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ICES Institute for Clinical Evaluative Sciences

Non-invasive Cardiac Testing in Ontario

ICES Investigative Report

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ICES is an independent, non-profit organization that conducts research on a broad range of topical issues to enhance the effectiveness of health care for Ontarians. Internationally recognized for its innovative use of population-based health information, ICES knowledge provides evidence to support health policy development and changes to the organization and delivery of health care services.

Unbiased ICES evidence provides fact-based measures of health system performance; a clearer understanding of the shifting health care needs of Ontarians; and a stimulus for discussion of practical solutions to optimize scarce resources.

Key to ICES' research is our ability to link anonymous population-based health information on an individual patient basis, using unique encrypted identifiers that ensure privacy and confidentiality. This allows scientists to obtain a more comprehensive view of specific health care issues than would otherwise be possible. Linked databases reflecting 12 million of 30 million Canadians allow researchers to follow patient populations through diagnosis and treatment, and to evaluate outcomes.

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Contents

Introduction

The diagnosis and management of cardiovascular disease relies heavily on non-invasive cardiac testing (NICT). While non-invasive cardiac testing helps shape management decisions, the vast majority of indications are discretionary. Utilization rates in Ontario, and elsewhere, have risen exponentially throughout the previous 10 years. The economic impact of NICT is staggering. Together, six NICTs accounted for nearly a quarter of a billion dollars in direct annual health expenditures in Ontario, which is fourfold greater than total costs for coronary angiography and approach the total direct and indirect expenditures for coronary angiography, angioplasty, and bypass surgery combined.

Nonetheless, Canadian health services researchers have focused little on the use of non-invasive cardiac testing, opting instead to identify factors that impact invasive cardiac procedures. In reality, utilization of specialized cardiac procedures is intermeshed within a referral cascade that usually begins with a non-invasive test. While some patients clearly benefit from NICT, others may benefit less, or not at all. As discussed in this report, available evidence from other jurisdictions suggests that a large proportion of non-invasive testing is inappropriate, a consequence of referrals being heavily governed by physician factors (e.g. gender, year of graduation, reimbursement, practicing centres), and non-clinical system characteristics (e.g. practicing centre, urban/rural differences, specialty service intensity), rather than by clinical necessity.[16,26,32-41]

In June of 2002, the Ontario Ministry of Health and Long-Term Care commissioned the Institute of Clinical Evaluative Sciences to report on the use of NICTs in Ontario, as part of a broader series of reports on diagnostic testing. This report focuses on utilization of the six most prevalent NICT methods:

1. Electrocardiography (ECG);
2. Stress testing or graded exercise treadmill testing (GXT);
3. Echocardiography (ECHO);
4. Holter monitoring or ambulatory electrocardiography (AECG);
5. Myocardial perfusion imaging (MPI); and,
6. Wall motion studies, including radionuclide angiography (RNA).

This study was not designed to address appropriateness of use of NICT, but to demonstrate variations in utilization and physician practice patterns in its use. The main objectives of this report are as follows:

1. To examine the temporal trends of NICT utilization in Ontario;
2. To determine age, sex, socioeconomic status specific utilization rates of NICTs;
3. To determine referral patterns and repeat testing trends of NICTs; and,
4. To examine regional variations of NICTs;

Data was derived from the following sources and studied for the period of 1992 to 2001:

- Ontario Hospital Insurance Plan (OHIP) billings
- Registered Persons Database
- Ontario Physician Human Resources Data Centre (OPHRDC)
- Statistics Canada

Key Messages

1. The relative frequencies of NICT for most investigations have increased over the past decade.
2. Age, gender, and socioeconomic status are important determinants of NICT utilization, with a proportionately higher number allocated to older and wealthier subgroups.
3. With the exception of ECG, fewer than 20% of patients had one or more NICTs and fewer than 5% of patients had two or more, repeated NICT investigations over the 2 years following the index test. Since patient clinical status can change over time, the frequency of repeat testing is likely appropriate.

4. Considerable small area variations were observed in the use of NICT; regional variations appear most pronounced for MPI, and least pronounced for ECGs.
5. Future cohort studies are required to clearly determine the reasons and implications of inter-regional rate variations for NICT in Ontario.
6. Conclusions regarding the appropriateness of NICT utilization cannot be drawn from this study.

Background

Diagnosis and management of cardiovascular disease relies heavily on the use of NICT. The most commonly used NICTs in Canada are ECG, GXT, ECHO, AECG, MPI, and RNA.[1] These tests provide information on structural abnormalities of the heart and impairment of heart function.[2-15] They not only help to establish the diagnosis of cardiovascular disease, but also assist in the evaluation of prognosis and help shape management decisions on drug therapy, surgery, and other cardiac interventions.[16-20]

Despite the fact that these tests are older technologies, the use of cardiac NICT over the past decade has risen exponentially in Canada, and elsewhere.[1, 21-26] The accelerated growth in Ontario has considerably outstripped demographic shifts in the population, and has occurred despite stringent expenditure control policy initiatives imposed during the early to mid 1990s.[21] The economic burden to Ontario third-party payers is staggering. During fiscal year 2000/01, the six non-invasive cardiac tests accounted for nearly one-quarter of a billion dollars in direct Ontario health expenditures, fourfold greater than for coronary angiography, and approaching the total direct and indirect expenditures for coronary angiography, percutaneous transluminal coronary angioplasty, and coronary artery bypass surgery, combined, during the same period (Table 1).

Moreover, non-invasive cardiac testing is associated with false positives, especially when conducted among younger healthier patients with low pre-test likelihood of disease. False positives may perpetuate a cascade of investigations in patients that may not have required evaluation in the first place.[27-30] Subsequent investigations resulting from abnormal index testing may, themselves, occasionally pose risks of serious physical and/or psychological harm.[31]

Table 1. Ontario expenditures for invasive and non-invasive services in 2000/01

Services	Volume	Cost per Service (C$)	Cost (C$ millions)
Invasive			
Coronary angiography	40,418	1,275.16	51.5
Percutaneous transluminal coronary angioplasty	10,363	5,401.55	55.9
Coronary artery bypass surgery (without concomitant valve surgery)	8,055	16,125.81	129.9
			237.4
Non-invasive			
ECG	1,728,839	21.40	36.9
ECHO*	320,068	229.63	73.5
GXT	220,459	99.81	22.0
MPI	154,260	335.83	51.8
AECG	125,636	129.22	16.2
Wall motion/myocardial scintigraphy	90,717	219.56	19.9
			220.5
			Total 457.9

*includes transesophageal ECHO

Data sources: Cardiac Care Network; Ontario Case Costing Initiative; Ontario Health Insurance Plan; Director, Economics, Ontario Medical Association

(See Appendix B for further detail.)

Available evidence from Ontario and elsewhere have demonstrated wide interregional variations in the utilization of cardiac NICT.[1,25,37,38,42-46] While earlier evidence in Ontario had suggested that regional variations were diminishing over time, a recent study commissioned by the Guidelines Advisory Committee conducted in 2001 suggests that significant variations have persisted. [21] If the assumption is made that the demographic and case-mix composition of a population are relatively homogenous across jurisdictions, then inter-regional variations in the utilization rates of a non-invasive test may result from inter-physician differences in clinical knowledge, medical uncertainty, or other decision-making processes.[34,36,46-49]

Proponents of NICT may reflect on the incremental benefits beyond those obtained from a history and physical exam.[2,9,12,23,50-53] In contrast, many studies have looked at whether such tests are used inappropriately in the population. [3,6,54-58] For example, the high normalcy rate of echocardiograms observed among a random sample of 11,000 patients from New Zealand, suggests that such investigations are associated with a low diagnostic yield, especially if employed non-selectively in the population.[59] Preliminary results confirm these findings in a random sample of 1,000 patients referred for ECHO to three community clinics in Ontario (Alter et al, research in progress). Moreover, the majority of these patients were healthy with no prior cardiac disease or interventions.

Clinical practice guidelines are generally unhelpful in distinguishing between appropriate and inappropriate indications for NICT.[60-84] While consensus guidelines contain several Level 1 indications that support the use of non-invasive testing, there are relatively few indications refuting their role. Furthermore, while several guidelines evaluate a wide-ranging set of clinical circumstances, most indications defer to “clinical signs and symptoms” to ultimately guide their recommendations. The lack of refined detail, and lack of consistency across (and within) individual reports, allow for sufficient clinical justification for testing.

While this study does not address the issue of appropriateness, the research does provide important insight on factors that impact physician decision-making processes for non-invasive cardiac investigations in Ontario. These studies will serve as the foundation for future outcomes analyses and prospective evaluations. The study of physician and system/supply factors will also help direct potential future policy reform initiatives.[85-87] Research and policy implications are discussed in the conclusions and recommendations section of this report.

Findings and discussion

Temporal trends in use of NICT

Exhibit 1 shows the absolute change in the number of NICTs from 1992 to 2001. **Exhibit 2** illustrates the relative change in each of the six NICTs, in reference to 1992 data. With the exception of the modest temporal decline in wall motion imaging, each NICT has increased steadily throughout the decade, with a marked jump from 1996 onward. From 1992, the greatest increases have been in MPI (a 2.35-fold increase from 1992 to 2001), which may indirectly reflect the more aggressive use of invasive coronary angiography over the same period.[88] Specifically, the age- sex-adjusted per capita rates of ECG, ECHO, AECG, GXT, MPI, and wall motion studies were 25,462, 3,162, 1,459, 2,020, 1,097, and 1,006, respectively, per 100,000 Ontarians in 2001. In contrast, the corresponding age-sex adjusted per capita rate of coronary angiography was 511 per 100,000 population during the same time (separate analysis). ECG increased 1.23-fold from 1992 to 2001 while ECHO, AECG, MPI and GXT increased 1.6-fold, 1.4-fold, 1.4-fold and 1.43-fold, respectively. The flattened utilization patterns observed for many of the non-invasive cardiac tests during the early to mid-1990s may be attributable to the "social contract" imposed by the provincial government during which restrictions in service across health services were encouraged. Once these were lifted, utilization increased steadily.

Age- sex-specific utilization rates for NICT

Exhibit 3 illustrates the age- and sex-specific rates for each of the NICTs in 2001. The most prevalent age group for ECG, ECHO, and AECG testing was 75 years and older, which may reflect the age-specific prevalence of congestive heart failure and valvular heart disease. In contrast, GXT and MPI testing were more common in the 65 to 74 year age group, which has higher prevalence of first presentation for coronary artery.

While older men received more non-invasive testing than did older women, gender disparities narrowed, and in some cases reversed, in younger age groups. While reasons for such age-gender treatment differences are unknown, recent evidence has demonstrated a similar interaction for the use of coronary angiography and specialty outpatient follow-up care after acute myocardial infarction (AMI) in Ontario.[89] Finally, the consistently lower referral rates of GXT and MPI among women as compared to men, may reflect their higher prevalence of atypical symptoms, which in turn, may impact the thresholds for investigations by the primary physician decision-maker at presentation.

Socioeconomic status-specific utilization rates of NICT

Exhibit 4 illustrates the absolute number of non-invasive tests in 2001 according to neighborhood median household income. The predominance of NICT among lower socioeconomic status (SES) subgroups apparently reflects the higher number of lower SES patients in the population. Once adjustment is made for the SES differences among the population, **Exhibits 5a–f** illustrate significant upward trend in the per capita rates of NICT utilization among higher, as compared to lower, SES subgroups. By 2001, the per capita rates of NICT were highest among patients with neighborhood median household incomes of $70,000 and beyond.

Exhibits 6a–f reaffirm the SES disparities by illustrating that the relative growth in NICT was disproportionately higher for affluent, than for non-affluent patients, suggesting that socioeconomic differences in NICT utilization rates are continuing to increase over time. Interestingly, the SES-specific temporal trends in NICT utilization appears congruent with corresponding temporal changes in the use of coronary angiography for patients hospitalized with AMI in Ontario.[88] The extent to which widening socioeconomic disparities in the use of NICT are attributable to patient, physician, or geographical factors is unknown.

Referral rates of NICT according to physician specialty

Exhibit 7 illustrates the utilization rates of NICTs by referring physician specialty in 2001. Using the developed hierarchical algorithm for referring physicians, cardiologists accounted for only 9% of referrals for ECG, and approximately 20% of referrals for ECHO, AECG monitoring and GXT. While primary care physicians accounted for the majority of ECG, ECHO, AECG, and GXT referrals, cardiologists accounted for majority of MPI studies. For reasons that are unclear, 40% of the referring physicians for gated wall motion studies were not classified as general practitioners/family practice, internal medicine, or cardiology.

Repeat testing rates for NICT

The proportions of patients that had one test and two or more tests (repeated test) in a two-year period (from 1999 to 2001) are shown in **Exhibit 8**. By the lag time definitions used in this study (see analytic methods in Appendix A and B), no test, with the exception of ECG, could have one or more repeats within 7 days of the first. Approximately half of patients that had ECG also had at least one subsequent test, while 22%, 20%, 17% 15% and 12% of persons having ECHO, AECG, MPI, GXT and wall motion studies, respectively, had more than one test within the 2 years after an initial test. When two or more tests were performed, most, with the exception of ECHO and MPI were done within 12 months of the first. Conversely, the majority of repeated ECHO (59%) and MPI tests (64%) were conducted beyond the first year. Finally, repeated testing within the first month of the index investigation was observed in only a small minority of patients. Specifically, among patients that received two or more tests within two years of follow-up, fewer than 12% of ECGs, 10% of AECGs, and 5% of all remaining NICTs were repeated within one month of the first corresponding investigation (**Exhibit 9**).

Regional variations in NICT rates

Exhibits 10 through 15 illustrate the age- and sex-adjusted per capita rates of NICT in 2001 by county of patient residence throughout Ontario. Regional variations appeared most pronounced for MPI, and least pronounced for ECG. **Exhibit 16** illustrates the age- sex-adjusted NICT intensity relative to the provincial average for ECG, ECHO, GXT, and MPI. While the relative NICT rankings for Kenora, Rainy River, Oxford, Perth, and Wellington were uniformly low for all tests, relative rankings differed according to the specific NICT evaluated. For example, Peterborough, Durham, Haliburton, and Nipissing were among the highest per capita rates of ECHO, GXT, and MPI, but were among the lowest in rankings for ECG. Further, regions with high intensity MPI services did not always have a high intensity of GXT (e.g., Kawartha Lakes, Toronto, Peel).

While inconsistencies in NICT intensity across regions may reflect regional differences in patient case-mix distribution, it might reasonably be hypothesized that such inconsistencies may also be explained by variations in the supply of hospitals, physicians, or non-invasive tests themselves. For example, the low correlation between county-specific ECGs and other NICTs (e.g., ECHO) (**Exhibit 17**) may reflect differences in physician specialty composition, a proxy marker for non-invasive test supply. Generally supplied by family/GP physicians, ECG may correspond to the intensity of primary care providers within a region, while corresponding variations for ECHO, a service generally provided by cardiology/internal medicine physicians, may reflect the intensity of specialty care service providers within a region.

Likewise, the modest correlation between GXT and MPI (**Exhibit 18**) may be explained by variations in hospital supply (which is the most significant provider of MPI testing in the province), or by outpatient specialty clinics (which provide GXT services). Alternatively, regions with higher concentration of MPI relative to GXT may reflect variations in the supply of downstream invasive cardiac services. In this regard, physicians may be attentive to constraints in the availability of coronary angiography within their region, thereby applying more rigorous selection criteria when assessing patients with coronary artery disease. The extent to which regional variations of NICT are explained by variations in the supply of downstream invasive services is the focus of future study by ICES researchers.

