	Individual Cost 98	Intercept (beta 0) + B1 (HCC001) 97 + B2 (HCC 002) + … + 16 age/sex groups except Reference Group (Men 18-34) + Residual
Step 2	Individual Predicted (Expected) Cost 99	Intercept (beta 0) 97+ B001-97*HCC001-98 + B002-97 * HCC002-98 + … 16 age groups except (Men 18-34) + Residual
Step 3	Linear regression of cost using 99 actual cost Actual Cost 99	Beta 0 + beta 1X predicted cost 98 + Residual

Table 8: Inferential Analysis Cont'd — Example of predictive model for dichotomous variables models

Results

Figures 5 and 6 are the only results that we will document here using only eight age groups (0-1; 1-17; 18-34; 35-54; 55-64; 65-74; 75-84; 85+) and two genders to predict costs for the same year (concurrent model) or the following year (prospective model) versus using the same age and gender information but also the DBRAS with the Quebec datasets. The same magnitude of results have been obtained using the others groupers in Quebec, Ontario, and Alberta. This is a telling tale of the relevance of using one or the other DBRAS grouper instead of only age/gender standardization to predict costs. Notice that the predictive power at the individual level for the prospective model is about half of what it is for the concurrent model, which is normal because predicting next year's expenditures is harder than predicting current year expenditures. Also truncated costs fare better as is to be expected.

Figures 7 and 8 represent another comparison of "classic needs indicators," using age/gender but also socio-economic ecological (geographically, not individually assigned) status as defined by the five-points scale from census tract information tested in the funding formula in Ontario in comparison with the results from the ADG Model of ACG in Ontario. Here again we notice that the DBRAS grouper enables much higher predictive power at the individual level.

