The Hospital for Sick Children
Technology Assessment at Sick Kids (TASK)

FULL REPORT

THE COST-EFFECTIVENESS OF CLINIC-BASED CHLORAL HYDRATE SEDATION VERSUS GENERAL ANAESTHESIA FOR PAEDIATRIC OPHTHALMOLOGICAL PROCEDURES

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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ABBREVIATIONS

AE	adverse event
ASA	American Society of Anaesthesiologists
CEA	cost-effectiveness analysis
CI	confidence interval
CMA	cost-minimization analysis
ERG	electroretinogram
EUA	exam under general anaesthesia
EUS	exam under sedation
GA	general anaesthesia
ICER	incremental cost-effectiveness ratio
LOS	length of stay
NICE	The National Institute for Health and Clinical Excellence
OHIP	Ontario Health Insurance Plan
OR	operating room
PACU	post anaesthetic care unit
PSA	probabilistic sensitivity analysis
QALY	Quality-adjusted life year
SDAU	same day admission unit
SD	standard deviation
UMSS	University of Michigan Sedation Scale
USD	United States dollars

EXECUTIVE SUMMARY

Introduction

The inability of young children to tolerate detailed eye examinations while awake often necessitates the need for sedation or general anaesthesia (GA). Examinations under anesthesia (EUA) are carried out in the operating room (OR) and require many staff and resources. Chloral hydrate sedation allows examinations to be carried out in a nurse-led unit conveniently based in an outpatient clinic and may be a cost-effective alternative to GA.

Objectives

The primary objective was to determine the incremental cost of paediatric eye examinations carried out in the clinic under sedation using oral chloral hydrate compared to examinations carried out in the OR using GA per additional successful procedure gained from a societal perspective. The secondary objective was to conduct a cost-minimization analysis (CMA) under assumptions of equivalent effectiveness between clinic-based sedation and GA.

Methods

A cost-effectiveness analysis (CEA) was carried out from a societal perspective to compare eye examinations carried out under sedation (EUS) to eye exams carried out under anaesthesia (EUA). The analysis was performed using stochastic patient-level data from a retrospective cross-over cohort of 80 pediatric ophthalmology patients that had an EUS within seven months (prior to or following) an EUA at the Hospital for Sick Children (SickKids), Toronto, Canada. An episode of care time horizon that represented the patients' total length of stay at Sick Kids was used. Costs included direct health care costs including all medical personnel and services, supplies and equipment used for sedation and GA, as well as parent or caregiver productivity losses. Effectiveness and safety were assessed from the number of successful ophthalmological procedures and the number of adverse events in each group. Adverse events of interest included paradoxical reactions, desaturation, nausea and vomiting, prolonged sedation, and reduced heart rate. To address uncertainty, univariate sensitivity analyses were conducted for select cost variables and a probabilistic sensitivity analysis (PSA) was conducted using 1,000 Monte Carlo simulations. Mean costs with 95% confidence intervals (CIs) were estimated for all cost-effectiveness findings.

Results

In the base case, the expected cost of EUS was $404 (95% CI $385, $424) per patient and the expected number of successful procedures was 1.36 (95% CI 1.20, 1.52) per patient. The expected cost of EUA was $1,134 (95% CI $1,094, $1,174) per patient and the number of successful procedures was 2.03 (95% CI 1.86, 2.19) per patient. EUA was an average of $730 more costly per patient than EUS and resulted in an additional 0.66 successful procedures per exam. EUS was less costly but also less effective. Three adverse events were observed in two EUS patients compared to 1 adverse event in the EUA group. Results from the one-way sensitivity analysis showed OR cost to be the most sensitive model input, followed by anesthesiologist fees. Varying the cost assumptions did not change the finding that EUS was less costly compared to EUA. The mean cost per patient from the PSA was $406 (95% CI $401, $411) for EUS and $1,135 (95% CI $1,125, $1,145) for EUA. The mean number of successful procedures per patient was 1.39 (95% CI 1.34, 1.42) for EUS and 2.06 (95% CI 2.02, 2.11) for EUA. EUA was $729 more costly on average than EUS but resulted in an additional 0.68 successful procedures per child. In the PSA, the number of planned procedures and the probability of a successful sedation were the most sensitive model inputs. In the CMA, when failed sedations in the clinic were assumed to be completed in the OR, the expected cost of EUS increased to $586.31 (95% CI $438.08, $734.54), but remained significantly less than EUA. The strategy that required patients to attempt an exam in the clinic first, and if needed (due to failed sedation), undergo a second visit in the OR, resulted in mean cost savings of $555.37 (95% CI $282.74, $818.13) per patient, approximately $187 less than the incremental savings per patient in the base case.

Conclusions

Hospital budgets are under increasing pressure to rationalize care. Interventions that reduce costs despite being slightly less effective can result in more efficient allocation of healthcare resources when the trade-off between costs and outcomes does not pose morbidity or mortality risks. EUS represents an easily adopted hospital-based intervention with negligible set-up costs, with savings that can accrue even when patient throughput is low. Results from this study demonstrated significant savings when ophthalmologic exams were carried out in an outpatient clinic using chloral hydrate sedation, albeit with fewer procedures completed per exam. When taking into account the proportion of failed sedations that have to be repeated in the OR, the clinic approach remained cost-saving. Exams carried out in the OR under GA may be more appropriate when a large number of procedures per patient are required.

1 INTRODUCTION

1.1 Background

Eye examinations in children are pain free but require moderate patient cooperation. Some young children find the use of bright lights and close proximity of equipment or a doctor to their face rather distressing. The inability to tolerate detailed eye examinations whilst awake often necessitates the need for sedation or general anesthesia (GA).[1] Performing exams under anaesthesia (EUA) in the operating room (OR) is the current standard of care in most ophthalmic units wherein an anaesthesiologist administers general anaesthesia to a patient prior to an exam.[2] An alternative to EUA is oral chloral hydrate sedation which can be administered in a hospital-based ophthalmology clinic by an appropriately trained nurse.[1,3,4] Indeed, the National Institute for Health and Clinical Excellence (NICE) in the UK recently recommended mild to moderate sedation with chloral hydrate for children under 15kg who require sedation to tolerate painless procedures.[5]

The safety and effectiveness of eye examinations under sedation (EUS) in the clinic was recently demonstrated in a large retrospective study of 813 patients who underwent 1,509 sedations in the ophthalmology clinic at The Hospital for Sick Children (SickKids) in Toronto, Canada.[1] In this study, the rate of successful sedation was 96.7% and minor adverse events occurred in 6.5% of patients. Adverse events included paradoxical reactions (hyperactivity) (n=20), desaturation (n=15), vomiting (n=8), prolonged sedation (n=4), and reduced heart rate with spontaneous recovery (n=2). Both age greater than 4 years or weight over 15kg were found to be significant predictors of failed sedations and adverse events.[1] Recently, there have been concerns regarding the influence GA may have on neurodevelopment in patients who require multiple exams and it is not clear if EUS is of any less concern.[6,7]

As health care spending continues to increase, there is a growing need for improved efficiencies within publicly funded systems. This includes the consideration of cost-saving technologies that result in improved health outcomes.[8] The ability to carry out paediatric eye examinations under chloral hydrate sedation in a nurse-led outpatient clinic[1] leads to questions about the cost-effectiveness of this approach compared to GA in the OR. Also, for a parent accompanying their child, a shorter visit to the clinic would mean less time away from work or other commitments.

Previous studies in dentistry[9,10] and echocardiography[11] have demonstrated cost savings for conscious sedation compared to GA, however no full cost-effectiveness analysis comparing both costs and outcomes of sedation versus GA in common ophthalmological procedures has been carried out. As health care institutions operating on fixed budgets increasingly seek ways to increase efficiency in the delivery of costly health care services, formal health technology assessment is essential to quantify value for money allocation decisions.

