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Original Research Article

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Measuring the impact of delayed access to elective cholecystectomy through patient's cost-utility: an observational cohort study

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Abstract

Background: Deferral of surgeries due to COVID-19 has negatively affected access to elective surgery and may have deleterious consequences for patient's health. Delays in access to elective surgery are not uniform in their impact on patients with different attributes. The objective of this study is to measure the change in patient's cost utility due to delayed elective cholecystectomy.
Methods: This study is based on retrospective analysis of a longitudinal sample of participants who have had elective cholecystectomy and completed the EQ-5D(3L) measuring health status preoperatively and postoperatively. Emergent cases were excluded. Patients younger than 19 years of age, unable to communicate in English or residing in a long-term care facility were ineligible. Quality-adjusted life years attributable to cholecystectomy were calculated by comparing health state utility values between the pre- and postoperative time points. The loss in quality-adjusted life years due to delayed access was calculated under four assumed scenarios regarding the length of the delay. The mean cost per quality-adjusted life years are shown for the overall sample and by sex and age categories.
Results: Among the 646 eligible patients, 30.1% of participants (N = 195) completed their preoperative and postoperative EQ-5D(3L). A delay of 12 months resulted in a mean loss of 6.4%, or 0.117, of the quality-adjusted life years expected without the delay. Among patients older than 70 years of age, a 12-month delay in their surgery corresponded with a 25.1% increase in the cost per quality-adjusted life years, from $10 758 to $13 463.
Conclusions: There is a need to focus on minimizing loss of quality of life for patients affected by delayed surgeries. Faced with equal delayed access to elective surgery, triage may need to prioritize older patients to maximize their health over their remaining life years.

Key words: cholecystectomy, COVID-19, delayed surgery, EQ-5D(3L), quality adjusted life year

Introduction

Delaying access to elective surgery has long been a contentious health policy issue [1–3]. COVID-19 has exacerbated the deferral of hospitals' elective surgeries for a myriad of reasons, including avoiding viral transmission, conserving personal protective equipment, fear among patients, redirection of health care workers and preserving operating room space for urgent and emergency cases [4–7]. Deferring elective surgeries creates or lengthens a queue of patients awaiting surgery. While delayed access to surgery may have deleterious consequences on patient's health, a number of countries, including Canada, restrict supply of publicly funded surgery and routinely have 'waits' [3, 8].

Elective cholecystectomy is one such surgery where waits are common in a number of Organisation for Economic Co-operation and Development (OECD) countries and whose waits are now longer with COVID-19-related delays [9, 10]. The American College of Surgeons published pandemic-related guidelines recommending that patients with symptomatic gallstones have their pain managed and delay cholecystectomy [11]. In March 2020, the Canadian Association of Gastroenterology recommended that facilities restrict gastrointestinal procedures to only those that are life-threatening, based on the availability of resources and to prevent transmission of COVID-19 [12]. The Canadian Association of General Surgeons' website links to recommendations by the Society of American Gastrointestinal and Endoscopic Surgeons, indicating that elective surgeries should be curtailed except among patients with life-threatening needs [13].

Irrespective of the cause of the delay, outside of degenerative conditions or cancer-related diagnoses, there is a dearth of research examining the impact of delayed surgery from a quality of life perspective. This study presents the perspective of the impact of delayed surgeries, COVID-19-related or otherwise, on health and health status on a cohort of patients from a societal perspective. A common approach to measuring the societal consequences of an intervention, drugs or medical devices is the concept of cost utility [14]. Cost utility is calculated as the quotient of the cost and quality-adjusted life years (QALYs), a value representing the health benefit attributable to the intervention vis-à-vis the intervention's cost [14, 15]. The cost utility of elective cholecystectomy in Canada has been recently published and reported to generate a very good return on health relative to the surgery's cost, observing that the average cost per QALY was $3663 (2018 Canadian dollars), a value far below thresholds reported for adoption of new drugs or health technologies.

