

# Neonatal Neurocritical care: Why and how?

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FRCPC( Neonatology), NNCC Diplomate (UCNS)



DAVID  
AND  
GOLIATH



UNDERDOGS, MISFITS, AND  
THE ART OF BATTLING GIANTS

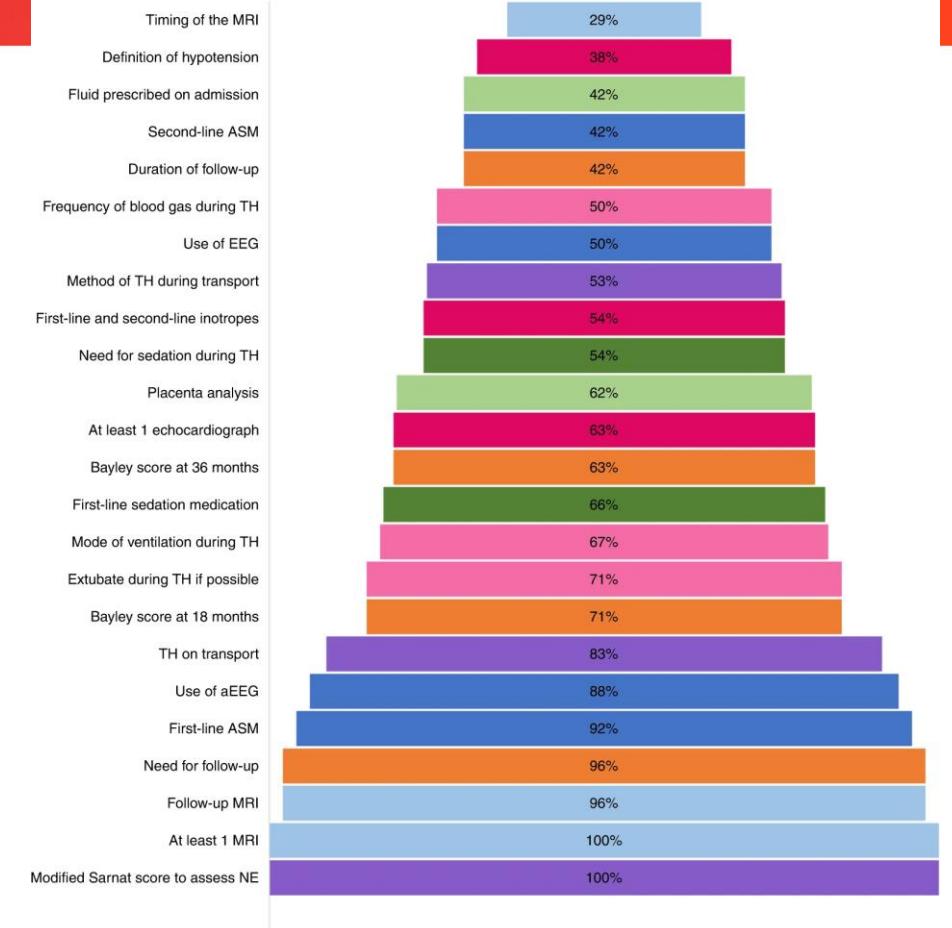
MALCOLM  
GLADWELL

# Training in neonatal neurocritical care: a proposal for a hybrid model of competence by design and time-based methods

Khorshid Mohammad<sup>1,31</sup>✉, Alexa K. Craig<sup>2,31</sup>, Taeun Chang<sup>3</sup>, Emily W. Y. Tam<sup>4</sup>, Mariam Ayed<sup>5</sup>, Linda S. de Vries<sup>6</sup>, Mohamed A. El-Dib<sup>7</sup>, Michael J. Esser<sup>8</sup>, Donna M. Ferriero<sup>9,10</sup>, Lena Hellström-Westas<sup>11</sup>, Steven P. Miller<sup>12</sup>, Janet S. Soul<sup>13</sup>, Brigitte Vollmer<sup>14,15</sup>, Hannah C. Glass<sup>16,17,18</sup>, Christopher D. Smyser<sup>19,20,21</sup> and on behalf of the Newborn Brain Society Guidelines and Publications Committee<sup>22\*</sup>

- 82 responses from 30 countries
- 29% reported having completed NNCC training
- 81% reported significant variability in clinical practices
- 88% in favor of standardization of training programs and accreditation





TH initiation  
and methods



Neuroimaging



Neuromonitoring  
and Seizures



**Cardiovascular** Mohammad K, McIntosh S, Lee KS, et al. Variations in care of neonates during therapeutic hypothermia: call for care practice bundle implementation [published online ahead of print, 2023 Jan 9]. *J Perinatol.* 2023;42(7):898-906. doi:10.1038/s41390-022-01412-7



Respiratory



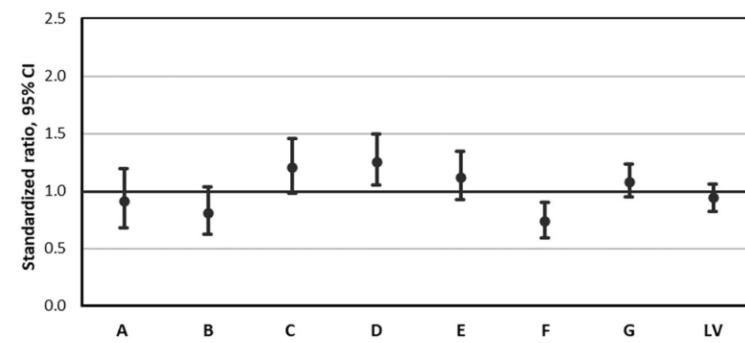
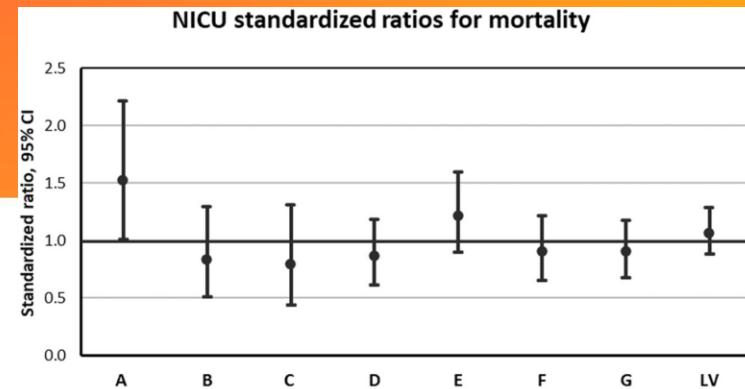
Sedation during TH



Fluids and other tests



Follow up



Belttempo M, Wintermark P, Mohammad K, et al. Variations in practices and outcomes of neonates with hypoxic-ischemic encephalopathy treated with therapeutic hypothermia across tertiary NICUs in Canada. *J Perinatol.* 2022;42(7):898-906. doi:10.1038/s41390-022-01412-7



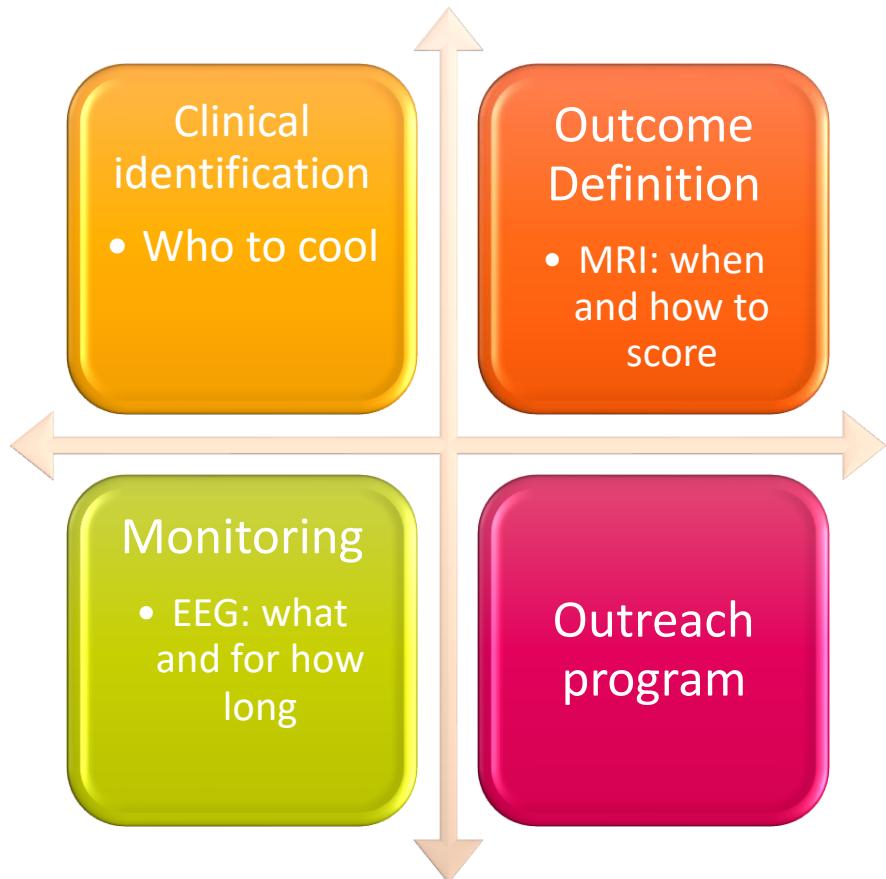
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# Collective Leadership: a framework to establish a neonatal neuro-critical care program



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# Hypoxic ischemic encephalopathy



# THREE MODELS OF NNCC CLINICAL CARE

The main goal across the models is to streamline communications and patient care.