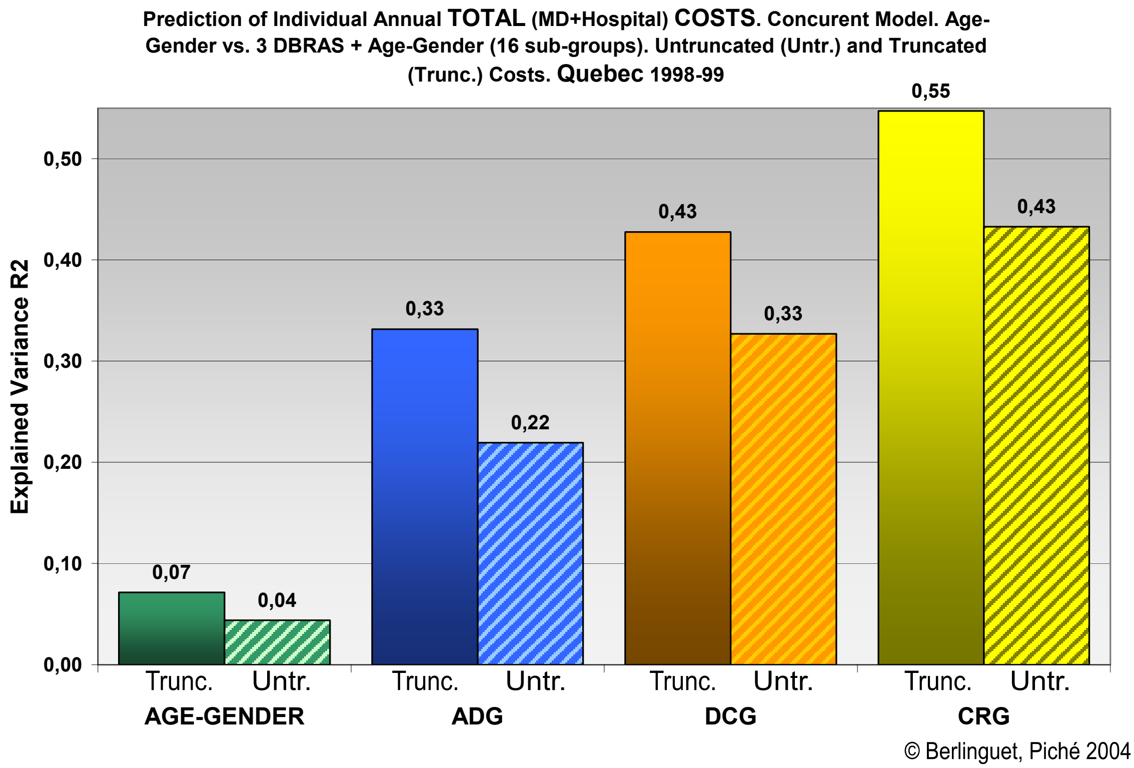


Figure 5

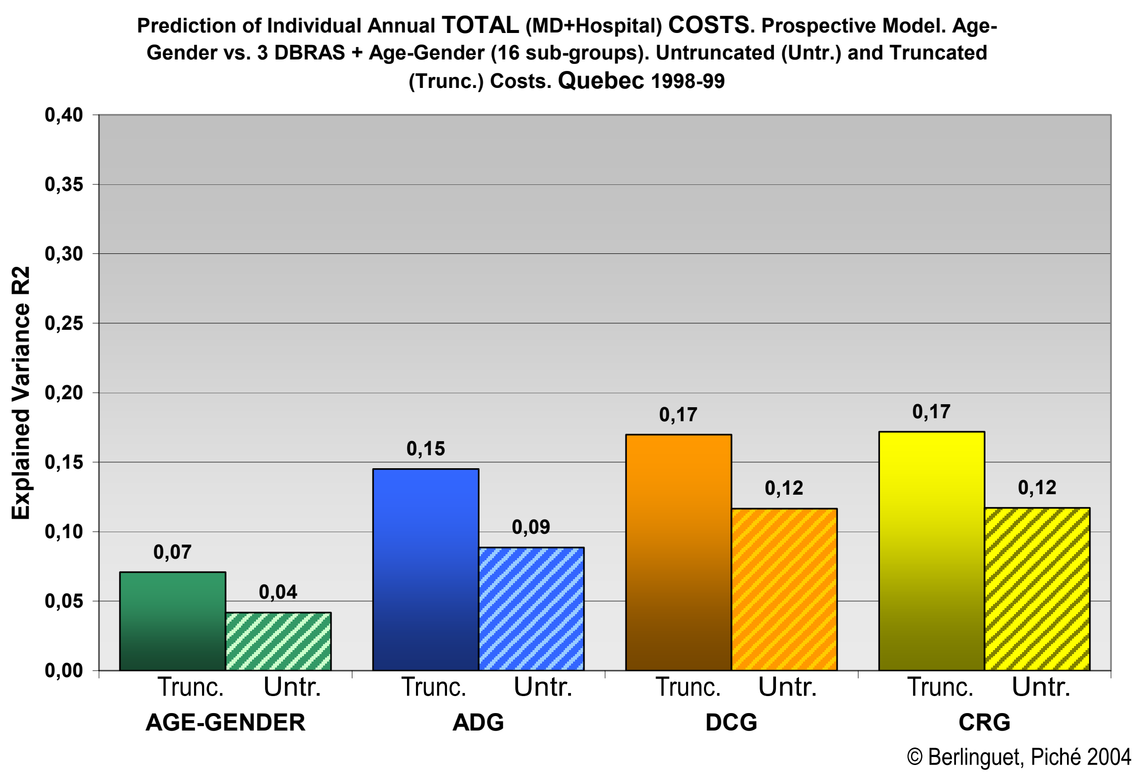


Figure 6

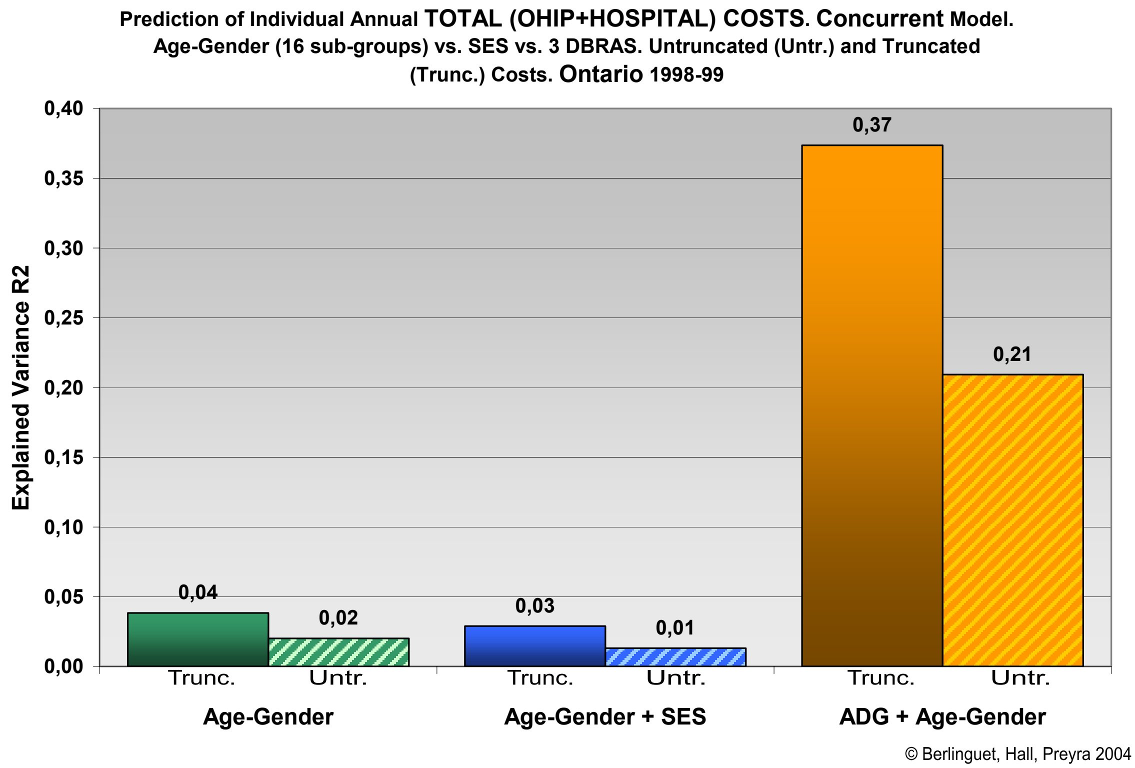


Figure 7

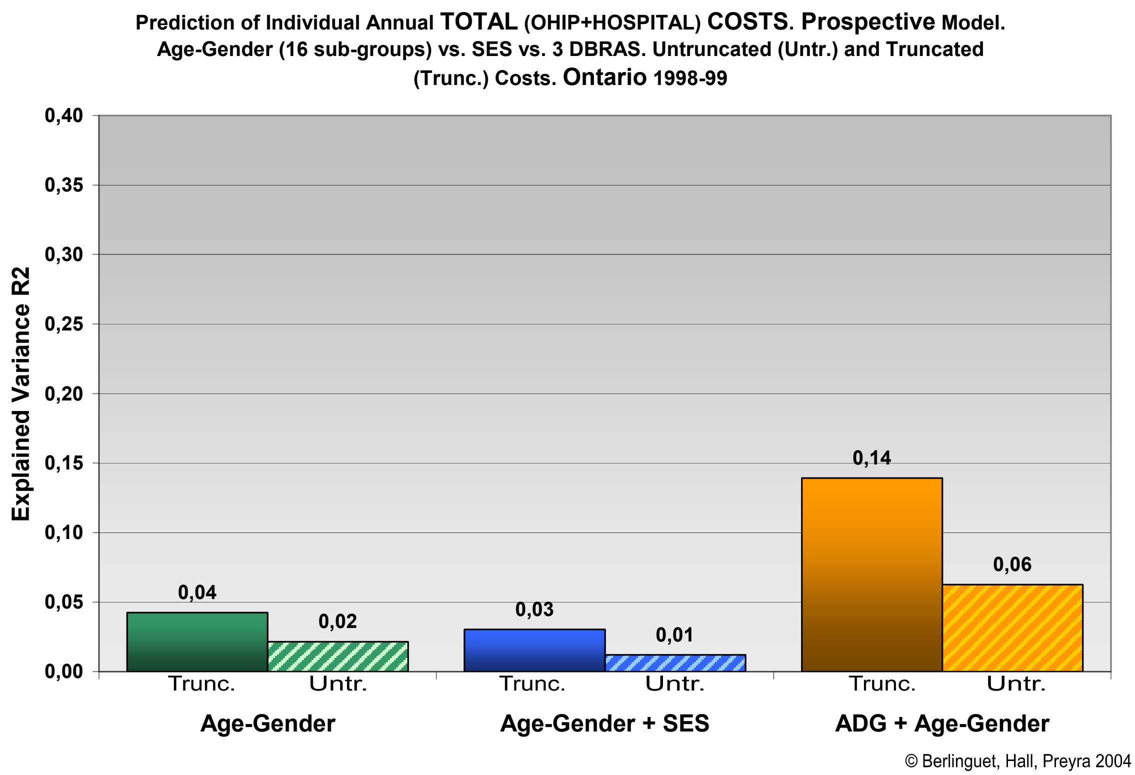
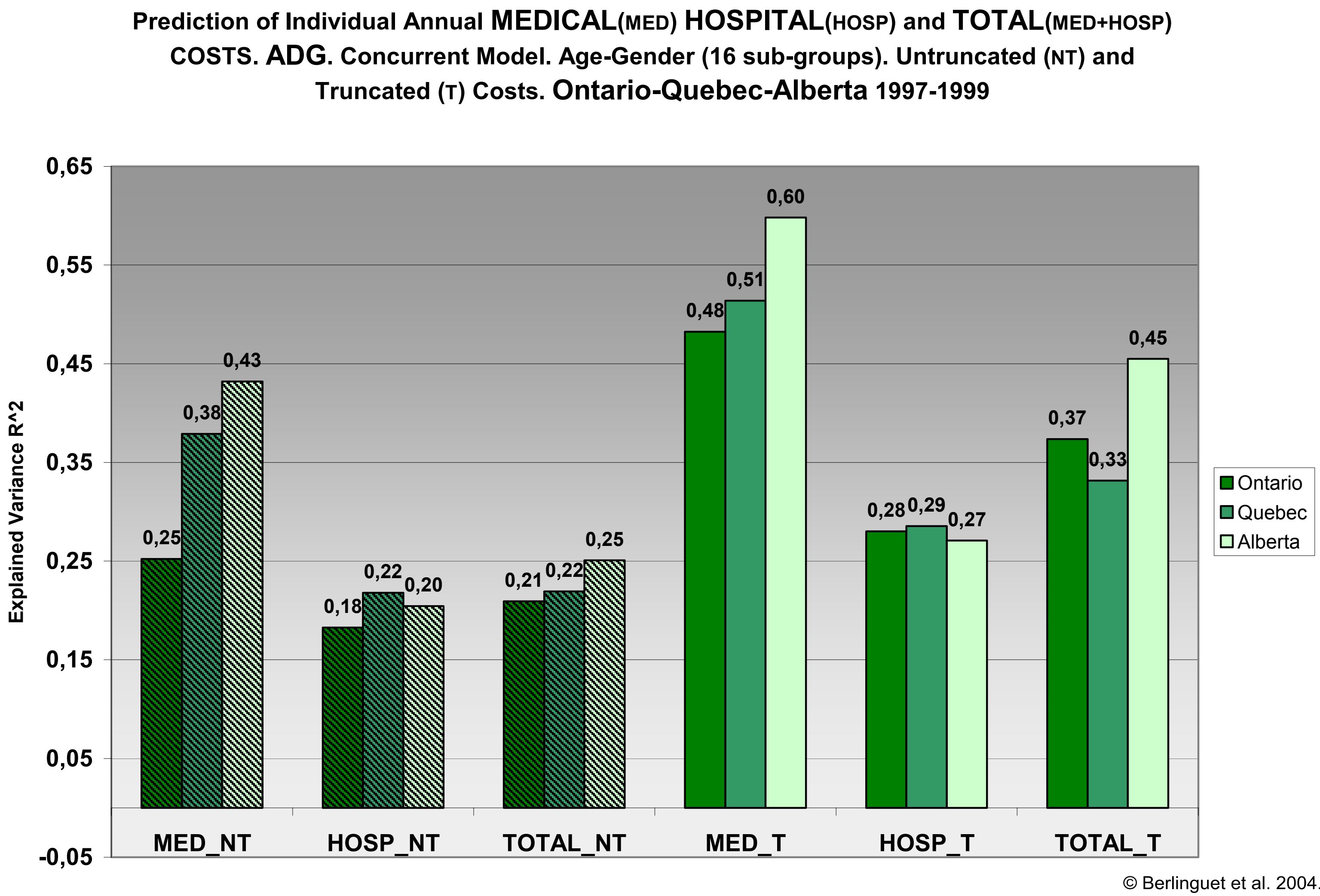


Figure 8



Prediction of Individual Annual MEDICAL(MED) HOSPITAL(HOSP) and TOTAL(MED+HOSP) COSTS. ADG. Concurrent Model. Age-Gender (16 sub-groups). Untruncated (NT) and Truncated (T) Costs. Ontario-Quebec-Alberta 1997-1999
Explained Variance R^2
0,65
0,55
0,45
0,35
0,25
0,15
0,05
-0,05
0,25
0,38
0,43
0,18
0,22
0,20
0,21
0,22
0,25
0,48
0,51
0,60
0,28
0,29
0,27
0,37
0,33
0,45
MED_NT
HOSP_NT
TOTAL_NT
MED_T
HOSP_T
TOTAL_T
Ontario
Quebec
Alberta
© Berlinguet et al. 2004.

