The costs of colonoscopy in a Canadian hospital using a microcosting approach

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BACKGROUND: Colonoscopy has become accepted as one of the most effective methods of screening patients for colorectal cancer, and is used to remove the majority of colonic adenomas.

OBJECTIVE: Because of the paucity of such estimates in the literature and the significant number of candidates for this procedure, the present study was performed to estimate the direct hospital costs of both diagnostic and therapeutic (polypectomy) colonoscopy.

METHODS: A microcosting methodology was used to itemize the costs of colonoscopy. Variable and fixed costs were divided into labour, supplies, equipment and overhead costs. A third-party payer perspective was adopted. All costs are expressed in 2007 Canadian dollars.

RESULTS: The cost of a diagnostic colonoscopy was \$157 and the cost of a therapeutic colonoscopy was \$199. Overhead costs represented approximately 30% of these amounts. When physician fees were added, these costs rose to \$352 and \$467, respectively.

CONCLUSION: Because the overhead costs represent a large proportion of the total costs, allocation methods for these costs should be improved to allow for a more precise determination of the total costs of a colonoscopy. These estimates are useful when analyzing the cost-effectiveness of a strategy that uses colonoscopy when screening for colorectal cancer.

Key Words: Colonoscopy; Cost; Microcosting

Canada has one of the most rapidly aging populations (1-3), which is, in part, why health care professionals, particularly in hospital endoscopy settings, have been overwhelmed with requests to perform both case-finding and screening colonoscopies. Indeed, colonoscopy is recommended as the primary method of screening for colorectal cancer or in follow-up to positive fecal occult blood test results by many societies, including the Canadian Association of Gastroenterology (4) and the Association des Gastro-Entérologues du Québec (5). It is also the preferred method of examining the colon in most adult patients with bowel symptoms, iron deficiency anemia, abnormal radiographic studies of the colon, postpolypectomy and post-cancer resection surveillance, and surveillance in inflammatory bowel disease and in people with suspected masses (6). Therefore, cost estimates of a colonoscopy can help in the allocation of resources and budgeting of an endoscopy unit. Such estimates

Les coûts de la coloscopie dans un hôpital canadien au moyen d'une démarche de « micro-coût »

HISTORIQUE : La coloscopie est acceptée comme l'une des méthodes de dépistage du cancer colorectal les plus rentables et elle permet d'extraire la majorité des adénomes coliques.

OBJECTIF : Étant donné le peu d'évaluations de ce genre dans les publications et le nombre important de candidats à cette intervention, la présente étude visait à évaluer les coûts hospitaliers directs tant de la coloscopie diagnostique que thérapeutique (polypectomie).

MÉTHODOLOGIE : Une méthodologie de micro-coût a permis de ventiler les coûts de la coloscopie. Les coûts variables et fixes ont été séparés en main-d'œuvre, fournitures, matériel et frais généraux. On a adopté une perspective de tiers payeur. Tous les coûts sont exprimés en dollars canadiens de 2007.

RÉSULTATS : Le coût d'une coloscopie diagnostique était de 157 \$ et celui de la coloscopie thérapeutique, de 199 \$. Les coûts généraux représentaient environ 30 % de ces sommes. Avec l'ajout des honoraires des médecins, ils passaient à 352 \$ et 467 \$.

CONCLUSION : Puisque les frais généraux représentent une forte proportion des coûts totaux, il faudrait améliorer les méthodes de répartition de ces coûts pour déterminer les coûts totaux de la coloscopie avec plus de précision. Ces évaluations sont utiles pour analyser l'efficacité des coûts d'une stratégie qui fait appel à la coloscopie pour dépister le cancer colorectal.

can also inform third-party payers, such as the Canadian provincial governments, in the planning of colorectal cancer screening programs. Cost estimates of medical procedures have only recently been studied, which explains their rarity in Canada and in the United States.

We therefore aimed to estimate the costs of colonoscopy by adopting a microcosting approach, rather than evaluating costs based on charges or reimbursement fees, because of the improved accuracy of this method (7-9).

METHODS

Study overview

The present study was performed in June 2006 at the Montreal General Hospital site of the McGill University Health Centre (MUHC) in Montreal, Quebec, which is a general adult, 450-bed university-affiliated health care institution. Utilization and costs at the level of the endoscopy unit

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Figure 1) Patient flow diagram for a colonoscopy performed in the Department of Gastroenterology at the Montreal General Hospital (Montreal, Quebec). Each box represents a step in the process. GI Gastroenterology

were estimated. The research was then broadened to include all costs at the institutional level.