1.2 Objective

The primary objective of this study was to conduct a cost-effectiveness analysis (CEA) to assess the incremental costs of paediatric ophthalmologic eye examinations carried out in a nurse-led outpatient sedation unit using oral chloral hydrate compared to exams carried out in the OR under GA per successful procedure gained from a societal perspective. A second CEA examined the incremental costs of outpatient sedation compared to GA per adverse event averted. A secondary objective was to conduct a cost-minimization analysis (CMA) under assumptions of equivalent effectiveness between clinic-based sedation and GA.

2 METHODS

This study was approved by the Research Ethics Board at Sick Kids, Toronto Canada. As all study data were extracted retrospectively from patient charts and subsequently anonymized, the requirement for informed consent was waived.

2.1 Study design

Costs and health outcomes were examined using a retrospective short interval cross-over design that included an observational cohort of patients who underwent both EUS and EUA during the study period. In a cross-over design all potential bias emanating from differences in patient characteristics between groups is eliminated. As the intervention of interest is a procedure rather than a treatment, there is no risk of contamination when a patient crosses over. Decision analysis was used to conduct a CEA and CMA.

2.2 Study interventions

2.2.1 Sedation protocol

Chloral hydrate sedation was performed by a trained nurse in a sedation room within the ophthalmology clinic at Sick Kids according to a local protocol based on current literature and the American Society of Anaesthesiologists (ASA) practice guidelines for sedation and analgesia by non-anaesthesiologists.[2] Medical contra-indications for chloral hydrate have been noted elsewhere.[1] Upon arrival at the clinic, patients were assessed by a nurse to ensure an ASA criteria of grade I or II (i.e. a normal healthy patient or with mild systemic disease), a body weight less than 20 kg, and consent obtained by the doctor. A dose of 80mg/kg of chloral hydrate syrup was administered orally and if necessary a top-up dose of up of 40mg/kg was given. Throughout the sedation induction, ophthalmological procedures, and recovery, a single sedation-trained nurse was present. Ophthalmology medical staff were also available as well as the hospital crash team if required. Vital signs were recorded every five minutes and included the University of Michigan Sedation Scale (UMSS) score,[12] heart rate and oxygen saturation. Body temperature was measured before and after the exam. All adverse events were recorded. Once awake, patients were discharged according to standard criteria which required the ability to sit or stand with minimal assistance (age appropriate) and tolerate clear fluids without nausea or vomiting.[2]

2.2.2 General anaesthesia protocol

Children scheduled to undergo an EUA were admitted to the same day admission unit (SDAU) where a registered nurse prepared them for the OR. Whilst in the SDAU an ophthalmologist obtained consent and an anaesthesiologist confirmed fitness for GA. An OR nurse delivered each child to the OR. General anaesthesia was performed by a staff anaesthesiologist as per their preferred technique. This typically involved delivery of inhalation gas via a face mask and/or by intravenous infusion. Patient's airways were secured by either laryngeal mask or endotrachial tube intubation. Anaesthesia was maintained for the entire EUA. Reversing agents were not used to wake the patients. Removal of airway was carried out based on the anaesthesiologists' preference. The anaesthesiologist and nurse brought the recovering patient to the post-anaesthesic care unit (PACU), where one nurse was responsible for a maximum of two patients. The nurse monitored each patient until they were stable enough for discharge.

2.3 Study sample

Medical charts and an ophthalmology clinic database were reviewed to identify patients less than seven years of age who were administered oral chloral hydrate for a scheduled eye exam (EUS or EUA) at Sick Kids between January 1, 2006 and December 31, 2010. Eligible patients had to have had both an EUS and an EUA within an eight-month period. Eye exams could include any combination of non-painful procedures including detailed examinations, RetCam™ (Clarity Medical Systems, Inc, Pleasanton, CA, USA) photography, electroretinograms (ERGs), A-scans or B-scan ultrasound, contact lens fitting and foreign body and planned suture removals. Patients that were referred to an EUA because a procedure was unable to be successfully completed during an EUS were eligible. EUAs were excluded if they included additional procedures that would not usually be done under sedation. These exclusions were painful procedures, planned fundus fluorescein angiography, laser treatment or planned suture removals as the only procedure. EUAs in patients within six weeks of keratoplasty were also excluded as these patients often require loose sutures to be replaced during the exam. EUAs in children who were having ultrasound biomicroscopy (UBM) were also excluded as a number of children during this period were participants in a study involving UBM that added significantly to the GA time. EUAs in children weighing less than 5kg were also excluded as patients in this weight category are not eligible for EUS. Patients were also excluded if the reason for an EUA was a medical contraindication to EUS.

When an eligible patient had more than one EUS or more than one EUA within the defined study period, the most recent EUS or EUA visits were selected. Also the two closest qualifying visits were selected in order to more closely match episodes of care by age and weight.

2.4 Data collection

Patient data were extracted from medical charts and the ophthalmology clinic database by two independent researchers (RL and SW). Patient characteristics included date of birth, sex, weight, and ASA score. For EUS, the visit date, dose of chloral hydrate administered (mg), time of arrival at the ophthalmology clinic, time of chloral hydrate administration, procedure end time, time of discharge, planned procedures, performed procedures, and any adverse events occurring during the exam and within 24 hours post-discharge were collected. For EUA, the time of arrival at the same day admission unit (SDAU), time of arrival in the operating room

(OR), time of arrival at the post-anaesthesia care unit (PACU), time of discharge, planned procedures, performed procedures, and any adverse events occurring during the exam and within 24 hours post-discharge were collected.

2.5 Cost-effectiveness analysis

A CEA was carried out to determine the incremental cost of EUS compared to EUA per successful procedure gained. A secondary CEA examined the incremental cost of EUS compared to EUA per adverse event averted. Cost-effectiveness was assessed from a societal perspective which took into account all of the direct health care costs incurred by the public health care system (The Ontario Ministry of Health and Long-Term Care) and the indirect costs including parent or caregiver productivity losses. Costs and consequences were assessed over an episode of care time horizon that represented the patients' total length of stay at Sick Kids. A decision analytic model was used to carry out the analysis of stochastic patient data. All results were first tabulated in a cost consequence analysis to determine the feasibility of calculating incremental cost-effectiveness ratios.

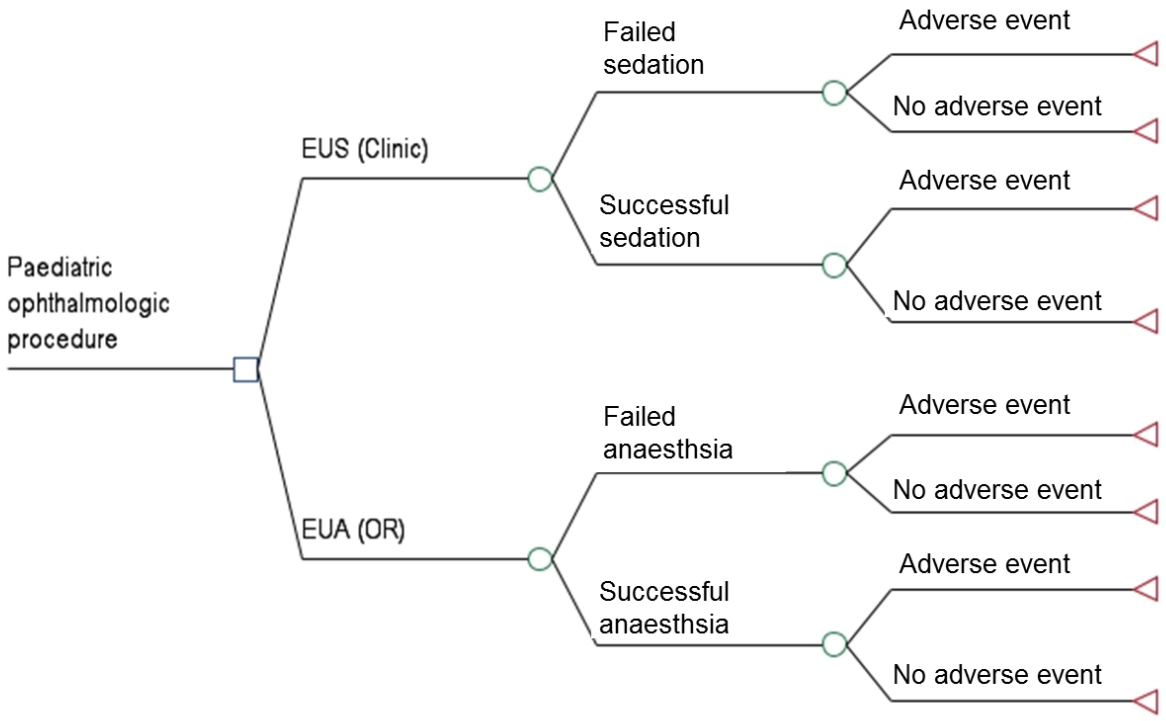
2.5.1 Statistical analysis of patient-level data