Figure 9

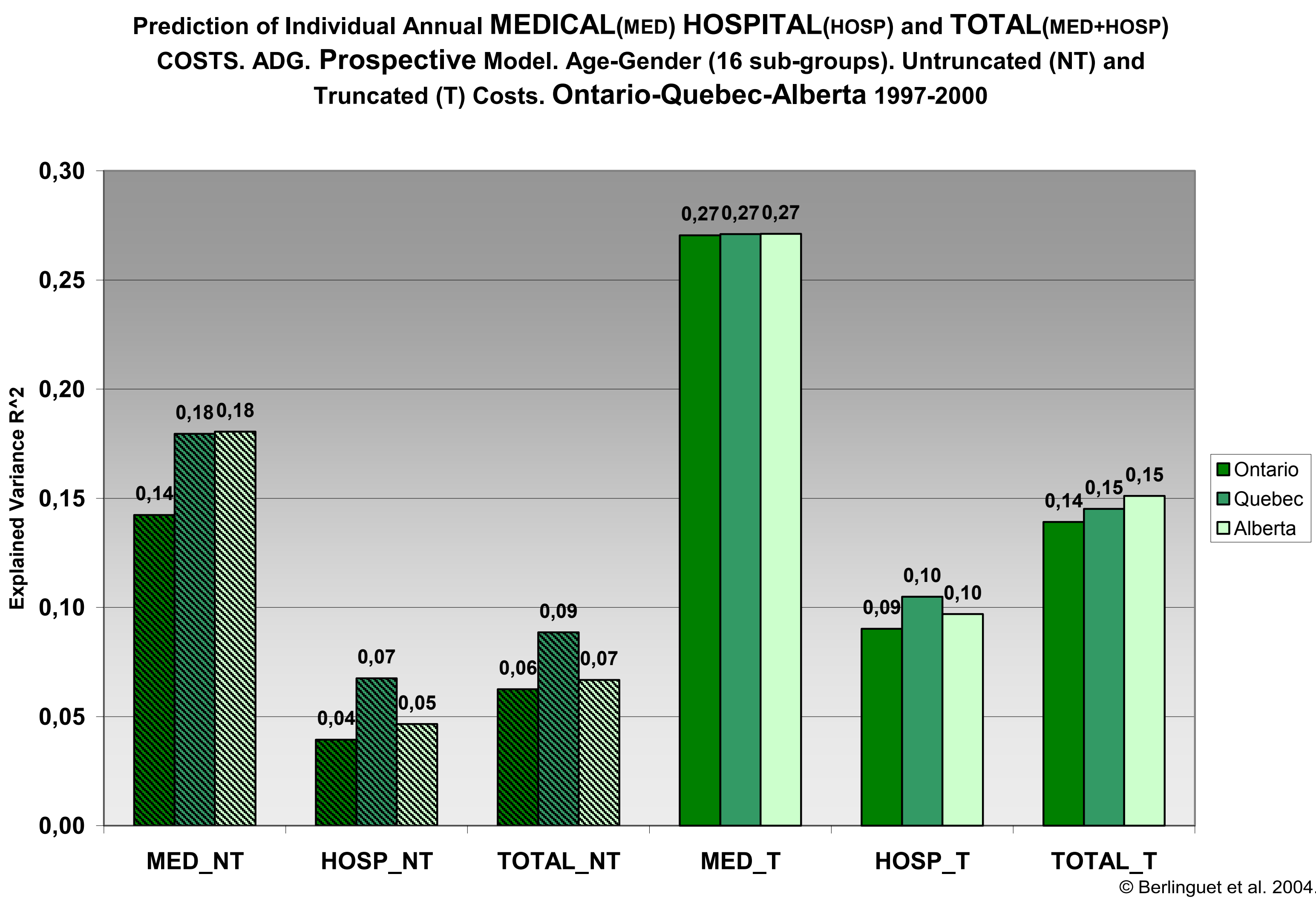

Prediction of Individual Annual MEDICAL(MED) HOSPITAL(HOSP) and TOTAL(MED+HOSP) COSTS. ADG. Prospective Model. Age-Gender (16 sub-groups). Untruncated (NT) and Truncated (T) Costs. Ontario-Quebec-Alberta 1997-2000
Explained Variance R^2
0,30
0,25
0,20
0,15
0,10
0,05
0,00
0,14
0,18
0,18
0,04
0,07
0,05
0,06
0,09
0,07
0,27
0,27
0,27
0,09
0,10
0,10
0,14
0,15
0,15
MED_NT
HOSP_NT
TOTAL_NT
MED_T
HOSP_T
TOTAL_T
Ontario
Quebec
Alberta
© Berlinguet et al. 2004.