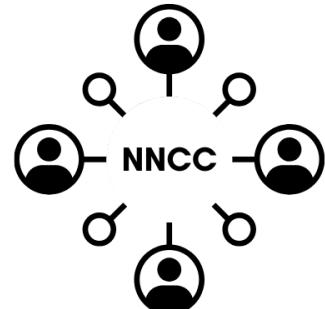
## DEDICATED UNIT/PHYSICAL SPACE



## DEDICATED TEAM PROVIDING CARE IN THE UNIT



## CONSULTATION MODEL



### PROS

- Suitable for large academic institutions. dedicated physical space for patients requiring NNCC care
- Advancing care, QI, and research

### CONS

- Not feasible in most centers due to the inability to maintain patient volume.

### PROS

- Daily intensive care management through a dedicated team
- Better consistency in care

### CONS

- May not be feasible due to :
- multidisciplinary team members conflicting responsibilities
  - Workforce and resources required

### PROS

- Separate NNCC clinical care team consulted by the NICU.
- One stop referral system
- Streamlines communications between specialties.

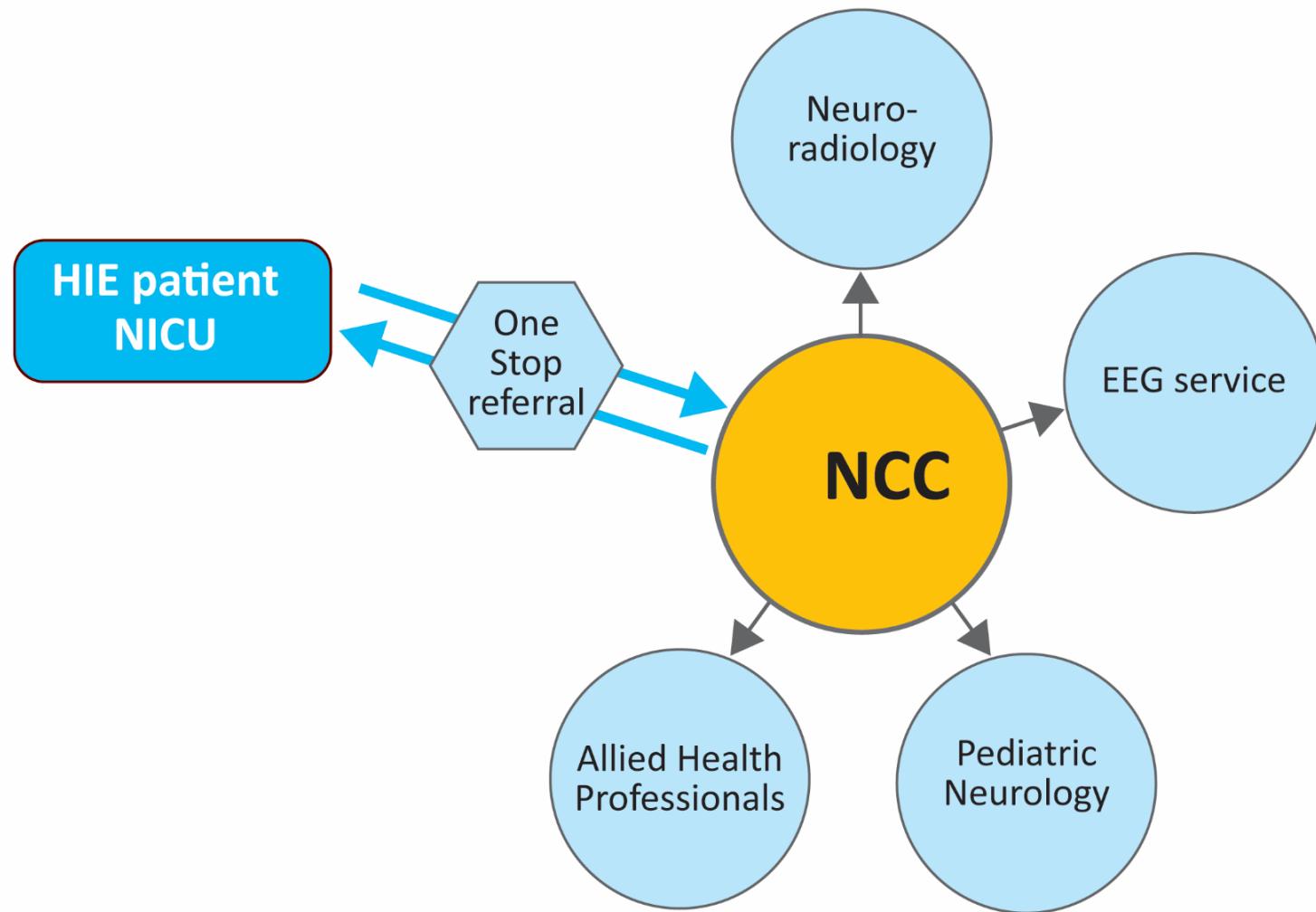
### CONS

- Requires ongoing collaboration between subspecialties.
- Expanding manpower is required



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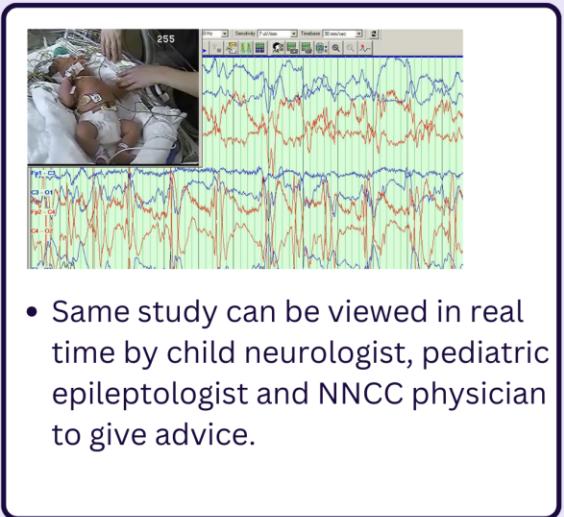
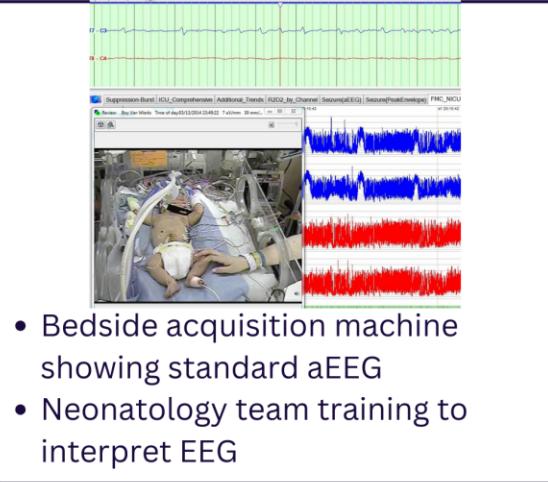
# Consultation Model (one stop referral system)



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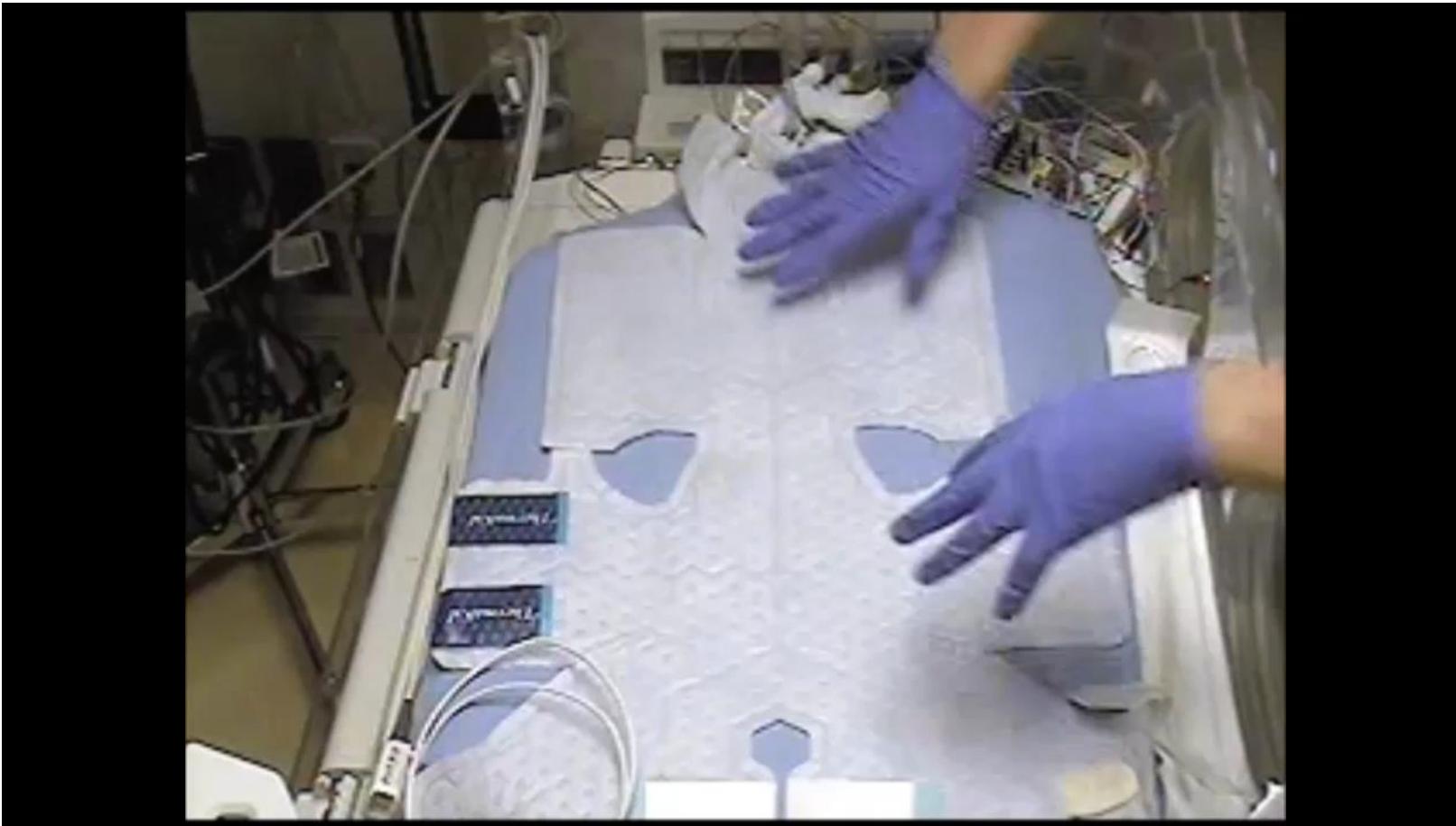


