Equity in Health Care Funding: Comparison of Expenditures in Ontario to Allocations Based on Population Need

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ABSTRACT

**Background:** The geographic distribution of health care funding in Canada has traditionally been based on past allocations and the distribution of health care facilities and providers. Whether this approach has succeeded in distributing resources among populations in keeping with relative health care needs is unknown.

**Methods:** Using data on self-assessed health status and utilization of health care services from the Ontario Health Survey, data on health care expenditures from the Ontario Ministry of Health and Long-Term Care, and population data from Statistics Canada, we compared actual health care expenditures for geographically-defined populations in Ontario to allocations based on relative population need as represented by age, sex and self-assessed health status. Comparisons were made at the regional (Health Region), district (District Health Council) and local (Public Health Unit) levels.

**Results:** Expenditures and needs-based allocations were significantly different for 4 of 7 regions, 9 of 15 districts and 23 of 42 local areas. At the regional level, needs-based allocations ranged from 8.9% higher to 6.4% lower than actual expenditures. For districts, needs-based allocations ranged from 12.9% higher to 9.8% lower than expenditures. At the local level, needs-based allocations ranged from 23.8% higher to 18.8% lower than expenditures. Intra-class correlation coefficients measuring agreement between needs-based per capita expenditures and actual per capita expenditures were 0.86, 0.74 and 0.58 for regions, districts and local areas respectively.

**Interpretation:** Although, on average, the differences between needs-based allocations and actual health care expenditures were not large, the discrepancies were substantial for many
geographic areas. The adoption in Ontario of funding methods based on relative population needs would improve equity in the allocation of health care resources to populations and result in a considerable redistribution of resources.

**Keywords:** Health care funding, health care resource allocation, Ontario, Needs-based funding, Equity.
INTRODUCTION

A basic objective of most publicly financed health care systems is to allocate health care resources among populations according to need.(1) This objective is consistent with the philosophy underlying the Canada Health Act.(2,3,4,5)

Traditionally, the geographic distribution of health care funding in Canada has been based on past allocations and the distribution of health care facilities and providers.(6,7,8,9,10,11,12) However, governments in Canada are increasingly considering or adopting approaches to health care resource allocation based on relative population needs.(6,7,8,9,10,11,12,13,14)

What is not known is whether the traditional approach to health care resource allocation has succeeded in distributing resources among populations in keeping with relative needs, despite not being explicitly needs-based. In this paper, we address this question by comparing actual health care expenditures for regional, district and local area populations in Ontario to allocations based on relative population need as represented defined by age, sex and self-assessed health.

The needs-based approach is relative in that total health care resources are distributed among geographically defined populations based on their level of need. The extent to which either the needs-based approach or the traditional approach can meet the absolute level of need depends, among other things, on the size of the budget. For brevity, in the remainder of this paper we use “need” to refer to relative population need for health care.

METHODS

Relative Needs-Based Allocations

In computing relative needs-based allocations, our measure of need was population size adjusted for the distribution of age, sex and self-assessed health status in the population. Variation in age and sex distributions among populations captures a substantial portion of variation in illness-related need for health care because, at the population level, the risk of experiencing health problems varies substantially and predictably with age and
Age and sex also capture much of the variation in need for preventive and reproductive care. We used self-assessed health status to represent the variation in need that is not accounted for by age and sex. An impressive body of evidence supports the validity of self-assessed health status as a health status measure. Numerous studies have demonstrated statistically significant relationships, usually of moderate strength, between variants of this single item measure of self-assessed health and other measures of health status, including physician assessments, measures of functional ability/disability, number and/or type of self-reported health problems, diagnoses or chronic diseases, number of medications, acute symptoms, and composite measures of health status based on either self-reports or a combination of physician- and self-reported conditions and health service utilization data.

Idler and Benyamini reviewed 27 longitudinal studies and found that self-assessed health status was nearly always an independent predictor of mortality. Adjustment for other health status measures sometimes diminished but rarely eliminated the significant independent effect of self-assessed health.

For this study, we obtained data on self-assessed health status and self-reported utilization of health care services from the 1990 Ontario Health Survey (OHS) and data on health care expenditures from the Ontario Ministry of Health. At the time the data for this study were assembled and analyzed, the most recent available health survey data were from the 1990 OHS and the most recent available health care expenditure data were from fiscal year 1995-96. Our analysis assumes – reasonably, we think – that between 1990 and 1995-96 major changes in the geographic distribution of health status within age categories were unlikely.

