THE HOSPITAL FOR SICK CHILDREN

DEPARTMENT OF ANESTHESIA & PAIN MEDICINE

CHIEF’S REPORT TO THE REVIEW COMMITTEE

2009 – 2013
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1. Members of the Department

ANESTHESIOLOGISTS

Mark Crawford, MBBS, FRCPC, Associate Professor
Anesthesiologist-in-Chief
Curtis Joseph and Harold Groves Chair in Anesthesia and Pain Medicine

Ross Barlow, MD, FRCPC, Assistant Professor

Steven Berdock, MD, FRCPC, Assistant Professor, Director of Liver Transplantation

Bernard Braude, MBChB, FRCPC, Assistant Professor

Stephen Brown, MD, FRCPC, Associate Professor, Director Chronic Pain Program

Fiona Campbell, MD, FRCA, Associate Professor, Co-Director Center for Pain Management

Karen Cybulski, MD, FRCPC, Assistant Professor

Joost de Ruiter, MBChB, FRCPC, Assistant Professor, Director Regional Anesthesia, Equipment Coordinator

Tara Der, MSc, MD, FRCPC, Assistant Professor, Director of Craniofacial and Neuroanesthesia

Bruce Dodgson, MD, FRCPC, Assistant Professor

Tobias Everett, MBChB, EDRA, FRCA, Assistant Professor

Carol Grant, MD, FRCPC, Assistant Professor

Eric Greenwood, MD, Lecturer

Jason Hayes, MD, FRCPC, Assistant Professor

Helen Holtby, MBBS, FRCPC, Assistant Professor, Interim Head, Division of Cardiac Anesthesia

Lisa Isaac, MD, FRCPC, Assistant Professor

Cengiz Karsli, MD, FRCPC, Assistant Professor

Sheelagh Kemp, MD, FRCPC, Lecturer, Director of Satellite Anesthesia and Sedation

Mark Levine, MBChB, DA, FRCPC, Associate Professor, U of T Anesthesia Residency Program Director

Igor Luginbuehl, MD, Associate Professor, Pharmacy and Therapeutics Representative

Bruce Macpherson, MD, FRCPC, Assistant Professor, Associate Chief, Clinical Director

Clyde Matava, MB ChB, MMed, Assistant Professor, Coordinator Departmental Rounds and Undergraduate Education

Jason Maynes, MD, PhD, Assistant Professor, Director of Research

Conor Mc Donnell, MB MD, FFARCSI, Assistant Professor, Director Patient Safety and Quality Program

M. Elizabeth McLeod, MD, FRCPC, Assistant Professor, Pediatric Anesthesia Conference Coordinator

Basem Naser, MBBS, FRCPC, Associate Professor, Director of Acute Pain Service

Elaine Ng, MD, FRCPC, Assistant Professor, Residency Site Coordinator, Director Simulation

James O’Leary, MBChB, BMedSci, MM (Clin Epi), FCARCSI, Assistant Professor

Arie Peliowski, MD, FRCPC, Assistant Professor

Guy Petroz, MD, Associate Professor, Director Qatar initiative, Medical Informatics

James Robertson, MD, FRCPC, Assistant Professor, Director Pre-Anesthesia Clinic

Lawrence Roy, MD, FRCPC, Professor

Illavajady Srinivasan, MD, FRCA, FRCPC, Lecturer, Director Fellowship Program, Bariatric Anesthesia

Elod Szabo, MD, PhD, FRCPC, Assistant Professor

Katherine Taylor, BMed, MMed, PG Dip Echo, FANZCA, Assistant Professor, Director of Renal Transplantation
Gail Wong, MBBS, FANZCA, Assistant Professor
Christian Zaarour, MD, Assistant Professor

ASSOCIATE STAFF
Mandy Lam, MD, FRCPC

CLINICAL EPIDEMIOLOGIST
Bradley Johnston, PhD Assistant Professor, Dept of Anesthesia, Institute for Health Policy, Management & Evaluation, U of T; Scientist, Child Health Evaluative Sciences, Research Institute

ANESTHESIA ASSISTANTS
Steve Jarvis, RRT
Marie Little, RN
Richard Suozzi, RRT

CLINICAL NURSE SPECIALISTS / NURSE PRACTITIONERS
Lorraine Bird, RN, BScN APN Acute Pain
Natasha Mills, RN, NPA
Lori Palozzi, RN, MScN, ACNP, NP Acute Pain
Jennifer Stinson, RN, PhD, CPNP, NP Chronic Pain
Jennifer Tyrrell, RN, MN, APN Chronic Pain

PROGRAM MANAGER, STRATEGY
Sharleen Friedman, RN, BAS

RESEARCH SUPPORT STAFF
Teichert Anouk-Martine, PhD, Research Associate
Kristofer Bandayrel, MPH, Project Coordinator
Shanil Ebrahim, PhD, Post-doctoral Fellow
Carolyne Pehora, RN, MN, Clinical Research Nurse Coordinator
Roman Pekhlets, PhD, Research Associate
Mohan Sarkar, PhD, Research Technician I
Sandra Singhroy, BSc, Research Technologist II
Michael Tropack, PhD, Research Associate
Ramesh Vanama, PhD, Lab Project Coordinator

ADMINISTRATIVE STAFF
Emma Spence, Administrative Supervisor
Annette Addison, Billing Clerk
Marie Gennaro, Administrative Coordinator
Portia Krishnan, Administrative Coordinator
Shue Lin Loo, Administrative Coordinator, Division of Cardiac Anesthesia
Melissa Mckay, Senior Secretary
2. Executive Overview
Dr. Mark W. Crawford, Anesthesiologist-in-Chief

The Department of Anesthesia and Pain Medicine at SickKids (hereafter called the Department) is committed to excellence in clinical care, research, education, innovation, and patient safety. As I look back over the past five years, I am excited about the opportunities and challenges that were presented to me, but most excited about the strides we have made in each of these areas. Taking already successful clinical programs to the next level, developing new programs and partnerships, recruiting new staff to advance our clinical and academic mandate, and the unique academic achievements that have afforded us international recognition are just some of the things that I as Chief am proud of.

I am pleased to present this executive overview of the outstanding work and accomplishments that recognize our team in the Department.

Clinical Programs
The Department provides anesthetic care to over 20,000 neonates, infants, and children each year (Table 1), making it one of the most clinically active pediatric anesthesia departments in the world. Our clinical mandate is broad and encompasses the care of all surgical subspecialty patients as well as medical patients requiring diagnostic and therapeutic interventions. This distinguishes us from many other pediatric anesthesia departments in Canada, whose mandate is less comprehensive.

Our perioperative environment combines diversity and volume of patient populations. Our 37 faculty (34.5 FTE) (Table 2) provide anesthetic care to the most challenging pediatric patients in Canada, and it is important to recognize everyone’s highly valued contributions in world-class quality and service excellence. The caseload is characterized by a large number (Table 1) of tertiary and quaternary patients, which are inherently complex and associated with multisystem disease. One-third of cases are ASA Physical Status III or IV (ASA distribution: I (33%), II (33%), III or IV (33%)).

Table 1: Clinical Volumes

<table>
<thead>
<tr>
<th></th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>O.R. Case volume</td>
<td>11,490</td>
<td>11,375</td>
<td>11,759</td>
<td>12,117</td>
<td>11,781</td>
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<tr>
<td>Hours</td>
<td>25,150</td>
<td>24,583</td>
<td>25,347</td>
<td>25,541</td>
<td>24,992</td>
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<tr>
<td>Satellite Case volume</td>
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<td>7,433</td>
<td>7,547</td>
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<td>8,535</td>
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<tr>
<td>Hours</td>
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<td>8,473</td>
<td>8,743</td>
<td>8,408</td>
<td>8,759</td>
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<tr>
<td>Acute Pain Service</td>
<td>1,022</td>
<td>930</td>
<td>899</td>
<td>928</td>
<td>1,010*</td>
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<tr>
<td>Chronic Pain Clinic</td>
<td>464</td>
<td>522</td>
<td>698</td>
<td>839</td>
<td>1,047</td>
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<tr>
<td>Pre-Anesthesia Clinic Consults</td>
<td>877</td>
<td>896</td>
<td>993</td>
<td>1036</td>
<td>1186</td>
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<tr>
<td>Telephone assessments</td>
<td>667</td>
<td>2110</td>
<td>3340</td>
<td>4290</td>
<td>4089</td>
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</table>

* estimated year to date
Table 2: Distribution of FTE by Clinical, Teaching, Research, and Administrative Activity.

<table>
<thead>
<tr>
<th>Name</th>
<th>FTE</th>
<th>Clinical/Teaching FTE</th>
<th>Research FTE</th>
<th>Administration FTE</th>
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<td>Barlow, Ross</td>
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<td>de Ruiter, Joost</td>
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<td>Lugimbuehl, Igor</td>
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<td>Robertson, James</td>
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<td>Roy, W. Lawrence</td>
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<td>Zaarour, Christian</td>
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<tr>
<td><strong>Total</strong></td>
<td>34.5</td>
<td>28.70</td>
<td>3.30</td>
<td>2.50</td>
</tr>
</tbody>
</table>

While main O.R. case volume and hours worked have remained relatively constant over the five years, there was a 22% increase in number of satellite cases (Table 1). This was driven largely by increases in the number of cases in MRI (75% increase), hematology/oncology, and GI endoscopy (approximate 50% increase each). Approximately 42% of our entire caseload currently occurs outside the main O.R. This type of practice will continue to expand. Currently, anesthetizing locations outside the main O.R. include ten Diagnostic Imaging sites (2CT, 4 IGT, 2 MRI, 1 MEG, and 1 Nuclear Medicine), three cardiac catheterization laboratories, and four other satellite locations (burn unit, GI, oncology, and Princess Margaret Hospital). The total number of satellite locations exceeds the 16 operating sites in the main O.R.
**Acute and Chronic Pain**

Over the past five years, there have been several innovative advances in Acute Pain (Section 3A) and Chronic Pain (Section 3B) under the leadership of Drs. Basem Naser and Stephen Brown, respectively. These include (1) developing and enhancing clearly formulated clinical policies, practice guidelines, and care plans (2) dedicated daily consultant and fellow coverage in acute pain (3) creation of a Pediatric Pain Fellowship (4) introduction of a Transitional Clinic to follow complex patients at risk of transitioning from acute to chronic pain, and (5) creation of a pain handbook and an electronic application to aid the management of pain. Referrals to our multidisciplinary chronic pain program have more than doubled in the past five years (Table 1). In the past year in particular there have been significant advances in pain management and program development through ongoing partnerships with the Ministry of Health and Holland Bloorview Rehabilitation Centre (Section 3B).

**Pre-Anesthesia Clinic**

The Pre-Anesthesia Clinic (Section 3C) has undergone considerable growth in the past 5 years. Dr. James Robertson took over leadership of the clinic in 2009. The goal is to assess preoperatively all children scheduled for elective surgery. The number of clinic consultations has burgeoned. Telephone assessments increased by 513% and formal clinic consultations increased by 35% (Table 1). Our team of anesthesiologists and nurse specialists has led several initiatives, including the design and development of educational pamphlets for patients and parents, e.g., a ‘coming for surgery’ video, web materials, and guidelines for parental presence at induction of anesthesia. These materials can be accessed via our website (http://www.sickkids.ca/VisitingSickKids/Coming-for-surgery). With the recent departure of the clinic’s remaining APN, increased nursing and administrative support is needed to realize the screening of all patients preoperatively.

**Division of Cardiac Anesthesia**

A Division of Cardiac Anesthesia (Section 3D) was formed within the Department in 2012. In terms of the three pillars of academic medicine, it is envisaged that divisional status will help promote excellence in clinical care, research, and education. Integration within the Labatt Heart Centre will facilitate academic enrichment through collaborations with other cardiovascular specialists in a multidisciplinary setting. There has been opportunity to expand the boundaries of cardiac anesthesia research, which has traditionally been confined to hemodynamics, electrophysiology, and pharmacology. For example, collaborations between Dr. Jason Maynes and Dr. John Coles of Cardiovascular Surgery have accelerated involvement in novel areas of research in cell and molecular biology, and helped create a critical mass of researchers in these areas. Dr. Helen Holtby is the Interim Division Head and an international search is underway.

In 2013, an advanced Fellowship in pediatric cardiac anesthesia was introduced. Under the guidance of members of the Cardiac Division, fellows admitted to the program gain experience in all aspects of the perioperative care of children with heart disease. The fellowship program capitalizes on an annual caseload of approximately 600 children undergoing open-heart surgery, together with more than 1,000 procedures in the CDIU and MRI.
Quality Program
The last departmental external review identified the absence of a departmental quality program. Time and effort was devoted to the creation and ongoing development of a Quality Program in order to guide and report safe, effective, timely, efficient, equitable, patient-centered care. A description of the program, led by Dr. Conor Mc Donnell, is in Section 4.

Bariatric Program
In 2011, a Bariatric Program was introduced in collaboration with STOMP (SickKids Team Obesity Management Program). Under the leadership of Dr. Ilavajady Srinivasan, this program has provided care to 23 patients in the past three years. The surgical procedures include laparoscopic banding, sleeve gastrectomy and gastric bypass. Preoperatively, the Pre-anesthesia Clinic assists in preparing these patients through focused evaluation of obesity-associated complications. Postoperative pain management is supported through the Acute Pain Service.

Integrated Sedation Model
Under the leadership of Dr. Mark Crawford, a project was initiated to develop a model to standardize the practice of procedural sedation throughout the hospital while ensuring safe, effective, efficient, equitable and timely patient/family centered care. The vision, guiding principles, scope of practice, model concept, governance structure, roles and responsibilities, technology and education recommendations and quality indicators were defined in 2012 and subsequently approved by the MAC. We have developed an implementation strategy and we are pilot testing aspects of the model. Details are in Section 7.

Recruitment
The Department continues to attract talented anesthesiologists who support our core mandate of providing the highest quality patient care, research, and education. Recruitment of new faculty began in 2009 to enhance competency in basic science research, clinical research, education, and simulation. Recruitment was possible through support from Perioperative Services and successful negotiations with the MOH (there is ongoing effort to secure additional FTEs). This recruitment effort aligns not only with our academic mission but also our strategic succession plan for fostering the development of future leaders in pediatric anesthesia. Four new faculty were recruited after completion of their fellowship at SickKids.

Dr. Clyde Matava joined in 2009 as a clinician-educator. He since completed a Master’s degree in Education. He is a member of the Undergraduate Educational Committee, the Faculty Development Committee, the Continuing Professional Development Committee, and the executive of the Canadian Pediatric Anesthesia Society, at which he holds the continuing medical education portfolio. He has twice received the Robert Creighton Award for Excellence in Resident Clinical Teaching. His focus in education is improving access to e-learning resources, including the development of quality web based training resources and a multi-center pod cast collaboration.
Dr. Tobias Everett was recruited in 2012 as a clinician-educator and clinician-investigator. He has twice received the Robert Creighton Award for Excellence in Resident Clinical Teaching (2012 and 2013). Dr. Everett is enrolled in the Master’s of Science Clinical Trials program at the University of London, UK. His research focus is medical simulation and he is becoming a national leader in this area. He is primary investigator on three international multi-center studies in simulation and is Chair of the Trans Canadian Telemedicine pediatric anesthesia rounds. He has received the U of T Department of Anesthesia, Merit Award to study inter-professional team simulation.

Dr. James O’Leary joined in 2012 as a clinician-investigator. He received a Master’s in Clinical Epidemiology with honours, and recently submitted his research thesis to the Doctor of Medicine (Anesthesia) program at the University College in Cork, Ireland. The focus of this work (carried out at SickKids) was pain and sensory processing in children with sickle cell disease. His interest includes elucidating the long-term neurocognitive effects of general anesthesia in children.

Dr. Jason Maynes joined the staff in 2011 as a clinician-scientist. Dr. Maynes’ research productivity has been quite extraordinary. His focus is biophysical techniques to study protein structure and function, mitochondrial bioenergetics, and drug design (see Section 9). Along with his scientific knowledge and skill, he has an innate ability to collaborate across boundaries to advance research and innovation. Dr. Maynes was appointed Director of Research in 2012.

Along with physician recruitment, two additional strategic positions were identified that would enhance the Department and differentiate us from other pediatric hospitals in world-class quality and service excellence.

The first additional strategic recruit was a clinical epidemiologist to participate in and provide support for clinical research in pediatric anesthesia and related areas. Dr. Bradley Johnston PhD was hired in 2011. Trained at McMaster University, his particular expertise is in systematic reviews and meta-analysis. This innovative strategy to enhance research productivity and knowledge translation has proven to be immensely successful. Dr. Johnston leads collaborative teams in publication and extramural funding, and mentors faculty and trainees in research methodology and biostatistics. He leads an emerging evidence synthesis methods unit, with a particular emphasis on methods for improving the interpretation of summary estimates from patient-reported outcomes.

The second additional strategic position was introducing a Program Manager, Strategy, for the Department. Ms. Sharleen Friedman was hired in October, 2013. With her background in heath care and organizational development, Sharleen has provided support and leadership in strategy planning for the Chronic Pain Program (Section 3B), the joint partnership with Holland Bloorview (Section 3B), the MOH Task Force to advance pediatric chronic pain management in the Province, and the Integrated Sedation Model (Section 7).
Retention
To help ensure staff retention, the Department has provided opportunities for professional
development. These investments have given members the help they need to advance their
careers and will yield significant returns over time.

Examples include:

- The Department has supported four faculty to obtain Master’s degrees:
  Clyde Matava (Education)
  Katherine Taylor (Clinical Epidemiology)
  Tobias Everett (Clinical Epidemiology)
  James O’Leary (Clinical Epidemiology)
- University of Toronto Patient Safety Centre Certification:
  Conor Mc Donnell
  Guy Petroz
- Research Laboratory start-up and ongoing funding:
  Jason Maynes
  Elod Szabo
- Leadership Development Course for Physicians in Academic Health Centers:
  Bruce Macpherson
- Specialized training in Regional Anesthesia:
  Ilavaday Srinivasan
- Rotman School of Management Advanced Health Leadership Program:
  Fiona Campbell, Guy Petroz, Mark Crawford

Educational Activities
The Department is committed to excellence in education. We provide training for medical
students, residents, and fellows in Anesthesia (Section 5) and other specialties such as Family
Medicine, Emergency Medicine, Pediatrics, and Dentistry. The department also accepts 15 to 25
international observers per year.

Clinical teaching includes hands-on teaching in the O.R., classroom, pain services, and clinics.
Since 2010, resident teaching effectiveness scores have surpassed those for other U of T
hospitals (Figure 1). Protected time was secured for the residency (Dr. Elaine Ng) and fellowship
(Dr. Ilavajady Srinivasan) Program Directors (0.2 FTE, one day per week each). Ensuring the
Directors have this time each week is a challenge at the current staffing level.

To recognize the commitment and dedication of our staff to teaching and mentoring, the
Department introduced new Excellence in Clinical Teaching Awards (Section 5). These include
(1) The Robert Creighton Award for Excellence in Resident Clinical Teaching, (2) The Award for
Excellence in Fellow Clinical Teaching (3) The Award for Excellence in Postgraduate Clinical
Teaching, and (4) The Award for Excellence in Undergraduate Clinical Teaching.
Several staff also received coveted *external* teaching awards. These include:

- Dr. Clyde Matava: U of T New Faculty Teaching Award, 2012
- Dr. Basem Naser: Interprofessional Teaching Award for Outstanding Teaching both within and outside the Anesthesia Community, University of Toronto, 2011
- Dr. Elaine Ng: Dr. Gerald Edelist Award for Excellence in Graduate Teaching, University of Toronto, 2011
- Dr. James Robertson: Dr. John Desmond Award for Excellence in Undergraduate Teaching, University of Toronto, 2011
- Dr. Elaine Ng: Network of Excellence in Simulation in Clinical Teaching and Learning (NESTCL), Ontario (Travel Award), 2009

Our fellowship program is one of the largest pediatric fellowship programs in the world. We receive over 100 applications to our program annually. We train 8 to 12 fellows annually over the course of a one-year general clinical and research fellowship. Fellows are exposed to all surgical subspecialties. There is opportunity for involvement in clinical and basic research, with the expectation of contributing to at least one peer-reviewed manuscript. The aim is to encourage interest in research and to impart the knowledge and skills required for completion of their projects. The program is committed to ensuring the development of fellows on an individual basis, including fostering caring, ethical and professional doctor-patient/parent relationships. Fellows consistently assert their satisfaction with the clinical experience at SickKids.

In addition to the general fellowship in Pediatric Anesthesia, the Department has established formalized advanced fellowships (Section 5) in (1) Pediatric Pain Medicine, (2) Research, and (3) Pediatric Cardiac Anesthesia.

The Department is committed to Continuing Medical Education (Section 5):

1. Weekly Departmental Grand Rounds
2. The Pediatric Anesthesia Conference. This conference is well recognized by the pediatric anesthesia community and receives accolades internationally. Our members, under the
leadership of Dr. Elizabeth McLeod, organize this 3-day biennial conference. It attracts international participation by approximately 275 academic and community pediatric anesthesiologists. The conference is funded by attendance fees and solicited industry sponsors.

(3) The Department hosts the Canadian Pediatric Anesthesia Society (CPAS) conference in conjunction with the PAC. The one-day CPAS conference is held on the Friday preceding the PAC and is organized by a committee of Department members.

(4) Telemedicine. The Department hosts Canada-wide pediatric anesthesia rounds via teleconference three times per year.

(5) Members of the Department give invited lectures and present research papers at major national and international anesthesia meetings (Section 10).

Simulation
The Simulation Program (Section 6), a relatively new departmental initiative, is proving to be a very valuable education tool, and has made enormous strides under the leadership of Drs. Elaine Ng and Tobias Everett. It is mandatory for every resident to attend the anesthesia simulator. Fellows have opportunity to participate as learners and also as facilitators and researchers. Our unit is the lead site in two international multicenter studies, and leads an international collaboration, the MEPA program (spanning Canada, USA, Europe, and Australia). Innovative programs were introduced, including Telesimulation (broadcasting SickKids anesthesia simulation internationally), and in-situ whole-real-team interprofessional simulation (Trauma team, CDIU, IGT, cardiac MRI, MRI, OR). Community outreach programs have begun, including sessions at NYGH and OMA workshops. Protected time for Drs. Ng, Everett, McLeod and Roy to run the program continues to be a challenge at the current staffing level.

Research
A strategic aim 5 years ago was to develop basic science and clinical research in the Department. Traditional metrics would be used to assess research productivity: peer-reviewed publications, awards, and grants. With respect to grants, the aim was to obtain principal investigator grants in particular. Another metric would be number of Scientist/Associate Scientist appointments to the Research Institute.

As a result of this strategic vision, our research productivity has grown substantially. The number of peer-reviewed publications increased more than three-fold, and this has been sustained over the past two years (Figure 2). Our research is accepted by the specialty’s leading journals (Section 10). Principal Investigator grants (representing research led by department members) were non-existent in 2009, but have increased exponentially in subsequent years (Figure 3). Our research has attracted several awards, which is testimony to the quality of our work (Section 10). We have investigated important clinical questions, and we translated the new knowledge directly to patient care, in keeping with the SickKids mission. Our results have been achieved with only 3.35 FTEs devoted to research (Table 2).

Our research is multidisciplinary and we continue to engage other departments/divisions to work collaboratively to tackle questions we have in common. Collaborations thus far include Cardiology, CVS, Clinical Pharmacology, ENT, Neurosurgery, Ophthalmology, Orthopedics,
Plastics, Psychiatry, and Respiratory. There is potential to expand this list and to develop collaborations with U of T researchers outside SickKids. This will provide opportunities for new peer-reviewed funding.

Figure 2: Peer reviewed Publications

![Peer reviewed Publications graph]

Figure 3: Principal Investigator Grants

![Principal Investigator Grants graph]

Principal Investigator grants—selected recent highlights:

- Jason Maynes (co-PI) awarded Canada Foundation for Innovation Grant ($946,008) for the development of a modern X-ray crystallography and structural biology facility at SickKids (2013)
- Jason Maynes, Mark Crawford awarded Canadian Anesthesiologists' Society Research Award ($30,000) for their research entitled "Discovering Pathologic Anesthetic Effects in Autistic Children: The Role of Anesthesia-Induced Mitochondrial Dysfunction" (2013)
- Elod Szabo ranked first (of 45 applicants) and awarded the CIHR/SickKids Foundation New Investigator Research Award ($299,000) "Understanding Voltage-Gated Sodium Channel-Related Cardiomyopathy" (2012)
- Jason Maynes, awarded Garron Foundation Award ($48,800) for his study “Repurposing of FDA-approved drugs to Prevent Cardiotoxicity in Cancer” (2012)
- Tobias Everett awarded a Royal College of Physicians and Surgeons of Canada, Medical Education Research Grant ($45,278) for his study “Simulation-based assessment for pediatric anesthesiology: a prospective, multicenter study” (2012)
- Katherine Taylor awarded the CAS Baxter Corporation Canadian Research Award ($20,000) in Anesthesia for her study ”Evaluating Precision of Therapy-Milrinone” (2012)

**Merit Awards:**
The Merit Award is the highest level of peer-reviewed funding offered by the University Department of Anesthesia. Funding is awarded on a competitive, peer-reviewed basis for 2 years. Several Department members have been successful in this grant competition (Table 3).

<table>
<thead>
<tr>
<th>Recipient</th>
<th>Year</th>
<th>Amount</th>
</tr>
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<tbody>
<tr>
<td>Fiona Campbell</td>
<td>2009</td>
<td>$20,000</td>
</tr>
<tr>
<td>Elod Szabo</td>
<td>2010</td>
<td>$60,000</td>
</tr>
<tr>
<td>Gail Wong</td>
<td>2010</td>
<td>$60,000</td>
</tr>
<tr>
<td>Elod Szabo</td>
<td>2011</td>
<td>$80,000</td>
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<tr>
<td>Gail Wong</td>
<td>2011</td>
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</tr>
<tr>
<td>Gail Wong</td>
<td>2011</td>
<td>$40,000</td>
</tr>
<tr>
<td>Katherine Taylor</td>
<td>2011</td>
<td>$80,000</td>
</tr>
<tr>
<td>Jason Maynes</td>
<td>2012</td>
<td>$40,000</td>
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<tr>
<td>Clyde Matava</td>
<td>2012</td>
<td>$40,000</td>
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<tr>
<td>Tobias Everett</td>
<td>2013</td>
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<td>Elod Szabo</td>
<td>2013</td>
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<tr>
<td>Jason Maynes</td>
<td>2013</td>
<td>$80,000</td>
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With respect to number of Scientist/Associate Scientist appointments to the Research Institute, in 2009 there was but one appointment (Mark Crawford, Senior Associate Scientist); today four members are appointed (Jason Maynes, Elod Szabo, Bradley Johnston (all Scientist Track), and Mark Crawford) and two others are in the process of applying (Tobias Everett, James O’Leary).

**Qatar/International**
In the past four years we have had the privilege of working under the auspices of SickKids International to build a department of pediatric anesthesia in Qatar. Under the leadership of Drs. Basem Naser and Guy Petroz, several faculty are involved in this important venture to improve the care of children in Qatar. The project requires ongoing visits, and many committed hours consulting on challenges and making specific recommendations. Major emphasis includes developing an HR plan for recruitment and retention of pediatric anesthesiologists, provision of anesthesia fellowship opportunities at SickKids, and clinical policy development. Dr. Guy Petroz is seconded to SickKids International as the director of the anesthesia initiative (0.2 FTE) and recently led a successful initiative aimed at the prevention and management of
perioperative pain (Section 3A). A description of reports and presentations is in the CD.

The Curtis Joseph and Harold Groves Chair in Anesthesia and Pain Medicine
The Curtis Joseph and Harold Groves Chair in Pediatric Anesthesia was established in 2013 under the auspices of the University of Toronto, The Hospital for Sick Children, and the SickKids Foundation. This $3 million endowment was made possible through generous donations from Mr. Curtis Joseph and the Groves family, who recognize the importance of advancing the broad and diverse body of knowledge in our field.

Several members of the Hospital and Foundation worked tirelessly over the past three years to establish this endowed Chair. We are indebted to their efforts.

Dr. Mark Crawford, Anesthesiologist-in-Chief, was named the inaugural holder in 2013.

The Chair comes with an academic commitment to make significant contributions to scholarship in our field and to build research infrastructure within the Department. The vision for the Chair is to generate new knowledge about pressing and important clinical issues. One such issue is the effect of general anesthesia on neurocognitive outcomes. There is mounting evidence to suggest that administration of general anesthesia early on in life (age < 4 yrs) can lead to long-term neurocognitive abnormalities. While several published animal studies are robust, their results cannot be extrapolated to humans. Human studies to date are retrospective and controversial. The issue has reached the lay press, and parents are asking questions and expecting answers. Well-conducted studies are needed to address this issue.

This endowment will be used to carry out (1) basic science research into the cellular mechanisms of anesthesia-induced injury and options for specific protective strategies, (2) clinical studies to evaluate susceptibility to injury in specific populations e.g. children with autism, and (3) large database studies in collaboration with the Institute for Clinical Evaluative Studies (ICES). Further detail can be found in the Research Section (Section 9).

Herbie Fund Department of the Year
In November 2013, the Department was recognized as the Herbie Fund Department of the Year. This charitable fund has impacted the lives of over 700 children from about 90 countries over the last 35 years. Since 2009 the Department has waived its fees for all Herbie Fund patients, thereby allowing more money to go directly to the fund. As active participants in global health work, members of the Department have cared for over 90 Herbie Fund children in the past 3 years alone. The Department is uniquely positioned to provide important clinical care to these children during the most critical phase of their hospitalization.

Each year, the Herbie Fund Committee selects a 'Doctor of the Year' to recognize "outstanding commitment and dedication to Herbie Fund patients." The Herbie Fund Committee chose to recognize the Department in 2013 for our "medical support, leadership, and commitment to
Herbie patients." The award was presented at the annual Mistletoe Ball & Auction, held in November, 2013.

**Future Developments**

**Anesthesia Information Management System (AIMS)**
The importance and need for an AIMS was recognized over 10 years ago. The attributes of an AIMS include (1) enhance patient care (2) facilitate data management, (3) link data throughout the continuum of peri-op care, and (4) permit improvements to quality, point-of-care decision support, and case costing.

The business proposal and budget, created by 12-member steering committee, was approved by MAC, COC, and Finance and Auditing. While much work is ongoing, there were several unexpected delays. For example, there was a change in ownership of the selected vendor, and the new parent company did not support AIMS as a strategic directive. The Clinical Operations Council has approved a second RFP combining AIMS and physiological monitors (targeted for April 2014). Acquisition of AIMS is absolutely crucial to our strategic execution.

**Ongoing Recruitment**

International searches are in progress for:

1. Head, Division of Cardiac Anesthesia. As noted above, following the formation of the Cardiac Division in 2012, Dr. Holtby was appointed Interim Head and an international search is currently underway. Three candidates (two external, one internal) have applied for the position of Head, and are being interviewed by a search committee that includes key stakeholders in anesthesia, cardiac surgery, cardiology, PICU, and CCU.

2. A leader in pediatric pain. While leaders in Acute and Chronic Pain Programs have deep expertise in their respective programs, the introduction of a new pain leader to head both portfolios has the potential to amalgamate programs, maximize efficiencies, and stimulate research and educational activities. An international search will begin shortly.

3. A clinician-investigator with subspecialty focus in transfusion medicine. Anesthesiologists transfuse more blood and blood products than any other physician group in the hospital. Yet there remain several gaps in knowledge with respect to the utilization of blood and blood products within the perioperative environment. The opportunity for evidence-based clinical practice guideline development as well as basic and clinical research is tremendous. Potential candidates have been identified.

4. A clinician-investigator with focus in Patient Safety to expand the Quality and Safety Program. As more attention is given to Patient Safety and Quality, the volume of work exceeds the capacity of one individual.

There is ongoing effort with the MOH to secure additional departmental FTEs.

**National Database**

Databases are important resources in healthcare. While it is challenging to define quality in clinical care, databases can be used to provide objective measures on the quality and cost of care and to analyze rare adverse events.
The use of databases in pediatric anesthesia is in its infancy. Currently, at least five major pediatric centers in Canada have an AIMS. As more and more departments across Canada acquire an AIMS, the pooling of data from multiple institutions will be possible.

The vision is to build a Canadian national database of outcomes in pediatric anesthesia as a means to 1) estimate incidences of serious adverse events, 2) identify risk factors, 3) establish benchmarks for standards of care, and 4) facilitate the conduct of large scale multicenter outcomes research and quality improvement initiatives. Ultimately, the goal is to use the database to improve patient safety. Upon acquisition of an AIMS at SickKids, we will work collaboratively with the vendor (who brings experience with clinical database management in the US) to establish a robust national database that will be a valuable resource for understanding the contribution of anesthesia to patient outcomes. We see our Department leading the way on this vital national initiative.

Research Funding

**Curtis Joseph and Harold Groves Chair in Anesthesia and Pain Medicine**: As noted above, the Department is extremely fortunate to have acquired a $3 million endowment, the Curtis Joseph and Harold Groves Chair in Anesthesia and Pain Medicine. Two other potential endowments are under consideration:

**Pediatric Pain**. The Foundation has committed to raising funds for pediatric pain, and it remains to be seen whether funds are sufficient to support a Chair.

**Pediatric Anesthesia Research/Education**: A physician-initiated fundraising effort is under discussion, whereby a research chair endowment ($3m) would be contributed to by the practice plan, the university department, and the Foundation.

It is anticipated that new endowments will be used to help support the recruitment and mandate of one of the positions listed under ongoing recruitment.

Governance

Plans are underway to establish a formal governance structure that will include leaders in the areas of clinical, cardiac, education, research and pain. This will address several issues expressed by team members. A governance structure will empower others to act on day-to-day issues, improve communication, increase transparency, broaden accountability, develop future leaders, and provide opportunities to expedite decision-making. Empowering this group of leaders will enable the Chief to focus on broader issues that support the entire Department.

Challenges and Opportunities

As shown in this report, many of our goals have been attained; however, we have much work to do, as highlighted in feedback from hospital engagement surveys, the June 2013 retreat, and recent round table discussions. For example, there is a perception that too much importance is placed on research. This was unexpected considering that clinical care and academic
productivity have been and will continue to be important mandates for the Department. In addition, I am remiss in not seeking opportunities to fully recognize faculty accomplishments and support the team on day-to-day clinical matters. At times I may have focused more on the big achievements and missed opportunities to recognize individual performance. We must continue to emphasize and develop our academic and institutional missions (institutional citizenship, research and education). We must also make some modifications to the leadership structure and practices in order to ensure that all aspects of our mission, including day-to-day issues of importance to patient care, are sufficiently discussed and get adequate ‘air time’ at departmental meetings. Finally, the Chief must endeavor to ensure maximal availability to all department members.

Thus several initiatives are underway:

1. Maximize departmental meetings to communicate important initiatives, seek departmental feedback, and recognize staff achievements
2. Designated weekly walk-in hours whereby staff may visit the Chief to discuss any matter
3. Individual meetings with all faculty (separate from their performance management) to discuss their individual goals and how I might assist them
4. An upcoming Departmental meeting with external and internal organizational management expertise to create a vision, mission and set of values that are developed collaboratively—values the team will commit to and to which they will hold each other and me accountable
5. Creation of a Leadership Team with representation from clinical care, research, education, pain and cardiac anesthesia. This formal governance structure will improve communication, enhance transparency in decision-making, and broaden accountability.
6. Review portfolio leadership in the Spring of 2014 (and subsequent every 5 years). This will enhance job satisfaction and develop future leaders.