## Brain monitoring system to combine neonatology and child neurology care.



Studies and events get interpreted by reading aEEG in real time and continuous video EEG in real time or later to assess and adjust the management overnight

# Video EEG and nurses



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## Standardizing clinician training and patient care in the neonatal neurocritical care: A step-by-step guide\*



Khorshid Mohammad #

Section of Newborn Critical Care, Department of Pediatrics, University of Calgary, Canada

1

SMALL GROUP  
DIDACTIC SESSION

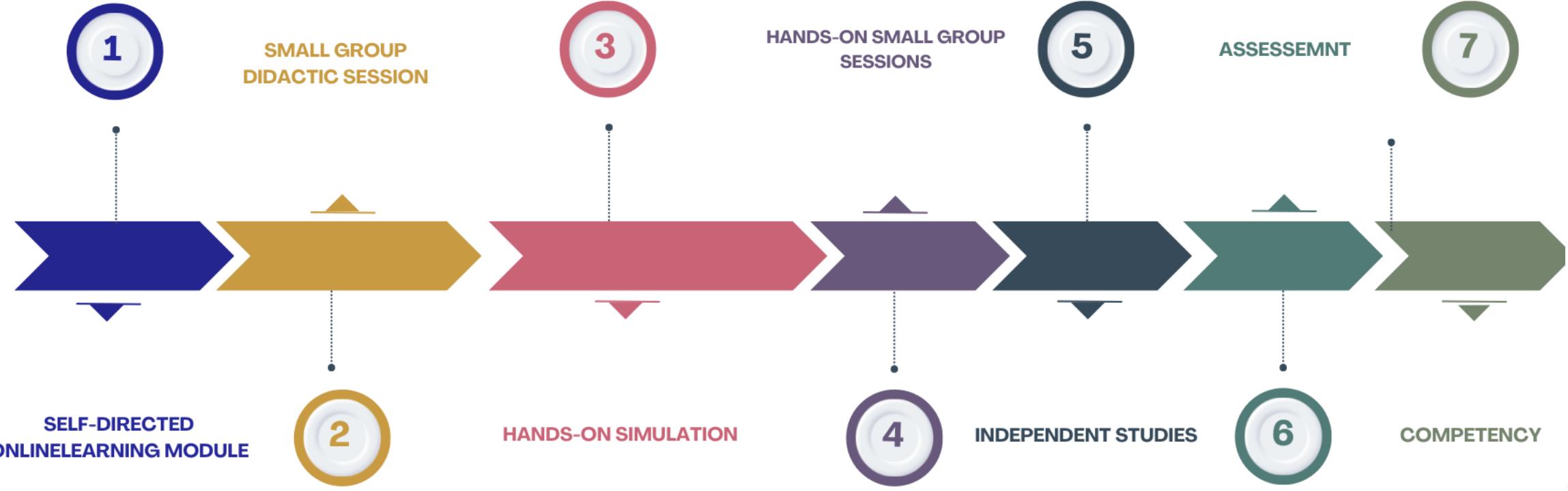
3

HANDS-ON SMALL GROUP  
SESSIONS

5

ASSESSMENT

7



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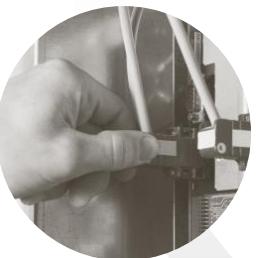
# NNCC



Clinical guidelines



Education



QI and databases



Research

# Neurology

Obstetrics

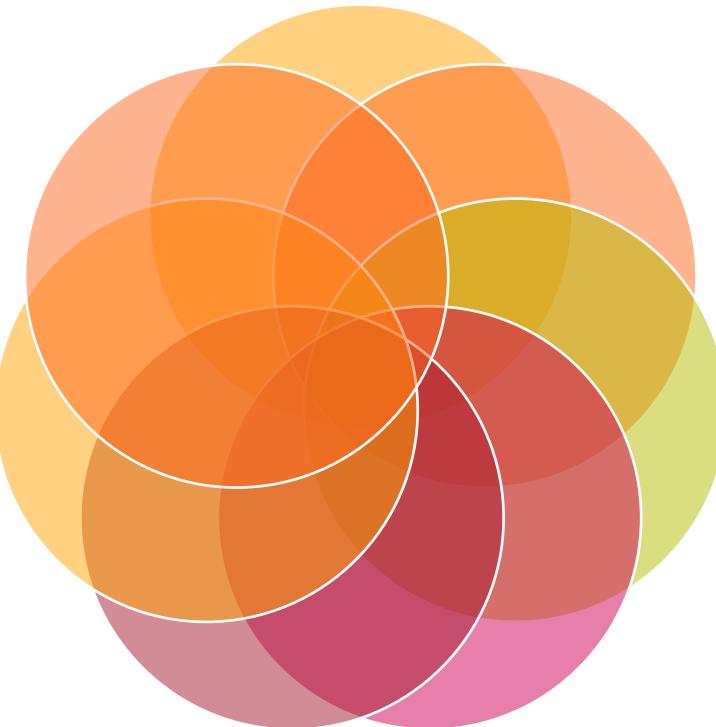
Golden hour

Follow up

Neonatology

Neuro-imaging

Outreach



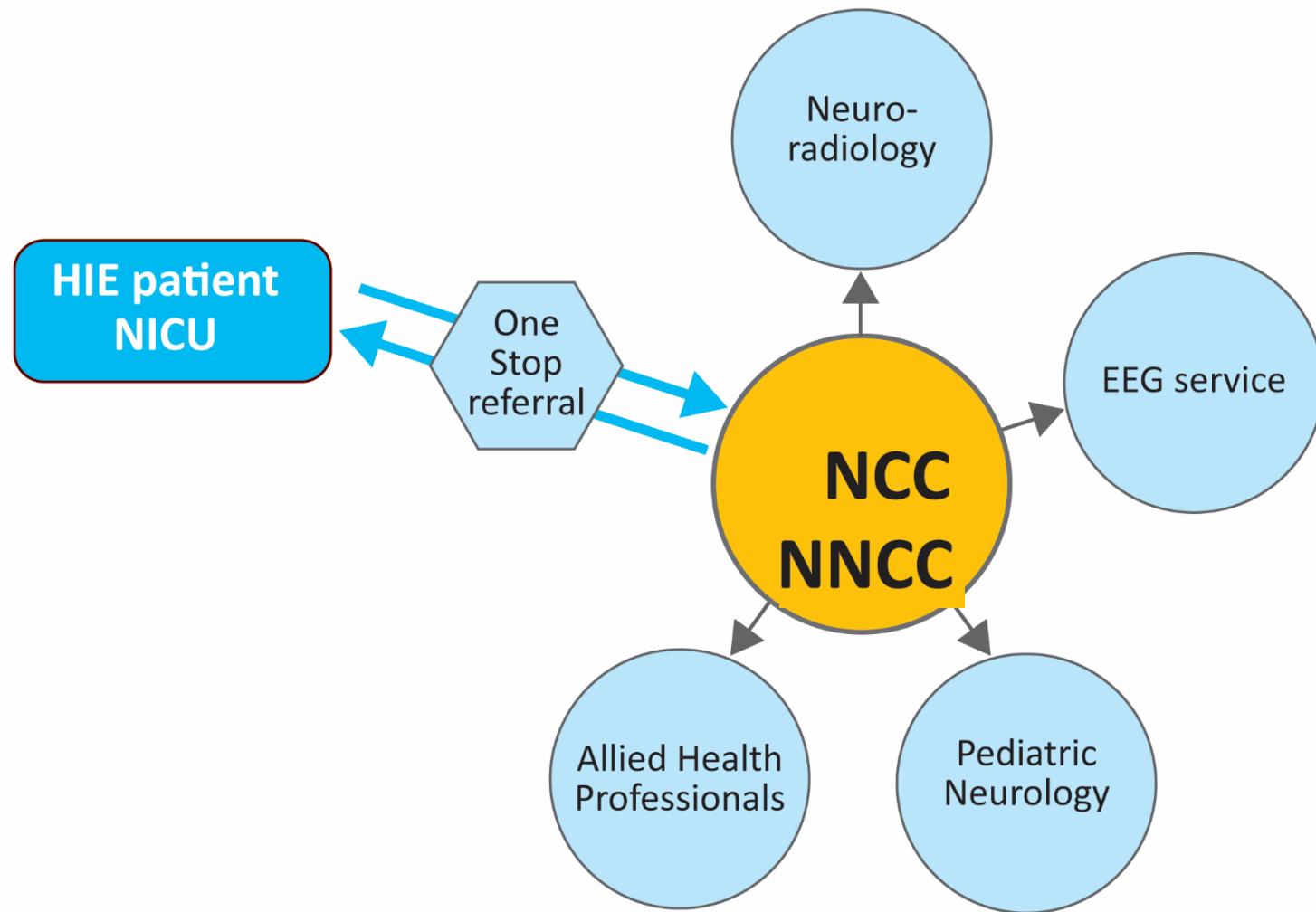
# Expanding consultation

- Drive IVH to zero
- Preterm brain injury classification taskforce
- PHVD
- Neurosurgical cases
- Neonatal Seizure
- Neonatal stroke
- Pain management/Sedation and analgesia use