Self-assessed health status was asked of all OHS respondents 12 years of age and over as part of the self-complete portion of the survey (response rate 77.2%). For children less than 12 years of age we used proxy respondent reports from the personal interview component of the
OHS (response rate 87.5%) on the presence or absence of activity-limiting health problems. Complete information for age, sex and health status was available for 62,413 respondents (98.8% of those who responded to both components of the survey).

To use the population distribution of age, sex and health status to allocate resources, we estimated the relationship between these variables and relative need for health care resources as represented by existing utilization and expenditures at the provincial level. We assumed that, at the provincial level of aggregation, the population in each age/sex/health status category received an appropriate relative share of health care resources. It is important to note that our approach did not assume that existing allocations to age/sex/health status categories within and among regional, district and local populations are necessarily appropriate.

For this study, we considered only those categories of health care resources that were examined in the OHS. For health professional services, the interview portion of the OHS contained self-reported information on the number of contacts with general practitioners, specialist physicians, optometrists, physiotherapists and chiropractors during the preceding twelve months. The health professionals for whom data were available from the OHS accounted for 97% of all Ontario Health Insurance Plan (OHIP) dollar expenditures. For hospital services, the OHS provided the self-reported total number of nights spent in hospital during the preceding twelve months. Acute hospital costs account for 66% of the overall operation of hospitals. Table 1 shows that together these categories represent 56% of the 1995-96 Ministry of Health expenditures for the provision of health care services. Hence, we are able to compare health care expenditures to needs-based allocations for services that make up over one-half of the total Ministry budget.

**Geographic Units**

The OHS was designed “to provide accurate and meaningful information at the Public Health Unit (PHU) level for all major indicators and characteristics.” PHUs in Ontario typically represent regional municipalities or counties. The 1995 population estimates for PHUs
range from 39,832 for Timiskaming to 875,588 for Peel. Local areas for this study were defined by PHUs. The local areas can be aggregated into larger administrative areas called health districts which ranged in population from 222,808 for the health district of Muskoka, Nipissing, Parry Sound and Timiskaming to 2,420,054 for Metropolitan Toronto (smaller districts were amalgamated in 1998 to those used in this study). Districts can in turn be aggregated into health planning regions (reorganized in 1999 to those used in this study) which are the largest administrative area with 1995 populations ranging from 919,310 for North to 2,420,054 for Toronto.

**Health Care Expenditures**

A critical requirement was that the health care expenditures for regions, districts and local areas be computed on the basis of the place of residence of the recipients of services, rather than on the basis of the location of health care providers and institutions. From the Ontario Ministry of Health, we were able to obtain acute hospital expenditures and fee-for-service payments for physician and practitioner services based on the residence of the recipients. These expenditures represented most of the budget considered in this study (97%). However, alternate payments for physician services, also obtained from the Ontario Ministry of Health, were based on the location of the provider and represented 3% of the budget considered in this study. For the hospital data, place of residence was based on the patient address as indicated by the patient on the hospitalization record. However, in the health professional (OHIP) data the patient address originates from the Health Card which was introduced in 1991/92. During the period when the OHIP data used in this study were collected, there were no systematic mechanisms in place for updating health card addresses, so some patient addresses may have been out of date. The degree of error in patient addresses probably varies by geographic area and would have the largest impact on this study at the smallest geographic level, the local area. The effect of any out of date addresses would be smaller at the district and regional levels.
Estimating Needs-Based Allocations

Age, sex and health status-specific resource shares were computed for each type of health professional service and for acute hospital services in two steps. First, the age-sex-specific resource shares were calculated based on the distribution of Ministry of Health expenditures for the fiscal year 1995-96 between age/sex strata. To illustrate, males aged 40-44 years represented 4% of the population but accounted for 3% of the provincial expenditures on general/family practitioner services. The provincial per-capita expenditure on general/family practitioner services was assigned a value of 1, so the per-capita resource share for males aged 40-44 was 0.03/0.04 = 0.75.