The impact of delayed access to elective cholecystectomy upends cost utility statistics since the gain in patient's health is delayed—and the expected health benefits accruing to patients is lower than without the delays. The impact of the delay of health status may not be uniform across all patients, with loss of health benefits concentrated among some subgroups. For perspective and motivation for this study, it has recently been reported that two provincial governments in Canada will take up to 18 months to clear the tens of thousands of surgical cases postponed due to COVID-19 [16, 17]—noting that a patient's place on the queue is deterministic and there is no population-based strategy for triaging some patients over others to minimize losses in health benefit.

The objective of this study is to measure the cost utility of elective cholecystectomy due to delayed surgery. The findings are important to government who funds elective surgery in hospitals, hospital administrator who administer surgical queues and access, and to patients facing delays in accessing surgery. The findings will also provide a basis for informing decision-making for healthcare systems and access to elective surgery in a post-COVID environment.

Methods

Study protocol

This study is based on retrospective analysis of a longitudinal sample of participants who have had elective cholecystectomy and completed patient-reported outcomes (PROs) measuring health status pre- and postoperatively. The setting of the study is Vancouver, Canada, where provincial government anticipates 17–24 months to 'catch up' on surgeries that were cancelled and delayed due to COVID-19 [16].

Preoperatively, patients consenting to surgery were contacted prospectively between 2013 and 2018. All consecutive patients of 14 general surgeons practicing in three hospitals and scheduled for elective cholecystectomy were contacted to participate. Patients newly scheduled to undergo elective cholecystectomy were contacted by phone. Emergent cases were excluded from this study since there were no opportunities to contact patients and record PROs among emergency surgery patients. Patients who were younger than 19 years of age, unable to communicate in English or resided in a long-term care facility were excluded from the study.

Participants completed PROs preoperatively and six months following their cholecystectomy. Participants who did not return their PROs were contacted by phone and mail to minimize loss to follow-up.

PRO data were linked to the participant's hospital discharge summary from their cholecystectomy to ascertain their age, sex and comorbidities. These data were also linked with population-based hospital discharge data and emergency department data to identify all hospital admissions or visits to the emergency department during the perioperative period. An anonymized dataset was made available to this research team for this study's analyses. This study was approved by the Behavioural Research Ethics Board of the University of British Columbia.

Measures

Participants' health status was measured pre- and postoperatively using EuroQoL's EQ-5D(3L) instrument [18]. The instrument measures health in five domains: mobility, self-care, usual activities, pain/discomfort and anxiety/depression and can describe 245 different health states. Health states, based on patterns of responses to the EQ-5D(3L), are linked with preference-weighted utility values available for the Canadian population [19]. A utility value of 1 represents perfect health while values less than 0 are considered worse than death [19, 20].

Calculating cost

We assume a societal perspective in measuring costs, representing Canada's publicly funded hospital and physician care. Hospital costs are derived from data reported by the Canadian Institute for Health Information and separate from this study. Fee-for-service billings are used to determine surgeon and anesthesiologist cost that, together, include the preoperative consultation, the surgery and hospital-based postoperative follow-up. Complications across the perioperative period can occur; delays may increase the risk of complications and emergency admissions in patients with gallstones. Should they occur, these events are included in participant's cost, noting that unrelated costs would bias patient's costs upwards.

Calculating QALY

The methods for calculating QALYs in this study are adapted from other studies reporting the cost-utility of elective surgeries in England and Canada [15, 21–23]. Participants' preoperative are annually discounted a rate of 3.5% per year, as recommended by the United Kingdom's National Institute for Clinical Excellence [24].

The impact of the delayed access on the cost-utility of elective cholecystectomy is based on four assumptions regarding the length of the delay. This study assumes four plausible scenarios given the government's announcements regarding the surgical queue: delays of 3, 6, 9 and 12 months, a range of values which are very plausible given the government's public announcements regarding delayed and deferred elective surgeries [16, 17].

As shown in Figure 1, participant's loss of QALY attributable to the delay is calculated from the participant's preoperative utility value. Participant's gain in QALY attributable to the surgery is calculated from the participant's postoperative utility value. Then, the participant's overall QALY is difference between the gain in health due to the surgery and the loss in health attributable to the delay.