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# Consultation Model (one stop referral system)



## Time-based Training

VS

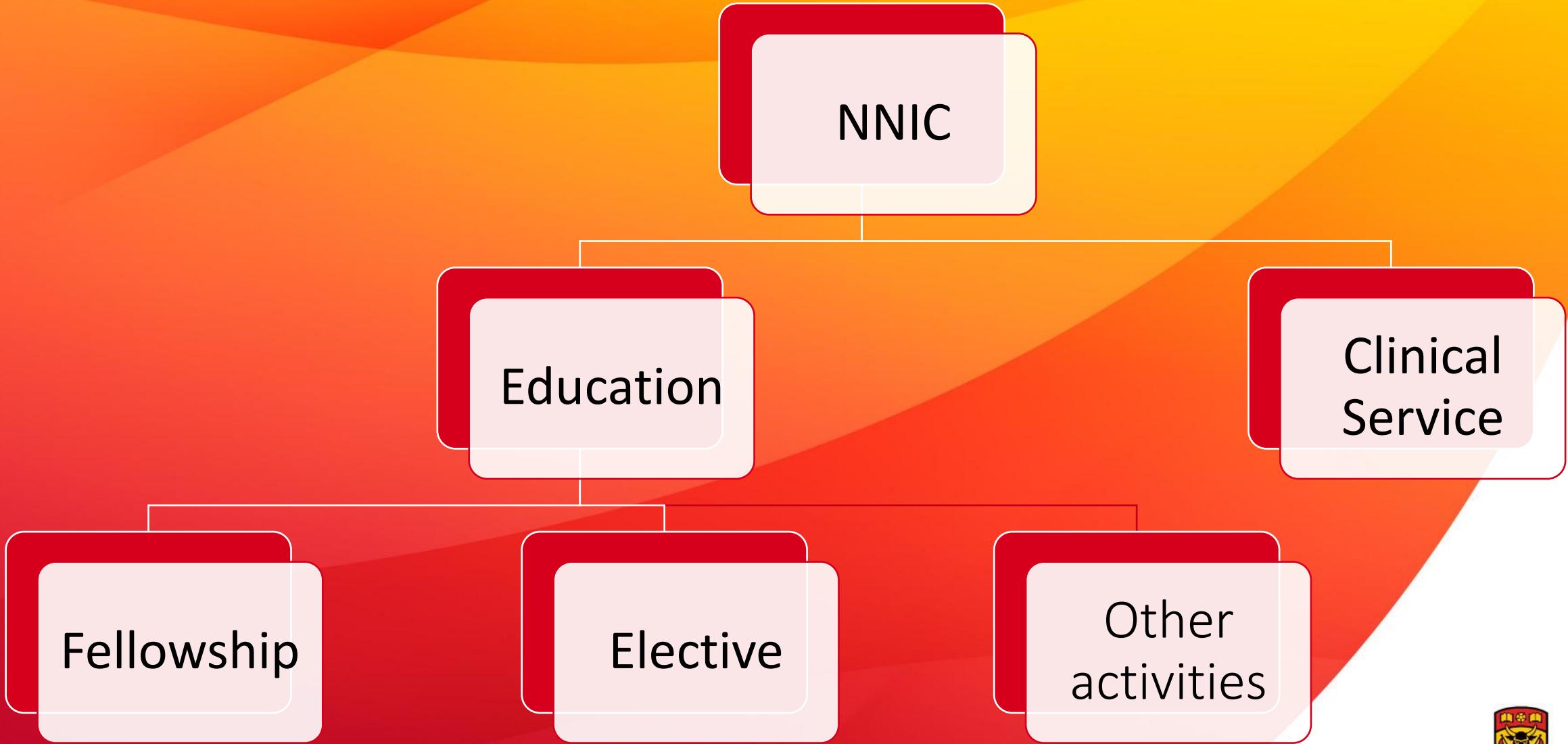
## Competency By Design (CBD)

ENTRY	Time spent is a surrogate for competence. <b>Resident</b> can be disempowered while greater burden is placed on <b>faculty</b>	Milestones are markers for competence <b>Residents</b> take ownership of achieving competencies.	ENTRY
ROTATION-BASED EVALUATION	Little direct observation and dichotomous judgement	More frequent direct observations by multidisciplinary team members and competency specific evaluations	COMPETENCY-BASED EVALUATION
FINAL EXAM/CERTIFICATE	High stakes final exam	Portfolio built overtime	PORTFOLIO COMPLETION/CERTIFICATE
	Variability in curriculum	Standard core competencies requirement	

**Hybrid model:** Competency by design within a predefined time. Time is surrogate for programs competency not trainees.



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# Fellowship

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DEPARTMENT OF PEDIATRICS

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## The Harvey Sarnat Clinical Research Fellowship in Neonatal Neurocritical Care

Dr. Harvey Sarnat Neonatal Neuro-Critical Care Fellowship is a one year program sponsored by the Section of Neonatology, Department of Pediatrics, University of Calgary.

[Apply here](#)

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Strong Heart & Healthy Brain

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# Online Educational Modules

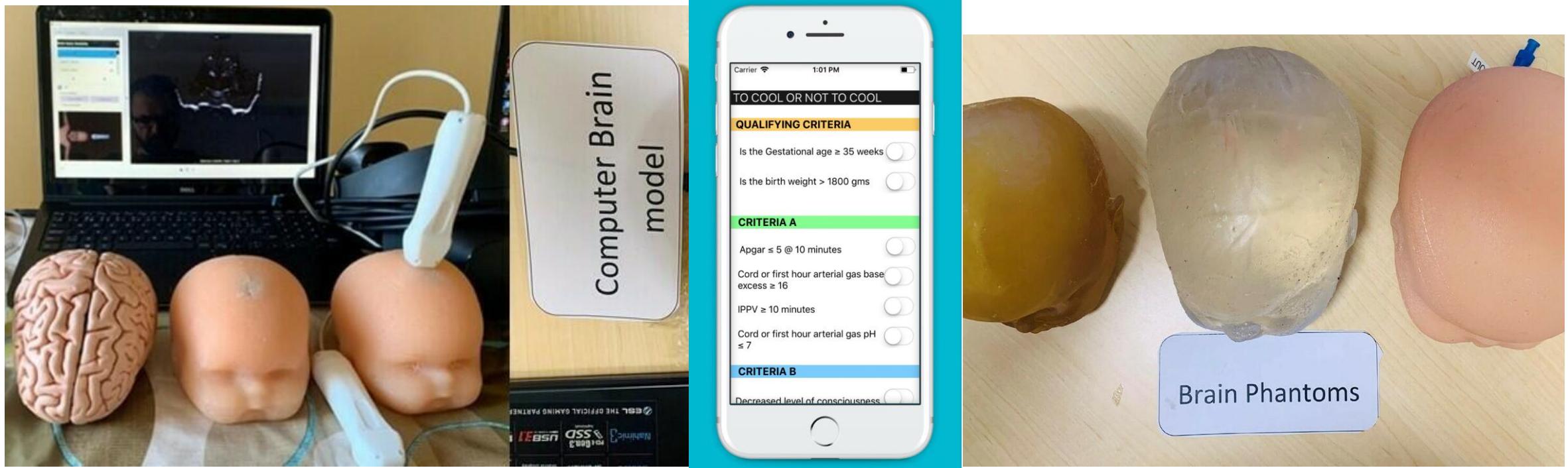
The screenshot shows the homepage of the NNCC online educational modules. At the top right are links for "Home", "Apply for NNCC training", and "Sign In". The main content area features three course cards:

- Neonatal Neuro-Critical Care online module 2: Neonatal Cranial Ultrasonography. RCPSC activity ID 00013318 (max 2 hours)**  
5.0 (6 reviews)  
Welcome to the Neonatal cranial ultrasound course. the goal of this course is to prepare participants for...  
Course
- Neonatal Neuro-Critical Care Module 3: Neurological Examination to Identify Neonates with HIE**  
5.0 (1 review)  
Welcome to the Neurological examination to identify neonates with HIE course. The goal of this course is to...  
Course
- NBS and Calgary NNCC : aEEG and EEG trends module**  
5.0 (1 review)  
Welcome to the aEEG teaching module . The goal of this course is to familiarize you implementation and...  
Free

The screenshot shows the continuation of the NNCC online educational modules. At the top right are links for "Home", "Apply for NNCC training", and "Sign In". The main content area features three course cards:

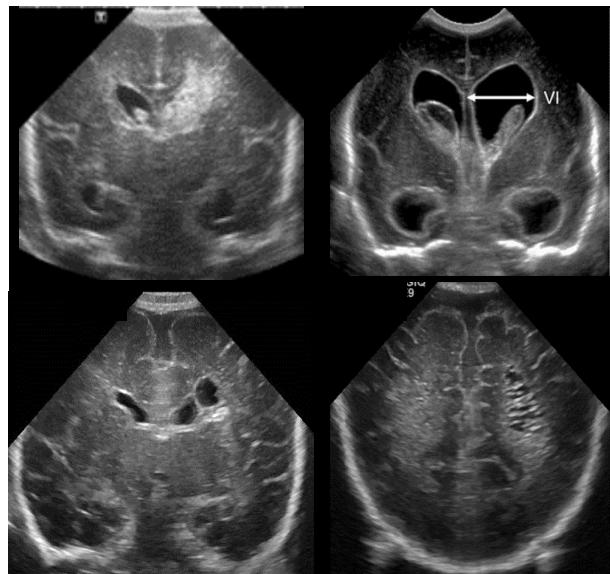
- Neonatal cVEEG set up online course**  
5.0 (1 review)  
Welcome to the Neonatal EEG set up course. The goal of this course is to certify NICU nurses in neonatal EEG...  
Course
- Neonatal Neuro-Critical Care Module 6: Neonatal Brain Monitoring. RCPSC activity ID 00013318 (max 2 hours)**  
5.0 (1 review)  
Welcome to the Neonatal brain monitoring teaching module . The goal of this course is to familiarize you with...  
Course
- Neonatal Neuro-Critical Care Module 9: Neonatal Stroke. RCPSC activity ID 00013318 (max 2 hours)**  
5.0 (1 review)  
By the end of this module you should be able to: Diagnose 3 acute stroke syndromes in the newborn. Outline...  
Course

# Simulation

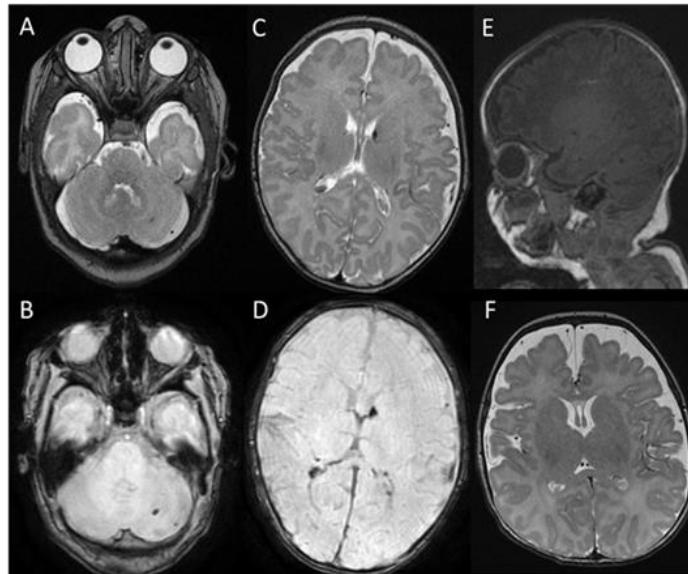


# Research Lines

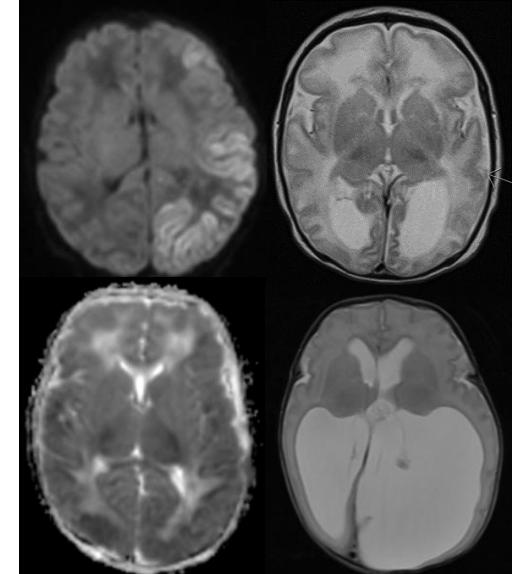
**Extremely - Very preterm**  
(<32 weeks)



