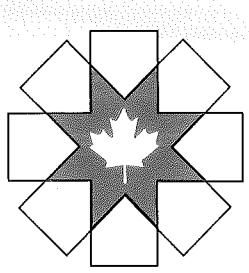

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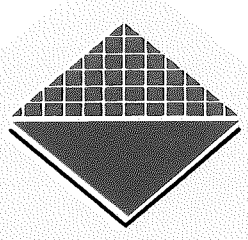

AUSTRALIAN INSTITUTE OF
HEALTH & WELFARE

The introduction of laparoscopic cholecystectomy in Canada and Australia

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Summary

- Data were collected on the number of cholecystectomies undertaken in Canada and Australia over a number of years, before and after the introduction of laparoscopic cholecystectomy. Estimates were also made of the costs of these surgical procedures to health programs and to patients.
- The Canadian data on numbers and costs of cholecystectomies were based on surveys undertaken in hospitals in all provinces and territories. The Australian estimates were derived from national and State databases.
- In both countries, cholecystectomy rates were steady for some years prior to the introduction of laparoscopic cholecystectomy. After the new procedure became available, rates increased by 17% in Canada and 24% in Australia within two years.
- Use of the laparoscopic procedure led to a reduction in average length of stay (ALOS) for cholecystectomy cases, but in terms of impact on costs, this was partly offset by the increase in the number of procedures.The cost to health programs decreased marginally in both Canada and Australia.
- Days lost by patients because of surgery, and the associated costs of this, decreased in Canada by 17% and 15% respectively between 1989–90 and 1991–92. The corresponding decreases in Australia were 25% and 23%.
- Estimates of potential savings to health programs through the new method indicated that, while some gains had been made, the estimated potential savings from the use of the new method had not been achieved due to increases in caseload.
- Possible reasons for the increase in surgery rates include extension of services to frailer patients, use of surgery rather than conservative management, use in asymptomatic cases and inappropriate diagnosis.
- As ALOS and rates of conversion to open surgery associated with laparoscopic cholecystectomy decline, there will be an improvement in the savings achieved for health programs and for patients. However, if the higher rates of surgery are maintained, there will be continued uncertainty as to the utility of some of these additional procedures.
- The experience of Canada and Australia suggests that the introduction of laparoscopic cholecystectomy has produced benefits though these were less than optimum during the first two years that the technique was in use. The increases in the rates of cholecystectomies observed suggests the need for appropriate mechanisms to establish appropriate indications and clear guidelines for this and other minimal access surgical techniques.

Introduction

Laparoscopic cholecystectomy

This report summarises and compares data from Canada and Australia on the use and cost implications of a recently introduced minimal access surgery (MAS) technique, laparoscopic cholecystectomy. The report has been prepared as a joint project between the Canadian Coordinating Office for Health Technology Assessment (CCOHTA) and the Australian Institute of Health and Welfare (AIHW). This work was undertaken because of the interest and concern regarding the introduction and use of new MAS methods into health care systems in each country.

Cholecystectomy (removal of the gall bladder) is a very common procedure in all western countries. Laparoscopic cholecystectomy has now become widely established and is generally regarded as the method of choice for treatment of most patients who have symptomatic gall bladder disease. It provides a less invasive alternative to open surgery for removal of the gall bladder and offers the promise of shorter hospital stay, faster return of patients to normal activities and decreased costs to health care programs. Access to the operating field is obtained through four small incisions in the abdomen. In a small proportion of cases surgery cannot be completed laparoscopically and the procedure has to be converted to an open operation. Following its introduction, the diffusion of the technique has been rapid in both Canada and Australia with minimal regulatory delay and without prior proof of effectiveness or assurance of appropriate training for surgeons and other hospital staff.

Both CCOHTA and the Institute have given previous consideration to this MAS technique as part of appraisals of methods for treatment of gall bladder disease, including shock wave lithotripsy.[1–3] The Australian Institute of Health and Welfare issued a discussion paper on laparoscopic cholecystectomy shortly after it was introduced to Australia and included further detail in a subsequent paper dealing more generally with MAS.[4,5] CCOHTA studied the diffusion of the technology in Canada.[6]

An early US report suggested that the laparoscopic method is cost-effective in comparison with open cholecystectomy: this has been supported by a more recent study in that country.[7,8] A modelling approach has suggested that laparoscopic cholecystectomy is likely to be less costly and more effective for most patients, provided it is not associated with routine post-operative tests, higher fees or increased risk of complications.[9] A review of two Canadian studies reported the superiority of the laparoscopic over open procedures with respect to duration of hospitalisation and of post-operative convalescence.[10]

In Australia, a cost–utility analysis by Cook, Richardson and Street showed that laparoscopic cholecystectomy was unambiguously superior to both open surgery and extracorporeal shock wave lithotripsy (ESWL), and more recently the superiority of the laparoscopic method on clinical and cost grounds has been reported by Hardy et al.[11,12] Both studies related to experience in large teaching hospitals.

While such studies have provided evidence of the benefits of laparoscopic cholecystectomy there are still few data on how the introduction of the technique has broadly affected health care in different countries, or how various issues related more generally to laparoscopic surgery, including changes to training and infrastructure, have been addressed.[13]

Outline of the study

In this report, an overview is given of data that were available on the initial diffusion of laparoscopic cholecystectomy in Canada and Australia. Data on numbers of cholecystectomies undertaken annually before and after the introduction of laparoscopic cholecystectomy were obtained for each country. Costs of these procedures to health programs and to patients were estimated and compared with historical levels of expenditure on cholecystectomies to obtain an indication of the impact of the new method on health care systems. A preliminary account of the analysis has been presented elsewhere.[14] The present report provides further details and draws on data that have become available from additional analysis.

Nationwide data on a newly introduced technique such as laparoscopic cholecystectomy are not readily available. This analysis relied on information obtained directly from hospitals and on projections from existing databases, including those held by Ministries and Departments of Health. A number of assumptions have been made to derive a broad perspective of developments during the period in which the technique was first used.

The data are considered in four sections. In the first, details are provided of the surveys undertaken by CCOHTA and of data on numbers and costs of cholecystectomies in Canada. The Australian experience is then outlined, drawing on databases available to the Institute. The sets of data from each country are then compared and a discussion section considers some of the significant issues related to the developments in this area of surgery.

For each country, numbers of procedures were adjusted to a constant population basis (1987–88) and all costs to constant 1991–92 dollars. No data were available on the proportions of laparoscopic procedures in which disposable instruments were used, so the costs of such devices are not included.

Canadian data on cholecystectomies

Sources of data

Data on new procedures are difficult to get. Canadian data on cholecystectomies were obtained from four different sources:

1. Survey A—a survey of Canadian hospitals to determine the pattern of diffusion of laparoscopic cholecystectomy adoption;
2. Survey B—a survey of the Ministry of Health in each province and territory to obtain actual numbers of procedures performed;
3. Survey C—a survey of hospitals across Canada to obtain numbers of open and laparoscopic cholecystectomies performed and associated costs of these procedures;
4. Survey D—a survey of hospitals to obtain information about requirements for introducing and performing laparoscopic cholecystectomy.

The results of each of these surveys, which form the basis of the comparison with Australian data, and the analysis of impact discussed later in the report, are described briefly in this section.

Diffusion of laparoscopic cholecystectomy adoption in Canadian hospitals

Survey A was conducted to establish how widely Canadian hospitals had adopted laparoscopic cholecystectomy. A total of 153 hospitals were surveyed up to six times each between April 1991 and February 1993. Hospitals were selected randomly from the 1989–90 Canadian Hospitals Directory, but excluded children's hospitals, psychiatric, extended care and rehabilitation hospitals.[15] This sample represents about 16% of eligible hospitals in Canada.

There were two major groups of hospitals, each subdivided into three categories. The first group of 90 'large' hospitals, categorised according to number of beds, consisted of 30 with fewer than 200 beds, 30 with 200–499 beds and 30 with 500 beds or more. The second group of 78 'small' hospitals consisted of 26 hospitals with fewer than 50 beds, 26 with 50–99 beds and 26 with 100–149 beds. Hospitals were selected so that the distribution of hospitals in each group reflected the regional population distribution of Canada. Fifteen hospitals were included in both the large and small hospital groups, because these two groups were selected independently.