Acknowledgments
It has been my pleasure to work with and lead a dedicated team of anesthesiologists and support staff that I believe are second to none. To them many thanks. In particular, my thanks to members who contributed to this report: Drs. Brown, Campbell, Everett, Holtby, Johnston, Levine, Macpherson, Matava, Maynes, McDonnell, McLeod, Naser, Ng, Robertson, Srinivasan, Szabo, and Wong.

No one person’s accomplishments are without the commitment of others in time, funding and support. I will take this opportunity to extend my sincere gratitude to Dr. James Wright, Chief of Perioperative Services; Ms. Mary Jo Haddad, former President and CEO; and Dr. Brian Kavanagh, Chair, Department of Anesthesia, University of Toronto for their unwavering support.

My thanks as well to Ms. Sharleen Friedman, Program Manager Strategy, for her help in preparing this report.
3. Clinical Program
3A. Acute Pain Service
Dr. Basem Naser, Director Acute Pain Service

Overview
The Acute Pain Service (APS) is a consulting service within the Department of Anesthesia and Pain Management at The Hospital for Sick Children. Referral to the APS is initiated through consults from surgeons, pediatricians, anesthesiologists and other healthcare professionals. The APS focuses on pain management in children undergoing major surgical interventions or who are diagnosed with painful medical conditions such as sickle cell disease, leukemia and cancer. Pain management modalities used by the APS include Patient Controlled Analgesia (PCA), Nurse Controlled Analgesia (NCA), epidural analgesia, peripheral nerve blocks, and opioid infusions in selected patients. The APS also helps in managing patients who are weaning from opioids, and benzodiazepines, and in the management of end-of-life issues in children receiving palliative care.

This is a five-year review of clinical, educational, administrative, and research activities for the period of July 1, 2009 to June 30, 2013. The clinical data analyzed in this review reflects calendar year, and 2013 data are not final at the date of this report.

Clinical
Clinical activity is the primary focus of the APS. The APS prides itself on quality clinical service as demonstrated by unsolicited positive comments from patients and colleagues. Many positive clinical changes have been made over the past 5 years. The “Transitional Clinic” was established to follow complex acute pain patients after hospital discharge in order to reduce the incidence of transition from acute to chronic pain. A Pediatric Pain Fellowship Program was created to train clinicians in pediatric pain management and allow timely assessment and follow-up of children with chronic pain. Other developments include the creation and incorporation of “Safe Pain Medication Limits” for local anesthetics and PCA opioids, a pain management protocol for children undergoing epilepsy surgery, expansion of Nurse Controlled Analgesia, and the introduction of continuous transverse abdominis plane (TAP) blocks to manage postoperative pain in general surgical patients and renal transplant recipients. With the Pediatric Intensive Care Unit the APS developed best practice Clinical Guidelines for weaning children from opioids, benzodiazepines, and chloral hydrate. The APS also helps manage end of life issues in children receiving palliative care, and children presenting with acute exacerbations of chronic pain. One of the major clinical challenges facing APS is the chronic shortage of APS nursing coverage; this is becoming more of an issue recently because of the increased involvement of APS in clinical initiatives, and increased numbers and complexity of the medical patients.

The following graphs present an overview of some of the activities of the past 5 years. Please note that data in all graphs represent calendar year Jan-Dec, and is the reason 2013 shows low numbers (Year to Date = July 21, 2013).
Clinical Consults to the APS Note: Data for 2013 are from January to July only.

**Number of Consults by Year**

Distribution of 4299 consults in a calendar year (Jan-Dec).

**APS Modalities of Intervention**

APS management modalities and interventions in 4299 consults. Empty = incomplete entries.
Patient Controlled Analgesia. Note: Data for 2013 are from January to July.

Yearly administration of PCAs.

Epidural Analgesia. Note: Data for 2013 are from January to July.

Yearly administration of epidurals.
Continuous Transverse Abdominis Plane (TAP) Block. **Note: Data for 2013 are from January to July.**

![Continuous TAP Blocks by Year](image)

Yearly distribution of continuous TAP blocks.

Non-PCA Opioid as the primary intervention in APS consults. **Note: Data for 2013 are from January to July.**

![Yearly distribution of intravenous (non-PCA) and oral opioids in 293 APS consults.](image)
Complex Pain Consults. *Note: Data for 2013 are from January to July.*

**Medical Pain Consults by Year**

Yearly distribution of medical consults for patients with severe or complex pain.

**Surgical and Medical Specialties Consulting the APS**

Distribution of surgical and medical subspecialties requesting APS consultation.
Orthopedics continues to be the main beneficiary of the APS with 1605 consults of the 4299 total. PAMOT = Multiorgan Transplant

**Education**

Education is a priority for the APS. Various healthcare professionals rotate through the APS, including anesthesia fellows, residents, pediatric fellows, nurses, pharmacists, and health care professionals from other countries. Formal bedside teachings and discussions are conducted daily. Many educational initiatives have been developed since 2009 such as:

**Pediatric Pain Fellowship Program**

i. This is a one-year fellowship program that is developed in collaboration with the chronic pain team. It is intended for anesthesia fellows who want to pursue a pediatric pain management career.

ii. The program started in July 2010. Two international fellows have since graduated. A third fellow started in July 2013.

iii. The program curriculum and outline is included in the CD.

**Pain Handbook**

i. A Pediatric Pain handbook was published internally in 2009/2010. It is formatted in 2 versions, a short version (133 pages) that contains pain medication dosing and pain management protocols, and a comprehensive version (255 pages) that contains additional information about regional analgesia, common pediatric painful conditions, ASRA guidelines for regional anesthesia, management protocol for local anesthetic cardiac arrest, and tables about pain medication compatibility and interactions.
Fellows Rotation in the APS
i. An annual average of 8-10 fellows rotate through the APS. Over the past 5 years a total of 40 fellows completed 4-5 week rotations in APS. Please refer to the Fellowship Program section for names.

Residents Rotation in the APS
i. Resident rotation in the APS is optional, and is based on requests from the pediatric anesthesia residents. The APS is proactive in accommodating all interested residents for a 1-2 day attachment with the APS clinical team. On average, 6-8 residents are accommodated annually.

Education by Advanced Practice Nurses (APNs)

i. Pediatric Pain Management Introduction. The APNs conduct regular training sessions for all new nursing recruits. On average, 200 new nurses are oriented every year. Approximately 1000 nurses have been trained over the past 5 years.

ii. Advanced Interactive Pain Management Program. The program is open to all health care practitioners and builds on past experiences in pain assessment and management with a focus on more complex issues utilizing a problem-based approach. The program educated approximately 60 nurses per year for a total of 300 since 2009.

iii. In-service training in use of Pain Management techniques. In-Service training to selected group of nurses on use of PCA and Epidural Pumps is offered to approximately 40 nurses per year. Over the past 5 years approximately 200 nurses have been trained.

iv. “Conquering the Hurt” Conference and Workshop. A bi-annual one-day conference and a workshop conducted in November are offered to inter-professional health care providers. Health care providers from other institutions and the community regularly attend this conference. Members of the APS are actively involved in the planning and facilitation of this conference. The conference program is available upon request.

v. Teaching pain management to undergraduate nursing students. This is a University of Toronto program conducted 3 times per year and attended by 150 students yearly. Approximately 750 students attended the course over the past 5 years.

vi. University of Toronto Interfaculty Pain Management Curriculum. Conducted once a year for 40 students. Approximately 200 students attended the course over the past 5 years.

vii. Preceptorship for graduate nursing student. One graduate nursing student per year for 4 months - 5 students were mentored over the past 5 years.

Pre and Post APS Rotation Assessment for Anesthesia Fellows
i. An initiative to evaluate the impact of APS on anesthesia fellows’ pediatric pain knowledge and practice started in 2010. It consists of attitude/knowledge surveys and MCQs that are administered at the beginning and end of the fellowship year.

ii. Approximately 15 fellows, 3 APS staff, and one nurse practitioner have completed the MCQs. The 70 MCQs cover areas in basic science, clinical practice, acute pain, chronic pain, opioid conversion, regional analgesia, and medical pain management. A full analysis of the data has not yet been completed. The survey and MCQ’s are available in database format.
ii. A poster describing the handbook was presented at the U of T Faculty Development Day in 2011. The handbook is popular among fellows, residents and international visitors. An electronic version of the handbook in PDF is also available and has been distributed to interested healthcare professionals. Please refer to the handbook for details.

Development of PediPain App
i. An innovation grant from SickKids ($10,000) was awarded in 2011 to Dr. Clyde Matava who in collaboration with other members of the Department (Dr. Basem Naser, Dr. Arie Peliowski, Lori Palozi NP, and Natasha Mills NP) developed an iphone App called “PediPain” to help pediatric health care professionals to manage pain in children. The App consists of sections addressing basic pain management using the balanced analgesia model, pharmacological guidelines, pediatric dosing calculator, and opioid convertor.
ii. The final release of the App is imminent, pending incorporation of additional features.

Developing Pediatric Pain Management System in Qatar
i. The APS is actively involved in a 5-year international project in collaboration with SickKids International (SKI) to establish a pediatric pain management system in the Middle East at Hamad Medical Corporation (HMC), Qatar. A comprehensive plan with a road map approach was developed, and it is in the implementation phase. Regular visits to Qatar of 1-2 weeks duration every 1-2 months are conducted by various members of the APS team. This is a successful and well-received initiative by the Qatari.
ii. Please refer to the project details in the SKI reports located in the CD.

Pain Management Courses in Qatar
i. As part of the Pediatric Pain Management System initiative in Qatar, an extensive Inter-Professional educational campaign was developed by members of the APS and chronic pain service at HSC and introduced to HMC Pediatric health care professionals.
ii. Dr. Clyde Matava in collaboration with members of the APS and others created a pain curriculum. The educational course consists of 2 modules conducted over 2 days, and repeated over a 2 week period in October 2012 and April 2013. It was administered to approximately 500 health care professionals with more registered for future courses. This course was well-received, and plans are in place to offer it annually, administered through training of local health care professionals.

iii. The course-needs assessment surveys, curriculum, attendance statistics, evaluation, and impact data are available upon request.

Pain Awareness Symposium in Qatar
i. In December 2012, a one-day symposium attended by approximately 400 pediatric health care professionals was conducted in Qatar. Members of the APS, Chronic Pain Service, Physiotherapy, and Child Life presented lectures to an inter-professional audience in various aspects of pain physiology, assessment and management.

ii. The symposium content and evaluations are available upon request.

Pain Clinical Mentorship in Qatar
i. Three series of clinical mentorships (1 week each) were conducted by APS physicians and nurses in 2011, 2012 (Dr. Basem Naser, Lori Palozzi NP, and Lorraine Bird APN). These visits consist of clinical rounds and presentations to a mixed audience of physicians and nurses in Hamad Medical Corporation. These sessions were very informative and helpful in advancing pediatric pain management in Qatar. Details about the visits are available in SKI reports in the CD.

Administration
The APS is involved in many administrative initiatives and activities related to pain management in the hospital. As outlined in the recommendations of an external review in 2008, lack of adequate protected time to further develop these administrative initiatives continues to be a challenge.

Pain Assessment Policy
i. In 2010, a hospital wide comprehensive Pain Assessment Policy was created through a collaborative effort between APS members, and other stakeholders in the hospital. The policy is located in the CD.

Pain Management Policy
i. In 2010, a hospital wide comprehensive Pain Management Policy was created through a collaborative effort between the APS, members of the chronic pain team and other stakeholders in the hospital. The policy is located in the CD.

Epidural and Peripheral Nerve Blocks Policy
i. In 2011/2012 the Epidural and Peripheral Nerve Blocks policy was rewritten.

ii. The current policy is available on the Hospital Intranet and will be replaced by the new policy upon approval.
PCA Policy Update
An update to the PCA policy to incorporate an increasing prescription of Nurse Controlled Analgesia is underway. Final publication is pending approval.

Medical Directives Renewal
i. Medical directives for the APNs are updated and renewed annually.
ii. The latest versions are available upon request.

Creation of Epidural and Nerve Blocks CAAD Pumps Medication Library, and Safety Limits
i. In 2010/2011 an extensive project to create a body weight based “Local Anesthesia Medication Library” for thoracic epidural, umbar epidural, peripheral nerve block, and continuous TAP block was developed in collaboration with Pharmacy and the IV PUMP Project. This was a time and resource consuming initiative; however it was essential for the safe delivery of regional analgesia in the hospital.
ii. Datasheets of the working principles, formulas and limits are available through Pharmacy and the APS.

Creation of PCA Drug Library and Safety Limits
i. In 2012 a Medication Library and safety limits initiative for PCA was developed in collaboration with Pharmacy. Implementation is pending trials and final review.

Preparation of Pain Medications by Pharmacy
i. Since 2009/2010 all epidural infusion mixtures are prepared by the pharmacy as recommended by an external review in 2008.
ii. Currently the APS enters the details of the local anesthetic solution into the electronic order system (KIDCARE) as a STAT order. The pharmacy requires 1 hour as a minimum preparation time.
iii. This initiative shifted the responsibility of preparing the solution from the nursing staff in PACU and floors to the pharmacy.
iv. Preparation of PCA solutions is partially carried out by the pharmacy (only the high concentration mixtures). The goal is to have pharmacy prepare all PCA solutions; however, this continues to be a challenge due to resource limitations.

Formatting the APS fellow coverage during weekdays and weekends
i. To improve quality and continuity of APS coverage during the weekdays and weekends, various models of coverage were trialed and reassessed. Currently, the fellow who covers APS on weekdays also covers APS on weekends. This has resulted in a major improvement in the quality of clinical care and a fulfillment of a recommendation of the 2008 external review.
Formatting the APS Staff Coverage on Weekdays and Weekend

i. Prior to 2009, the APS physician had dual responsibilities to the Operating Room and APS during the day. In addition, APS night time coverage was carried out by a non-APS on-call Anesthesia Staff. This was changed to the current system in which the Acute Pain Service Staff is exclusively responsible for updates on the status of all patients admitted to the Acute Pain Service, irrespective of weekday or time of day.

ii. Quality and continuity of care have benefited from this change as demonstrated by positive feedback from APS nurses, floor nurses, and colleagues.

Creation of a new Pediatric Pain Policy in Qatar

i. In 2012 a new Pediatric Pain Policy was created at Hamad Medical Corporation (HMC) in Qatar. This was done in collaboration between members of the APS at Sick Kids and the Pain Task Force in Qatar. The policy is pending final approval by HMC.

Research

Generating new knowledge in pediatric pain is a priority for the APS. This is in alignment with the departmental core mandate of research productivity. Many challenges face this goal such as lack of dedicated pain researchers and the scarcity of dedicated academic time. Our research activity includes defining and assessing acute pain prevalence in children, auditing acute pain interventions, understanding opioid-induced hyperalgesia, and optimizing pain management using balanced analgesia model. Understanding the basic pathophysiology of pain and developing novel management strategies are future directions for the APS; however, this is a resource intensive goal that will require recruitment of clinician investigators and the cooperation of various stakeholders and disciplines.

Conclusion

The APS continues its tradition of excellence in clinical care as outlined in a previous external review in 2008. Many positives changes have ensued since that review including dedicated APS coverage, an advanced fellowship in pediatric pain, the Transitional Pain Clinic, electronic pain medication libraries and pump safety limits, mixing of pain medications by pharmacy, updates to epidural and peripheral nerve block policies, opioid-benzodiazepine withdrawal clinical guidelines, and a trial of a new epidural transition protocol.

International work to advance pain management in Qatar has enhanced our reputation. The pain handbook and the iphone APP are successful projects that need dedicated time and resources for further improvement. Ongoing projects include auditing pain management for foot surgery and establishing a standardized epidural transition protocol.

Ongoing work in the APS includes evaluating nursing resources to ensure daily patient coverage and the appropriate allocation of time for clinical initiatives such as policy development, quality audits and educational materials. Advancing the pain research agenda is a priority. This has to be approached through recruitment of a clinical investigator and the involvement of various stakeholders and disciplines within the hospital.
3B. Chronic Pain Program
Dr. Stephen Brown, Director Chronic Pain
Dr. Mark Crawford, Anesthesiologist-in-Chief
Ms. Sharleen Friedman, Program Manager Strategy

Overview
The Pediatric Chronic Pain program at SickKids was developed in 1998. The first of its type in Ontario, the clinic provides care for children with chronic pain on an outpatient basis. Over the 15 years of its existence, the chronic pain program has evolved and expanded to not only involve clinical care but also has ongoing educational and research components. Children with chronic pain typically require an integrated, multimodal treatment program (often referred to as the 3 P’s) incorporating pharmacological, psychological, and physical therapies. Evidence suggests that such an approach, delivered in a ‘child-centered’ program provides the best outcomes for patients and families (Eccleston et al, 2002 and 2003; American Pain Society, 2001).

The Chronic Pain Division comprises a multidisciplinary team that includes a staff anesthesiologist, psychiatrist, pain nurse practitioner, pain fellow, physical therapist, and psychologist. In our clinic, each team member works closely with the child and family to provide comprehensive diagnostic assessment and treatment planning. Our chronic pain anesthesiologists also provide consultation on inpatients with chronic pain.

Retention of staff has been remarkable. We have had very little or no turnover, which has allowed the clinic staff to develop deep expertise and consistency within this patient population. The quality and success of our chronic pain clinic staff is secondary to none in Canada – and rivals those of the top centers in the United States (Boston and Philadelphia) and beyond (Great Ormond Street, London, UK).

The volume of patients has grown from 143 in 2001 to over 1000 in 2013, more than doubling since 2008 (Figure 1). Table 1 shows the distribution of patients by diagnosis.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSK</td>
<td>34%</td>
<td>32%</td>
<td>35%</td>
<td>39%</td>
<td>43%</td>
</tr>
<tr>
<td>CRPS</td>
<td>13%</td>
<td>7%</td>
<td>7%</td>
<td>12%</td>
<td>19%</td>
</tr>
<tr>
<td>Abdominal Pain</td>
<td>18%</td>
<td>16%</td>
<td>28%</td>
<td>22%</td>
<td>11%</td>
</tr>
<tr>
<td>Chronic Widespread Pain</td>
<td>10%</td>
<td>30%</td>
<td>14%</td>
<td>16%</td>
<td>11%</td>
</tr>
<tr>
<td>Neuropathic Pain</td>
<td>16%</td>
<td>8%</td>
<td>7%</td>
<td>4%</td>
<td>9%</td>
</tr>
<tr>
<td>Headaches</td>
<td>9%</td>
<td>8%</td>
<td>9%</td>
<td>6%</td>
<td>7%</td>
</tr>
</tbody>
</table>

MSK = musculoskeletal
In 2009, the Chronic Pain Clinic was seen as a “victim of its own success.” Increasing new referrals and follow-up patients, a burgeoning wait list, increasing patient complexity and patient care demands, and limited resources all necessitated implementation of a number of initiatives detailed in the following sections.

**Staffing**

Additional FTE’s were added across the multidisciplinary team (Table 2).

<table>
<thead>
<tr>
<th>FTE by Discipline</th>
<th>Prior to 2009</th>
<th>2009 to current</th>
<th>Funding source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthesiology</td>
<td>0.2</td>
<td>0.4</td>
<td>Dept. of Anesthesiology and Pain Medicine</td>
</tr>
<tr>
<td>Nursing</td>
<td>0.9</td>
<td>1.3</td>
<td>1.3 FTE Perioperative Services</td>
</tr>
<tr>
<td>Physiotherapy</td>
<td>0.4</td>
<td>0.8</td>
<td>Rehab Services</td>
</tr>
<tr>
<td>Psychology</td>
<td>0.5</td>
<td>1.0</td>
<td>Perioperative Services</td>
</tr>
<tr>
<td>Psychiatry</td>
<td>0.3</td>
<td>0.3</td>
<td>Dept. of Psychiatry</td>
</tr>
<tr>
<td>Admin Assistant</td>
<td>0</td>
<td>1.0</td>
<td>Perioperative Services</td>
</tr>
<tr>
<td>Pain Fellow</td>
<td>0</td>
<td>1.0</td>
<td>Dept. of Anesthesiology and Pain Medicine</td>
</tr>
</tbody>
</table>
**Chronic Pain Clinics**

Multidisciplinary clinics were increased from four to six per month in 2009 (Table 3). Fourteen new patients and 16 follow-ups are seen monthly at these clinics.

Two additional clinics were created (Table 3):

(i) a nurse practitioner-led clinic that is used to follow-up specific patients (that do not require the entire multidisciplinary team). These clinics are held twice monthly. On average, 8 follow-up patients are seen each month at the nurse-led clinics.

(ii) a Transitional Pain Clinic was introduced to follow surgical patients at high risk of transitioning from acute to chronic pain. This type of clinic is a first for Canada.

<table>
<thead>
<tr>
<th>Type of Clinic</th>
<th>Prior to 2009</th>
<th>2009 to current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multidisciplinary</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Nurse-practitioner led</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Transitional</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

The impact of these operational changes on patient wait times is shown in Table 4. Average wait time for patients deemed in critical need for multidisciplinary assessment (21-day triage) decreased by 79% from a peak of 55 days in 2009/10. Similarly, average wait time for the 42-day triage decreased by 35% from a peak of 73 days in 2009/10. We have realized these decreases in wait time despite a 57% increase in monthly referrals (Table 4). Of concern, the 90-day triage has increased, in part due to patient unavailability and lack of timely supporting documentation from referring physicians. Overall, percent out of window wait time has more than halved since 2008/9 (Table 4).

Table 4: Chronic Pain Program Referrals and Wait Times*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average New Referrals per Month</td>
<td>12</td>
<td>14</td>
<td>18</td>
<td>17</td>
<td>22</td>
</tr>
<tr>
<td>AWT (21 day triage)</td>
<td>40</td>
<td>55</td>
<td>1.0</td>
<td>24.5</td>
<td>10.7</td>
</tr>
<tr>
<td>AWT (42 day triage)</td>
<td>37.8</td>
<td>73.0</td>
<td>48.7</td>
<td>35.5</td>
<td>47.5</td>
</tr>
<tr>
<td>AWT (90 day triage)</td>
<td>106.0</td>
<td>122.9</td>
<td>88.8</td>
<td>91.0</td>
<td>135.0</td>
</tr>
<tr>
<td>% Out of Window Wait Time</td>
<td>71.2%</td>
<td>65%</td>
<td>48%</td>
<td>33%</td>
<td>33%</td>
</tr>
</tbody>
</table>

*source: ARMs system (Chronic pain program launched ARMs August 2007).
AWT = Average wait time
Transitional Pain Clinic
This clinic specifically targets patients at high risk for transitioning from acute to chronic pain (based for example, on type/duration of surgery, degree of tissue injury, and pre-existing pain). Early intervention and treatment decreases the risk of transitioning to chronic pain. An aggressive preventive multimodal analgesic approach is used after surgery, and these patients are often discharged home on opioid analgesics, necessitating early follow up by the clinic. This new clinic has decreased the wait time for clinic appointment after discharge (from several months to two weeks at most). Prior to the introduction of this clinic, the Acute Pain Service (APS) was following these patients in surgical outpatient clinics and GP offices, often using telephone consultation to make treatment decisions. This process improvement has enhanced patient care, improved safety, and maximized efficiency within the APS. It is the only clinic of its type in Canada. Large resource savings are realized when transition to chronicity is prevented in even a single patient – in Canada, the annual cost of chronic pain is estimated to be $56 – 60 billion (the Canadian Pain Society, November 2013).

Chronic Pain Program Facilities
The chronic pain clinic is located at 525 University Avenue. The suite of nine rooms currently provides clinic space, a research lab, administration, and offices for our nurse practitioner, physical therapists, and psychologist. The psychology office supports both a private working office and space that allows 1:1 patient visits. The general administration area has space for administration and group therapy sessions. Overall, the current clinic space is sufficient for ongoing clinical work, research, and education.

Team Development/Mission and Vision Creation
During the last 12 months, two team development meetings (3 hours each) were held. Led by Ms. Sharleen Friedman, Program Manager Strategy and facilitated by Ms. Cindy Bruce-Barrett, Director Corporate Strategic Projects, both meetings were highly successful. The first meeting on April 16, 2013 started a dialogue about a collective vision and direction for the chronic pain program that would be firmly rooted in clinical care, research and educational excellence. Outcomes were prioritized as follows:

Model of Care Action Plan
i. Conduct an environmental scan of evidenced based chronic pain models of care and best practice
ii. Determine the preferred model of care and best practice for implementation by the SickKids chronic pain program
iii. Identify resource implications and determine an implementation plan with reasonable, achievable timelines
iv. Collaborate with other internal and external programs to leverage resources to support implementation of the preferred model of care
v. Review processes and identify opportunities for improvement as part of model of care implementation
Process of Care Action Plan

i. Based on the preferred model of care, determine the supporting processes to enhance intake, assessment, pre-clinic preparation, treatment, and follow-up

ii. Implement the necessary changes and process improvements that will help ensure the right patient receives the right level of care, at the right time and in the right place.

Collaboration Action Plan

i. Engage team members and leadership in program planning leveraging existing resources and identifying opportunities for internal and external partnerships to support implementation and sustainability of the preferred model and processes of care

ii. Based on the preferred model and more streamlined, efficient processes of care, incorporate time to enhance communication, problem solving and team building through pre-clinic huddles and/or post clinic de-briefs

iii. Provide opportunities for education and interdisciplinary rounds within weekly or monthly schedules for team members.

iv. Engage team members in developing and delivering chronic pain education/consultation to help build capacity for patient management in the community

The second meeting was held June 4, 2013 with the specific action items identified:

i. Referral Guidelines and Priority levels (draft completed and waiting sign-off)

ii. Discharge process/guidelines (benchmarking completed)

iii. Intake Process and Package development (pre-anaesthesia model)

iv. Formalized partnerships (e.g. consult with pediatrics and partner with them on patient management for patients new to SickKids; develop a process for patients who have never been to SickKids)

v. Access/scheduling procedures

vi. Outcomes/quality measures (work will be aligned with MOHLTC task force initiatives – see next section)

vii. Education

viii. Research

Ministry of Health Task Force for Pediatric Chronic Pain in Ontario

In early 2013, the Ministry of Health and Long Term Care reached out to pediatric hospitals in Ontario with the purpose of advancing pediatric chronic pain programs for the province. The governance structure focuses on clinical, education and research within pediatric pain. SickKids was approached to provide leadership to this group. Dr. Fiona Campbell is the committee Co-lead, and Dr. Jennifer Stinson and Sharleen Friedman (Program Manager, Strategy) also sit on the committee. Initial focus is on the following: standardizing treatment of care, standardizing referral guidelines, treatment algorithms, throughput of patients, core staffing requirements, process standards, and registry requirements.
At the request of the Ministry, SickKids submitted a business case for independent funding for the chronic pain clinic. The request centered on increased staffing to further decrease wait times and minimize the number of patients that are referred to U.S. hospitals for in-patient/out-patient treatment. Feedback from the Ministry is expected by April 2014.

Joint Partnership with Holland Bloorview Kids Rehabilitation Hospital (HB)
Currently, there is a lack of facilities and resources to treat children with chronic pain in an aggressive rehabilitation model. Many children have required transfer to the United States. Site visits to Boston and Cleveland confirmed the benefits of an intensive “in-patient and day-patient to out-patient program”. Discussions with the MOHLTC Task Force support the concept of a “Center of Excellence” in Ontario.

Subsequent to the chronic pain funding initiative by the government, SickKids and HB are discussing a joint partnership. HB has considerable rehab facilities that are not fully used. In addition, they currently do not have psychiatric resources available to them. Closing the identified gaps would further expand and improve the care for children with chronic pain in Ontario. Led by Sharleen Friedman, Program Manager Strategy at SickKids, an additional request is in development with HB, Anesthesia, and Psychiatry at SickKids. Pending internal approval, this proposal will be submitted to the MOH with expectation that both proposals will be reviewed and approved simultaneously.

Education
Education is an important mandate of the clinic. For a number of years, various anesthesia fellows have taken initiatives to sub-specialize in chronic pain. Starting in 2011, a formally funded and organized pain fellowship began. Our third fellow was admitted in 2013 (see full fellowship curriculum in CD).

Our chronic pain anesthesiologists also provide consultation on inpatients with chronic pain. The addition of a fellow to the multidisciplinary team has contributed significantly to seamless management of inpatient chronic pain.

In May 2012, a pain education symposium targeting patients and parents was held. A biennial pain symposium for nursing and medical staff was introduced in 2012. Dr. Fiona Campbell leads pain education for incoming residents and fellows. The entire clinic staff participates in the annual pain education week symposia at U of T, and are regular invitees to speak on pain education. The pain education website was launched in 2012. Future plans include adding educational videos to the website.

Research
Though less than 15 years old, the Chronic Pain program is one of the two leading Chronic Pain programs in Canada, the other being at Dalhousie University. Centers in the United States are difficult to compare to Canadian counterparts as they have vastly greater funding for clinical care and research and have been in existence for longer periods of time. The centers we would compare ourselves favorably to include Boston, St Louis, Philadelphia and Los Angeles.
For a decade, Dr. Patricia McGrath, an internationally recognized authority in pain research led the pain research program through our clinical service. This research was supported by grants from NIH in the United States and through The Canadian Institutes of Health Research. Dr. McGrath retired in December 2011. Ongoing research derived from her work continues through Dr. Stephen Brown and Dr. Danielle Ruskin, psychologist. Drs. Campbell, Isaac and Stinson have also conducted chronic pain research (see Section 10).

Dr. Stinson (appointed to Nursing and the Research Institute) has an established, focused program of research and has received consistent funding from the Canadian Institutes of Health Research (CIHR). The focus of primary research is on the use of information and communications technologies to (a) improve child health outcomes, and (b) promote social support networks for children and youth with chronic health conditions. Additional secondary research foci are development and evaluation of patient reported outcome measures (PROMs), knowledge translation, and inter-professional pain education activities. Below are the main areas of Dr. Stinson’s research and her awards:

(a) **Electronic pain and symptoms management diaries**  
(a) extend work developing and validating e-diaries to assess pain in other at-risk populations (i.e., sickle cell disease, inflammatory bowel disease); and (b) focus on the development and evaluation of Computerized Clinical Decision-making Support (CCDS) tools that will be employed on smartphones and web-based applications for children and youth with painful chronic health conditions. For example, Dr. Stinson will be applying in January 2014 to The Arthritis Society (TAS) to fund the development and evaluation of a CCDS tool for youth with persistent arthritis pain. She will also be applying to the Canadian Foundation for Innovation for infrastructure funds to build a pediatric mobile-health (m-health) unit at SickKids that will be linked with the Centre for Global e-Health Innovation at UHN.

(b) **Online self-management Programs.**  
The focus is on determining the: (a) essential ingredients of the online programs (dismantling studies) using a theory-driven approach, (b) minimum amount of support required to improve outcomes (health coach), (c) most appropriate person to provide that support (health care professionals, trained non-health care personnel or peers), and (d) cost-effectiveness of these programs. Grant applications are in to develop an online self-management program for young adults with chronic pain and for an online game for children with JIA (CIHR September 2013).

(c) **Patient Reported Outcome Measures (PROMs).**  
Plans are in place to submit an operating grant to CIHR to evaluate the psychometric properties of the RACER tool (transition readiness tool for youth with rheumatic conditions) in Spring of 2014 to The Arthritis Society and CIHR.

**Awards:**

<table>
<thead>
<tr>
<th>Year</th>
<th>Award Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013 - 2018</td>
<td>Peter Lougheed CIHR, New Investigator Salary Award, $250,000</td>
</tr>
<tr>
<td>2013 – 2018</td>
<td>CIHR New Investigator Salary Award, $60,000</td>
</tr>
<tr>
<td>2012 - 2012</td>
<td>The Early Career Award. The Canadian Pain Society</td>
</tr>
<tr>
<td>2011 - 2016</td>
<td>Use of ehealth Technologies to promote Pediatric Chronic Disease self-Management. Round 7 Early Research Award. Ministry of Research &amp; Innovation, $140,000</td>
</tr>
<tr>
<td>2011 – 2013</td>
<td>Canadian Arthritis Network &amp; The Arthritis Society, Network Scholar Award, $120,000</td>
</tr>
<tr>
<td>2011 – 2012</td>
<td>The MayDay Fund, Mayday Pain &amp; Society Fellowship, Media and Communications Training</td>
</tr>
<tr>
<td>2010</td>
<td>Nursing Excellence in Pain Management, Canadian Pain Society Award, $1,000</td>
</tr>
<tr>
<td>2009 – 2011</td>
<td>Ministry of Health &amp; Long-Term Care, Career Scientist Award, $350,000</td>
</tr>
<tr>
<td>2009</td>
<td>Interprofessional Nursing Project, Canadian Pain Society Award, $2,000</td>
</tr>
</tbody>
</table>
2009 Institute of Human Development, Child and Youth Health New Investigator Skills Travel Award, $5,000 (visited Dr. Chambers & Palermo’s pain and sleep labs)

2009 Canadian Pain Society Inter-professional Project Award – Nursing Research, $3,000

An overall leader in research has not yet emerged for our program. Preliminary discussions have taken place to attract such a leader. One option under consideration is to create a Chair in Pediatric Pain.

**Conclusion**

The literature reveals that comprehensive, outpatient rehabilitation, inclusive of physical, occupational and psychological therapies, have the potential to dramatically improve clinical outcomes for children suffering from chronic pain. Since 2009, we have expanded clinic capacity by increasing staff resources and clinic type and frequency. As a result, patient throughput has increased exponentially (Figure 1) and wait times have decreased (Table 1). A pediatric pain fellowship was implemented in 2011, which has helped to expand clinical capacity, enhance research opportunities, and extend educational activities.

Pursuit of funding for additional clinics and a theoretical rehab program would provide an opportunity to further leverage existing resources and to enhance the model of care creating a more coordinated, comprehensive, chronic pain program. This will ultimately better meet the needs of children and youth living with chronic pain in Ontario.
3C. Pre-Anesthesia Clinic  
*Dr. Jamie Robertson, Director, Pre-Anesthesia Clinic*

**Overview**
The Pre-Anesthesia Clinic provides anesthesia consultation and screening in order to improve quality of care for the patient and family within the perioperative period. The Clinic is provided by the Department of Anesthesia and Pain Medicine, under shared Physician and Advanced Practice Nursing leadership. Established in 2001 the Pre-Anesthesia Clinic (PAC) has undergone considerable growth in the past few years.

The mandate of the Clinic is to assess all children scheduled for elective surgery to optimize their preoperative care and experience. The goal is to identify, investigate, communicate, and plan to reduce or mitigate risks associated with the provision of anesthesia for surgical or diagnostic procedures in pediatric patients. Much time is spent in assessment, fact finding the preoperative medical status, networking and communicating concerns with the referring physician and surgeon as well as other stakeholders in order to optimize the child’s care.

The PAC also has a duty to educate, guide and alleviate the concerns of patients and their families. Discussion with patients and parents is often about the mechanics of the perioperative experience and their emotional response to it. Multiple resources including pamphlets and the newly created (2013) “Coming For Surgery Video” and “Preparing Your Child and Family for Anesthesia” website are widely by parents to better understand fasting guidelines and what to expect before, during and after surgery. These new additions to the website will help improve the overall experience. Resources such as Child Life are also encouraged to alleviate concerns of the anxious patient or family.

Consultation is available by direct referral from physicians or other stakeholders in a patient’s care. Beginning in 2011, the goal was to screen 100% of patients coming for surgery requiring “same day admission” and ambulatory surgery patients would be screened and contacted by the PAC prior to their procedures.