**Moderate - Late preterm**  
(32-36<sup>+6</sup> weeks)

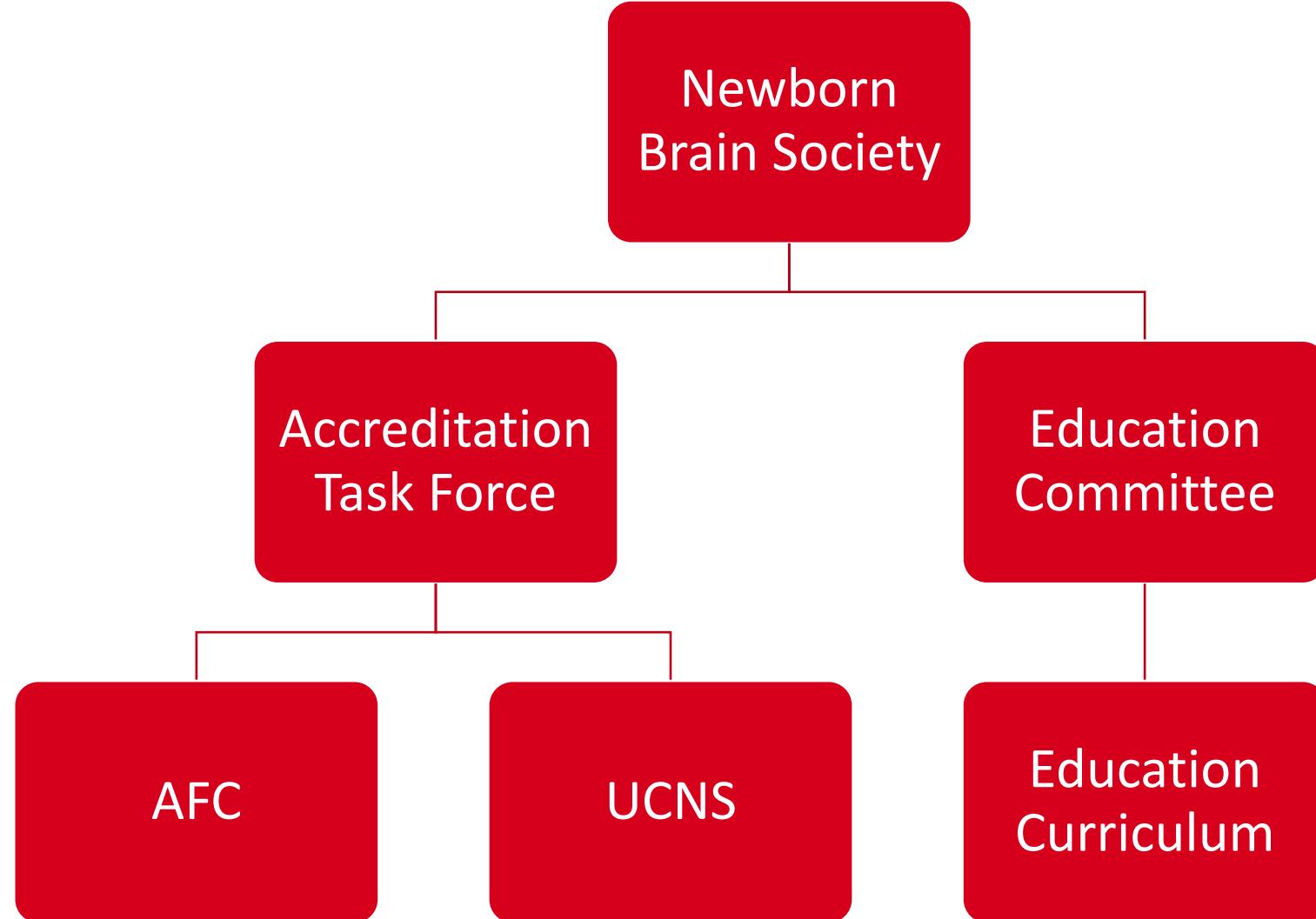


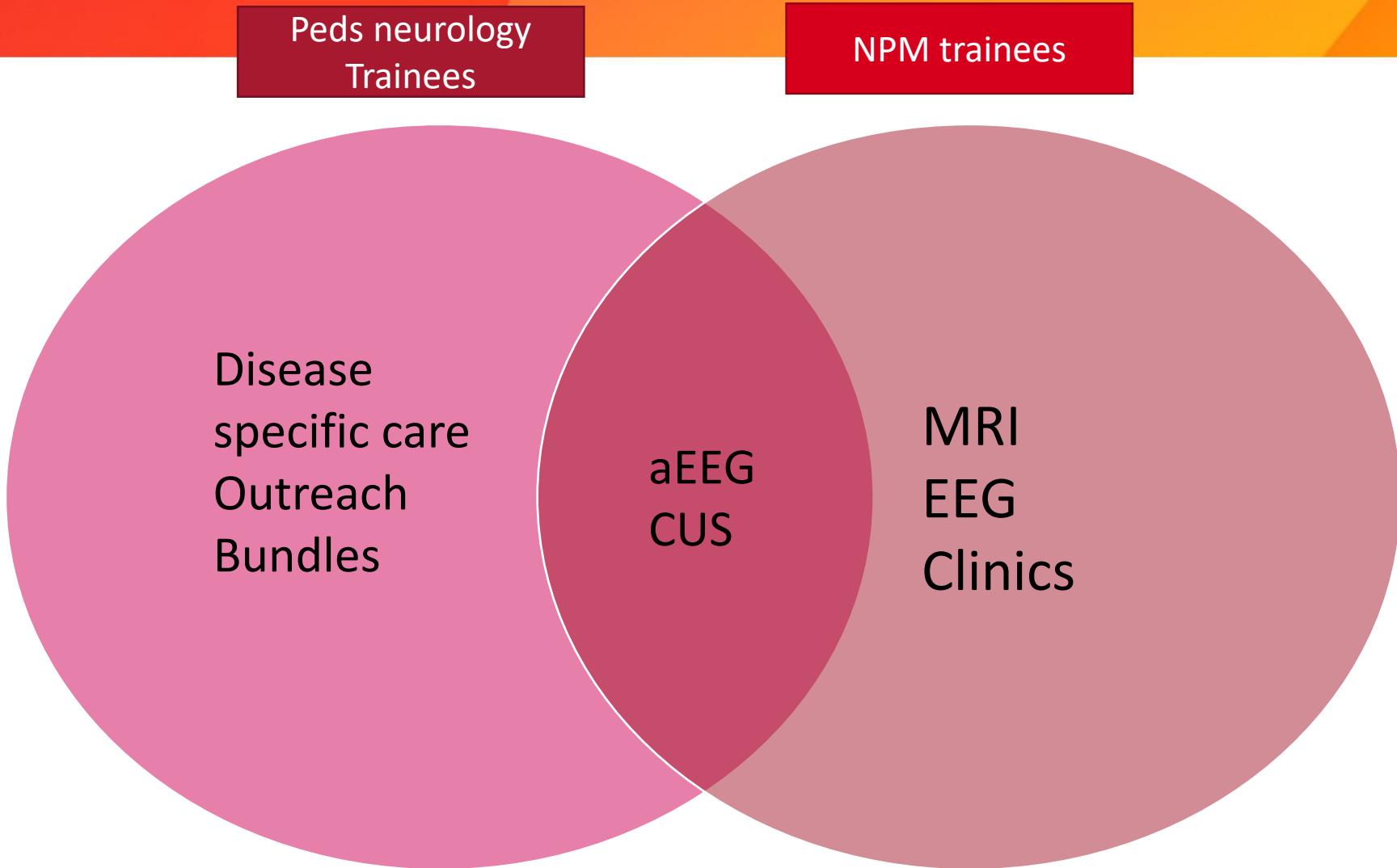
**Term-born**  
(>37 weeks)



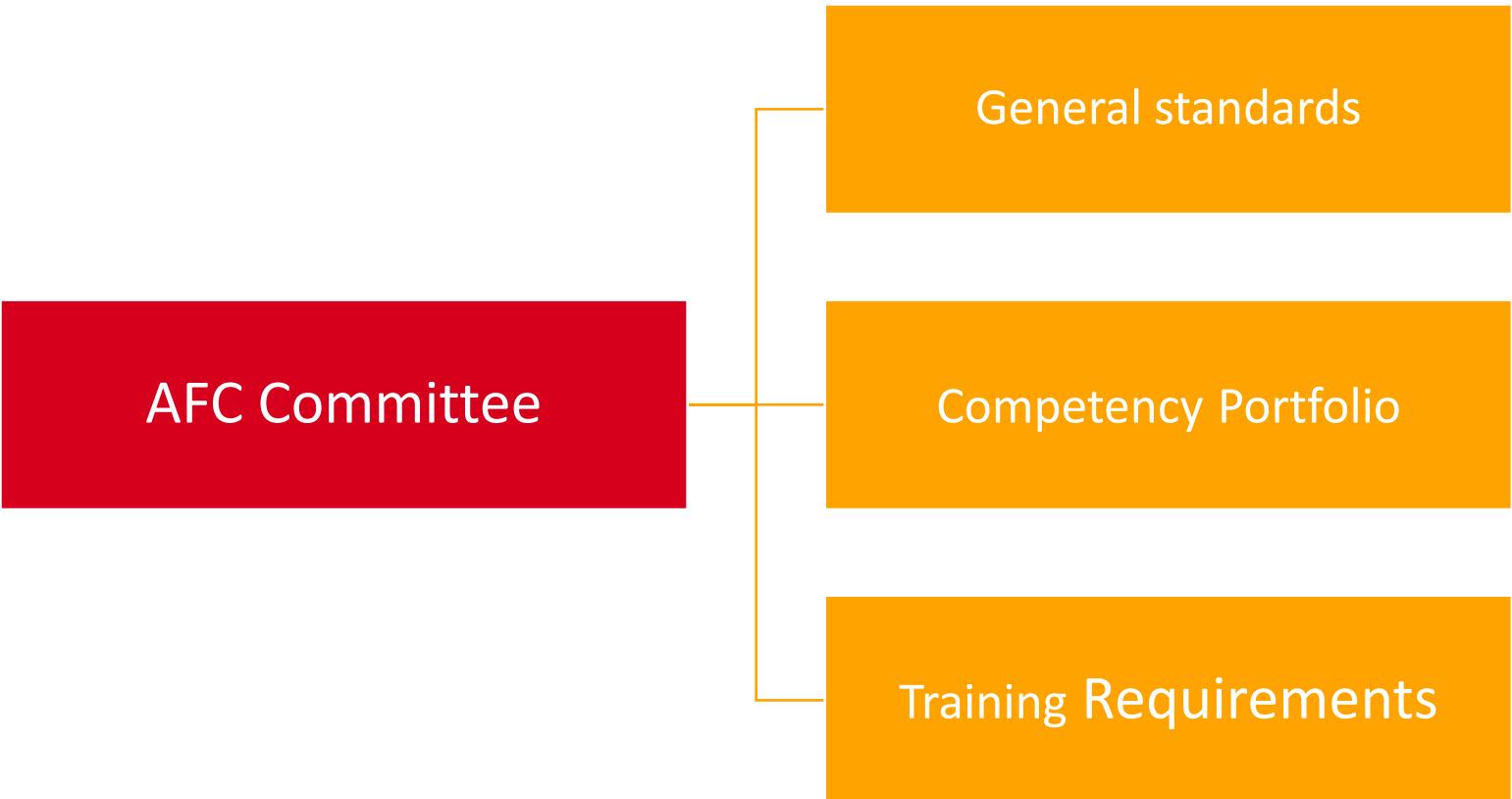
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# Working Groups and Task Force

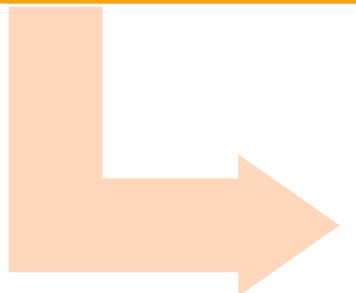




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Universities set  
up NNCC  
program



NNCC AF fellow  
submit required  
documents to RC



NNCC AFC  
diploma  
certificate

# Clinical and patient outcomes



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Original Article

## Implementation of a Neurocritical Care Program: Improved Seizure Detection and Decreased Antiseizure Medication at Discharge in Neonates With Hypoxic-Ischemic Encephalopathy

Rani Ameena Bashir MD<sup>a</sup>, Liza Espinoza MD<sup>a</sup>, Sakeer Vayalathrikkovil MD<sup>a</sup>, Jeffrey Buchhalter MD<sup>b,c</sup>, Leigh Irvine MN<sup>a</sup>, Luis Bello-Espinosa MD<sup>b,c</sup>, Khorshid Mohammad MD<sup>a,\*</sup>

<sup>a</sup> Section of Neonatology, Department of Pediatrics, University of Calgary, Calgary, Alberta, Canada<sup>b</sup> Section of Pediatric Neurology, Department of Pediatrics, University of Calgary, Calgary, Alberta, Canada<sup>c</sup> Department of Pediatrics, Alberta Children's Hospital Research Institute, University of Calgary, Calgary, Alberta, Canada