Figure 10

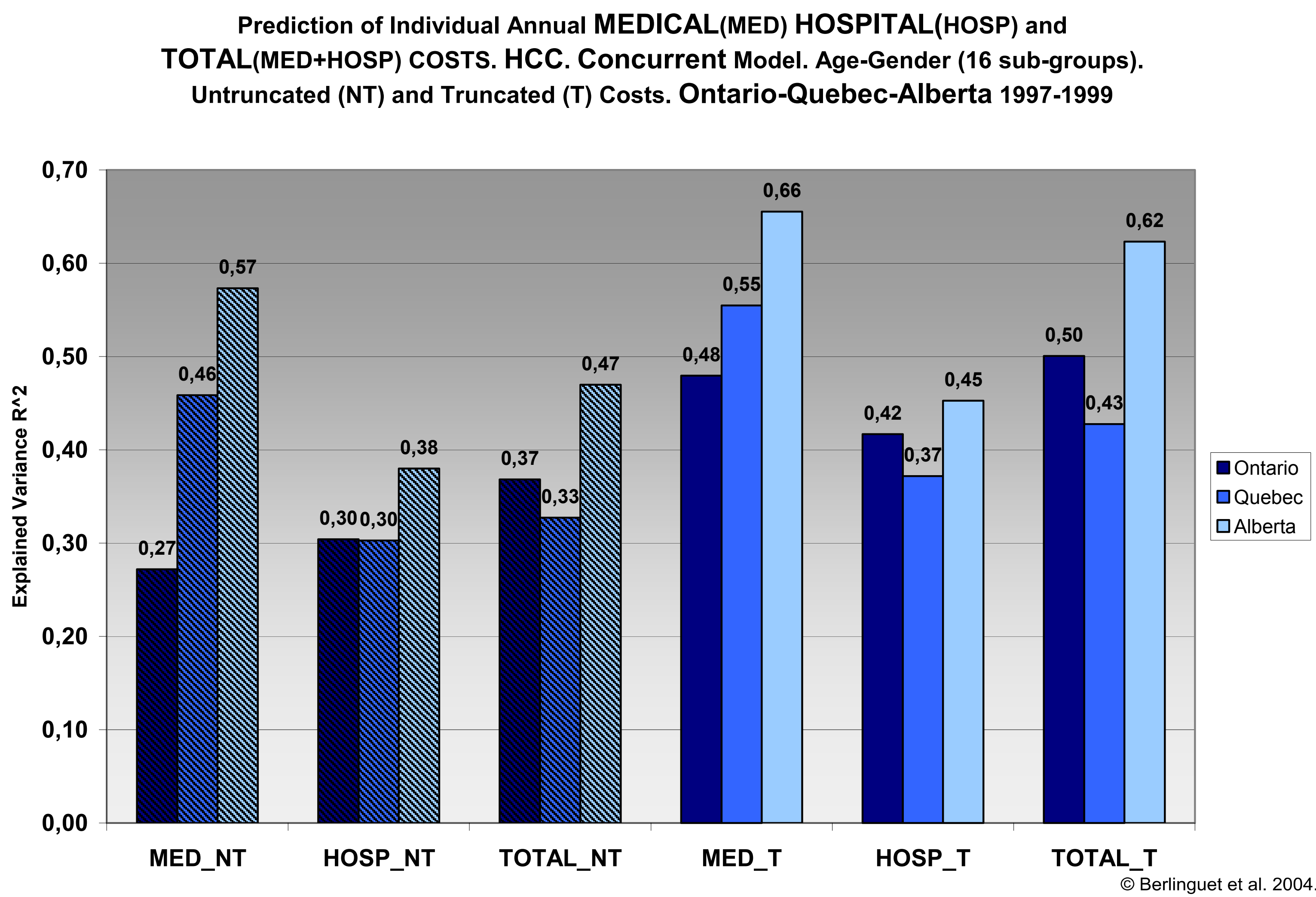
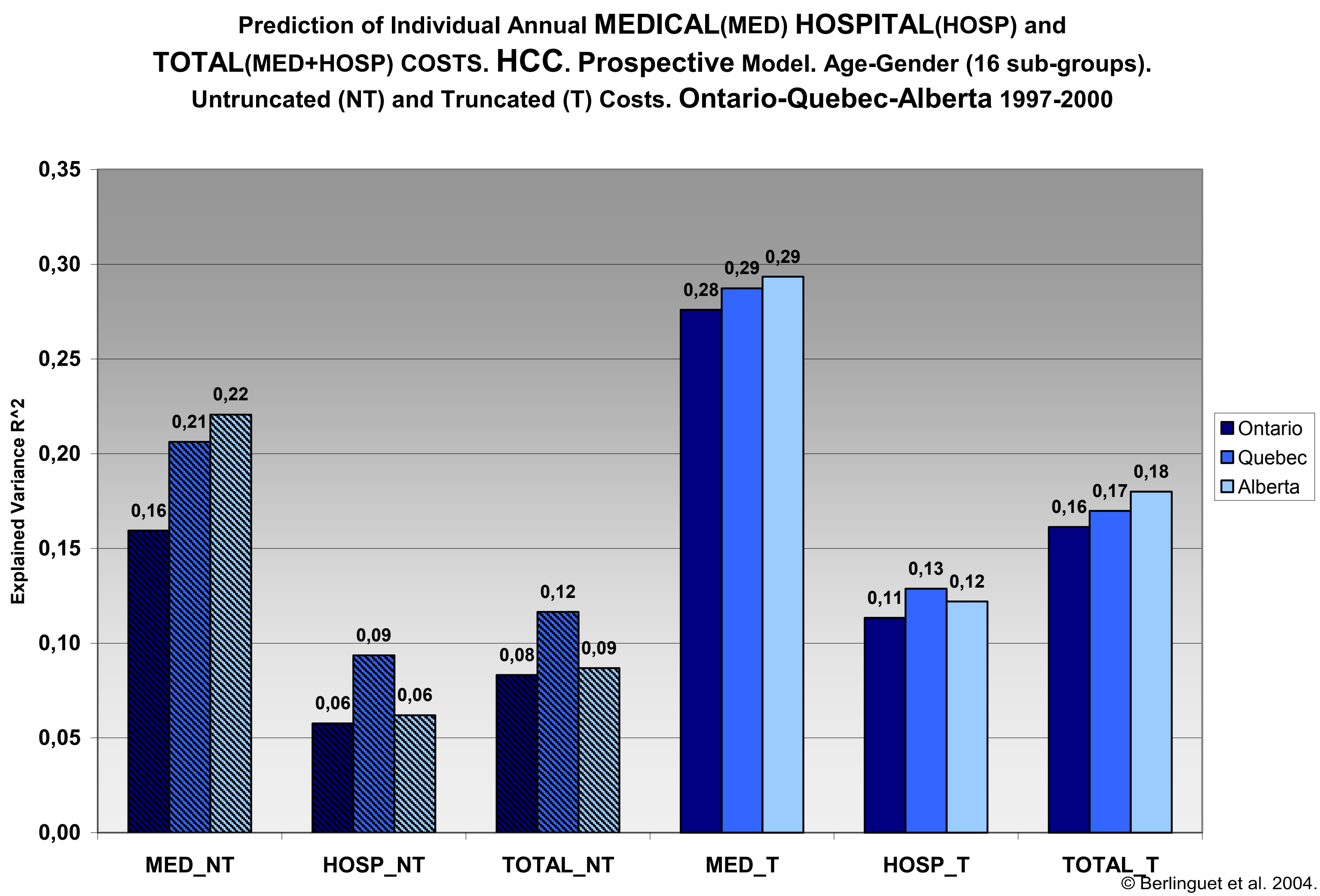

Prediction of Individual Annual MEDICAL(MED) HOSPITAL(HOSP) and
TOTAL(MED+HOSP) COSTS. HCC. Concurrent Model. Age-Gender (16 sub-groups).
Untruncated (NT) and Truncated (T) Costs. Ontario-Quebec-Alberta 1997-1999
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
Explained Variance R^2
0,27
0,46
0,57
0,30
0,30
0,38
0,37
0,33
0,47
0,48
0,55
0,66
0,42
0,37
0,45
0,50
0,43
0,62
MED_NT
HOSP_NT
TOTAL_NT
MED_T
HOSP_T
TOTAL_T
Ontario
Quebec
Alberta
© Berlinguet et al. 2004.

Figure 11



Prediction of Individual Annual MEDICAL(MED) HOSPITAL(HOSP) and TOTAL(MED+HOSP) COSTS. HCC. Prospective Model. Age-Gender (16 sub-groups). Untruncated (NT) and Truncated (T) Costs. Ontario-Quebec-Alberta 1997-2000
Explained Variance R^2
0,35
0,30
0,25
0,20
0,15
0,10
0,05
0,00
0,16
0,21
0,22
0,06
0,09
0,06
0,08
0,12
0,09
0,28
0,29
0,29
0,11
0,13
0,12
0,16
0,17
0,18
MED_NT
HOSP_NT
TOTAL_NT
MED_T
HOSP_T
TOTAL_T
Ontario
Quebec
Alberta
© Berlinguet et al. 2004.