The economic analysis was carried out with stochastic patient-level data obtained as described above. Study patient data were analyzed descriptively using Microsoft Excel 2010. Means and standard deviations were calculated for continuous variables including: patient age, weight, length of stay, and number of planned procedures. Paired t-tests were carried out where appropriate to compare continuous variables across EUS and EUA visits. Frequencies were calculated for categorical variables including: patient gender, ASA scores, days between EUS and EUA, and planned procedures. Fisher's exact tests were carried out where appropriate to compare categorical variables across EUS and EUA visits. For all costs and outcomes input in the economic model, means, standard deviations, maximum and minimum values, and 95% confidence intervals (CIs) were calculated in Excel using patient level data. Probabilities used in the model were also calculated in Excel using patient level data. The distributions of all economic model inputs were assessed using tests for normality in SAS version 9.3 (SAS Inc., Cary, NC). The cost-effectiveness analysis, including the univariate sensitivity analysis, was carried out using Excel while the probabilistic sensitivity analysis (PSA) was carried out using TreeAge™ Pro 2013. The results of all economic analyses were presented as the mean costs and health consequences per patient as well as incremental costs and consequences per patient and included 95% CIs.

2.5.2 Decision analysis

The decision tree consisted of two arms (see Figure 1). The decision node (square) compares the clinical choice between the experimental intervention of EUS, defined as ophthalmology exams carried out under chloral hydrate sedation in a nurse led sedation unit located within the ophthalmology clinic, and standard care EUA, defined as ophthalmology exams carried out under GA in the OR. The next chance node (circle) indicated that the sedation in either setting could fail or be successful. A failed sedation was defined as an exam wherein one or more of the planned procedures could not be completed per standard protocol resulting in an incomplete exam. Failed sedation or anaesthesia were due to the inability of the chloral hydrate or GA to result in an adequate level or duration of reduced consciousness. A failed or successful sedation may or may not be associated with an adverse event (AE). AEs of interest included paradoxical reactions, desaturation, nausea and vomiting, prolonged sedation, and reduced heart rate. Mortality and hospitalizations were documented where appropriate. There were a total of eight unique pathways in the decision tree.

Figure 1: Decision tree



All base case probabilities, outcomes, resource use and outcomes were derived from the patient-level data set unless otherwise noted.

2.5.2.1 Decision tree parameters

The branch probabilities used in the base case analysis are listed in Table 1. For the EUS (clinic) arm, the probability of a failed sedation was 0.125. This value represented the proportion of patients (12.5%) that had incomplete exams (i.e. fewer completed procedures than planned procedures). The probability of adverse events (AEs) in the EUS arm for patients with successful sedations was 0.025. This value represented the proportion of patients in the EUS arm that experienced an AE (2.5%). None of the patients with failed sedations in the EUS arm experienced an AE. For the EUA arm, the probability of a failed anaesthesia was zero. None of the patients in the EUA arm had incomplete exams. The probability of AEs in the EUA arm for patients with successful anaesthesia was 0.0125. This value represented the proportion of patients in the EUA arm that experienced an AE (1.25%).

The terminal nodes of each of the eight pathways were populated with a value for outcomes and a value for total costs, each representing the mean parameter values for patients in that pathway.

2.5.2.2 Outcomes

The outcomes used in the base case analysis are listed in Table 1. Typically, two or more ophthalmologic procedures are undertaken in a single exam. The number of procedures successfully completed during a single exam was the primary outcome used to compare the effectiveness of EUS to EUA. A successful procedure was defined as the ability to successfully complete a procedure subsequent to the administration of chloral hydrate or general anaesthetic as per standard clinical protocol. The mean numbers of successful procedures per patient-exam used as model inputs are presented in Table 1. Secondary outcomes included the total number of successful exams per intervention group, which required all of the planned procedures to be completed per standard clinical protocol, and the total number of adverse events per group, including those that occurred as a result of chloral hydrate, GA, or the ophthalmology procedure.

Table 1: Probabilities and outcomes used in the base case analysis

Items	Base Case Value
Probabilities	
EUS	
Probability of failed sedation in clinic	0.125
Probability of adverse event in clinic	0.025
EUA	
Probability of failed anaesthesia in OR	0.000
Probability of adverse event in OR	0.013
Outcomes	
EUS	
Number of procedures for failed EUS + AEs	0.000
Number of procedures for failed EUS, no AEs	0.300
Number of procedures for successful EUS + AE	1.500
Number of procedures for successful EUS, No AEs	1.515
EUA	
Number of procedures for failed EUA + AEs	0.000
Number of procedures for failed EUA, no AEs	0.000
Number of procedures for successful EUA + AE	0.000
Number of procedures for successful EUA, No AEs	2.025

Abbreviations: EUS = exam under sedation; EUA = exam under anaesthesia; OR = operating room; AE = adverse event

2.5.3 Costing

Cost items in the analysis included physician specialist services, nursing services, supplies and equipment used for EUS and EUA, sedatives and inhaled gases, and parent or caregiver productivity losses. Patient length of stay was a component variable in all time-dependent cost items, including nursing time, anaesthesiologist assessments and parent/caregiver time losses. The volume of resource use was multiplied by price to determine the cost of each item (see technical appendix table 1). Total costs at the terminal nodes were calculated by summing all related costs for each branch.

2.5.3.1 Resource use

The resource use data used in the base case analysis are listed in Table 2. Length of stay was calculated as the difference between the time of arrival and discharge across each pathways of care. For the EUS arm, the mean length of stay in the ophthalmology clinic was 2.30 hours per patient. For the EUA arm, length of stay consisted of time spent in the SDAU (1.67 hours), the OR (0.72 hours) and the PACU (0.98 hours). The mean length of stay per EUS patients was

4.03 hours.

It was conservatively assumed that only study patients would be treated from a 500mL bottle of chloral hydrate (100mg/mL) every 28 days as per the drug's shelf-life. The date of EUS was collected from patient charts and chloral hydrate waste was allocated across all study patients treated within a 28-day interval. The mean volume of chloral hydrate administered per patient was 9mL (929mg) and the mean waste per patient was 284mL (28,446mg) for a total of 294mL (29,375mg) per patient. The mean volume used in the model is likely an over-estimate of the total amount of chloral hydrate waste occurring at Sick Kids, but would be reasonable for a smaller clinic that sees fewer patients.

2.5.3.2 Prices

Prices, fees and cost data and sources used in the analysis for all medical personnel, supplies and equipment used for EUS and EUA, sedatives and inhaled gases, and parent or caregiver productivity losses are presented in Table 2.

For EUS, the start-up and overhead costs associated with establishing the nurse-led sedation unit were deemed negligible since the unit operates within the existing ophthalmology clinic (personal communication, clinic staff), the space can be repurposed for patient encounters when not used for sedation, and no additional equipment is required. (All clinical areas in the hospital have access to resuscitation equipment on a movable crash trolley.) The sedation unit is led by a single nurse who operates within the SickKids ophthalmology clinic and is trained in administering oral sedation. The cost of training was not included. The mean operating cost of the sedation unit was calculated by multiplying the length of stay in the ophthalmology clinic by the average hourly wage of a Sick Kids nurse ($35.21), as reported by Sick Kids human resources.