The second step was to calculate resource shares across health status levels within age/sex strata by determining the proportion of the particular health care service used during the preceding 12 months by persons in each of the five levels of self-assessed health from the OHS. For example, 7% of 40-44 year old males reported fair health but accounted for 13% of all self-reported general/family practitioner contacts in this age-sex group, so the needs-specific resource share for males aged 40-44 in fair health was 0.13/0.07 = 1.9. Combining this with the previously computed resource share for 40-44 year old males (0.75), resulted in an age/sex/health status specific share of provincial expenditures for general/family practitioner services of 1.4 (1.9 x 0.75) for males age 40-44 years in fair health. That is, the needs-based share of resources for general/family practitioner services for a 40-44 year old male in fair (self-assessed) health would be 1.4 times the provincial per-capita expenditure on general/family practitioner services. The formula for the general/family practitioner need-specific shares is:

\[
NSS_{i,j,h} = \left[ \frac{\text{proportion of provincial expenditures accounted for by cell i, j}}{\text{proportion of provincial population accounted for by cell i, j}} \right] \times \left[ \frac{\text{proportion of physician contacts within cell i, j for individuals within cell i, j, with health status h}}{\text{proportion of population within cell i, j, with health status h}} \right]
\]

for i=sex, j=age group, and h=health status.
Resource shares for each type of service were weighted according to the proportion of the total 1995-96 health care budget allocated to that service and then summed in order to compute overall needs-specific resource shares for each age/sex/health status category.

Population data by age and sex at the census division level were obtained from Statistics Canada CANSIM estimates for July 1, 1995. These data were aggregated and combined with the OHS data by local areas, districts and regions to obtain estimates of age, sex and health status distributions of the populations in these geographic areas. The needs-adjusted dollar allocations for each geographic area were calculated by multiplying age, sex- and health status-specific population estimates for the area by the corresponding resource shares, summing for the area to get total shares, and multiplying by the provincial per-capita expenditure for the health care services included. Per-capita needs-based expenditures were calculated by dividing each area’s total dollar allocation by its total population.

**Comparing Expenditures with Needs-based Allocations**

Standard errors and confidence intervals were calculated for the estimates of the needs-based allocations. Appendix 1 shows the derivation of the formula used. The power to detect relative differences of 5% and 10% between expenditures and needs-based allocations was also calculated. Intraclass correlation coefficients were used to measure agreement between needs-based and actual per-capita expenditures.(35)

**RESULTS**

Tables 2 to 4 compare expenditures and needs-based allocations for regions, districts and local levels, respectively. Expenditures and needs-based allocations were significantly different for 4 of the 7 regions (57%), 9 of the 16 districts (56%) and 23 of the 42 local areas (55%). We had at least 80% power to detect a 5% difference in 7 of the 7 regions (100%), 3 of the 16 districts (19%) and 4 of the 42 local areas (10%). We had at least 80% power to detect a 10%
difference in 7 of the 7 regions (100%), 14 of the 16 districts (88%) and 17 of the 42 local areas (40%).

At the regional level, needs-based allocations ranged from 8.9% higher than expenditures for Central West to 6.4% lower than expenditures for Toronto, with a mean absolute difference of 4.2% (Table 2). At finer geographic levels the relative difference between expenditures and needs-based allocations was greater. For districts, the needs-based allocations ranged from 12.9% higher than expenditures for Waterloo Region-Wellington-Dufferin to 9.8% lower than expenditures for Hamilton-Wentworth, with a mean absolute difference of 5.8% (Table 3). At the local level, needs-based allocations ranged from 23.8% higher for Northwestern to 18.8% lower for Kingston, Frontenac, Lennox and Addington, with a mean absolute difference of 8.0% (Table 4).

At the regional level, Toronto region had the highest average per-capita needs and the highest per-capita expenditures (Table 2). Central West had the lowest per-capita needs and the lowest expenditures.

At the district level, Muskoka-Nippissing-Parry Sound-Timiskaming’s needs per-capita were the highest but Metro Toronto received the most per-capita (Table 3). Both needs and expenditures were lowest for Halton-Peel.

At the local level, York City (within Metropolitan Toronto) had the highest per-capita needs while Toronto City had the highest per capita expenditures (Table 4). York region (the local area north of Metropolitan Toronto) had the lowest per-capita needs and received the fewest resources per-capita.

Intraclass correlation coefficients measuring the agreement between needs-based per-capita expenditures and actual per-capita expenditures by place of residence were 0.86, 0.74 and 0.58 for regions, districts and local areas respectively. Figure 1 shows the needs-based allocations plotted against actual expenditures.
DISCUSSION

Our results suggest that health care expenditures are not fully consistent with relative population needs for health care. However, the high intraclass correlations at the regional and district levels between per-capita needs-based allocations and per-capita expenditures indicate that in many cases expenditures are quite closely aligned with need. Despite this, implementation of needs-based funding would see a substantial redistribution of resources, especially at the local level. The potential redistributions are proportionally larger for smaller geographic areas because large aggregations average out variability within a region or district. Future research might explore whether there are systematic differences in geographic area characteristics that are related to the probability of relative over- or under-funding.