The survey instrument was a simple questionnaire consisting of four questions asked over the telephone. These questions established if: cholecystectomies were performed at the hospital; if laparoscopic cholecystectomy was being offered; if a laser was used (first three data points only); and, if laparoscopic cholecystectomy was not offered yet, if there were plans to introduce it in the future.

Based on the results from this survey, it was possible to plot diffusion curves of laparoscopic cholecystectomy adoption. The curves for the large hospital group and the small hospital group are shown in Figures 1 and 2. These diffusion curves bear out models of diffusion of innovations,[16] showing that the larger hospitals adopted laparoscopic cholecystectomy both earlier, and to a greater extent, than smaller institutions.

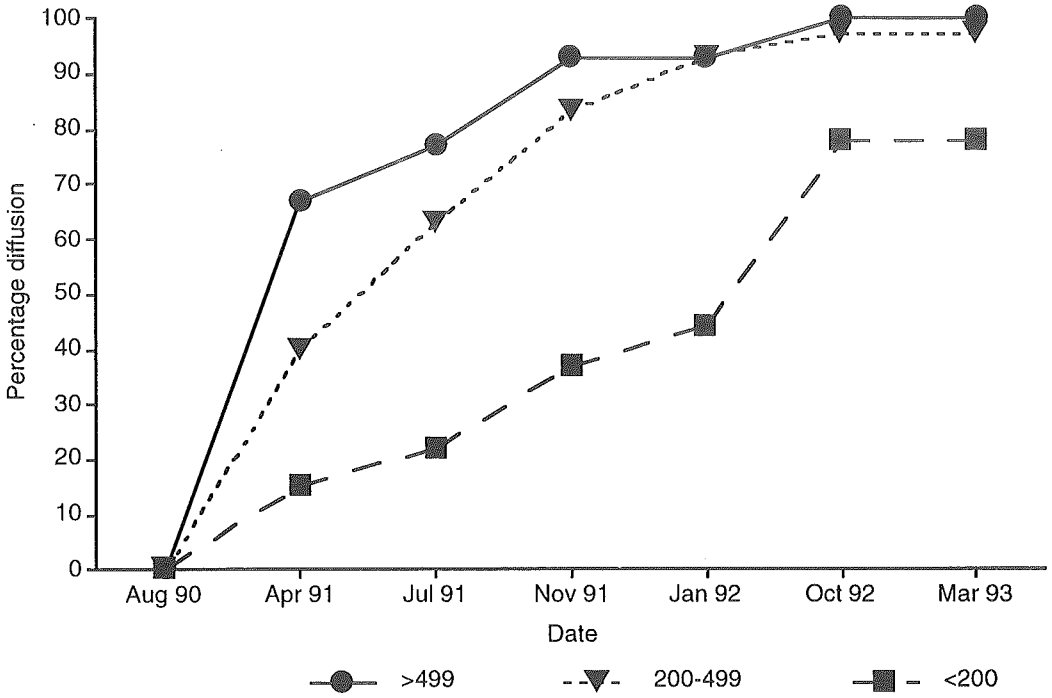

Figure 1: *Diffusion curve for the adoption of laparoscopic cholecystectomy in Canada – large hospital group*

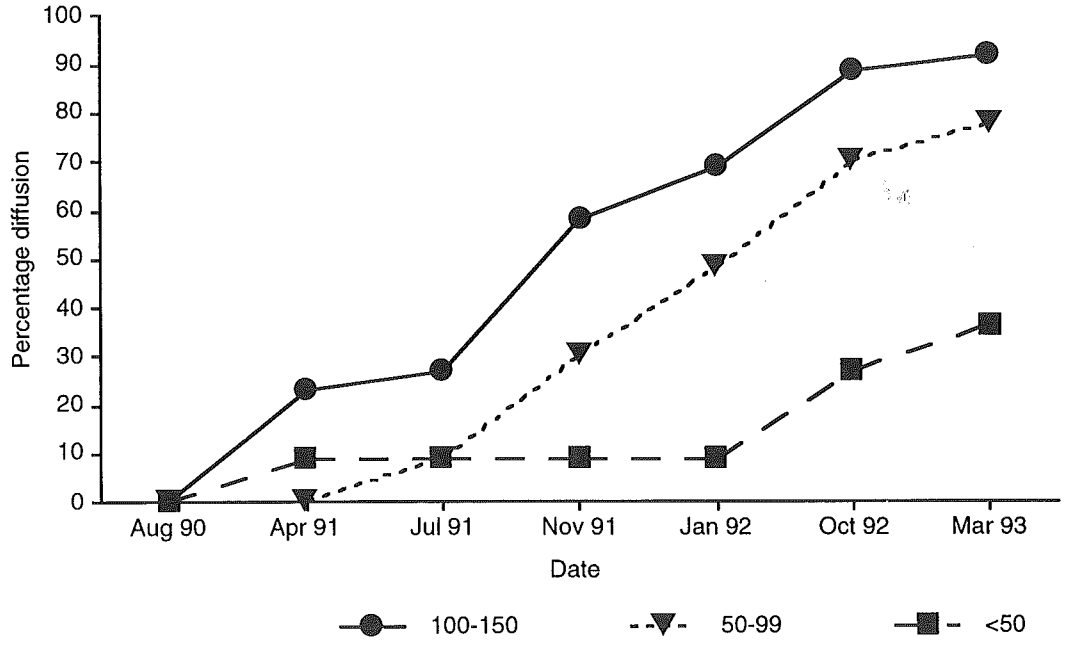

Figure 2: *Diffusion curve for the adoption of laparoscopic cholecystectomy in Canada – small hospital group*

Based on the diffusion data, the time taken to reach 75% adoption (T_{75}) for laparoscopic cholecystectomy ranged from 10 months for hospitals with over 500 beds to 29 months for hospitals with 50–99 beds. By March 1993, 90% of the large hospital group and 64% of the small hospital group either performed laparoscopic cholecystectomy or planned to adopt the technology.

In addition, a regional comparison of the rate of adoption of laparoscopic cholecystectomy indicated that Québec was the fastest and most extensive adopter among the provinces. Every Québec hospital included in this study had adopted laparoscopic cholecystectomy by January 1992, only 18 months after the introduction of the procedure to Canada.

Lasers were used in only 9% of all hospitals offering laparoscopic cholecystectomy as of January 1992. Subsequently, this question was dropped from the questionnaire.

Numbers of cholecystectomies performed across Canada, 1987–88 to 1991–92

In order to determine the actual number of cholecystectomies performed, a survey was sent to the Ministry of Health of each province and territory in Canada in January 1993 (Survey B). The survey was sent by mail requesting the numbers of both open and laparoscopic cholecystectomies for each year from 1987–88 to 1991–92, the professional fee paid per case, and the total professional fees paid for each year.

All 10 provinces and both territories responded. Results on the number of procedures are given in Table 1. Based on these results, it is evident that the overall trend for this time period had been an increase in the rates of cholecystectomies. Almost all of this increase occurred in the period between 1989–90 and 1991–92. The overall increase on an aggregate basis between 1987–88 and 1991–92 was 17%, with a 15% increase over the last two years of this period

Given that laparoscopic cholecystectomy was first introduced to Canada in the fall of 1990, these data suggest that the increase in cholecystectomies was associated with the availability of the new procedure.

Only one ministry was able to provide data that distinguished between open and laparoscopic cholecystectomy procedures. In order to determine the actual proportion of cholecystectomies that were performed laparoscopically, an additional survey of hospitals across Canada was undertaken and is described in the next section.

No province or territory was able to identify a separate fee for laparoscopic cholecystectomy. The professional fee per case of cholecystectomy for each province and territory is shown in Table 11 (Appendix 1). The fees ranged from $284 in Newfoundland to $766 in the North West Territories with an average of $450 and a weighted average (based on number of procedures performed) of $393.