Achieving this goal required growth of the PAC. Support was received in the form of a full time information coordinator in 2008 and in 2009 one RN was hired to facilitate screening. Over the next 4 years staffing increased to 1.0 FTE APN, 3.8 RN FTEs (.8 – 1.0) and 1.4 information coordinators. A second APN was lost in 2012 due to a career change and with current austerity the PAC did not receive funding to replace that much needed position. The clinic formally receives 0.6 FTE physician support from the Department of Anesthesia and Pain Medicine.

Over the past 4 years the volume of patients screened has increased. In 2009, when RN telephone screening assessments began, there were 667 such assessments and an additional 877 patients were evaluated in the clinic. In 2012 the number of telephone screens increased by 550% to 4343, and the number of clinic consultations increased by 18% despite no increase in resources or time. In fact, there was a 50% reduction in APN support. In 2013, the clinic
screened 4089 patients by telephone and saw 1186 physician and APN consults, which represent increases of 513% and 35%, respectively, compared with 2009 volumes. This growth is shown graphically below.

The Advanced Practice Nurse (APN) sees patients independently and in association with the Clinic physician. The APN assists in identifying patients appropriate for telephone screening, triages questions and concerns and liaises where appropriate with the Clinic physician. The APN coordinates the flow of information gathering, networking with primary care and specialist physicians involved with patient care and ensures that information is communicated as necessary within the Clinic and to stakeholders.

The RNs are responsible for identifying patients booked for procedures under anesthesia and triaging them through chart review to either RN telephone assessment, APN consultation or formal clinic consultation, based on set criteria regarding patient and procedural complexity. They conduct telephone assessments with appropriate patients and families. There is an established screening protocol to identify issues and risks. The RN also provides education and instruction, reassurance and answers or directs questions.

Surgical survices and their respective average screening rate for the past 6 months are shown in the Table. Current barriers to screening all patients include (1) timely and complete receipt of surgical booking information and (2) staff resources for triage and assessment.
Table: Surgical services and average screening rate (May – Oct 2013)

<table>
<thead>
<tr>
<th>Service</th>
<th>CVS</th>
<th>Dental</th>
<th>ENT</th>
<th>Gastro</th>
<th>Gen Surg</th>
<th>Gynae</th>
<th>Neuro</th>
<th>Ophth</th>
<th>Ortho</th>
<th>Plastics</th>
<th>Urol</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate</td>
<td>99%</td>
<td>76%</td>
<td>9%</td>
<td>23%</td>
<td>77%</td>
<td>5%</td>
<td>29%</td>
<td>35%</td>
<td>88%</td>
<td>78%</td>
<td>91%</td>
<td>62%</td>
</tr>
</tbody>
</table>

Our clinic has a role in professional development and quality improvement. In particular, the lead APN is involved in policy development and review, education, and quality improvement. Recently we have participated in formal systematic quality improvement programs such as IMPACT to further enhance the efficacy of our clinic. The IMPACT program (Improving Perioperative Access Care Transparency) has targeted standardization of information and cases into the clinic but is yet to address consultation, networking, reporting or outcome analysis.

**Future Plans**

Goals moving forward include further increasing volumes towards the target goal of “100% of patients screened”. The Clinic will also seek to formalize assessment of the Pre-Anesthesia Consultation Clinic outcomes through surveys of stakeholders and auditing changes to perioperative plans. These goals will be achieved by continued support of the Departments of Anesthesia and Pain Medicine, Nursing and Perioperative Services. Challenges to our success include resources. At time of this report, our APN has resigned, which leaves a current vacancy but an opportunity to replace with a Nurse Practitioner. Increased RN and administrative support is also needed to help reach the target goal of 100%.
3D. Division of Cardiac Anesthesiology
Dr. Helen Holtby, Director of Cardiac Anesthesia

Overview
The Division of Cardiac Anaesthesia was formed as part of the Department of Anesthesia and Pain Medicine in 2012. Prior to this date, the care of children with heart disease was undertaken by many members of the department, with the exception of cardiac surgery and cases requiring the use of cardiopulmonary bypass. The care of this population in the operating room, catheterization laboratory and critical care unit has evolved over the last two decades with increased subspecialty focus, including the formation of clinical teams for such issues as Hypoplastic Left Heart Syndrome and airway reconstruction surgery. The division has clinical links with the Labatt Family Heart Centre (LFHC), Neonatal Intensive Care, and Diagnostic Imaging. We provide consultation and clinical care for all children with CHD and acquired heart disease undergoing investigations, cardiac or non-cardiac procedures.

There are presently nine full time staff members in the division. There is also one associate staff (superfellow), and funding for one clinical fellow per year. There are three individuals with significant research commitments (Drs. O’Leary, Szabo, and Taylor).

The clinical expertise of the members of the division is outstanding. Dr. Bruce Macpherson has been recognized by the Department of Anesthesia at the University of Toronto for clinical excellence. There is a large neonatal practice due to the caseload and demographics of children with heart disease. All members of the division have had experience with liver and lung transplantation. Until recently, Dr. Holtby was the anaesthetic lead member of the Airway Reconstruction Team. More than 50% patients are ASA 3 and higher. With respect to recruitment and retention, turnover within the division is low, and we were able to recruit steadily over the last few years. There is a balance with respect to protecting academic commitments, on-call obligations and case volumes for competence. There is a consensus that individuals need to do a minimum of 50 pump cases annually. With our current volumes, that means at most, 10 people.

Funding is available from the Department of Anesthesia and Pain Medicine for staff and also for one fellow annually. However, planning is difficult -there is no defined budget per se, either in dollars or FTE’s. Equipment is funded via the hospital capital equipment program, and through the Department but again items are all on an ad hoc basis. There is travel support for presentations at meetings and research support from the Labatt Family Heart Center.

Clinical Care
Clinical care is provided in multiple sites in the hospital. Clinic facilities are available in the atrium (4A cardiac clinic) and in the Pre-Anesthesia clinic. All elective outpatients are seen in the cardiac clinic. There are two operating rooms in the Main OR, two cardiac catheterization laboratories plus an MRI suite in the CDIU. Children with CHD
also present to other sites for investigations and non-cardiac surgery. There are plans underway for renovations in the OR to help ensure ergonomic delivery of anesthetic care. The expense of renovating these sites will be considerable, and when new construction is planned, there should be a geographically co-located Heart Centre.

A current risk to the care of children with CHD (and other critical patients) is the proposed renovation to the IGT suite and loss of the corridor, which runs on the west side of the IGT space. This corridor constitutes the only unfettered access to the OR from anywhere in the hospital, but most importantly from CCU and also from DI. It should not be closed off without some immediately proximate replacement.

The equipment available for anesthetic care of children with CHD is generally suitable, with the important exception of the lack of automated record keeping and data collection, the absence of which is a threat to clinical research and audit. There is also a need to update other monitoring equipment (NIRS monitors specifically, and this process is underway in concert with CCU and NICU).

There is a need for updated ultrasound machines (and for more availability). It is likely that echocardiography machines will be site specific in the future. While cardiology provides a strong service to the OR, it is likely that the use of echocardiography will become more widespread and part of routine anaesthetic care for major cases including outside the cardiac division. This is an opportunity where clinical expertise will need to be developed (see below).

**Staffing**
The current range of the Cardiac Anesthesia Division makes it one of the larger programmes in North America, both in terms of case volumes and number of staff anesthesiologists. In 2012 there were 666 surgical cases taking 3,214.7 hours. From January to October 2013 544 cases were done, totaling 2,829 hours. The 2012-2013 (April 1 to March 31) CDIU caseload consisted of 1,481 cases, the majority involving members of the cardiac anesthesia division. This includes 48 MRI procedures, and MRI is a likely area of growth.

A major difference between SickKids and other peer institutions (Boston Children’s Hospital, Texas Children’s, CHOP), is the full integration with the Department of Anesthesia, so that cardiac practitioners take general anesthesia on-call, do general lists etc. This has advantages in terms of clinical practice expertise, and disadvantages in terms of focus and team identity and communication with the Labatt Family Heart Center. The allocation of appropriate personnel can be challenging with this model. Multidisciplinary research within the cardiac program is more difficult as well.

**Future Development**
Plans for future development for the Division of Cardiac Anesthesia include short-term goals of managing personnel and succession planning over the next 3-5 years as several
members of the division may be viewed as at least mid-career, if not senior. There is a search underway for a full-time division head.

It would be ideal for the Division to be responsible for its own allocation of clinical assignments both from a patient care and a research perspective. The care of children with CHD is the first priority, followed by academic activity, and then general practice anesthesia. Moving the clinical focus of all members to align with the Labatt Family Heart Centre mission is part of the reason for forming the cardiac division. The aim of providing integrated care throughout the life of the patient with CHD favours the development of connections with The Toronto Hospital and the adult congenital program, and preliminary discussion and identification of a suitably qualified individual is underway. Dr. Peter Laussen (Chief of Department of Critical Care Medicine) has established a Critical Care Executive and the Division Head of Cardiac Anesthesia is part of that team. This will provide some uniformity in equipment (monitoring specifically) and disposables purchasing, and should establish better communication and more seamless patient transition from one area to another.

Education Programs
The education provided for (multidisciplinary) trainees by the members of the division includes didactic teaching of fellows and residents in the Department of Anesthesia and Pain Medicine, seminars for trainees in Cardiology and Critical Care, as well as Critical Care Nursing (George Brown College), and Perfusion lectures. There are weekly rounds on CHD, which were instigated and organized by Dr. Holtby. There is considerable effort to provide clinical teaching in the OR, the quality of which may be deduced by the fact that in the first four years of the “Fellows’ Clinical Teaching Award” it has always been presented to a member of the division (Dr. Holtby three times, and Dr. Szabo). Drs. Taylor and Luginbuehl have also been recognized for teaching excellence. There is a newly established fellowship position in cardiac anesthesia and the first full-time fellow has been appointed for 2014.

Multiple members of the division have been invited speakers and Visiting Professors both in Canada and internationally (Drs. Holtby, Macpherson, Taylor).

Dr. Holtby is one of the founding Board of Directors of the Congenital Cardiac Anesthesia Society (CCAS), and is the current President. SickKids is a charter member. Part of the mandate of the society is to provide education in the care of children with CHD. A working party provided a proposal for training, which was published in 2010 (Anesth Analg 2010 Apr 1;110 (4):1121-5).

The division (and the cardiac group before this) and the department have been very successful in training leaders in both pediatric anesthesia and pediatric cardiac anesthesia in multiple countries around the world. The division has also provided peer-to-peer mentorship to colleagues in hospitals across Canada, specifically to CHEO.
The educational facilities available to the division specifically are limited (and for the Department are inadequate). There is the expected access to the U of T and SickKids library and the generous help of the library staff, but there is limited teaching space and poor wireless access. There is limited available time for presentations other than prior to 0730 hours, or after 1700 hours. It can be difficult for staff to commit to teaching activities with other groups, as it is unpredictable whether staff will be free at 1400 hours for a seminar. The only space within the department large enough for teaching all the fellows, is not large enough for the fellows and the residents, and is a city block away from the operating room. For comparison, the Critical Care Unit, Interventional Cardiology and Diagnostic Imaging and IGT have reasonable facilities immediately proximate to the clinical work area. There are no simulation facilities specific to the Cardiac Division. This is an area of patient care where there is a considerable use of technology. There are important and complex team interactions, and there remains significant mortality and major morbidity. The appropriate use of simulation could speed up learning and improve team function.

The short-term educational goals for the division include succession planning for the Thursday morning seminars, and establishing teaching and research expectations for new division members. It would be worthwhile to integrate some of the multidisciplinary teaching within the LFHC. The absence of echocardiography teaching and training is a disadvantage for our trainees and staff anesthesiologists and that this will need to be addressed moving forward.

Longer-term goals include the incorporation of the CCAS training proposal into a formal curriculum, and development of simulation programmes suitable for pediatric heart surgery and cardiopulmonary bypass. It will be helpful to identify an individual to take on the role of education leader within the division. It will be extremely important for the division and the department to have both office and teaching facilities that are near to the operating room, and populated in such a way as to encourage team performance and cohesion. In other institutions the Cardiac program has offices adjacent to each other (TCH), and the offices of the Department of Anesthesia are immediately proximate to the OR (TCH, TTH VCH).

Clearly the funds needed for this are considerable, and it will be difficult to achieve these goals until there is a new patient tower, but the quality of work life, efficiency and productivity of the division is hampered by the current arrangements. The loss of teaching and meeting space during the recent renovation is regrettable.

Research Programs
Four members of the cardiac division are actively involved in research activities: Dr. Helen Holtby is involved in multidisciplinary research with several members of the LFHC. She is a co-investigator in several CIHR funded studies focused on bleeding and coagulation in children with CHD.
Dr. James O’Leary is the most recent addition to the cardiac division and has a Masters degree in Clinical Epidemiology. His research interests thus far include anesthetic effects on neurodevelopment, pain sickle cell disease and measurement of research performance.

Dr. Elod Szabo has an appointment at the Research Institute and is involved in research into cell membranes and channelopathy (See Research Section). He was awarded a CIHR grant in 2012. His application to the CIHR was ranked first out of over 30 applicants.

Dr. Katherine Taylor has a research focus on outcomes in high-risk pediatric congenital heart disease patients and resuscitation. She has grant support for a study of milrinone pharmacokinetics and has published recent papers on outcomes in single ventricle CHD, and in patients with cardiomyopathy.

The total research FTE for the division is 1.8.

There were 11 publications in peer-reviewed journals in 2012 and 2013. Dr. Holtby published two invited reviews, one on neurological outcomes in CHD (Future Cardiology) and the other on Blalock Taussig shunts (Pediatric Anesthesia).

Dr. Holtby was an invited speaker at the International Assembly of Pediatric Anesthetists in Washington in 2012, at the Chinese Pediatric Anesthesia Meeting (Guangzhou) and at the European Society of Pediatric Anesthesia (Geneva Switzerland) in 2013. Dr. Holtby is on the editorial board of the Journal of Cardiovascular and Thoracic Anesthesia.

Planning for future activity needs to be focused on removing barriers to productivity and encouraging collaboration. Control of clinical allocation and a separate call schedule would be helpful. In the short term, Dr. Holtby will reduce her academic productivity, and hopes to step aside from the leadership role once the appropriate individual is in place. Dr. O’Leary will increase his academic output, being at the start of his career. New recruits to the division should have clear expectations for academic productivity, and increasing focus on such activity being relevant to cardiovascular medicine in pediatric patients. It is anticipated that the current fruitful and collaborative research relationships with both the LFHC, the Department of Anesthesia and Pain Medicine, and the RI will continue and expand.

The CCAS-STS Database represents another unique opportunity to participate in multicentre research into anesthetic outcomes for children with CHD. SickKids does not currently participate in this database, which is a disadvantage. The reasons for this are multiple (a surgeon sponsor is required, it requires funding, and there are some intellectual disagreements regarding the structure and usefulness of the STS database). Nonetheless, this is the only multicenter system for the evaluation of the anesthetic care of children with CHD, providing benchmarking and research opportunities. The annual anesthesia cost (excluding software and surgical participation) is $3,300 US.
**Departmental/Divisional Administration**

As a new division (but within the structure of a long-standing department), the structures for quality assurance and improvement are quite robust. There are weekly LFHC rounds on Monday and Friday at which the attendance of the cardiac anesthesia division is welcomed. The Monday rounds are to present the work in the upcoming week, and Friday “Performance Rounds” review the activity of the previous weeks. The challenge as a new division is to establish our identity for all division members, and to change long-established patterns of activity. For example, attendance at Monday rounds is frequently inconsistent. Friday rounds coincide with departmental rounds, so there is a conflict there also.

Within the division, M&M issues are the responsibility of Drs. Taylor and Dodgson. Self-reporting, risk reports and performance rounds analysis constitute the majority of reports.

There have been recent QI processes arising from suggestions made by the cardiac anesthesia division at a previous LFHC retreat. Specifically, an initiative to reduce blood product exposure has prompted collaboration to have children start on oral iron, when they are listed for surgery.

The clinical contribution of the members of the cardiac division is welcomed and acknowledged. The relationship with the LFHC is robust. The relationship and cooperation with the Perfusion Department is equally collegial and rewarding. In recent years, communication has improved considerably, mostly through staff to staff communication via email and cell phones. A major communication barrier for the division is the practice of holding “Huddles” or mini rounds to discuss urgent patients at 0830 hours. At present the division has no mechanism to send anyone to these rounds because of commitments to the Department of Anesthesia and Pain Medicine.

It has taken over 20 years for the various Departments involved to acknowledge that the care of children with CHD can be better provided through individuals whose attention is focused on heart disease. The Department of Critical Care formed the CCCU approximately a decade ago. It is too recent to have any assessment of relationships with hospital administration outside the Departmental aegis. Leadership will ensure that the new supply system in the OR is being trialed in the cardiac ORs because of the need for feedback and robust performance, which may suggest that the team function, attention to detail, and willingness to innovate is recognized.

**Financial Issues**

The key financial issue is the completion of the development of the division as outlined in the hospital by-laws, and the appropriate devolution to the divisional chief of necessary resources in terms of FTE’s, discretionary funds etc. It should be a crucial part of negotiation with the individual appointed to the definitive department head. If not
addressed it will be very difficult to measure productivity either clinically or academically and to recruit and manage manpower.

**Human Resource Issues**

There are three immediate human resource issues to be addressed.

The first pertains to changes in on-call and clinical workload. Traditionally fairness and equity has been established using clinical time as the “currency”. Individuals who did extra (and unplanned) clinical work were compensated with additional time off. The cardiac division works harder than the general group by this measure, and by the amount of on-call. If this organization is changed (see above: there are good reasons to make changes), then a different mechanism is needed to measure and or compensate the members of the cardiac division.

The second issue is recruitment and retention. Two members of the division (Drs. Dodgson and Holtby) have stated their intention to change their work commitments over the next two years, and it is possible that other individuals will make changes because of the demographics of the division. Efforts are underway to address this in the short term. In effect Dr. O’Leary would replace Dr. Dodgson. It is hoped that Dr. Chin will be able to be licensed in Ontario, as her training makes her well suited for a joint appointment to both SickKids and The Toronto Hospital, and be a liaison between pediatric and adult CHD.

It is important for the division to have a geographic centre, and sufficient space to be able to meet, both formally and informally (see above). This would be helpful in multiple ways: it establishes an entry portal to the division for visitors and staff; it helps to establish an identity for the division; it aids in communication. The cardiac division administrative assistant has recently been given a new office, and it would be ideal to gradually move division members into nearby offices.

Administrative responsibilities are shared as listed:

Dr Holtby as Interim Head is responsible for weekend call allocation, for clinical liaison with LFHC and for the standards, organization and productivity of division members. The organization of weekly rounds remains in her domain, as does ad hoc membership of the Critical Care Executive. Dr. Macpherson is Clinical Chief of the Department of Anesthesia and Pain Medicine. He is also chair of the Department Appointments Committee in the Department of Anesthesia, University of Toronto. Dr. Taylor is responsible for M&M and clinical liaison with the Cardiac Critical Care Unit. Dr. Luginbuehl is responsible for equipment.

In terms of restructuring the division, there is a need for an identified individual to be responsible for education on a wider scale, including staff and allied health professionals. It would be helpful to have an identified individual to liaise with the Perfusion Department, as there are research opportunities and clinical care improvements, which could be facilitated.
An opportunity exists to strengthen the relationship with Transfusion Services, since children undergoing cardiac surgery frequently require blood products.

The major impediment to these opportunities is time, and responsibility for clinical allocation (see above).

It is likely that additional administrative assistance will be needed, as the responsibility for 9 or 10 staff, even excluding research needs, but assuming responsibility for all other requirements (including some clinical responsibility) is a heavy workload.

**Conclusion**

In summary, the Cardiac Division has evolved over the last 20 years. All members of the division have (or had), leadership roles, and research commitments have had various successes over 2012-2013.

The strength of this division at present is the clinical expertise of the senior staff, and the overall caliber of the members of the division.

The future of the division depends on the academic achievements and clinical expertise of the next generation. They need the opportunity to maximize their clinical experience with children with CHD, as well as pursue their academic careers.
3E. Satellite Anesthesia
*Dr. Mark W. Crawford, Anesthesiologist-in-Chief*

**Overview**
The Department provides care to medical patients undergoing diagnostic and therapeutic procedures outside the main O.R. The anesthetizing sites include ten Diagnostic Imaging sites (2CT, 4 IGT, 2 MRI, 1 MEG, and 1 Nuclear Medicine), three cardiac catheterization laboratories, and four other satellite locations (burn unit, GI, oncology, and Princess Margaret Hospital (radiation oncology)). The total number of satellite locations exceeds the 16 operating sites in the main O.R.

The total number of satellite cases has increased each year (Figure 1). Based on current referral patterns, it is expected that this caseload will continue to expand. The overall increase is driven largely by an increase in patient volume in MRI, hematology/oncology (LP, bone marrow aspirate or biopsy), and GI endoscopy. In the past five years, the number of MRI cases has increased by 75% (Figure 2), and hematology/oncology and GI cases have each increased by approximately 50% (data not shown).

Figure 1: Total number of satellite cases by year

**MRI**
Reasons for the increase in patient volume include: (1) increased number of referrals for MRI, and (2) in 2009 mounting concerns prompted Diagnostic Imaging to ask the Department to take over all sedation in MRI. This was in part because some radiologists expressed concern that they no longer felt comfortable ordering and supervising the administration of sedative drugs to a diverse and increasingly complex patient population.

In response, the Department established a plan for the graded take over of radiologist-supervised sedation in MRI. From 2009 to 2012, Ministry of Health approval for the hiring of anesthesiologists allowed the Department to increase the daily allocation to MRI. The increase was implemented in a graded fashion commensurate with the annual increase in staff numbers. Until 2009, the MRI suite was staffed daily with one anesthesiologist. Currently, one
anesthesiologist is assigned daily and a second anesthesiologist from Wednesday to Friday (for a total of 8 lists per week).

Figure 2: Number of MRI cases and referrals per month

Referrals continue to surpass capacity as shown in Figure 2. The impact is that wait time has once again increased. Although Anesthesia Assistants (AAs) have been considered as a potential resource, the complexity of the caseload and the remote location of MRI limit their utilization.

Funding from the MOH secured two AAs primarily for the provision of care in MRI. One AA is currently assigned daily to MRI to enhance room turnover. Their role was expanded to assist with procedures outside the O.R., primarily in hematology/oncology. They work under the direct supervision of the attending anesthesiologist. They currently provide daytime coverage, but no nights or weekends. The AAs are an integral part of the delivery of anesthesia care outside the main O.R. In the future, it is expected that their scope of practice will expand to our Integrated Sedation Model, in the roles of sedation provider and educator.

Additional anesthesiology staff are required to increase utilization of the second MRI room to five days a week to help decrease wait time.

**CT**

For similar reasons, the Department also took over cases referred for CT. Prior to this, long-acting drugs (chloral hydrate and pentobarbitone) were used for procedures that can be as short as 3 min. The use of the rapid onset, shorter acting IV agent propofol by anesthesiologists has enhanced efficiency and enabled more rapid discharge from PACU after CT.

Another change recently implemented by the Department is the site of recovery. Historically, children requiring GA were transported from the CT suite (located in the Elm wing) to the main PACU (located in the Atrium) for recovery. The total time needed to transport the child, handover to the PACU nurse, and return to CT was often longer than the procedure itself. This was an inefficient use of nursing and anesthesia resources. The Department worked collaboratively with Nursing and DI to implement the use of the existing recovery area in CT. The resulting efficiency has permitted an increase in capacity in CT from the historic four or five cases per daily list to the current nine.
3F. Post-Anesthesia Care Unit

*Dr. Mark W. Crawford, Anesthesiologist-in-Chief*

**Overview**

The Post-Anesthesia Care Unit (PACU) at SickKids admits over 10,000 patients each year, and of these approximately one-half are outpatients (Table 1).

<table>
<thead>
<tr>
<th>Table 1: PACU Admissions by year.</th>
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<tbody>
<tr>
<td><strong>PACU Admissions</strong></td>
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<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Inpatients</td>
</tr>
<tr>
<td>Outpatients</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

Several methods to assess PACU discharge readiness have evolved, including 1) a time-based approach in which length of stay is dependent on the surgical procedure, and more recently, 2) discharge scoring systems based on physiological parameters. For several decades, a time-based protocol was used at SickKids (Table 2). This time-based protocol was implemented when anesthetics agents were relatively long acting. With the advent of shorter acting drugs (e.g., propofol, sevoflurane, rocuronium) and improved methods for the prevention and treatment of postoperative pain, nausea, and vomiting, it was clear that our discharge criteria could be revised.

<table>
<thead>
<tr>
<th>Table 2: SickKids Time-based PACU Discharge Criteria</th>
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</thead>
<tbody>
<tr>
<td><strong>Surgical Procedure</strong></td>
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<tr>
<td></td>
</tr>
<tr>
<td>Dental</td>
</tr>
<tr>
<td>Ophthalmology</td>
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<tr>
<td>Gynaecology</td>
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<tr>
<td>Radiology</td>
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<tr>
<td>ENT</td>
</tr>
<tr>
<td>General Surgery</td>
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<tr>
<td>Orthopedics</td>
</tr>
<tr>
<td>Plastic Surgery</td>
</tr>
<tr>
<td>Urology</td>
</tr>
</tbody>
</table>
In 2010, the Department undertook a prospective study to evaluate the efficacy of a physiological criterion-based method. Some pediatric institutions had already adopted this method, but studies comparing physiological with the traditional time-based criteria were lacking in children. The specific aims of our study were (1) to evaluate the effectiveness, in terms of reduction of time spent in PACU, of physiological discharge criteria in pediatric ambulatory patients, and (2) to generate descriptive statistics that could be applied to future studies evaluating PACU discharge in this patient population.

We implemented a physiological scoring system (a modification of the systems reported by Aldrete (White et al, 1999) and Chung (Chung et al, 1995)) (Table 3). Using this scoring system, patients are considered fit for discharge once they attained a physiological score ≥12, provided there were no scores of 0 (maximum score, 14).

Our results show that the use of the physiological scoring system decreased the median PACU stay by 30 min. Kaplan-Meier analysis (a distribution-free statistical method) was used to show the probability of discharge readiness for the two discharge methods (Figure). Analysis of the curves indicated a significant difference between groups (P < 0.0001, log-rank test).

The findings demonstrate that the physiological scoring system is a simple reliable tool that can be applied to determine fitness for discharge from PACU. We have shown that this scoring system can significantly speed the transit of pediatric patients through PACU without compromising patient safety, thereby enhancing PACU efficiency and resource utilization.

Following completion of our study, the physiological scoring system was implemented at SickKids, replacing the traditional time-based discharge criteria. An analysis of costs with respect to PACU care is complex and multifaceted (Dexter et al, 1995); however, assuming a median reduction in PACU stay of 30 min and a caseload of 10,000 patients annually, the physiological scoring system has decreased PACU utilization by 5,000 patient-hours annually, which is equivalent to approximately 625 nursing shifts.
Table 3: The physiological scoring system used was a modification of the scoring systems reported by Aldrete and Chung.

<table>
<thead>
<tr>
<th>Discharge Criteria</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conscious Level &amp; Activity</td>
<td></td>
</tr>
<tr>
<td>Awake &amp; orientated, appropriate movements</td>
<td>2</td>
</tr>
<tr>
<td>Rousable with minimal stimulation, weak movements</td>
<td>1</td>
</tr>
<tr>
<td>Responsive only to tactile stimulation, no movement</td>
<td>0</td>
</tr>
<tr>
<td>Respiratory Stability</td>
<td></td>
</tr>
<tr>
<td>Able to cough, deep breath or cry</td>
<td>2</td>
</tr>
<tr>
<td>Hoarseness with crying or coughing</td>
<td>1</td>
</tr>
<tr>
<td>Stridor, dyspnoea or wheeze</td>
<td>0</td>
</tr>
<tr>
<td>Oxygen Saturation</td>
<td></td>
</tr>
<tr>
<td>Maintains &gt; 95% on room air</td>
<td>2</td>
</tr>
<tr>
<td>90% - 95% on room air</td>
<td>1</td>
</tr>
<tr>
<td>Requires O2 to maintain &gt; 90%</td>
<td>0</td>
</tr>
<tr>
<td>Hemodynamic Stability</td>
<td></td>
</tr>
<tr>
<td>HR &amp; systolic BP within 15% of baseline value</td>
<td>2</td>
</tr>
<tr>
<td>HR &amp;/or systolic BP within 15 - 30% of baseline</td>
<td>1</td>
</tr>
<tr>
<td>HR &amp;/or systolic BP outside 30% of baseline, mottled</td>
<td>0</td>
</tr>
<tr>
<td>Post-Op Pain</td>
<td></td>
</tr>
<tr>
<td>None, or mild discomfort</td>
<td>2</td>
</tr>
<tr>
<td>Moderate to severe, controlled with IV analgesia</td>
<td>1</td>
</tr>
<tr>
<td>Persistent severe pain</td>
<td>0</td>
</tr>
<tr>
<td>Post-Op Nausea or Vomiting</td>
<td></td>
</tr>
<tr>
<td>None, or mild nausea with no vomiting</td>
<td>2</td>
</tr>
<tr>
<td>Transient vomiting or retching</td>
<td>1</td>
</tr>
<tr>
<td>Persistent moderate to severe nausea &amp; vomiting</td>
<td>0</td>
</tr>
<tr>
<td>Surgical Site</td>
<td></td>
</tr>
<tr>
<td>No blood or fluid loss</td>
<td>2</td>
</tr>
<tr>
<td>Minimal loss, no intervention required</td>
<td>1</td>
</tr>
<tr>
<td>Ongoing losses, dressing changes required</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure. Kaplan-Meier curve showing probability of discharge readiness vs. time. Analysis of the curves revealed a significant difference between groups ($P < 0.0001$, log-rank test). Cox proportional hazard ratio = 5.43 (95% CI: 4.51, 6.53)

CBD = physiological criteria-based discharge; TBD = time-based discharge
4. Quality Program Review
Dr. Conor Mc Donnell, Director of Patient Safety and Quality Program

Overview
Between 2006 and 2009 the Department oversaw many developments within its M&M program. Leading this development was the new appointment of an M&M Program Director, charged with updating practices from simple retrospective case-reviews to a forward-thinking rapid response program. Identifying many areas that required change, interventions were developed that were both measurable and recordable. Briefly, the interventions proposed were:

- To convene an M&M committee that had representation from all facets within the department
- Restrict methods of review request to formal avenues such as the hospital incident reporting database
- Educate colleagues on incident reporting
- Convene true multidisciplinary M&M ‘grand rounds’
- Address shortfalls in the system such as follow up on recommendations and dissemination of findings
- Nominate department members as clinical liaisons to ‘problematic’ clinical areas in order to improve communication and flow of information.

The M&M program proposed to demonstrate improved quality of care by demonstrating efficiency (measures such as numbers of reviews, frequency of meetings, attendance at meetings), effectiveness (measures such as increased self reporting, increased case review, discussion of close calls and near misses, influence on department policy and practice), and productivity (measures such as educational and teaching output, research projects and publications). The program was REB-approved as a Quality Improvement project and ultimately became the blueprint upon which a future Quality Program would be built. In the first 3 years, self-reporting by department members increased from 20% to 50%. The ever-present issue of ‘miss the meeting, miss the message’ was overcome by developing an all-inclusive review and reporting system. Success in implementing the M&M program as a QA/QI project was recognized by publication of this initiative in The Joint Commission Journal on Quality and Patient Safety.

Quality Program Introduction
With the M&M program functioning efficiently, Drs. Mc Donnell and Crawford focused on creating a Quality Program. The vision was to become a leading site for Pediatric Anesthesia Quality Assurance & Improvement (QA/QI). The mission was to implement and maintain a high quality, reportable, reproducible program that would foster innovation, excellence, integrity, and collaboration to enhance the quality of care delivered to our patients, the quality of information available to colleagues, and the ability to communicate and collaborate with other departments, facilities and faculties regarding Quality Improvement and Research initiatives.
By establishing a formalized QA/QI program the goal was to create a model that would be adopted by other departments, and create a culture of excellence in Patient Safety, Quality Assurance and Improvement.

No Canadian pediatric anesthesia department had taken a leadership role in this field. Dr. McDonnell undertook and completed (with departmental support and funding) certification in Patient Safety and Quality Improvement by enrolling in the U of T’s Patient Safety Center Certification program from October 2009 to May 2010. He was invited to join the University’s Patient Safety Center as a core faculty member. His affiliation with this Center would prove invaluable during subsequent work in developing the Department’s Quality Program.

Quality Program Development
The creation and development of the Quality Program adopted best practices from both Industry and Healthcare Safety and Quality resources in order to guide and report safe, effective, timely, efficient, equitable, patient centered care. Table 1 demonstrates how the department addressed and approached each of the 6 tenets of Quality Health Care (Safety, Effectiveness, Timeliness, Efficiency, Equity, Patient Centered Care) by prioritizing clinical areas that warranted assessment, selecting measure or Quality Indicators (QIs) and developing those QIs as reliable indications of the quality of care as delivered by the Department.

<table>
<thead>
<tr>
<th>Steps to develop quality measures for use in health care</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Prioritize clinical areas for assessment</td>
<td>• Area should be important (i.e. they should affect morbidity, mortality, or costs).</td>
</tr>
<tr>
<td></td>
<td>• Caregivers’ performance varies.</td>
</tr>
<tr>
<td></td>
<td>• Caregivers can change the system.</td>
</tr>
<tr>
<td>2. Select the type of measure</td>
<td>• Rate, continuous or ratio</td>
</tr>
<tr>
<td>3. Write design specifications</td>
<td>• Define: who, what, when, where, and how the data will be collected</td>
</tr>
<tr>
<td>4. Develop data collection tools</td>
<td>• Evaluate validity and reliability</td>
</tr>
<tr>
<td></td>
<td>• Evaluate ease of use and burden on staff</td>
</tr>
<tr>
<td>5. Pilot test</td>
<td>• Does the consumer of the data believe it is important?</td>
</tr>
<tr>
<td>6. Develop scoring and analytical specifications</td>
<td>• Develop dummy run or control chart</td>
</tr>
<tr>
<td></td>
<td>• What will be the measure of performance?</td>
</tr>
<tr>
<td></td>
<td>• What will be the unit of analysis?</td>
</tr>
<tr>
<td>7. Obtain baseline data</td>
<td>• Identify baseline performance</td>
</tr>
<tr>
<td></td>
<td>• Ensure data collection systems work</td>
</tr>
</tbody>
</table>

Data from Departmental audit identified the O.R., PACU and Acute Pain Service as the areas with greatest potential for assessment and improvements to Quality Care. For each area we selected potential marker practices (i.e. QIs) to examine quality of delivered care for each tenet of Quality (Table 2).
Table 2: Potential Quality Indicators (July 2010)

<table>
<thead>
<tr>
<th>Department of Anesthesia &amp; Pain Medicine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality indicators</td>
</tr>
<tr>
<td>Safety</td>
</tr>
<tr>
<td>• Serious adverse events in the OR,</td>
</tr>
<tr>
<td>respiratory complications in PACU</td>
</tr>
<tr>
<td>Efficacy</td>
</tr>
<tr>
<td>• Quality of anesthesia induction</td>
</tr>
<tr>
<td>• Pain management in PACU</td>
</tr>
<tr>
<td>• Antibiotic administration compliance*</td>
</tr>
<tr>
<td>• SSI bundle compliance, Huddle/</td>
</tr>
<tr>
<td>Checklist / Timeout compliance*</td>
</tr>
<tr>
<td>• Quality of Documentation</td>
</tr>
<tr>
<td>Patient centered</td>
</tr>
<tr>
<td>• Parental satisfaction</td>
</tr>
<tr>
<td>Efficiency</td>
</tr>
<tr>
<td>• ASA units / FTE / day</td>
</tr>
<tr>
<td>Timeliness</td>
</tr>
<tr>
<td>• Discharge time from PACU following</td>
</tr>
<tr>
<td>carefully chosen day case surgeries</td>
</tr>
<tr>
<td>• On-time start in certain off-site</td>
</tr>
<tr>
<td>rooms e.g. MRI, 4C, Dental, etc.*</td>
</tr>
<tr>
<td>Equity</td>
</tr>
<tr>
<td>• Safety, efficacy, and patient centered indicators compared by age</td>
</tr>
</tbody>
</table>

*These indicators are shared with Perioperative Services

The First Quality Indicator

The first QI was launched within OR and PACU in 2010. This measured ‘distress calls or internal calls for help’. A reliable paper-based data collection system was implemented that reported pilot data per 1,000 GAs over a twelve-month test period. This pilot data guided the team to choose ‘laryngospasm resulting in internal OR codes’ as the first QI which would reflect the first tenet of Quality in Health Care (i.e. Safety). Having measured the baseline data the team designed an intervention (centered around education through M&M rounds, Journal Clubs, Paper of the Week, email communication and suggested treatments) to educate, prevent and treat laryngospasm. Data were continually measured for the following 18 months.