This study is limited in its conclusions to the 56% of total expenditures by the Ontario Ministry of Health for the provision of health care services that we were able to include in our analysis. Also, we did not adjust the needs-based allocations for differential costs between regions beyond those caused by differences in need. Because there has been limited examination of unavoidable geographical variation in the cost of providing health care in Ontario, we had no data on which to base such an adjustment.

Alternate payments, which represent 3% of all expenditures allocated in this study, were based on the location of provider. For the primary care portion of alternate payments, the location of the provider is likely to be fairly close to the place of residence of the recipient of the services. As a result, primary care alternate payments for out-of-area residents would be small relative to payments for in-area residents. However, some providers who receive alternate payments serve broad areas, for example, physicians on the staff of the Hospital for Sick Children in Toronto and specialist physicians participating in the Southeastern Ontario Academic Medical Organization associated with Queen’s University in Kingston. This would have the effect of over-estimating current expenditures for areas in which these organizations are located while under-estimating current expenditures for areas in which out-of-area patients
reside. For example, Kingston-based medical specialists received almost 44 million dollars in alternate payments in 1995-96. If 50% of the services of these specialists were provided to patients living outside the Kingston, Frontenac, Lennox and Addington Public Health Unit area, the difference between the per-capita needs-based allocation and per-capita expenditures for that PHU would decrease from $182 to $59 and the relative difference from 19% to 7%. Specialists located in the Toronto City Public Health Unit area, mainly those associated with the Hospital for Sick Children, received over $47 million in alternate payments in 1995-96. If 70% of their services were provided to out-of-area residents, the per-capita difference between the needs-based allocation and actual expenditures for the Toronto City PHU would be reduced from $140 to $91, and the relative difference from 13% to 9%.

CONCLUSIONS

Although on average the difference between needs-based allocations and actual health care expenditures were not large, ranging from 4.2% at the health region level to 8.0% at the Public Health Unit level, for many geographic areas the discrepancies were substantial (up to 8.9% at the health region level, 12.9% at the district health council level and 23.8% at the public health unit level). Based on these findings, the adoption of new funding methods based on relative population needs would improve equity in the allocation of resources to populations and result in a considerable redistribution of resources. Replication of our analysis as new data become available would establish whether discrepancies between needs-based allocations and those resulting from traditional funding approaches are changing over time.
REFERENCES


Table 1: 1995-96 Ministry of Health expenditures* for the provision of health care services and expenditures included in this project

<table>
<thead>
<tr>
<th>Details of Expenditure</th>
<th>Ministry of Health (dollars)</th>
<th>Project (dollars)</th>
<th>Percent Covered by project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grants Subsidies, etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation of Hospitals</td>
<td>7,248,400,712</td>
<td>4,764,397,791</td>
<td>65.7%</td>
</tr>
<tr>
<td>Operation of Related Facilities</td>
<td>330,273,850</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Ontario Health Insurance Plan (OHIP)</td>
<td>4,690,862,555</td>
<td>4,553,431,264</td>
<td>97.1%</td>
</tr>
<tr>
<td>Fee-for-service to physicians/practitioners</td>
<td>4,410,760,466</td>
<td>4,273,329,175</td>
<td>96.9%</td>
</tr>
<tr>
<td>Alternate payments†</td>
<td>123,597,234</td>
<td>123,597,234</td>
<td>100.0%</td>
</tr>
<tr>
<td>Health Service Organizations†</td>
<td>77,136,300</td>
<td>77,136,300</td>
<td>100.0%</td>
</tr>
<tr>
<td>Community Health Centres†</td>
<td>79,368,555</td>
<td>79,368,555</td>
<td>100.0%</td>
</tr>
<tr>
<td>Ontario Drug Benefit Plan</td>
<td>1,002,165,174</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Mental Health (Community and Institutional-Based)</td>
<td>143,089,554</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Official Local Health Agencies</td>
<td>185,301,294</td>
<td>0.0%</td>
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</tr>
<tr>
<td>Ambulance and Related Emergency Services</td>
<td>176,898,464</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Long Term Care</td>
<td>2,200,262,325</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>767,520,519</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Government Pharmacy Account</td>
<td>4,659,329</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Total Expenditures*</td>
<td>16,749,433,776</td>
<td>9,317,829,055</td>
<td>55.6%</td>
</tr>
</tbody>
</table>

* These expenditures exclude those not directly used for the provision of health care services, such as, Ministry staff salaries, benefits and travel, Ministers’ salaries, Parliamentary Assistants’ salaries, Ministry materials and supplies, funding for district health councils, the Health Resources Development Plan and Professional Relations, the Association of Local Official Health Agencies, the Ontario Council on Community Health Accreditation, the Ontario Public Health Association, clinical education and research.