Proportion of cholecystectomies performed by laparoscopy and comparative costs

A third survey was undertaken to determine the proportion of cholecystectomies performed by laparoscopy and to obtain hospital costs of both procedures (Survey C). Thirty-nine hospitals were surveyed, selected at random from the Canadian Hospital Directory[15] according to the three categories of 'large' hospitals defined for the previous diffusion survey (Survey A). The proportion of hospitals from each region was chosen to represent the regional population distribution in Canada (as for Survey A). An additional three hospitals were added to this list based on knowledge of availability of cost data at these hospitals. Children's, psychiatric, extended care and rehabilitation hospitals were again excluded.

Table 1: *Numbers of cholecystectomies[a] in Canada by province/territory for the period 1987–88 to 1991–92*

Province/territory	1987–88	1988–89	1989–90	1990–91	1991–92	Ratio, 1991–92: 1987–88
British Columbia	6,100[a]	6,111	6,098	6,657	6,993	1.15
Alberta	4,866	4,945	4,802	5,065	5,524	1.14
Saskatchewan	2,183	2,288	2,279	1,914	2,517	1.15
Manitoba	2,241	2,057	2,254	2,062	2,354	1.05
Ontario	20,862	20,502	21,818	22,984	25,124	1.20
Québec	13,123[b]	13,252	13,013	14,376	16,213	1.24
New Brunswick	2,074	1,975	2,039	2,008	2,102	1.01
Nova Scotia	2,631	2,585	2,695	2,824	2,900[b]	1.10
Newfoundland	1,458	1,440	1,524	1,396	1,449[b]	0.99
Prince Edward Island	269	259	313	273	263	0.99
Yukon	45[a]	44	49	44	59	1.31
North West Territories	47	33	70	66	102	2.17
Totals	**55,900**	**55,491**	**56,954**	**59,669**	**65,600**	**1.17**

(a) Adjusted to a constant population basis (1987–88)

(b) These numbers have been extrapolated from the data.

The survey sought information on the numbers of open and laparoscopic procedures performed, average length of stay (ALOS), post-hospital recovery time, complications, and the costs of hospital stay, fees, surgery and diagnostic procedures. Twenty-one responses were received (response rate 50%), although not every hospital was able to provide data for all questions. Eleven hospitals provided cost data.

Based on the responses for the number of procedures performed, the survey sample represented 9% of all cholecystectomies performed in Canada in 1991–92. The distribution of these hospitals according to the size categories used previously was 5 (24%) hospitals with fewer than 200 beds, 10 (48%) with 200–499 beds and 6 (29%) with more than 500 beds. Of the 21 hospitals responding, one did not offer laparoscopic cholecystectomy at the time of the survey, 18 performed laparoscopic cholecystectomy in 1991–92, and 10 performed laparoscopic cholecystectomy in 1990–91.

Since it was not possible to obtain direct data on the numbers of laparoscopic cholecystectomies in Canada, it was necessary to estimate these on the basis of data on total cholecystectomies provided by the Ministries of Health combined with the data from the hospital responses in Survey C on the proportion of laparoscopic cholecystectomies performed.

If it is assumed that the 21 responding hospitals represented a random sample of all hospitals in Canada, the ratio of laparoscopic to open cholecystectomies from the survey results can be simply adjusted to national levels using data on the total numbers of cholecystectomies performed. However, this assumption is weak, since most of the hospitals responding to the survey (20 of 21) were performing laparoscopic cholecystectomies. This introduces a bias, tending to overestimate the number of laparoscopic cholecystectomies being performed in Canada.

The method used to derive the estimates used in this report considered the data only from those hospitals performing laparoscopic cholecystectomy in each year. Values were adjusted to take account of the fact that they represented only a proportion of all hospitals in Canada. This adjustment was made using a diffusion factor (R) from the diffusion curve generated for all hospitals from the Hospital Diffusion Survey

(Survey A) outlined previously. For 1991–92 the diffusion factor was 0.6 and for 1990–91 it was 0.1. The results of this method suggest that 25,730 laparoscopic cholecystectomies were performed in Canada in 1991–92 (39% of all cholecystectomies) and 1,430 in 1990–91 (2% of all cholecystectomies). Details of the method are shown in Appendix 1.

For 1991–92, the weighted average length of stay (weighted by the number of procedures performed at each hospital) was 9.0 days and 2.8 days for open and laparoscopic procedures respectively. These values were taken to apply to all open and laparoscopic procedures undertaken during the period under study (1987–88 to 1991–92).

Cost data were limited, but hospitals that were able to provide cost data did so based on their own patient costing systems. The values seemed to be reasonably consistent with the Australian estimates (p. 12) and with the rather wide range of results reported in the literature (Appendix 4). Reported costs were $5,027 to $5,764 for the open procedure and $1,791 to $2,746 for the laparoscopic procedure. These included hospital hotel costs, surgical costs, associated diagnostic procedures, and pharmacy costs.

When professional fees (surgical fees only, excluding anesthetist and surgical assistant) of $393 are added, the costs are estimated at $5,420 to $6,157 and $2,184 to $3,139 for open and laparoscopic cholecystectomy respectively (Table 11, Appendix 1). Average weighted costs for open and laparoscopic procedures (based on number of procedures performed in 1991–92) are $5,712 and $3,025 respectively.

Credentialing considerations

A fourth survey (Survey D) was undertaken in April 1993 to determine the extent to which requirements of some kind—through policies, guidelines or credentialing—had been established in Canadian hospitals for introducing and performing laparoscopic cholecystectomy. A total of 117 hospitals were surveyed, 53 (45%) of which were teaching hospitals. These hospitals had been previously identified, on the basis of results from Survey A, as having introduced laparoscopic cholecystectomy.

Responses were received from 62 hospitals (53%), only 30 (48%) of which had some sort of policy regarding requirements for laparoscopic cholecystectomy. The rate of policy establishment was similar for both teaching and non-teaching hospital respondents: 17 (57%) of the teaching hospitals and 13 (41%) of the non-teaching hospitals had policies in place.

Hospitals were also asked about the level at which policies were approved. Fifty-three per cent of hospitals had this policy approved at the board level, 30% by the medical committee or medical staff, and 17% by the Department of Surgery.

With respect to credentialing of surgeons performing the procedure, only 18 hospitals (29% of those responding) indicated that they had credentialing requirements for surgeons who wished to perform laparoscopic cholecystectomy. Over half of the respondents indicated that it was necessary for a surgeon wishing to perform the procedure to be trained in general surgery, have been an assistant in laparoscopic cholecystectomy, have completed a structured course in laparoscopic cholecystectomy, and have observed laparoscopic cholecystectomy being performed.

Table 2: *Policy requirements for laparoscopic cholecystectomy in Canadian hospitals*

	Number surveyed	Number of responses	Number with policy
Teaching hospitals	53 (45%)	30 (57%)	17 (57%)
Non-teaching hospitals	64 (55%)	32 (50%)	13 (41%)
All hospitals	**117 (100%)**	**62 (53%)**	**30 (48%)**

Australian data on cholecystectomies

Methods used

A different approach was taken in obtaining Australian data on cholecystectomies. Rather than undertaking surveys of hospitals, estimates were derived from national and State databases. More detailed data were also available from four large teaching hospitals and some of the cost data were obtained from recent studies.

In Australia, surgery is undertaken both on a fee-for-service basis and within public hospitals funded directly by governments. Roughly equal numbers of cholecystectomies have been performed under each set of arrangements for some years. Patients undergoing procedures which attract fee-for-service are able to claim medical benefits through the Medicare insurance scheme, which is administered by the Health Insurance Commission (HIC). Numbers and proportions of open, laparoscopic, and converted laparoscopic methods were available from the HIC database.

Information on total numbers of cholecystectomies performed in Australia, and associated ALOS, are included in hospital morbidity data which are collected by each State health authority. Numbers of non–fee-for-service cases can then be obtained by subtracting the number of HIC-funded procedures from the hospital morbidity data figures.

Hospital morbidity data were available for New South Wales and South Australia for 1988–89 and 1991–92, corresponding to the periods immediately prior to introduction of laparoscopic cholecystectomy and after diffusion of the technique had occurred to a significant extent. National estimates for numbers of procedures were derived by multiplying the totals for these States by appropriate population ratios obtained from the Australian Bureau of Statistics and taking account of known interstate variation in rates of surgery.[17] Details are given in Appendix 2.