For example, if a patients' postoperative utility value is 0.9 and their preoperative utility value is 0.8, the 1-year gain in QALYs attributable to cholecystectomy is the difference of these two values, or 0.1. For each patient, this gain is calculated over the duration of the expected gain in health, discounting the preoperative and postoperative preference weights by 3.5% per year. The loss of QALYs due to delayed surgery is similarly calculated as the difference between the postoperative and preoperative preference utility values for the length of the delay.

The analyses calculate participant's QALYs due to the surgery under two different scenarios: (i) assuming that health benefits of the cholecystectomy accrue to patients for 25 years, or (ii) assuming that the health benefit accrue to the average life expectancy of Canadians (i.e. 82 years of age).

Frequencies and percentages are reported to summarize participants' demographic characteristics. EQ-5D(3L) utility values are summarized using means, standard deviations, and ranges both preoperatively and at six months postoperatively. To compare participants' pre- and postoperative utility values, a paired *t*-test is used.

The mean QALY and standard deviation are shown for the overall sample of participants and among demographic subgroups for the four delay scenarios. Confidence intervals are calculated for the mean QALY using nonparametric bootstrap sampling methods, resampling with replacement from the original data [25]. The mean cost (2018 Canadian dollars) and mean cost per QALY are shown for the overall sample and by sex and age categories for each of the four delay lengths. Confidence intervals are calculated using nonparametric bootstrap sampling methods.

Results

Among the 646 eligible patients, 336 agreed to participate (52%). Of the 336 participants, 195 also completed their postoperative PROs (58%,) providing pre- and postoperative data from 30.1% of all eligible patients. Over 70% of participants were female, and 84% were less than 70 years of age (Table 1). Participants were, on average, 3 years older than non-participants ($P < 0.01$; results not shown) based on observable characteristics, no differences in sex or comorbidities between participants and non-participants were identified.

Among the sample of 195 participants, there were no emergency department visits between the date the surgery was scheduled and the date the surgery occurred. However, six participants (3.0%) were hospitalized between the date the surgery was scheduled and the date the surgery occurred; the hospitalization's cost was included in the analyses.

Among participants, the preoperative mean utility value was 0.8410 with standard deviation 0.1310. The postoperative mean utility value was 0.9125 with standard deviation of 0.1342. The difference represents a statistically significant 0.07 gain in utility value ($P < 0.001$) and also exceeds the minimally important difference for EQ-5D instrument reported in other studies, suggesting meaningful improvement from patients' perspective [26, 27].