The methodology consisted of introducing a specially trained research assistant into the endoscopy unit, who interviewed doctors, nurses, secretaries and patient attendants to develop a detailed workflow scheme. Then, hospital administrators in the Departments of Medicine, Nursing, Finance, Purchasing and other relevant institutional departments (such as Maintenance and Informatics) were contacted to determine both the units of resource use related to a colonoscopy and the corresponding estimates of unit costs. This approach was similar to what has been used previously when determining the costs of a gastroscopy (10).

The measurement of direct costs included variable costs such as medical supplies, labour costs and fixed costs (ie, overhead costs – printing supplies, administration purchase services and housekeeping functions).

Patient flow analysis

A microcosting approach consists of tracking patients from the time they enter the hospital until they are discharged (Figure 1) (10-15).

The cost of every service provided (eg, a secretary preparing a hospital card) and every good received by a patient undergoing a screening colonoscopy (eg, a gown, a hospital bracelet, etc) was identified. Every component of the procedure and a corresponding unit price were also identified. The utilization was divided into pre-endoscopic (first encounter, waiting room, patient preparation), procedural and postendoscopic phases (recovery and discharge), as has been reported previously (10).

Cost components

Equipment costs: The equipment used for colonoscopy is often used for other types of endoscopic procedures. The colonoscopy procedure was divided into different steps (Figure 1) to provide a framework to identify the resources used at each step of the procedure.

For example, a patient's preparation consists of describing the procedure to the patient, measuring arterial pressure, administering sedatives and, finally, transporting the patient to the endoscopy room. These steps are monitored by a nurse; therefore, the hourly rate of a nurse applied to this specific duration, the price of the medications administered and the

estimated cost of the equipment used needed to be determined. For each step of the procedure presented in Figure 1, the resources used were divided into three categories: labour (time), supplies and equipment (including maintenance and repair). Overhead costs were added proportionately at the end.

Equipment and repair costs: Expenses for equipment were annualized over their economical lifespan (16). The nominal interest and inflation rates were provided by the Bank of Canada (17). The lifespan was five years for the pulse oximeter and the vital sign monitor; seven years for the light source, the processor, the video monitor, the maintenance unit endoscopy room, the maintenance unit cleaning room and the cleaning machines; and 10 years for the trolleys, the stretcher and the ERBE endoscope (ERBE USA Inc, USA).

Annualized equipment expenditures were calculated for each piece of equipment used and allocated over the different activities on a per procedure basis. A part of the cost associated with these shared resources was attributed to their use (ie, the proportion of endoscopies that were colonoscopies).

Repair and maintenance costs of the equipment are based on a fixed contract per year. The proportions that were applied for the cost utilization were applied in the same way for the repair and maintenance costs.

No allowances were made for the building costs of the facilities themselves.

Labour costs: Labour included the time spent by a secretary scheduling an appointment and registering a patient; the nurse's time for patient preparation, assistance during scoping, check-in and check-out, and cleaning the scope; the technician's time for cleaning the room and the accessories; and the porter's time for transferring patients to and from the recovery room.

Department-specific overhead costs: The cost per colonoscopy also included a part of all the financial accounts of overhead gastroenterology (GI) department costs (ie, office and printing supplies, purchase services, plant maintenance supplies, wearing apparel, data processing, housekeeping paper products, etc). The proportion of visits for colonoscopy among all the patient visits to the GI department were used as the proportion of all these overhead GI costs.

Hospital institutional overhead costs: Overhead hospital costs were taken into account to consider the indirect support by other hospital departments such as reception, archives and security. Recovery room costs were included in the hospital overhead costs as a function of the space occupied in the hospital and the average time spent by a patient for a colonoscopy. In an ideal accounting system, hospital-wide overhead expenses would have been allocated by the accounting system to every department. However, such detailed accounting was not available. Therefore, a direct allocation method was used. Another question is which hospital-wide overhead costs should be allocated to a specific procedure. An extreme view would be to allocate all types of overhead, first to the clinical departments or patient-oriented centres, and then to allocate costs in each department to the specific procedures performed in the department. However, not all general, hospital-wide overhead expenses are related to a colonoscopy visit. Therefore, it would not be fair to add these expenses to the cost of a colonoscopy.

As a compromise, centre expenditures related to administration, reception, computer services, archives, linen and laundry, housekeeping, waste disposal, heating and electricity, security, general maintenance and repair of installations were

retained because they appear in the yearly financial hospital report (2005 to 2006) submitted each year to the provincial Ministry of Health.