Conclusions

Summary of findings

This study demonstrated several important findings. First, it illustrated accelerated growth in the utilization of NICT over the previous decade, with relative increases most pronounced for ECHO. Second, absolute rates of non-invasive tests were higher among elderly and affluent patients, than among younger or impoverished citizens. Third, while significant regional variations in NICT utilization were observed, the regional patterns were not consistent across tests, for example, some regions were "high rate users" for some NICTs, and lower rate users for others. Finally, repeated testing rates, particularly within short time intervals from the index investigation, were low.

Until now, most, but not all evidence [22,90,91] exploring the factors that influence non-invasive cardiac testing in the population have been based on survey data or on selected samples of patients from community/hospital-based settings.[25,32,34-36,39,42,43,53,92-95] The majority of population-based studies that have characterized cardiac NICT variations have done so using the test claim as the major unit of analysis. By employing the use of correlations and small area variations, such studies have provided important descriptive information.[1,21,37,44,45] However, they have not been able to properly characterize the patient, the decision-maker, or the system to be able to examine how each factor alone, and together, impact the utilization of non-invasive testing in the population. In contrast, this study utilized the patient, not the test claim, as the major unit of analysis.

This study highlighted the importance of age, gender, and socioeconomic status, as determinants of NICT utilization in Ontario. Reassuringly, age-specific variations in NICT corresponded to age-specific variations in cardiac hospitalization rates in Ontario (e.g., GXT and MPI testing were conducted most commonly among the 65 to 74 year age group, which corresponds to the highest prevalence of hospitalizations for coronary artery disease), though socioeconomic disparities favoured higher NICT utilization rates among the most affluent patients.[89] Such socioeconomic disparities in NICT referrals are especially disconcerting, given the higher prevalence of cardiovascular hospitalizations among poorer rather than more affluent patients. Moreover, available evidence has demonstrated similar socioeconomic disparities in the use of invasive cardiac testing post-MI.[96]

These results are consistent with other international jurisdictions and may suggest that non-invasive test referrals are based on factors other than clinical indication and disease severity.[32,37,90,93-95,97] Furthermore, the positive relationship between supply and utilization of cardiovascular health services in Ontario, and elsewhere, may explain inter-regional variations in the use of NICT throughout Ontario.[98-101] Studies demonstrating the importance of physician (e.g., physician gender, year of graduation, reimbursement, practicing centres), and system characteristics (e.g., practicing centre, urban-rural differences, specialty service intensity), further reinforce the relationship between non-clinical factors and non-invasive cardiac testing in the population.[32-39] The importance of non-invasive testing in risk-stratification for downstream interventions might also explain why similar non-clinical factors influence the use of coronary angiography in the population.[20,44,102] In summary, the interrelationship between physician behaviour and their exposures to NICT and/or specialty cardiac service supply, may impact the decision-making processes that apply to a whole variety of cardiovascular investigations, rather than for any single selected investigation alone.

Nonetheless, the relationship between the supply of specialty cardiac services and non-invasive test utilization is extremely complex, and one that might vary across jurisdictions.[21] This might explain why supply-side reform initiatives have not always successfully curtailed utilization of non-invasive testing in Ontario, or elsewhere.[21,38,43] For example, the disproportionately high utilization rate of GXT observed within rural regions may suggest that physicians compensate for limited access to angiography facilities. Such physicians may aggressively employ the use of GXT as their predominant selection modality for patients that might have otherwise have been directly referred to coronary angiography in urban jurisdictions.[21]

Appropriate utilization of NICT

To what extent are utilization patterns of NICT in Ontario inappropriate? The evaluation of appropriateness for cardiac non-invasive testing is challenging. Clinical practice guidelines, for instance, are generally unhelpful in distinguishing between appropriate and inappropriate indications.[60-84] Most indications are considered as either appropriate or uncertain (Class I or II); only few indications are considered inappropriate. Most guidelines emphasize that decisions for non-invasive cardiac testing should be driven, in large part, by clinical suspicion of disease or disease progression. Such statements assume that the clinical exam is reliable, valid, and responsive over time. Yet available evidence may suggest otherwise, especially among non-cardiac specialists.[103-106] Furthermore, variations in clinical judgment from patient to patient may dramatically alter the perceived necessity of investigations. Physician variations in the use of cardiac NICT may be driven by a multitude of subtle factors, including the need for patient reassurance, physician risk aversion and malpractice fears, process breakdowns in the continuity of care, or inconsistencies in data quality and interpretations.[16,26,36,40,41,107] It can be reasonably concluded that the vast majority of cardiac NICT indications carry considerable uncertainty.

It can be hypothesized that duplicate repeat testing conducted within short time intervals serves as a surrogate for inappropriate referral behavior. Reassuringly however, our results demonstrated a relatively low prevalence of repeated testing in Ontario. With the exception of ECGs (for which there is justification for repeated testing in cases of acute chest pain syndromes), fewer than 5% of Ontarians received two or more repeated non-invasive tests within two-years of their index investigation. The low prevalence of repeated testing is reassuring, and may be consistent with fluctuations in disease severity among patients with established cardiovascular disease.

Given that cardiovascular practice variations are, in large part, driven by the utilization of discretionary indications rather than by underuse or overuse,[48] appropriateness must be evaluated within a clinical context and may be better reflected as risk/benefit trade-offs rather than by all or none phenomena.[37,51,108] The understanding of marginal trade-offs requires that researchers first identify those factors that determine utilization. Only then can researchers better interpret the impact of utilization on patient, physician, and system outcomes. Cardiovascular researchers have incorporated such organizational approaches to demonstrate the importance of physician and system factors on invasive cardiac procedure use and outcomes.[109,110]

While invasive cardiac procedures have been studied extensively, health services researchers have not extensively evaluated non-invasive testing in the population, despite its fundamental role in the selection of patients for invasive cardiac interventions. With few exceptions,[22,90,91] most of the evidence exploring the factors that influence non-invasive cardiac testing in the population has been based on survey data or selected samples of patients from community/hospital-based settings.[25,32,34-36,39,42,43,53,92-95]

While this report provides important hypothesis generating data, and serves as a foundation for additional research, future studies in Ontario, as elsewhere, require the construction of cohort studies, which will allow for the disentangling of patient factors from those related to the primary physician decision-maker and the regional/system of practice. Such studies will also allow researchers to explore the extent to which NICT utilization impacts downstream outcomes, a necessary requirement prior to any inferences being drawn on yield/appropriateness. Moreover, to better understand the impact of supply on utilization, regions must be re-defined in terms of service supply intensity (and/or geographical proximity between regions of high and low service supply). The studies must accompany chart abstraction pilot projects that allow researchers to examine high and low-rate testing regions for differences in referral indications, which will provide capability for international comparisons.

To this end, Ontario health services researchers at ICES have secured peer-reviewed funding from the Heart and Stroke Foundation of Canada to initiate the next phase of research. Future studies will address many of the previous research limitations by incorporating the patient, and his/her primary physician (rather than referral physician specialty code which is associated with a high frequency of missing information) as the major units of analyses. Case-mix characteristics of patients undergoing NICT, and

the extent to which system and provider characteristics impact a physician's decision to refer a patient for NICT, will be examined.

The amalgamation of multiple administrative databases longitudinally over time will allow broad characterization of the cardiac risk profile of every patient, and the referral characteristics of every patient's physician in the province of Ontario. Based on the relationship between non-clinical factors and non-invasive testing suggested by studies elsewhere,[32,32-37,37-39,90,93-95,97] it is hypothesized that variations in utilization rates of non-invasive testing will be explained by intrinsic physician factors, such as their underlying propensity to refer patients for a variety of ancillary investigations. Moreover, physician referral patterns themselves are also likely to be guided by the availability of specialty cardiac services within their region of practice.

Not only is it expected that these physician/system factors will impact a patient's likelihood to receive one investigation, these factors may also determine the likelihood that a patient will receive repeated investigations in the weeks and months that follow the first evaluation. Finally, collaboration with health services researchers from Dartmouth New Hampshire will combine the expertise of both centres, and explore the link between cardiac service intensity and outcomes between the U.S. and Canada.[1,21,37,44,45]

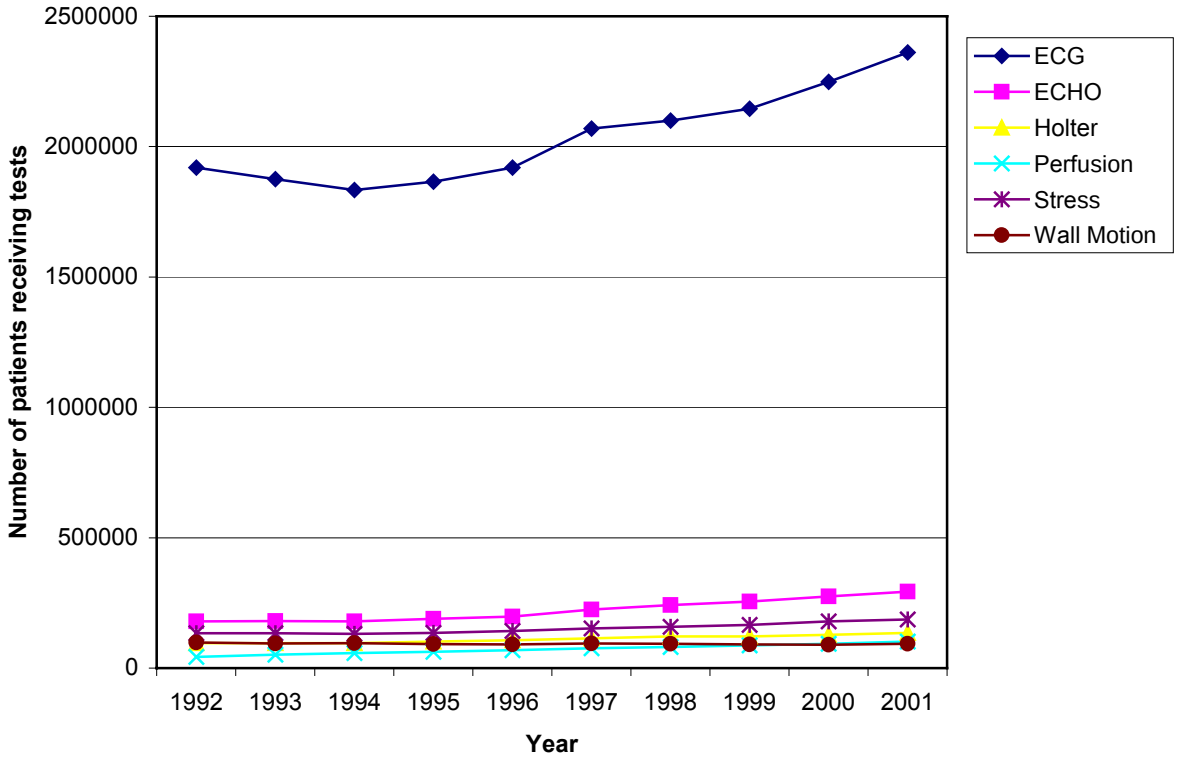
Recommendations

1. Given the relative and absolute magnitudes of NICT, as well as their downstream health service utilization and costs, the determination of referral appropriateness is essential. The following recommendations would facilitate better understanding of appropriateness of NICT utilization in Ontario.
2. Identify cardiac service supply areas, so that regional characteristics are more reflective of the supply of primary care providers, specialists, hospitals, non-invasive tests, and invasive cardiac health services.
3. Determine how the use of NICT correlates with subsequent invasive cardiac testing, and revascularization procedures.
4. Obtain information regarding the test results, which would allow better yield assessment (i.e., abnormal vs. normal studies).
5. Conduct chart reviews to determine indications by auditing high and low-rate regions to best identify differences in case-mix and referral behaviors.
6. Consider other mechanisms, such as provider profiling (feedback and audits) of provider referral patterns, academic detailing, or policies designed to influence physician behaviors and perspectives with regard to the use of NICT.

Exhibits

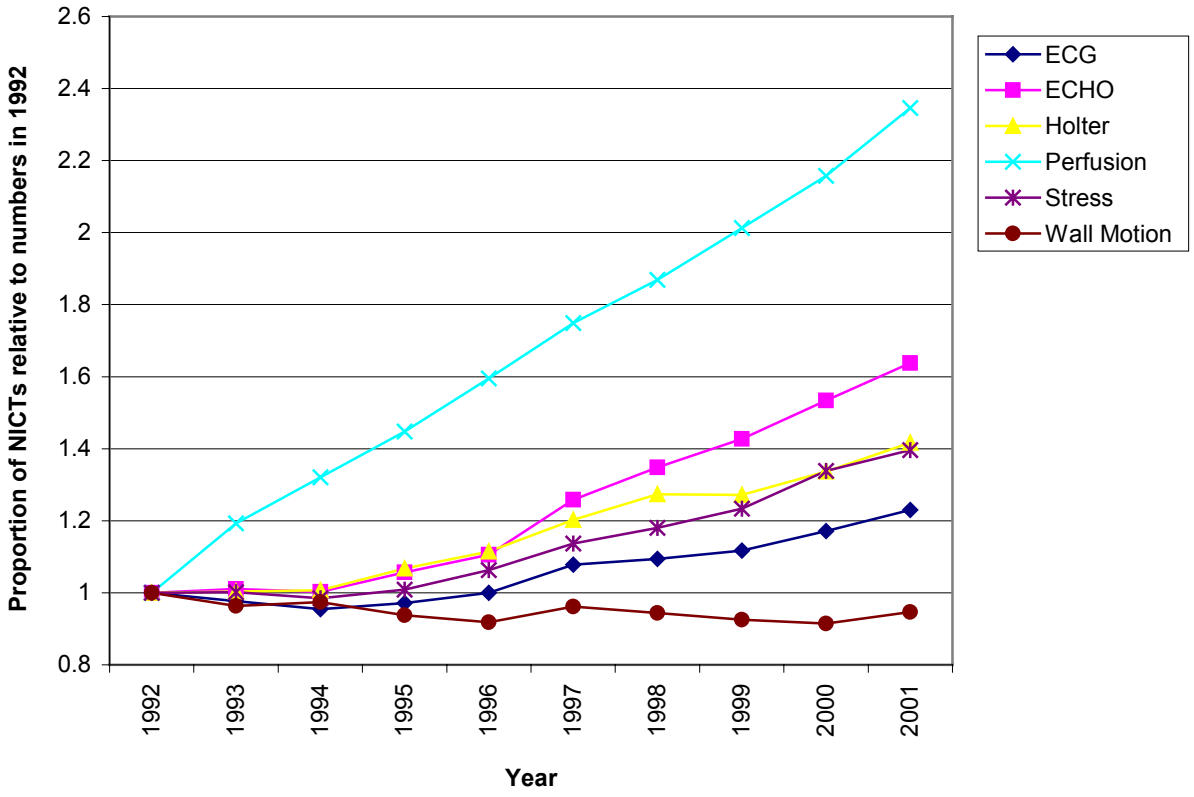
Legend

Exhibit 1. Absolute number of non-invasive cardiac tests per year, in Ontario, 1992 to 2001