The cost of equipment and supplies required for all ophthalmologic procedures were assumed to be equal for EUS and EUA patients and were excluded from the analysis. The fees for the ophthalmology physician services for EUS were based on the combination of separate procedures performed during an exam. Ontario Health Insurance Plan (OHIP) Schedule of Benefits and Fees fee codes used for the procedures included in the analysis were provided by a Sick Kids staff ophthalmologist and included both physician fee codes and technician services. The frequency of each procedure or combination of procedures were multiplied by the

appropriate OHIP fee and divided by the total number of patients per arm (see technical appendix table 2).

The unit price ($0.05 per ml) of chloral hydrate was obtained from the Sick Kids Pharmacy 2012 list price. The total volume of chloral hydrate per patient (including waste) was multiplied by the unit price to derive a mean total cost of chloral hydrate of $14.69 per patient.

For EUA, all consumables and equipment used in the induction process, prescription and non-prescription medications, induction gases, and nursing wages were provided as a bundled OR cost. The bundle price was provided by Decision Support services at Sick Kids which conducted case-costing for all study patients that visited after May 1, 2009 (n=41), the first date for which case costing records are complete. Validation of the items included in the bundled price was carried out by cross-referencing resource use for the bundled items with patient charts for a random sample of 10 patients. The mean bundled OR cost of $472.08 per patient from the 41 patients that visited after May 1, 2009 was used to represent all EUA OR services.

The EUA pathway of care requires patients to transition across several hospital departments. In the SDAU a nurse prepares patients for transfer to the OR, and following the exam a nurse cares for and monitors recovery of two patients at a time in the PACU. The mean cost of the SDAU nurse was calculated by multiplying the length of stay in the SDAU by the mean hourly wage of a Sick Kids nurse ($35.21). The mean cost of the PACU nurse was calculated by multiplying the length of stay in the PACU by half of the mean hourly wage of a Sick Kids nurse ($17.61).

As described above, the cost of equipment and supplies required for ophthalmologic procedures were assumed to be equal for EUS and EUA. Similar to EUS, the fees for of ophthalmology physician services derived using the OHIP Schedule of Benefits and Fees fee codes. The mean fee for ophthalmology procedures performed under GA was $281.86. Anaesthesiologist fees were provided by a Sick Kids billing clerk who followed the point system (1 point = $15.01) outlined in the OHIP Schedule of Benefits and Fees. This was used to determine the total fee per study patient based on age and length of stay in the OR (see technical appendix table 3). The base fee for patients aged 1-5 years was $120.08 with one point being assigned for every 15 minutes within the first hour, two points being assigned every 15 minutes within the second hour, and three points being assigned every 15 minutes within the third hour. Patients less than

1 year of age were assigned an additional two points. The mean fee for anaesthesiologist services was $185.00 per patient.

For both EUS and EUA the human capital approach was used to value caregiver productivity losses.[13] It was assumed that one caregiver (e.g. mother) would be present for the duration of an exam. The cost of productivity losses were calculated by multiplying the total length of stay for each strategy by the average hourly wage ($23.70) in 2012 Canadian dollars for a woman 25-54 years of age, as reported by Statistics Canada.[14] The mean cost of productivity losses for EUS was $54.46 and EUA was $95.72.

Table 2: Costing data used in base case analysis

Items	Base Case Value	Source
Resource use		
EUS		
Chloral hydrate + waste (mL)	294	Clinic database
LOS successful EUS + AE (hours)	4.17	Clinic database
LOS successful EUS, no AEs (hours)	2.23	Clinic database
LOS failed EUS (hours)	2.37	Clinic database
EUA		
LOS SDAU (hours)	2.34	Patient charts
LOS OR (hours)	0.71	Patient charts
LOS PACU (hours)	0.99	Patient charts
LOS successful EUA + AE (hours)	4.04	Patient charts
LOS successful EUA, no AE (hours)	4.04	Patient charts
Prices		
EUS		
Chloral hydrate (100mg/mL) per mL	$0.05	Sick Kids Pharmacy
Fee for successful EUS	$277.28	OHIP Fee Schedule
Fee for failed EUS	$93.72	OHIP Fee Schedule
Nursing wage (hourly)	$35.21	Sick Kids Human Resources
Parent wage (hourly)	$23.70	Statistics Canada
EUA		
OR Bundle	$472.08	Sick Kids Decision Support
Fee for successful EUA	$281.86	OHIP Fee Schedule
Fee for anaesthesiologist	$185.00	OHIP Fee Schedule
Nursing wage (hourly)	$35.21	Sick Kids Human Resources
Parent wage (hourly)	$23.70	Statistics Canada

Abbreviations: LOS = length of stay; mL = milliliter; EUS = exam under sedation; AE = adverse event; SDAU = same day admit unit; PACU = post-anaesthetic care unit; OR = operating room; EUA = exam under anaesthesia; OHIP = Ontario Health Insurance Plan; Sick Kids = Hospital for Sick Children

2.5.4 Base case analysis

Expected values for costs per patient and for outcomes for the experimental (EUS) and standard care (EUA) arms were determined by folding back the branches of the decision tree.[13] Incremental values for costs and outcomes were determined by subtracting the standard care EUA group values from the experimental EUS group values.

Incremental costs and outcomes were presented in a cost-consequence analysis. The location of incremental costs and outcomes on the cost-effectiveness plane determines whether an incremental cost-effectiveness ratio that reports the incremental costs of the experimental intervention per unit of effectiveness gained can be calculated.

2.5.5 Sensitivity analysis

2.5.5.1 Univariate sensitivity analyses

One-way sensitivity analyses were performed by altering various uncertain cost inputs including ophthalmologist and anaesthesiologists fees, nursing wages, and OR bundles. The maximum and minimum values observed at the patient level were used for the analysis. Additional one-way sensitivity analyses were conducted to examine the effects of varying the number of planned procedures per EUS by assuming the number to be equal to that of EUA, but maintaining the probability of failed sedation for EUS. In all one-way sensitivity analyses extreme (maximum and minimum) observed patient level values were used (see Table 3). One-way sensitivity analysis results were reported in a Tornado diagram.

2.5.5.2 Probabilistic sensitivity analysis

In order to further test model assumptions and uncertain inputs, a probabilistic sensitivity analysis (PSA) was performed using TreeAge™ software. The PSA provided an estimate of the variation of the expected costs and outcomes of each strategy. In the PSA probabilities, costs, and outcomes were varied simultaneously along specified ranges and distributions in a Monte Carlo simulation with 1,000 replications. For the PSA, means and standard deviations were used as inputs for each variable. The ranges and distributions for each variable varied in the PSA are presented in Table 3 SAS version 9.3 was used to test and confirm the distributions of the raw patient-level data.

Table 3: Variables and ranges used in the univariate and probabilistic sensitivity analyses

Items	Base Case Value	Range	Distribution
Probabilities			
Probability of failed sedation in clinic (EUS)	0.125	0.00 - 0.20	Beta
Probability of AE in clinic (EUS)*	0.025	0.00 - 0.10	Beta
Probability of failed sedation in OR (EUA)	0.000	NA	Fixed
Probability of AE in OR (EUA)*	0.013	0.00 - 0.05	Beta
Outcomes			
Number of procedures for successful EUS	1.515	1.0 - 3.0	Normal
Number of procedures for successful EUS + AE	1.500	1.0 - 3.0	Normal
Number of procedures for failed EUS	0.300	0.0 - 2.0	Normal
Number of procedures for successful EUA	2.025	1.0 - 3.0	Normal
Number of procedures for successful EUA + AE	2.025	1.0 - 3.0	Normal
Resource use			
LOS successful EUS + AE	4.17	2.04 - 6.29	Normal
LOS successful EUS	2.23	1.17 - 3.92	Normal
LOS failed EUS	2.37	2.08 - 2.75	Normal
LOS SDAU	2.34	0.62 - 5.28	Normal
LOS PACU	0.99	0.08 - 2.08	Normal
LOS successful EUA	4.04	2.07 - 6.67	Normal
LOS successful EUA + AE	4.04	2.07 - 6.67	Normal
Costs			
Fee for successful EUS	$277.28	$260.00 - $434.75	Normal
Fee for failed EUS	$93.72	$22.45 - $260.00	Normal
Fee for successful EUA	$281.86	$260.00 - $434.75	Normal
Fee for anaesthesiologist	$185.00	$135.09 - $375.25	Normal
Chloral hydrate	$14.69	$6.25 - $25.00	Normal
Nursing wage (hourly)	$35.21	$28.10 - $43.36	Normal
OR Bundle	$472.08	$140.79 - $931.84	Normal
Parent wage (hourly)	$23.70	$13.73 - $46.80	Normal