Figure 1, a Statistical Process Control chart (SPC), shows the monthly incidence of ‘calls for help’ due to laryngospasm per 1,000 general anesthetics delivered over the 30 months prior to January 2013. The solid black line represents the mean, the hashed black lines represent upper and lower limits of control and the red graph indicates actual recorded incidence of the QI under review.

The success of this Quality Intervention project was recognized by Drs. Dean Kurth (Anesthesiologist-in-Chief, Cincinnati Children’s Hospital) and Peter Lachman (Deputy Medical Director for Safety at Great Ormond Street Hospital) and was published as a peer-reviewed manuscript in a quality-themed issue of Pediatric Anesthesia.
Moving forward we solicited input from Department members to develop additional QIs. Where possible we also collaborated with SIS to data for robust, reliable departmental QIs. Table 3 demonstrates how, over the same time period, we have brought the Quality Program to the point where it reports on > 80% of the QIs first proposed in July 2010.

Table 3: Quality Indicators Measured (July 2013):

<table>
<thead>
<tr>
<th>Department of Anesthesia &amp; Pain Medicine</th>
<th>Quality indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safety</strong></td>
<td>• Serious adverse events in the OR</td>
</tr>
<tr>
<td></td>
<td>• Respiratory complications in PACU</td>
</tr>
<tr>
<td><strong>Efficacy</strong></td>
<td>• Pain Management in PACU</td>
</tr>
<tr>
<td></td>
<td>• Number of Incident Reports received and reviewed</td>
</tr>
<tr>
<td></td>
<td>• Huddle / Checklist / Timeout compliance</td>
</tr>
<tr>
<td><strong>Patient &amp; Family Centered</strong></td>
<td>• Parental satisfaction</td>
</tr>
<tr>
<td></td>
<td>• Quality of anesthesia induction</td>
</tr>
<tr>
<td><strong>Effectiveness</strong></td>
<td>• Unanticipated postoperative ICU admits</td>
</tr>
<tr>
<td></td>
<td>• PONV in CDIU EPS cases</td>
</tr>
<tr>
<td><strong>Timeliness</strong></td>
<td>• Prolonged stays in PACU</td>
</tr>
<tr>
<td><strong>Equity</strong></td>
<td>• Patient centered indicators compared by age</td>
</tr>
<tr>
<td><strong>Staff Engagement</strong></td>
<td>• Staff compliance with Induction Scores</td>
</tr>
</tbody>
</table>

Different QIs can be chosen, developed and reported at any time to examine any facet of the Quality of care that we as a Department deliver. For each QI chosen, we decide on a ‘**target level**’ (short term improvement level that we want to achieve) and ‘**goal**’ (long term KPI that we wish to attain and maintain) in order to gradually move toward benchmarking status. For QIs that require the development of a score or questionnaire (e.g. our Satisfaction scores) we created small focus groups. The goal is that ultimately the Quality Program will become all-inclusive and encourage multiple levels of participation. However, at present, all QI data are collected and processed by the Dr. Mc Donnell with help from an Anesthesia NP. Data are
processed monthly and dashboard reports are created at three-month intervals in order to provide suitable scope but also critical, real-time information that prompts appropriate decision making and rapid mid-course corrections in policy and/or clinical practice.

Example of Dashboard.

<table>
<thead>
<tr>
<th>Dimension Addressed</th>
<th>Title of Indicator</th>
<th>Goal 2013</th>
<th>Current Quarter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Button Presses (BP)</td>
<td>&lt; 3 (2 SE below the mean)</td>
<td>2.5</td>
</tr>
<tr>
<td>Safety</td>
<td>BP for laryngospasm</td>
<td>&lt; 1.5(2 SE below the mean)</td>
<td>1.9</td>
</tr>
<tr>
<td>Safety</td>
<td>Serious Event (CPR)</td>
<td>&lt; 0.4(2 SE below the mean)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Dimension Addressed Induction Compliance</td>
<td>Goal 2013</td>
<td>Current Quarter</td>
</tr>
<tr>
<td></td>
<td>Staff Engagement</td>
<td>Staff compliance with ICC</td>
<td>To be set</td>
</tr>
<tr>
<td></td>
<td>Patient Centred</td>
<td>ICC &gt; 5 / 10</td>
<td>2.60%</td>
</tr>
<tr>
<td></td>
<td>Equitable</td>
<td>ICC by age</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - 4 years</td>
<td>3.60%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-10 years</td>
<td>3.20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11-14 years</td>
<td>0.90%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 14 years</td>
<td>1.90%</td>
</tr>
<tr>
<td></td>
<td>Service Quality</td>
<td>Post-op care increase</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ICU admit</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prolonged PACU stay</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>CDIU EPS PONV</td>
<td>N20 Maintenance</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 or more antiemetics</td>
<td>96%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PACU Nausea</td>
<td>16%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PACU vomiting</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PACU antiemetics</td>
<td>28%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Positioning Issues</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Parental Satisfaction</td>
<td>Numbers surveyed</td>
<td>n</td>
</tr>
<tr>
<td></td>
<td></td>
<td>% with satisfaction &lt; 4/5</td>
<td>3.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>85</td>
<td></td>
</tr>
</tbody>
</table>
**Program Productivity**
The Quality Program serves to measure, report and ensure Quality of Care to our patients. Since inception, we have measured QIs across some 36,000 patient interactions. Some successes achieved to date include but are not limited to:

1. Decreased number of internal codes or ‘calls for help’ in OR from 6.1 to 2.5 per 1,000 GAs (Safety)
2. Decreased incidence of respiratory events in OR and PACU from 3.1 to < 1.5 per 1,000 GAs (Safety & Efficacy)
3. Decreased incidence of unanticipated post-operative ICU admissions from 2.3 to 0.95 per 1,000 GAs (Efficiency)
4. Decreased incidence of unanticipated increases in post-operative care requirements from 3.6 to 1.9 per 1,000 GAs (Efficiency)
5. Increased use of anti emetics in CDIU Electrophysiology cases from 65% to > 90% and decreased rate of postoperative nausea and vomiting from 35% to less than 20% (Effectiveness)
6. Reliably demonstrated that less than 3% of patients experience ‘stressful’ induction of anesthesia (Patient Centered). We have initiated systematic reviews examining the efficacy of premedication and parental presence at induction. We maintain ongoing collaboration with members of Childlife Services (Equitable & Multidisciplinary)
7. Executed full review for the systems and processes for epidural and peripheral neural blockade catheters. This review was performed by Dr. Tina Kerelska as her course project for the St. Michaels Hospital Fellowship in Quality Improvement. By streamlining processes and introducing a pre-emptive early morning pain round to the OR, Dr. Kerelska was able to decrease time from catheter insertion to receipt of infusion from a mean of 170 minutes to 54 minutes. Since this intervention was introduced we have not received a single incident report describing postoperative pain due to failure to commence epidural or peripheral neural blockade infusions in a timely fashion (Efficiency & Timeliness)
8. A Continuous Improvement Process in Pain Management (Effectiveness and Patient Centered)
9. 95% of our Patient & Family Satisfaction Score Questionnaire describe a satisfaction level of 4 or 5 out of 5 (Family Centered).

**Administration**
The Quality Program is involved in many administrative initiatives and activities related to QA/QI within and beyond the Department. In recognition of the many new processes put into place, Dr. Mc Donnell was asked to join various committees such as Co-chair of SickKid’s newly created Medication Safety Committee, the Society for Pediatric Anesthesia’s International Patient Safety & Quality Committee and the newly created CCCU Safety & Quality Committee.

**Teaching, Education & CPD**
These are ongoing priorities. We are constantly looking for original and interesting ways to contribute to the culture of Safety and Quality throughout the Hospital.

1. In 2011, Perioperative Services (POCU) Safety Rounds, multilevel interdisciplinary education rounds were created by the Quality Program to highlight and discuss issues of
safety and quality among perioperative staff. These take place four times a year and are organized and chaired by the Dr. Mc Donnell.

2. The M&M/Patient Safety Handbook was developed and implemented to promote the culture of safety and an awareness of practices, policies and clinical guidelines. It was first introduced in 2010 and is included in the orientation of new staff. It includes common clinical problems and ways to avoid complications. It is an easy to use handbook that acts as a reference source and has led to a marked decrease in specifically targeted problem cases such as hypoglycemia after gastrostomy insertion, laryngospasm in the OR, use of volatile anesthetic agents in patients with muscular dystrophy, and, significant increases in voluntary incident reporting by members of the Department.

3. Introduction to Patient Safety & Quality Program is part of orientation of new staff. Details of safety resources, personnel, and instruction on creating safety reports are presented.

4. Trends and findings from data analysis of the Quality Program are presented at Departmental Grand M&M Rounds.

Research Arising From Quality Program
Generating new knowledge in QA/QI is one of the highest priorities for the Quality Program. Safety & Quality forms one of the pillars of Research within the Department. Research activity to date has largely been restricted to Medication Error, Opioid Error, and Development of Quality Indicators; however, there is now a significant interest from residents and fellows to undertake QA/QI research projects.

Mentoring, Collaboration and Future Projects
The Quality Program has begun to attract significant interest amongst the Anesthesia residents and fellows. Dr. Mc Donnell has recently acted as Course Mentor to Dr. Tina Kerelska (PGY 5, Anesthesia U of T) on the St. Michaels’s Hospital Quality Improvement Fellowship Program and is current Thesis Co-Supervisor (with Ross Baker) to Dr. Andrea Brovender (Master’s in Health Care and Quality Improvement), Project Co-Supervisor to Dr. Michelle Batthish (Master’s in Health Care and Quality Improvement) and Project Supervisor to Ms. Renu Roy (Master’s in Health Care and Quality Improvement).

Two fellows have worked on Quality manuscripts and presented posters at international meetings (Drs. Catherine Doherty and Michael O’Sullivan). One project was ultimately published in Pediatrics and the other is currently submitted for peer review.

We have started to conduct systematic reviews and develop clinical practice guidelines for patients with OSA. This work is carried out under the guidance of the Quality Program in collaboration with Dr. Reshma Amin (Respirology) and by our two current fellows, Amanda Schwartz and Soichiro Obara. The Pain Fellow for 2013-2014, Dr. Daniel Stocki, is currently working on Continuous Pain Improvement with Drs. Mc Donnell, Gail Wong and Fiona Campbell.
5. Education
Dr. Clyde Matava, Undergraduate Elective Coordinator
Dr. Elaine Ng, Residency Site Coordinator
Dr. Mark Levine, Residency Program Director, University of Toronto
Dr. Gail Wong, Director of Fellowship Program (until 2012)
Dr. Ilavajady Srinivasan, Director of Fellowship Program (2012-present)
Dr. Mark Crawford, Anesthesiologist-in-Chief

5A. Undergraduate and Elective Programs
The Department continues to attract a wide range of trainees, including undergraduate medical students, residents from other programs, emergency or critical care fellows, and neonatal transport team nurses seeking enhanced training and experience in airway management skills (Table 1).

Increase in Number of Trainees From 2008 to 2012
The total number of trainees receiving placements in the department is shown in Table 1. Overall, the number of trainees increased approximately 200%, which continues to challenge our teaching resources. The spots for training were oversubscribed in 2011 and 2012 (Figure 1). New trainee groups such as Anesthesia Assistants (AA) and the Neonatal Transport Team started to rotate through the Department in 2008. The AA program is run in conjunction with the Michener Institute. The first group of AA trainees was successfully recruited to the Department in 2010. That year also saw the training of a Nurse Practitioner Anesthesia.

Table 1: Number of anesthesia electives

<table>
<thead>
<tr>
<th>Trainee Group</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canadian Medical Students</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>International Medical Students</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>ACTS NICU Transport</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Dentistry Trainees</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>ER Trainees</td>
<td>4</td>
<td>12</td>
<td>12</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Peds/PICU Trainees</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Anesthesia Assistants/Nurse Practitioner</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Anesthesia</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Observers</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>54</td>
<td>66</td>
</tr>
<tr>
<td>Total Accepted</td>
<td>19</td>
<td>29</td>
<td>31</td>
<td>46</td>
<td>56</td>
</tr>
</tbody>
</table>
Figure 1: Total number of electives. Number applying in red, number accepted in blue.

Figure 2: Anesthesia electives 2008 to 2012

Comparison of Distribution of Anesthesia Education Trainees
2008 v 2012
Core Medical Students in 2011
The Department undertook the training of core medical students from the U of T for the first time in 2010-11 as a result of a change in the medical education curriculum. A total of 8 Core Medical students successfully completed their rotations. The evaluations from these students are included below in Figure 3.

Figure 3: Overall evaluations from Core Medical Students in 2011.

Challenges and Future Direction
The main challenge for the anesthesia elective education program is an increase in demand for spots. This has stretched the already limited and finite teaching resources and finite patient encounter opportunities. The hospital’s critical care team and emergency program have both requested at least eight spots each for their trainees as part of certification requirements. Following consultation with the resident and fellowship program directors, an elective distribution plan with limits for trainee groups was instituted aiming for equitable distribution of elective spots (Table 2).
Teaching Impact and Evaluations
Trainees continue to rate departmental teaching positively (Figure 4):

![Graph showing ratings of teaching effectiveness]

- Orientation to clinical rotation, duties in OR and hospital, and responsibilities.
- Adequate time allotted to become familiar with patient’s problems
- Teaching was directed to the student level
- Adequate opportunity to acquire required basic knowledge
- How well did the rotation course achieve stated goals.
- Professionalism of faculty involved teaching in the rotation
- Professionalism of fellows/residents involved with the course.
- Adequate opportunity to develop interpersonal skills with STAFF.
- Adequate opportunity to develop technical skills.
- Staff interest in teaching students
- Overall EVALUATION of the rotation

Table 2: Distribution of anesthesia education elective spots by training group from 2013

<table>
<thead>
<tr>
<th>Trainee Group</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical Students (electives)</td>
<td>22</td>
</tr>
<tr>
<td>ER Fellows</td>
<td>8</td>
</tr>
<tr>
<td>PICU Fellows</td>
<td>8</td>
</tr>
<tr>
<td>ACTS NICU</td>
<td>8</td>
</tr>
<tr>
<td>Dentistry trainees</td>
<td>8</td>
</tr>
<tr>
<td>Anesthesia Assistants</td>
<td>3</td>
</tr>
<tr>
<td>Others including observers</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
</tr>
</tbody>
</table>
5B. Residency Program

Overview
Three groups of anesthesia residents rotate through the Department.

1. Anesthesia residents who are enrolled in the Royal College of Physicians and Surgeons of Canada (RCPSC) accredited program at U of T. Dr. Mark Levine is program director.
2. Residents from the Family Practice/Anesthesia (FPA) program at U of T. Dr. Henderson Lee is program director.
3. Dental anesthesia residents from the dental anesthesia program at U of T. Dr. Daniel Hass is program director.

The Department frequently hosts residents from other Canadian universities who choose to do an elective in pediatric anesthesia, including Queen’s University. In the future, anesthesia residents from the Northern Ontario School of Medicine will come here for their pediatric anesthesia rotation.

Duration of Rotation
Anesthesia residents are required to complete at least 3 months of pediatric anesthesia according to the guidelines set out by the RCPSC. As of July 2013, a block system was introduced into the program at U of T, requiring residents to complete a minimum of 3 blocks (i.e. 12 weeks) of pediatric anesthesia. Typically, anesthesia residents at U of T complete three to six blocks of pediatric anesthesia in Postgraduate year four (PGY4). FPA residents complete 3 blocks. Dental anesthesia residents complete 4 months.

Number of Residents
In general, 8-10 residents rotate through the Department at a given time. These include 6-8 Anesthesia residents from U of T, 1 Family Practice Anesthesia resident, 1 Dental Anesthesia resident, and 1 elective resident. There was a 30% increase in the total number of residents in 2012-13 compared with 2009-10, (Table 1).

Table 1: Number of residents in Department (2009 to 2013)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of U of T anesthesia residents</th>
<th>Number of FPA residents</th>
<th>Number of dental anesthesia residents</th>
<th>Number of elective residents</th>
<th>Queen’s residents</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009-10</td>
<td>17</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>23</td>
</tr>
<tr>
<td>2010-11</td>
<td>18</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td>2011-12</td>
<td>24</td>
<td>3</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td>2012-13</td>
<td>20</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>2013-14</td>
<td>17</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>21 (YTD)</td>
</tr>
</tbody>
</table>
Curriculum
In April 2010, a National Curriculum (incorporating Medical Expert competencies as defined by the Royal College of Physicians and Surgeons of Canada) was developed in collaboration with Anesthesia program directors across the country. Once completed, this document was reviewed by the Resident Program Committee (RPC) and distributed to all residents, site coordinators and faculty members. It was added to the Departmental Goals and Objectives in 2011.

Education Program
The education program comprises clinical work and teaching.

Clinical Work
Residents are booked to work under the supervision of staff anesthesiologists. The O.R. anesthesia clinical coordinator assigns daily lists to residents. They are expected to provide preoperative, intraoperative, and postoperative care. The site coordinator ensures residents are exposed to all aspects of pediatric anesthesia. Residents are required to keep a log of their cases. In addition, while on-call residents consult on inpatients, participate in emergency cases, and provide acute resuscitation during medical emergencies and trauma. As of July 2012, selected residents participate in a 2-week rotation at North York General Hospital to increase their exposure to ambulatory pediatric anesthesia.

Teaching Program
The teaching program is offered at the U of T and at SickKids. The schedule is determined by the site coordinator. The anesthesia national curriculum is used as a resource.

At U of T, a series of 6 pediatric anesthesia sessions is offered to all PGY4 residents. The FPA resident and dental anesthesia residents are invited to attend. Residents are excused from clinical duties to attend these sessions that take place at the beginning of the academic year. Problem based learning, interactive case discussions, and didactic presentations are offered.

At SickKids, teaching is delivered at the bedside and clinic, in the O.R., in the classroom, and also in the simulation lab.

- Residents receive 1:1 teaching in the O.R. during case management. The topics are determined by the staff anesthesiologist and/or the resident and are often related to the clinical cases that day.
- In the classroom, a series of 30 min sessions are offered 3 mornings per week prior to the start of the day. Topics are taken from the national curriculum in pediatric anesthesia and are offered twice a year in July-December and January-June. Problem based learning, interactive case discussions, and didactic presentations are offered. Residents are also required to present a topic and they have opportunity to teach their peers in “resident rounds”.
- In the simulation lab, residents have an opportunity to manage critical events in pediatric anesthesia. The knowledge, skills and attitudes required for crisis management
are discussed. They may have an opportunity to participate in in-situ simulation in the trauma room, operating room or a satellite anesthesia location. Additional hands-on sessions are provided to review difficult airway management techniques and resuscitation equipment.

**Competencies and Evaluation**

Residents are assessed for competency in CANMEDS roles. Staff anesthesiologists evaluate residents daily using an online survey tool. Each resident meets with the site coordinator to discuss evaluations as well as review clinical caseload in their on-line logbook. The residents are encouraged to discuss their own specific objective(s) and the site coordinator tries to accommodate specific objective(s) depending on availability. As well, Program Directors meet with residents regularly.

The summative reports for mid-term and end-of-rotation evaluations are documented on the U of T web-based POWER system for anesthesia and FPA residents. A paper copy is submitted to the dental anesthesia program director.

Residents are given the opportunity to evaluate their teachers daily. At the end of each resident/teacher encounter, residents are sent an email requesting them to complete an online evaluation. This information is acquired and collated and used by the site chief to provide evaluation data and feedback to teachers. In addition, at the end of each rotation, residents can evaluate all teachers using the POWER Web evaluation system.

The evaluations are stored on the central POWER site. Teachers have access to summary aggregate reports for prior years once a minimum of three evaluations are complete. Departmental education leads and rotation coordinators have a higher level of access that allows review of individual evaluations for individual teachers in real time. An ‘alert’ system is built into POWER so that identified individuals are alerted whenever a teacher or rotation receives a score below a minimum threshold. These are investigated in real time to ensure no threat to resident well-being and educational integrity are present and appropriate action is taken.

The Postgraduate Medical Education (PGME) office provides a ‘report card’ each year to the program detailing the completion rates for teacher evaluation forms and comparators including year-over-year change and PGME benchmarks. Finally, an annual report is produced by the PGME office that outlines average teaching and rotation scores for each rotation across all hospitals, again comparing sites and year-over-year change (Table 2).

A summary of evaluations for all teachers is provided to the Program Director, Department Chair and Vice Chair of Education. In addition, copies of evaluations for faculty members at each site are sent to the respective site chiefs and individual teachers each get a copy of their evaluations for the preceding year. Residency program committee members are notified when the reports are sent to the teachers and site chiefs.
The results for the past 5 years are noted in the following table.

Table 2: Rotation Effectiveness Score

<table>
<thead>
<tr>
<th>Year</th>
<th>SickKids</th>
<th>Other Hospitals (average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-2009</td>
<td>7.89</td>
<td>7.83</td>
</tr>
<tr>
<td>2009-2010</td>
<td>7.49</td>
<td>7.66</td>
</tr>
<tr>
<td>2010-2011</td>
<td>7.93</td>
<td>7.83</td>
</tr>
<tr>
<td>2011-2012</td>
<td>8.60</td>
<td>8.41</td>
</tr>
<tr>
<td>2012-2013</td>
<td>8.59</td>
<td>8.70</td>
</tr>
</tbody>
</table>

Seminars and seminar leaders are also assessed using the POWER system and these reviews are provided to the individual teachers and the Curriculum Director.

**Program Review**

Residents complete online evaluations of individual rotation. These reviews include an evaluation of, not only the quality of the learning environment, but also the resources and facilities at each site. These Rotation evaluations are reviewed annually at the RPC and the resident members on the RPC are encouraged to and do participate very actively in the discussions. Changes to the teaching program are made as a result of this feedback.

**Teaching Awards**

To advance our teaching mission, the department has established Excellence in Clinical Teaching Awards. These awards recognize the commitment and dedication of our staff to excellence in teaching of medical students, residents, and fellows.

These awards include the following:

- The Robert Creighton Award for Excellence in Resident Clinical Teaching
- Award for Excellence in Fellow Clinical Teaching
- The Award for Excellence in Postgraduate Clinical Teaching
- The Award for Excellence in Undergraduate Clinical Teaching

The aim of the teaching awards is to encourage outstanding clinical teaching at all levels, undergraduate and postgraduate, and to honour staff members who, through distinguished contributions to clinical teaching, have fostered a stimulating intellectual environment within our department. They provide undergraduate students, residents, and fellows with an opportunity to acknowledge the contributions that our departmental teachers make to clinical teaching each day in the operating room, the clinics, and the classroom.

**THE ROBERT CREIGHTON AWARD FOR EXCELLENCE IN RESIDENT CLINICAL TEACHING**

The Award for Excellence in Resident Clinical Teaching is named for one of the department’s preeminent former clinical teachers, Dr. Robert Creighton. This award is presented bi-annually to a faculty member for her/his exceptional contribution to the resident program, whether through teaching or administration. The recipient is determined by consensus among the
residents. The award is presented twice per year, at the end of each six-month resident rotation, typically at the department’s biannual dinner.

Nomination criteria include any or all of the following:
1. Excellence in resident clinical teaching
2. Excellence as a role model
3. Excellence in resident education administration
4. Teaching program development
5. Innovation in teaching

<table>
<thead>
<tr>
<th>Date</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2009 - December 2009</td>
<td>Katherine L. Taylor, BMed, BA, FANZCA, PG Dip ECHO</td>
</tr>
<tr>
<td>January 2010 - June 2010</td>
<td>Igor A. Luginbuehl, MD</td>
</tr>
<tr>
<td>July 2010 - December 2010</td>
<td>Clyde Matava, MBChB</td>
</tr>
<tr>
<td>January 2011 - June 2011</td>
<td>Cengiz H. Karsli, MD, FRCPC</td>
</tr>
<tr>
<td>July 2011 - December 2011</td>
<td>Bernard M. Braude, MB ChB, FRCPC</td>
</tr>
<tr>
<td>January 2012 - June 2012</td>
<td>Clyde Matava, MB ChB, Med, MMed Anaesthesia</td>
</tr>
<tr>
<td>July 2012 - December 2012</td>
<td>Tobias Everett, MBChB, EDRA, FRCA</td>
</tr>
<tr>
<td>January 2013 - June 2013</td>
<td>Elaine Ng, MD, FRCPC</td>
</tr>
<tr>
<td>July 2013 - December 2013</td>
<td>Tobias Everett, MBChB, EDRA, FRCA</td>
</tr>
</tbody>
</table>

AWARD FOR EXCELLENCE IN FELLOW CLINICAL TEACHING

The Award for Excellence in Fellow Clinical Teaching is presented annually to a faculty member for her/his exceptional contribution to the fellowship program, whether through teaching or administration. The recipient is determined by consensus among the fellows. The award is presented at the department’s biannual dinner.

Nomination criteria include any or all of the following:
1. Excellence in fellow clinical teaching
2. Excellence as a role model
3. Excellence in fellow education administration
4. Teaching program development
5. Innovation in teaching
Award Winners for 2009 to 2013 are:

<table>
<thead>
<tr>
<th>Date</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2009 - June 2010</td>
<td>Helen M. Holtby, MBBS, FRCPC</td>
</tr>
<tr>
<td>July 2010 - June 2011</td>
<td>Helen M. Holtby, MBBS, FRCPC</td>
</tr>
<tr>
<td>July 2011 - June 2012</td>
<td>Helen M. Holtby, MBBS, FRCPC</td>
</tr>
<tr>
<td>July 2012 - June 2013</td>
<td>Elod Z. Szabo, MD, PhD, FRCPC</td>
</tr>
</tbody>
</table>

AWARD FOR EXCELLENCE IN POSTGRADUATE CLINICAL TEACHING

This award is presented annually to a faculty member for exceptional contribution to the department’s postgraduate teaching program. The recipient is determined by evaluating the daily on-line staff teaching evaluations submitted by our residents and fellows. These evaluations rate each staff anesthesiologist along a five-point Likert scale for each of the following seven teaching attributes: approachability, availability, stimulus, feedback, professionalism, opportunity/autonomy, overall teaching effectiveness. The recipient is the staff anesthesiologist who has the highest median responses in the “Consistently Exceeds” category, weighted by the number of responses. The award is presented each December at the annual departmental holiday dinner.

Award Winners for 2012 to 2014 are:

<table>
<thead>
<tr>
<th>Date</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2012- January 2013</td>
<td>W. Lawrence Roy, MD, FRCPC</td>
</tr>
<tr>
<td>January 2013 – June 2013</td>
<td>Mark F. Levine, MBBS, FRCPC</td>
</tr>
<tr>
<td>July 2013 – January 2014</td>
<td>Igor A. Luginbuehl, MD</td>
</tr>
</tbody>
</table>

THE AWARD FOR EXCELLENCE IN UNDERGRADUATE TEACHING

This recently created award is presented bi-annually to a faculty member for exceptional contribution to the department’s undergraduate teaching program. The recipient is determined by evaluating on-line staff teaching evaluations submitted by medical students, similar to the process described above for the Postgraduate Teaching Award. The award is to be presented at the department’s biannual dinner. Recipients TBA.

Postgraduate Overview
Dr. Levine is Director of the Residency Training Program and receives two academic days per week from the Department to fulfill this role. The Residency Training Program is the largest in Canada and is responsible for producing anesthesiologists for academic and community settings throughout Ontario.
A number of new initiatives were introduced during Dr. Levine’s tenure:

- The program received full accreditation by the Royal College Survey in April 2013.
- All residents now complete a one-month rotation dedicated to the acquisition of knowledge and skills required to become proficient in administration of regional anesthesia.
- Call duties for residents were revised.
- The number of months in anesthesia was increased in the PGY1 year to the maximum allowable (4 months).
- A dedicated two week structured rotation in obstetrical anesthesia was introduced for all PGY 1 residents.
- The PGY 1 curriculum was completely revamped and expanded with increased utilization of low and high fidelity simulation to introduce junior residents to the basic and advanced concepts of airway management and vascular access.
- Greater use of simulation and live models in the training of PGY2 residents, particularly in the use of ultrasound for regional anesthesia.
- Refresher seminars for senior residents (PGY 2-5) aimed at maintaining skills in management of the difficult airway and performing a “surgical airway”.
- The use of Portfolios to document achievement in some of the non-medical expert CanMEDS roles.
- The introduction of reflective portfolios to demonstrate participation and competency in these areas.
- Contributed to the “National Curriculum in Anesthesia” – a document that is now used to guide the Medical Expert component of the Residency training programs across the country.
- Introduced a centralized system, the POWER system, which provides annual reports of teacher and rotation effectiveness.
- Introduced a daily, online evaluation system for both residents and faculty members that allows us to collect, collate and provide timely feedback to residents, teachers and teaching sites.

**Future Directions**

1. “Competency by Design” – In 2015 the RCPSC will roll out CanMEDS 2015 which will shift the focus to competency based education and evaluation.
   a. There will be a need to develop and utilize Entrustable Professional Activities (EPA’s) – i.e. descriptions of specific sets of competencies and how residents at different stages will be able to demonstrate achievement of these competencies.
   b. This will require significant change in delivery of curriculum and, in particular, evaluation of residents.
   c. The expectations will be better defined and there will be a need for extensive faculty involvement around how to evaluate these competencies. There will be a greater need for faculty to evaluate residents more closely to document achievement of the competencies.
   d. There will almost certainly be an increased emphasis on simulation and ensuring that residents are exposed to the uncommon but important scenarios they may not see during a rotation. A national simulation curriculum (a set of scenarios which every resident will have to experience in a simulator) is under development and will include pediatric scenarios. Dr. Toby Everett is an active member of the working group.

2. Perioperative teaching and evaluation: in keeping with the principles above and the general principle of continuing to provide the best possible education to our residents we need to:
a. Continue to strive for improved perioperative teaching – engage all faculty members
b. Encourage rigorous, transparent, timely, effective, honest and useful evaluations and feedback.
c. Optimize models of supervision and case assignment. Double booking affects fellows more often than residents but may involve residents at times. Double booking at peak times affects:
   i. Complexity of lists assigned to residents and fellows – it is difficult to cover two complex cases and therefore interesting and challenging cases are sometimes done by faculty alone
   ii. It can be difficult to teach effectively while supervising multiple trainees.

There needs to be continued representation to the Ministry of Health for an increase in the number of departmental staff to minimize the need for double booking.

3. Trainee numbers:
   a. There will probably be a slight increase in number of residents rotating through Sickkids:
      i. 2 residents per year from NOSM (not together)
      ii. 1 or 2 VISA trainees/year. i.e. trainees from the Middle East who are sponsored by their governments and will return home (as we have had in the past).
      iii. Consideration is being given to having PGY5 residents return for a “consolidation” month.
      iv. Rotation at NYGH is successful but requires collaboration and accommodation of AA’s assigned to NYGH in return.

5C. Fellowship Programs

Overview
The Pediatric Anesthesia Fellowship is a twelve-month training program in all aspects of pediatric anesthesia. It is designed to train physicians who aspire to a career in pediatric anesthesia practice in a specialist pediatric hospital or tertiary referral centre.

Beginning in 1962 with a single fellow from the UK, the Fellowship program has expanded considerably and continues to attract robust interest from trainees around the world. In the past year, we received 188 enquiries about our program. Of these, 165 candidates submitted formal applications for ten fellowship positions. The selection criteria and process for entry into the program were revised in 2009. In the past five years we have trained 50 fellows from 18 different countries, with many of our fellows subsequently securing positions as consultant pediatric anesthesiologists in academic institutions around the world, including three recruited to our own department. Table 1 shows a list of our fellows and their country of origin.
Clinical Program
Fellows work under staff supervision in the provision of anesthetic care for neonates, infants and children from all surgical and medical subspecialties. Fellows also actively participate in the acute pain management of pediatric patients through the performance of neuraxial and peripheral nerve blockade in the operating room and regular rotations with the APS.

Teaching
A lecture series, problem-based learning discussions and weekly departmental rounds provide education in core topics in general pediatric anesthesia, pediatric cardiac anesthesia and pain management. On a weekly basis, fellows attend three didactic teaching sessions in addition to departmental rounds. Further educational sessions include participation in simulation scenarios and nationally broadcast telemedicine conferences with pediatric departments.

Fellows are expected to develop skills as an educator by teaching residents, medical students or other health professionals; organizing and moderating problem based learning discussions or journal clubs; and creating and delivering lectures. These activities allow fellows to develop skills in lecture preparation and presentation.

Research
Fellows participate in clinical and/or basic science research projects that are ongoing within the department. The program includes 20% protected research time. Fellows are encouraged to contribute to the design, data collection and analysis of research projects, and attend lectures in research methodology and statistical analysis.

Research awards presented to our fellows include:

2010 – Dr. James O’Leary. The Residents and Fellows Tuition Award for trainees who best demonstrate the relationship of graduate studies to their chosen career path.
2012 – Dr. Grant Stuart. The R. J. Byrick Award for the best Fellow’s research paper on the Annual University of Toronto Shields Research Day.

Evaluation
The clinical performance of fellows is evaluated regularly. The program director reviews all evaluations and completes a summary evaluation at four-month intervals. Fellows are requested to complete regular on-line evaluations of staff anesthesiologists with whom they have worked. These evaluations indicate a high level of satisfaction with the quality of clinical teaching received by trainees over the years. Feedback about the fellowship program is invited at any time and is formally sought by the program director at four-month intervals. On completion of the fellowship year, fellows may complete a summative evaluation of the program. Evaluations submitted thus far indicate that the overall clinical and educational experience of fellows consistently meets or exceeds expectations.
Program Development
Our program continues to evolve and expand with the establishment of advanced pediatric anesthesia fellowships. We now offer three additional fellowships: (1) pain medicine (curriculum available in CD) (2) research, and (3) pediatric cardiac anesthesia (curriculum in development).