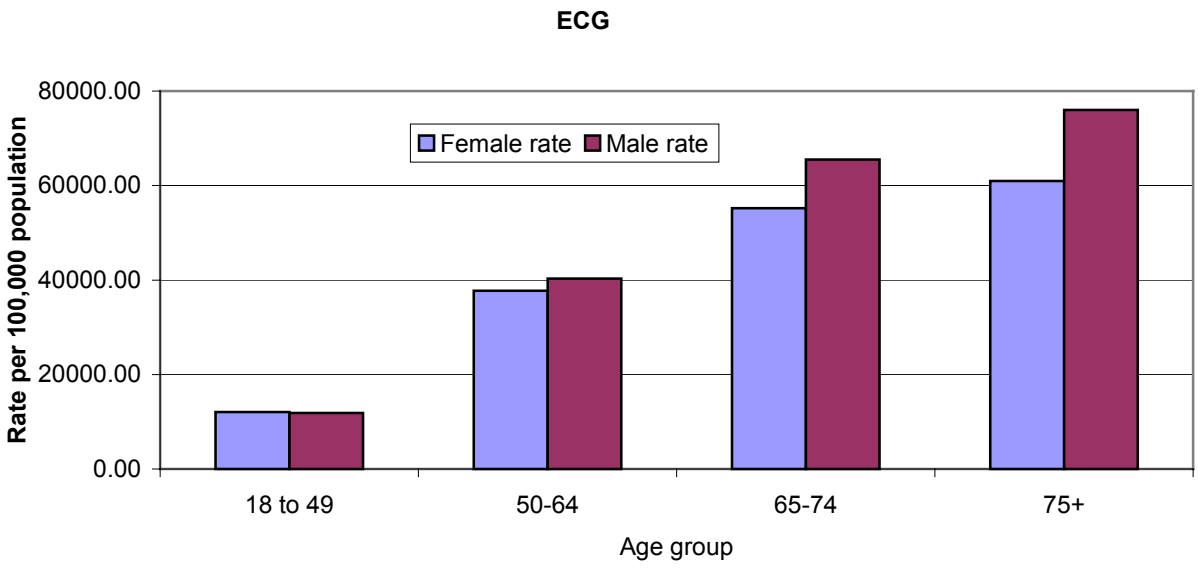
Data source: Ontario Health Insurance Plan

Exhibit 2. Temporal trends in the use of non-invasive cardiac tests, in Ontario, relative to 1992

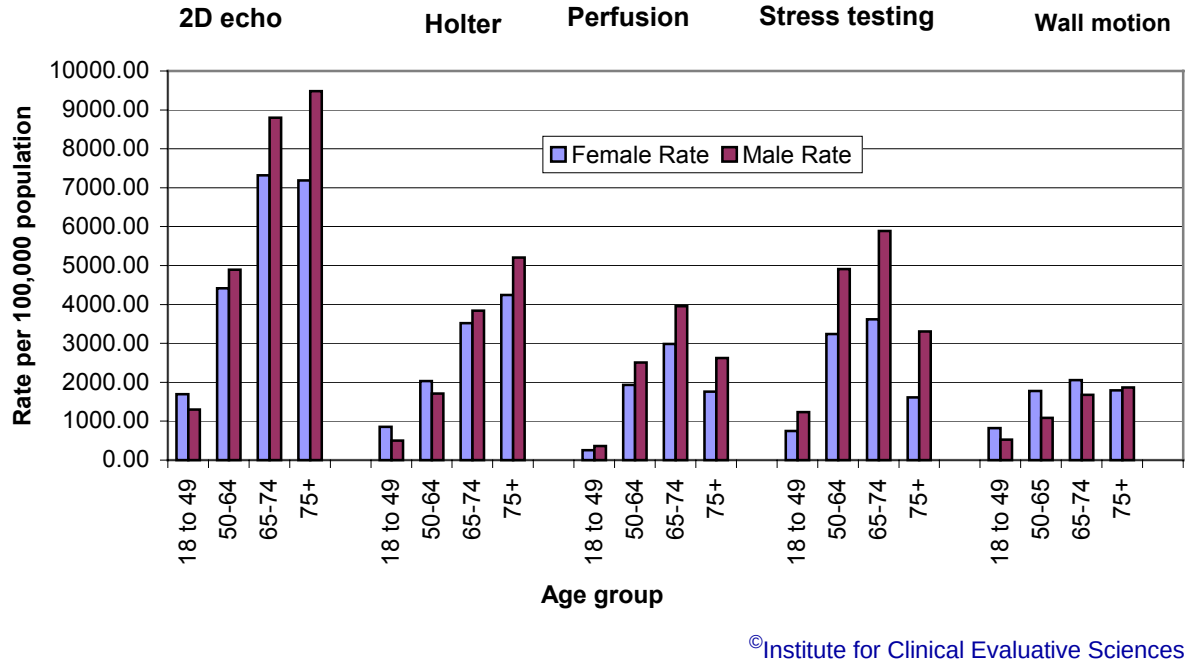


Data source: Ontario Health Insurance Plan

Exhibit 3. Age- and sex-specific non-invasive cardiac testing rates per 100,000 population, in Ontario, 2001

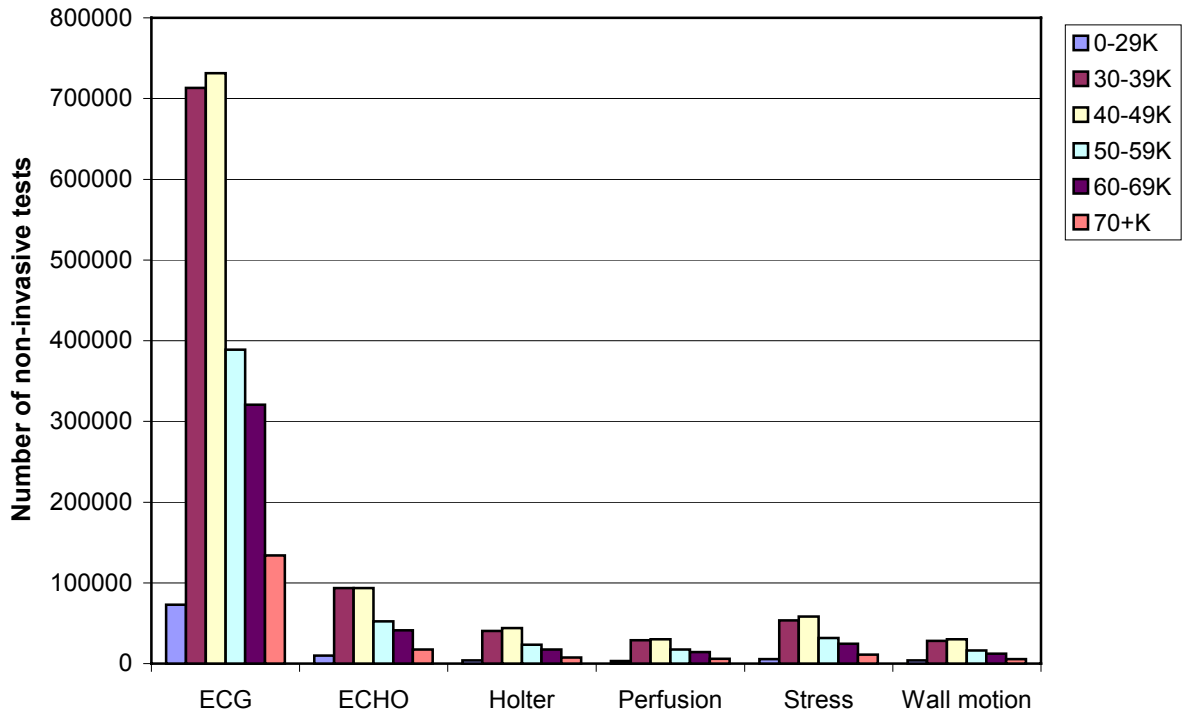


Data sources: Ontario Health Insurance Plan; Registered Persons Data Base



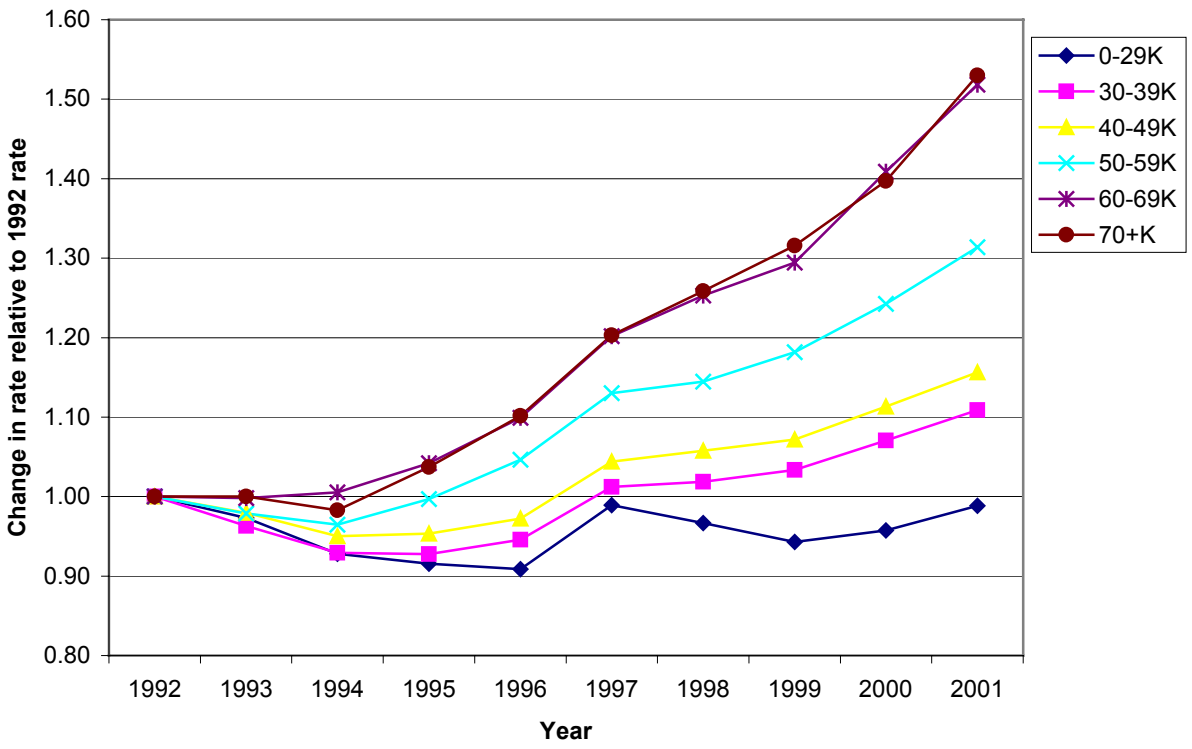
Data sources: Ontario Health Insurance Plan; Registered Persons Data Base

Exhibit 4. Absolute number of non-invasive tests, by socioeconomic status, in Ontario, 2001



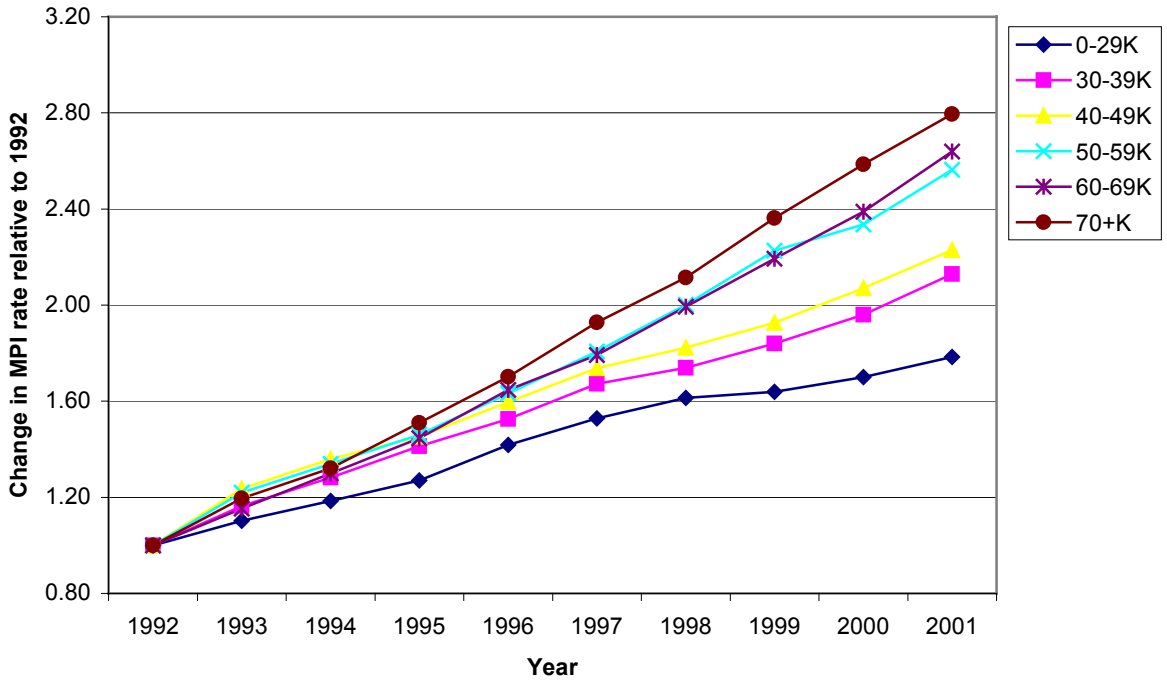
Data sources: Ontario Health Insurance Plan; 1996 Census data

Exhibit 5a. Temporal trends in ECG, by socioeconomic status, in Ontario, relative to 1992



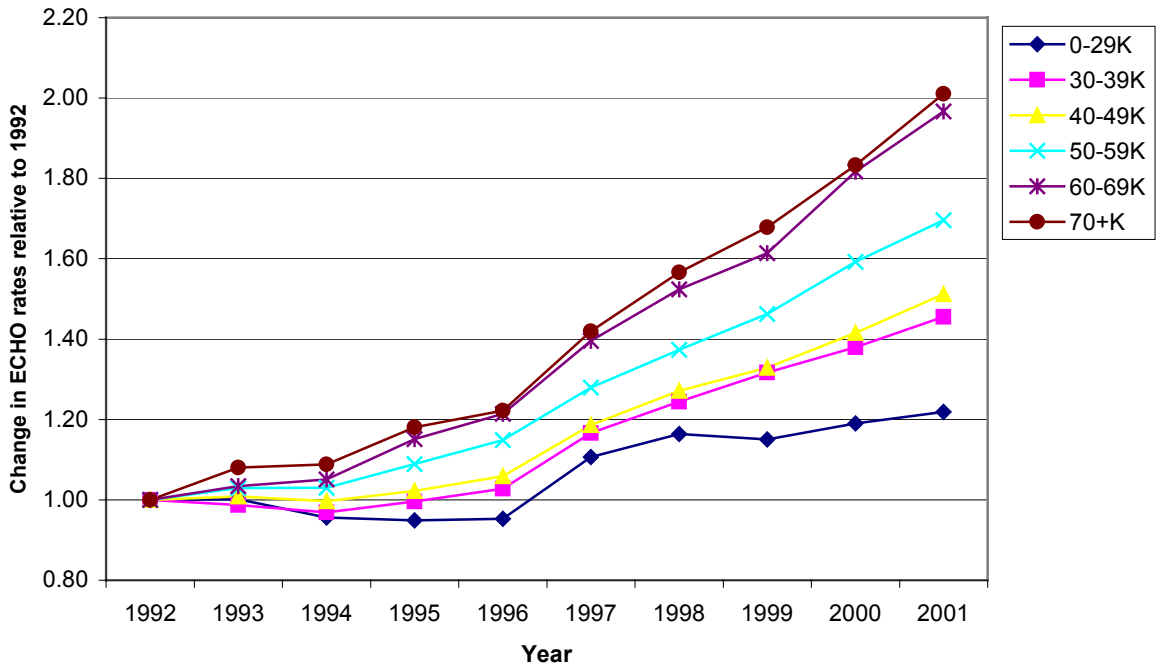
Data sources: Ontario Health Insurance Plan; 1996 Census data

Exhibit 5b. Temporal trends in MPI, by socioeconomic status, in Ontario, relative to 1992