Data on cholecystectomies performed on a fee-for-service basis and which attracted Medicare benefits were obtained from the HIC for 1987–88 to 1991–92, with individual totals for laparoscopic, converted laparoscopic, and open procedures for 1990–91 and 1991–92.

It was assumed that the proportions of open, laparoscopic, and converted procedures shown by the HIC data were applicable to those procedures undertaken in public hospitals on non–fee-for-service patients. Data made available by four major teaching hospitals suggested that this was a reasonable assumption.

Numbers and costs of procedures

Estimated annual numbers of cholecystectomies performed in Australia between 1987–88 and 1991–92 are shown in Table 3. After being almost constant, or declining slightly, for a number of years, rates of cholecystectomy increased considerably following the introduction of laparoscopic cholecystectomy. It is notable that a high proportion of the laparoscopic procedures (14.3% in 1991–92) were converted to open operations.

The hospital morbidity data indicated that most of the growth in cholecystectomy rates had been in private hospitals. In New South Wales, comparison of hospital morbidity data for 1991–92 and 1988–89 showed a 100% increase in numbers of procedures in private hospitals and 2% in public hospitals. For South Australia, the numbers of procedures increased by 53% for private hospitals and 28% for public hospitals.

Estimates of ALOS for cholecystectomies prior to the introduction of the laparoscopic method were based on the available hospital morbidity data, adjusted to take account of population factors. Estimates of ALOS for the different types of procedure following the introduction of laparoscopic cholecystectomy and the time for patients to return to normal activity were based on data from recent Australian assessments as details were not available from the hospital morbidity data.

Costs of procedures performed on a fee-for-service basis were derived using Medicare Benefits Schedule fees and costs per average hospital bed day published by the Australian Institute of Health and Welfare.[18] Costs of procedures in non–fee-for-service cases were based on those obtained in a recent assessment.[3]

Available data indicated that open cholecystectomies undertaken after the introduction of laparoscopic cholecystectomy had a longer ALOS than those undertaken before the new method became available. It would appear that more complex cases continue to be performed by open surgery while simpler cases are now undertaken laparoscopically. Thus, open cholecystectomy costs more following the introduction of laparoscopic cholecystectomy.

Estimated costs for open cholecystectomy in 1991–92 were $4,722 and $4,877 (fee-for-service and non–fee-for-service). The corresponding costs per unconverted laparoscopic procedure were $2,447 and $2,800. Details are given in Appendix 2.

Table 3: *Estimated numbers[(a)] of cholecystectomies in Australia, 1987–88 to 1991–92*

Year	Open procedures	Laparoscopic procedures [(b)]	Converted laparoscopic procedures [(c)]	Total procedures
1987–88	27,248	–	–	**27,248**
1988–89	27,198	–	–	**27,198**
1989–90	25,422	–	–	**25,406**
1990–91	22,142	2,205	625	**24,972**
1991–92	8,970	21,295	3,555	**33,820**

(a) Adjusted to a constant population basis (1987–88)

(b) Procedures completed laparoscopically

(c) Procedures started laparoscopically and completed as open operations

Comparison of trends in each country

Trends in surgery rates

Trends in surgery rates for each country between 1987–88 and 1991–92 are shown in Table 4. The laparoscopic technique was introduced in Canada in the latter half of 1990 and in mid 1989 in Australia. In both countries, rates for all cholecystectomies increased markedly after the laparoscopic method became available, following a period where surgery rates had been steady or had declined slightly. For Canada there was an increase of 17% between 1987–88 and 1991–92, with 88% of this increase occurring over the last year of this period. In Australia the overall increase was 24% with all of the increase occurring over the last year of this period. The higher proportion of laparoscopic procedures in the Australian data for the given time periods may reflect the earlier introduction of the technique in that country.

Table 4 also includes the numbers of laparoscopic cholecystectomies derived from hospital survey data in Canada and from HIC data in Australia. In 1990–91, laparoscopic procedures accounted for about 2% of all cholecystectomies in Canada, but by 1991–92 they represented 39% of total procedures. In Australia, the proportion of cholecystectomies which were completed laparoscopically increased from 9% in 1990–91 to 63% in 1991–92. The proportions started laparoscopically were 11% and 73% for the two years respectively.

There was a striking difference between the two countries in the proportion of laparoscopic procedures which were converted to open operations. The Australian rate of 14.3% is substantially higher than published values while the Canadian rate of 4.2% (based on data from Survey C) is more typical of experience in other countries.

Impact on costs of health programs

Total hospital bed days associated with cholecystectomies are shown in Table 5. Details of calculations are given in Appendices 1 and 2. In both countries numbers of bed days decreased following introduction of the new method. In Canada, the decrease in total hospital bed days between 1987–88 and 1991–92 was 19% (18% between 1989–90 and 1991–92). Most of the decrease occurred after the introduction of the laparoscopic procedure. Similarly, in Australia there was a 14% decrease in total hospital bed days between 1987–88 and 1991–92, with most again occurring since the introduction of the laparoscopic procedure.

Estimated costs to health programs for each year are shown in Table 6. According to these data, costs to health programs decreased only marginally in both countries following the introduction of the laparoscopic method. It can be suggested that the reduction in bed day costs from the reduced length of stay associated with laparoscopic cholecystectomy was apparently offset by costs associated with an increase in the total number of procedures.

Impact on costs to patients

In societal terms, an important component of the impact of laparoscopic cholecystectomy is the effect on time lost by patients through hospitalisation and because of their delayed return to work or other normal activities after discharge.

Table 4: *Estimated numbers of cholecystectomies[a] performed in Canada and Australia, 1987–88 to 1991–92*

	Laparoscopic cholecystectomies[b]		Total cholecystectomies		Ratio of no. of procedures: no. in 1987–88	
Year	Canada	Australia	Canada	Australia	Canada	Australia
1987–88	–	–	55,900	27,248	1.00	1.00
1988–89	–	–	55,491	27,198	0.99	1.00
1989–90	–	–	56,954	25,406	1.02	0.93
1990–91	1,430	2,205	59,669	24,972	1.07	0.92
1991–92	25,730	21,295	65,600	33,820	1.17	1.24

(a) Adjusted to a constant population basis (1987–88)

(b) Procedures which were completed laparoscopically

Table 5: *Comparison of estimated hospital bed days associated with cholecystectomies in Canada and Australia, 1987–88 to 1991–92*

	Number of hospital bed days[a]		Ratio of no. of bed days:no. in 1987–88	
Year	Canada	Australia	Canada	Australia
1987–88	503,100	272,480	1.00	1.00
1988–89	493,426	271,980	0.98	1.00
1989–90	496,612	254,220	0.99	0.93
1990–91	507,557	260,360	1.04	0.96
1991–92	408,038	233,603	0.81	0.86

(a) Adjusted to a constant population basis (1987–88)

Table 6: *Estimated costs[a] of cholecystectomies to health programs in Canada and Australia, 1987–88 to 1991–92*

	Costs to programs ($m)		Ratio of costs to programs:costs in 1987–88	
Year	Canada (CDN$)	Australia (A$)	Canada	Australia
1987–88	319	120	1.00	1.00
1988–89	317	120	0.99	1.00
1989–90	325	112	1.02	0.93
1990–91	337	115	1.06	0.96
1991–92	306	116	0.96	0.96

(a) In 1991–92 prices for cholecystectomies adjusted to a constant population basis (1987–88)

In order to obtain a general indication of levels of cost to patients through surgery, data from an Australian study were applied to each country. Estimates of costs to patients—comprising those due to loss of employment, home duties, leisure activities, costs of care received outside the hospital and travel—were based on an analysis by Street which related to patients at a Melbourne hospital and data from the Australian biliary lithotripsy trial.[19,3] The estimates made by Street gave costs to patients of open cholecystectomy of A$3,235 to A$4,350 with a corresponding range of A$1,416 to A$1,831 for laparoscopic cholecystectomy. It was assumed that these levels of cost were broadly applicable to both the Australian and Canadian populations. For each

country, these estimates were adjusted to take account of data which were obtained from hospitals on ALOS, and time for patients to return to normal activity (Appendix 3).