† Preliminary estimates from the Ministry of Health based on unpublished data.

Table 2: Needs-Based Allocations and Health Care Expenditures (1995-96) at the Health Region Level*  

<table>
<thead>
<tr>
<th>Region</th>
<th>Needs-Based Allocation</th>
<th>Expenditures</th>
<th>Difference between Needs-Based Allocation and Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per-capita in dollars (95% CI)</td>
<td>Per-capita in dollars</td>
<td>Per-capita Difference in dollars†</td>
</tr>
<tr>
<td>South West (SW)</td>
<td>835 (812, 858)</td>
<td>843</td>
<td>-8</td>
</tr>
<tr>
<td>Central South (CS)</td>
<td>872 (846, 897)</td>
<td>876</td>
<td>-4</td>
</tr>
<tr>
<td>Central West (CW)</td>
<td>750 (733, 767)</td>
<td>689</td>
<td>61§</td>
</tr>
<tr>
<td>Central East (CE)</td>
<td>779 (759, 799)</td>
<td>728</td>
<td>51§</td>
</tr>
<tr>
<td>Toronto (TO)</td>
<td>898 (879, 917)</td>
<td>959</td>
<td>-61§</td>
</tr>
<tr>
<td>East (E)</td>
<td>799 (776, 822)</td>
<td>831</td>
<td>-32§</td>
</tr>
<tr>
<td>North (N)</td>
<td>895 (865, 925)</td>
<td>881</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>829</td>
<td>829</td>
<td>33</td>
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</tbody>
</table>

* These allocations include general practitioner, all medical specialists, optometrists physiotherapists, chiropractors and acute hospital covering 56% of the total expenditures by the Ministry of Health for the provision of health care services in 1995-96.

† Needs-Based – Expenditures; calculations based on unrounded data.

‡ (Needs-Based – Expenditures)/Expenditures; calculations based on unrounded data.

§ Significantly different at the 5% significance level.
### Table 3: Needs-Based Allocations and Health Care Expenditures (1995-96) at the Health District Level

<table>
<thead>
<tr>
<th>Region</th>
<th>District</th>
<th>Needs-Based Allocation</th>
<th>Expenditures</th>
<th>Difference between Needs-Based Allocation and Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Per-capita in dollars (95% CI)</td>
<td>Per-capita in dollars</td>
<td>Per-capita Difference in dollars†</td>
</tr>
<tr>
<td>SW</td>
<td>Essex-Kent-Lambton</td>
<td>848 (808, 888)</td>
<td>890</td>
<td>-42§</td>
</tr>
<tr>
<td></td>
<td>Thames Valley</td>
<td>816 (782, 851)</td>
<td>788</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Grey-Bruce-Huron-Perth</td>
<td>844 (792, 895)</td>
<td>856</td>
<td>-12</td>
</tr>
<tr>
<td>CS</td>
<td>Niagara</td>
<td>903 (858, 949)</td>
<td>819</td>
<td>84§</td>
</tr>
<tr>
<td></td>
<td>Hamilton/Wentworth</td>
<td>861 (824, 898)</td>
<td>954</td>
<td>-93§</td>
</tr>
<tr>
<td></td>
<td>Grand River</td>
<td>838 (779, 897)</td>
<td>817</td>
<td>21</td>
</tr>
<tr>
<td>CW</td>
<td>Halton-Peel</td>
<td></td>
<td></td>
<td>728 (707, 748)</td>
</tr>
<tr>
<td></td>
<td>Waterloo Region-Wellington-Dufferin</td>
<td>793 (760, 826)</td>
<td>702</td>
<td>91§</td>
</tr>
<tr>
<td>CE</td>
<td>Durham-Haliburton-Kawartha-Pine Ridge</td>
<td>824 (790, 857)</td>
<td>781</td>
<td>43§</td>
</tr>
<tr>
<td></td>
<td>Simcoe-York</td>
<td>743 (717, 769)</td>
<td>685</td>
<td>58§</td>
</tr>
<tr>
<td>TO</td>
<td>Metropolitan Toronto</td>
<td>898 (879, 917)</td>
<td>959</td>
<td>-61§</td>
</tr>
<tr>
<td>E</td>
<td>Champlain</td>
<td>786 (759, 813)</td>
<td>816</td>
<td>-30§</td>
</tr>
<tr>
<td></td>
<td>Quinte-Kingston-Rideau</td>
<td>828 (783, 873)</td>
<td>865</td>
<td>-37</td>
</tr>
<tr>
<td>N</td>
<td>Algoma-Cochrane-Manitoulin-Sudbury</td>
<td>891 (847, 936)</td>
<td>911</td>
<td>-20</td>
</tr>
<tr>
<td></td>
<td>Muskoka-Nipissing-Parry Sound-Timiskaming</td>
<td>954 (884, 1024)</td>
<td>895</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>Northwestern</td>
<td>852 (797, 906)</td>
<td>818</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>829</td>
<td>829</td>
<td></td>
</tr>
</tbody>
</table>