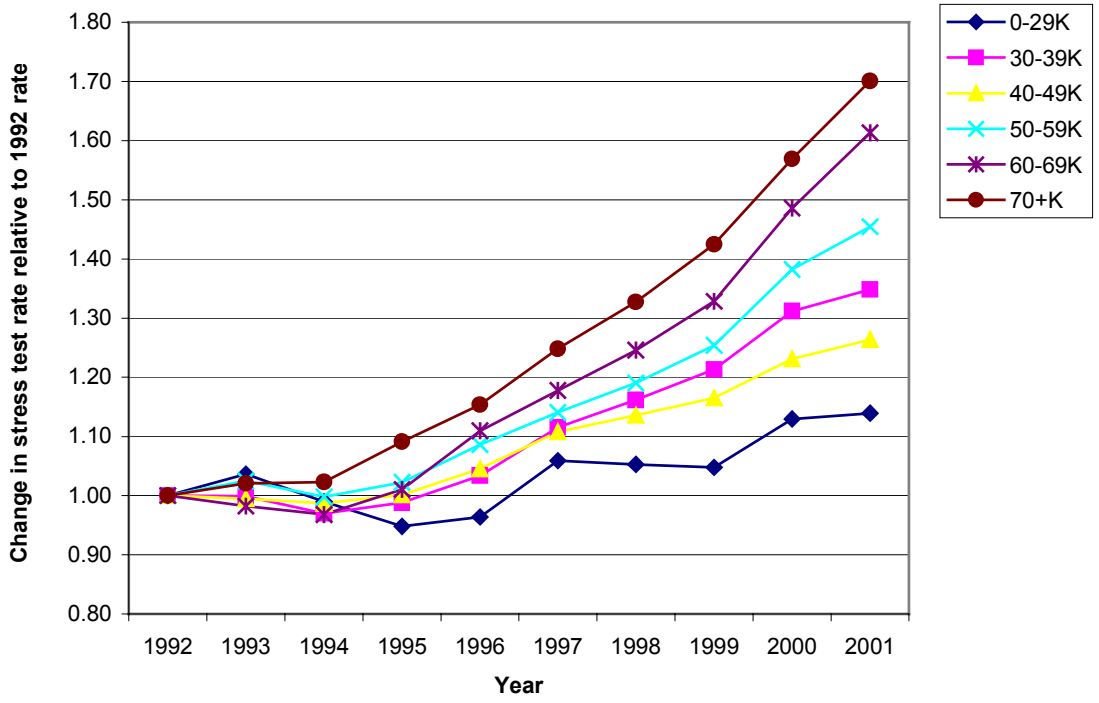
Data sources: Ontario Health Insurance Plan; 1996 Census data

Exhibit 5c. Temporal trends in ECHO, by socioeconomic status, in Ontario, relative to 1992



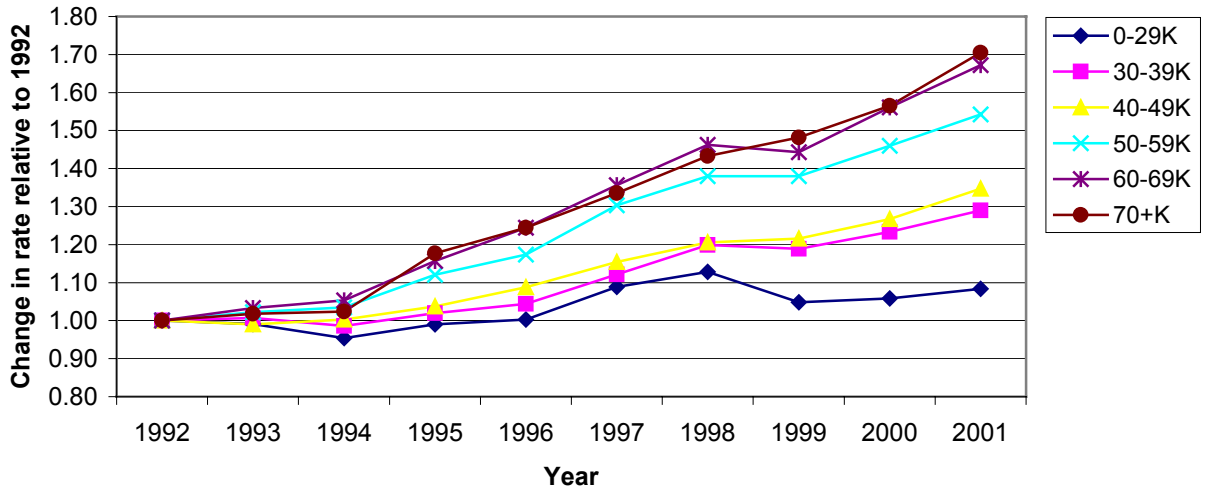
Data sources: Ontario Health Insurance Plan; 1996 Census data

Exhibit 5d. Temporal trends in GXT testing, by socioeconomic status, in Ontario, relative to 1992



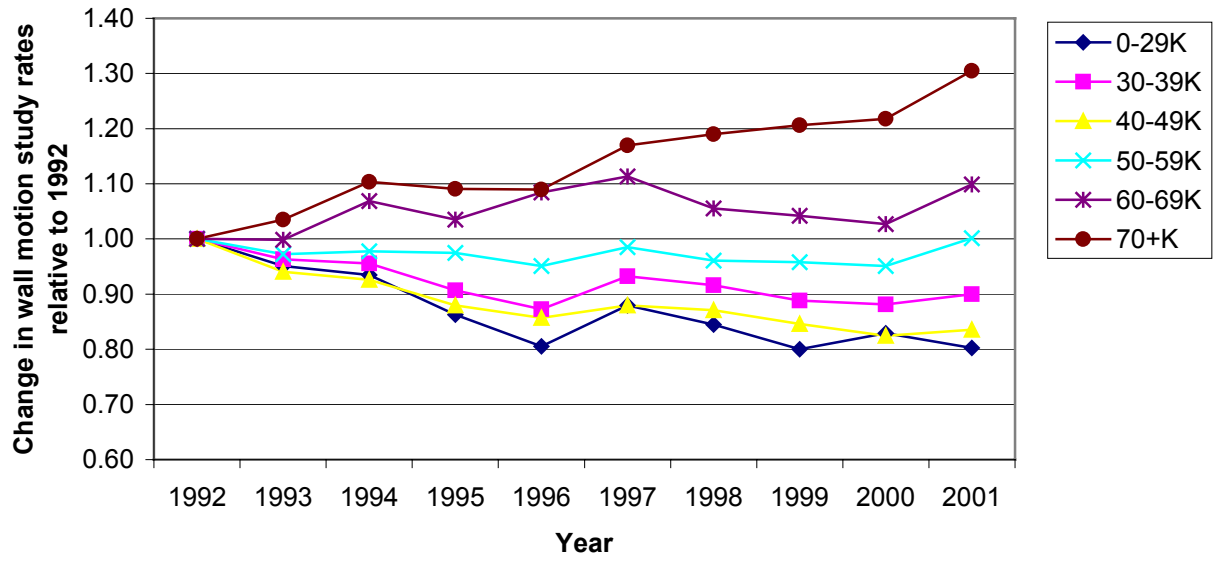
Data sources: Ontario Health Insurance Plan; 1996 Census data

Exhibit 5e. Temporal trends in AECG, by socioeconomic status, in Ontario, relative to 1992



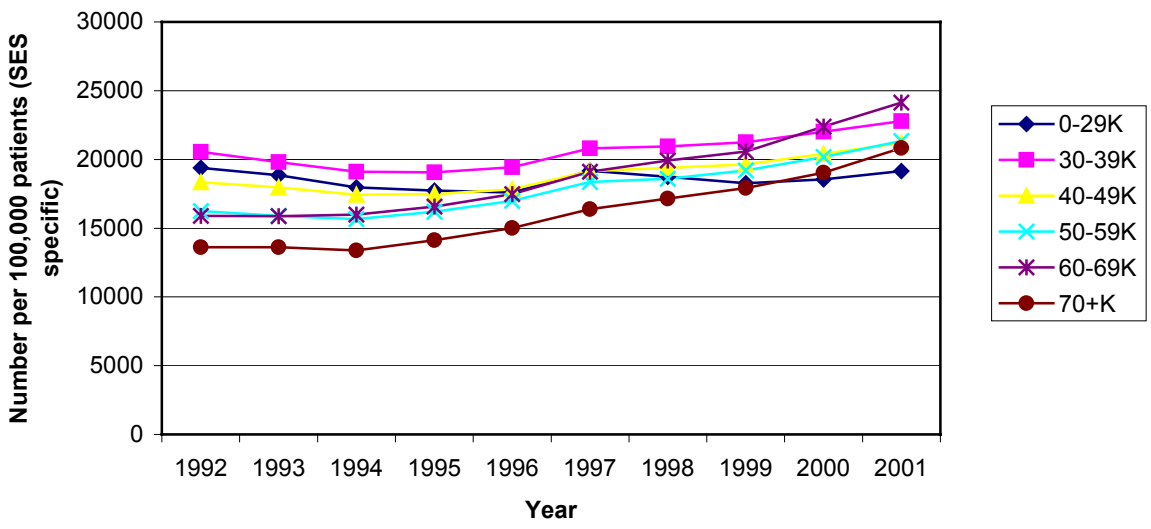
Data sources: Ontario Health Insurance Plan; 1996 Census data

Exhibit 5f. Temporal trends in wall motion studies, by socioeconomic status, in Ontario, relative to 1992



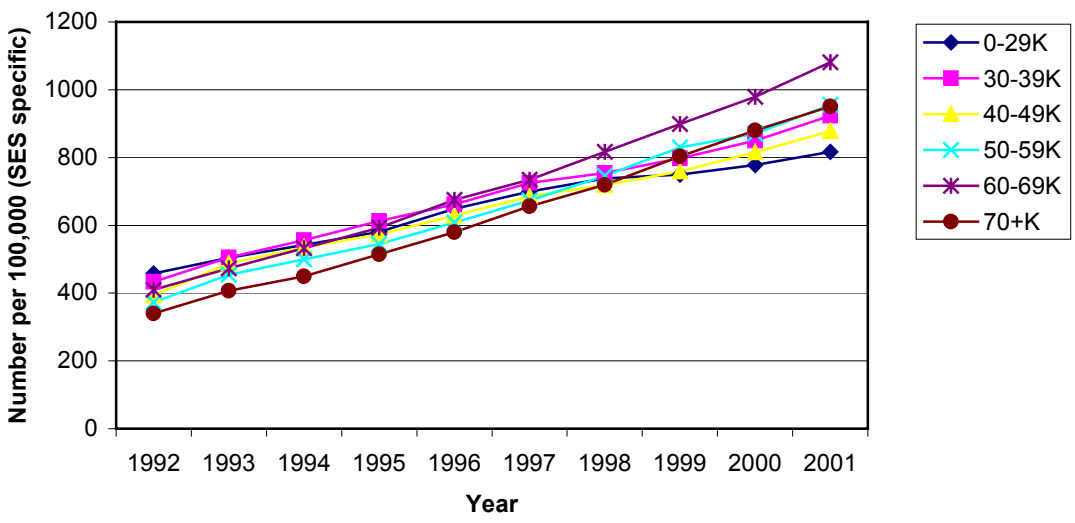
Data sources: Ontario Health Insurance Plan; 1996 Census data

Exhibit 6a. Temporal trends in per capita ECG, by socioeconomic status, in Ontario, 1992 to 2001



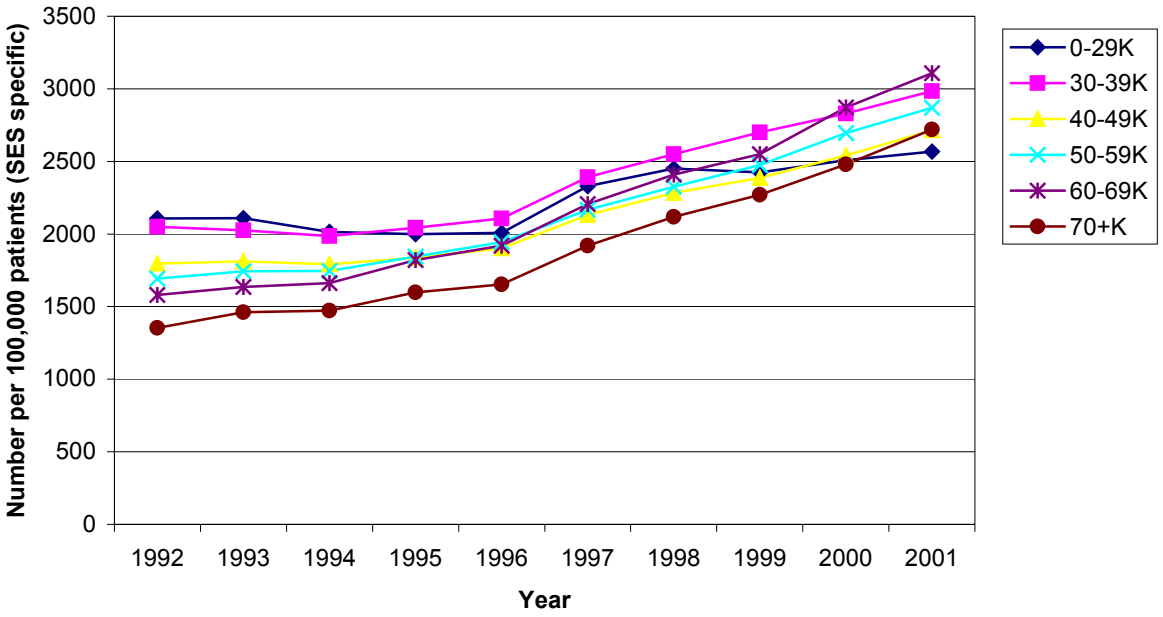
Data sources: Ontario Health Insurance Plan; 1996 Census data

Exhibit 6b. Temporal trends in per capita MPI, by socioeconomic status, in Ontario, 1992 to 2001



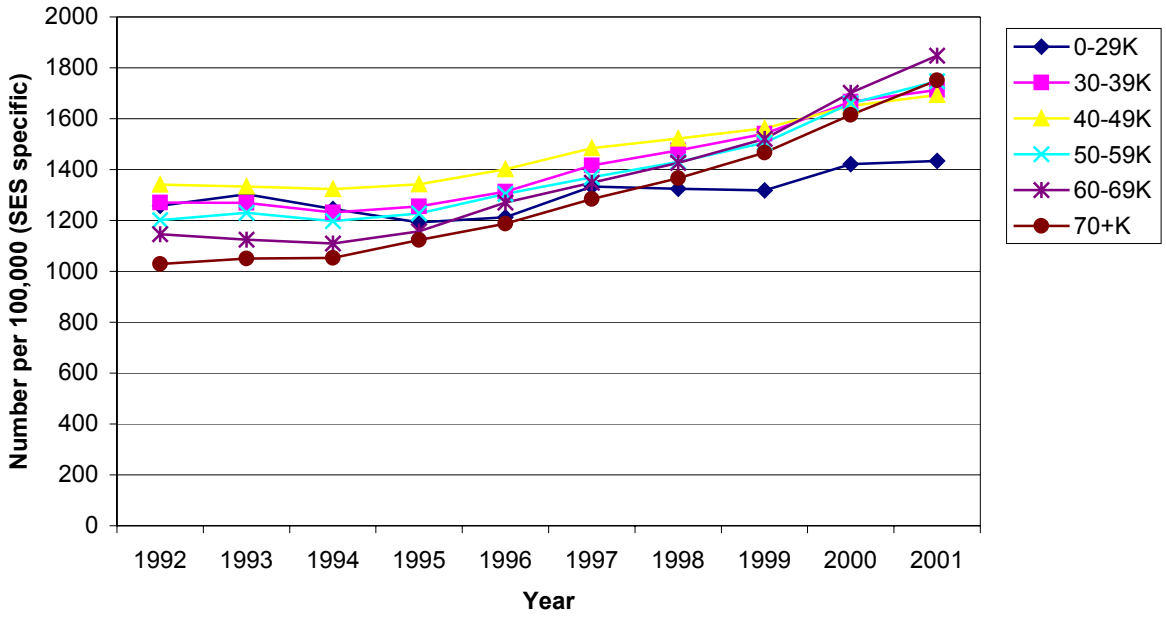
Data sources: Ontario Health Insurance Plan; 1996 Census data