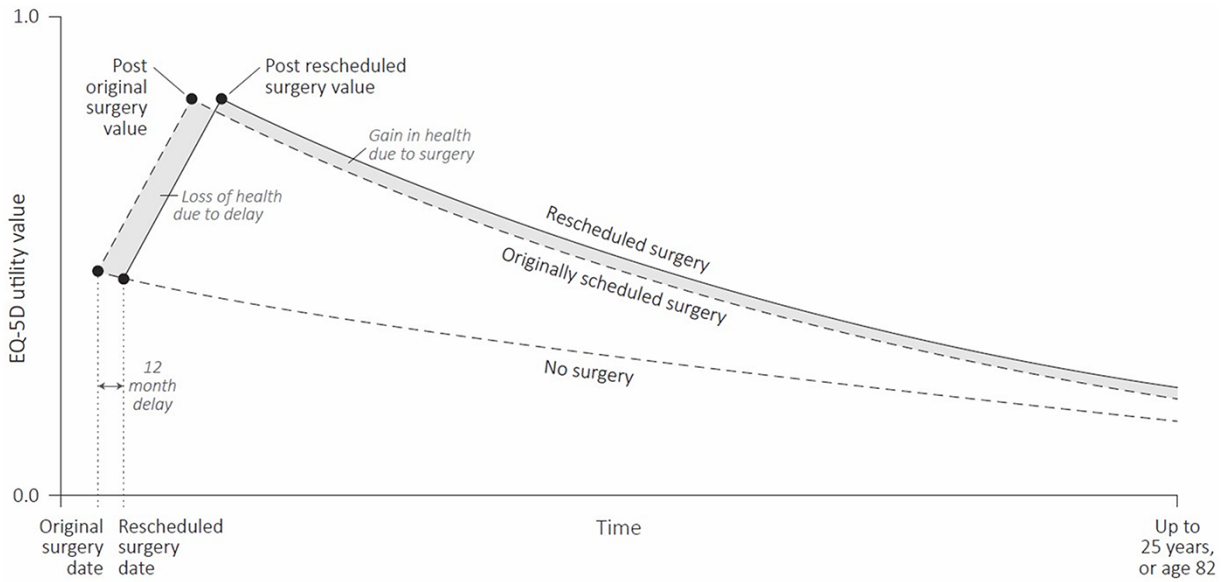

Figure 1 Illustration of the impact of delayed surgery and gain in health utility.

Table 1 Summary statistics of participants at baseline and 6 months post-cholecystectomy

Characteristic	*N (%)*
Count (*N*)	195 (100)
Sex	
Females	139 (71.3)
Males	56 (28.7)
Age group	
≤50	57 (29.2)
51–60	43 (22.1)
61–70	64 (32.8)
70 +	31 (15.9)
Co-morbidities	
0	68 (34.9)
1	62 (31.8)
2+	65 (33.3)
Utility value	
Preoperative mean	0.8410
Std dev/range	0.1310/(0.3400, 1)
Postoperative mean	0.9125
Std dev/range	0.1342/(0.3400,1)
Paired *t* test *P* value	<0.0001

Assumption 1: health gains accrued for 25 years after surgery

Table 2 details the results of health gain accrual. The mean gain in QALYs over that time period was 1.816 with standard error of 0.132. If patient's cholecystectomy was delayed 3 months, the mean loss was 0.030, or 1.7%, of the QALY expected if the surgery had not been delayed. A delay of 12 months resulted in a mean loss of 0.117, or 6.4%, of the QALY expected without the delay in surgery.

Table 3 details the cost per QALY. The mean cost per QALY was $2200. A 12-month delay corresponded to an average increase of $420 (19.0%) in cost per QALY.

These findings highlight that, from the health system perspective, while short delays do not impact the mean cost per QALY significantly in absolute terms, among thousands of delayed surgeries, longer delays generate substantial societal costs in terms of the foregone health benefits accruing to patients.

Assumption 2: health gains accrued until age 82 after surgery

The mean gain in QALYs was 1.797 with standard error of 0.154 if there was no delay in surgery. A 12-month delay was associated with a mean gain of 1.739 QALYs with standard error of 0.124, or interpreted as 96.8% of the QALYs expected without the delay in surgery.

Under this assumption, the value of the cost per QALY does not change appreciably for the overall sample. However, among the oldest patients, the mean cost per QALY was $10 758 for the undelayed surgery; assuming a 12-month delay in surgery, the mean cost per QALY increased to $13 463 in the same group ($2705 difference), a 25.1% increase in mean cost per QALY, owing to the gain in health accruing for a shorter period among the most elderly participants.

Discussion

Statement of principal findings

The objective of this study was to estimate the effect of delaying elective cholecystectomy as measured through the surgery's health gain—and delayed health gain. This study begins the work to demonstrate that there are different opportunity costs associated with surgical delays—depending on the characteristics of who is being delayed.

For elective cholecystectomy, there was a difference of nearly $2000 in mean cost per QALY between the oldest and youngest age groups associated with a 12-month delay if the health benefits accrued for 25 years. This difference increased to over $12 000 if the benefits only accrued until the age of 82.

At an individual level, and for many people, the QALYs lost due to delaying surgery may not seem significant; however, depending on the projections of patient's longevity, there may be a meaningful decrease in patients' QALY associated with their delayed surgery. Cost-utility and delayed health benefit information can be one factor for governments and health system administrators to consider when triaging patients. Specifically, surgical triage may consider prioritizing older patients for elective surgery to maximize their health over patients' remaining life years.