Figure 12

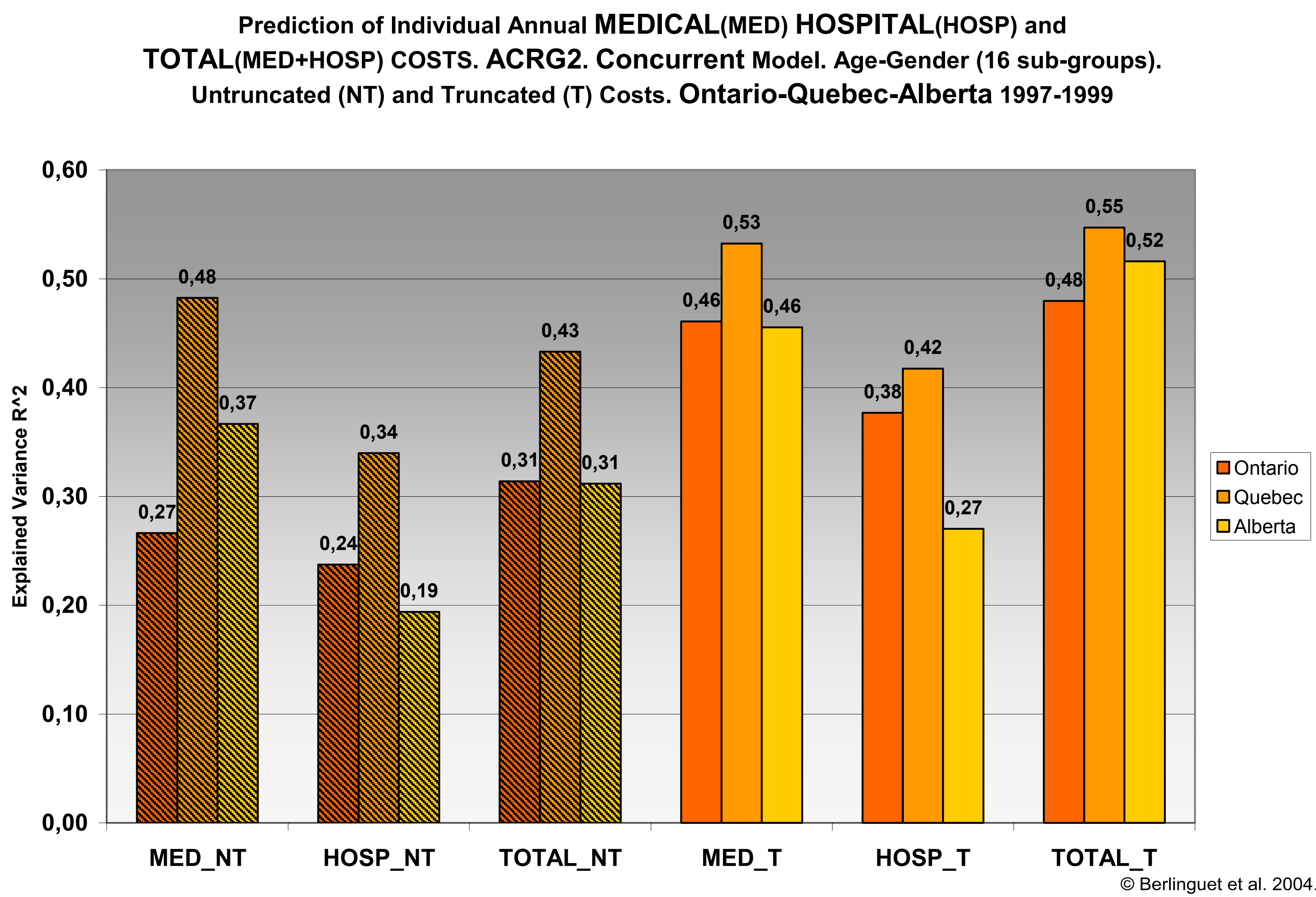

Prediction of Individual Annual MEDICAL(MED) HOSPITAL(HOSP) and
TOTAL(MED+HOSP) COSTS. ACRG2. Concurrent Model. Age-Gender (16 sub-groups).
Untruncated (NT) and Truncated (T) Costs. Ontario-Quebec-Alberta 1997-1999
Explained Variance R^2
0,60
0,50
0,40
0,30
0,20
0,10
0,00
0,27
0,48
0,37
0,24
0,34
0,19
0,31
0,43
0,31
0,46
0,53
0,46
0,38
0,42
0,27
0,48
0,55
0,52
MED_NT
HOSP_NT
TOTAL_NT
MED_T
HOSP_T
TOTAL_T
Ontario
Quebec
Alberta
© Berlinguet et al. 2004.