Exhibit 6c. Temporal trends in per capita ECHO, by socioeconomic status, in Ontario, 1992 to 2001



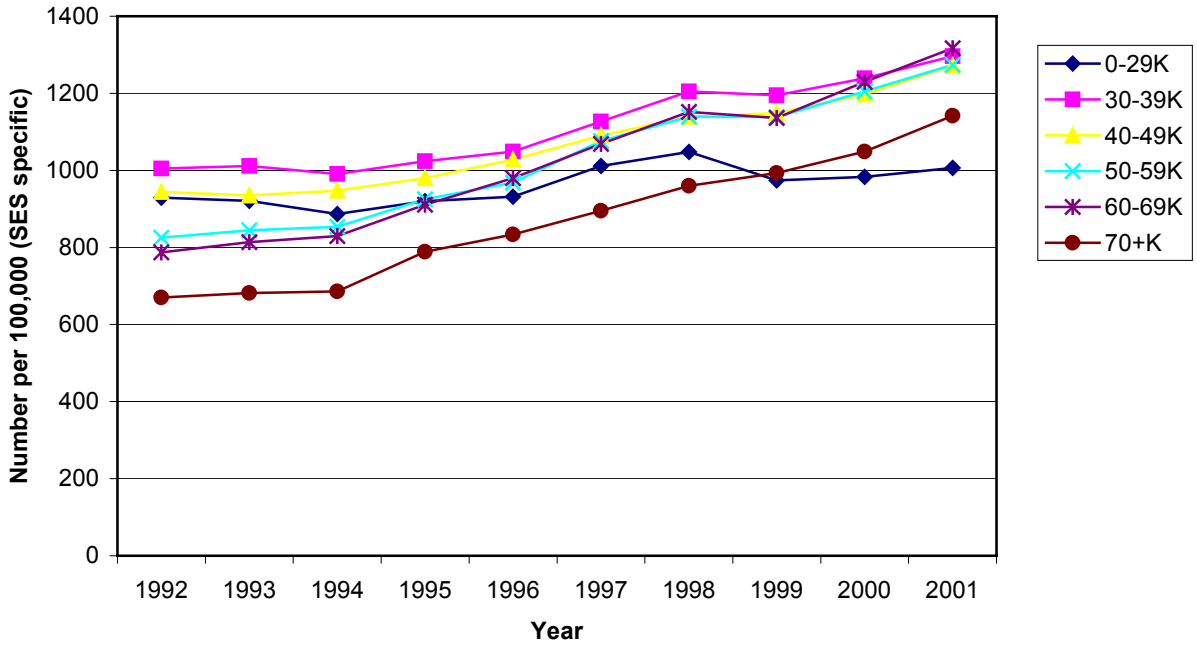
Data sources: Ontario Health Insurance Plan; 1996 Census data

Exhibit 6d. Temporal trends in per capita GXT testing, by socioeconomic status, in Ontario, 1992 to 2001



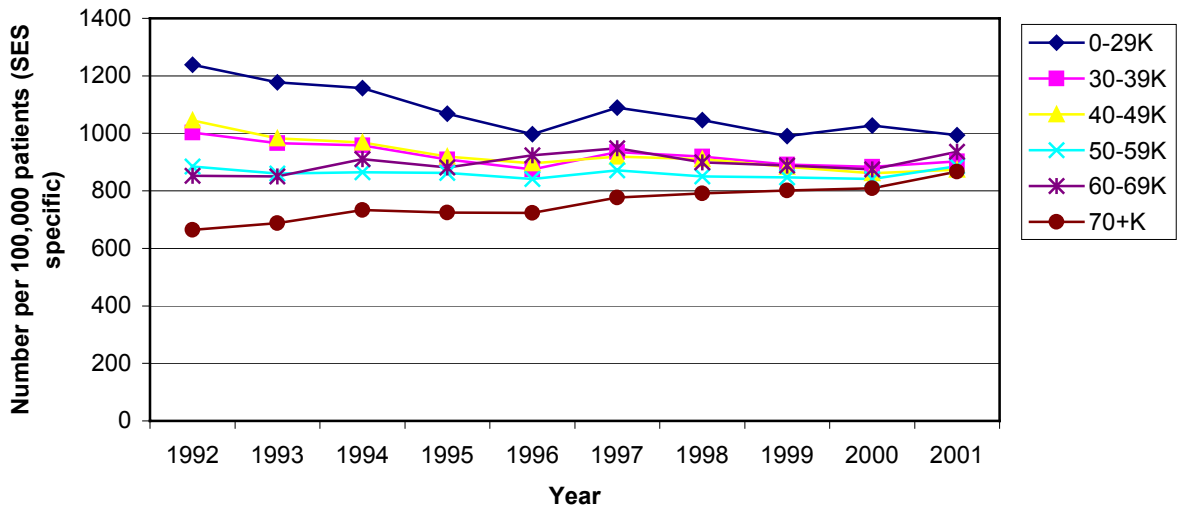
Data sources: Ontario Health Insurance Plan; 1996 Census data

Exhibit 6e. Temporal trends in per capita AECG, by socioeconomic status, in Ontario, 1992 to 2001



Data sources: Ontario Health Insurance Plan; 1996 Census data

Exhibit 6f. Temporal trends in per capita wall motion studies, by socioeconomic status, in Ontario, 1992 to 2001



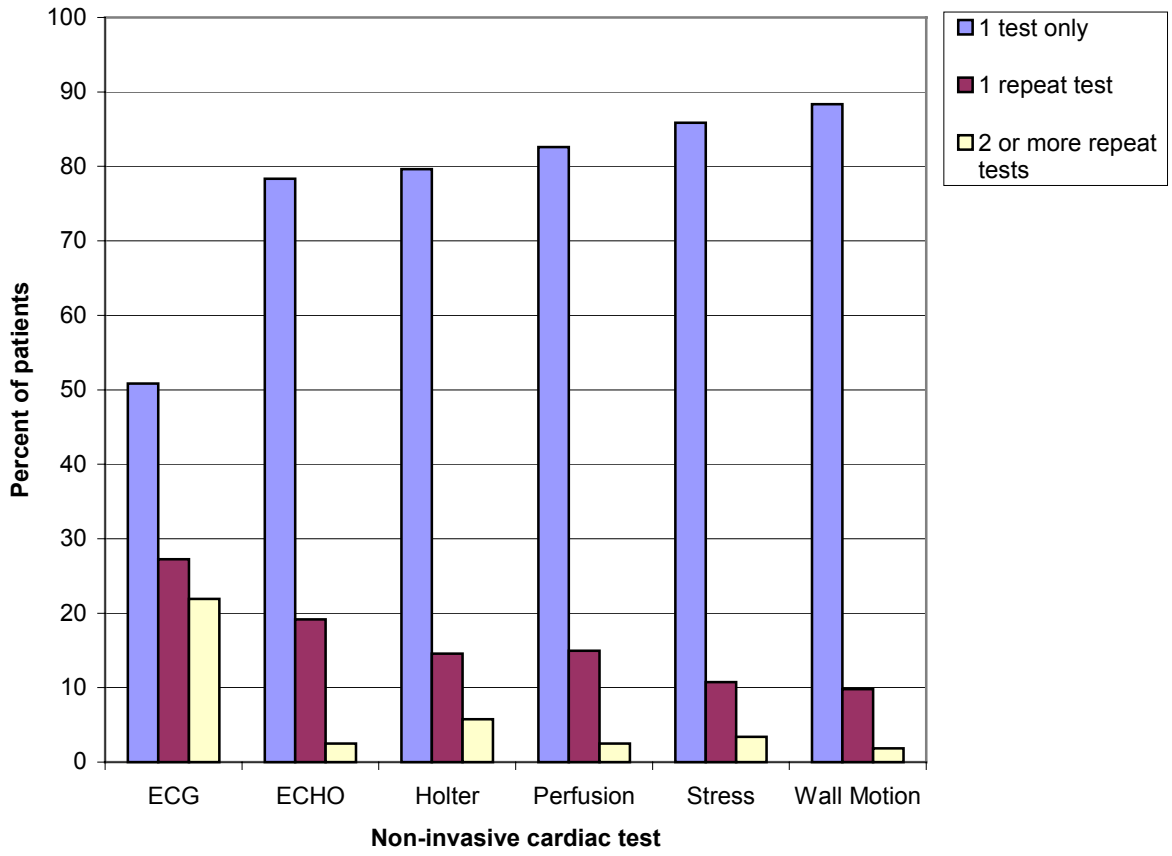
Data sources: Ontario Health Insurance Plan; 1996 Census data

Exhibit 7. Percent of non-invasive cardiac tests ordered by referring physician specialty, in Ontario, 2001

Referring physician specialty	ECG (%)	ECHO (%)	AECG (%)	MPI (%)	GXT (%)	Wall Motion (%)
Cardiology	8.96	19.62	20.12	49.44	21.52	3.13
Internal Medicine	2.83	5.75	5.86	13.54	9.47	5.17
FP/GP	66.58	63.69	67.35	30.92	64.69	51.66
Other	21.63	10.94	6.67	6.1	4.33	40.05
Total number of tests	1,707,067	250,127	113,141	101,582	155,719	97,484
Percent of records with missing referral codes	28.84	20.00	18.23	0.24	17.05	0.38

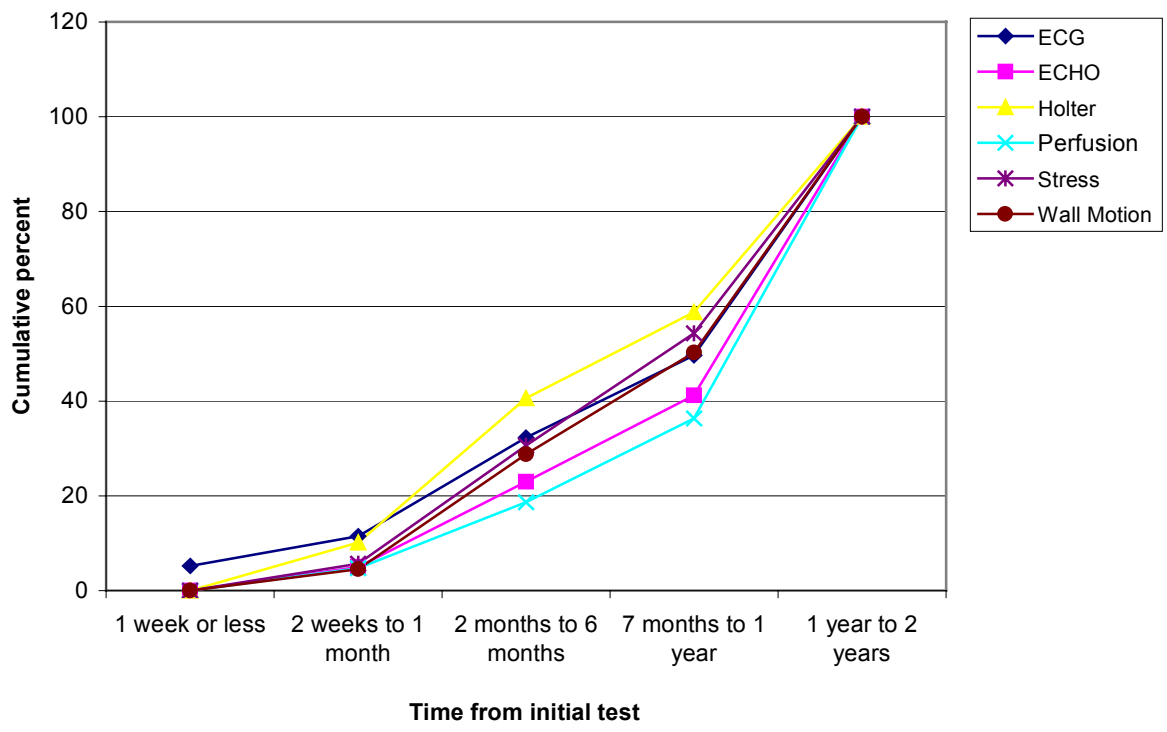
Data sources: Ontario Health Insurance Plan; Ontario Physician Human Resources Data Centre (OPHRDC)

Exhibit 8. Percent of patients that received index non-invasive cardiac test in 1999 and subsequent repeat tests within the following 2 years, in Ontario, 1999 to 2001



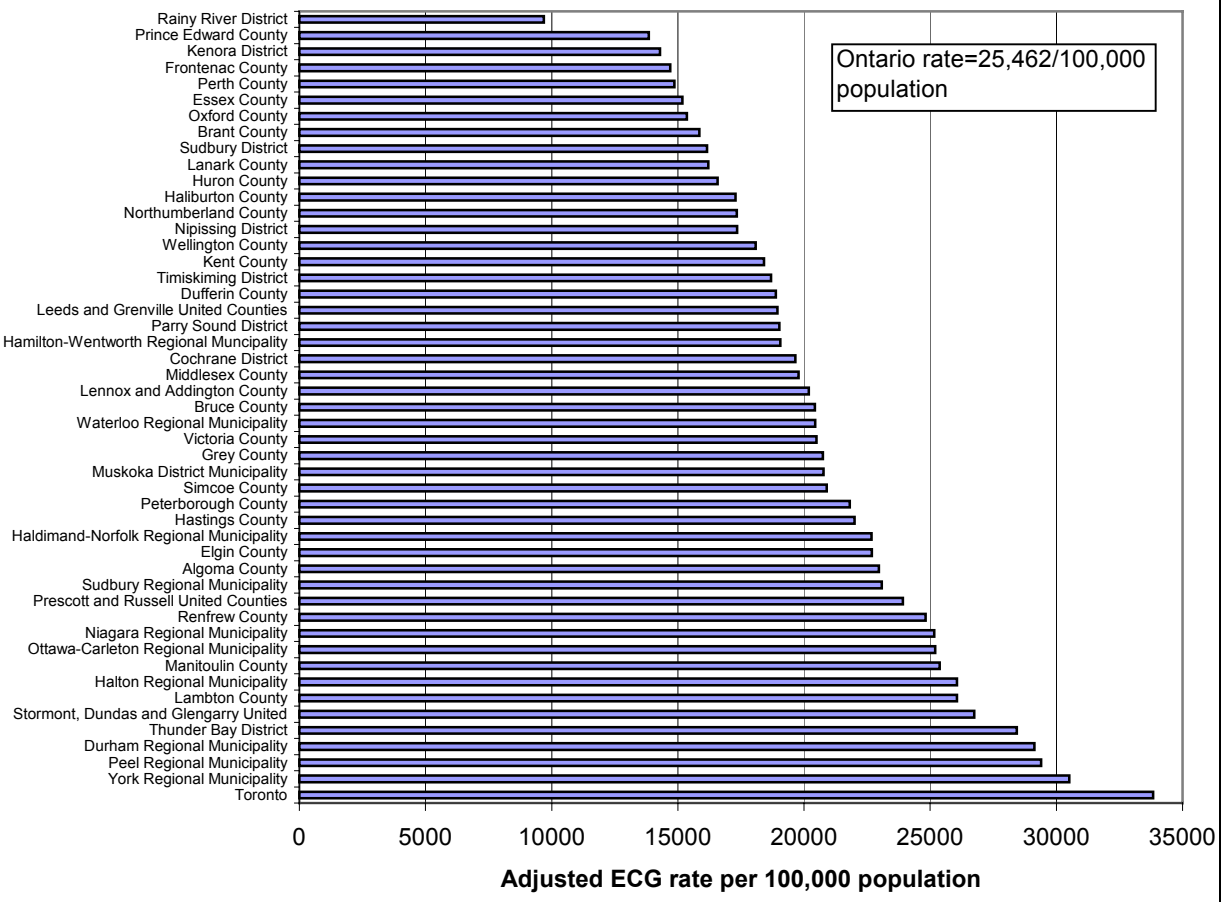
Data source: Ontario Health Insurance Plan