**TABLE 4.**  
Antiepileptic Drug Burden in Infants With rEEG Versus cvEEG Monitoring

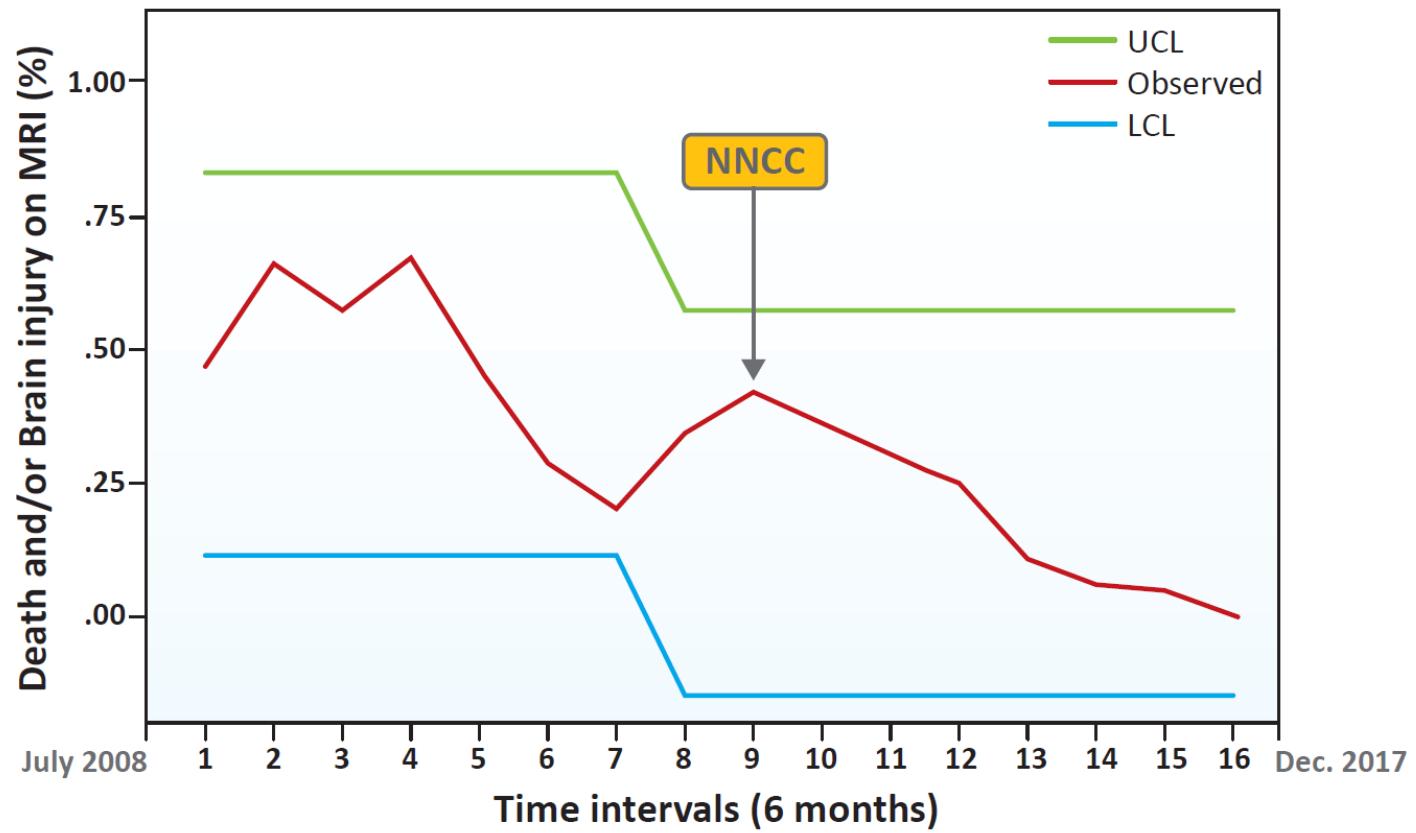
Seizure Treatment	rEEG, <i>n</i> = 30/86	cvEEG, <i>n</i> = 35/71	P Value*
Maintenance ASM, <i>n</i> (%)	26 (87)	25 (71)	0.14 <sup>#</sup>
ASM on discharge, <i>n</i> (%)	21 (70)	13 (37)	<b>0.008<sup>#</sup></b>
More than one ASM, <i>n</i> (%)	16 (53)	17 (49)	0.70 <sup>#</sup>
Duration of maintenance, days; mean (SD)	8.5 (6.0)	11.7 (23.1)	0.87
Phenobarbital burden, mg/kg; mean (SD)	62.2 (33.8)	46.0 (25.9)	<b>0.04</b>
		27.9 (16.5)	0.87

**TABLE 2.**  
Seizure Burden in Infants With rEEG Versus cvEEG Monitoring

Seizure Types and Treatment	rEEG, <i>n</i> = 86	cvEEG, <i>n</i> = 71	P Value*
Clinical-only seizures, <i>n</i> (%)	32 (37)	16 (23)	<b>0.018</b>
Electro-clinical seizures, <i>n</i> (%)	12 (14)	18 (25)	0.12
Electrographic seizures, <i>n</i> (%)	12 (14)	23 (32)	<b>0.016</b>
ASM use, <i>n</i> (%)	30 (35)	35 (49)	0.07

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## Interrupted time series analysis

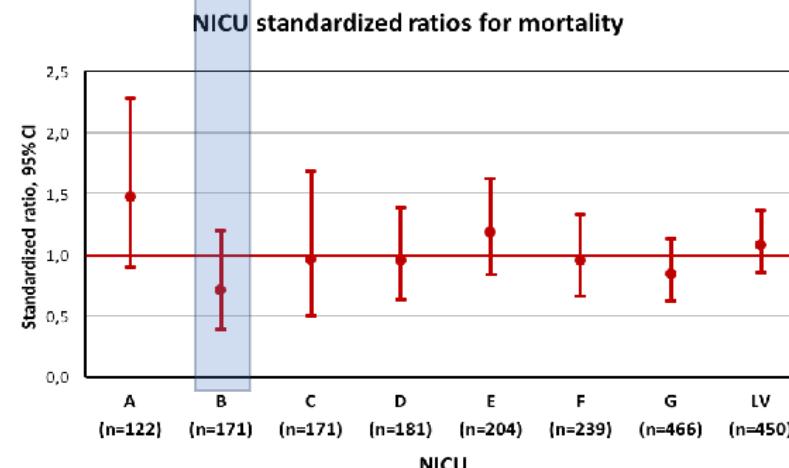
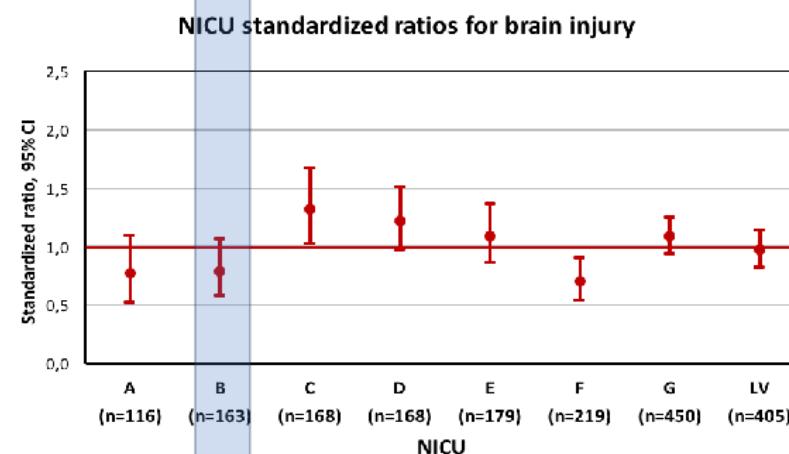
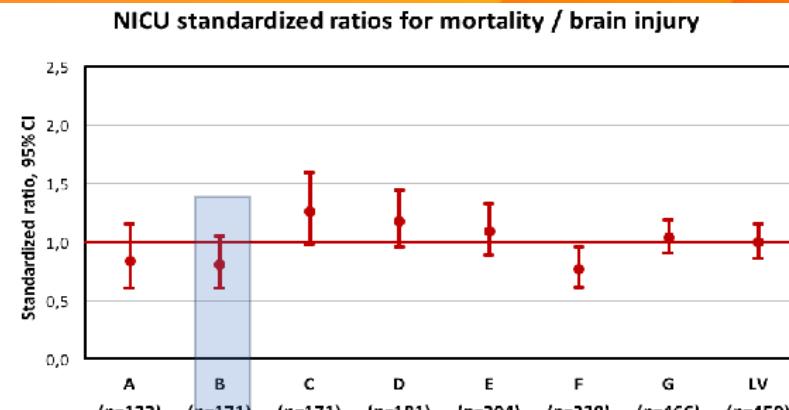




## ARTICLE

# Variations in practices and outcomes of neonates with hypoxic ischemic encephalopathy treated with therapeutic hypothermia across tertiary NICUs in Canada

Marc Beltempo<sup>1</sup>✉, Pia Wintermark<sup>1</sup>, Khorshid Mohammad<sup>1</sup>, Elias Jabbour<sup>1</sup>, Jehier Afifi<sup>1</sup>, Sandesh Shivananda<sup>1</sup>, Deepak Louis<sup>1</sup>, Stephanie Redpath<sup>6</sup>, Kyong-Soon Lee<sup>7</sup>, Carlos Fajardo<sup>2</sup>, Prakesh S. Shah<sup>8</sup> and Canadian Neonatal Network Investigators\*