Table 7 gives values for days lost to patients through surgery—calculated using information from the Canadian survey (Survey C) and Australian hospital data—and the associated costs, using the estimates based on the study by Street. Availability of the laparoscopic procedure in both countries was associated with significant savings to patients with reductions in days lost and the associated costs.

Estimates of proportions of potential savings achieved

A further consideration in assessing the impact of laparoscopic cholecystectomy is the extent to which potential savings have been achieved through the use of the technique. In each country, rates of cholecystectomy were relatively stable prior to the introduction of the laparoscopic technique. A simple approach to estimating the notional extent of savings is to compare the actual differences in costs before and after introduction of laparoscopic cholecystectomy with the differences that would have occurred had there been no increase in the number of procedures.

Table 8 compares estimated actual costs to health programs and patient days lost in 1991–92 with the corresponding values had there been no increase in the rate for all cholecystectomies from those in 1987–88. Details are given in Appendix 3. For this analysis, it was assumed that all of the procedures over and above those corresponding to the 1987–88 rate of surgery were undertaken laparoscopically.

Because of the overall increase in the rates of surgery following the introduction of laparoscopic cholecystectomy, neither country realised the potential savings that introduction of the new method might have achieved over the initial period of its use. Both Canada and Australia appear to have achieved only a small proportion of potential savings in health program costs. Both countries made gains through reducing patient days lost but the overall increases in numbers of procedures limited the benefit achieved. While this is a simplistic approach which does not take account of any appropriate widening of indications for surgery, it nevertheless gives some additional insight into trends following introduction of the new method.

Table 7: *Estimates of days lost to patients from cholecystectomy and associated costs[(a)] to them, Canada and Australia*

	Patient days lost (millions)		Costs to patients ($m)	
Year	Canada	Australia	Canada (CDN$)	Australia (A$)
1987–88	2.6	1.1	209–280	88–119
1989–90	2.7	1.0	213–285	82–111
1991–92	2.2	0.8	178–237	68–91
Ratio 1991–92 to 1989–90	0.83	0.80	0.85	0.83
Ratio 1991–92 to 1987–88	0.85	0.75	0.86	0.77

(a) In 1991–92 prices for cholecystectomies adjusted to a constant population basis (1987–88)

Table 8: *Estimates of proportion of potential savings achieved following introduction of laparoscopic cholecystectomy*

a) Health program costs:

	Canada (CDN$ millions)	Australian (A$ millions)
Costs in 1987–88	319	120
Potential costs in 1991–92	276	96
Actual costs in 1991–92	306	116
Proportion of savings achieved	30%	20%

b) Patient days lost:

	Canada	Australia
Patient days lost 1987–88 (millions)	2.6	1.1
Potential patient days lost 1991–92 (millions)	2.1	0.4
Actual patient days lost 1991–92 (millions)	2.2	0.8
Proportion of savings achieved	80%	70%

Discussion

The results presented here give an indication of the impact of laparoscopic cholecystectomy on rates of surgery and costs to health programs and patients during the initial diffusion of this technique in Canada and Australia. A number of assumptions have been made in order to derive estimates from national perspectives.

For both countries, data on numbers of laparoscopic procedures, ALOS, and hospital costs were incomplete. The numbers of respondents in the Canadian surveys were small. Many of the data were obtained by survey and have the inherent problems of bias and generalisability associated with such an approach. For Australia, it was assumed that the projections made from available databases and studies reflected the national values. There is a further difficulty in making comparisons between two countries which differ in their health care systems and in the types of statistics which are available: to overcome this, ratios have been used wherever possible to compare the results. The estimates of costs to patients can provide only a very approximate indication of levels of impact.

Nevertheless, this study has given a useful general perspective on some trends that emerged during the introduction of this minimal access surgery technique. Results of a sensitivity analysis (Appendix 3) suggest that variation in values for ALOS, costs, and the proportions of laparoscopic procedures undertaken make little difference to the overall trends reported in this paper.

Rate of diffusion

Laparoscopic cholecystectomy has diffused considerably faster than many other health care technologies. As in other countries, both the rate and extent of uptake have been striking, with rapid acceptance of this new approach to a common operation in general surgery. Based on the data from Survey A reported here, the time taken in Canada to reach 75% adoption for laparoscopic cholecystectomy ranged between 10 months for hospitals with over 500 beds, to 29 months for hospitals with 50–99 beds. By March 1993, 90% of larger hospitals and 64% of smaller hospitals either performed or planned to adopt laparoscopic cholecystectomy. The Australian data indicate a 74% uptake of the new procedure, with most hospitals using it within two years of its introduction. By late 1992 all major hospitals and the majority of minor centres had acquired the technique (Royal Australasian College of Surgeons, personal communication).

In comparison, the values extracted from published studies[20] are approximately 10.5 years, 8 years and 11 years to reach 75% adoption for the automated batch analyser, electronic fetal monitoring and ultrasound imaging respectively. A study of diffusion of technologies in a sample of 566 Australian hospitals showed a slow uptake for four therapeutic methods—percutaneous stone removal, coronary artery bypass grafting, percutaneous transluminal coronary angioplasty (PTCA), and intraocular lens transplant—in a small proportion of institutions.[21] For PTCA, 25 hospitals (4%) acquired the technology over a period of eight years. The comparative data for percutaneous stone removal are 151 hospitals (27%) over 22 years, with 90% of the uptake occurring over the last 10 years. With endoscopic retrograde cholangiopancreatography, 165 hospitals (29%) adopted the technique over 17 years. Hysteroscopic endometrial resection/ablation, another minimally invasive technique, has taken 12 years to be accepted by 41% of specialists, with most of the uptake occurring within the last two years.[22] Diffusion of laparoscopic cholecystectomy has been notably rapid in comparison with other minimally invasive therapy approaches and with health care technologies generally.

Rates of surgery and impact on costs

In both countries, the introduction and initial use of laparoscopic cholecystectomy was associated with an increase in the rate of cholecystectomies. The increases followed a period of several years when rates for cholecystectomies had been steady, or had declined slightly.

This increase in surgery rates offset the savings to health programs expected from laparoscopic cholecystectomy because of the reduction in ALOS using a minimal access surgical approach. Indicative estimates are that 30% of potential savings to health program costs were achieved in Canada, and only 20% in Australia.

These may be optimistic estimates of savings as no provision was made for use of disposable instruments which would have been used in laparoscopic cholecystectomy for a proportion of cases. Costs of disposable equipment in Australia are about A$600 per procedure,[4] and estimated costs in Canada, based on non-Canadian sources, are about CDN$700 per procedure. While the relative overall costs of disposable and reusable instruments do not seem to have been well defined, use of disposable equipment might be expected to increase the cost of laparoscopic surgery. A Belgian study has suggested that reusables are a cheaper alternative to disposable instruments.[23] However, Cuschieri considers that there are no hard data on this topic and that cost considerations will have to take into account newer developments which include semidisposable and limited reuseable instrumentation.[24]

Reduction in numbers of days lost to patients through surgery and the associated costs have been achieved in both countries but potential savings have not been fully realised, again because of the overall increase in the number of procedures.

The estimates in this paper of potential and actual savings achieved through introduction of laparoscopic cholecystectomy have been derived, making the assumptions that the incidence rates for gallstone disease have not undergone any recent change and that the rates of surgery prior to 1990–91 were appropriate for management of this condition. It is recognised that this may be a simplistic approach and that there is a need to consider in more detail the reasons for the recent increase in rates of cholecystectomies.