Pediatric Pain Medicine Fellowship
The curriculum for our pain fellowship was developed collaboratively with Drs. Basem Naser, Gail Wong, and Mark Crawford. Since its launch in July 2011, we have received ongoing interest in this fellowship, which is currently in its third year.

The pain fellowship is a 12-month clinical fellowship that provides multidisciplinary training in pediatric pain medicine. The fellowship consists primarily of experience in the inter-professional chronic pain program and the acute pain service, with rotations through interventional radiology, palliative and bereavement care, sedation and procedural pain management, regional anesthesia and pediatric rehabilitation. Fellows also provide anesthetic care to infants and children in the operating room and satellite locations. Research and education are an integral part of the fellowship.

Research Fellowship
Our research fellowship was established in July 2013 for candidates intending to pursue a career in academic anesthesia. Supervised by Dr. Jason Maynes, Director of Research, the fellowship provides an opportunity for fellows to conduct clinical and/or basic science research in areas related to pediatric anesthesia and pain medicine while working under the guidance of a research mentor.

Conclusion
The past five years have seen the fellowship program continue to grow. Advanced fellowship programs were developed to support further learning and experience in selected sub-specialty fields. Future goals of the fellowship program include the refinement of the advanced programs in research and pediatric pain medicine, and curriculum development for a pediatric cardiac program.

Table 1: List of Fellows and Country Of Origin

<table>
<thead>
<tr>
<th>Name</th>
<th>Year</th>
<th>Country of Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salah Al-Otaibi (self-funded)</td>
<td>Jul 1/08 - Jun 30/09</td>
<td>Saudi Arabia/Canada</td>
</tr>
<tr>
<td>Maria Clement</td>
<td>Jul 1/08 - Jun 30/09</td>
<td>Trinidad/Canada</td>
</tr>
<tr>
<td></td>
<td>Jul 1/09 - Jun 30/10</td>
<td></td>
</tr>
<tr>
<td>Peter Darby</td>
<td>Jul 1/08 - Jun 30/09</td>
<td>Canada</td>
</tr>
<tr>
<td></td>
<td>Jul 1/09 - Jun 30/10</td>
<td></td>
</tr>
<tr>
<td>Clyde Matava</td>
<td>Jul 1/08 - Jun 30/09</td>
<td>Zimbabwe / Canada</td>
</tr>
<tr>
<td>Antonia Mayell</td>
<td>Jul 1/08 - Jun 30/09</td>
<td>UK</td>
</tr>
<tr>
<td>Robert Schwartz</td>
<td>Jul 1/08 - Jun 30/09</td>
<td>Canada</td>
</tr>
<tr>
<td>Motoshi Tanaka</td>
<td>Jul 1/08 - Jun 30/09</td>
<td>Japan / Canada</td>
</tr>
<tr>
<td>Dylan Bould</td>
<td>Aug 1/08 - Jul 31/09</td>
<td>UK / Canada</td>
</tr>
</tbody>
</table>
Michael Letal  
Abeer Arab (self-funded)  
James O’Leary  
James Armstrong  
Natasha Broemling  
Catherine Heidi Doherty  
Dermot Roger O’Donnell  
Damian Simpson  
Marcella Marino Malavazzi  
Ralph Gertler  
Joanne Lynch  
Adrienne Vraets  
James Koziol  
Faden Mazen (self-funded)  
Sue Chew  
Jamuna Navaratnarajah  
Iris Henzi  
Rajeev Subramanyam  
Vannessa Chin  
Phil Kruger  
Preethy Mathew  
Michael O’Sullivan  
Jens Petersen  
Nina Plant  
Sachin Rastogi  
Tripiti Sinha  
Grant Stuart  
Darlene Weekes  
Andrew Seuss  
Sinead Ahern  
Samia Ali  
Nicole Goh  
Kevin McCarthy  
Dagmar Moulton  
Diana Raj  
Tracy Tan (self-funded)  
Jason Denis Cyr  
John Dowling  
Monia Lachance  

**Current Fellows**

Vannessa Chin (superfellow)  
Daniel Stocki  
Matthew Coghlan  
Sindu Balakrishnan  
Dean Bunbury  
Olivia Finnerty  
Soichiro Obara  
Amanda Schwartz  
Alasdair Howie
<table>
<thead>
<tr>
<th>Name</th>
<th>Start Date</th>
<th>End Date</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marie-Laure Laskine-Holland</td>
<td>Sep 2/13 - Aug 31/14</td>
<td></td>
<td>Canada</td>
</tr>
<tr>
<td>Teresa Skelton</td>
<td>Nov 1/13 - Oct 31/14</td>
<td></td>
<td>Canada</td>
</tr>
<tr>
<td>David Heather</td>
<td>Jan 1/14 - Dec 31/14</td>
<td></td>
<td>Canada</td>
</tr>
<tr>
<td>Elizabeth Richards</td>
<td>Jan 1/14 - Dec 31/14</td>
<td></td>
<td>UK</td>
</tr>
<tr>
<td>Victoria Howell</td>
<td>Jan 15/14 - Dec 31/14</td>
<td></td>
<td>UK</td>
</tr>
<tr>
<td><strong>Future Fellows</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kazuyoshi Aoyama</td>
<td>Jul 1/14 - Jun 30/15</td>
<td></td>
<td>Canada</td>
</tr>
<tr>
<td>Jim Klonarakis</td>
<td>Jul 1/14 - Jun 30/15</td>
<td></td>
<td>Canada</td>
</tr>
<tr>
<td>Mark McVey</td>
<td>Jul 1/14 - Jun 30/15</td>
<td></td>
<td>Canada</td>
</tr>
<tr>
<td>Katy Nicholson</td>
<td>Jul 1/14 - Jun 30/15</td>
<td></td>
<td>UK</td>
</tr>
<tr>
<td>Annabell Pearson</td>
<td>Jul 1/14 - Jun 30/15</td>
<td></td>
<td>UK</td>
</tr>
<tr>
<td>James Riddell</td>
<td>Jul 1/14 - Jun 30/15</td>
<td></td>
<td>Canada</td>
</tr>
<tr>
<td>Jessica Watkins</td>
<td>Sep 1/14 - Aug 31/15</td>
<td></td>
<td>Canada</td>
</tr>
</tbody>
</table>
5D. Continuing Medical Education

(1) Pediatric Anesthesia Conference
Dr. Elizabeth McLeod, Pediatric Anesthesia Conference Coordinator

The Pediatric Anesthesia Conference is a biennial meeting that attracts about 200 attendees, most of who are experts in pediatric anesthesia. It has grown from its beginnings as a small weekend meeting held in the auditorium of the Hospital for Sick Children to an international conference comprising lectures, workshops, and round table discussions. It occupies a unique niche within the Pediatric Anesthesia community. Demographic information has led us to aim our program at the specialist pediatric anesthesiologist. In 2013, attendees came from across Canada, Chile, Hong Kong, Pakistan Saudi Arabia, Switzerland and the US.

The Pediatric Anesthesia Conference was started by Dr A W Conn in 1964. On his retirement, the Conn Lectureship was added to the program and continues to this day. The last four Conn Lecturers are:

2007 - Dr. William Splinter (CHEO): The Role of the Anesthesiologist in Pediatric Palliative Care
2009 - Dr. Steven Yentis (UK): Evidence-based medicine: Big questions, small answers
2011 - Dr. Brian Kavanagh (University of Toronto): Leadership in Anesthesia: Building the Future Based on the Past
2013 - Dr. Andrew Wolf (UK): Beyond the Horizon: The Unseen Consequences of Pediatric Anaesthesia

Both Drs. Yentis and Wolf are former fellows of the Department of Anesthesia and Pain Medicine at SickKids.

In order to present a global perspective on pediatric anesthesia issues, we ensure that our invited speakers are experts from Canada and various countries around the world.

Many of the attendees return to this meeting on a regular basis creating a warm, collegial forum for the discussion of the management of difficult cases and future directions for the specialty.

Attendee evaluations for 2009, 2011, and 2013 are summarized below.
(2) Canadian Pediatric Anesthesia Society Toronto Meeting
Dr. Bruce Macpherson, Associate Chief, Director of Clinical Care

The Canadian Pediatric Anesthesia Society (CPAS) / Société d’anesthésie Pédiatrique Canadienne (SAPC) is the organization that represents pediatric anesthesiologists in Canada. CPAS interacts with the broader Canadian Anesthesia community through its role as the Pediatric Section of the Canadian Anesthesiologists’ Society.

CPAS hosts a biennial pediatric anesthesia meeting with content aimed at specialty pediatric anesthetic practice. These meetings are organized by University Departments of Pediatric Anesthesia across the country. On alternate years the CPAS meeting is held in Toronto in conjunction with the SickKids Pediatric Anesthesia Conference (PAC). The one-day CPAS conference is held on the Friday preceding the PAC in Toronto and is organized by a committee of staff anesthesiologists from SickKids.

In 2009, 2011 and in 2013, the organizing committee consisted of Dr. Bruce Macpherson, Dr. Conor Mc Donell, Dr. Gail Wong, and Dr. Clyde Matava (2011, 2013). As the organizing committee, they are responsible for organizing the venue, developing the program, selecting and inviting high quality faculty, and obtaining Royal College CME Accreditation. They also collect and collate evaluations of the program and presentations by the attendee’s to ensure that future programs address current topics of particular interest to Pediatric Anesthesiologists.

This meeting is well attended and highly regarded with registration of approximately 100 pediatric anesthesiologists primarily from Canada, with some international representation. The program is comprised of a mixture of clinical case presentations with panel discussions, basic science and clinical research updates, and topics that are of specific interest to pediatric anesthesiologists related to quality, safety, and outcome measurements. The meeting does attempt to target some Canadian pediatric anesthesia specific issues as well as include broader pediatric anesthesia topics. Dialogue generated from this meeting provides the framework to help the CPAS Executive develop policy platforms and practice guidelines for the Canadian Pediatric Anesthesia community.

The Toronto CPAS meeting is an outstanding meeting that continues to improve each year. The Department of Anesthesia and Pain Medicine at SickKids is extremely proud to organize and host this extremely important biennial meeting.
(3) Telemedicine
Dr. Tobias Everett

On three occasions each academic year SickKids anesthesia organises, coordinates and chairs the National Pediatric Anesthesia Telemedicine Rounds. For these rounds, every tertiary level children’s hospital in Canada is offered the opportunity to connect simultaneously via the existing telemedicine videoconferencing infrastructure. Members of the SickKids Department of Anesthesia present one session per year, the other two sessions being presented by other centres. Dr Tobias Everett chairs each telemedicine session.

The format of the rounds is a case presentation of an interesting or challenging case experienced at one of the contributing centres followed by a digest of the medical literature pertinent to the case. Importantly there is plenty of opportunity for questions and discussion between centres. This facilitates exchange of ideas and strategies between the centres in order to explore alternative solutions and discover practice patterns and preferences among a community of pediatric anesthesiologists.

Telemedicine rounds present a regular opportunity for SickKids Department of Anesthesia to host a meeting on a National level and maintain a prominence among the children’s hospitals of Canada. The rounds are especially productive in fostering a community of pediatric anesthesiologists across the Country, forging connections and promoting inclusiveness and collegiality.

The cost of hosting the rounds, including all the videoconferencing links, are covered by an unrestricted educational grant.

There are usually over 100 attendees at Telemedicine rounds. Evaluations are collected following each session demonstrating the rounds to be useful, popular and well received. The rounds are attended by staff and trainees from the following centres:

- Toronto – SickKids
- Halifax – IWK Health Centre
- Vancouver – BC Children’s Hospital
- Winnipeg Children’s Hospital
- Montreal Children’s Hospital
- Montreal – Ste Justine Hospital
- Quebec City - Centre mère-enfant du centre hospitalier de l'Université Laval
- Ottawa – CHEO
- Kingston General Hospital
- Calgary – Alberta Children’s Hospital
- Edmonton - Stollery Children’s Hospital
- Saskatoon – Children’s Hospital of Saskatchewan
- London Health Sciences Centre
- St Johns – Memorial University Hospital
6. Simulation Program

Dr. Elaine Ng, Residency Site Coordinator, Director Simulation Program
Dr. Tobias Everett

Overview
During this five-year period, the simulation program provided by SickKids department of Anesthesia has expanded and evolved locally, nationally and internationally. These will be considered in turn followed by a summary of scholarly activity associated with the program and finally plans for the future.

Local Impact – The Hospital for Sick Children & University Of Toronto
The Department provides simulation-based medical education in several contexts. The Learning Institute accommodates the central Simulation centre from which some of the educational activities are offered. An unused O.R. has been converted to one of three “satellite” simulation laboratories, where anesthesia simulations are provided. Members of the Department also provide in-situ simulations, where the mannequins are taken to actual clinical care areas and scenarios conducted in the clinical environment in order to achieve maximal environmental fidelity.

The Learning Institute (LI) has recently been accredited by the Royal College of Physicians and Surgeons of Canada as an approved simulation site. One of the advantages of accreditation is that all simulation-based activities provided by LI instructors (including Drs. Ng and Everett) are automatically accredited for section 3 Maintenance of Certification points. This has translated to Drs. Ng and Everett providing increasing quantities of accredited CME.

Examples of on-going rolling simulation programs are:
- Managing Emergencies in Pediatric Anesthesia (MEPA) – OR crisis simulation for anesthesia trainees
- Whole team in-situ interprofessional team training
- In-situ trauma team training
- Airway training for ICU trainees
- Anesthesia Assistant training at the Michener Institute
- SickKids Interprofessional Sedation Education

In addition, simulations are arranged on a case-by-case basis where a need is identified.

Table 1 shows the number of participants in simulation-based education activities facilitated by members of the Department. These data were collected from a range of teaching activities including O.R. simulation for residents, interprofessional team training exercises in multiple clinical areas, workshops on simulation and/or debriefing etc.
Anesthesiologists as Learners

Table 1 shows that there has been an increase in the number of Staff Anesthesiologists (SickKids or Uof T) participating in simulation-based activities facilitated by the Department. The data show that the quantity of simulation encounters for Anesthesia Residents and Fellows has remained consistent over the years since evaluations have been collated electronically. Every Anesthesia Resident rotating through SickKids has an opportunity to participate in specialty-specific pediatric anesthesia simulation. Anesthesia fellows have the opportunity to participate in simulation as learners but also as facilitators, if that is where their non-clinical interest lies. The static quantity of trainees in each academic session and the fact that we nearly achieve saturation with each new group explains the fairly unchanged numbers of simulation encounters for Anesthesia trainees.

Anesthesiologists as Educators

Four staff anesthesiologists have received formal training in teaching with simulation: Drs. Tobias Everett, Elizabeth McLeod, Elaine Ng and Lawrence Roy. A few staff anesthesiologists who have not had formal training also teach with simulation (e.g. Drs. Robertson and Matava in the Anesthesia Assistant program at the Michener Institute, Drs. Szabo and Taylor in the ICU airway course). Figure 1 is a bar chart representation of the data from Table 1. It shows a consistent increase in the simulation based medical education provided by the Department of Anesthesia, as measured by number of participants taught by Anesthesia staff members. The increase can largely be explained by the increase in participants from other medical specialties and non-MD healthcare practitioners. This is consistent with the prevailing concept of postgraduate medical education and continuing medical education as an interprofessional activity. In order to best represent real-life situations in our simulations, we are increasingly assembling whole interprofessional teams.

Drs. Everett and Ng are supervisors for fellows in the longitudinal simulation elective offered by the Learning Institute at SickKids. Three anesthesia fellows completed the elective (2011-13). A fourth started her simulation elective in January 2014. Offering this fellowship experience in simulation-based medical education means that the Department is now providing a structured program in simulation educator training. The fellows contribute to educational and research activities and receive training in all components of instructional design. At the completion of their program they are able to independently design, arrange and deliver simulation courses.

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anesthesia Staff</td>
<td>4</td>
<td>6</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Non-anesthesia MDs</td>
<td>18</td>
<td>21</td>
<td>26</td>
<td>31</td>
</tr>
<tr>
<td>Anesthesia Trainees</td>
<td>39</td>
<td>45</td>
<td>46</td>
<td>44</td>
</tr>
<tr>
<td>Non-anesthesia non-MDs</td>
<td>36</td>
<td>75</td>
<td>68</td>
<td>78</td>
</tr>
<tr>
<td>Total</td>
<td>97</td>
<td>147</td>
<td>152</td>
<td>162</td>
</tr>
</tbody>
</table>
Furthermore, the scholarly activity associated with the projects has resulted in national presentations and/or publication.

Figure 1. Total number of participants in simulations facilitated by Anesthesia personnel increasing over four years (since start of electronic record collection)

Learners evaluate all simulations provided by the Department. These data have been collated electronically since 2010. Participants rate both the session and the facilitators. The key performance indicators for the last 139 sessions are presented here. Participants are asked to rate their agreement with a series of statements, which are paraphrased in Table 2. A score of 1 indicates “strongly disagree”, 2 is “disagree”, 3 is “neither agree nor disagree”, 4 is “agree” and 5 is “strongly agree”.

Visual inspection of the raw data shows that the scores of 1, 2 and 3 were historical, with more recent scores trending towards 4 and 5.

Incidents of scores of 1 and 2 are investigated and an explanation sought such that we can continuously improve the participants’ experience. Evaluation scores and comments from individual sessions are analyzed to refine content and delivery.
### University of Toronto Department of Anesthesia Simulation Curriculum

This cross-site collaborative committee is breaking down historical silos of simulation-based medical education in various locations across the city. It is chaired by Dr. Tobias Everett. By coordinating the activity of all the U of T Department of Anesthesia simulation experts, we can provide a seamless, integrated simulation curriculum to run throughout the Residency Program. Each component complements the next, streamlining the process and maximizing the learning potential of their simulation experience. We have also established a cross-site simulation journal club, promoting scholarly activity associated with simulation and further nurturing a cross-site collaborative community of anesthesia simulation educators.

### Pediatric Anesthesia Simulation Outreach

There have been several examples of the Department providing simulation workshops outside of the traditional context of the hospital or University. We have brought our mannequins to provincial conferences and community hospitals in order to provide continuing medical education to practicing anesthesiologists with an occasional commitment to pediatric anesthesia. In so doing, as well as the educational benefit for the participants we augment the profile of the Department by showcasing our simulation activities to a wider audience.

### National Impact

#### Managing Emergencies in Pediatric Anesthesia

The Managing Emergencies in Pediatric Anesthesia (MEPA) course is a simulation-based program aimed at allowing anesthesia trainees to rehearse strategies for the management of intraoperative crises in pediatric anesthesia. It was conceived in Bristol, UK in 2006 since when

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### Table 2: Evaluation responses from the most recent 139 simulation encounters (note: if a participant did not respond to all statements, the sum of responses for that row will be less than 139)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitator - Created a positive environment</td>
<td>8</td>
<td>14</td>
<td>47</td>
<td>61</td>
<td></td>
<td>4.24</td>
</tr>
<tr>
<td>Facilitator - Demonstrated knowledge of topic</td>
<td>1</td>
<td>4</td>
<td>51</td>
<td>74</td>
<td></td>
<td>4.52</td>
</tr>
<tr>
<td>Facilitator - Framed how sim will run</td>
<td>1</td>
<td>5</td>
<td>66</td>
<td>58</td>
<td></td>
<td>4.39</td>
</tr>
<tr>
<td>Facilitator - Provided constructive feedback</td>
<td>1</td>
<td>4</td>
<td>12</td>
<td>47</td>
<td>64</td>
<td>4.32</td>
</tr>
<tr>
<td>Facilitator - Reinforced learner contributions</td>
<td>1</td>
<td>5</td>
<td>18</td>
<td>44</td>
<td>61</td>
<td>4.23</td>
</tr>
<tr>
<td>Overall, the facilitator(s) supported my learning.</td>
<td>2</td>
<td>13</td>
<td>51</td>
<td>61</td>
<td></td>
<td>4.35</td>
</tr>
<tr>
<td>Session - Duration of session was appropriate</td>
<td>1</td>
<td>5</td>
<td>63</td>
<td>70</td>
<td></td>
<td>4.45</td>
</tr>
<tr>
<td>Session - Increased my confidence</td>
<td>1</td>
<td>2</td>
<td>17</td>
<td>56</td>
<td>62</td>
<td>4.28</td>
</tr>
<tr>
<td>Session - Learning objectives clearly stated</td>
<td>1</td>
<td>2</td>
<td>10</td>
<td>59</td>
<td>67</td>
<td>4.36</td>
</tr>
<tr>
<td>Session - Learning objectives were met</td>
<td>2</td>
<td>8</td>
<td>62</td>
<td>67</td>
<td></td>
<td>4.40</td>
</tr>
<tr>
<td>Session - Number of learners was appropriate</td>
<td>1</td>
<td>7</td>
<td>66</td>
<td>63</td>
<td></td>
<td>4.39</td>
</tr>
<tr>
<td>Session - Sim technology augmented my learning experience</td>
<td>2</td>
<td>7</td>
<td>56</td>
<td>74</td>
<td></td>
<td>4.45</td>
</tr>
<tr>
<td>Session – Overall, I was satisfied?</td>
<td>12</td>
<td>50</td>
<td>67</td>
<td></td>
<td></td>
<td>4.43</td>
</tr>
<tr>
<td>Session – Overall, I felt engaged?</td>
<td>11</td>
<td>49</td>
<td>69</td>
<td></td>
<td></td>
<td>4.45</td>
</tr>
</tbody>
</table>
it has expanded in terms of content, scope and diversity of centres delivering the curriculum. Dr Everett is former National UK coordinator of MEPA and currently leads its international development. In 2010, MEPA was first provided for anesthesia trainees at SickKids. At the same time an international multicentre study was set up led by Dr. Everett (SickKids) and Dr. Bould (CHEO). This both prompted and facilitated (via grant funding) the rollout of the MEPA curriculum to nine centres across Canada. MEPA scenarios were also incorporated into the national simulation curriculum for pediatric anesthesia. Dr. Ng is the pediatric lead for the national anesthesia simulation curriculum.

The pilot data from the MEPA study have been published (citation below). It received the Best Paper in Education Award from the Canadian Anesthesiologist Society. The main MEPA I study is in data analysis phase. We collected data from 12 centres internationally each of which videoed multiple standardized simulation scenarios. The utilization of technology we used to ensure standardization of delivery across all sites (telesimulation below) was recognised for a Program Innovation Award by the International Society for Simulation in Healthcare.

Drs. Everett and Bould also conducted a MEPA II study (investigating debriefing patterns in simulation). This multicentre trial is in the write-up phase.

The MEPA III trial is in its inception phase and is described below under “International” and “plans for the future”.

Cannasc Task Force
Dr. Everett represents Toronto on the National Anesthesia Simulation Curriculum committee. As medical education and assessment evolves, we are creating a curriculum that will be delivered as a standardized baseline across all Canadian Postgraduate Schools of Anesthesia. Working closely with the College, we are moving towards a situation where all Canadian Anesthesia residents will have to participate and succeed in some fundamental anesthesia simulations before being put forward for their College fellowship examinations.

Royal College Simulation Educator Training (SET) Course
Dr. Everett was recently invited to become faculty on this National course provided by the Royal College of Physicians and Surgeons of Canada. The three-day course is provided in various sites across Canada three times per year.

International Impact

Through presentations and networking at national and international conferences, the MEPA course is now used by centres on four continents. We have been using “Telesimulation” to bring on new centres and introduce them to the MEPA content. The existing telemedicine secure videoconferencing infrastructure is used for multiple new centres to observe remotely the course conducted at SickKids. Between scenarios, collaborators can contribute to the debriefing of learners (“tele-debriefing”) or observe debriefs. Thus there is a faculty development component to the activity. Similarly, new centres’ first courses are observed
remotely by established faculty to provide support, feedback and guidance. In this way, the scenarios are conducted identically in all the centres worldwide as they are the foundation of our multicentre education research studies.

Figure 2. Telesimulation – initiated and hosted by SickKids Department of Anesthesia

Figure 2 shows the satellite anesthesia simulation laboratory configured for an international telesimulation session (the anesthesia workstation, not shown, is to the right of the photographer). Visible against the far wall is the mobile telemedicine unit, with high definition camera mounted on top. The screen shows five active windows – in this instance, the five centres in the US that were simultaneously viewing the SickKids anesthesia simulation. Those five US centres (Washington University St Louis, Mott’s Children’s Ann Arbor, Children’s Hospital of Philadelphia, The Cleveland Clinic, and UC Davis Medical Centre Sacramento are all regularly providing the MEPA program to anesthesia trainees. In a similar way we have facilitated the set-up of MEPA course in Europe and South Africa and just recently, four centres in Australia.

Dr. Everett is presenting this work at the International Meeting for Simulation in Healthcare in San Francisco in January 2014. The submission received a Program Innovation Award. This international award is another accolade for SickKids Department of Anesthesia.
Dr. Ng participated in the CASIEF (Canadian Anesthesiologists’ Society International Education Foundation) program in Rwanda in April 2013. She introduced case-based simulation teaching for the local residents in anesthesia using selected cases from MEPA and modified for the local environment.

Dr. Ng is currently a member of the education committee at the International Pediatric Simulation Society.

The MEPA III international multicentre simulation study (Dr. Everett PI) exploits the momentum generated by recent studies and recruitment of new centres and is the most ambitious project to date. More than twenty centres on three continents have declared their interest in contributing to this study, which will examine the impact of implementation of pediatric operating room critical event checklists. This has the potential to exert an influence at the patient care level, even ultimately impacting on patient outcomes.

Awards
In addition to those awards already mentioned, the simulation educators in the department of Anesthesia have received multiple teaching awards locally, nationally, and internationally.

Distinctions and Research Awards in Simulation

Dr. Tobias Everett:
INTERNATIONAL
2014 Jan
Program Innovation Award, International Society for Simulation in Healthcare, San Francisco, California, United States. (Distinction) Program Innovation: Transcontinental Telesimulation: The Global Proliferation of the Managing Emergencies in Paediatric Anaesthesia (MEPA) Course

NATIONAL
2012 Jul - 2013 Jun
Best Paper in Education and Simulation, Canadian Anesthesiologists’ Society, Canada. (Research Award)

LOCAL
2013 Jul - 2015 Jun
Merit Award, University of Toronto Department of Anesthesia, Toronto, Ontario, Canada. (Research Award) Discovering determinants of clinical team performance using in-situ interprofessional simulation

Dr. Elaine Ng:
2009
Network of Excellence in Simulation in Clinical Teaching and Learning (NESTCL), Ontario (Travel Award)

Scholarly Activity

Grant Funding

Table 3 shows recent grants funding for simulation-based research activities conducted by SickKids anesthesiologists. Included are all grants involving a Staff member of the Department of Anesthesia (be it in a Principal applicant or Collaborator role).
Table 3: Simulation research grant funding

<table>
<thead>
<tr>
<th>Academic session</th>
<th>Total amount funded (CAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-12</td>
<td>$128,256</td>
</tr>
<tr>
<td>2012-13</td>
<td>$128,435</td>
</tr>
<tr>
<td>2013-14</td>
<td>$117,754</td>
</tr>
</tbody>
</table>

**Future Plans**

As is clear from this report, the simulation program at SickKids has grown significantly during the five-year period under review. In terms of education sessions provided and scholarly activity associated, we will continue to work at those projects already established, while ensuring there are robust projects in the development phase to allow uninterrupted productivity. As Staff members, we are currently heavily involved in all components of the research process. As we become more experienced investigators, we can take a more supervisory role in the research, nurturing fellows through their simulation educator development. This will allow us to contribute to more projects contemporaneously, augment the output of the department and provide a greater quantity of fellowship experience for our fellows.

We plan to expand out provision of outreach pediatric anesthesia simulation to contribute to the care of children in the GTA and wave the SickKids Anesthesia flag high and wide.

The in-situ, interprofessional team training study for which we are still in the recruitment phase will require on-going non-clinical time, motivation from investigators and buy-in from colleagues to complete. It is funded by a University of Toronto Department of Anesthesia Merit Award, so funding should not jeopardise that project.

The MEPA III project, as described above will see SickKids front and centre in one of the largest international, multicentre simulation-based studies ever completed. It will require significant time and energy commitment and importantly, high-level grant funding. We have not begun to seek grants for this project yet, but this will be a major project in the medium term future for SickKids Anesthesia Simulation.

Through committee positions on a City, National and International level, SickKids anesthesiologists are well-placed to represent views, shape policy and contribute to the evolution of medical education into the future.

As we are invited to more national and international teaching obligations, we will apply for VP/PC non-clinical time in an itemised and transparent manner, consistent with departmental policy.
7. Integrated Sedation Model

Dr. Mark Crawford, Anesthesiologist-in-Chief
Dr. Tobias Everett, Dr. Sheelagh Kemp
Ms. Sharleen Friedman, Program Manager Strategy

Overview
The number of non-invasive and minimally invasive procedures performed on pediatric patients outside the operating room has grown exponentially over the last few decades. Procedural sedation and/or analgesia is necessary for many of these interventional or diagnostic procedures.

Procedural sedation for children undergoing diagnostic or therapeutic procedures is practiced by a diverse group of specialists using a variety of care delivery models. In North America, Europe, and the United Kingdom, procedural sedation delivered by properly trained non-anesthesiologist providers is common, cost-effective, well-studied, and has a proven safety record. Benchmarking for best practices reveals that many major pediatric hospitals have developed in-house training and credentialing for sedation providers, and other organizations are planning to do the same. At the Hospital for Sick Children, procedural sedation is delivered by non-anesthesiologists to approximately 4,000 patients on an annual basis for a variety of procedures and encompasses the spectrum of minimal to deep sedation via intravenous, oral, inhaled, and intramuscular routes.

The increasing number of non-surgical procedures has resulted in an enormous demand for sedation services. An analysis of sedation practices in 2011 identified a number of systemic issues:

- Individual departments have a diverse group of practitioners who perform sedation, but there is minimal dedicated operational support to optimize quality, safety, and innovation
- Institutional leadership is lacking and physician accountability is held with varying degrees of comfort across the Hospital
- There is significant variability in practice and provider preparation among departments related to sedation practice
- Sedation protocols have not kept pace with the growth of available agents
- Hospital-wide audits of adverse events and formal reporting mechanisms are lacking - estimates of denominators are best guesses and are based on voluntary reporting
- Finally, there is a lack of sufficient and consistent educational resources and infrastructure to support development of maintenance of competency among sedation providers across the organization

Given the escalating need to provide optimal pediatric procedural sedation, immediate attention was required to support an infrastructure to ensure best practices.
Methodology

Project Description
A project was initiated under the Executive leadership of Dr. James Wright and Project Sponsorship of Dr. Mark Crawford to develop a model to standardize the practice of procedural sedation at SickKids while ensuring safe, effective, efficient, equitable and timely patient/family centered care, with complete oversight by the Department of Anesthesia and Pain Medicine.

Project Team Structure
To ensure that the perspectives of various stakeholders were appropriately represented, a working group infrastructure was established comprising members from several disciplines at SickKids including: Anesthesia & Pain Medicine, Perioperative Services, Dentistry, Ophthalmology, Image Guided Care, Cardiology, Nursing practice, Nursing education, Pharmacy, and Emergency Department.

Project Approach
The project was informed through the following processes:

- Environmental Scan
  - Onsite Ambulatory Audits
  - Nursing questionnaire
  - External Site Benchmarking
  - Literature review
  - Policy, standards and guideline document review
- Model Development
  - Working group discussions and planning sessions

As part of the environmental scan to determine baseline practices, current education requirements, and efficiencies, The Sedation Project team administered a nursing questionnaire that focused on practices related to procedural sedation and conducted onsite visits to ambulatory settings that currently provide procedural sedation. Both the Ambulatory Procedural Sedation Onsite Visits and the Nursing Questionnaire were carried out within the framework of quality improvement.
Out of Scope

The onsite visits focused on areas that have scheduled procedural sedations. The following elements were considered out of scope:

- Ad hoc or urgent in-patient procedural sedation
- Satellite Anesthesia (General Anesthesia)

Key Findings

The environmental scan provided useful baseline data regarding areas of strength and improvement to ensure safe and efficient sedation practices. Major concerns included:

- Lack of consistent 1:1 monitoring during the procedure and during recovery
- Guidelines recommending capnography for moderate/deep sedation were not followed
- Lack of availability of medical staff for sedation complications
- Lack of strategy to manage failed sedatives
- Inconsistencies in PALS training
- Lack of annual competency assessments and ongoing education
- Frequency sedation administration is highly variable, with some providers managing as few as five sedations per year
- Inconsistent utilization of the procedural sedation record
- Complications of procedural sedation are infrequently reported
- Less than half of respondents feel moderately comfortable with their knowledge of sedation pharmacology and assessment skills in identifying patient-related risk factors.

The data support the development of a Sedation Model to standardize the practice of procedural sedation at SickKids while ensuring safe, effective, efficient, equitable and timely patient/family centered care. A sedation provider database with the ability to track all trained practitioners will ensure sedation providers are meeting hospital standards and educational requirements.

SickKids Pediatric Procedural Sedation Model

Vision

Excellence in the provision of safe, effective and efficient sedation for all children undergoing diagnostic and therapeutic procedures at SickKids.

Guiding Principles

The following guiding principles were identified to guide the creation of a comprehensive model for the provision of procedural sedation throughout the organization.

- Centralized oversight by the Department of Anesthesia and Pain Medicine
- Ensure safe, effective, efficient, equitable and timely patient/family centered care
- Focus on continued quality improvement through centralized data collection and monitoring of quality indicators
- Ensure consistent and standardized education/training and competency evaluation
- Ensure flexibility in meeting the needs of unique and specialized cases/services, without compromising standards of practice
- Focus on advancing the practice of sedation based on best evidence, research and innovation

Based on the information gathered through the environmental scan, literature review, questionnaire, on site audits, and benchmarking with other leading paediatric organizations, the project team recommended an integrated sedation service model to meet the growing needs of the paediatric population undergoing interventional or diagnostic procedures outside the Operating Room.

**Integrated Sedation Service**

In order to address the identified criteria, an Integrated Sedation Service was proposed. This model comprises a centralized sedation unit, an associated mobile sedation team, and satellite sedation areas. Potential advantages of this model include:

- Facilitate equity in patient access to appropriate level of sedation for procedure
- Flexibility in meeting needs of unique and specialized cases/services
- Enhance safety and efficient use of resources
- Consistent policy, standards and guidelines across the hospital
- Facilitate seamless coordination of service delivery across the hospital
- Implementation of consistent standards for training and competency assessment
- Centralized data management to allow for evaluation and continuous quality improvement
- Patient transportation wait-times and delays eliminated or minimized
The Integrated Sedation Service is built on five key components:

1. **Centralized Coordination**
   Success of this model depends on the ability to coordinate human resources and define criteria for triage to the sedation unit, the mobile team (primarily inpatients), or on-site sedation. At the outset, the model requires a booking coordinator to manage the schedules of the central unit and the mobile team, as well as a quality analyst to help monitor and support the quality improvement program. The model requires anesthesiologists, anesthesia assistants and/or anesthesia NPs, as well as RNs with more advanced sedation experience and education. It also assumes that the procedure will be performed by the specific service requesting the sedation.

2. **Integrated Service Delivery**
   The integrated service comprises 3 distinct elements:
   1. a **centralized sedation unit** servicing primarily outpatients
   2. a **mobile sedation team**, servicing primarily inpatients
   3. **satellite sedation teams** staffed by the procedure/treatment specific area (teams currently in existence) where sufficient numbers of procedures are performed to maintain competency, e.g. echocardiography.