Table 2 Mean gains in QALYs assuming either a 25-year accrual period after surgery or an accrual to the average life expectancy of a Canadian (82 years of age)

Time point	Mean gain in QALYs	Std Dev	95% Conf interval		Mean loss in QALYs	Percent loss QALYs
			Lower	Upper		
Scheduled surgery—no delay 25 years of gains	1.816	1.848	1.555	2.077	–	–
Delay in months						
3 months	1.786	1.818	1.530	2.043	0.030	1.7%
6 months	1.757	1.788	1.504	2.010	0.059	3.2%
9 months	1.728	1.759	1.479	1.976	0.088	4.8%
12 months	1.699	1.731	1.455	1.944	0.117	6.4%
Scheduled surgery—no delay up to age 82 (life exp)	1.797	2.157	1.492	2102	–	–
Delay in months						
3 months	1.783	2.145	1.479	2.086	0.014	0.8%
6 months	1.768	2.134	1.467	2.069	0.029	1.6%
9 months	1.754	2.123	1.454	2.053	0.043	2.4%
12 months	1.739	2.111	1.441	2.037	0.058	3.2%

Participants aged 82 and over are excluded for the life expectancy analysis (n = 12).

Table 3 Cost per quality-adjusted life year whose health benefits accrue for 25 years after surgery or whose health benefits accrue until age 82, Canadian life expectancy

	Mean	No delay in surgery	Delayed surgery—length of delay, mean (95% CI)			
Characteristic	Cost	Mean (95% CI)	3 Months	6 Months	9 Months	12 Months
Health benefits for 25 years						
Overall	3996	2200 (1882, 2595)	2301 (1969, 2712)	2404 (2058, 2828)	2510 (2151, 2947)	2620 (2246, 3070)
Sex						
Females	3600	1949 (1647, 2400)	2044 (1725, 2516)	2141 (1808, 2636)	2243 (1865, 2689)	2346 (1953, 2812)
Males	4978	2865 (2113, 3829)	2979 (2205, 3981)	3097 (2300, 4138)	3218 (2454, 4517)	3342 (2550, 4687)
Age group						
≤50	3822	1663 (1273, 2464)	1741 (1334, 2366)	1821 (1398, 2470)	1904 (1464, 2577)	1989 (1532, 2687)
51–60	3994	2043 (1532, 2954)	2135 (1608, 3094)	2232 (1687, 3238)	2330 (1769, 3376)	2432 (1851, 3518)
61–70	3687	2557 (1975, 3462)	2680 (2073, 3619)	2806 (2174, 3781)	2936 (2277, 3947)	3071 (2384, 4118)
70 +	4956	3285 (2165, 5311)	3416 (2260, 5505)	3553 (2359, 5705)	3692 (2460, 5911)	3835 (2564, 6123)
Health benefits until age 82						
Overall	3996	2224 (1887, 2656)	2305 (1961, 2749)	2389 (2035, 2851)	2473 (2110, 2946)	2560 (2185, 3047)
Sex						
Females	3600	1914 (1571, 2400)	1989 (1606, 2478)	2067 (1700, 2589)	2145 (1766, 2689)	2225 (1830, 2791)
Males	4978	3136 (2237, 4493)	3237 (2345, 5055)	3339 (2398, 4789)	3446 (2480, 4942)	3552 (2565, 5098)
Age group						
≤50	3822	1212 (937, 1628)	1253 (972, 1682)	1297 (1008, 1736)	1341 (1043, 1791)	1384 (1077, 1849)
51–60	3994	1962 (1479, 2845)	2033 (1536, 2953)	2105 (1594, 3063)	2178 (1653, 2164)	2252 (1713, 3263)
61–70	3687	3426 (2606, 4635)	3576 (2725, 4824)	3729 (2846, 5027)	3885 (2970, 5238)	4046 (3098, 5454)
70 +	4956	10 758 (6419, 21 201)	11 368 (6757, 22 639)	12 000 (7147, 24 125)	12 705 (7563, 25 597)	13 463 (8009, 27 204)

Participants aged 82 and over are excluded for the life expectancy analysis (n = 12).