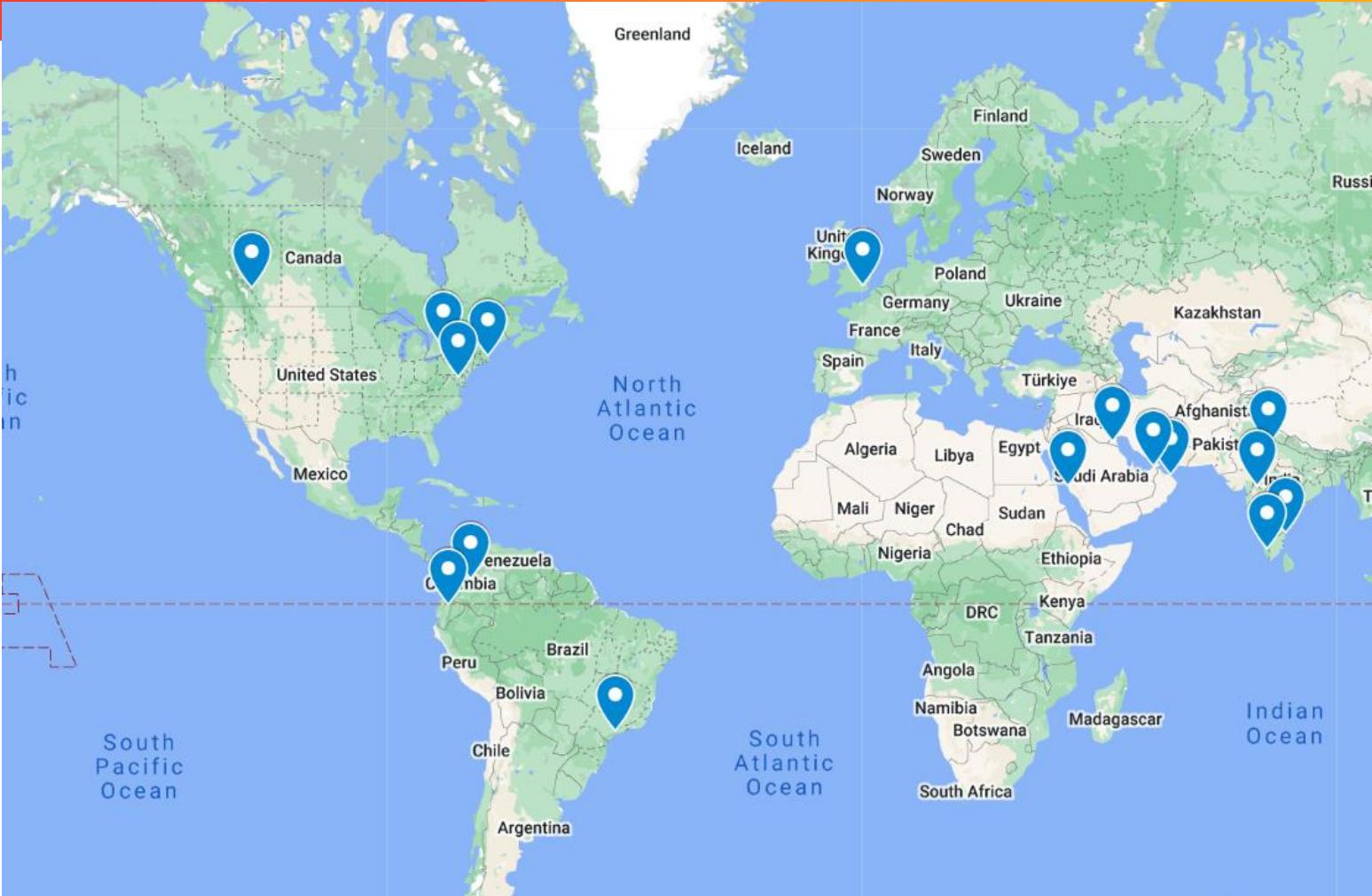


# Impact of outreach education program on outcomes of neonates with hypoxic ischemic encephalopathy

Khorshid Mohammad<sup>1,\*</sup>, Dinesh Dharel<sup>1,\*</sup>, Ayman Abou Mehrem<sup>1</sup>, Michael Esser<sup>1</sup>, Renee Paul<sup>2</sup>, Hussein Zein<sup>1</sup>, James N. Scott<sup>3,4</sup>, Elsa Fiedrich<sup>1</sup>, Prashanth Murthy<sup>1</sup>, Salma Dossani<sup>2</sup>, Kaley Kopores<sup>2</sup>, Derek Kowal<sup>2</sup>, John Montpetit<sup>2</sup>, Essa Al Awad<sup>1</sup>, Sumesh Thomas<sup>1</sup>

Clinical parameters	Before outreach education (N=77)	After outreach education (N=88)	P value
Death and/or severe brain injury on MRI, n (%)	27 (35)	10 (11)	<0.001
Death, n (%)	10 (13)	3 (3)	0.02
Severe brain injury on MRI, n (%)	22* (29)	7 (8)	<0.001
Any change compatible with HIE on MRI, n (%)	29 (38)	20 (23)	0.04
Did not start therapeutic hypothermia within 6 h of birth, n (%)	15 (19.5)	4 (4.5)	0.003
Use of inotrope, n (%)	38 (49)	13 (15)	<0.001
Use of normal saline bolus, n (%)	39 (50.7)	40 (44.3)	0.5
Use of anticonvulsant, n (%)	39 (50)	34 (38)	0.1
Temperature variables (data available for 131 infants)	Before (N=53)	After (N=78)	
Lowest temperature < 33°C, n (%)	20 (38)	16 (21)	<0.001
Target temperature 33°C–34°C on admission to tertiary care facility, n (%)	15 (28)	51 (65)	0.03
Time from birth to reach target temperature (minutes), median (IQR)	255 (168–335)	263 (203–318)	0.89
Time from birth to referral call (minutes), median (IQR)	93 (57–147)	85 (58, 139)	0.77
Stabilization time (minutes), median (IQR)	114 (95, 137)	105 (81,135)	0.16

*Paediatr Child Health.*  
2020;26(5):e215-e221. Published  
2020 Jul 22.  
doi:10.1093/pch/pxaa075



**11** modules for **54** CME credits. **1518** subscriber to **8678** **modules**  
from **78** countries  
**~4000** NNCC exam questions

# Term-born Infants



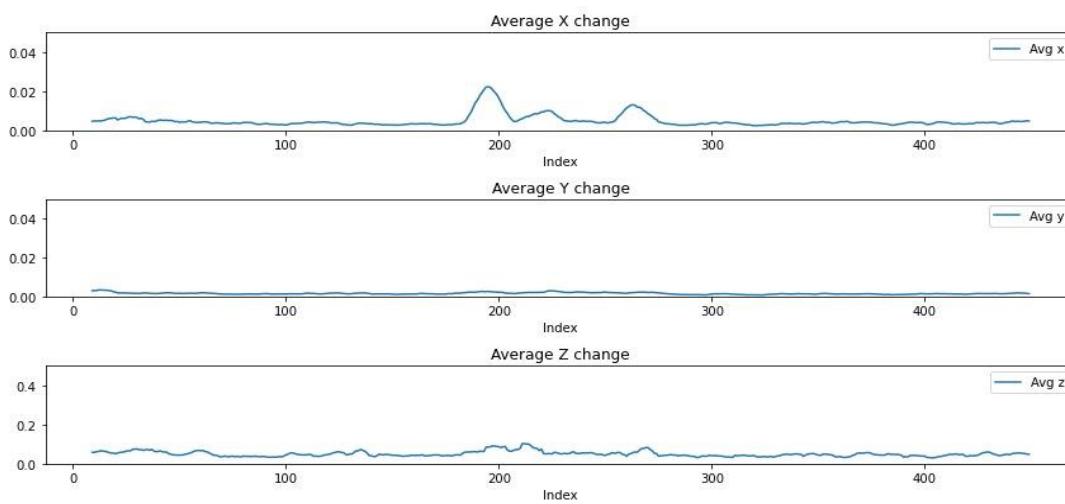
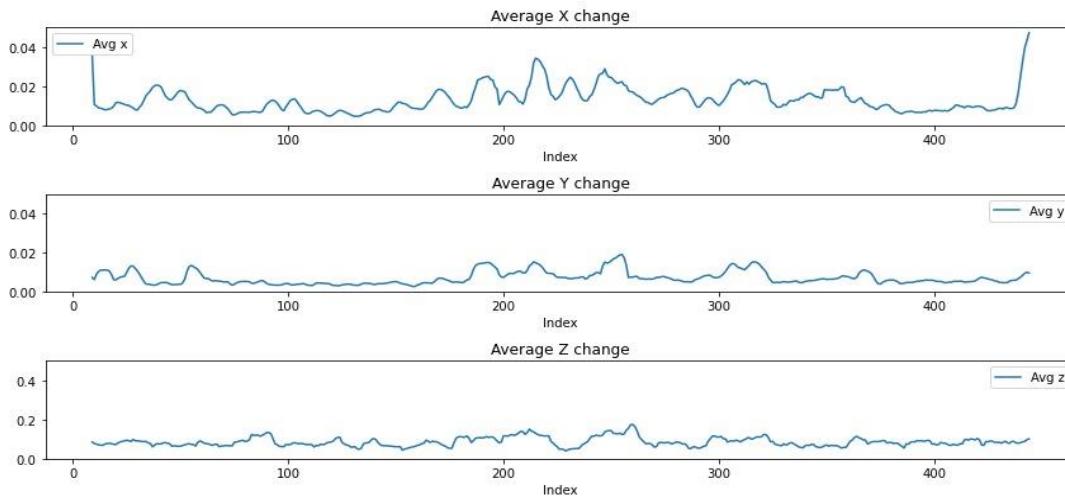
**Baseline**

Variable (mean, max score 5)	Group 1 (n=16)	Group 2 (n =17)
<b>Level of Consciousness</b>	4.19	4.39
<b>Spontaneous movement</b>	4.16	4.47
<b>Posture</b>	3.93	4.31
<b>Ventral suspension</b>	3.40	3.55
<b>Vertical suspension</b>	4.02	4.11
<b>Heel to ear</b>	3.90	3.85
<b>Popliteal angle</b>	2.98	3.13
<b>Scarf sign</b>	3.88	4.26
<b>Pull to sit</b>	2.92	2.94
<b>Pupillary reaction to light</b>	4.17	4.31
<b>Moro reflex</b>	3.88	3.87
<b>Sucking reflex</b>	4.26	4.06
<b>Global rating scale</b>	3.63	3.79
<b>Diagnostic exam for moderate to severe HIE, pass (%)</b>	*15/16 (93.75%)	16/17 (94.11%)

**3-month follow up**

Variable (mean, max score 5)	Sim group (n=16)	Traditional group (n =17)
<b>Level of Consciousness</b>	3.77	3.58
<b>Spontaneous movement</b>	3.64	4.31
<b>Posture</b>	3.87	3.7
<b>Ventral suspension</b>	3.08	2.86
<b>Vertical suspension</b>	3.08	2.86
<b>Heel to ear</b>	4.03	3.55
<b>Popliteal angle</b>	3.33	3.40
<b>Scarf sign</b>	3.94	3.93
<b>Pull to sit</b>	2.77	2.43
<b>Pupillary reaction to light</b>	4.21	3.7
<b>Moro reflex</b>	3.75	3.17
<b>Sucking reflex</b>	4.00	3.81
<b>Global rating scale</b>	3.69	3.50
<b>Diagnostic exam for moderate to severe HIE, pass (%)</b>	*11/13 (84.61%)	8/12 (66.66%)

# Term-born Infants



PBSF AI for good squad:

Cutting-edge technology to  
Protect Brains and Save Futures



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