For these activity costs, the attribution of the costs for a colonoscopy were based on the units of measurement used in the hospital report. The units of measurement used were the time duration of a colonoscopy, the number of visits per colonoscopy and the space occupied by the GI department.

However, expenses related to meals, lodging, ambulance and personal expenses were excluded from the hospital-wide support activities. Teaching charges and residents' costs were also excluded because they are supported by sources other than the hospital budget.

Cost-volume function

To better understand the relationship between endoscopic volumes and costs, three possible scenarios of equipment sharing were examined, using previously reported methodology (10,18-20).

RESULTS

The cost of a colonoscopy

Between 2003 and 2006, approximately one-half of all endoscopies performed at the Montreal General Hospital were colonoscopies, including 20% that were accompanied by a polypectomy (Figure 2) (notwithstanding a very small proportion of colonoscopies for hemostasis or other therapies).

The average time spent in the recovery room was 30 min, after which time, patients were discharged.

The total direct costs, including and excluding physician fees, can be found in Table 1. Table 1 shows the breakdown of the direct cost per category of costing (labour, supplies and equipment) for the colonoscopy with and without a polypectomy, excluding department or general hospital overhead costs that are detailed in Table 2. The overhead costs related to the endoscopy unit total \$13, and amount to \$41 for the rest of the hospital (Table 3).

The overall costs, including physician fees, totalled \$352 for a diagnostic colonoscopy and \$467 for a therapeutic colonoscopy (Table 3).

The difference in cost between a colonoscopy with and without polypectomy is attributed to the additional physician professional fees (including pathologist fees) and supplies needed for the polypectomy (snare and cautery, as well as materials used in pathology). The breakdown of costs for diagnostic and therapeutic colonoscopy are presented in Figures 3 and 4, respectively. The greatest contributions to overall costs are attributable to the overhead costs and physician fees.

Endoscopy cost-volume function

Figure 5 shows three possible evolutions displaying costs as a function of the number of colonoscopies. As procedural volume decreases or increases, the cost per procedure might go up or down, depending on the number of procedures and the need to purchase additional equipment. An additional consideration is whether the equipment is shared for other purposes (indications/procedures).

One possible scenario is a naive approach, whereby no new equipment is purchased or discarded as the number of procedures changes, and professional time is considered variable. Fixed costs are only adapted in relative proportion to the number of procedures performed. A second possible scenario is a

Figure 2) Proportion of colonoscopies among endoscopies performed in the Department of Gastroenterology at the Montreal General Hospital (Montreal, Quebec). The values presented are the yearly means of the number of procedures performed based on statistics from 2004 to 2006 at the Montreal General Hospital

shared approach, whereby additional equipment is shared for other endoscopic procedures based on the current observed ratio (ie, equipment is considered divisible). The final possible scenario is an unshared approach, whereby all the equipment is dedicated solely to colonoscopies, but the current staff levels and equipment density per 1000 colonoscopies are the same as those observed in the study. However, when the volume of procedures increases, additional equipment has to be purchased only for colonoscopies (labour is considered variable). All three approaches show that over 4000 procedures, the cost per colonoscopy does not change appreciably.

DISCUSSION

Although very time consuming because of the level of detail required, a microcosting method provides a valid estimate of final costs that is reported to be quite reliable (14,21,22). The microcosting method consists of breaking down the different steps that are performed when delivering the resource (in this case, the colonoscopic procedure), and making an estimate of the cost of each component (21,23-26).

In particular, we did not attempt to tabulate indirect costs, as in the case of other similar efforts, but adapted a template we previously devised to measure the costs of a gastroscopy where preprocedural, procedural and postprocedural intervals of care were identified (10). For example, to evaluate the cost of patient preparation, we needed to take into account the price of the different consumables used (sheets of paper, bracelets, alcohol swabs, intravenous needles, etc), as well as the professional fees of the different health care team members involved (secretaries, nurses).

Nonetheless, our estimations have several limitations. Several items have no actual recorded prices and have to be estimated in the absence of accurate financial systems and the paucity of precise records tracking the costs and quantities of resources associated with specific procedures in Canadian hospitals.