Strengths and limitations

This study was based on a unique dataset that had linked PRO information with population-based hospital discharges, emergency department visits and physician costs. There are few studies that provide insights into the implications of delaying access to elective surgeries such as a persistent health policy issue among a number of OECD countries, including Canada.

This study is not without limitations that should be considered when interpreting the results. First, this was not intended to be a cost-effectiveness analysis of different treatment modalities since all participants were already scheduled for their cholecystectomy. Then, patients' costs were derived from the publicly funded system that administers healthcare to residents of Vancouver, Canada. These costs may differ across different types of systems.

This study's findings were based on the assumptions regarding the timeframes over which health gains accrued to patients; for other surgeries, these time-based assumptions may need to be different. This is especially true for conditions with higher near-term mortality. The study's QALY calculations assumed a constant discount rate between demographic categories; it is possible that, for some patients (e.g. the youngest or oldest), a more robust discount rate is needed [28].

In addition, the utility of cholecystectomy was calculated from a fairly modest sample size; however, since this study's interest was in the mean, given the standard errors of our findings, we do not expect that we would observe a significantly different conclusion resulting from a much larger sample. However, given the standard errors, there is likely some uncertainty regarding the gain in QALYs. Also, the change in PROs was based on data collected prior to the onset of COVID-19 and the related shut down in elective surgeries that it caused; it could be that patients' health status has changed because of surgical delays and uncertainties surrounding post-COVID rescheduled surgical dates. It is also possible that in prospective analyses of patient's health status, the other clinical factors could impact acceleration or deceleration of patient's surgery.

Interpretation within the context of the wider literature

The findings from this study are broadly consistent with related empirical research; the cost per QALY statistics of this study was similar to that in other research [15], and the incidence of adverse events associated with delayed surgery observed in this study, that affected patient's cost per QALY, were not dissimilar from other studies [29].

Given that cholecystectomy is very common with thousands occurring across Canada each year, the aggregate value of health gain is definitely lower than otherwise would have been without delays. Consequently, the societal cost of delaying a commonly performed procedure like cholecystectomy could be seen to be quite high and not only borne in the short-run, but as our data showed, continue to accrue over the course of individual patients' lives.

Implications for policy, practice and research

As health systems focus on managing surgical queues or resumption of surgical services post-COVID-19, there are scenarios where already scarce resources become further strained due to demands of urgent and necessary surgical procedures. For example, while oncologic care, including cancer surgery, has continued in many jurisdictions through COVID-19-related disruptions to healthcare, the delay in elective, but necessary surgical care, will need to be addressed.

For cholecystectomy patients, a subgroup of patients will return to the emergency room with symptoms necessitating emergency care and surgical intervention. How a system addresses the backlog of patients remains a difficult question to answer, though this study provides insights into how gains in health were not equally shared among cholecystectomy patients.

There is a budding literature examining the societal impact of restrictions to accessing surgery [30–32], predominantly using Markov model simulations; this study differs by using a pragmatic sample of patients whose costs and utility values are observed in a longitudinal cohort. Given some diversity in methods and applications to policy, additional simulated and observed data-driven studies are needed to develop a more robust body of evidence regarding the effect of delaying access to surgery.

This study presents an empirical approach to measuring patient's and society's loss of utility from delayed access to surgery. This approach, despite the limitations of this study, may be applicable to a range of elective surgeries where preoperative and postoperative utilities are reported elsewhere. There may be, however, a need for more research involving surgeries staged over time in order to accommodate tissue healing.

Conclusions

While it is clear that a long-term and sustained increase in surgical resources will be required to catch up with delayed operations, it has been estimated that it will take upwards of a year—or more—to catch up with the backlog in this study's setting of publicly funded healthcare. Within this time frame, there is a need to focus on minimizing loss of patient's utility from health and maximizing overall societal gains in health.

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Data availability statement

Anonymized data can be obtained from the corresponding author.

Contributorship

Each author has significantly contributed to the design of the study, interpretation of the results, drafting and editing the final version. GL and JS led the statistical analyses. All authors approve the submitted text.

Ethics and other permissions

This study was approved by the Behavioural Research Ethics Board of the University of British Columbia.

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