* Ranges of AEs were derived from the literature (for EUS = West et al. 2013[1]; for EUA = Bryan et al. 2009[15])

Abbreviations: EUS = exam under sedation; EUA = exam under anaesthesia; OR = operating room; AE = adverse event; LOS = length of stay; SDAU = same day admit unit; PACU = paediatric acute care unit

2.6 Cost-minimization analysis

A cost-minimization analysis was carried out to compare the incremental costs required to complete all planned procedures. This approach accounted for patients who failed EUS and were then referred EUA in order to complete procedures. Thus the approach assumes equal effectiveness between groups. Only patient-level data for patients who had an EUS prior to an EUA (n=58) were used in the analysis. The costs to complete all planned procedures in the OR for patients who failed EUS in the clinic (n=10) were added to the clinic sedation unit costs, including the costs of repeating procedures that were successfully completed in the EUS. Mean total costs per patient to complete all planned procedures when an EUS was scheduled first were compared to mean total costs per patient to complete all procedures during an EUA.

3 RESULTS

3.1 Patient characteristics

A total of 80 patients were eligible for the study from a cohort of 816 patients who underwent EUS between January 1, 2006 and December 31, 2010. Characteristics of all study patients (n=80) are described in Table 4. Age and weight were collected for both EUS and EUA visits but are reported only for first study visit. There were no statistically significant differences between visits for age and weight of study patients (p=0.64 and p=0.52 respectively). The number of days between EUS and EUA visits varied between patients with a minimum of 7 days and maximum of 225 days. The majority of patients (72.5%) had an EUS prior to an EUA.

The observed combinations of planned procedures for all EUS and EUA visits are summarized in Table 5. The number and combination of procedures planned for EUS were statistically significantly different from those planned for EUA ($p<0.0001$). The total number of planned procedures for EUS was 122 compared to 162 for EUA and the mean number of planned procedures per patient were 1.53 (SD=0.62) and 2.01 (SD=0.75) respectively ($p<0.0001$).

Table 4: Study patient characteristics (n=80)

Characteristic	n (%)	Mean ± SD	Range (Min, Max)
Female	40 (50%)		
Age at earliest study visit (years)		1.76 ± 1.27	0.01 - 6.92
Weight at earliest study visit (kg)		10.97 ± 3.59	4.87 - 24.5
Days between EUS and EUA		97.51 ± 61.10	7.00 - 225.00
≤ 1 month	14 (18%)		
1-2 months	15 (19%)		
2-3 months	14 (18%)		
3-4 months	9 (11%)		
4-5 months	6 (8%)		
5-6 months	14 (18%)		
6-7 months	7 (9%)		
7-8 months	1 (1%)		
EUS before EUA	58 (73%)		

Abbreviations: EUS = exam under sedation; EUA = exam under anaesthesia; n = sample size; SD=standard deviation

Table 5: Summary of non-painful procedures planned during ophthalmology examinations

Planned procedures	EUS (clinic)		EUA (OR)		p Value ʃ
	n	%	n	%	
Exam only (general)	43	53.75%	22	27.50%	<0.0001
Exam + Retcam	20	25.00%	29	36.25%	
Exam + A-scan*	0	0.00%	1	1.25%	
Exam + ERG	11	13.75%	2	2.50%	
Exam + Contact lens fitting	4	5.00%	1	1.25%	
Exam + Plugs	0	0.00%	1	1.25%	
Exam + Foreign Body removal	0	0.00%	1	1.25%	
Exam + Retcam + A scan	0	0.00%	11	13.75%	
Exam + Retcam + ERG	1	1.25%	9	11.25%	
Exam + Retcam + B-scan	1	1.25%	0	0.00%	
Exam + Retcam + Contact fitting	0	0.00%	2	2.50%	
Exam + Retcam + Suture removal	0	0.00%	1	1.25%	

* A-scan equipment was not available in clinic during the study period

ʃ Fisher's exact test performed

Abbreviations: EUS = exam under sedation; EUA = exam under anaesthesia; OR = operating room; n = sample size; ERG = electroretinogram

3.2 Safety and effectiveness

Table 6 provides an overview of the safety and effectiveness outcomes observed for all study patients. Of the 80 EUS, 67 exams (83.75%) were completed as planned, resulting in a total of 109 (89.34%) of the 122 planned procedures being successfully completed in the group. Failed procedures included four general exams, two exams with RetCam images and 4 exams with ERGs. During one exam with a Retcam image and two exams with ERGs only a general examination could be successfully carried out. Failed sedations were not the result of adverse events, but rather an inability to achieve adequate sedation to carry out the planned procedure and/or exam. The age, weight, and length of stay for patients who failed EUS were not statistically significantly different (p=0.58, p=0.55, and p=0.41 respectively) from the study sample. All of the EUA were successful, resulting in 162 (100%) of the planned procedures being completed. The differences in the number of successful exams and the number successful procedures between groups were statistically significant (p<0.0001).

A total of three adverse events were observed in two EUS patients, all of which were side-effects known to be associated with the administration of oral chloral hydrate. One patient experienced a paradoxical reaction (hyperactivity) and the other a combined case of oxygen desaturation and prolonged sedation. In the EUA group, one patient experienced hypertension and tachycardia which were believed to be reactions to eye drops used during the ophthalmology exam. The difference in the number of adverse events between groups was statistically significant (p<0.0001).

Table 6: Study patient outcomes

Outcome	EUS (clinic)		EUA (OR)		p Value*
	n	%	n	%	
Successful exams	67	83.75%	80	100.00%	<0.0001
Successful procedures per group	109	89.34%	162	100.00%	<0.0001
Adverse events per group	3	3.75%	1	1.25%	<0.0001

* Paired t-test performed

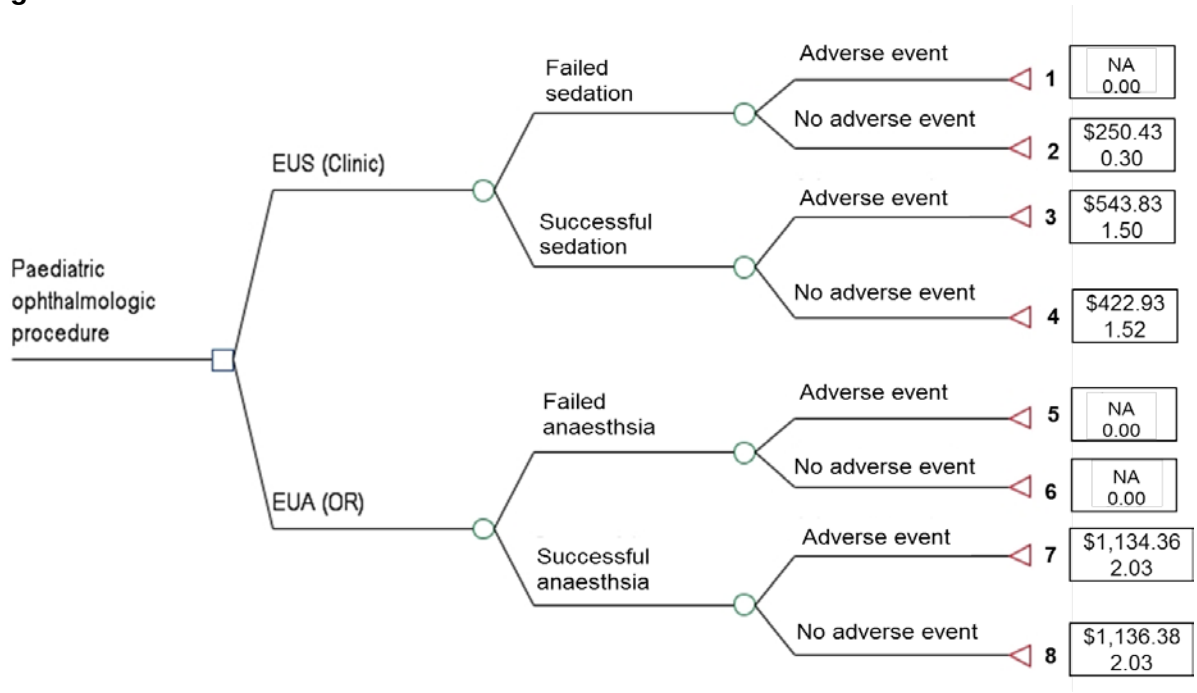
Abbreviations: EUS = exam under sedation; EUA = exam under anaesthesia; OR = operating room

3.3 Base case results

Table 7 presents a summary of the total costs and mean number of successful procedures per patient at the terminal nodes for all eight EUS and EUA pathways. The decision analysis was carried out by calculating the expected value of costs and of successful procedures per patient associated with each arm in the decision tree (Figure 2) as explained in Methods section 2.5.3.