The equipment used (eg, endoscopes, lights, processors, the recovery room bed, etc) are often used for other purposes. Assumptions have to be made when evaluating the actual cost of the procedure. In our study, we assumed that fixed costs related to the use of equipment varied with the number of procedures and their duration, as has been previously reported (21). We also needed to estimate the overhead costs that amounted to nearly 15% of the total cost estimates. Other investigators have chosen to ignore these (27), to divide a global overhead cost by the number of procedures (28), or to use a very approximate cost

TABLE 1
Direct variable costs of a colonoscopy at the Montreal General Hospital (Montreal, Quebec)

Activity	Cost, \$				
	Labour*	Supplies	Equipment†	Total, excluding physician fees	Total, including physician fees
Patient appointment and administration	2.80	—	—	2.80	—
Consultation and follow-up	—	—	—	—	90.96
Patient preparation	12.63	14.14	—	26.77	—
Performing colonoscopy without polypectomy	10.91	4.99	41.19	57.09	104.10
Supplement for polypectomy	—	20.83	—	20.83	41.65
Cleaning and disinfection	7.83‡	3.47	4.98	16.28	—
Pathology for the polypectomy	—	20.83	—	20.83	31.24
Total	—	—	—	—	—
Without polypectomy	34.00	23.00	46.00	103.00	340.00
With polypectomy	34.00	64.00	46.00	145.00	413.00

All costs are expressed in 2007 Canadian dollars. Costs associated with the use of the recovery area included direct variable costs (the porter time for moving a patient) and overhead costs (electricity, heating, housekeeping, security, general maintenance and repair of installations). *This includes the secretary's time for scheduling an appointment (8 min) and registering a patient (10 min), the nurse's time for patient preparation (10 min), assistance during scoping (20 min) and cleaning the scope (5 min), the porter's time for moving patients to the recovery room (10 min), and the technician's time for cleaning the room (7 min) and the accessories (8 min); †The proportions of the equipment used for the colonoscopies (52% and 72%) represent the proportion of the colonoscopies among all the endoscopies between 2004 and 2006, and the proportion of the decontamination assigned to the colonoscopies that was observed during 15 days at the department; ‡The time for cleaning was based on the proportion given by the ratio of the total number of scope decontaminations by the number of colonoscopies performed (mean per day)

TABLE 2
Overhead costs at the Montreal General Hospital (Montreal, Quebec)

Activity	Total cost per year, \$	Unit cost per colonoscopy*, \$
Department of Gastroenterology		
Linen	17.00	0.002
Wearing apparel	44,094.00	1.03
Housekeeping clean-up	4,778.00	0.73
Plant maintenance supplies and purchase services	15,903.00	0.21
Equipment (printing, etc)	24,125.00	7.52
Data processing	6,447.00	0.96
Biomedical	3,165.00	0.47
Office/printing supplies	5,859.00	0.86
Administration purchase services	8,498.00	1.26
Total	—	13.00
Hospital		
Nursing administration	4,947,164.00	0.54
General administration	31,741,831.00	3.09
Technical service administration	1,615,121.00	0.18
Computer services	13,160,617.00	1.44
Reception/archives/communication	17,967,964.00	18.69
Linen and laundry	6,595,431.00	10.17
Housekeeping†	15,749,752.00	2.37
Waste disposal	661,882.00	1.95
Heating and electricity†	17,429,246.00	2.08
Security†	2,537,016.00	0.50
General maintenance and repair of installations†	13,539,960.00	0.15
Total	—	41.20
Total cost	—	55.00

All costs are expressed in 2007 Canadian dollars. *Sixty-seven per cent of all overhead costs of the department were attributed to the colonoscopies. This proportion was based on the ratio of the number of patient visits for colonoscopy to the total number of visits at the gastroenterology department between 2005 and 2006, assuming an average of 1.3 visits per colonoscopy; †These activities were estimated based on the surface area and volume of the common space of the department, the space of the endoscopy room and the space of the recovery room attributed to colonoscopies

TABLE 3
Total costs of a colonoscopy at the Montreal General Hospital (Montreal, Quebec)

Variable	Colonoscopy without polypectomy	Colonoscopy with polypectomy
Direct cost	103.00	145.00
Fixed overhead departmental cost	13.00	13.00
Fixed overhead hospital cost	41.00	41.00
Physician fees	195.00	268.00
Total cost without physician fees	157.00	199.00
Total cost with physician fees	352.00	467.00

All costs are expressed in 2007 Canadian dollars

estimate per square foot of medical space used (8,24), although not all overhead costs apply to colonoscopy (10).