Exhibit 9. Cumulative percent of patients receiving tests within 2 years of initial test, in Ontario, 1999 to 2001



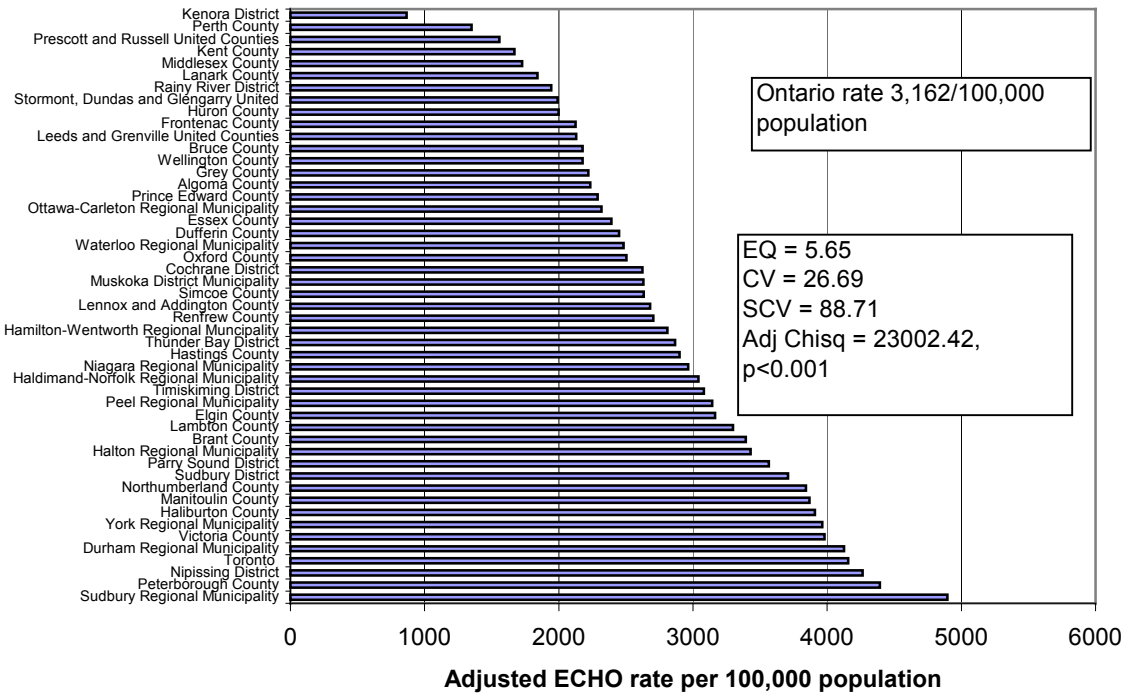
Data source: Ontario Health Insurance Plan

Exhibit 10. Age- and sex-adjusted ECG rates per 100,000 population aged 20 and older, by county, in Ontario, 2001



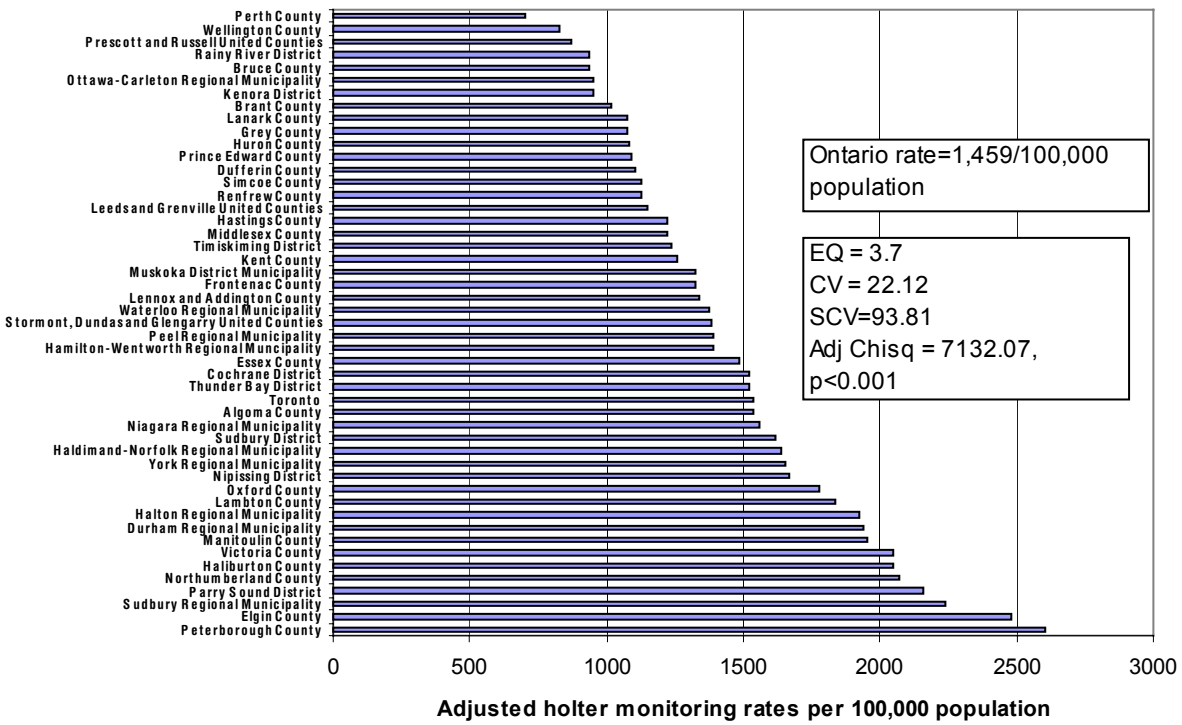
Data sources: Ontario Health Insurance Plan; Registered Persons Data Base; Statistics Canada postal code conversion files

Exhibit 11. Age- and sex-adjusted ECHO rates per 100,000 population aged 20 and older, by county, in Ontario, 2001



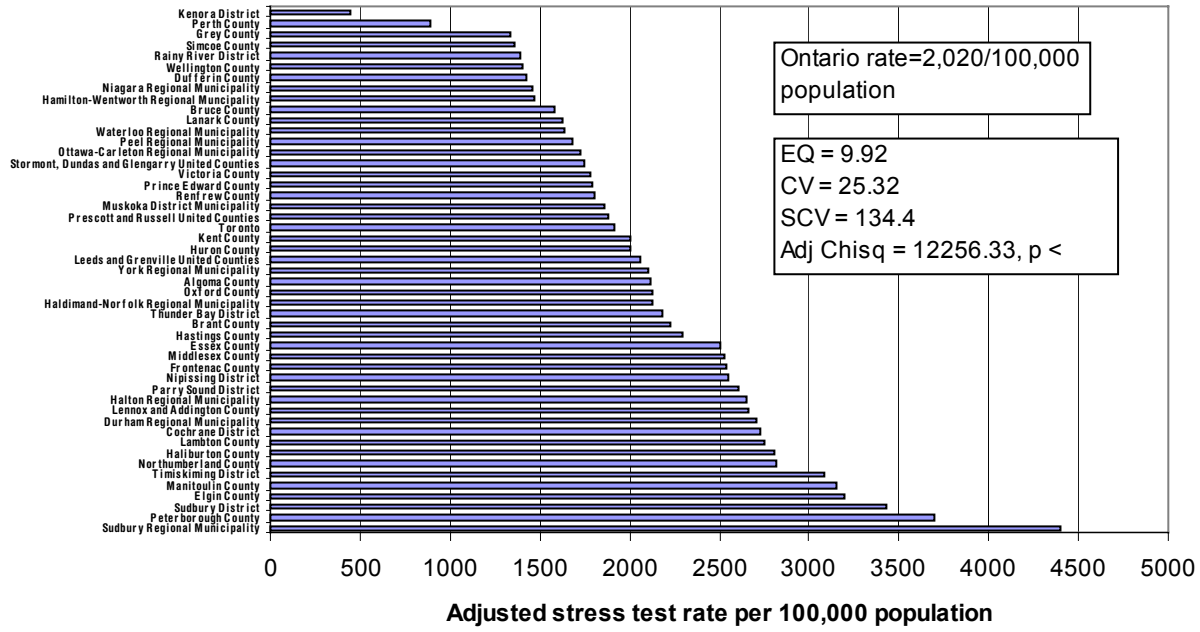
Data sources: Ontario Health Insurance Plan; Registered Persons Data Base; Statistics Canada postal code conversion files

Exhibit 12. Age- and sex-adjusted AECG rates per 100,000 population aged 20 and older, by county, in Ontario, 2001



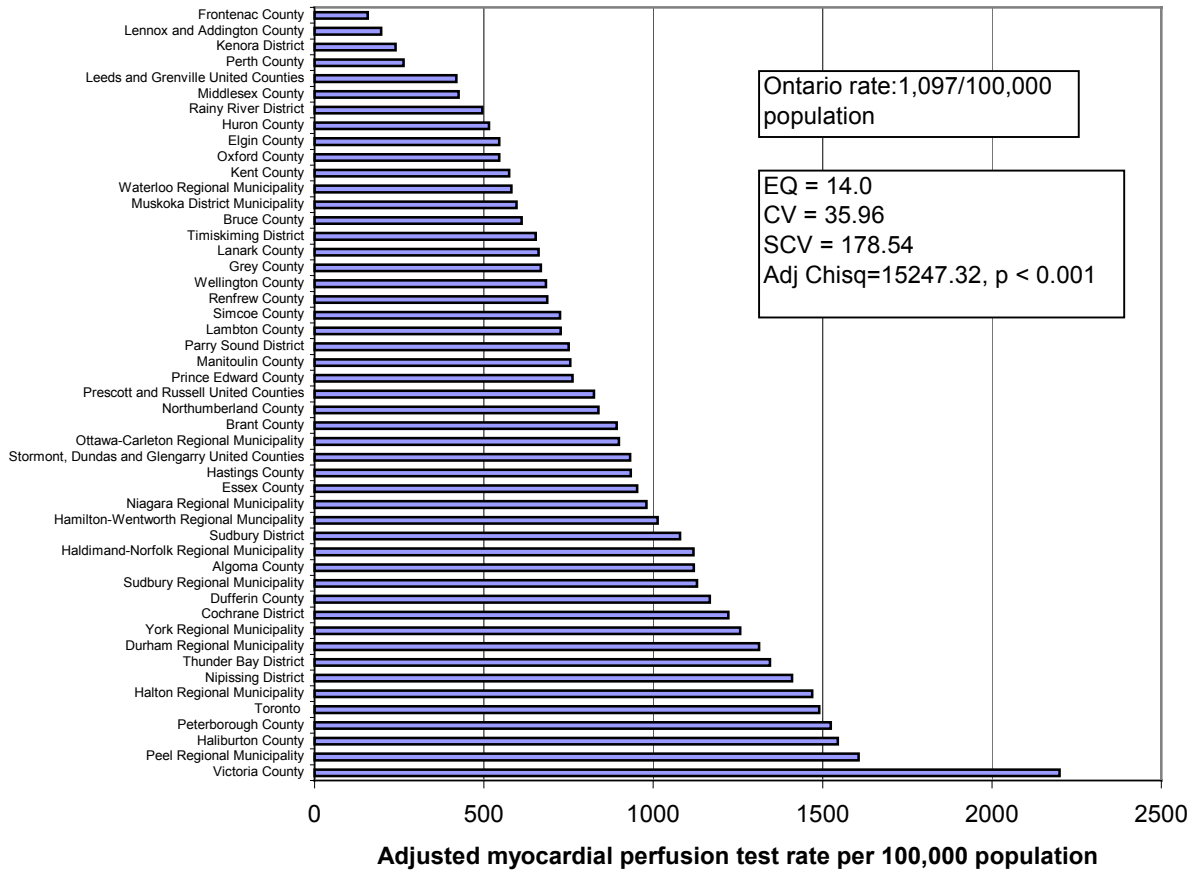
Data sources: Ontario Health Insurance Plan; Registered Persons Data Base; Statistics Canada postal code conversion files

Exhibit 13. Age- and sex-adjusted GXT testing rate per 100,000 population aged 20 and older, by county, in Ontario, 2001



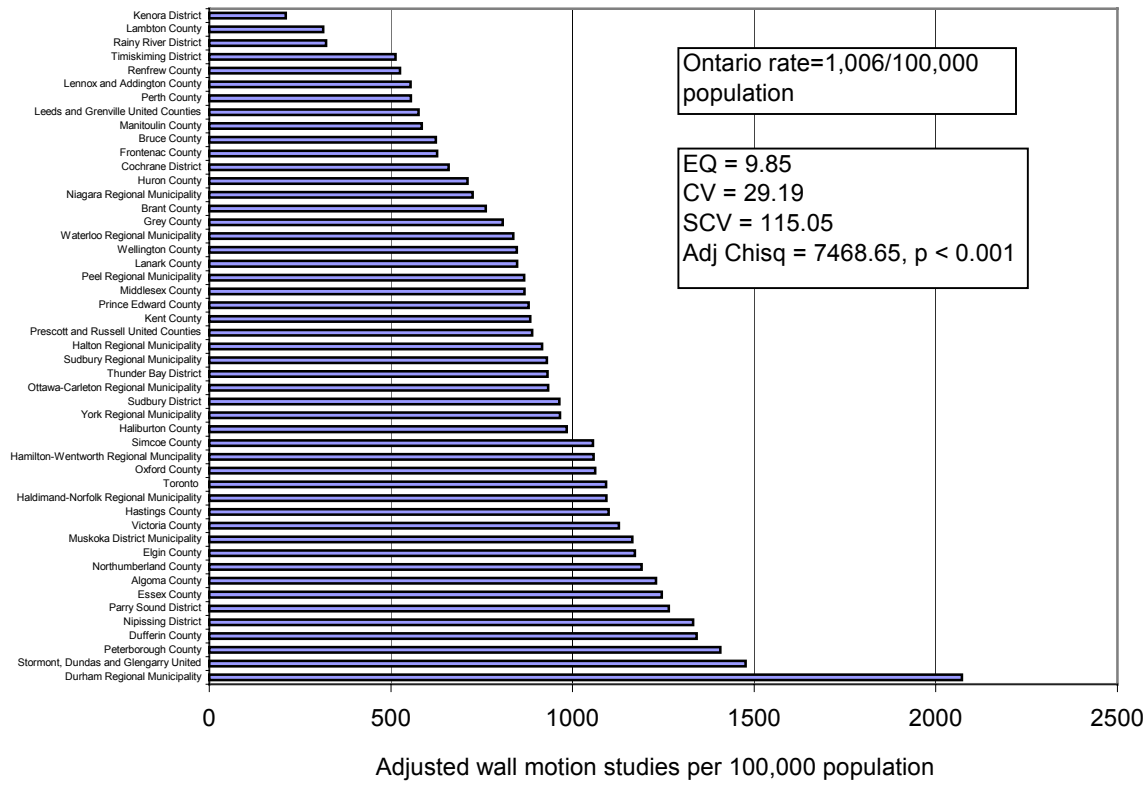
Data sources: Ontario Health Insurance Plan; Registered Persons Data Base; Statistics Canada postal code conversion files