The expected cost of the EUS arm was $404.39 (95% CI $384.54, $424.24) per patient and the expected number of successful procedures was 1.36 (95% CI 1.20 - 1.52) per patient. The expected cost of the EUA arm was $1,134.36 (95% CI $1,094, $1,174.37) per patient and the number of successful procedures was 2.03 (95% CI 1.86, 2.19) per patient.

Figure 2: Decision tree with terminal values



Note: The box at each terminal node contains the cost and number of successful procedures per patient observed in that pathway.

Table 7: Mean costs, number of successful procedures, and branch probabilities for the EUS and EUA arms

Branch	Mean cost (95% CI)	Mean number of successful procedures (95% CI)	Probability
1	$0.00 (N/A)	0.00 (N/A)	0.000
2	$250.43 ($178.54, $322.32)	0.30 (0.001, 0.60)	0.125
3	$543.83 ($368.03, $719.63)	1.50 (0.52, 2.48)	0.025
4	$422.93 ($409.57, $436.29)	1.52 (1.36, 1.67)	0.850
EUS TOTAL	$404.39 ($384.54, $424.24)	1.36 (1.20, 1.52)	1.000
5	$0.00 (N/A)	0.00 (N/A)	0.000
6	$0.00 (N/A)	0.00 (N/A)	0.000
7	$1,134.36 ($1,094.34, $1,174.37)	2.03 (1.86, 2.19)	0.013
8	$1,134.36 ($1,094.34, $1,174.37)	2.03 (1.86, 2.19)	0.988
EUA TOTAL	$1,134.36 ($1,094.34, $1,174.37)	2.03 (1.86, 2.19)	1.000

Abbreviations: CI = confidence interval; EUS = exam under sedation; EUA = exam under anaesthesia; OR = operating room

The EUA arm was $729.96 more costly than the EUS arm and resulted in an additional 0.66 successful procedures per exam. EUS was less costly but also less effective. Results in Table 8 are presented as the incremental costs and consequences of EUS compared to EUA.

Table 8: Incremental costs and effects per patient of EUS compared to EUA

	Incremental Cost (95% CI)	Incremental number of successful procedures (95% CI)
EUS vs. EUA	-$729.96 (-$770.73, -$689.20)	-0.663 (-0.456, -0.869)

Abbreviations: CI = confidence interval; EUS = exam under sedation; EUA = exam under anaesthesia

3.4 Sensitivity analysis

3.4.1 Univariate sensitivity analysis

One-way sensitivity analyses were performed by varying costly model inputs for OR cost, anaesthesiologist fee, ophthalmologist fee and nursing wages (Table 9).

Table 9: Incremental costs of EUS compared to EUA in univariate sensitivity analysis

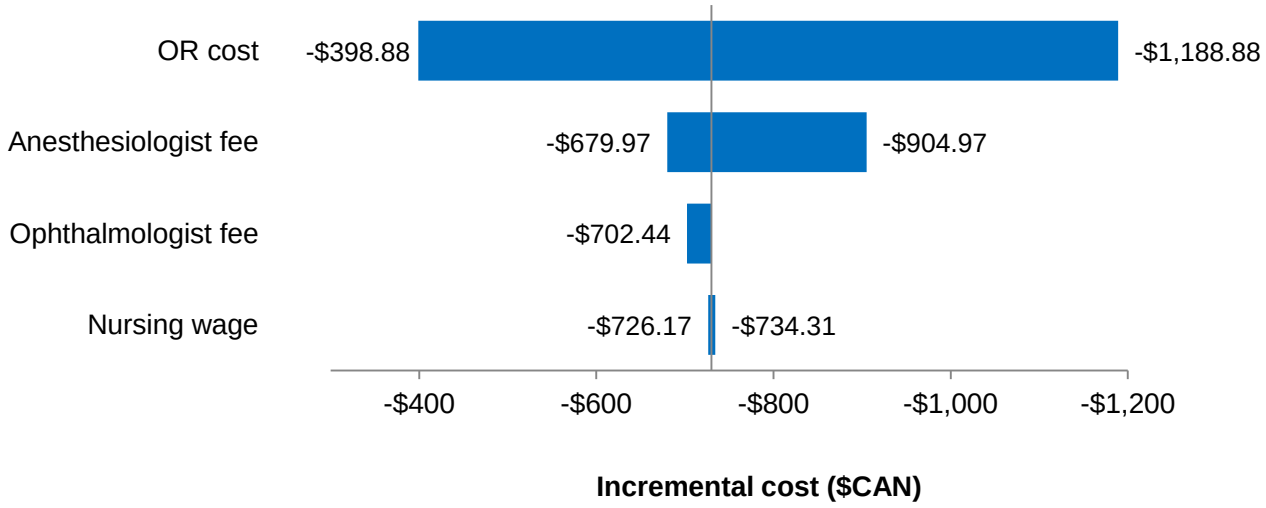
Sensitivity analysis model input range (Min – Max)	Base case value	Incremental costs (95% CI)	
		Minimum value	Maximum value
OR cost ($141 - $931)	$472.08	-$398.88 (-$425.39, -$372.38)	-$1,188.88 (-$1,215.39, -$1,162.38)
Anaesthesiologist fee ($135.09 - $360.24)	$185.00	-$679.97 (-$714.70, -$645.23)	-$904.97 (-$939.70, -$870.23)
Ophthalmologist fee ($260.00 - $434.75)	$268.09	-$702.44 (-$738.68, -$666.21)	-$702.44 (-$738.68, -$666.21)
Nursing wage ($28.10 - $43.36)	$35.21	-$726.17 (-$766.48, -$685.86)	-$734.31 (-$775.69, -$692.94)

Abbreviations: Min = minimum; Max = maximum; CI = confidence interval; OR = operating room

Results of the sensitivity analysis are presented in a tornado diagram (Figure 3). The vertical line represents the incremental cost from the base case analysis (-$729.96). Each of the horizontal bars depicts the impact of that associated variable on overall incremental cost. Varying the cost assumptions for these four variables did not change the finding that EUS was less costly compared to EUA. Changing the OR cost had the greatest impact on incremental costs, with savings over $1,000 per patient observed in the case of costly OR time. When the anaesthesiologist fee was varied, savings were also increased. Changes to ophthalmologist

fees or nursing wages had little effect on the incremental costs since both of these items were nearly equivalent cost components for both EUS and EUA.

Figure 3: Tornado diagram of incremental cost of EUS compared to EUA



In addition to varying costs, a sensitivity analyses that assumed an equal number of planned procedures for patients undergoing EUS and EUA was also performed. In this analysis the number of planned procedures for EUS was assumed to be equal to EUA (n=162), while the rate of failed sedations remained at 12.5%. This resulted in an incremental cost of $723.04 (-$758.58 to -$687.51) and an incremental effect of -0.25 (-0.4, -0.1) successful procedures (representing 0.25 fewer successful procedures per EUS). Varying the assumed number of planned procedures did not change the overall savings of EUS compared to EUA.