|        | Mean absolute difference                    | 47                      | 5.8          |                                                           |                              |

* These allocations include general practitioner, all medical specialists, optometrists physiotherapists, chiropractors and acute hospital covering 56% of the total expenditures by the Ministry of Health for the provision of health care services in 1995-96.

† Needs-Based – Expenditures; calculations based on unrounded data.

‡ (Needs-Based – Expenditures)/Expenditures; calculations based on unrounded data.

§ Significantly different at the 5% significance level.

|| Peel is located in the region of Central East.
Table 4: Needs-Based Allocations and Health Care Expenditures (1995-96) at the Public Health Unit Level*

<table>
<thead>
<tr>
<th>Region</th>
<th>Local Area</th>
<th>Needs-Based Allocation</th>
<th>Expenditures</th>
<th>Difference between Needs-Based Allocation and Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Per-capita in dollars (95% CI)</td>
<td>Per-capita in dollars</td>
<td>Per-capita Difference in dollars†</td>
</tr>
<tr>
<td>SW</td>
<td>Windsor-Essex</td>
<td>841 (795, 887)</td>
<td>899</td>
<td>-59§</td>
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Mean absolute difference 67 8.0
These allocations include general practitioner, all medical specialists, optometrists, physiotherapists, chiropractors and acute hospital covering 56% of the total expenditures by the Ministry of Health for the provision of health care services in 1995-96.

† Needs-Based – Expenditures; calculations based on “unrounded” numbers.
‡ (Needs-Based – Expenditures)/Expenditures; calculations based on “unrounded” numbers.
§ Significantly different at the 5% significance level.
|| Data on alternate payments for physician services were not available for the local areas within Metro Toronto. We estimated the HSO portion of the alternate payments in each local area within Metro Toronto using the number of patients enrolled in HSOs and the average per-capita payment to HSOs. The remainder of the alternate payments were distributed through the local areas according to population.
Figure 1: Per-Capita Needs-Based Allocations versus Actual Expenditures*

*The diagonal line on each graph represents needs-based allocations = actual expenditures.
Appendix 1

Confidence Interval Derivation for Needs-Based Allocations

The variance of the needs-based allocation (NBA) for a given geographic region is

\[
Var(NBA) = Var(C1\hat{Y})
= C1^2 Var(\hat{Y})
\]  

(1)

where \(C1\) is the provincial per capita expenditure in which sampling variability is disregarded and \(Y\) is the total resource shares for the geographic region. Now,

\[
\hat{Y} = \sum_{i,j,k} NSS_{i,j,k} n_{i,j,k}
\]

(2)

where \(NSS_{i,j,k}\) is the need-specific share and \(n_{i,j,k}\) is the estimated population of the given geographic region for age group \(i\), sex \(j\) and health status group \(k\).

\[
NSS_{i,j,k} = \sum_t K_t NSS_{t,i,j,k}
\]

where \(t\) indicates the type of service (general practitioner, specialist, optometry, physiotherapy, chiropractic or acute hospital) and \(K_t\) is the proportion of the Ministry of Health budget covered by each type of service. For each \(t\),

\[
NSS_{t,i,j,k} = C2_{t,i,j} \frac{p1_{t,i,j,k}}{p2_{i,j,k}}
\]

where \(C2_{t,i,j}\) is the ratio of the proportion of provincial expenditures for service \(t\) accounted for by age-sex group \((i,j)\) to the proportion of the provincial population in that group. Because this ratio is based on provincial data from the Ontario Ministry of Health, sampling variability can be disregarded. The proportion of health care service contacts (or acute hospital nights stayed) for service \(t\) for age-sex group \((i,j)\) that are associated with individuals in health status group \(k\) for the province is \(p1_{t,i,j,k}\) and the proportion of the Ontario Health Survey (OHS) provincial sample in group \((i,j)\) that are in health status group \(k\) is \(p2_{i,j,k}\).