Exhibit 14. Age- and sex-adjusted MPI test rate per 100,000 population aged 20 and older, by county, in Ontario, 2001



Data sources: Ontario Health Insurance Plan; Registered Persons Data Base; Statistics Canada postal code conversion files

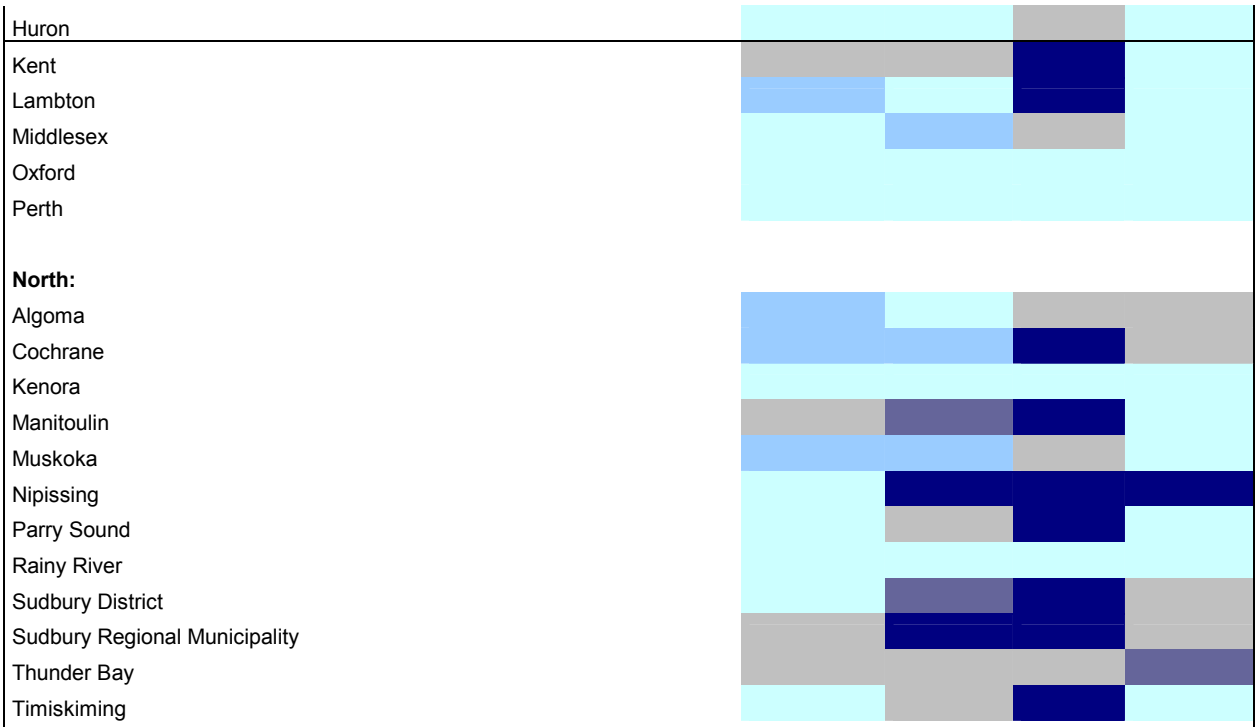
Exhibit 15. Age- and sex-adjusted wall motion studies per 100,000 population aged 20 and older, by county, in Ontario, 2001



Data sources: Ontario Health Insurance Plan; Registered Persons Data Base; Statistics Canada postal code conversion files

Exhibit 16. Geographic variation of ECG, ECHO, GXT, and MPI, by county* and health region, in Ontario, 2001

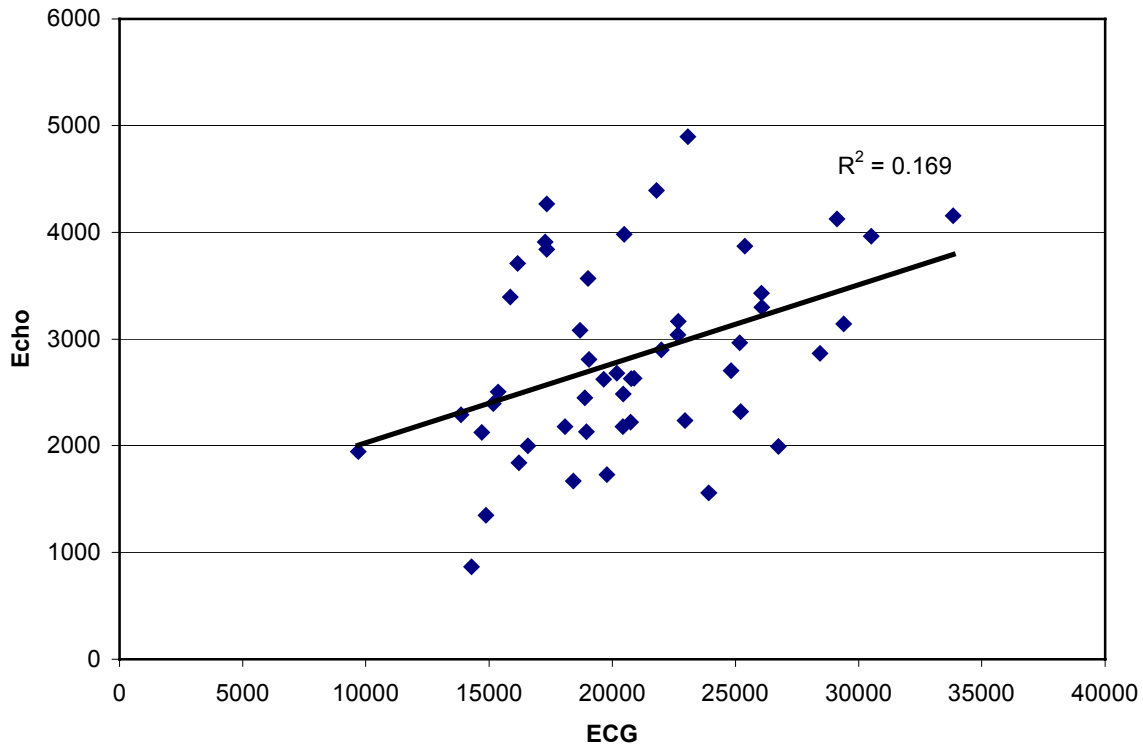
Variation displayed by ratio of adjusted rate over Ontario rate:	0 to 0.75	0.76 to 0.9	0.91 to 1.1	1.2 to 1.3
Ministry of Health and Long-Term Care Regions/Ontario Counties	**ECG**	**ECHO**	**GXT**	**MPI**
East				
Frontenac				
Hastings				
Lanark				
Leeds-Grenville				
Lennox-Addington				
Ottawa				
Prescott-Russell				
Prince Edward				
Renfrew				
Stormont-Dundas-Glengarry				
Central East				
Durham				
Haliburton				
Northumberland				
Peterborough				
Simcoe				
Kawartha Lakes				
York				
Toronto				
Toronto				
Central West				
Dufferin				
Halton				
Peel				
Waterloo				
Wellington				
Central South				
Brant				
Haldimand-Norfolk				
Hamilton				
Niagara				
South West				
Bruce				
Elgin				
Essex				
Grey				



*County corresponding to patients' residence postal code

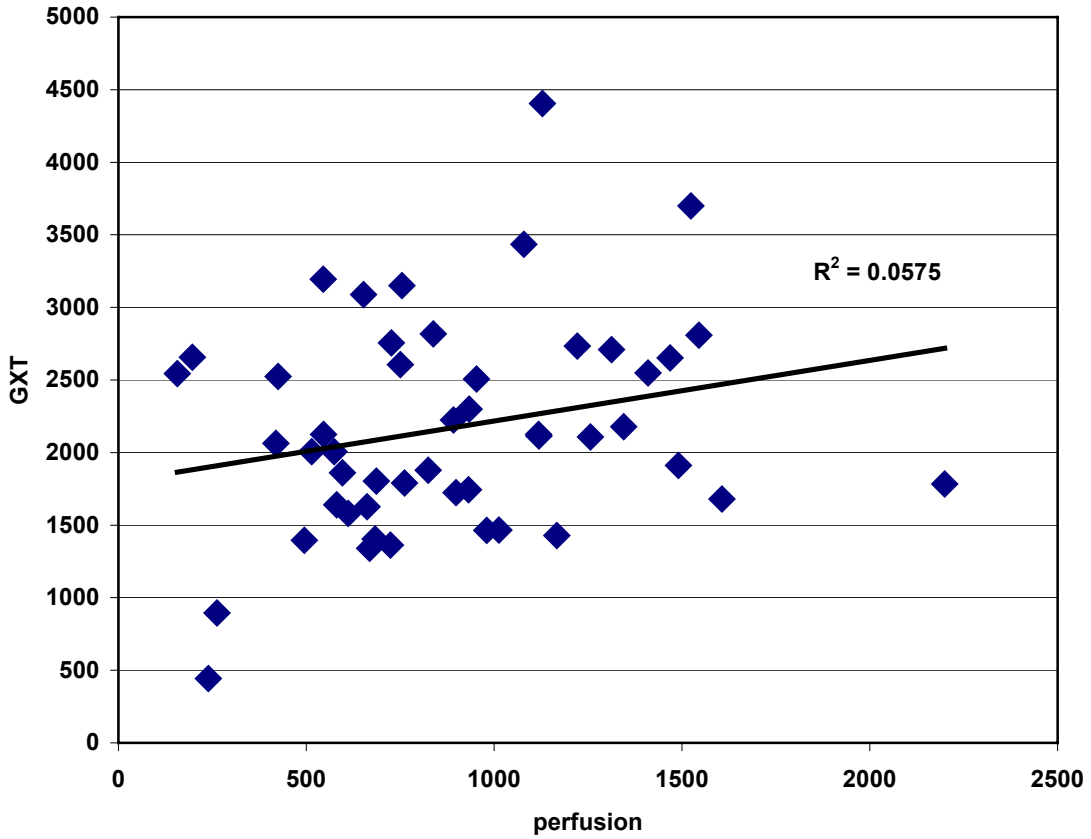
Data sources: Ontario Health Insurance Plan; Registered Persons Database; Statistics Canada postal code conversion files

Exhibit 17. Correlation between county-specific age- and sex-adjusted ECG and ECHO rates, in Ontario, 2001



Data sources: Ontario Health Insurance Plan; Registered Persons Data Base; Statistics Canada postal code conversion files

Exhibit 18. Age- sex-adjusted regional variations for GXT testing vs. MPI, in Ontario, 2001



Data sources: Ontario Health Insurance Plan; Registered Persons Data Base; Statistics Canada postal code conversion files

Appendix A. How the research was done

(See Appendix B for further detail.)

Data sources

The professional component of physician billing claims reimbursed by the Ontario Health Insurance Plan (OHIP) between January 1, 1992 and December 31, 2001 for non-invasive cardiac tests (NICTs) including electrocardiography (ECG), echocardiography (ECHO), Holter monitoring or ambulatory electrocardiography (AECG), myocardial perfusion imaging (MPI), stress testing or graded exercise treadmill testing (GXT) and wall motion tests were identified. For financial reimbursement, each NICT is comprised of several, and in some cases, multiple, professional and technical fee codes. Professional fee codes are rendered to physicians for the interpretation of test data, while technical fees reimburse the physician/clinic for provision of technical services and ownership of supplies and equipment required for the non-invasive test. Unlike previous studies, this study incorporates the patient rather than the test-claim, as the major unit of analysis. Finally, the analysis was restricted to outpatient records, since in-patient cardiac tests are covered by hospital global budgets and are not submitted to OHIP.

Referring physician specialty was obtained from the Ontario Physician Human Resources Data Centre (OPHRDC) file modified at ICES. A hierarchical algorithm was applied in cases for which there were multiple specialties for a given referring physician assigned in the following order: cardiology, internal medicine, family physician/general practitioner and other specialties. In some cases, multiple physicians could refer for one given test. To rectify this, all the billings for the index test day were extracted and the hierarchical algorithm was applied.

Patients' age, gender and postal codes were obtained from the Registered Person Database (RPDB). Patients were divided into gender and age-specific groups: men and women; aged 18 to 49 years, 50 to 64 years, 65 to 74 years and 75+ years. Patient county of residence was inferred from postal codes using Statistics Canada conversion files. Median household income of persons living within forward sortation area (FSA), which is the first three postal code digits, was obtained from 1996 Census data, and used as the ecological measure of patients' socioeconomic status.

Analyses

The number of each NICT was derived by year from 1992 to 2001. Age-, sex-, and socioeconomic status (SES)-specific rates of NICTs were calculated for 2001 using inter-censual estimates based on the 2001 Census population as the denominator. To evaluate these rates in reference to invasive cardiac services, the age- sex-adjusted per capita rates of coronary angiography were calculated as a comparator (coronary angiography codes were obtained from OHIP and from the Canadian Institute for Health Information). The effect of SES was determined by stratifying income into quintiles and assessing the correlation between NICT utilization and SES.

Referring physician specialty was obtained from the modified Ontario Physician Human Resources Data Centre (OPHRDC) file. Referring physician data was available for approximately 75% of the NICTs, but the proportion of missing data did vary. For example, 40.7% of ECGs did not have referring physician codes, whereas only 0.24% of MPI tests were missing referral physician information. Further, wall motion studies had a disproportionately high number of referring physicians from "other" physician specialties (e.g., orthopaedics). Such reasons may relate to errors in coding or in the physician specialty database. Finally, a few referring physicians (0.02% or less depending on the test) had more than one specialty. In such cases, both specialties were listed.

To estimate the rate of repeat testing for the same patient, an incident NICT in 1999 was flagged. In order to determine that this test was the first of such tests per patient, patients that had the same test in 1997 and/or 1998 were excluded. The percentage of patients with a first test in 1999 that underwent the same test in the following two years and the time between the first and the second tests were then identified. To minimize the potential for double counting, a test count was determined using associated professional fee

codes only. Further, some NICTs (e.g., rest/redistribution thallium) are conducted over the course of two (or more) consecutive days.

Physicians may also be delayed in their billing submissions to OHIP, and may incorrectly substitute the "date of service" with the "date of service submission". Accordingly, fees pertaining to one particular test may be billed over several days. To address this limitation, a 7-day rule (with one exception) when tallying NICT codes was applied. As such, no patient could receive two or more of the identical NICT within a 7-day interval. ECGs served as the one exception where patients could receive multiple such tests within a single day (for example, 0.4% of the population referred for ECGs received two or more ECGs on a single day (see Appendix B for the full list of codes and selection procedures). The use of the 7-day lag period allows for a conservative estimate of test utilization. For example, the 7-day rules may impact MPI testing most significantly, where 30.3% of codes are billed over a 7-day period (Appendix B, Figure 1). In such cases, the analysis would only count all codes as one, rather than multiple tests.

The age- and sex-adjusted rate per 100,000 population in each of the 49 Ontario counties was calculated for NICTs using the 2001 Ontario population as the standard in the adjusted rate calculation. Each patient's county was identified using the resident postal code and the Statistics Canada Postal Code Conversion File. Small area variations consisted of the Extremal Quotient, Coefficient of Variation, Systematic Component of Variation, and Adjusted Chi Square.

Limitations

There are several important caveats that must be considered in reviewing this study's findings.