Figure 13

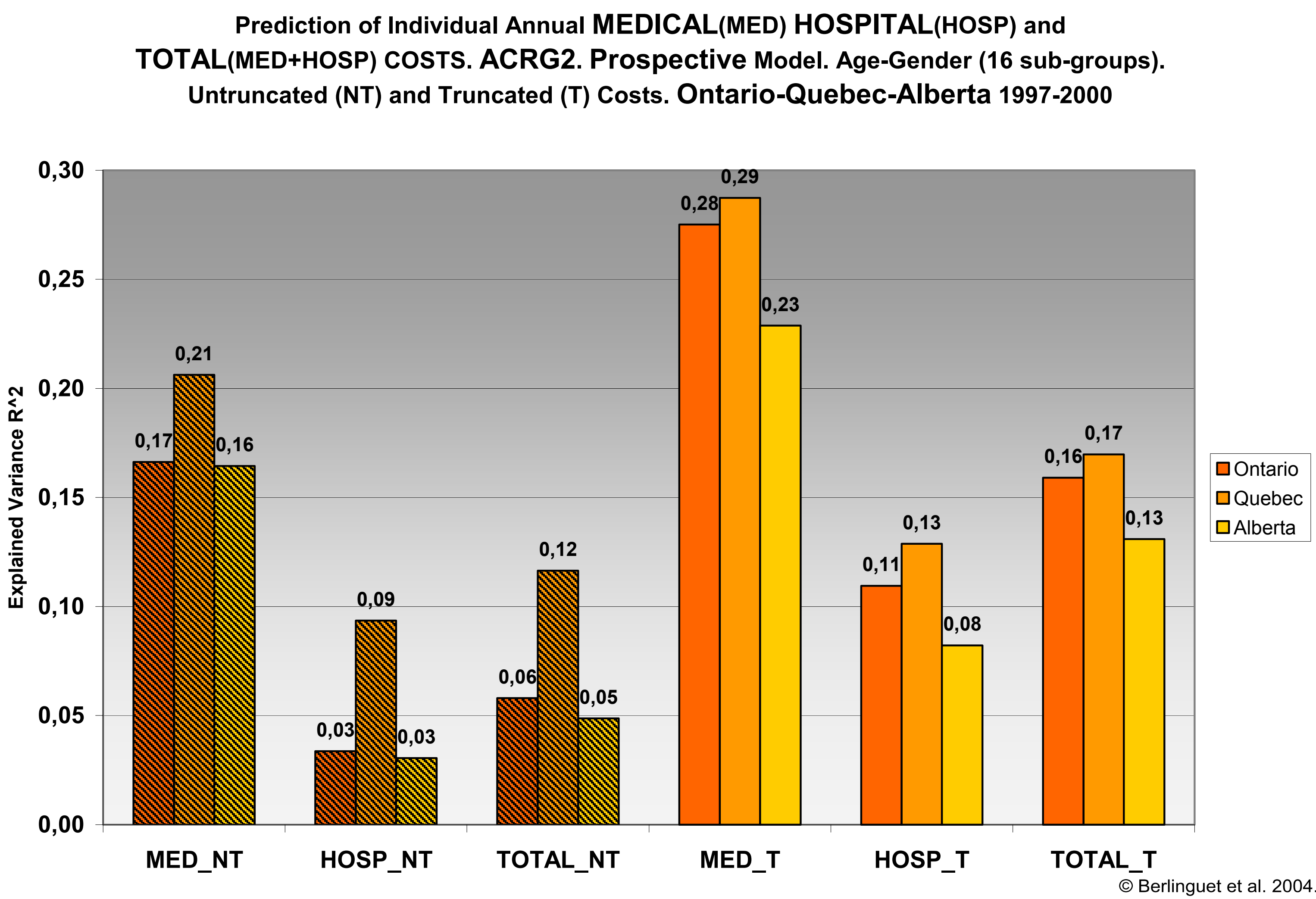

Prediction of Individual Annual MEDICAL(MED) HOSPITAL(HOSP) and
TOTAL(MED+HOSP) COSTS. ACRG2. Prospective Model. Age-Gender (16 sub-groups).
Untruncated (NT) and Truncated (T) Costs. Ontario-Quebec-Alberta 1997-2000
Explained Variance R^2
0,30
0,25
0,20
0,15
0,10
0,05
0,00
0,17
0,21
0,16
0,03
0,09
0,03
0,06
0,12
0,05
0,28
0,29
0,23
0,11
0,13
0,08
0,16
0,17
0,13
MED_NT
HOSP_NT
TOTAL_NT
MED_T
HOSP_T
TOTAL_T
Ontario
Quebec
Alberta
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Figure 14

Figures 9-10, 11-12, and 13-14 contain the main results of the testing of ADG, HCC, and CRG to explain same year expenses (concurrent model) or next year expenses (prospective model) for the various costs sectors under study, namely medical services costs (all locations), hospital costs (inpatient and ambulatory surgery except for Alberta), and total costs (sum of medical and hospital costs) at the individual level. Tables 10 and 11 summarize those finding and add a rank (first, second, or third) from the investigators (in parenthesis) for each of three evaluated groupers.

Cost Bucket/ Model/Product	ADG	DCG-HCC	CRG
MD conc.	26-38-43(3)	28-48-57(1)	27-48-37(2)
MD prosp.	14-18-18(3)	16-21-22(1)	17-21-16(2)
HOSPITAL conc.	18-22-20(3)	30-30-38(1)	24-34-19(2)
HOSPITAL prosp.	4-7-6(2)	6-9-6(1)	3-9-3(3)
TOTAL conc.	21-22-25(3)	37-33-47(1)	31-43-31(2)
TOTAL prosp.	6-8-7(3)	8-12-9(1)	6-12-5(2)

Table 9: Explained Variance (R2) in %. And Ranking by Authors (1-3). Ontario-Quebec-Alberta. Medical services; Hospital Inpatient and Day Surgery (exc. ALT) and Total (MD+HOSP) Costs Untrimmed. Concurrent and Prospective Models. 1997-2000.

Cost Bucket/ Model/Product	ADG	DCG-HCC	CRG
MD conc.	48-51-60(2)	48-55-66(1)	46-48-37(3)
MD prosp.	27-27-27(2)	28-29-29(1)	26-28-23(3)
HOSPITAL conc.	28-29-27(3)	42-37-45(1)	38-42-27(2)
HOSPITAL prosp.	9-10-10(3)	11-13-12(1)	11-13-08(2)
TOTAL conc.	37-33-46(3)	50-43-62(1)	48-55-52(2)
TOTAL prosp.	14-15-15(3)	16-17-18(1)	16-17-13(2)

Table 10: Explained Variance (R2) in %. And Ranking by Authors (1-3). Ontario-Quebec-Alberta Medical services (MD); Hospital Inpatient and Day Surgery HOSP (exc. ALT) and Total (MD+HOSP) Costs Trimmed. Concurrent and Prospective Models. 1997 - 2000.

These results demonstrate the relatively high predictive power of expenditures for all three groupers evaluated. Also, as expected, they show the superiority of using truncated costs over raw expenditures, even if the raw expenditures test shall be preferred in universal publicly funded systems like in Canada. The following Figures 15 and 16 illustrate how each of the three tested systems fare when the predictive power is not compared between the observed and predicted costs of each enrolee (as for the previous variance analysis using simple linear regression) but rather by using plain predictive ratios totalling all expected costs over all observed/same year costs (concurrent model) by decile (creation of 10 groups of individuals that are equal in numbers) of actual costs (Figure 15) and decile of expected total costs (Figure 16) in Ontario (minus other ambulatory hospital costs but inclusive of day surgeries costs). As empirically observed in other studies, the DBRAS systems usually over-predict costs for low-cost deciles and under-predict for high-cost deciles. However, we witness here the phenomenon of negative predicted costs for the HCC and ADG models, given the presence of negative regression coefficients in the low-decile cost buckets, given we made no correction of the models to take out such negative coefficient to do comparable comparisons of all systems without distortion. This introduces the notion that regression models may need such adjustments not to have to explain counter-intuitive negative costs, and this may bring in applications some limitation to simple explanation and comparison of results. Figure 16 brings another evaluation artifact when using the decile of expected cost, which make appear a categorical model like CRG much more predictive than the regression model ADGs and HCCs, while the main reason is that there is only one group per individual and its expected costs are more homogeneous.