3. **Quality Improvement Program**
   The Integrated Sedation Service will set quality indicators for services provided. Indicators for each of the six tenets of quality (as defined by the IOM) have been developed.
4. Centralized Governance

The governance structure will include general oversight by the Department of Anesthesia and Pain Medicine, with ultimate accountability given to the Anesthesiologist-in-Chief to oversee the quality of the service, education and competency evaluation through defining and monitoring performance indicators. The Sedation Leadership team will be responsible for the overall administration, management and education for the sedation service. The Sedation Leadership Team includes the Director of Sedation, a sedation manager and a sedation advanced nursing practice educator. The Sedation Teams (Sedation unit, mobile and satellite teams) will be accountable for the day-to-day operationalization of procedural sedation.

A Sedation Advisory Committee will serve as a forum to assess the level of services provided to the various departments, discuss any practice gaps and/or improvements and ensure that the service has the necessary resources needed to support demand.

5. Education/Training

Evidence suggests that the following components are necessary to include in a Procedural Sedation Education Program for health care providers: performance of a pre-procedural risk assessment, practical knowledge and experience of applied sedation medication, implementation of appropriate monitoring and observation, recognizing and interpreting sedation levels, and immediately recognizing and effectively acting on adverse effects or complications (Leroy, Schipper, Knape, 2010).

Comprehensive education programming ideally should include two areas of focus. A competency based program that addresses the needs of various levels of health care providers and a supportive program that attends to the information and learning needs of children and family members.
It is suggested there are varying levels of education required depending on the role of the health care provider in the process of procedural sedation. The recommendation is for two levels of education programs; one at a basic level for all nursing staff who would be involved in the pre- and post-procedural aspects of the process and a more advanced program for those professionals who would be involved in the administration of procedural sedation.

### Introduction to Procedural Sedation

**Level 1 Learner:** This session targets nursing staff involved in the preparation of the child for sedation and post-procedural recovery. The program introduces the nurse to the procedural sedation process, their role in the process, the standardized sedation checklist, the SickKids Sedation Program, and the role of the sedation team/unit. All nursing staff are expected to provide basic education and teaching to the child and family using standardized tools, techniques and information guides.

### Advanced Program for Procedural Sedation Providers

**Level 2 Learner:** This level is applicable to all health care providers delivering sedative agents for procedures (primarily members of the satellite sedation teams). All providers in this category are required to complete this course as a part of their orientation. Sedation providers will need to complete mandatory annual competency assessments. This will include a procedural sedation simulation class, eLearning modules, and a required number of sedation procedures per year.

### Technology Recommendations

The hospital-wide sedation program will generate a wealth of clinical data. There are several advantages to the use of an anesthesia information management system (AIMS) at each point-of-care to collect, organize, display, archive, and retrieve the data.

The AIMS enhances patient safety by providing clinical decision support and preemptive risk management. Through interfaces with other information systems, the AIMS can provide timely electronic access to patient health information at the point-of-care (including for example, current diagnoses, laboratory results, alerts for medication allergies, and medication lists). Automated data collection by an AIMS greatly enhances workflow and efficiency. The AIMS facilitates data acquisition for quality improvement, research, and education, all of which are important tenets of the sedation program. It is envisaged that the procedural sedation information management system will be an extension of the OR AIMS and that resources for continuous quality improvement will be shared.

### Sedation Pilot Studies

1. **Central Unit Pilot**

Based on clinical need, the project team aimed to pilot procedural sedation for dental out-patients on 4C. The pilot start date was September 9th, 2013. The pilot population comprised dental out-patients scheduled for maxillary extractions. Historically, these patients undergo dental extraction with no or little (a small dose of oral midazolam) sedation. Patient and
provider satisfaction with this technique is low, as considerable patient restraint by dental staff and/or parents is needed frequently. Failure rates were as high as 60%.

To estimate the sample size required for the pilot study, we assumed that procedural sedation provided by the central unit team would decrease the failure rate by at least 50%. For a two-tailed type I error rate equal to 5% and power equal to 80% a sample size of 30 patients per group was estimated.

The pilot is targeted for completion by March 2014 with full results of satisfaction questionnaires given to parents and staff.

2. Mobile Unit Pilot
An education/feedback session was held on November 25, 2013 with nurse managers/nurse educators/CSN’s from unit wards that perform the most sedation (4D, 5C, and 7B/C/D). There was significant feedback for the pressing need to establish the mobile unit in a timely manner. While 4C can be used for outpatient needs, there is support for creating the mobile unit in parallel to address inpatient needs.

A pilot study of the mobile unit is planned. Two inpatient units will be piloted, one of which is cardiac patients on ward 4D undergoing procedures such as removal of chest tubes and pacing wires.

3. Education Pilot
The Model implementation project includes an education and training component (see Education/Training above). The project has achieved Learner 1 and Learner 2 education programs for health care professionals. A milestone was the launch of the first education pilot workshop on October 28, 2013.

To-date, two pilot workshops have been completed with two more planned in early 2014. The number of trainees (nursing and other regulated health professionals) in the two pilot workshops is 35.

The Learning Institute provides technical support, space and equipment to support the project. Existing sedation resources, supplemented by internal support are used; however, funds for an information system, web portal, and for course materials will help sustain it. The pilot is helping to determine future resource needs.

Evaluation of the pilot workshops is underway. Two other institutions are interested in adopting our program suggesting that SickKids is very much at the forefront of education and training in pediatric procedural sedation.
Conclusion

It is anticipated that the new integrated procedural sedation model will have a positive effect on care. We expect that with coordinated care, enhanced expertise of providers, as well as a centralized quality improvement program, patients and families will have a greatly enhanced experience. Options for sedation regimens will be increased, as protocols will no longer be limited by what the proceduralist is comfortable with. The proposed model builds on existing expertise and incorporates the specialized services of trained anesthesia assistants and nurse practitioners in anesthesia. It is anticipated that there will be a reduction in the number of sedation failures and enhanced pre-sedation patient assessment. Proceduralists should also be able to focus their efforts on the procedure itself, with the confidence that their patient’s sedation needs are well cared for.

Overall this should have a positive impact on the patient experience at SickKids, and enable SickKids to lead in world-class quality and service excellence in the area of procedural sedation.
Executive Summary
In the 1980’s under the leadership of the late David Fear (anesthesiologist) the first hospital-wide pain committee was established at SickKids. Subsequently two specialized pain services were established: the Acute Pain Service in 1992 and the Chronic Pain Service in 1998. In 2008, the Pain Center was launched as the seventh integrated research and clinical Center at SickKids. The primary goal of the Pain Center (reflected in its mission and vision) is to achieve an organizational culture of “zero tolerance”. As shown in the governance structure (Appendix A), the Anesthesiologist-in-Chief is an Executive Sponsor. This year, a number of significant milestones have been achieved. Although areas are highlighted under separate headings, each activity reflects an integration of pain management, research and education.

Pain Management
- In 2012 pain was identified as a “priority one” indicator at SickKids. As such, pain is an integral component of the hospital Quality Improvement Plan (QIP) for 2012-2013 featuring improvement initiatives including: (a) Monitoring and feedback/process improvements, (b) Reminders, and (c) Skills development strategies.
- An all-time high parent and child satisfaction score (NRC Picker; Pain dimension) of 79.6% was achieved this year. Satisfaction scores have been maintained above the national average for the past six years. The target pain dimension score for 2012-2013 is 80%.

Pain Research
- SickKids pain researchers have secured over $23 million from external funders, have published 59 papers in leading journals and have supported 27 trainees at all levels.
- Five CIHR funded national Webinars were undertaken this year to disseminate evidence-based pain management solutions and knowledge translation (KT) strategies nationally and internationally for children of all ages with acute and chronic pain.
- In the new SickKids Research and Learning Tower, pain researchers will be located on one floor; providing new opportunities for collaboration and innovation between basic and clinical pain scientists.

Pain Education
- Nine out of ten modules for the international web-based Core Curriculum for Inter-Professional Education in Pain (funded by national and international pain organizations including the Canadian Pain Society, International Society for Pediatric Pain, Mayday Foundation) have been developed and are ready for launching locally and internationally.
• An Inter-Professional Pediatric Pain Conference “Conquering Procedural Pain” with a focus on pain prevention was held in November 2012. National and International speakers provided plenary presentations.
• The inaugural “Pain Cross-talks” was held in November in conjunction with the Inter-Professional Pediatric Pain Conference and in partnership with the University of Toronto Centre for the Study of Pain (UTCSP).

Introduction
The vision of the Pain Centre at SickKids is to be the leading international pediatric centre in pain prevention and management. The Centre’s mission is to prevent and minimize pain for all children in a family-centered care environment by fostering collaboration, excellence, integrity and innovation between inter-professional teams that integrate high quality clinical care, education, and research.

Governance Structure
Drs. Fiona Campbell and Bonnie Stevens are the Co-Directors of the Pain Centre. In 2010, Audrey Tong was appointed as the Pain Centre Manager. The governance structure includes the (a) Executive Committee, which provides support for strategic direction and priority setting, (b) Advisory Committee comprised of pain experts who act as key informants to the SickKids pain agenda, (c) Program Manager, who is responsible for the management of operational aspects of the Centre, and (d) Standing Committees (Pain Matters Task Force, Pain Education Task Force, Pain Research Task Force), which address specific initiatives with the ultimate aim of improving pain outcomes for children (Appendix A). Membership is drawn from (i) the clinical Departments of Anesthesia and Pain Medicine, Nursing, Pharmacy, Psychiatry, Child life and Rehabilitation Services, (ii) the Learning Institute and (iii) the Child Health Evaluative Sciences and Neurosciences & Mental Health Programs within the Research Institute.

Key Benchmarks against Goals

<table>
<thead>
<tr>
<th>Goal</th>
<th>Benchmark</th>
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<tbody>
<tr>
<td>Pain Management</td>
<td>Process outcomes (e.g. pain assessment and management), clinical outcomes (e.g. pain intensity) and satisfaction outcomes as identified in the Pain Centre’s ‘Pain Indicators Report’ (2011)</td>
</tr>
<tr>
<td>Improve pain process outcomes</td>
<td>(a) Pain assessment - compliant with hospital Pain Assessment Policy (b) Pain Management – consistent with the Pain Management Clinical Practice Guideline (CPG)</td>
</tr>
<tr>
<td>Achieve acceptable clinical outcomes for pain</td>
<td>Pain intensity scores should reveal either zero pain or pain in the mild range - as per the Pain Assessment Policy.</td>
</tr>
<tr>
<td>Improve patient and parent satisfaction outcomes</td>
<td>NRC Picker Survey - quarterly and annual results. Internal prospective pain satisfaction surveys.</td>
</tr>
<tr>
<td>Pain Research</td>
<td>Number, amount and source of external research grants, scholarly outputs (e.g. publications, systematic review and syntheses) and trainees/research associates.</td>
</tr>
</tbody>
</table>
Provide leadership to enhance educational outreach; partnering with local and national organizations (e.g. ISPP; UTCSP), Canadian Association of Paediatric Health Centres (CAPHC), community partners and families.

Number and type of Pain Education activities for:
(a) Health Care Professionals (pre-licensure, graduate, postgraduate, continuing education) - e.g. developing educational materials and inter-professional curriculum, presenting education lectures, organizing conferences, Webinars, Café Scientifique; and
(b) Children and families (e.g. number of hits on the Pain Resource Centre on AboutkidsHealth.ca, Pain Education days, Café Scientifique).

### Progress to Date against Goals for 2012

<table>
<thead>
<tr>
<th>Goals</th>
<th>Progress To Date</th>
<th>Timelines</th>
<th>Comments</th>
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<tbody>
<tr>
<td><strong>Integrated Pain Centre Activities</strong></td>
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<tr>
<td>1) Achieve endorsement of Pain Centre fundraising priorities from Senior management and establish partnership with Foundation.</td>
<td>Senior management committee endorsement of Pain Centre Fundraising Priorities. Currently working with assigned Development Officer from Foundation on fundraising strategies.</td>
<td>Senior management approval January 2012.</td>
<td>Meet once a month with Foundation Development Officer to discuss and strategize fundraising strategies for the year.</td>
</tr>
<tr>
<td>2) Develop and launch the Pain Centre Internal and External website.</td>
<td>Internal Pain Centre Web Site completed. All web content has been developed for External Micro Site. Currently working with SickKids Creative Services and Public Affairs on design to ensure the site aligns with hospital brand.</td>
<td>Internal site launched January 2012. External site launch planned for Spring 2013</td>
<td>The Pain Centre Web Site has helped inform the development of the SickKids Chronic Pain Web Site. Currently, awaiting approval from Creative Services and Public Affairs on a site design that will be consistently used among all hospital Centres.</td>
</tr>
<tr>
<td>3) Enhance integration and performance in clinical, education, research, and operational excellence in pain through a comprehensive Blueprint plan.</td>
<td>Blueprint for Pain – The next phase of the Blueprint will involve professionally publishing hard copies of the document to distribute to all stakeholders. The Blueprint will be updated annually.</td>
<td>Blueprint completed August 30, 2012; distribution via e-format Fall 2012. Professionally prepared hard copies distributed Winter 2012.</td>
<td>Novel and innovative integrated approach informed by and fashioned after the SickKids Blueprint for Patient Safety.</td>
</tr>
<tr>
<td><strong>Pain Management</strong></td>
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<tr>
<td>4. Enhance process, clinical and satisfaction outcomes (identified in the Pain Indicators Report; 2011) through three key initiatives, outlined in the patient centered dimension of the hospital Quality Improvement Plan.</td>
<td>As identified in the Quality Improvement Plan 1) Monitoring and feedback/process improvements, 2) Reminders, and 3) Skills development strategies will be aligned with: 1) Process Outcomes: Improve pain practices in (a) Assessment (using validated pain tool) and (b) Management (implementing appropriate pain intervention strategies); 2) Clinical Outcomes: Decreased prevalence of moderate to severe pain; and 3) Satisfaction Outcomes: Key QIP initiatives developed and completed in 2013. QIP published April 2012. Roll out of planned improvement initiatives in QIP commenced September 2012 with quarterly Audit and Feedback. Reminders and educational modules developed</td>
<td>Met with hospital administrators, director and educator groups to discuss their role in improving hospital pain indicators and targets Spring Summer 2012 Pilot units identified for first QIP initiative, Audit and Feedback planned for Fall 2012. Other QIP initiatives will be piloted and initiated in Spring 2013.</td>
<td></td>
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<tr>
<td></td>
<td>Increased satisfaction with pain relief through strategies integral to the QIP</td>
<td>Spring, 2013.</td>
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<tr>
<td>(a) Improve Pain Processes (i.e. Pain assessment as per Pain Assessment Policy; and Pain Management as per Pain Management CPG).</td>
<td>Hospital Quality Improvement Plan – 1) Implement a monitoring and feedback/process to (a) Audit and report to inpatient areas on a quarterly basis for frequency of pain assessment, use of appropriate pain interventions for those with moderate to severe pain (pain intensity ≥4/10).</td>
<td>Planning commenced Summer 2012. Implementation of 24 hr hospital Pain chart Audit continued through 2012 – 2013.</td>
<td>•Pain Assessment on admission increased from 80% in 2010/11 to over 90% in 2011/12. •In the NICU, the proportion of infants with documented pain intensity scores has remained 100% for the past 2 years (2010-2012).</td>
</tr>
<tr>
<td>(b) Improve Clinical Outcomes (reduce prevalence of moderate to severe pain).</td>
<td>Hospital Quality Improvement Plan – Implement a monitoring and feedback/process to (a) Target areas with high prevalence of moderate to severe pain – develop strategies to improve pain management interventions (pharmacological, physical and psychological).</td>
<td></td>
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<tr>
<td>(c) Improve Pain Satisfaction Scores.</td>
<td>The NRC Picker questions on pain inform the satisfaction scores</td>
<td>2012-ongoing</td>
<td>•NRC Picker pain dimension scores for emergency dept improved to 73.9% (2011-2012) from 67.9% (2010-2011) and above the Ontario mean 63.2%</td>
</tr>
</tbody>
</table>

### Pain Research

5) Enhance research and scholarly productivity.

A sample of 5 leading pediatric pain researchers at SickKids have together brought in a total of:
- 26 grants as PI
- over $23 million in grants
- 59 publications
- 37 trainees and research associates.

A Post Doctoral member of the Pain Centre team will join the hospital Palliative Care.

<table>
<thead>
<tr>
<th></th>
<th>August 2011-2012</th>
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### Pain Education

6 For Health Care Professionals: Develop educational material and outreach events to create greater awareness of pain in children and provide tools to enhance pain management.

One CIHR funded National Webinar Series in Children’s Pain – Making it Happen: How Clinicians Are Improving Pain Practices on the Frontline was held. This is the fifth successful webinar in the Pediatric Pain Series.

|---|---|---|

Inter-Professional Pediatric Pain Conference - a bi-annual one-day event for health care professionals entitled Conquering Procedural

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<tr>
<th></th>
<th>Conference Date November 8th, 2012.</th>
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A total of 383 participants with national (Canada and the U.S.) and international representation. Attendees constituted different health care professions (i.e. pharmacists, nurse managers, child life specialists, psychologists). Over 70% of respondents ranked their knowledge as improved after attending the webinar.

Invited international leaders in pediatric pain management and research, Dr. William Zempsky and Dr. Bonnie Stevens deliver keynote addresses. The conference features
Pain will be hosted by SickKids. The key focus is on pain prevention. Development of Web-Based Core Curriculum for Inter-Professional Education in Pain. Nine out of ten modules have been reviewed and translated into the e-learning program.

Formal links established with the Palliative and Bereavement Care Program: 
(i) Clinical Pain Fellow has formal rotation with PBCB; 
(ii) Two invited presentations given by members of the Dept of Anaesthesia and Pain Medicine to optimize new techniques in pain relief.


Goals for 2013

<table>
<thead>
<tr>
<th>Goals</th>
<th>Timelines</th>
<th>Progress Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Integrated Pain Centre Activities</strong></td>
<td>2013-2014</td>
<td>Develop funding database with key potential funders. Achieve funding for at least 1 key priority area (e.g. Seed grant funding competition).</td>
</tr>
<tr>
<td>Establish a sustainable funding base for the Pain Centre in collaboration with SickKids Foundation.</td>
<td>External micro-site launch Spring 2013.</td>
<td>Feedback from committee members on pilot launch.</td>
</tr>
<tr>
<td>Launch Pain Centre Website. The purpose of the website is (i) to provide the tools for SickKids staff and health care professionals to enhance competencies and facilitate excellence in pain practices, (ii) to provide patients and families resources in pain management through an external micro-site, and (iii) support fundraising initiatives.</td>
<td></td>
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</tr>
<tr>
<td><strong>Pain Management</strong></td>
<td>2013-2014</td>
<td>From NRC Picker: % of inpatients who respond Excellent, Very Good or Good to questions about physical comfort/pain. Target pain satisfaction score for 2012-13 is 80%.</td>
</tr>
<tr>
<td>As mandated in the SickKids Quality Improvement Plan:</td>
<td>By April 1st, 2013</td>
<td></td>
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<tr>
<td>• Achieve 100% of inpatient units with quarterly audits completed through monitoring and feedback/process redesign.</td>
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<tr>
<td>• Achieve 100% of inpatient areas with reminders in place.</td>
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<td>• Achieve 75% of eligible clinical staff who have</td>
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completed pain management e-learning modules on hospital learning management system (LMS).

By April 1st, 2013

<table>
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<tr>
<th>Pain Research</th>
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<tbody>
<tr>
<td>Host a national KT consensus conference to disseminate findings of CIHR Team in Children’s Pain research and discuss potential clinical, research, education and policy implications.</td>
</tr>
<tr>
<td>Fall 2012 or Winter 2013</td>
</tr>
<tr>
<td>Funding from CIHR Team in Children’s Pain Grant. Application submitted for a CIHR meeting grant October, 2012. Funding for new Pain KT grant submitted to CIHR Spring 2013.</td>
</tr>
</tbody>
</table>

| Extend knowledge translation initiatives through national Webinar series on children’s pain. |
| Fall 2013 |
| Approval for funding from CIHR. Develop topics and select presenters. |

| Obtain funding and initiate Seed Grant Competitions and/or Knowledge translation competitions to build research capacity (e.g. for new investigators) and stimulate novel KT strategies. Seek opportunities to collaborate with the Cancer centre and Palliative care team. |
| Aim to hold first competition Spring 2013 – dependent on funding. |
| Funds raised to develop competitions. |

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<tr>
<th>Pain Education</th>
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<tbody>
<tr>
<td>(a) Education for Health Care Professionals</td>
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<tr>
<td>Launch Cross-talk Seminars to bring researchers, clinicians and educators together on key pain issues. Collaboration with other centres such as pain in children with cancer or palliative care, events and organizations (e.g. UTCSP).</td>
</tr>
<tr>
<td>Start Fall 2012 in conjunction with biannual Pain Conference November, 2012.</td>
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<tr>
<td>Funds raised to develop seminars.</td>
</tr>
</tbody>
</table>

| Complete Web-Based Core Curriculum for Inter-Professional Education in Pain that support education on pain for pre-licensure health professional trainees and health professionals on an international basis. |
| Complete by Winter 2013. |
| Evaluate curriculum content translated into e-learning format during pilot phase. |

| (b) Education for Children and Families |
| Extend Pain Education Day for Children with Chronic Pain – set as annual event. |
| May 2013 |

| Extend Café Scientifique events. |
| Summer 2013 |
| Approval for funding from CIHR. Select topics and speakers. |

**Conclusion**

The Pain Centre at SickKids is an innovative and collaborative centre that brings together scientists, clinicians, and educators to work on interdisciplinary and inter-professional activities related to pain. Pain remains one of the most common, debilitating, and perplexing symptoms experienced by infants, children, and adolescents of all ages. The Pain Centre’s integrated and family-centered approach to practice supports the improvement of pain care, research and education. Continued fundraising through the SickKids Foundation is integral to meeting Centre initiatives that have a direct impact on improved quality of life and health outcomes of children coping with pain.
Appendix A: Governance Structure

Executive Sponsor
Pam Hubley
Department Head (Anesthesiology and Pain Medicine)
Mark Crawford

Directors
Fiona Campbell
Bonne Stevens

Program Manager
Audrey Tong

Advisory Committee

Executive Committee

Standing Committees
Pain Matters Task Force (PMTF)
Pain Education Task Force (PETF)
Pain Research Task Force (PRTF)
9. Research

Dr. Jason Maynes, Director of Research  
Dr. Mark W. Crawford, Anesthesiologist-in-Chief

Overview

The Department aims to produce high-quality impactful research that addresses major questions in pediatric anesthesia and beyond. Our research goals are aligned with the mission pillars of the Hospital for Sick Children (excellence, impact and innovation, integrity, and collaboration). We capitalize on our strength of a devoted group of research faculty who possess an astounding diversity of expertise and ability. Combined with input from clinical staff, we are constantly striving to enhance the perioperative care we provide to children.

A strategic aim 5 years ago was to develop basic science and clinical research in the Department. Traditional metrics would be used to assess research productivity: peer-reviewed publications, awards, and grants. With respect to grants, the aim was to obtain principal investigator grants in particular. Another metric would be the number of Scientist/Associate Scientist appointments to the Research Institute.

As a result of this strategic vision, our research productivity has grown substantially. The number of peer-reviewed publications increased more than three-fold, and this has been sustained over the past two years (Figure 1). Our research is accepted by the specialty’s leading journals (Section 10). Principal Investigator grants (representing research led by department members) were non-existent in 2009, but have increased exponentially in subsequent years (Figure 2). Our research has attracted several awards, which is testimony to the quality of our work (Section 10). We have investigated important clinical questions, and we translated the new knowledge directly to patient care, in keeping with the SickKids mission.

Figure 1: Peer reviewed Publications
An internal audit of major academic pediatric anesthesia programs (excluding intensivists) showed that our department ranked the highest in terms of publications per FTE and publications per research author. Impact factor per author was also high for our institution, illustrating productivity and quality.

<table>
<thead>
<tr>
<th>Publications at Selected Major Academic Pediatric Anesthesia Departments</th>
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<tr>
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<tr>
<td>Children's Hospital of Pittsburgh</td>
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<tr>
<td>Lucille Packard (Stanford)</td>
</tr>
<tr>
<td>Greater Ormond Street</td>
</tr>
<tr>
<td>CHOP</td>
</tr>
<tr>
<td>Boston Children's Hospital</td>
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<tr>
<td>SickKids</td>
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With respect to number of Scientist/Associate Scientist appointments to the Research Institute, in 2009 there was but one appointment (Mark Crawford, Senior Associate Scientist); today four members are appointed (Jason Maynes, Elod Szabo, Bradley Johnston (all Scientist Track), and Mark Crawford) and two others are in the process of applying (Tobias Everett, James O’Leary).

**Research Themes**

After soliciting input from faculty members and research staff, we developed a consensus set of research themes to focus our resources. The consensus themes reflect the diverse expertise that members of our research team possess:

1. Basic research: focusing on drug design and toxicity, mitochondrial function and cardiac physiology
2. Clinical research and epidemiology: focusing on cardiac/heart failure therapy, pharmacokinetics/dynamics, pain, systematic reviews and data interpretation/presentation
3. Quality improvement: focusing on medication administration, narcotics in the perioperative period, OSA
4. Education: focusing on the use/development of electronic resources
5. Simulation: focusing on team management in crisis situations and the use of simulation in education

The Hospital for Sick Children through the Research Institute has a history of excellence in basic science research, and a current initiative to improve translational implementation. We have two PhD-trained clinician scientists with full RI appointments.

Current basic science projects are aligned in the areas of:
1. Heart conduction/ion channel function
2. Anesthetic neurotoxicity
3. Mitochondrial function
4. Protein structure and function
5. Drug screening/design
6. Stem cells

Our location within a large tertiary care pediatric facility supports a strong clinical research environment. Despite inherent challenges of performing clinical research in the pediatric population, our faculty are able to identify and study key questions in pediatric anesthesia. Our unique blend of personalities and specialties, allows for investigation along many different lines of clinical research. Specific areas of study include:
1. Pediatric pharmacokinetics
2. Pain and opioid dosing
3. Epidemiological methods to improve clinical practice
4. New metrics for patient-reported outcomes
5. Scientometrics/quantifying academic contributions
6. Cardiac/pulmonary hypertension
7. Pediatric airway

Quality improvement is an active area in pediatric research. We are well integrated into the hospital quality and safety network, and we are currently investigating the following:
1. Predictors of post-operative complications for patients with OSA
2. Correlation of pain and anxiety in the pediatric population
3. Transition from nerve blockade to oral pain therapy

Education is an important component of our academic program. We have developed new methods of teaching, especially in the area of technology as a teaching tool. These include:
1. Development of a pediatric drug dosing phone application
2. Use of telemedicine to facilitate simulation teaching
Simulation is a growing and important area in education, training and accreditation. Historically, anesthesia has been at the forefront of simulation research and we have an active program in simulation research, including:

1. Emergency/crisis management
2. Improving communication among team members

**Strategic Initiatives**

1. **Excellence:** Without the proper development and support, small ideas cannot come to fruition and larger concepts will not evolve. This is especially true in the resource-limited environment that exists in the current funding climate. Smaller awards that clinician researchers would historically have been successful in obtaining are now quite competitive and challenging to obtain. Supporting high-quality, high-impact ideas and furthering translational and clinical medicine is vital to ensure that SickKids remains at the forefront of clinical care. We will continue to develop new ideas and methods to improve support for clinician researchers.

2. **Impact and Innovation:** We strive to identify issues and develop research questions that have the potential to advance the field of pediatric anesthesiology. Monthly research meetings were initiated where early stage projects are presented, critiqued and improved before the studies begin. The caliber of the questions being asked and the quality of study design is enhanced by this process. The Maynes lab has developed innovative new methods of determining drug cardiotoxicity using stem cells, and forged industry alliances to facilitate translational research. A prospective study of PACU care, developed and led by Dr. Crawford identified key factors to improve post-anesthesia care, changing the clinical practice. Moving forward, we will use the above themes of research (basic, clinical and epidemiology, QI, education and simulation) to identify key questions to investigate, focusing our research resources on questions of the highest impact.

3. **Research Integrity:** Unfortunately, anesthesia has the distinction of having the largest number of retracted published articles in medicine. We strive for integrity. Fellows have mandatory sessions on research integrity and honesty. One-to-one mentoring of clinical fellows by staff assists the trainee in data analysis and interpretation. In addition, we are developing an instructional and informational seminar on intellectual integrity to be given at Grand Rounds each year. This seminar will ensure that all trainees and staff have support for ethical academic advancement and publication.

4. **Improving collaborations:** Our research is multidisciplinary and we continue to engage other departments/divisions to work collaboratively to tackle questions we have in common. Collaborations thus far include Cardiology, CVS, Clinical Pharmacology, ENT, Neurosurgery, Ophthalmology, Orthopedics, the Pain Centre, Plastics, Psychiatry, and Respirology. Within the department, the previously mentioned monthly research meeting was established to facilitate research collaboration and communication. Since its inception 18 months ago, feedback about the seminar has been extremely positive. Importantly, non-research clinical staff attend the meeting, which is vital, as these members lend decades of cumulative clinical knowledge and experience that is used to formulate research questions. We will
continue to facilitate collaboration and communication in research, both within and external to the department.

Areas for Attention

1. Allocation and use of resources: We need to maximize research and academic productivity in the face of limited resources. Time is an especially valuable resource. Frequent communication and planning facilitate the distribution of resources to meet ongoing demands at any given time. We are developing a new system for allocation of academic time, based on productivity, innovative ideas and, ultimately, acquired funding. The dedication and sacrifice of clinical staff to facilitate academic work is appreciated, and accordingly we will establish a committee to assist in the allocation of academic time for research. Research time that is allocated must be protected. However, due to staffing issues this has been possible only for those with Research Institute appointments. The recent hiring of associate staff/superfellows has facilitated the protection of allocated research time.

2. Facilitating research focus groups: Consistent with allocating resources on research questions with the highest impact, we continue to develop focus groups within the department. We are working to develop an electronic resource in which all projects will be registered before REB submission. This will facilitate communication between and within focus groups, diminish the chance of study overlap and duplication, and optimize the use of resources. Important questions arise from direct patient care, and this process should facilitate discussion with clinical staff.

3. Supporting the team is the departmental research nurse who has extensive experience with the Research Ethics Board and facilitates the progression of clinical research projects. Additionally, we are currently recruiting two clinical research assistants who will be dedicated to helping the current cohort of clinician researchers. The two new research assistants will facilitate literature searches, IRB applications, data collection and interpretation and manuscript writing.

We have great ability to capitalize on the unique talents and training of our faculty members. Our team of young clinical researchers will continue to foster innovative projects and ideas. The questions we develop will be high impact. While there are always areas to improve, our research capability will continue to be at the forefront of pediatric anesthesia.

The three Research Institute Programs are described below.
1) Jason T. Maynes, Scientist Tract, Molecular Structure and Function, SickKids Research Institute

**Overall Investigation Theme**
While pharmaceuticals are intended to prevent and treat disease, those same drugs can be toxic or produce unwanted actions in patients because of genetic predisposition, nonselective/off-target action, or inappropriate use of the drug. Every year, the FDA spends approximately one billion dollars testing the safety of new candidate drugs and ensuring the continued safety of already approved and marketed compounds (www.fda.gov). Toxicity often limits the advancement of new candidate drugs in the approval process and creates additional morbidity and mortality for patients using established drugs. The observed toxicities, which usually include cardiac, neuronal, renal or liver damage, are primarily a result of off-target effects of the designed therapeutic. This means that other cellular proteins/molecules are adversely affected by the drug; in addition to the known therapeutic target. Often the toxicity is observed in a tissue that is not even where the therapeutic action of the drug is expected to occur.

In a broad, overarching theme, our lab focuses on investigating mechanisms of drug toxicity and damage. Much of the unpredictability of drug toxicity is from inadequate pre-clinical models to identify cellular dysfunction that would require massive numbers to identify in Stage III/IV clinical trials, owing to the potential diversity of the clinical phenotype resulting from the underlying toxicity being observed on a whole-organism scale. This concept leads to another key issue with drug toxicity, specifically the development of assays to measure cellular dysfunction in more complex systems than at the single enzyme level, taking into consideration the cellular ecosystem using a systems biology approach. The mitochondria are the primary metabolic organelles in the cell and also play important roles in modulating cell health including when to induce cell death via several different pathways. This organelle then is often a key component of drug toxicity. Our lab addresses these concepts in drug toxicity by looking at new models to predict toxicity, the development of new assays to identify when it does occur and investigating fundamental concepts in mitochondrial form, function and health. We link current concepts and problems in clinical medicine with our research techniques to form an active translational medicine research programme.

**Anesthetic Toxicity and the Metabolic Effects of Anesthetics**

**Anesthetic Neurotoxicity**
The potential for anesthesia-induced neuronal damage was first published in 1999 when the group of John Olney showed that agents used in a common anesthetic could induce widespread neuronal apoptosis in a rat model. They were subsequently able to reproduce these results in non-human primates and show that this neuronal damage produced a developmental phenotype including deficiencies in cognition and learning when compared to age-matched controls. Importantly, the observed neuronal damage was most significant when the anaesthetic agent was administered during the period of peak synaptogenesis and brain development (seven days of life for the rat). The human correlation for this period is challenging to determine but, depending on the region of the brain being observed, would correlate to between 20 weeks intra-uterine gestation to six years of life.
The clinical implications of anesthesia-induced neuronal damage were first published in two main papers in 2009 by Wilder et. al. and Dimaggio et. al. Both groups were able to show that anesthetic exposure before four years of age was correlated with poorer IQ, cognition and development. With a larger study group, Wilder was able to show that the adverse effects of anesthetics on neurodevelopment occurred primarily after two or more anesthetics and did follow a dose-response relationship between the degree of impairment and the cumulative time of anesthesia exposure. Subsequent papers from both groups have attempted to control for other risk factors for the development of a learning disability, only to show a more positive correlation between anesthesia exposure under three years of life and the diagnosis of a learning disability. As these and subsequent studies were retrospective, it was not possible to control for the anesthetic technique or agents used, and indeed a broad heterogeneity of pharmaceuticals was utilized. The lack of a common anesthetic technique did not then inform on a potential mechanism of damage.

Since the lab was established two years ago, we have investigated the potential mechanisms of anesthesia-induced neuronal damage. Borrowing from mechanisms involved in chronic neurodegenerative diseases, including Alzheimer’s and Parkinson’s diseases, we have investigated the role of anesthesia-induced mitochondrial damage as a potential mechanism to produce neurocognitive deficits.

**Project Hypothesis:** The adverse changes in neurocognition and neurodevelopment observed after early exposure to anesthesia are mediated through damage to the mitochondria, which can produce a persistent cellular metabolic deficit and therefore a permanent cellular dysfunction.

Using four different cellular models (HeLa cells were used as a standard cell model, allowing for easy comparison to the literature, HepG2 cells were used a common model for mitochondrial toxicity and metabolism and induced pluripotent stem cell derived cardiomyocytes and neurons were used to better approximate human end-organ effects) we analysed the effect of clinically relevant concentrations of anesthetic agents on mitochondrial form and function, when exposed for time spans that would occur during a normal anesthesia. In this analysis, we determined (Figure 1):

1. Anesthetic agents change the amount of mitochondria in the cell in time spans as short as one hour. A reduction of mitochondrial mass is indicative of the removal of damaged mitochondria, usually through the process of mitophagy. The removal of damaged organelles avoids apoptosis and attempts to correct for a more moderate cellular insult (like a mild ROS insult from low dose peroxide 20 uM). An increase in the amount of mitochondria is indicative of stress-induced mitochondrial hyperfusion (SIMH), a survival response in the cell that attempts to correct for a sudden and more profound damage to the mitochondria (like from higher dose peroxide 200 uM). Interestingly, anesthetic agents induced both of these types of responses. Isoflurane and ketamine significantly reduced the mitochondrial mass at one hour. The other agents tested, including
morphine, propofol and midazolam, all induced the SIMH phenotype at one hour, before causing loss of mitochondrial mass as the cell begins to proceed through apoptosis and death.