1. The analysis utilizes administrative data, which lack the necessary clinical detail required to characterize illness severity, and to describe the appropriateness of testing. It should also be noted that even if such data were available, physician decision-making behaviors depend on a host of more subtle factors, which may include patient reassurance. Therefore, these results should only serve as hypothesis generating data.
2. Algorithms required for the tally of unique NICTs may have resulted in an overly conservative estimate of true counts (e.g., MPI).
3. Referral physician information was unavailable on a significant minority of tests. Even where available, the accuracy of the referral physician information is questioned based on wall motion testing, which observed a disproportionately high number of physicians in non-cardiac or primary-care specialties. Furthermore, primary care physicians often work in conjunction with physician specialists. The extent to which physician decision-making behavior reflects the "referring physician", the primary physician decision-maker, or both (if discrepant) is unknown.
4. Socioeconomic information was obtained using 1996 ecological, rather than individual-level, indicators. The extent to which SES-specific utilization rates are similar when using individual-level determinants (or more recent Census data) is unknown.

Appendix B. Detailed analytic methods

Ontario expenditures for invasive and non-invasive services

In Table 1, (page 2) volume of invasive cardiac services was obtained from the Cardiac Care Network and refers to completed cases for Ontario and non-Ontario residents, except coronary artery bypass surgery volume, which refers to exclusively to Ontario residents.

Total expenditures for invasive cardiac services, obtained from the Ontario Case Costing Initiative, reflect direct costs (i.e., related to patient care including nursing, operating room, intensive care unit, diagnostic imaging, pharmacy and laboratory) and indirect costs (i.e., hospital overhead expenses related administration, finance, human resources, plant operations etc.). The typical coronary angiography case consisted of a same-day surgery admission (average total cost of $917.21). The typical percutaneous transluminal coronary angioplasty case was based on 3,076 patients admitted to 8 Ontario hospitals, and consisted of 90.9% use of stents, 19.2% use of glycoprotein 2B-3A inhibitors, and an average hospital stay of 2.28 days (total average cost of $4,903). The typical coronary artery bypass surgical case was based on 2,291 patients admitted to 8 Ontario hospitals, and consisted of an average hospital stay of 9.88 days (total average cost of $13,822). Invasive service procedure codes were obtained using ICD-9 CM primary diagnosis codes and independently verified by two cardiologists.

Expenditures for invasive services also included physician procedural reimbursement fees obtained from the Ontario Health Insurance Plan, which were $357.95, $498.55, and $2,303.81 for coronary angiography, percutaneous transluminal coronary angioplasty, and coronary artery bypass surgery based on 2-vessel grafting, respectively.

Volume and costs associated with non-invasive services were obtained from the Director of Economics, Ontario Medical Association. Cost per service was rounded to the nearest second digit and is comprised of professional and technical fees. The total cost per service was rounded to the nearest two digits and accounts for the reason that the total cost column is not identical to the multiplication of cost per service by volume.

Professional versus technical billing codes

Several most commonly used OHIP billing codes for cardiac testing have two billing components – professional, billed by physicians performing and/or interpreting the tests and technical, billed by the institutions where the tests are provided to recuperate the cost of supporting staff (i.e., technicians). Such components are billed independently. It means that one test may have two or even more billings submitted to OHIP. Only one component, professional, was used.

The following example for ECG testing shows that using either component would give an almost identical number of ECG tests.

Number of OHIP billings reimbursed from 1992 to 2001:

G310 (technical component)	20,667,815 (50.02%)
G313 (professional component)	20,651,495 (49.98%)
Total	41,319,310 (100%)

- 92% of ECG technical and professional codes were billed on the same day
- 43% of the remaining 8% (roughly 3.4% of total) were billed within ± 1-3 days of each other

Repeat testing within 7 days

All billings within the 7-day window were counted as one test. See Figure 1 for percentages of billings.

Figure 1. Percentages of NICT tests billed within 7-day period

	ECG	ECHO	AECG	MPI	GXT	WALL MOTION
% of total	4.63%	1.86%	4.98%	30.31%	1.49%	4.40%

Data source: Ontario Health Insurance Plan

Determining the number of tests

1. ECG

Selected billing code: G313 Cardiov – ECG – professional component
Billings: 20,651,495
Number of patients: 5,635,941

Each ECG billing was counted as one test (i.e., 2 ECG billings on one day counted as 2 ECG tests). 74,526 out of 20,651,495 (0.4%) patients had a double billing (two or more identical codes on the same day).

2. ECHO (transthoracic)

Selected billing codes: G561 Echocardiography – Compl study – 1 dim. – prof comp (P1)
G562 Echocardiography – Compl study – 1 dim. – prof comp (P2)
G567 Echocardiography – Compl study – 2 dim. – prof comp (P1)
G568 Echocardiography – Compl study – 2 dim. – prof comp (P2)
G571 Echocardiography – Compl study – 1 & 2 dim. – prof comp (P1)
G572 Echocardiography – Compl study – 1 & 2 dim. – prof comp (P2)
G575 Echocardiography – Ltd study – 1 or 2 dim. follow-up studies – prof comp.
Billings: 2,670,710
Number of patients: 1,592,956

Only one test per patient per day was considered (regardless of the number of billings). All the tests within the 7-day period were considered as one test. The first test for each patient was selected and all the tests that were billed up to 7 days later were removed. The next test that was more that 7 days after the initial test was selected and the whole procedure was repeated until the maximum number of tests per patient was reached. For comparison with technical code see Figure 2.

Figure 2. ECHO professional codes and G570 (technical code to G571/572) billed for the same patient on the same day (row %)

Codes*	G561	G562	G567	G568	G570	G571	G572	G575	G581
G570 (n=2,698,784)	0	0	0	0	2.5	86.2	11.3	0.1	0.6

* double billings within the same code on the same day for the same patient were excluded from these calculations; G561 – 0, G562 – 0, G567 – 1, G568 – 0, G570 – 3620, G571 – 280, G572 – 67, G575 – 1, G581

Note: these codes could be billed in combination of more than 2 per day and per patient (thus total percentage might be higher >100). Grey shade: code billed by itself (no other code from that group was billed for the same patient on the same day).

Data source: Ontario Health Insurance Plan

3. AECG (Holter testing)

Selected billing codes: G650 Cont ECG Monitoring/AECG
G653 Cont ECG Monitoring/AECG

Billings: 1,323,477

Number of patients: 776,587

Holter tests were divided into following categories:*

a) Single-day test – no consecutive day billings
b) 48-hour tests – 2 claims on 2 consecutive days in a row
c) 72-hour tests – 3 claims on 3 consecutive days
d) 96-hour tests – 4 consecutive days
e) Test longer than 4 consecutive days

*Consecutive day Holter tests were identified without consideration of presumably missed billings (i.e., a test on the first day, second day and third day was counted as one 72-hour test. A test on the first day, second day and fourth day was counted as one 48-hour test and one single test. A test on Feb. 1, Feb. 2, Feb. 3, Feb. 5, Feb. 6, Feb. 7 was counted as two 72-hour tests and was not assumed to be a 7-day test with one missed billing on Feb. 4).

Patients that had a double billing (two or more identical codes on the same day) were considered to have only one Holter test on that day. There were 426 double billings for G650 and one double billing for G653.

G650 and G653 were considered as separate tests even if they were billed on the same day, though G650 and G653 were very rarely billed on the same day, occurring in only 117 cases.

There is no strict rule for the reimbursement of consecutive day tests. Often, they are reimbursed at the full rate even though they should be reimbursed only at half (more of a problem with 48-hour Holters and less of a problem with 72-hour Holters). Reimbursement was not taken into consideration when counting the tests.

G660 (event recorder) codes: n=112,704 (without doubles). G660 billing codes were not counted as a separate Holter test. G660 is an event recording and is used with long-lasting Holter. Infrequently, physicians may order sequential Holter monitors over multiple consecutive days as a substitute for G660. 56.4% of G660 codes were billed on the same day as any G650 and/or G653 test. An additional 9.1 % of G660 codes were billed within ± 1-3 days of G650/G653 billing.

Holters billed on 4 consecutive days or longer n=1,046:

- Only 1.1 % had an additional G660 billing on the same day
- Additional 1.9 % had a G660 billing within a week
- Additional 2.4 % had a G660 billing within a month

Number of Holter tests:

One-day	1,062,042
48-hr	117,852
72-hr	6,082
96-hr	404
Multiple-day	647
TOTAL	1,187,027

Only one test per patient per day was considered (regardless of the number of billings). All the tests within the 7-day period were considered as one test. The first test for each patient was selected and all the tests that were billed up to 7 days later were removed. The next test that was more that 7 days after the initial test was selected and the whole procedure was repeated until the maximum number of tests per patient was reached.

4. MPI, GXT and wall motion tests

Selected MPI billing codes: J607 NUCL. NED. Myocardial perfusion scintigraphy post str. rest
J608 NUCL. MED. Myocardial – Delayed
J807 NUCL. NED. Myocardial perfusion scintigraphy post str. rest
J808 NUCL. MED. Myocardial – Delayed

Billings: 1,967,415

Selected GXT billing code*:* G319 Cardiov – Max Stress – professional component

Billings: 2,034,870

Selected MUGA (Myocardial Uptake Gated Angionuclide) billing codes:
J604 NUCL. MED. First transit. without blood pool images
J606 NUCL. MED. Cardioangiography. First pass shunt detection output & transit.
J611 NUCL. MED. Myocard. wall motion studies
J613 NUCL. MED. Myocard. wall motion studies/ejection fract
J667 NUCL. MED. First transit. with blood pool images
J804 NUCL. MED. First transit. without blood pool images
J806 NUCL. MED. Cardioangiography. First pass shunt detection output & transit.
J811 NUCL. MED. Myocard. wall motion studies
J813 NUCL. MED. Myocard. wall motion studies/ejection fract.
J867 NUCL. MED. First transit with blood pool images

Billings: 1,859,701

Selected SPECT billing codes: J609 NUCL. MED. Application of SPECT max 2 per exam add
J666 NUCL. MED. Tomographic examination (SPECT)
J809 NUCL. MED. Application of SPECT max 2 per exam
J866 NUCL. MED. Tomographic examination (SPECT)

Billings: 1,520,167

Selected dipyridamole billing code:
G112 Cardiov. – Dipyridamole thallium stress test prof fee

Billings: 261,054
Number of patients: 1,859,466

Only one MPI, SPECT, MUGA, dipyridamole or GXT test was allowed per patient per day (if there were more than one per day, the most common one was selected as a base of such test). However, a patient could have had any combination of these tests on the same day.

a) MPI

MPI tests were the starting point, and then other tests were identified (SPECT, MUGA, Dipyridamole or Stress) within ±2 days (5 days of difference in total) of the MPI test.

MPI + Stress (no MUGA, no SPECT, no Dipyridamole) (MS) = 11,077 (1.4%)
MPI + Stress + MUGA (no SPECT, no Dipyridamole) (MSM) = 2,721 (0.4%)
MPI + Stress + SPECT (no MUGA, no Dipyridamole) (MSP) = 225,582 (29.5%)
MPI + Stress + MUGA + SPECT (no Dipyridamole) (MSMP) = 229,317 (29.0%)

MPI + Stress + Dipyridamole (no MUGA, no SPECT) (MSD) = 74 (0.01%)
MPI + Stress + Dipyridamole + MUGA (no SPECT) (MSDM) = 21 (0.00%)
MPI + Stress + Dipyridamole + SPECT (no MUGA) (MSDP) = 841 (0.1%)
MPI + Stress + Dipyridamole + MUGA + SPECT (MSDMP) = 1,050 (0.1%)

MPI + Dipyridamole (no Stress, no MUGA, no SPECT) (MD) = 6,394 (0.8%)
MPI + Dipyridamole + MUGA (no Stress, no SPECT) (MDM) = 2,546 (0.3%)
MPI + Dipyridamole + SPECT (no Stress, no MUGA) (MDP) = 109,478 (14.1%)
MPI + Dipyridamole + MUGA + SPECT (no Stress) (MDMP) = 137,036 (17.6%)

MPI alone (no Stress, no MUGA, no SPECT, no Dipyridamole) (M) = 4,956 (0.6%)
MPI + MUGA alone (no Stress, no SPECT, no Dipyridamole) (MM) = 531 (0.1%)
MPI + SPECT alone (no Stress, no MUGA, no Dipyridamole) (MP) = 26,636 (3.4%)
MPI + MUGA + SPECT (no Stress, no Dipyridamole) (MMP) = 19,307 (2.5%)

b) Dipyridamole alone

(no Stress, no MUGA, no SPECT, no Dipyridamole) (D) = 0 (0%)

c) Wall motion tests

Without MPI

MUGA tests were the starting point and then other tests were identified (SPECT, Dipyridamole or Stress) within ±2 days (5 days of difference in total) of that MUGA test. MUGA tests that were billed within ±2 days of a MPI test were excluded from these calculations (they were already counted as perfusion tests above).

MUGA alone (no SPECT, no Stress, no Dipyridamole) (MU) = 786,404 (MUGA test)
MUGA + Dipyridamole (no SPECT, no Stress) (MUD) = 2154 (Dipyridamole MUGA)
MUGA + SPECT (no Stress, no Dipyridamole) (MUP) = 136,093 (MUGA test)
MUGA + SPECT + Dipyridamole (no Stress) (MUPD) = 148 (Dipyridamole MUGA)
MUGA + Stress (no SPECT, no Dipyridamole) (MUS) = 17,444 (Stress MUGA)
MUGA + Stress + Dipyridamole (no SPECT) (MUSD) = 7 (Stress MUGA)
MUGA + SPECT + Stress (with or without Dipyridamole) (MUPS) = 624 (Stress MUGA)

Without MPI and MUGA

(Starts with SPECT test and looks for other tests within ±2 days)

SPECT tests were the starting point and then other tests were identified (Dipyridamole or Stress) within ±2 days (5 days of difference in total) of that SPECT test. SPECT tests that were billed within ±2 days of a MPI and/or MUGA test were excluded from these calculations (they were already counted above).

SPECT alone (no Stress, no Dipyridamole) (P) = 52,345 (MUGA test)
SPECT + Dipyridamole (no Stress) (PD) = 262 (Dipyridamole MUGA)
SPECT + Stress (with or without Dipyridamole) (PS) = 114 (Stress MUGA)

d) GXT alone

(No MPI, no MUGA, no SPECT within ±2 days) = 1,561,037

Stress tests that were billed within ±2 days of an MPI and/or MUGA test were excluded from these calculations (they were already counted above).

Only one test per patient per day was considered (regardless of the number of billings). All the tests within the 7-day period were considered as one test. The first test for each patient was selected and all the tests that were billed up to 7 days later were removed. The next test that was more that 7 days after the initial test was selected and the whole procedure was repeated until the maximum number of tests per patient was reached.

5. Angiography

Selected billing codes:	OHIP (Z442 and G297) only reimbursed by OHIP
Billings:	73,014
Number of tests:	41,019 (one test per patient per day)
Selected billing codes:	CIHI (4892 to 4898; 4996; 4997) both same-day surgery and inpatient data
Billings:	48,858
Number of tests:	43,774 (one test per patient per day)

To find a date of angiography the date of first procedure was identified (dxcode1) and if the angiography code was there, that day was recorded as a date of testing. If the code was not there, the second procedure was used (dxcode2), then the third, etc. until the 10th and the last one. If there was no date for any of the procedures, the date of admission was used. To match CIHI and OHIP together, a person with a record of angiography in OHIP and CIHI within 3 days counted as having only one test.

1 angiography test is defined as:

- A patient having a CIHI record and a matching (±3 days) OHIP record; or
- CIHI record only (no OHIP record within 3 days); or
- OHIP record only.

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