Nevertheless, it is noteworthy that similar trends have emerged for each country, even though the approaches taken to data collection and analysis have necessarily been somewhat different. Also, it is of interest that similar increases in surgery rates following the introduction of laparoscopic cholecystectomy have now been reported in the USA for persons enrolled in a health maintenance organisation in Pennsylvania, in Blue Cross/Blue Shield, and for the states of Connecticut and Maryland.[25–28]

Reasons for changes in rates of surgery

While further study is required, it seems possible that four factors may have contributed to the trend to higher rates of surgery.[14]

In a proportion of cases, the availability of the laparoscopic technique means that treatment may be offered to those who would not otherwise be candidates for surgery. Extending the availability of treatment to frailer patients is an important gain offered by minimally invasive therapies. However, a difficulty is that a proportion of laparoscopic procedures will be completed as open surgery, so that careful judgement in patient selection is needed.

As an extension to this situation, availability of laparoscopic cholecystectomy may tend to increase the probability of surgical intervention in symptomatic patients who are potential candidates for open surgery, and decrease the likelihood of conservative management. The new technique may be seen as providing a better opportunity to definitively resolve a clinical problem. Watchful waiting may become less popular. This essentially was the reason suggested by Legorreta et al. in discussing the increase

in cholecystectomy rates among members of a health maintenance organisation in Pennsylvania.[25]

A further possibility is that the technique is being offered in asymptomatic cases, for example when gallstones are detected opportunistically during an unrelated imaging examination. The rationale for cholecystectomy in such circumstances would appear to require very careful consideration, including appraisal of the relative risks to the patient of watchful waiting as against laparoscopic surgery.

Laparoscopic cholecystectomy is possibly being offered following inappropriate diagnosis. Spiro has considered the situation where symptoms remain after surgery has been undertaken, when part of the rationale for surgery was that the new procedure was much less invasive.[29] The possibility of this category of surgical intervention points to the need for adequate training and appropriate guidelines for physicians and surgeons in this field.

These possibilities will tend to be driven by the public's awareness of the availability of less invasive surgery and a wish by health professionals to extend use of the technology to new applications. The utility of these additional surgical procedures remains unclear and further clinical and economic studies would be desirable.

Conversion of laparoscopic procedures

In Australia, a high proportion of laparoscopic cholecystectomies were converted to open operations during the initial period of use of the technique, with an associated increase in hospital stay (and in time taken to return to normal activity). Debate continues as to what might be an appropriate proportion of conversions to open surgery, and a very low rate could be associated with unacceptable risks to patients. The Australian conversion rates were high in comparison with results from other countries, for reasons that are not clear. The difference between the Australian and Canadian data on the proportion of conversions points to the need for definition of appropriate standards for laparoscopic procedures, including case selection and training.

Complications

The true cost of surgery includes a component due to complications. There is considerable interest in defining the rates of major complications for laparoscopic surgery in comparison with those for open procedures, particularly with reference to the size of the centre performing surgery and levels of training. Data on complication rates remain sparse and there are no standard definitions on what is considered to be a complication, or how to document complications. Reliable data were not available for either country. Problems through complications associated with laparoscopic cholecystectomy, such as bile duct injury, were not revealed through the data available for this study.

Concerns remain regarding the standards of performance of laparoscopic cholecystectomy in smaller centres and there have been anecdotal accounts of serious complications. Routine intraoperative cholangiography has declined in Australia by 66% since the introduction of laparoscopic cholecystectomy.[30] It has been suggested that routine laparoscopic exploration of the bile duct should be adopted as standard practice to permit treatment of common duct calculi at the time of laparoscopic surgery.[30]

The increase in rates of surgery may also have a significant effect on numbers of complications. In Maryland, although the adoption of laparoscopic cholecystectomy has been associated with a 33% decrease in overall operative mortality per procedure, the total number of cholecystectomy-related deaths has not fallen because of the 28% increase in the total rate of cholecystectomy.[28]

Concern regarding standards of performance is supported by the results of the survey of Canadian hospitals' requirements for introducing laparoscopic cholecystectomy (Survey D, p.8). Fewer than 50% of responding hospitals had established a policy for the introduction of laparoscopic cholecystectomy and only 29% had established credentialing requirements for surgeons wishing to perform the procedure. All the hospitals surveyed had already introduced laparoscopic cholecystectomy.

Further developments

The data reported here refer to the early stages of use of a new minimal access surgical technique. Given the popularity of the method and the benefits it offers through shorter hospital stay and earlier return of patients to their normal activities, further diffusion can be expected. It can also be expected that ALOS for laparoscopic cholecystectomy will decrease as further experience is gained with the technique and hospitals undertake restructuring. The proportion of laparoscopic procedures converted to open operations could also be expected to fall. Such trends should be associated with a consequent decrease in costs to health programs beyond the estimates presented in this paper, which reflect early national experience with the technique. For full benefits of any such trends to be realised, it will clearly be necessary for appropriate post-discharge support systems for patients to be in place and for there to be back up for those procedures which are converted to open surgery.

Recent Australian data suggest that such changes to patterns of use are occurring. By the second half of 1993 the conversion rate for laparoscopic to open operations had decreased appreciably, with HIC data for 1992–93 showing a national average of 8.6%.[31] The limited data available from teaching hospitals indicates that ALOS for laparoscopic cholecystectomies is decreasing, with some patients now being treated on a day case basis. The HIC data also suggest that the increase in cholecystectomy rates may be starting to plateau, though they remain considerably higher than the rates prior to the introduction of laparoscopic cholecystectomy. Steiner et al. have reported a similar plateauing of surgery rates in Maryland.[28] Further changes to the ALOS for laparoscopic surgery and any trend to performance outside the acute hospital setting will increase the need for more accurate information on complications.

The experience of Canada and Australia suggests that the introduction of laparoscopic cholecystectomy has produced benefits through reduction in costs to health programs and in days lost by patients because of surgery. However, these benefits have been less than optimum during the first two years that the technique was in use. The increase in the rates of cholecystectomies observed suggests the need for mechanisms to establish appropriate indications and clear guidelines for other minimal access surgical techniques. Use of less invasive therapeutic technologies can provide major gains to patients and to health services. The need remains for them to be used appropriately and competently.

Appendix 1: Derivation of estimates for numbers and costs of cholecystectomies undertaken in Canada

A. Numbers of procedures and proportions of laparoscopic cholecystectomies

The annual totals of cholecystectomies in Canada over the period studied, N_T, were obtained from Health Ministries (Survey B) and are shown in Table 1 (page 7).

The rate of uptake of laparoscopic cholecystectomy in hospitals throughout Canada was calculated from Survey A. From the data obtained, a diffusion factor (R) was calculated, corresponding to the proportion of hospitals which were using the laparoscopic procedure in October for each year.

The proportions of all cholecystectomies which were undertaken laparoscopically (P_S) were available from Survey C for hospitals performing laparoscopic cholecystectomy in each year.

Numbers of laparoscopic procedures undertaken nationally (N_L) were then derived using the formula:

$$N_L = P_S \times N_T \times R$$

For 1990–91, N_L = 1,430 and for 1991–92, N_L = 25,730, corresponding to 2.4% and 39.0% of all cholecystectomies undertaken (Table 9). Using the rate of conversion obtained in Survey C (4.6%), an estimated 1,241 laparoscopic cholecystectomies were converted to open operations in 1991–92.

B. Hospital bed days associated with cholecystectomies

Total hospital bed days

= (Number of open cholecystectomy procedures
x ALOS open cholecystectomies)
+ (number of laparoscopic cholecystectomy procedures
x ALOS laparoscopic cholecystectomies)

Results are summarised in Table 10.

For the purpose of this calculation, all conversions from laparoscopic procedures to open procedures are considered as open procedures, with a similar ALOS. Estimates for ALOS were based on responses from Survey C. The open cholecystectomy weighted ALOS was 9.0 days and the laparoscopic cholecystectomy weighted ALOS was 2.8 days.

Table 9: *Number of cholecystectomy procedures*

Period	No. of open procedures	No. of laparoscopic procedures
1987–88	55,900	–
1988–89	55,491	–
1989–90	56,954	–
1990–91	58,239	1,430
1991–92	37,870	25,730

Table 10: *Calculation of hospital bed days (constant 1987–88 population)*

Period	Total hospital bed days	Population correction factor(1)	Total corrected hospital bed days
1987–88	503,100	1.000	**503,100**
1988–89	499,419	0.988	**493,426**
1989–90	509,346	0.975	**496,612**
1990–91	528,155	0.961	**507,557**
1991–92	430,874	0.947	**408,038**

(1) Population statistics from Dumas, J Lavoie Y. Report on the demographic situation in Canada 1992: Current demographic analysis. Ottawa: Statistics Canada, 1992.