2. In addition to changes in mitochondrial mass, there are obvious and early changes in mitochondrial morphology, away from a cell-wide network toward a more punctate perinuclear formation (Figure 2). This change occurs with all anesthetic agents, more profoundly with isoflurane than the other agents tested.

3. The remaining mitochondria in the cell after anesthetic exposure also have a lower polarization, indicating a lower functionality. This again was most profound with isoflurane where the cell maintained about 50% of its functionality, worse at four hours than one. A similar, although slightly less profound, decrease was seen with propofol (to 60% functionality). Morphine, midazolam and ketamine also decreased function, although to a lower degree (90%, 90% and 80% respectively).

4. All anesthetic agents induced bulky, oxidative DNA lesions in the mitochondrial genome. Astoundingly, isoflurane induced lesions with almost the same frequency as a high dose oxidative load, where the other agents produced a smaller, but still significant, number of mtDNA lesions (1.3 lesions per 10kb of mitochondrial DNA) (Figure 1).

Our results indicate that anesthetic agents can induce significant mitochondrial changes in a very short time period (within an hour), and in concentrations that are clinically relevant. The observed changes are most profound with isoflurane for all metrics tested. Importantly, we also discovered a mechanism by which a brief anesthetic exposure could produce a lasting and long-term cellular dysfunction (mtDNA lesions).
Figure 2. Example of anesthesia-induced changes in mitochondrial morphology in HeLa cells, (A) control cells illustrating a networked, fibrous mitochondria, (B) after a four hour exposure to 1MAC (300 uM) isoflurane the mitochondria become punctate and cluster around the nucleus, mitochondria are stained with MitoTracker Green and imaged at 20x magnification in the Cellomics ArrayScan VTI robotic imager.

We wanted to verify that these changes were also observable in human samples after anesthesia exposure. To reduce the potential confounders from surgical stimulus, we selected patients in the Emergency Department undergoing minor procedures, almost exclusively small laceration repair. We obtained a blood sample upon IV insertion, the patient then received ketamine (2 mg/kg) for the small procedure. Just before discharge from the ED (usually ~3 hours), a second blood sample was obtained. The peripheral lymphocytes were purified from each blood sample and mitochondrial polarization and mass were determined. Additionally, the presence of mtDNA oxidative lesions was observed. Each patient served as his or her own control (pre- versus post-treatment).

Thus far, 23/30 patients are recruited to this study. We found that a single exposure to ketamine was able to significantly drop the mass of mitochondria present in the patient lymphocytes, on average a 24% reduction in the mitochondrial mass (p = 0.004). We also observed evidence of stress-induced mitochondrial hyperfusion, with a 16% increase in mitochondrial function per cell and a mean mitochondrial intensity increase of 5%. Importantly, the single dose of ketamine was able to create the presence of oxidative DNA lesions (Figure 3).

Figure 3: Oxidative mtDNA lesions observed per patient after a single dose of ketamine (2 mg/kg)

These results are the first to illustrate that anesthetic agents can induce mitochondrial damage after a single exposure and in a very short time period (within three hours of exposure). Importantly, the presence of mitochondrial lesions provides a mechanism by which the single exposure could produce lasting cellular dysfunction.
Planned/On-going studies:

1. Measuring the effect of isoflurane on long-term mitochondrial form and function in a rat model of anesthesia neurotoxicity. In a collaboration with Greg Stratmann at UCSF, we have obtained 13 rats from his model of anesthesia-induced neurocognitive deficiency (7 control and 6 isoflurane exposed). The rats all underwent either a genuine or sham anesthetic exposure during a period of peak synaptogenesis (P7), and then were grown to adulthood. Neurocognitive testing confirmed that the anesthesia-exposed rats had neuronal damage. We have received heart, brain and liver from all thirteen rats. We are in the process of measuring mitochondrial ultrastructure via EM, mitochondrial content and function, the presence of mtDNA lesions and the levels of proteins important for mitochondrial biogenesis and health (Mfn2, OPA-1, PGC1a, SirT1, SirT3, ERRa, MFF, Drp-1, PPARa).

2. Measuring the effect of anesthesia on autistic children. Although no large prospective studies exist, autistic children are thought to have a regression in their clinical phenotype after anesthesia exposure. Although autism is a polygenetic disease, with hundreds of gene associations, significant evidence exists that an underlying cellular metabolic derangement is present that may be a unifying mechanism for the neuronal dysfunction observed. We have obtained 50 autistic patient lymphoblastoid cell lines from the Autism Genetic Resource Exchange (AGRE) and five control cell lines from the NIH tissue repository (Coriell). We are currently in the process of exposing each of these cell lines to anesthetic agents including isoflurane and propofol, with quantification of the anesthetic effects on mitochondrial form and function, cellular redox status and the generation of mtDNA lesions. Our project will inform us as to how anesthetics affect autistic patients and whether the exacerbation of an underlying metabolic disorder by anesthesia could be responsible for autistic patient regression.

**Anesthesia-Induced Protein Misfolding**

The PHOX-2B transcription factor is expressed in a small number of neurons present in the retrotrapezoid nucleus of the brainstem. Despite the small number of neurons that express the protein, it provides a vital function, controlling respiratory drive during sleep by sensing the blood pH/carbon dioxide levels. From a protein structure viewpoint, the protein is very unique. The N-terminal half of PHOX-2B consists of a paired-like homeobox domain for DNA binding. The C-terminal half of the protein is predicted to be intrinsically disordered and possess no structure but also, amazingly, has a section of sequence that possesses twenty consecutive alanine residues. The polyalanine residue region is the part of the protein that is affected in Congenital Central Hypoventilation Syndrome (Ondine’s Curse). An expansion to 23 alanines usually go unnoticed, however at 30 or 33 alanines, the protein is known to remain stuck in the cytoplasm of the retrotrapezoid cells, unable to perform the transcription factor role. Additionally, they induce cell death, eliminating the cells responsible for carbon dioxide sensing during sleep. Patients with 30 or 33 alanines will be born without the ability to control their breathing during sleep and require a permanent tracheotomy and ventilation. Patients with 25 or 27 alanines do not present at birth with a respiratory phenotype, but do present at a later age (usually around five years) after an inciting incident (like a viral infection). Recent case
reports, including from Montreal, illustrated the ability of anesthesia to induce onset of CCHS in this moderate mutation population.

Project Hypothesis: Anesthetic agents can induce misfolding of the PHOX-2B protein, causing localization and aggregation of the protein in the cytoplasm. This effect has the potential to facilitate the onset of Congenital Central Hypoventilation Syndrome.

We produced all common mutants of the PHOX-2B protein, including the wild-type, 23 alanine (three extra alanines), 25 (five extra), 27 (seven extra), 30 (ten extra) and 33 (13 extra) alanine variants. The coding sequence for these proteins was placed downstream of a fluorescent reporter protein (mCherry) and the entire sequence cloned into a mammalian protein expression vector. HeLa cells were transfected with the constructs and the cells were exposed to three anesthetic agents (morphine 1 uM, propofol 10 uM and isoflurane 1MAC) for four hours. The cells were imaged using a robotic fluorescent imager (Figure 4).

![Figure 4: PHOX-2B variants after exposure to anesthetic agents. Nuclei are stained with Hoechst, the PHOX-2B protein is imaged using the mCherry reporter.](image)

The results illustrate that the wild-type, 23, 25, 27 and 30 alanine variants localize to the nucleus at baseline. The 33 alanine variant however is aggregated in the cytoplasm for approximately 50% of cells, consistent with the physiological effect of the 33 alanine mutation. Exposure to propofol did not affect protein localization for any of the variants. However, exposure to isoflurane (1 MAC concentration) induced a further shift, where more of the 33 alanine variant was now located in the cytoplasm (Figure 5). Additionally, isoflurane induced a proportion of the 25, 27 and 30 alanine variants to also localize to the cytoplasm, where no cytoplasmic protein was found in these variants under control conditions. Additionally, morphine induced movement of the 30 alanine mutant from the nucleus to the cytoplasm.
Figure 5: Anesthetic agent effects on PHOX-2B protein localization. Isoflurane promotes cytoplasmic localization and aggregation in the 33 alanine variant and induces cytoplasmic localization in the 25, 27 and 30 alanine variants (blue arrows). Morphine also induces cytoplasmic localization in the 30 alanine variant but did not induce changes in any other variant to a statistically significant degree. Propofol did not induce changes for any variant.

Our results show for the first time that anesthetics can induce the onset of CCHS by inducing protein aggregation and misfolding of PHOX-2B. This data is also the first evidence of anesthetic agents inducing the misfolding of a natural human protein. The implications of this research for generalized protein misfolding diseases, like Alzheimer’s disease, is interesting and our results may be linked to the observed post-operative cognitive decline noted in the elderly population. The cellular based system developed may also be used to test for attenuating agents that may attenuate or abrogate the effects seen.

Planned/On-going studies:
1. Ongoing investigations are aimed at delineating the activation of the unfolded protein response (UPR) by anesthetic agents, and how activation of this pathway is affected. We are also investigating potential therapeutic agents including antioxidants (trolox, vitamin C), HSP70 activators (17AAG) and multifunctional pharmaceuticals (ibuprofen, antioxidant and induces the HSP pathways).

Epigenetic Changes Induced by Anesthetics
Isocitrate dehydrogenase (IDH) is the most regulated enzyme in the citric acid cycle and is the rate-limiting step in flux through the cycle. Not entirely surprisingly then, the enzyme (and its metabolic products) have additional functionality other than their pure energetic roles. The product of the reaction, α-ketoglutarate, is also a substrate for dioxygenases and the TET family of DNA demethylases. IDH has the additional distinction of being the most mutated metabolic enzyme in cancer. The most common mutation, IDH:R211H, doesn’t just inactivate the enzyme but actually creates another enzymatic product (R2-hydroxyglutarate). Without α-ketoglutarate, DNA is demethylated to a lower extent and additionally the new R2-hydroxyglutarate product directly inhibits DNA methylation. The double hit increases DNA methylation and works to promote cancer metastasis.
**Project Hypothesis:** Anesthetic agents could alter cellular metabolism by affecting the activity of IDH and thereby also alter DNA methylation and cancer growth.

We began by cloning and purifying the two most common forms of IDH, IDH1 (cytoplasmic) and IDH2 (mitochondrial). The enzymes have similar, but not identical, amino acid sequences. Using a colorometric assay, we determined if common anesthetic agents affect IDH activity (Figure 6). Morphine was the only agent that was able to inhibit IDH and the $K_i = 36.5 \, \mu M$ was within normal serum levels for morphine, illustrating the practical significance of the results. Interestingly, despite the similarities in the sequences between IDH1 and IDH2, the latter was not inhibited. Also, hydromorphone, differing in structure from morphine only by the conversion of a single hydroxyl group to a ketone, did not inhibit either of the IDH enzymes. The inhibition profile showed that morphine was not a competitive inhibitor but an allosteric one, consistent with the several known allosteric sites on IDH that are used for metabolic regulation.

<table>
<thead>
<tr>
<th>Agent</th>
<th><strong>IDH1 (cytoplasmic)</strong></th>
<th><strong>IDH2 (mitochondrial)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoflurane</td>
<td>No inhibition</td>
<td>No inhibition</td>
</tr>
<tr>
<td>Midazolam</td>
<td>No inhibition</td>
<td>No inhibition</td>
</tr>
<tr>
<td>Ketamine</td>
<td>No inhibition</td>
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<td>Propofol</td>
<td>No inhibition</td>
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<tr>
<td>Lidocaine</td>
<td>No inhibition</td>
<td>No inhibition</td>
</tr>
<tr>
<td>Morphine</td>
<td><strong>$K_i = 36.5 , \mu M$</strong></td>
<td>No inhibition</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>No inhibition</td>
<td>No inhibition</td>
</tr>
<tr>
<td>Hydromorphone</td>
<td>No inhibition</td>
<td>No inhibition</td>
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</tbody>
</table>

Figure 6: Assay results for the inhibition of IDH1/2 by anesthetic agents

To verify the intracellular metabolic consequences of IDH1 inhibition, we looked at the end results of IDH inhibition. In HeLa cells, morphine was able to reduce the concentrations of α-ketoglutarate, showing a direct inhibition of IDH (Figure 7). Additionally, cellular ATP was lowered and an anaerobic metabolism was induced (increased lactate). Having verified that morphine inhibited IDH1 in cell culture, we also wanted to see if morphine affected the mutant IDH:R132H. We performed site-directed mutagenesis, expressed and purified the enzyme. Using the same colorometric assay, morphine was a specific enzyme inhibitor of the mutant IDH1 with a slightly higher potency than the wild-type enzyme ($K_i = 20 \, \mu M$).

Figure 7: Morphine effects on cellular metabolism including (A) α-ketoglutarate, (B) ATP and (C) lactate levels.
To verify the end effects of decreased intracellular 2-ketoglutarate concentration, HeLa cells were treated with morphine for five days, the media replaced every two days to account for metabolism. The resulting DNA was analysed for DNA methylation levels (Figure 8). The increased level of total DNA methylation induced with morphine illustrates that morphine treatment could indeed alter the epigenetic profile of the patients who receive the medication.

Our results indicate that morphine is a specific inhibitor of cytoplasmic IDH1, inhibiting both the wild-type enzyme and the R132H mutation present in certain cancers. It may be that the pain opioid prescribed in cancer therapy would depend on the genotype of the cancer involved. If the cancer maintained a wild-type IDH1, then treatment with morphine would be disadvantageous, since 2-ketoglutarate would be reduced and the potential for metastasis increased. However, if the cancer had a IDH1:R132H genotype, then treatment with morphine would be advantageous since inhibition of that enzyme would reduce the production of R2-hydroxyglutarate (2-ketoglutarate is already lost by with the R132H mutation) and reduce DNA methylation.

Future/Ongoing Studies
1. To determine the total cellular metabolic alterations associated with morphine treatment, we are performing metabolomics on cells treated with morphine. Using mass spectrometry-based methods, we are able to determine the intracellular concentration of 16-18 000 small molecules. From this analysis, we hope to determine what other pathways morphine affects, some that may be beneficial and others detrimental to certain metabolic conditions and states.
2. Recent studies indicate that IDH1 inhibition may be detrimental to glioma cancers, a cancer that is highly dependent on the IDH1:R132H mutation. We will perform experiments to see if morphine is able to differentially affect cancers with the R132H genotype, indicating the need for a genotype specific cancer pain therapy.
**Mitochondrial Morphology and Long-term Mitochondrial Function**

The changing of mitochondrial morphology includes the fission of mitochondria to create smaller, less function units and the fusion of smaller fragments into larger mitochondria. The processes of fusion and fission are used to control mitochondrial quality and function, repair the mitochondrial genome and avoid (or induce) apoptosis (Figure 9). We have focused on the adapter protein mitochondrial fission factor (MFF), which is involved in the very early cellular stress response and recruits the GTPase Drp-1 to the mitochondrial surface to perform the mitochondrial scission.

![Morphology Diagram](image)

**Project Hypothesis**: Changes in mitochondrial morphology are vital to maintain mitochondrial health and function. Delineation of the role of MFF could inform on the mechanisms of mitochondrial quality control and neurodegenerative diseases like Alzheimer’s.

Our extensive biochemical and biophysical analysis of MFF has revealed:

(a) MFF is a dimer in solution, interacting through its N-terminal domains

(b) using 15N labeled NMR HSQC, MFF is an intrinsically disordered protein that forms no definite structure

(c) using small angle X-ray scattering (SAXS), we verified that MFF is intrinsically disordered but that there is enough transient structure to give a molecular surface with an approximate two-fold axis for the MFF dimer (Figure 10)

(d) using isothermal titration calorimetry, MFF bound to the GTPase Drp-1 with a Kd=10 uM, but very interestingly 10 MFF molecules bound per Drp-1, showing how oligomerization may occur to bring Drp-1 to the mitochondrial surface

(e) a second adapter protein, MiD49 binds in a mutually exclusive fashion to Drp-1 with a similar Kd=10 uM, but only one MiD49 binds to Drp-1, highlighting a potential differential mechanism of Drp-1 recruitment

![MFF Dimer Diagram](image)
We have also created stably transfected cell lines expressing MFF bound to CFP, YFP and mCherry fluorescent markers. These constructs will be used to determine MFF localization after certain stresses (the CFP and YFP being used in a FRET experiment for dimer localization) and to determine MFF post-translational modifications.

Future/Ongoing Studies
1. Determine how the subcellular localization of MFF is altered by different cellular stresses, and determine how post-translational modifications affect MFF structure and function
2. Determine the X-ray crystal structure of MFF and MiD49 bound to Drp-1

**Dilated Cardiomyopathy and Cardiac Dysfunction**

**Chemotherapy-Induced Cardiac Dysfunction**
While pharmaceuticals are intended to prevent and treat disease, those same drugs can be toxic or produce unwanted actions in patients because of genetic predisposition, nonselective/off-target action, or inappropriate use of the drug. Every year, the FDA spends approximately one billion dollars testing the safety of new candidate drugs and ensuring the continued safety of already approved and marketed compounds (www.fda.gov). Toxicity often limits the advancement of new candidate drugs in the approval process and creates additional morbidity and mortality for patients using established drugs. Cardiac toxicity is particularly common, resulting in pro-arrhythmic alteration of ion channel activity or an overall reduction in cardiac function. The impact of adverse cardiac effects on patient care and health in both short and long term can be profound. It has been shown that more than half of pediatric cancer patients treated with chemotherapy (specifically the antracycline class of anti-neoplastics) will have some degree of permanent heart dysfunction, leading to heart transplantation in ten percent of cases. Although vital, the study of cardiotoxicity is challenging and commonly involves testing drugs on isolated non-human hearts (Langendorff preparations) or whole animals (usually mice). These models are extremely expensive, time consuming, and often inaccurate primarily because of the different genetic backgrounds between humans and tested species. Such models also ignore how drug effect and toxicity is substantially altered by genetic variation between patients. To identify and prevent drug cardiotoxicity, a new comprehensive approach is needed that can assess both the potential adverse cardiac effects of a pharmaceutical and the variation in toxicity between individuals. If possible, heart cells from each patient would be tested for drug toxicity and effect, providing general information on cardiomyocyte function and health, and also revealing adverse effects specific for that particular patient.

**Project Hypothesis:** Induced pluripotent stem cell derived cardiomyocytes (iPSC-CMs) can be used as a new, human model for drug toxicity. Using iPSC-CM we should be able to better predict the general cardiotoxicity of a drug and also determine patient-specific treatment protocols.
We have utilized the Acea xCELLigence system to measure the effect of drugs and proteins on cardiomyocyte function. The iPSC-CMs are placed into 96-well plates containing a network of gold leads across the bottom. The cells settle to the bottom of the well, adhere, form gap junctions and begin to beat spontaneously. By measuring impedance changes through the gold leads on a millisecond time scale, the beating of the cells can be analysed (Figure 11). Our lab is one of only a handful of academic labs worldwide with this technology. By collecting information on changes in beat rate, amplitude and rhythm, we have developed a metric based on Chaos Theory that allows for quantification of a drug’s ability to induce cardiac dysfunction. We have shown that this system can be used to model known cardiotoxic drugs, for example the cancer chemotherapeutic doxorubicin, and also screen/test for small molecules that attenuate cardiomyocyte damage.

Figure 11: (A) example gold-treated plate used to measure iPSC-CM beating in xCELLigence, (B) example tracing of iPSC-CM beating as collected by measuring impedance changes in gold-lined wells, control (DMSO) shows perfect regular beating (blue), treatment with the known arrhythmogenic drug doxorubicin induces changes in the beating profile (purple), treatment with experimental drug (JC-1) does not induce an arrhythmia on its own (green) and returns regularity to the doxorubicin treatment (red), also measurable are amplitude of beating and overall rate changes, (C) Chaos plot of beat-to-beat intervals from (B), control wells (green) show a very tight dispersion indicating regular beating (small green circles, triplicate experiments), doxorubicin treated wells (red) show a much larger dispersion indicating irregularity in beating and arrhythmia (large red circle), treatment with JC-1(blue) restores the beating regularity (smaller blue circle, shown in duplicate) (Manuscript in review, Nature Methods).

Using this system, we have focused on the protein Integrin-linked kinase as a potential cardiotherapeutic protein. Integrin-linked kinase (ILK) is a known cardioprotective protein that promotes cardiomyocyte function and survival. Although not fully elucidated, ILK’s mechanism of protection is mediated through scaffolding of other proteins in the cardiomyocyte, including the parvin class of proteins (α and β parvin). Potentiation of the ILK:β-parvin interaction or inhibition of the ILK:α-parvin interaction provides protection during ischemic or oxidative stress. We propose to explore the intracellular mechanisms of ILK:parvin association by determining the temporal and spatial formation of the complexes during oxidative and ischemic stress. Using the X-ray crystal structure of ILK:parvin, we (in collaboration with a local pharma company Encycle who specializes in cyclic peptide chemistry) designed a cyclic peptide that disrupts the ILK:parvin interaction. In preliminary studies, this peptide protected the iPSC-CMs against doxorubicin-mediated damage (Figure 11).

Future/Ongoing Studies
1. We will generate personalized iPSC-CM for a patient who received anthracyclines for glioblastoma and acquired end-stage dilated cardiomyopathy from a single dose of the
drug. The cardiomyocytes generated from this patient will be used as a model to test for small molecules that attenuate anthracycline-induced cardiomyocyte damage.

2. In addition to (1) we will also screen a larger sampling of small molecules using generic iPSC-CMs treated with anthracyclines to identify new potential therapeutics for anthracycline-induced cardiomyocyte damage.

3. Determine the subcellular localization of ILK, α-parvin and β-parvin and how the association of these proteins change after exposure to oxidative and ischemic stress in cardiomyocytes;

4. Determine how removal of ILK, α-parvin and β-parvin (via shRNA) from the cardiomyocyte affects recovery, survival and function of the cell after ischemic and oxidative stress;

5. Determine how a cyclic peptide, designed to disrupt ILK:parvin interactions, provides cardioprotection and refine this peptide for optimal cardioprotective benefit.

Inherited Dilated Cardiomyopathy

Inherited right ventricular arrhythmogenic dilated cardiomyopathy is known to have a genetic component, a specific founder population for this disease being present in Newfoundland. The altered protein identified in this population is TMEM43. Very little information exists about the function of this protein, other than the primary structure indicates that it contains a transmembrane domain.

Project Hypothesis: Alteration in TMEM43 function is detrimental to cardiomyocyte function and creates right ventricular dilation. A small molecule chemical chaperone may be used to facilitate proper function of the protein and correct the underlying pathophysiology.

We started by cloning and expressing both TMEM43 and the mutant disease-causing version in HeLa cells. These studies show that wild-type TMEM locates in the perinuclear region, but the mutant protein has a very low expression level and is primarily located in the cytoplasm. Interestingly, if the cells are grown at 28C, the wild-type protein continues to locate to the nucleus but the mutant protein has higher expression levels, forming aggregates in the cytoplasm. This is analogous to CFTR where lower expression temperatures assist in the folding of a poorly/misfolded protein. Our investigations continue into TMEM43 action and location in this early project.

Future/Ongoing Studies

1. Verify the temperature sensitivity of the mutant protein in iPSC-cardiomyocytes, and determine how mutation of TMEM43 alters cardiomyocyte beating.
2. Using CrispR-Cas9 genome editing, we will modify the endogenous TMEM43 in HL1 cells, creating a model that can be used for small molecule chaperone screening.
3. Create a genome-edited version of TMEM43 in zebrafish and perform small molecule chaperone screening using the zebrafish model.
New Therapeutics for Respiratory Syncytial Virus

Respiratory Syncytial Virus (RSV) produces a large morbidity and mortality effect in the pediatric population. The recent emergence of an RSV vaccine has brought promise to treatment, although the vaccine is only partially efficacious and is currently only given to high-risk patients owing to its costs. The majority of current treatment regimens is supportive and the discovery of new anti-RSV treatments would be highly beneficial to pediatric medicine.

Project Hypothesis: The identification of FDA-approved small molecules that prevent RSV entry/propagation would be highly beneficial clinically with a rapid translation and the ability for quick implementation.

In collaboration with Theo Moraes, we developed an assay for RSV entry into human pulmonary epithelial cells. The RSV genome was edited so that GFP is the first protein produced after viral infection of a host cell. Using the modified virus and human lung epithelial cells, we screened a library of 2500 compounds, including a majority of the FDA-approved pharmaceuticals. The end points of the assay were reduced RSV-infection (green cells), no/minimal reduction in the cells density (drug not toxic to the cells themselves) and the reduction of syncytia (Figure 12).

Our screening was able to identify three classes of drugs that could reduce RSV entry/propagation:

(a) Na+/K+ ATPase inhibitors: example digoxin
(b) Statins: example atorvastatin
(c) Sex steroids: example Levonorgestrel

Figure 12: Assay for RSV infection, (A) showing a control infection with a constant infection rate at 72 hours of ~50% and the presence of syncytia, (B) positive control drug showing a gross reduction in the infection rate (~15% infection), a reduction in the presence of syncytia and no overall loss of cells.

A remote singular publication reported that RSV has internally-encoded proteins that attempt to control the function of the host cell Na+/K+ ATPase, thus inhibitors of this channel are not totally unexpected. The main concern with this class of medications is the narrow therapeutic index. There is no literature indication for the other two classes that we identified. The most intriguing are the statins. Every statin in the screen showed similar results, illustrating a likely class effect. Statins are obviously well tested and well used in a large population, offering the possibility of rapid translation as a well-established safety profile is already present.
Future/Ongoing Studies

1. We are currently verifying the identified hits in an air-water interface of human epithelial cells intended to mimic the lung.
2. Following verification, we plan on testing a more limited set of drugs in a mouse model of RSV in collaboration with Dr. Theo Moraes
3. If validity holds, we hope to be in limited local clinical trials by the end of the calendar year

_Pulmonary Vein Stenosis (PVS)_

Stenosis of the pulmonary veins occurs either post-surgically, after left heart repair, or as an idiopathic disease. The vein stenosis in either case is not limited to a certain anatomic site (even if it starts at the PV-left atrial junction in the surgical cause) but spreads up into the pulmonary parenchyma. Stenting in the catheterization lab can temporarily alleviate the right heart strain but a combination of disease spread and in-stent re-stenosis eventually overcomes any stenting. The five-year mortality for diffuse disease is essentially 100%. In collaboration with Dr.’s John Coles and Chris Caldarone, we have developed a Yorkshire piglet model of PVS to study the pathophysiology of PVS and develop therapeutics.

*Project Hypothesis:* A combination of surgically stenosed Yorkshire piglet, human patient and human endothelial cell culture cells can be used to model PVS and develop new therapeutics for this otherwise untreatable disease.

Using surgical techniques, we banded four of the five pulmonary veins of Yorkshire piglets. At seven weeks post-banding, the pigs underwent hemodynamic examination before sacrifice for histological and biochemical analysis (Figure 13). Hemodynamic examination confirmed that the Yorkshire piglet model was able to develop pulmonary venous stenosis, affecting pulmonary and right heart pressures and function. Additionally, histopathological analysis showed that the pigs underwent intimal hyperplasia, both within the band and outside of the band in the upstream venous system, analogous to the human disease (Figure 13). Immunohistochemical analysis showed that there was a generalized loss of endothelium, in the band and outside, and that the endothelium was replaced by myofibroblasts (MyoFB) (downregulation of the endothelial markers CD31 and vWF and upregulation of the MyoFB markers smooth muscle actin (SMA) and fibronectin). As a potential source of MyoFB, we looked for and found increased levels of TGF-β in PVS samples, an indication that endothelial-to-mesenchymal transition (EndMT) was occurring as a pathological process and inducing fibrosis in the pulmonary veins. Importantly, this process may spread, accounting for the upstream spread of PVS seen clinically. Using patient samples with PVS, we verified that these pathological findings also occur in the human disease (Figure 14).
We next attempted to develop a cell model for screening of pharmaceuticals that may attenuate the PVS pathological process. Taking cell samples from banded pigs and culturing, plus treatment of human endothelial cells (HUVECs) with TGF-β created a cell system for looking at pharmaceuticals that may prevent the progression of PVS. Using our assay system, we performed a limited drug screen (owing to the limited availability of primary cells in culture) and identified an FDA-approved small molecule that blocks the proliferation of the MyoFB cells, reduces fibronectin and SMA in the cells.

![Figure 13: Yorkshire pig model of PVS. (A) hemodynamic parameters from banded pigs showing increased mean PAP and PVR, (B) histopathological samples from pigs, showing intimal hyperplasia and disorder of intimal layer, (C) immune-histochemistry showing loss of endothelial markers (CD31 and vWF) and increase in myofibroblast markers (fibronectin and SMA), (D) increase in TGF-β expression with banding.](image)

We have created a model to delineate the pathophysiology of PVS and verified the findings of this model in human samples. We have also created an assay system that was used to identify an FDA-approved small molecule that blocks the progression of PVS.
Future/Ongoing Studies

1. Using samples from patients with diffuse PVS and control samples from patients having heart transplantation, we will use single cell RNAseq techniques to describe the transcriptome of the pathologic cells present in the pulmonary endothelium.

2. Determine how both the transcript and protein levels are altered in the endothelium of pigs induced into PVS and treated with our FDA molecule. This will determine if the proliferation of mesenchymal cells is reduced by the therapeutic in the piglet model. This analysis will be performed on a tissue layer basis by utilizing laser microdissection of pig vein samples.

3. If the discovered drug continues to show improvements in the pathological phenotype in the piglet model, we hope to be in clinical trials by the end of the calendar year.

Current Laboratory Personnel

1. Ramesh Vanama – lab manager
2. Sandra Singhroy – technician
3. Mohan Sarkar – technician
4. Anouk-Martine Teichert – research associate
5. Michael Tropak – research associate
6. Matthew Coghlan – research fellow
7. Julia Plakhotnik – graduate student
8. Manpreet Malhi – graduate student
9. Daniel Stocki – clinical fellow
10. Dean Bunbury – clinical fellow

Current Collaborators

1. Dr John Coles, Cardiovascular Surgeon, HSC
   a. Chemotherapy Induced Cardiac Dysfunction
   b. Pulmonary Vein Stenosis
2. Dr. Christopher Caldarone, Cardiovascular Surgeon, HSC
   a. Pulmonary Vein Stenosis
3. Dr. Mark Crawford, Chair of Anesthesia, HSC
   a. Anesthetic Neurotoxicity
   b. Anesthesia-Induced Protein Misfolding
4. Dr. Theo Moraes, Pulmonologist, HSC
   a. New Therapeutics for Respiratory Syncytial Virus
5. Dr. Robert Hamilton, Cardiologist, HSC
   a. Inherited Dilated Cardiomyopathy
6. Dr. Yaron Finkelstein, Emergency Physician, HSC
   a. Anesthetic Neurotoxicity
7. Dr. Meredith Irwin, Oncologist, HSC
   a. Chemotherapy-Induced Cardiac Dysfunction
8. Dr. Boris Hinz, Faculty of Dentistry, University of Toronto
   a. Pulmonary Vein Stenosis
Cardiac voltage-gated Na-channel-related cardiomyopathy

Initial studies
My research program started off as the analysis of a then recently discovered cardiac Na-channel (Nav1.5) mutation, R222Q, associated with a striking ECG phenotype (Figure 1) and high penetrance cardiomyopathy. The initial analysis consisted of the heterologous expression of the mutant and wild-type channels in CHO and HEK cells and whole-cell voltage clamp and single channel patch-clamp electrophysiology. The results were published in a combined clinical/basic science paper. (1) I am including the relevant Figures (Figures 2-4) with abbreviated explanations of methodology in small print.

Figure 1: The electrocardiographic signature of heterozygous Nav1.5 R222Q - escape capture bigeminy - in 5 members of the index family.
Figure 2: Leftward shift in channel gating compared to wild-type leading to activation of R222Q channels at more negative potentials. No change in maximal conductance, suggesting no interference of the mutation with trafficking of the channel. I_{Na} measurements of WT and R222Q SCN5A expressed in Chinese hamster ovary K1 cells. Typical WT (A) and R222Q (B) currents (I_{Na}) recorded in response to voltage steps from -80 to +100 by 10 mV from a holding potential of -80 mV. I_{Na} is shown for every second voltage step for clarity. C: Normalized peak I_{Na} (n = 8 for both groups) as a function of step voltage for WT and R222Q. D: The estimates of the maximal conductance (G_{max}) for WT and R222Q (N = 12) show no differences between the groups.

Figure 3: Steady-state activation and inactivation profiles of R222Q and WT channels. The more pronounced negative shift in activation leads to an increased window current (green) in R222Q channels at physiologically relevant potentials.
Steady-state activation and inactivation curves. Normalized conductance derived from the peak $I_{\text{Na}}$ measurements was used to generate steady-state activation curves ($n = 8$) for WT channels (closed triangle) and R222Q channels (open circles). Normalized conductance plotted as a function of the prepulse voltage was used to generate steady-state inactivation curves ($n = 8$), which are shown for WT channels (open triangles) and R222Q channels (closed circles). Black lines are the best fits of the data to a Boltzmann function with 2 voltage components. The inset shows the overlap region between the fitted activation and inactivation curves (WT—orange and R222Q—green background).

Figure 4: Faster Na current decay in R222Q, consistent with differences in steady-state activation. No difference in recovery from inactivation attesting to similar inactivation state stability for mutant and wild-type channels.

Fast inactivation and recovery from inactivation. A: Typical normalized $I_{\text{Na}}$ traces recorded in response to -40 mV step for WT (grey) and R222Q (pink) SCNA5 channels. The decline of $I_{\text{Na}}$ was fit to a biexponential (fast and slow time constants: $\tau_{\text{fast}}$ and $\tau_{\text{slow}}$) decay function. B: The fast time constants ($\tau_{\text{fast}}$) as a function of voltage ($n = 8$). C: A typical protocol and superimposed current traces used to measure the recovery from fast inactivation. In these studies, after applying steps to +20 mV (prepulse), the membrane potential was repolarized for variable periods of time to -100 mV followed by a second step to +20 mV (test pulse). D: The recovery is determined by taking the ratio of the $I_{\text{Na}}$ peak in the test pulse to the peak $I_{\text{Na}}$ in the prepulse as a function of time. R222Q whole-cell current (bottom) shown in the panel; the 1st (green trace) and last (red trace) pulses are highlighted for clarity; interpulse interval was set to 2 seconds.

Two further, intriguing, and not yet published, aspects of R222Q is an increased prevalence of bursting conduction mode compared to wild-type channels as evidenced on single-channel
recordings (Figure 5). Such bursting activity has the potential to contribute to late Na current, a type of current implicated in the pathomechanism of long QT syndrome and also identified in cardiomyocytes derived from failing hearts.

Figure 5: Single-channel recordings of WT (top panels) and R222Q (bottom panels) channels. Observe one of the two channels present in the patch in bursting gating (bottom left).

R222Q enters a slow inactivated state at negative potentials to resting membrane potential (Figure 6) providing a substantial pool of recruitable channels in response to depolarization. The extent of these latter two features of R222Q seems to depend on the state of the cytoskeleton. Therefore, in the absence of data obtained from native systems mechanistic claims of their relevance is unconvincing.