In (2), \(n_{i,j,k}\) is estimated from Statistics Canada regional population figures by age and sex, \(N_{i,j}\), combined with the proportion of the age-sex group in health status group \(k\) for that geographic region estimated from the OHS, \(rp2_{i,j,k}\), such that,

\[
n_{i,j,k} = N_{i,j} rp2_{i,j,k}
\]
Then, from (2)

\[
\text{Var} (\hat{Y}) = \text{Var} \left[ \sum_{i,j,k} \left( \sum_t K_i C_{t,i,j} \frac{p_{1t,i,j,k}}{p_{2t,i,j,k}} \right) \left( N_{i,j} r_{p2} \right) \right]
\]

\[
= \sum_{i,j,k,t} \text{Var} \left[ K_i C_{t,i,j} \frac{p_{1t,i,j,k}}{p_{2t,i,j,k}} N_{i,j} r_{p2} \right]
\]

assuming that the number of shares in each sex, age, health status and type of service group are independent of one another. So,

\[
\text{Var}(\hat{Y}) = \sum_{i,j,k,t} K_i^2 C_{t,i,j}^2 n_{i,j}^2 \text{Var} \left( \frac{p_{1t,i,j,k} r_{p2}}{p_{2t,i,j,k}} \right).
\]

Suppressing the subscripts for clarity and using Taylor series approximations we have,

\[
\text{Var} \left( \frac{p_{1t,i,j,k} r_{p2}}{p_{2t,i,j,k}} \right) = \left( \frac{p_{1t,i,j,k} r_{p2}}{p_{2t,i,j,k}} \right)^2 \text{Var} \left[ \ln \left( \frac{p_{1t,i,j,k} r_{p2}}{p_{2t,i,j,k}} \right) \right].
\]

\[
\text{Var} \left[ \ln \left( \frac{p_{1t,i,j,k} r_{p2}}{p_{2t,i,j,k}} \right) \right] = \text{Var} [\ln(p1) + \ln(rp2) - \ln(p2)]
\]

\[
= \text{Var} [\ln(p1)] + \text{Var} [\ln(rp2)] + \text{Var} [\ln(p2)] - 2 \text{Cov} [\ln(rp2), \ln(p2)]
\]

\[
= \frac{\text{Var}(p1)}{p1^2} + \frac{\text{Var}(p2)}{rp2^2} + \frac{\text{Var}(p2)}{p2^2} - 2 \text{Cov}(rp2, r2)
\]

noting that \(p1\) is independent of \(p2\) and \(rp2\). The proportion \(p1\) is estimated by \(r1/n1\) where \(r1\) is the number of health care service contacts for type-of-service-age-sex-health status group \((t,i,j,k)\) and \(n1\) is the total number of health care service contacts for type-of-service-age-sex group \((t,i,j)\). Similarly, \(p2\) is estimated for the province by \(r2/n2\) and \(rp2\) is estimated for the geographic region by \(rr2/rn2\).

Note that the OHS data were population weighted for each public health unit, age and sex group. The analytic weights are used so as not to under-estimate the variance by using an inflated population size. In addition, to compensate for the cluster design that was used in the OHS we will divide the analytic weight by the square root of the appropriate design effect \((\text{deff})\).\(^{(36)}\) For variance calculation purposes the weights, \(w\), are given by,

\[
w_{i,j,PHU} = \frac{\sum n_{i,j,PHU}}{n_{2,i,j,PHU} \sum N_{i,j,PHU} \sqrt{\text{deff}}} = \frac{N_{i,j,PHU}}{n_{2,i,j,PHU} \sqrt{\text{deff}}} \frac{62,413}{11,098,109}
\]
From the binomial we have,

\[ \text{Var}(p1) = \frac{r1}{n1^3} (n1 - r1), \]

\[ \text{Var}(rp2) = \frac{rr2}{rn2^3} (rn2 - rr2), \]

and,

\[ \text{Var}(p2) = \frac{r2}{n2^3} (n2 - r2) \]

where \( r1, n1, r2, n2, rr2 \) and \( rn2 \) are weighted as discussed above. To calculate the covariance, let \( or2 = r2 - rr2 \) and \( on2 = n2 - rn2 \) where \( o \) indicates all the other geographic regions.