C. Calculations of cost to the health care system

Data on professional fees for cholecystectomies obtained from provincial and territory authorities in Survey B are shown in Table 11.

Total cost = (number of open procedures x cost per open procedure)
+ (number of laparoscopic procedures
x cost per laparoscopic procedure)

where the cost of open procedures includes both procedures started and completed as open procedures, and procedures started as laparoscopic, but completed as open procedures.

Table 11: *Professional fees (surgeon only) for cholecystectomy: data from survey of provincial/territorial Ministries of Health, 1991–92*[a]

Province	Fee for cholecystectomy ($)	Number of procedures (1991–92)	
British Columbia	415	6,993	(11%)
Alberta	445	5,524	(8%)
Saskatchewan	392[b]	2,517	(4%)
Manitoba	422	2,354	(4%)
Ontario	415	25,124	(38%)
Québec	340	16,213	(25%)
New Brunswick	329	2,102	(3%)
Nova Scotia	417	2,900	(4%)
Newfoundland	284	1,449	(2%)
Prince Edward Island	486	263	(0.4%)
Yukon	686[c]	59	(0.1%)
North West Territories	766	102	(0.2%)
Average	**450**	**Weighted average = 493**	

(a) Where fees were provided for cholecystectomy with and without a cholangiogram, the fee for cholecystectomy without a cholangiogram was used.

(b) Average of the fees for cholecystectomy when performed by a specialist ($435) and by a general practitioner ($348).

(c) Includes anesthetist and surgical assistant fees.

Table 12: *Estimates for costs ($m) of procedures*

Year	Open procedure[a]	Laparoscopic procedure[b]	All procedures
1987–88	319	–	319
1988–89	317	–	317
1989–90	325	–	325
1990–91	336	1	337
1991–92	259	47	306

(a) Cost per procedure $5,712

(b) Cost per procedure $3,025

Appendix 2: Derivation of estimates of numbers and costs of cholecystectomies in Australia

A. Numbers of procedures and proportion of laparoscopic cholecystectomies

Hospital morbidity data provided the total number of cholecystectomies (N_S) performed in New South Wales and South Australia in 1988–89 and 1991–92 and in Tasmania in 1991–92. National estimates (N_a) were obtained by adjusting the data for these States by appropriate population ratios obtained from the Australian Bureau of Statistics and by known rates of variation in surgery between States.[17] In the case of Tasmania, no State rate of variation was available. The formula used to estimate total cholecystectomies performed in Australia was:

$$N_a = P_a / \sum_s P_S \times \sum_s (N_S \times 100 / R_S)$$

where

- s refers to each State;
- P_a is the population of Australia for the year in question;
- P_S is the population of the States,
- R_S is the variation in rates of surgery between States.

Numbers of open, laparoscopic and converted laparoscopic procedures undertaken on a fee-for-service basis were obtained from the HIC database. The number of non–fee-for-service cases for 1988–89 and 1991–92 could then be obtained directly by subtracting the numbers of fee for service cases from the national estimates for total cholecystectomies obtained from the hospital morbidity data.

For 1987–88, the ratio of fee-for-service to non–fee-for-service cases was assumed to be the same as for 1988–89 for the purpose of estimating total numbers of cases. This ratio increased between 1988–89 and 1991–92; the increase was assumed to be constant over this period, allowing estimation of the value of the ratio and national caseloads for 1989–90 and 1991–92. Estimated caseloads for the period 1987–88 to 1991–92 are shown in Table 12. The proportions of open to laparoscopic to converted laparoscopic procedures was assumed to be the same for both fee-for-service and non–fee-for-service cases both in 1990–91 and 1991–92.

Table 13: *Estimated numbers of cholecystectomies in Australia by type of service and year*

Year	Fee-for-service procedures	Non–fee-for-service procedures	Total procedures
1987–88	12,373	14,875	**27,248**
1988–89	12,350	14,848	**27,198**
1989–90	12,159	13,247	**25,406**
1990–91	12,564	12,408	**24,972**
1991–92	17,765	16,055	**33,820**

B. Hospital bed days associated with cholecystectomies

An estimate for ALOS of 10 days for cholecystectomies, prior to introduction of the laparoscopic method, was obtained using the hospital morbidity data for New South Wales and Victoria, in cases where cholecystectomy was the principal procedure. Estimates of ALOS after the introduction of laparoscopic cholecystectomy were based on values reported in a recent Australian assessment.[3] The ALOS for laparoscopic cholecystectomy was taken to be 4.5 days, corresponding to the situation where a hospital had gained experience with the technique (following the period after introduction).

This study also indicated that ALOS for the open procedure increased after laparoscopic cholecystectomy was introduced, reflecting use of open surgery for more difficult cases. An ALOS of 11 days was used in the estimates for open cholecystectomy for 1990–91 and 1991–92. The ALOS for cases where a laparoscopic procedure was converted to open surgery was assumed to be the same as for open surgery prior to 1990–91 (10 days).

Total hospital bed days

= (numbers of open cholecystectomies x ALOS open cholecystectomy)
+ (number of laparoscopic cholecystectomies x ALOS laparoscopic cholecystectomy)
+ (number of converted procedures x ALOS converted procedures)

C. Calculation of costs to the health care system

Procedure costs for fee-for-service cases were estimated as shown in Table 13. For non–fee-for-service cases, procedure costs were based on those reported in a recent Australian assessment.[3] The cost was taken to be $4,500 for an open cholecystectomy prior to introduction of laparoscopic cholecystectomy and $2,800 for laparoscopic procedures. Converted laparoscopic procedures were assumed to be the same cost as open cholecystectomy prior to the introduction of laparoscopic cholecystectomy. Since the ALOS used for open cholecystectomies after 1989–90 was one day longer, $377 (the cost of one bed day) was added to the earlier open cholecystectomy cost to give a cost of $4,877 for open cholecystectomy after 1989–90 (Table 14).

Costs to the health care system were obtained by multiplying the number of each type of procedure by its associated unit cost, and summing the results.

Table 14: *Estimates of costs ($) to service providers of fee-for-service cholecystectomies*

Item	Open procedure		Laparoscopic procedures	Converted laparoscopic procedures
	Pre-laparoscopy	Post-laparoscopy		
Specialists' fees (a)	575	575	671	683
Hospital costs (b)	3,732	4,147	1,697	4,147
Equipment costs (c)	0	0	79	79
Total	**4,307**	**4,722**	**2,447**	**4,909**

(a) Estimated as 75% of fees from the Medicare Benefits Schedule for one surgeon, one assistant and one anesthetist.

(b) Hospital costs were calculated from the cost per bed day and the average length of stay. A cost per bed day of $377 was used, derived from average bed day costs for public hospitals from the Hospital Utilisation and Costs Study and brought to 1991–92 prices using health expenditure deflators. This cost excludes fees for visiting medical officers but includes salaries and wages for other medical staff as well as for non-medical staff. It also includes non-salary recurrent expenditure such as surgical and drug supplies. This makes the assumption that surgical and drug supplies used in each procedure is constant (which may not be the case). Larger capital items are excluded.

(c) Equipment was assumed to dedicated and was annuitised with a 5% discount rate on a five year basis with a patient throughput of 200 per year. Average costs for each type of equipment were used. Possible use of disposable instruments was not considered.

Table 15: *Estimates of costs to service providers of non–fee-for-service procedures*

Procedure	Cost ($)
Open procedure prior to laparoscopic cholecystectomy	4,500
Open procedure after laparoscopic cholecystectomy	4,877
Laparoscopic procedure	2,800

Appendix 3: Estimates of costs to patients and proportions of potential savings achieved

A. Days lost to normal activities

The days lost to normal activities by Australian open cholecystectomy patients was found to be 39.0 days by Street, when all cases were considered ("untrimmed" results).[17] Street also reports a recovery period of 15.3 days following laparoscopic cholecystectomy, which includes 5.6 days in hospital. However, an average hospital stay of 4.5 days has been used in this analysis, based on the St Vincent's Hospital, Melbourne assessment.[3] Since the average hospital stay used was 1.1 days shorter, the recovery period used for laparoscopic cholecystectomy in Australia has been shortened similarly to 14.2 days (see Table 16).