3.4.2 Probabilistic sensitivity analysis

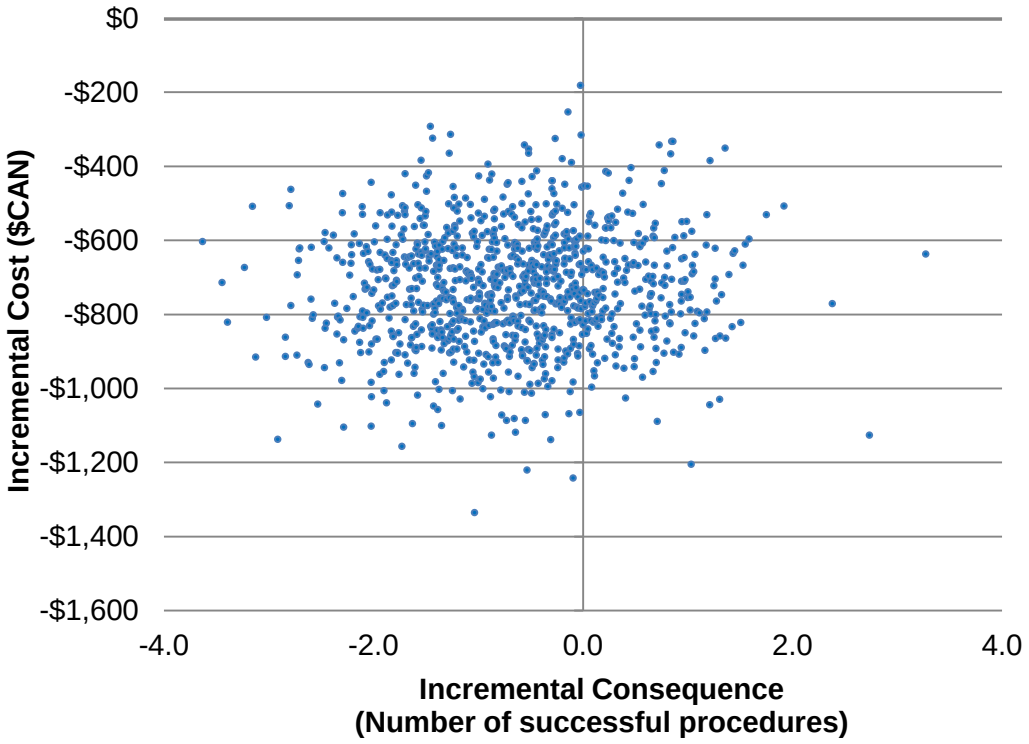
The results from the PSA validated the base case analysis and showed that EUS resulted in cost savings of $729 compared to EUA (Table 10). The distribution of Monte Carlo simulations across the cost-effectiveness plane demonstrated EUS to be less costly than EUA 100% of the time, while EUA resulted in more successful procedures 77% of the time (Figure 4). The probability of EUS being cost-effective compared to EUA was 23%.

Table 10: Incremental costs and effects per patient of EUS compared to EUA in probabilistic sensitivity analysis

Strategy	Mean cost per patient (95% CI)	Mean no. successful procedures per patient (95% CI)	Incremental cost (95% CI)	Incremental number of successful procedures (95% CI)
EUS (clinic)	$406 ($401, $411)	1.39 (1.34, 1.42)	-$729 (-$738, -$719)	-0.678 (-0.738, -0.618)
EUA (OR)	$1135 ($1125, $1145)	2.06 (2.02, 2.11)		

Abbreviations: CI = confidence interval; EUS = exam under sedation; EUA = exam under anaesthesia; OR = operating room

Figure 4: Scatter plot of ophthalmologic exam strategies



Results from the PSA showed the number of planned procedures and probability of successful sedation to be the most sensitive model inputs.

3.5 Cost-minimization analysis

In total, ten patients failed EUS and had procedures completed during a second appointment in the OR. A CMA was carried out to determine the incremental costs when effectiveness (number of successful procedures) is assumed to be equivalent between strategies. The mean cost to complete failed EUS procedures in the OR for was $1,363.51 (95% CI $1,076.12, $1,650.89) per patient. These costs were added to the EUS strategy. Results from the cost-minimization analysis that compared the total cost to complete all planned procedure for study patients with an EUS prior to an EUA (n=58) are shown in Table 11. The mean total cost for patients who visited the clinic first (including those with repeat exams) was $586.31 (95% CI $438.08, $734.54), approximately $190 more than the mean cost per patient in the base case EUS. Exams carried out in the clinic prior to the OR, resulted in mean cost savings of $555.37, approximately $187 less than the incremental savings per patient in the base case.

Table 11: Cost to complete all planned procedures, including repeat visits as a result of failed EUS

Strategy	Mean cost (95% CI)	Incremental cost (95% CI)
Clinic (n=58)	$586.31 ($438.08, $734.54)	-$555.37 (-$818.13, -$282.74)
OR (n=48)	$1,141.68 ($1,027.51, $1,255.85)	-

4 DISCUSSION

Findings from this study illustrate a significant cost-savings when paediatric ophthalomological exams are carried out in a nurse-led hospital-based outpatient clinic using chloral hydrate sedation, compared to exams carried out in the OR using GA. The clinic approach is particularly favorable when fewer procedures are planned per exam.

Increased healthcare spending has led to an increased focus on more efficient allocation of healthcare resources and dollars. As a result, cost-saving interventions that do not adversely affect overall outcomes are attractive to decision-makers.[8] In a typical cost per quality-adjusted life year (QALY) approach, economic evaluations of new health care technologies seek to maximize QALY gains and report results in an incremental cost-effectiveness ratio (ICER). The ICER is subjected to an acceptability criterion, such as a threshold of $50,000. Interventions with ICERs below the decision-maker's threshold for acceptability are determined to represent

good value for money and a recommendation to accept the technology is made *even though it will result in a net increase in health expenditures*. Hospitals however, operate on fixed budgets and cannot easily apply a cost-per-QALY approach with threshold decision-making. Moreover, hospitals are under increasing pressure to reduce expenditures and demonstrate value for money in their services. Economic evaluations allow health care institutions to determine where the adoption of less expensive interventions and clinical care processes could lead to increased efficiencies and where obsolete interventions and practices may be removed. By focusing on maximizing allocative efficiency of a fixed budget, hospitals can spend a relatively greater proportion of their budget on higher value-for-money interventions and reduce consumption of costly health care resources. Such changes are particularly desirable when the quality or effectiveness trade-off with cost does not pose morbidity or mortality risks, as was the case with EUS resulting in fewer successful examination procedures at significantly lower cost. Results from the cost-minimization analysis show that even when failed clinic sedation procedures had to be repeated in the OR (to achieve equivalent effectiveness), EUS still resulted in significant cost-savings compared to EUA. In the base case analysis, savings of $730 per patient was associated with 0.66 fewer completed procedures per patient exam. EUS represents an easily adopted hospital-based intervention. As a dominant strategy with negligible set-up costs, savings can be expected even when patient throughput is low. It is also expected that children and parents would prefer EUS over EUA, but this was not assessed in the present study.

The cost of sedation compared to GA has been examined in the field of paediatric dentistry.[9,10] Results from a study carried out in the UK showed the mean cost of GA per child to be £359.91, 46.6% more costly than conscious sedation (£245.47) using combined techniques such as inhaled nitrous oxide with sevoflurane or intravenous agents such as midazolam and fentanyl.[9] Children in that study who failed conscious sedation were assumed to undergo GA, with subsequent direct medical costs being accounted for in estimates of the mean cost per patient. A second cost analysis in paediatric dentistry carried out in the US, also compared GA to oral conscious sedation.[10] In that study, authors accounted for the direct costs as well as parent time loss, and showed the mean societal cost of GA per child to be $2,698 USD, 22.5% more costly than conscious sedation ($2,203 USD). The cost of sedation in the US study was sensitive to the complexity of the dental treatment, which was measured in 'treatment units' as per a recognized fee schedule.[10] Neither of these two studies weighed incremental savings of conscious sedation against differences in effectiveness in a full cost-effectiveness analysis.