\[
\text{Cov}(rp2, p2) = \text{Cov}\left( \frac{rr2}{rn2^3}, \frac{rn2 + on2}{rn2} \right) = \frac{rr2}{rn2^3} \left( \text{Cov}\left( \frac{rr2}{rn2}, \frac{rn2 + on2}{rn2} \right) \text{ln}\left( \frac{rr2}{rn2} \right), \text{ln}\left( \frac{rn2 + on2}{rn2} \right) \right). \tag{6}
\]

\[
\text{Cov}\left( \text{ln}\left( \frac{rr2}{rn2} \right), \text{ln}\left( \frac{rn2 + on2}{rn2} \right) \right) = \text{Cov}\left[ \text{ln}(rr2) - \text{ln}(rn2), \text{ln}(rr2 + or2) - \text{ln}(rn2 + on2) \right] = \text{Cov}\left[ \text{ln}(rr2), \text{ln}(rr2 + or2) \right] - \text{Cov}\left[ \text{ln}(rn2), \text{ln}(rn2 + on2) \right] - \text{Cov}\left[ \text{ln}(rr2), \text{ln}(rn2 + on2) \right] + \text{Cov}\left[ \text{ln}(rn2), \text{ln}(rr2 + or2) \right] = \frac{\text{Cov}(rr2, rr2) + \text{Cov}(rr2, or2)}{rr2(rn2 + on2)} - \frac{\text{Cov}(rr2, rn2) + \text{Cov}(rr2, on2)}{rn2(rn2 + on2)}
\]

because all terms but the first are 0 because we condition on the \( n \)'s and only consider variation in the \( r \)'s. Thus, from (6),

\[
\text{Cov}(rp2, p2) = \frac{rr2}{rn2^3} \cdot \frac{Var(\frac{rr2}{rn2})}{\frac{rn2 + on2}{rn2}} \cdot \frac{\text{Var}(\frac{rr2}{rn2})}{\frac{rr2}{rn2}} = \frac{\text{Var}(\frac{rr2}{rn2})}{\frac{rn2 + on2}{rn2}} \cdot \frac{\text{Var}(\frac{rr2}{rn2})}{\frac{rr2}{rn2}}
\]

and

\[
\text{Cov}(rp2, p2) = \frac{rr2}{rn2^3} \cdot \frac{rn2}{n2} = \frac{rr2}{rn2 \cdot n2}
\]

so,

\[
\text{Var}(rr2) = \frac{rr2}{rn2} \cdot \frac{rn2}{n2}
\]
From (5) we have,

\[
Var \left[ \ln \left( \frac{p1rp2}{p2} \right) \right] = \frac{n1^2}{r1^2} - \frac{r1}{n1} (n1 - r1) + \frac{rn2^2}{r2^2} + \frac{rr2}{rn2^2} (rn2 - rr2) + \frac{n2^2}{n2^3} (n2 - r2)
\]

\[
- \frac{2rn2n2}{r2} \frac{rr2(rn2 - rr2)}{rn2^2n2}
\]

\[
= \frac{n1 - r1}{r1n1} + \frac{rn2 - rr2}{rr2rn2} + \frac{n2 - r2}{r2n2} - \frac{2(rn2 - rr2)}{r2rn2}.
\]

Substituting into (4) we have,

\[
Var \left( \frac{p1rp2}{p2} \right) = \left( \frac{p1rp2}{p2} \right)^2 \left( \frac{n1 - r1}{r1n1} + \frac{rn2 - rr2}{rr2rn2} + \frac{n2 - r2}{r2n2} - \frac{2(rn2 - rr2)}{r2rn2} \right).
\]

Substituting into (3) gives,

\[
Var(\hat{Y}) = \sum_{i,j,k,t} K_i^2 C_{t,i,j}^2 N_{i,j}^2 \left( \frac{p1rp2}{p2} \right)^2 \left( \frac{n1 - r1}{r1n1} + \frac{rn2 - rr2}{rr2rn2} + \frac{n2 - r2}{r2n2} - \frac{2(rn2 - rr2)}{r2rn2} \right).
\]

So, from (1),

\[
Var(NBA) = C1^2 Var(\hat{Y}).
\]

The 95% confidence interval is,

\[
NBA \pm 1.96 \sqrt{Var(NBA)}
\]

assuming that Y, the total number of shares, is approximately normally distributed.