We then decided to select activity items most relevant to colonoscopy. For example, we decided to ignore expenses that are funded otherwise, such as in-hospital meals or education, as has been reported previously (10). We also ignored expenses that might not represent resources used consistently across different institutions.

For hospital overhead costs, we adopted units used by the Finance department of the hospital (duration of the procedure, space used). For the specific endoscopy unit overhead costs, we estimated a proportion of the patient visits attributable to colonoscopies as a fraction of all visits to the GI outpatient area. Our estimates are based on averages of monthly institutional and GI divisional financial reports that are quite representative. Of course, our estimates are drawn from one institution, and a broader sampling of Quebec hospitals would provide a more representative value approximation of colonoscopy costs in the province. All charges associated with labour costs and paid by the hospital (health, life and disability insurance, etc) were also included in the labour costs. Some microcosting studies are based on following a group of patients (24,29,30). In contrast, we determined the average cost for

Figure 3) Breakdown of diagnostic colonoscopy costs at the Montreal General Hospital, McGill University Health Centre (Montreal, Quebec). GI Gastroenterology

Figure 4) Breakdown of therapeutic colonoscopy costs at the Montreal General Hospital, McGill University Health Centre (Montreal, Quebec). GI Gastroenterology

each resource used for a typical patient undergoing a colonoscopy. Therefore, our estimates for each item were based on very representative costs. Interestingly, in the cost-volume analysis, all three adopted approaches show that over 4000 procedures, the cost per colonoscopy does not change significantly. This was especially true for the naive approach, which tended to overestimate the cost. This finding suggests that the cost of colonoscopy lies above the threshold at which economy of scales would apply.

The results we present are validated by comparisons of our total costs to other similar published works, although only a few cost studies of colonoscopy have been published to date. A recently published abstract from British Columbia (31) estimated the per-procedure cost of a conventional colonoscopy in an outpatient endoscopy clinic using a microcosting approach. The total overall cost for a therapeutic colonoscopy (with polypectomy) was \$522 compared with the present study's cost of \$467. The major difference arises from the lower physician fees in Quebec (without physician fees, the respective costs were \$206 and \$199), with a small increase (\$15) in costs in British Columbia attributable to labour costs. This is not much more expensive than our overall cost of \$467 for the same procedure in our study. This difference can be explained by the fact that the physician reimbursement fees are higher in British Columbia than they are in Quebec. However, their amount might not be as representative as the one we found, because they based their results on only 104 patients, whereas our study used statistics from the last three years, which amounts to 13,578 colonoscopies.

A decision analysis was conducted based on Ontario fees and evaluated the costs of four different strategies: flexible sigmoidoscopy to the splenic flexure, flexible sigmoidoscopy with air contrast barium enema, virtual colonoscopy and colonoscopy (32). The costs (including physician fees) for investigating a patient with a colonoscopy amounted to \$360, with an additional \$157 for performing a polypectomy. These results date back to 2002 and are very close to those of the two aforementioned analyses.

Performing such studies is increasingly relevant for many reasons. First, due to the advancement of technology, different screening tools are now available and microcosting studies aid in their comparisons. Moreover, such studies are very useful for estimating budgets, as long as the optimization of patient care remains the premise that any resultant funding decision is based

Figure 5) Cost-volume function of colonoscopy. All costs are expressed in 2007 Canadian dollars

on. As an example, the Ministry of Health may then have a more precise idea of how much needs to be invested for colorectal cancer screening, at least from the point of view of colonoscopic resource use. Microcosting studies may also become increasingly useful in the transfer of resources from the public to the private sector debate because they provide an accurate indicator of the costs (and their relationship to volumes) of diagnostic and therapeutic colonoscopies. Finally, such data are required for the completion of decision analyses.

Our detailed analysis from an activity-based approach of colonoscopy, offers a blueprint that can be replicated across different settings nationwide because it is well known that endoscopy units vary in their staffing and utilization levels (18,20). This would be particularly useful in helping to define 'optimal' practices and to define guidelines for setting up endoscopy units.

The importance of improving hospital accounting systems to better allocate overall hospital overhead costs to medical departments and units, and ultimately to individual procedures, should be stressed. We have shown that these overhead costs are an important component in the estimation of the overall total cost of the procedure. Full costing of medical procedures in itself is an important prerequisite for setting provincial reimbursement levels and hospital budget allocation,

either from the perspective of the Ministry of Health or from that of the hospital administrator, although colonoscopy relates more specifically to a prototypical digestive endoscopy unit. Such detailed analyses of routine medical procedures are needed to help optimize health care expenditures.

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