Canadian recovery periods were based on responses from the hospital survey (Survey C, n = 9). Average recovery times were obtained using only those responses that provided data for numbers and recovery days for both open and laparoscopic procedures. Overall recovery time was 47.0 and 13.0 days respectively for open and laparoscopic cholecystectomy.

B. Costs to patients

Street has estimated costs to Australian patients of open and laparoscopic cholecystectomy, which include the costs of loss of employment, home duties and leisure activities, of travel to and from hospital, and of care received outside the hospital.[19] In the case of laparoscopic cholecystectomy, Street's cost was adjusted for the one day shorter hospital stay, as follows:

$$C_D = T + \left[(C_S - T) \times \frac{R_D}{R_S} \right]$$

where

- C_D is the derived cost to the patient used for this analysis;
- C_S is Street's total cost to the patient;
- R_D is the recovery period derived for this analysis;
- R_S is Street's recovery period;
- T is the cost of travel to and from the hospital.

The cost to patients of a converted laparoscopic procedure was assumed to be the same as an open procedure. The costs of open and laparoscopic cholecystectomy to Canadian patients were not specifically available. Instead, these costs were derived from the Australian costs, adjusting for differences in recovery periods as above.

The derived costs to patients are summarised in Table 16. Costs to patients of converted laparoscopic cholecystectomies were assumed to be the same as for open cholecystectomies. National annual costs were estimated by multiplying the caseload for each type of procedure by the appropriate cost. No account was taken of the currency conversion rate.

Table 16: *Costs incurred by patients due to surgery*[a]

	Total time lost		Cost per patient	
	Open	Laparoscopic	Open	Laparoscopic
Street	39.0	15.3	A$3,235–4,350	A$1,416–1,831
Canada	47.0	13.0	CDN$3,736–5,012	CDN$1,159–1,446
Australia	39.0	14.2	A$3,325–4,350	A$1,316–1,706

(a) Includes loss of employment, home duties, leisure activities, travel to and from hospital, and costs of care received outside the hospital.[19]

C. Potential savings achieved for health program costs and patient days lost

Potential savings to health care programs due to replacement of open with laparoscopic cholecystectomy were estimated to determine what proportion of these savings were actually achieved in 1991–92. Assuming that all additional cholecystectomies over and above those performed in 1987–88 were performed laparoscopically, then the costs of patient days lost and health program costs are calculated for a scenario where there was no increase in overall cholecystectomy procedures. This assumes that rates of surgery prior to the introduction of laparoscopic cholecystectomy were appropriate and that there had been no recent increase in the incidence of gall bladder disease.

If all the increased caseload is performed laparoscopically, then the expected number of cholecystectomies started laparoscopically in 1991–92 (EL_{92}) is given by:

$$EL_{92} = L_{92} - (N_{92} - N_{88})$$

where

L_{92} is the number of cholecystectomies started laparoscopically actually performed in 1991–92;

N_{92} is the total number of cholecystectomies actually performed in 1991–92;

N_{88} is the total number of cholecystectomies performed in 1987–88.

Results are summarised in Table 17.

The expected number of laparoscopic cholecystectomies converted to open procedures was estimated by assuming the same proportions to cholecystectomies started laparoscopically as actually occurred. Similarly, the expected number of laparoscopic procedures performed in public and private hospitals was estimated by assuming the same proportions in each type of hospital as actually occurred. The potential cost of cholecystectomy in 1991–92 can then be calculated by multiplying the caseload of each type of procedure by the appropriate procedure cost (see Appendix 2).

The potential and actual savings made are then given by:

potential savings = cost of cholecystectomy in 1987–88
– potential cost of cholecystectomy in 1991–92

actual savings = cost of cholecystectomy in 1987–88
– actual cost of cholecystectomy in 1991–92

The proportion of savings achieved is then:

$$\frac{\text{actual savings}}{\text{potential savings}}$$

In a similar fashion, the potential savings to patients in terms of days lost from normal activities can be calculated.

Table 17: *Expected cholecystectomy caseload in 1991–92*

Expected caseload	Canada	Australia
Open cholecystectomy	42,480	8,970
Laparoscopic cholecystectomy[(a)]	13,420	18,278

(a) Includes laparoscopic cholecystectomies converted to open procedures

D. Sensitivity analysis

1. Vary number of procedures

Vary by ± 10% the number of laparoscopic cholecystectomies as a proportion of the total number of procedures performed.

	Canada			Australia		
	+10%	0	–10%	+10%	0	–10%
Number of cholecystectomies, 1991–92:						
open	32,800	39,870	45,920	5,588	8,970	12,352
laparoscopic[(a)]	32,800	25,730	19,680	28,232	24,850	21,468
Total costs to health care services ($m)	287	306	379	109	116	122
Ratio 1991–92 to 1987–88	0.90	0.96	1.01	0.91	0.96	1.01
Proportion of potential savings	52%	30%	0%	37%	20%	0%

(a) Includes converted procedures

2. Vary ALOS by ± 1 day for both open and laparoscopic procedures

	Canada			Australia		
	+1 day	0	–1 day	+1 day	0	–1 day
Bed days:						
1987–88	559,000	503,100	447,200	288,728	272,480	245,232
1991–92	470,161	408,038	345,915	267,423	233,603	199,783
Ratio 1991–92 to 1987–88	0.84	0.81	0.77	0.89	0.86	0.81
Days lost to normal patient activity:						
1987–88	2.7M	2.6M	2.6M	1.1M	1.1M	1.0M
1991–92	2.3M	2.2M	2.1M	0.8M	0.8M	0.8M
Ratio 1991–92 to 1987–88	0.85	0.85	0.81	0.73	0.75	0.80
Proportion of potential savings	67%	80%	100%	73%	70%	62%

3. Vary cost of all procedures by ± 20%

	Canada			Australia		
	+20%	0	−20%	+20%	0	−20%
Total costs to health care services ($m):						
1987–88	383	319	255	144	120	96
1991–92	367	306	245	139	116	92
Ratio 1991–92 to 1987–88	0.96	0.96	0.96	0.96	0.96	0.96
Proportion of potential savings	31%	30%	31%	20%	20%	20%

Appendix 4: Values for costs of laparoscopic cholecystectomies cited in the literature

Study	Currency	Cost of laparoscopic procedure	Cost of open procedure	Comments
Reddick & Olsen, 1990 [32]	US$	1,817		
Hirsch, 1990 [4]	A$	3,649	5,581	Estimate from limited health insurance data
Peters et al,1991 [33]	US$	3,620		
Anderson & Hunter, 1991 [34]	US$	4,070		
Gilchrist et al, 1991 [35]	US$	5,528		
Jordan, 1991 [36]	US$	6,013	7,523	
Marshall,1991 [1]	CDN$	2,605	3,437	Estimate
McIntyre et al, 1992 [37]	US$	6,471		
Llorente, 1992 [38]	US$	7,500		
Kilshaw & Robinson, 1992 [39]	CDN$	1,060	2,188	
St Vincent's Hospital, 1993 [3]	A$	2,800	4,500	
Bass et al, 1993 [9]	US$	5,354	5,525	Women
		6,036	6,830	Men
Kelley et al,1993 [40]	US$	5,390	5,392	
Voyles, 1993 [41]	US$	1,817		
Kesteloot, 1993 [23]	BF	51,906	57,667	No overhead
		67,384	80,521	With overhead
McMahon, 1994 [42]	£	1,486	1,080	Mini laparotomy for open procedure
Hardy et al, 1994 [12]	A$	2,868	3,706	Pre-operative stay excluded

Approximate currency values in US dollars: A$=0.7; BF=0.033; CDN$=0.85; £=2.37

Note: There are considerable differences between these studies with regard to definition of cost factors, types of institution and methods of analysis. Comparison of these results should be made with caution.

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