Figure 6: Slow inactivated state of R222Q. Protocol for these experiments consisted of a prepulse to -80 to -110 mV for 500 msec from a holding potential of -80 mV followed by a test pulse to +20 mV. Data presented as peak I_{Na} in response to the test pulse as a function of the prepulse potential normalized to the response at -80 mV.

Altogether, the above features constitute a gain-of-function phenotype for R222Q providing electrophysiologic substance to increased myocardial excitability. This data presents theoretical framework for the explanation of escape capture bigeminy, however, mechanistic proof of any arrhythmic tendencies of a mutant Na channel would require the presence of all the native ion
channels of the cardiomyocyte in physiologic stoichiometry, such a system is unavailable at present (see below).

**Nav1.5 channelopathies**
Recognized pathogenic mutations in Nav1.5 number in the 200-300 range. Most of these channelopathies manifest as one of a group of arrhythmogenic diseases. The biophysical properties of the mutant channels delineated by voltage-clamp studies in heterologous systems predict the disease phenotype with reasonable certainty. E.g. Brugada-syndrome is caused by loss-of-function mutations, while long QT-syndrome is caused by gain-of-function mutations of Nav1.5. Recent evidence associates a handful of Nav1.5 mutations with cardiomyopathy. The 10-12 cardiomyopathy-promoting Nav1.5 mutant channels have no clear common characteristics. In fact, some even lack significant macroscopic (whole-cell voltage-clamp) biophysical traits. However, these substitutive mutations tend to cluster in the S3-S4 regions, the voltage sensors, of Nav1.5.

**Voltage sensor of voltage-gated channels**
Study of the structure and function of the voltage sensor reveals a structure of water filled crevices, the gating pore, sinking into the membrane that act to focus the membrane potential over a very short, diaphragm-like, distance (Figure 7).(2) The diaphragm is created by conserved amino acids, some of which are implicated in Na-channel-related cardiomyopathies.

The disease hypokalemic periodic paralysis is caused by mutations in the skeletal muscle voltage-gated Na- and Ca-channel that are analogous or identical to some of the cardiomyopathy mutations located in voltage sensor regions of Nav1.5. Structure-function analyses of the voltage sensor of voltage-gated K-channels demonstrate a small, non-selective, leak current, the gating pore current, that runs through the voltage sensor when its structure is perturbed by substitutions similar to mutations causing cardiomyopathy.(3, 4) The leak current is activated at a specific voltage depending on the position of the substituted conserved amino acid along S4. Substitutions closer to the extracellular end of S4 cause leaking at hyperpolarized potentials (Figure 7).

Figure 7: Schematic structure of the voltage sensor: the gating pore. The gating pore is separate from the main pore of the channel, and with the discussed mutations will conduct a small, non-selective, rectifying current, the gating pore current.
**Gating pore current and cardiomyopathy**

Cardiomyopathy can be the consequence of inherited defects in several classes of proteins including mutations affecting cytoskeletal proteins, proteins involved in force generation, force transmission, nuclear membrane proteins, proteins involved in Ca ion homeostasis, and metabolic sensing. Though many of these genes are directly or indirectly connected to Ca ion homeostasis and contraction/relaxation protein machinery, the mechanism of onset for the final common phenotype of dilated ventricles, decreased systolic function, and clinical heart failure is not yet resolved. Based on the above literature evidence and the structural homology of voltage sensors, I hypothesized that cardiomyopathy-related Na-channel mutants exhibit a gating pore current. The current is likely very small compared to the main pore current, but, because it would be activated by hyperpolarization, it would run during diastole and potentially will load the cell with Na and/or H ions. Such intracellular ion homeostasis change will then initiate secondary changes in signalling pathways that have the potential to precipitate intrinsic mechanic failure of cardiomyocyte function i.e. cardiomyopathy.

I further propose that the cellular development of cardiomyopathy of various etiologies proceeds through a common step that involves such disturbance of intracellular ion homeostasis. I wish to investigate this hypothesis through the paradigm of Na-channel-related cardiomyopathy. The proposal was successful in securing the New Investigator Grant by SickKids/CIHR in 2012 providing funds for my research for three years ending in Nov, 2015. The general strategy of the proposal is summarized in Figure 8, with aims of the grant depicted. In the following sections, I will describe my research directions and achievements of the past year and a half.

**Figure 8. Possible mechanism of Nav1.5-associated cardiomyopathy and summarized strategy of the proposal. Aims 1)**

- Characterization of R222Q Igp (pore selectivity, relative permeabilities, blocking agents?);
- Functional consequences of Igp (alterations in intracellular Na/Ca/H in response to Igp in neonatal cardiomyocytes transfected by adenoviral constructs of WT and R222Q on C374Y background);
- Development of knock-in transgenic mouse model.

**Identification of gating pore current (Aim 1)**

The gating pore current (Igp), based on evidence from the literature, is likely very small, about 0.1% or less of the main pore current. Such small current is only reliably detected by the cut-open oocyte platform (COO). COO provides superior noise reduction and the availability to manipulate both intra- and extracellular ionic content. I have acquired the platform, but to date, I have not been able to achieve the seal required for the resolution of Igp. Unfortunately, in the mean time, another group has been successful in proving the existence of Igp in an analogous mutant, Nav1.5 R219H. While the priority is lost, I hope to demonstrate Igp for cardiomyopathy mutants in which the substitution involves conserved negatively charged amino acids of S3. Unlike the conserved positively charged amino acids of S4, and their role in the structure of S4, relatively little is known about the conserved S3 aspartate and glutamate.
Approaches to study functional consequences of Igp

A. ADENOVIRUS BASED TRANSECTION OF NEONATAL CARDIOMYOCYTES

Introduction of supernumerary Na channels into cardiomyocytes will alter the stoichiometry of native ion channels. Such alteration will, at the least, transform the action potential, and may even kill the cell. One approach to overcome the problem of stoichiometry is to transfect mutated Na channels of interest that carry no main pore functionality. Although, there are no known modified Na channels devoid of Na current, the mutation C374Y turns the TTX-resistant Nav1.5 isoform into TTX-sensitive. In the presence of millimolar TTX, native Na channels will function as normal, while R222Q channels based on C374Y Nav1.5 background will only present Igp. My lab has most of the necessary constructs ready to conduct these experiments.

B. KNOCK-IN MOUSE MODEL

Transgenic mice may fail to recapitulate human physiology. Short of a human cell-based model, however, a knock-in mouse model provides the most accurate system to study a monogenic disease. A mouse model has the added advantage of the ability to study the disease at the organ and whole organism level. Multiple successful knock-in mice have been created in the analysis of arrhythmogenic Nav1.5 channelopathies, and there are successful mouse models of Ca ion homeostasis related cardiomyopathy as well. Clinical evidence distinguishes R222Q from other Na channelopathies as highly penetrant. In order to extend my studies of Nav-related cardiomyopathy, I proceeded to obtain the R222Q mouse line. Genoway has achieved germline transmission in Dec, 2013.

C. CRISPR GENOME EDITING

CRISPR-Cas9 system allows high efficiency genome editing.(8) I am in the process of engineering heterozygous R222Q HL-1 cells. HL-1 cells are derived from mouse atrial tumor cells, and are the only passable cardiomyocyte cell-line. Such an engineered cell-line will be far superior to any other transfected cardiomyocyte (making A. obsolete) or heterologous cell system. The emphasis of my research for the coming months is to establish the cell line and conduct the experiments proposed in Aim 2 of the grant (Na, H, and Ca ion homeostasis), and extend the studies towards identifying the signalling pathways activated by Igp using proteomics.

References
3) Dr. Bradley Johnston, Clinical Epidemiologist, Assistant Professor, Department of Anesthesia and Pain Medicine, Institute for Health Policy, Management and Evaluation, University of Toronto; Scientist Track, Child Health Evaluative Sciences, SickKids Research Institute

Dr. Johnston has published 24 peer-reviewed articles, and has secured $346,216 as a principal investigator since arriving at The Hospital for Sick Children in September of 2011. He leads an emerging evidence synthesis methods unit, with a particular emphasis on methods for improving the interpretation of summary estimates from patient-reported outcomes (PROs). PROs provide patients’ perspective on treatment benefit including symptoms, physical and emotional function, and well being. PROs are crucial for clinical decision-making, the results of which are often difficult to interpret. Clinical trials evaluating medical treatments and health interventions increasingly incorporate PROs such as anxiety, pain, satisfaction and multi-dimensional health-related quality of life measures. Dr. Johnston leads a series of articles in the open access journal, *BMC Health and Quality of Life Outcomes* on the methodology of meta-analyzing PROs, and plays an active role with the Cochrane Collaboration as the lead author on the Cochrane Handbook chapter on PROs.

**Ongoing and planned research over the next 5 years:**

**Objectives:** Develop the first SickKids evidence synthesis methods unit. Objectives of the unit include:

1) Conduct surveys, methodological reviews and develop software to optimize strategies for the presentation and uptake of systematic reviews and meta-analyses of PROs;
2) Support, develop and apply pair-wise meta-analysis, network meta-analysis and individual patient data meta-analysis methods to systematic reviews of clinical trials;
3) Provide lectures and workshops on evidence synthesis methods.

**Objective 1.**

*Surveys:* Dr. Johnston currently leads two randomized surveys (anesthesiology, family medicine, internal medicine) of clinicians’ understanding and interpretation of summary data from patient-reported pain outcomes.

*Methodological reviews:* Given the wide use of PROs in clinical trials, evidence syntheses of trials, and practice guidelines, and the necessity to accurately interpret treatments' magnitude of effect, Dr. Johnston is leading the synthesis of the current minimal important difference (MID) literature, and will develop: a) quality appraisal criteria for MID estimates, b) a compendium of validated MIDs for use by decision-makers. This evidence synthesis project is currently under CIHR review. Dr. Johnston also leads a large evidence synthesis of the use of PROs in patients with rare diseases.

*Software development:* Dr. Johnston is developing statistical software to pool PROs using various presentation approaches (e.g. Ratio of Means, MID units, Risk Difference). He is working with the GRADE Working Group to incorporate this software into GRADEprofiler.

**Objective 2.** Dr. Johnston supports six anesthesia and pain-related systematic reviews currently underway, including: a) opioids for chronic-non cancer pain (lead: Dr. J. Busse), b) ketamine plus
morphine for post-operative pain (lead: Dr. J. Martin), c) background PCA for post-operative pain (lead: Dr. J. Hayes), d) local infiltration anesthesia for knee replacement (lead: Dr. C. McCartney), e) glucocorticosteroids as adjuvants to peripheral nerve block (lead: Dr. M. Crawford), f) platelet rich plasma at improving pain and function after orthopaedic fractures (lead: Dr. M. Bhandari).

**Objective 3.** Monthly lectures and workshops will provide an overview of evidence synthesis methods, including: Why are High Quality Systematic Reviews Essential; Defining the Research Question and Developing a Protocol; Systematic Searching of the Literature; Critical Appraisal and Risk of Bias assessment; Analysis and Interpretation of Study Results; ReviewManager 5.2 and GRADEprofiler software.
(see Section 9 Overview)

Grants and Awards

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Peer-Reviewed Funding 2010

<p>| <strong>Fiona Campbell</strong>, Co-Investigator | Canadian Institutes of Health Research | Translating research on pain in children (TROPIC study) | <strong>$1,587,782</strong> |
| <strong>Fiona Campbell</strong>, Co-Investigator | Canadian Institutes of Health Research | CIHR team in children’s pain | <strong>$4,054,611</strong> |
| <strong>Fiona Campbell</strong>, Co-Investigator | Hospital for Sick Children, Pediatric Consultants | Proposal to evaluate the Sickle Cell Day | <strong>$10,000</strong> |</p>
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<td>Treatment of congenital central hypoventilation syndrome by recovering Phox2b function</td>
<td>$3,500</td>
</tr>
<tr>
<td>Jason Maynes, Co-Principal Investigator</td>
<td>The Rare Disease Foundation</td>
<td>Cellular Toxicity of Anesthetics with Mitochondrial Disease</td>
<td>$3,500</td>
</tr>
<tr>
<td>Jason Maynes, Co-Principal Investigator</td>
<td>University of Toronto Innovation Grants</td>
<td>High-throughput screening using pediatric disease targets</td>
<td>$10,000</td>
</tr>
<tr>
<td>Conor McDonnell, Co-Investigator</td>
<td>Pediatric International Patient Safety &amp; Quality Committee</td>
<td>Post-operative nausea and vomiting in children undergoing radiofrequency catheter ablation under general anesthesia: the development and implementation of a bundled anti-emetic prevention strategy</td>
<td>$5,000</td>
</tr>
<tr>
<td>Elod Szabo, Principal Investigator</td>
<td>SickKids Foundation and Canadian Institutes of Health Research</td>
<td>Understanding Voltage-Grated Sodium Channel Related Cardiomyopathy</td>
<td>$299,981</td>
</tr>
<tr>
<td>Principal Investigator</td>
<td>Institution</td>
<td>Funding Proposal</td>
<td>Total Funding</td>
</tr>
<tr>
<td>------------------------</td>
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</tr>
<tr>
<td>Katherine Taylor,</td>
<td>Canadian Anesthesiology Society</td>
<td>Evaluating Precision of Therapy - Milrinone</td>
<td>$20,000</td>
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<tr>
<td>Principal Investigator</td>
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<tr>
<td><strong>Total</strong></td>
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<td>Principal Investigator</td>
<td>$795,138</td>
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<tr>
<td>Co-Investigator/Collaborator</td>
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<td>$169,803</td>
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</table>

### Peer-Reviewed Funding 2013

<table>
<thead>
<tr>
<th>Principal Investigator</th>
<th>Institution</th>
<th>Funding Proposal</th>
<th>Total Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobias Everett,</td>
<td>University of Toronto, Department of Anesthesia Merit Award</td>
<td>Discovering determinants of clinical team performance using in-situ interprofessional simulation</td>
<td>$40,000</td>
</tr>
<tr>
<td>Co-Investigator</td>
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<td></td>
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</tr>
<tr>
<td>**Tobias Everett,</td>
<td>Academy for Innovation in Medical Education (AIME)</td>
<td>Does an early booster session improve performance and retention of skills in neonatal resuscitation compared to a later booster? A simulation based randomized controlled trial</td>
<td>$19,957</td>
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<tr>
<td>**Tobias Everett,</td>
<td>The Ottawa Hospital Academic Medical Organization (TOHAMO)</td>
<td>Does an early booster session improve performance and retention of skills in neonatal resuscitation compared to a later booster? A simulation based randomized controlled trial</td>
<td>$57,797</td>
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<tr>
<td>Co-Investigator</td>
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<tr>
<td>Bradley Johnston,</td>
<td>BioK+ International</td>
<td>A prospective observational study of the incidence of antibiotic-associated diarrhea in children</td>
<td>$33,287</td>
</tr>
<tr>
<td>Principal Investigator</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>**Bradley Johnston,</td>
<td>The Hospital for Sick Children Department of Psychiatry Endowment Fund</td>
<td>Screening and early identification of preschool-aged children with disruptive behavior disorders in primary care settings</td>
<td>$21,825</td>
</tr>
<tr>
<td>Co-Investigator</td>
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<td></td>
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</tr>
<tr>
<td>**Jason Maynes,</td>
<td>The Hospital for Sick Children Innovation Grant</td>
<td>Cellular toxicity after anesthetic exposure for short surgical procedures and identification of attenuating agents in young children: An innovative translational pilot study</td>
<td>$8,500</td>
</tr>
<tr>
<td>Co-Principal Investigator</td>
<td></td>
<td></td>
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<tr>
<td>**Jason Maynes,</td>
<td>University of Toronto, Department of Anesthesia Merit Award</td>
<td>The use if iPSC-derived cardiomyocytes as models for drug toxicity</td>
<td>$80,000</td>
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<tr>
<td>Principal Investigator</td>
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<tr>
<td>Principal Investigator</td>
<td>Co-Investigator/Collaborator</td>
<td>Funding Source</td>
<td>Project Title</td>
</tr>
<tr>
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</tr>
<tr>
<td>Jason Maynes Co-Principal Investigator</td>
<td>Canada Foundation for Innovation (CFI)</td>
<td>SickKids X-ray Diffraction Facility</td>
<td>$946,008</td>
</tr>
<tr>
<td>Jason Maynes Co-Principal Investigator</td>
<td>Canada Foundation for Innovation (CFI)</td>
<td>Robotic crystallization and imagining facility (RCIF) for the SickKids X-ray diffraction facility&quot;</td>
<td>$394,014</td>
</tr>
<tr>
<td>Jason Maynes Co-Principal Investigator</td>
<td>University of Toronto Translational Medicine Award</td>
<td>Pulmonary Vein Stenosis: From Disease Pathology to Therapeutic Drug Discovery</td>
<td>$50,000</td>
</tr>
<tr>
<td>Jason Maynes, Mark Crawford Co-Principal Investigators</td>
<td>Canadian Anesthesiologists’ Society Research Award</td>
<td>Discovering pathologic anesthetic effects in autistic children. The role of anesthesia-induced mitochondrial dysfunction</td>
<td>$30,000</td>
</tr>
<tr>
<td>Elod Szabo, Principal Investigator</td>
<td>University of Toronto, Department of Anesthesia Merit Award</td>
<td>Defining gating pore current elicited signaling pathways in cardiac cells</td>
<td>$80,000</td>
</tr>
<tr>
<td>James O'Leary Principal Investigator</td>
<td>Hospital for Sick Children Heart Centre Innovation Fund</td>
<td>The protective effect of the alpha-2 agonist dexmedetomidine on mitochondrial structure and function for children with non-cyanotic congenital heart defects having cardiac surgery. A randomised controlled trial</td>
<td>$25,000</td>
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<tr>
<td><strong>Total</strong></td>
<td>Principal Investigator</td>
<td><strong>$1,603,572</strong></td>
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<td></td>
<td>Co-Investigator/Collaborator</td>
<td><strong>$99,580</strong></td>
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</table>

**Non-Peer Reviewed Funding 2013**

<table>
<thead>
<tr>
<th>Principal Investigator</th>
<th>Funding Source</th>
<th>Project Title</th>
<th>Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bradley Johnston, Principal Investigator</td>
<td>BioK+ International</td>
<td>A prospective observational study of the incidence of antibiotic-associated diarrhea in children</td>
<td>$33,287</td>
</tr>
<tr>
<td>Bradley Johnston, Co-Principal Investigator</td>
<td>Genzyme Inc.</td>
<td>Patient-reported outcomes in rare diseases: A systematic review and survey of experts in the field</td>
<td>$312,929</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>Principal Investigator</td>
<td><strong>$346,216</strong></td>
<td></td>
</tr>
</tbody>
</table>
Publications
2009 Peer Reviewed Publications

   Pediatric Anesthesia 19:725-731, 2009


**Book Chapters**


**Abstracts**


26. Yamada J, Stevens B, Harrison D, **Campbell FA et al & CIHR Team in Children’s Pain.** Integrating local and research evidence to inform and support health professionals’ pediatric pain practice changes. KU09 Knowledge Utilization Colloquium. Deganway, Wales, United Kingdom, June 2009

**2010 Peer Reviewed Publications**

1. Adudu OP, Le NH, Devito I, **Campbell FA, Levine MF.** Medical student impressions of anesthesia and anesthesiologists. Canadian Journal of Anesthesia 57:792-793, 2010


Book Chapters


Abstracts


4. Campbell FA, Stinson J, Friedman J, Sulowski C. Gastric ulcer perforation in an adolescent with sickle cell disease treated with intermittent nonsteroidal anitinflammatories. 8th International Symposium on Pediatric Pain. Acapulco, Mexico, March 2010


7. Doherty C, Ng E, McLeod E. Does succinylcholine still have a place in pediatric anesthesia? A79663. Canadian Anesthesiologists’ Society Annual Meeting, Montreal, Quebec, June 2010


19. Page MG, **Campbell F**, Stinson J, **Isaac L**, Martin A, Katz J. Gender differences in pediatric postoperative pain, anxiety and pain catastrophizing. International Association for the Study of Pain, 13th World Congress on Pain, Montreal, Quebec, August 2010

20. Palozzi L, Sangha G, Dodds A, Hurdowar A, **Campbell FA**. An algorithm to guide effective pain assessment and management. 8th International Symposium on Pediatric Pain. Acapulco, Mexico, March 2010

21. Simpson D, Tyrrell J, **de Ruiter J**, **Campbell FA**. Use of ultrasound guided transversus abdominis plane (TAP) block to treat chronic abdominal wall pain in a pediatric patient. International Association for the Study of Pain (IASP). Montreal, Quebec, August 2010


24. Stevens B, **Campbell FA**, CIHR Team in Children’s Pain Frequency and management of painful procedures in hospitalized children across Canada. 8th International Symposium on Pediatric Pain. Acapulco, Mexico, March 2010


2011 Peer Reviewed Publications


**Book Chapters**


**Abstracts**


6. da Costa BR, Rutjes AW, Johnston BC, Reichenbach S, Nüesch E, Guyatt GH, Jüni P. Standardized mean differences may be used to derive odds ratios of treatment response: meta-epidemiological study. 19th Cochrane Colloquia. Madrid, Spain, October 2011


2012  Peer Reviewed Publications


8. Holtby HM. Neurological injury and anesthetic neurotoxicity following neonatal cardiac surgery: Does the head rule the heart or the hearts rule the head? Future Cardiology 8:179-88, 2012


17. **Mc Donnell C**: Interventions guided by analysis of quality indicators decrease the frequency of laryngospasm during pediatric anesthesia. Paediatric Anaesthesia 2012


**Book Review**


**Book Chapters**


**Abstracts**


estimation reporting in systematic reviews. 20th Cochrane Colloquium, Auckland, New Zealand, September 2012


10. Johnston BC, Akl EA, Goldenberg JZ, Ma SS, Ebrahim S, Guyatt GH. Methods for handling missing participant data in systematic reviews of dichotomous outcome data: a case example of plausible and extreme plausible assumptions. 20th Cochrane Colloquium, Auckland, New Zealand, September 2012


extravesical reimplantation for primary bilateral vesicoureteral reflux. 23rd Annual ESPU Congress - Zurich, Switzerland, May 2012


2013 Peer Reviewed Publications


8. Everett TC, Ng E. Mobile, wireless, multi-camera audiovisual solution for simulation: a novel application of existing technology. Internet Journal of Medical Simulation 4, 2013


**Book Chapters**


**Abstracts**

1. Akl EA, **Johnston BC, Ebrahim S, Neumann I, Briel M.** Workshop: Addressing missing participant data in systematic reviews: Part I – Dichotomous outcomes. 21st Cochrane Colloquia, Quebec City, Quebec, September 2013

2. Boet S, Riem N, **Levine M,** Tavares WT, Bould D. Workplace-based assessment in Canadian anesthesiology residencies. Accepted for presentation at the Canadian Anesthesiologists’ Society Meeting, Calgary, Alberta, June 2013


4. Coglan M. Shaik S, **Maynes JT.** Anesthetic agents induce protein misfolding and affect carbon dioxide response in the brainstem. Shield’s Day Department of Anesthesia, University of Toronto, Toronto, Ontario, May 2013


6. **Campbell F,** Stinson J, **Isaac L,** Fashler S, Katz J. Time dependent psychological predictors of pain intensity and unpleasantness in children up to one year after pediatric major surgery: pain trajectories from hospital to home. Canadian Pain Society Annual Conference, Winnipeg, Manitoba, May 2013
7. Ebrahim S, Akl EA, Briel M, Johnston BC. Workshop: Addressing missing participant data in systematic reviews: Part II – Continuous outcomes. 21st Cochrane Colloquia, Quebec City, Quebec, September 2013


15. Johnston BC. Minimal Important Difference in Pediatric Phase III trials. 3rd Annual StarChild Meeting, Quebec City, September 2013


23. Moulton D, Taylor K. Pulmonary hypertension and anesthesia risk-where are we now? Society of Pediatric Anesthesia Annual Meeting, Las Vegas, Nevada, March 2013


**Invited Presentations**

**2009 International**

Helen Holtby

Bruce Macpherson

Elaine Ng

Cengiz Karsli

Lawrence Roy

Katherine Taylor
1. 2009 Dec Invited Speaker. What’s new in paediatric cardiac anaesthesia? Dr Elizabeth Hill. Newcastle, New South Wales, Australia. (Continuing Education).
2. 2009 Dec Invited Speaker. The single ventricle. Dr Elizabeth Hill. Newcastle, New South Wales, Australia. (Continuing Education).
3. 2009 Jun Invited Speaker. 2009 Non invasive cardiac output measurement using Physioflow™ in children undergoing cardiac MRI. 5th World Congress of Pediatric Cardiology and Cardiac Surgery. Cairns, Queensland, Australia.

Gail Wong

2009 National

Lisa Isaac
Clyde Matava
1. 2009 Nov Facilitator. To TAP or NOT to TAP? Canadian Pediatric Anesthesia Society. Toronto, Ontario, Canada.

Bruce Macpherson

Conor Mc Donnell

Joost de Ruiter
1. 2009 Nov Invited speaker. To TAP or NOT to TAP? Canadian Pediatric Anesthesia Society. Toronto, Ontario, Canada.

2009 Provincial/Regional

Jason Hayes

Cengiz Karsli

Conor Mc Donnell

Elaine Ng

2009 Local

Fiona Campbell
7. **2009 Apr** Invited Speaker. Pain management strategies: Complex challenges for acute pain in the presence of persistent pain. Advanced Pain Management across Clinical Settings, Faculty of Nursing Lecture, University of Toronto. Faculty of Nursing Lecture, University of Toronto. (Continuing Education).

8. **2009 Mar** Invited Speaker. The impact that the Mattamy Endowment gift has had on pain management. Mattamy Homes Celebration Event, The Hospital for Sick Children, Toronto, Ontario.


**Cengiz Karsli**


4. **2009 Apr** Invited Lecturer. Update on regional techniques for the trauma patient. Pediatric Trauma Program, Hospital for Sick Children, Toronto, Ontario.


**Bruce Macpherson**

1. **2009 Oct** Pediatric anaesthesia at the millenium. Queensville Lecture Series, York County Hospital. Newmarket, Ontario, Canada. (Continuing Education).


**Clyde Matava**


2. **2009 Sep** Invited Speaker. Safety with opioid use. CME Rounds- Department of Anesthesia and Pain Medicine, Hospital for Sick Children. Toronto, Ontario, Canada.

3. **2009 Sep** Invited Speaker. Lidocaine toxicity - A case presentation. CME Rounds- Department of Anesthesia and Pain Medicine, Hospital for Sick Children. Toronto, Ontario, Canada.

**Connor Mc Donnell**


**Arie Peliowski**


**Ilavajady Srinivasan**

1. **2009 Mar** Awareness under anesthesia -. PACU nurses rounds, Etobicoke General Hospital. Etobicoke. Ontario

**Elod Szabo**

2. 2009 Jul Invited Lecturer. Advanced airway management - Difficult airway and induction techniques in the critically ill child. Critical Care Teaching Rounds, Faculty of Medicine, Department of Pediatrics, Hospital for Sick Children, Toronto, Ontario.

2010 International

Fiona Campbell

Helen Holtby

Cengiz Karsli

Conor McDonnell

Lawrence Roy

2010 National

Lisa Isaac
1. 2010 Nov Case presentation. Shall we cancel this case? Anesthetic Practice, University of Toronto. Toronto, Ontario, Canada.
Clyde Matava

Conor Mc Donnell

Gail Wong

2010 Provincial/Regional

Fiona Campbell

Elaine Ng

Gail Wong

2010 Local

Fiona Campbell

Cengiz Karsli

Conor Mc Donnell

Elaine Ng
1. 2010 Sep Presenter. Simulation in Continuing Education. Continuing Education in Health Professions CHL 5609 (Graduate Course), University of Toronto. Toronto, Ontario.

Lawrence Roy

Elod Szabo
1. 2010 Sep Invited Lecturer. Pediatric fluid and electrolyte management, thermoregulation and monitoring. Pediatric Anaesthesia Teaching Block, Dept of Anesthesiology, Faculty of Medicine, Toronto, Ontario.
2. 2010 Jul Invited Lecturer. Advanced airway management - Difficult airway and induction techniques in the critically ill child. Critical Care Teaching Rounds, Faculty of Medicine, Dept. of Pediatrics, Toronto, Ontario.

Katherine Taylor
2011 International

Mark Crawford

Helen Holtby

Fiona Campbell
5. 2011 Apr Invited Speaker. Codeine is a poor choice for the management of acute pain - but what are the alternatives? Paediatric Update. Toronto, Ontario, Canada.
7. 2011 Dec Invited Speaker. Improving pain outcomes in hospitalized children. Credit Valley Hospital & Trillium Hospital, Department of Paediatrics. Mississauga, Ontario, Canada. (Continuing Education).
11. 2011 Feb Invited Speaker. If NSAIDs are not enough - an approach to pelvic pain in teens. Toronto, Ontario, Canada. (Continuing Education).

Cengiz Karsli

Conor McDonnell

Katherine Taylor
2. 2011 Nov Moderator. Stressful Situations. The Hospital for Sick Children. Toronto, Ontario, Canada An international pediatric meeting hosted by the Hospital for Sick Children.
2011 National

Lisa Isaac
1. 2011 Nov Case presentation. Shall we cancel this case? Anesthetic Practice, University of Toronto. Toronto, Ontario, Canada.

Clyde Matava
2. 2011 Feb Facilitator. Saturday night is NOT all right. Canadian Pediatric Anesthesia Society. Toronto, Ontario, Canada.

Conor Mc Donnell
1. 2011 Nov Invited Speaker. Tenfold medication errors: The elephant in the paediatric hospital. Institute for Safe Medication Practices Canada. Toronto, Ontario, Canada. 60 minute Nationally broadcast webinar symposium on my research into tenfold medication error. This webinar was purchased by 22 different sites with 69 total attendees for the duration of the presentation.
2. 2011 Nov Invited Speaker. A Quality Program for pediatric anesthesia in Canada. Canadian Pediatric Anesthesia Society. Toronto, Ontario, Canada. An invited talk that proposes the setting up of a nationwide Pediatric Anesthesia Quality Program under the guidance of the CPAS.

2011 Provincial/Regional

Fiona Campbell
1. 2011 Dec Invited Speaker. Improving pain outcomes in hospitalized Children. Credit Valley Hospital & Trillium Hospital, Department of Paediatrics. Mississauga, Ontario, Canada. (Continuing Education).
5. 2011 Feb Invited Speaker. If NSAIDs are not enough - an approach to pelvic pain in teens. Toronto, Ontario, Canada. Presenter

Jason Hayes
Clyde Matava
4. 2011 Sep Invited Speaker. Recent studies that have changed Pediatric Anesthesia. Ontario’s Anesthesiologists. Toronto, Ontario, Canada.

Conor Mc Donnell

Elaine Ng
2. 2011 May Presenter. The Managing Emergencies in Paediatric Anaesthesia (MEPA) simulation course: the combination of healthcare professional training, faculty development and an international multicenter validation study. 1st International Conference on Faculty Development in the Health Professions. Toronto, Ontario, Canada. Oral research presentation.

2011 Local
Fiona Campbell
5. 2011 Aug Lecturer. Theories of pain: Impact on the individual, family and society. Professor Bonnie Stevens, Faculty of Nursing, University of Toronto. Toronto, Ontario, Canada.
9. 2011 Mar Invited Speaker. Interfaculty Pain Curriculum Panel. Faculty of Medicine, University of Toronto. Toronto, Ontario, Canada.
Carol Grant

Eric Greenwood

Cengiz Karsli

Clyde Matava

Conor Mc Donnell

Elaine Ng
1. 2011 Sep Presenter. Simulation in continuing education. Continuing Education in Health Professions CHL 5609 (Graduate Course), University of Toronto. Toronto, Ontario.

Jason Maynes
2012 International

Fiona Campbell

Mark Crawford

Helen Holtby

Bradley Johnston

Lisa Isaac

Cengiz Karsli

Conor McDonnell
1. 2012 Jun Invited Speaker. Papers that have changed my practice. Canadian Anesthesiologists’ Society Annual Meeting. Quebec, Quebec, Canada.
2. 2012 Jun Invited Speaker. Latest evidence and research findings from studies describing opioid error: New approaches to monitoring PCA opioid efficacy and QI initiatives to Improve Opioid safety. International Conference on Opioids. Boston, Massachusetts, United States. Invitation to speak at inaugural international meeting attended by anesthesiologists, pain specialists, legislators and legal experts.

Clyde Matava

Conor Mc Donnell
1. 2012 Jun Invited Speaker. Papers that have changed my practice. Canadian Anesthesiologists’ Society Annual Meeting. Quebec, Quebec, Canada.
2. 2012 Jun Invited Speaker. Latest evidence and research findings from studies describing opioid error: New approaches to monitoring PCA opioid efficacy and QI initiatives to improve opioid safety. International Conference on Opioids. Boston, Massachusetts, United States. Invitation to speak at inaugural international meeting attended by anesthesiologists, pain specialists, legislators and legal experts.

James Robertson

Lawrence Roy

Katherine Taylor

2012 National

Lisa Isaac
1. 2012 Nov Case presentation. Shall we cancel this case? Anesthetic Practice, University of Toronto. Toronto, Ontario, Canada.

Bruce Macpherson

Conor Mc Donnell

2012 Provincial/Regional

Tobias Everett
Conor Mc Donnell

Elaine Ng

2012 Local

Fiona Campbell

Tara Der

Tobias Everett

Eric Greenwood

Bradley Johnston

Cengiz Karsli

Jason Maynes
2. 2012 May Putting your mitochondria to sleep. Toxic effects of anesthetics on the cell’s powerhouse. Ki Ka Shing Research Institute Research Seminar, Toronto, Ontario, Canada.

Conor Mc Donnell

Gail Wong

2013 International

Mark Crawford

Bradley Johnston
1. 2013 Sept Moderator. Addressing missing participant data in systematic reviews: Part I-Dichotomous outcomes. 21st Cochrane Colloquia. Quebec City, Quebec.
2. 2013 Sept 19 Presenter. Minimal important difference in pediatric phase III trials. 3rd Annual StarChild Meeting, Quebec City, Quebec

Fiona Campbell

Tobias Everett

Conor Mc Donnell

Katherine Taylor
2. 2013 Apr Invited Speaker. Anaesthesia for paediatric cardiac catheterisation. 10th COPA - Congress of Anesthesiology of the State of São Paulo. Sao Paulo, São Paulo, Brazil. Presenter(s): Katherine Taylor.
4. 2013 Apr Invited Speaker. Paediatric Pulmonary Hypertension. 10th COPA - Congress of Anesthesiology of the State of São Paulo. Sao Paulo, São Paulo, Brazil.

2013 National

Tobias Everett

2013 Provincial/Regional

Katherine Taylor
1. 2013 Mar Visiting Professor. Overview Congenital Heart Disease. University of Winnipeg, Department of Anesthesia. Winnipeg, Manitoba, Canada.

2013 Local

Fiona Campbell
7. 2013 Mar Chair. Opioid Panel. IPC Pain Week, University of Toronto Centre for the Study of Pain. Toronto, Canada.

Tobias Everett

Helen Holtby

Bradley Johnston
3. 2013 Sept Presenter. Patient reported outcomes in meta-analysis. Departmental Rounds, Department of Anesthesia and Pain Medicine, The Hospital for Sick Children, Toronto, Ontario

Cengiz Karsli
Jason Maynes

Lawrence Roy

Katherine Taylor