Predictive Ratios (E/O) by Decile of Actual Total Costs (-HOSP Ambulatory). ACRG2, ADG and DCG. Concurrent Model. Ontario 1998-1999

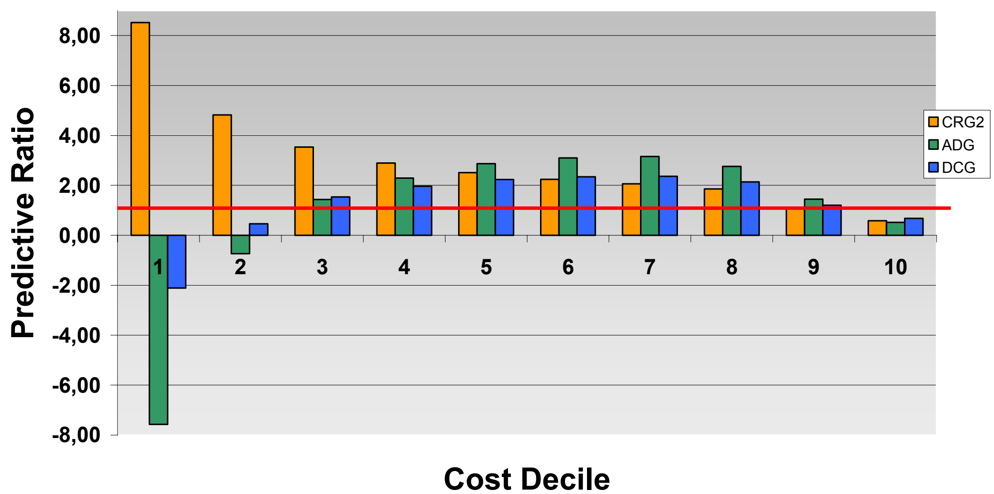

Figure 15

Predictive Ratios (E/O) by Decile of Expected Total Costs (-HOSP Ambulatory). ACRG2, ADG and DCG. Concurrent Model. Ontario 1998-1999

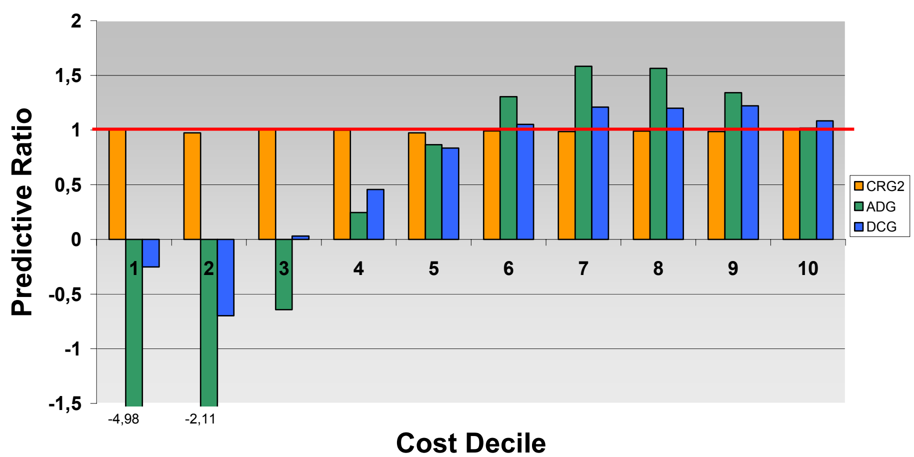

Figure 16

Discussion

The three principal investigators identified by consensus the following principal evaluation criteria:

Discrimination and predictive value of categories
Accuracy and precision for cost prediction

Clinical and administrative value of categories
Face value/clinical relevance and level of granularity

Convenient resource weight calculation
Transparency, ease, and simplicity

Other evaluation criteria were also looked at but appeared as secondary for this exercise:

Interface with ICD-10 and interventions classifications (when applicable)
Capability to use pharmacy-based information solo or together with diagnoses
Capability to include prior cost experience
Capability to integrate episodes of care
Possible expansions using more clinical information
Availability of analytical modules
Support from development team/consultants
Cost of license and cost-efficiency

Conclusions

Given the principal selection and evaluation criteria finally retained and in view of the results described in this report and the comments made by clinicians, evaluators, and other knowledgeable people during the course of this evaluation, the following summary table was produced. We believe all three groupers are basically good, sound, and usable in Canada: selecting one depends on one's preference, experience, and intended usage.

Criterion/Product	Clinical Relevance	Resources Prediction	Convenient Resource Wighting
ADG/ACG	+	+ +	+
DCG-HCC	+ +	+ + +	+
CRG	+ + +	+ +/+ + +	+ + +

Table 11: Global Canadian Evaluation of DBRAS-Consensus of Leading Authors. Final Report

The main contributors in kind and co-investigators from Calgary Health Region, RAMQ, and the Ministry of Health and Long-Term Care received these results and approved them. A multimedia DVD containing all relevant material plus interviews with two of the investigators and a one-hour voice-over presentation of the methodology and results has been produced and made available to all researchers and administrators that have been involved in this project, as well as outside researchers and consultants who have made a request for it. A copy has also been sent to the Canadian Health Services Research Foundation liaison person for this project. More copies are available from the author upon request and will be sent to each provincial jurisdiction not already involved in this project by Mid-march 2005.

The objectives, methods, results, and recommendations of this evaluation were widely disseminated between January 2004 and December 2004: for audiences attending the January 2004 ICES Clinical Workshop in Toronto, Ontario, at the seminar organized at Calgary Health Region, and at the Alberta Health and Wellness offices in May 2004, at the Canadian Institute for Health Information in April and June 2004, at the *Regie de l'Assurance Maladie du Quebec* in September 2004, at the Ministry of Health and Long-Term Care in December 2004, and finally at various international conferences and presentations during 2004, including a presentation of the main initial results in Washington, D.C. at the annual meeting of the Patient Classification Systems (International) Association (Proceedings Nov. 2003).