Results from dentistry may not be the best comparison to ophthalmology exams, as many dental procedures are painful. Sedation used in echocardiography provides a better comparison since the procedure is painless and requires the patient to be still. Roach et al[11] compared the direct medical costs of chloral hydrate sedation with midazolam and propofol. Results from that study showed the mean cost of deep sedation using midazolam and propofol per child to be $3,628 USD, five times more costly than sedation with chloral hydrate ($709 USD).[11]

Unlike other studies that compared the cost of sedation to GA, results from the present study report incremental costs per successful procedure gained. Both cost and outcomes data were based on a cross-over cohort of patients who underwent exams in the clinic and OR within a eight-month period. The cross-over short-interval design averts bias due to baseline differences between groups in all patient-related variables and in particular, due to age and weight, two factors known to greatly impact how well a child responds to sedation.[1] Additionally, it allowed for data from a small sample size to be maximized. The short-interval cross-over design is especially useful for economic evaluations in health care institutions that are often transitioning from older to newer processes, clinical practices or health technologies, as it reflects the natural process of diffusion and change that occurs within institutions. Disadvantages to the cross-over design include a lack of randomized allocation and the fact that a proportion of exams carried out in the OR were a result of a failed sedation in the clinic, therefore biasing our results towards greater OR effectiveness. In a separate analysis, our group reviewed 1,509 sedation episodes at The Hospital for Sick Children and reported a failure rate of only 3.31%, which is much lower than 12.5% seen in the current study.[1] In the present study, 73% of patients had an EUS prior to an EUA, which may have increased the propensity for failed sedations in the analysis. Nonetheless, this was the most conservative approach to compare the cost and effectiveness of sedation to GA, since it incorporated fewer successful exams in the clinic. In the PSA, assuming a higher probability of sedation success resulted in a more favorable cost-effectiveness ratio for EUS compared to EUA.

Another limitation is that the number of planned procedures and time per exam in the OR may have been overestimated. It was more likely that EUAs were used for teaching purposes, which may have led to more procedures being performed. This may also have contributed to higher costs, as a result of additional time and resources required in the OR. The inclusion criteria limited the number of planned procedures to a maximum of three per appointment in order to

attempt to control for cases wherein an EUA was used for extra procedures or teaching. It is unknown whether or not ophthalmologists preferentially scheduled exams in the OR when more procedures were required. It is also unclear whether or not the OR operates at capacity and whether or not there is a shortage of paediatric anaesthesiologists resulting in a queue for service. These factors were not taken account in the analysis but would potentially lead to additional savings for EUS compared to EUA. In the present study a bundled OR cost based on case-costing from a subset of study patients was extrapolated to all EUA patients as individual case costs were not available for all study patients . In the sensitivity analysis the price of OR services had a significant impact on incremental cost, a finding that may be useful to individual centers who can use the results from this study and a knowledge of local OR costs to predict cost-effectiveness in their own institutions.

Other limitations to this study included the short time horizon, which failed to take into account wait times, in particular for exams scheduled in the OR. The modeling of costs and outcomes over a single episode of care was intended to capture any additional visits or care required as a result of adverse events. None of the patients in this study experienced adverse events that required additional health care resources with the exception of additional time spend in the PACU or sedation unit. Prolonged length of stay was accounted for through the cost of additional nursing time. The present study did not assess patient or family preferences, satisfaction, or differences in health-related quality of life between treatment groups.

5 CONCLUSION

This was the first full cost-effectiveness analysis to compare chloral hydrate sedation to GA for pediatric ophthalmology patients. Ophthalmology exams carried out in a nurse-led sedation outpatient clinic offer significant cost-savings for young children who are unable to tolerate conscious painless eye exams and imaging. The study represents a unique application of a short interval cross-over study design in health economic evaluation. This approach mitigates sources of bias that affect non-experimental designs and reflects the natural process by which new health care technologies and practices are adopted within institutions. EUS represents an easily adopted hospital-based intervention with negligible set-up costs, with savings that can accrue even when patient throughput is low.

This report may be useful to institutional and regional health care decision-makers requiring evidence to support and fund optimal institution-based care. The findings may also benefit clinical practitioners wishing to establish clinic-based sedation units as well as patients and parents who may seek alternatives to conventional OR based anaesthesia for routine ophthalmologic procedures. We demonstrate that following NICE recommendations for mild to moderate sedation using chloral hydrate in children under 15 kg who require sedation to tolerate painless procedures produces significant cost savings.

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TECHNICAL APPENDIX

Table 1: Description of calculations used for cost inputs

Description of model input	Calculation	Sample calculation
Opthalmologist fee*	[Frequency of procedure per arm x OHIP fee for procedure(s)]/ Number of patients per arm	[(25 x $260.00) + (10 x $434.75) + (5 x $308.85)]/ 40 = $309.79
Anaesthesilogist fee*	(Frequency of patients per arm x OHIP baseline fee) + (Number of points per arm x OHIP fee per point)/ Number of patients per arm	(40 x $120.08) + (171 x $15.01)/40 = $185.00
Chloral hydrate	(Mean volume administered per arm (mL) + mean waste volume (mL)) x Price per mL	294 x $0.05 = $14.70
OR bundle*	[(Frequency of patients per arm with visits after May 1, 2009 x patient level OR price) + (Frequency of patients per arm with visits before May 1, 2009 x Mean OR price)]/ Number of patients per arm	[(15 x $375) + (10 x $418) + (5 x $624)) + (10 x $472)]/ 40 = $441
Nursing wage (sedation unit)	Mean LOS sedation unit per arm x Hourly wage for 1 nurse	2.23 x $35.21 = $78.52
Nursing wage (PACU)	Mean LOS PACU per arm x Hourly wage for 0.5 nurse	0.99 x $17.61 = $17.59
Nursing wage (SDAU)	Mean LOS SDAU per arm x Hourly wage for 1 nurse	2.34 x $35.21 = $82.40
Parent time loss	Mean LOS per arm x Hourly wage for 1 parent	4.04 x $23.70 = $95.75

Table 2: Ophthalmologist fees assigned to planned procedures

Description of procedure(s)	Fee	OHIP fee code
Exam only (general)	$260.00	Z850, E982
Exam + Retcam	$260.00	Z850, E982
Exam + Plugs	$260.00	Z850, E982
Exam + retcam + suture removal	$260.00	Z850, E982
Exam + debris removal	$260.00	Z850, E982
Exam + retcam + B scan	$306.55	Z850, E982
Exam + A scan	$308.85	Z850, E982, J108C, J108B*
Exam + retcam + A scan	$308.85	Z850, E982, J108C, J108B*
Exam + ERG	$318.00	Z850, E982, G439, G852*
Exam + retcam + ERG	$318.00	Z850, E982, G439, G852*
Exam + contact lens fitting	$434.75	Z850 + E982
Exam + retcam + contact lens fitting	$434.75	Z850 + E982
Failed sedation	$22.45	A234

* technical component (technician required)
Abbreviations: OHIP=Ontario Health Insurance Plan

Table 3: Anaesthesiologist fees assigned in addition to base fee ($120.08)

LOS; patient age	Fee	Number of points assigned
15 minutes; > 1 year	$135.09	1
30 minutes; > 1 year	$150.10	2
45 minutes; > 1 year	$165.11	3
1 hour age; > 1 year	$180.12	4
1 hour 15 minutes; > 1 year	$210.14	6
1 hour 30 minutes; > 1 year	$240.16	8
1 hour 45 minutes; > 1 year	$285.19	11
2 hours; > 1 year	$330.22	14
2 hours 15 minutes; > 1 year	$375.25	17
15 minutes; < 1 year	$165.11	3
30 minutes; < 1 year	$180.12	4
45 minutes; < 1 year	$195.13	5
1 hour; < 1 year	$210.14	6
1 hour 15 minutes; age < 1 year	$240.16	8
2 hours age < 1 year	$360.24	16

Abbreviations: LOS=length of stay