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All, for your one.

ECPR Simulation:
Is it worth the time and effort??

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Disclosures

- None

Circulation
Volume 140, Issue 24, 10 December 2019; Pages e904-e914
https://doi.org/10.1161/CIR.0000000000000731

American Heart Association.

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2019 American Heart Association Focused Update on Pediatric Advanced Life Support: An Update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Recommendation—Updated 2019

1. **ECPR may be considered for pediatric patients with cardiac diagnoses who have IHCA in settings with existing ECMO protocols, expertise, and equipment (*Class 2b; Level of Evidence C-LD*).**

- 2010 ILCOR and AHA guidelines for the first-time recommended consideration of ECPR for in-hospital cardiac arrest (IHCA) in centers with existing protocols and expertise. 2019 guidelines strengthened that recommendation
- There has been expanding use of ECPR for IHCA in pediatric patients with known cardiac diagnoses (and attempts to expand to other populations)
- While outcomes with ECPR are worse than non-CPR ECMO, both mortality and neurologic outcomes are better than conventional CPR
- There is currently insufficient evidence to recommend for or against the use of ECPR for pediatric out-of-hospital arrest or arrest in the setting of noncardiac disease

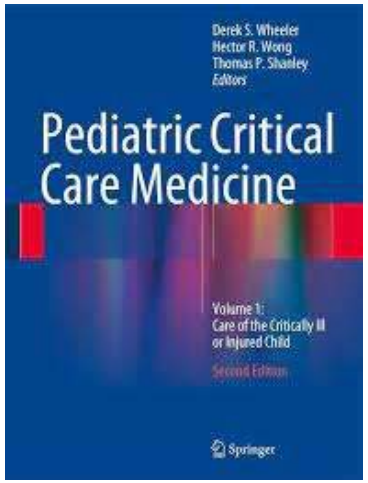
ECPR Background

PEDIATRIC CARDIAC CRITICAL CARE CONSORTIUM

PC4 Improving outcomes and quality through collaboration

Characteristics, risk factors & outcomes of extracorporeal membrane oxygenation use in pediatric cardiac intensive care units: a report from the PC4 Registry

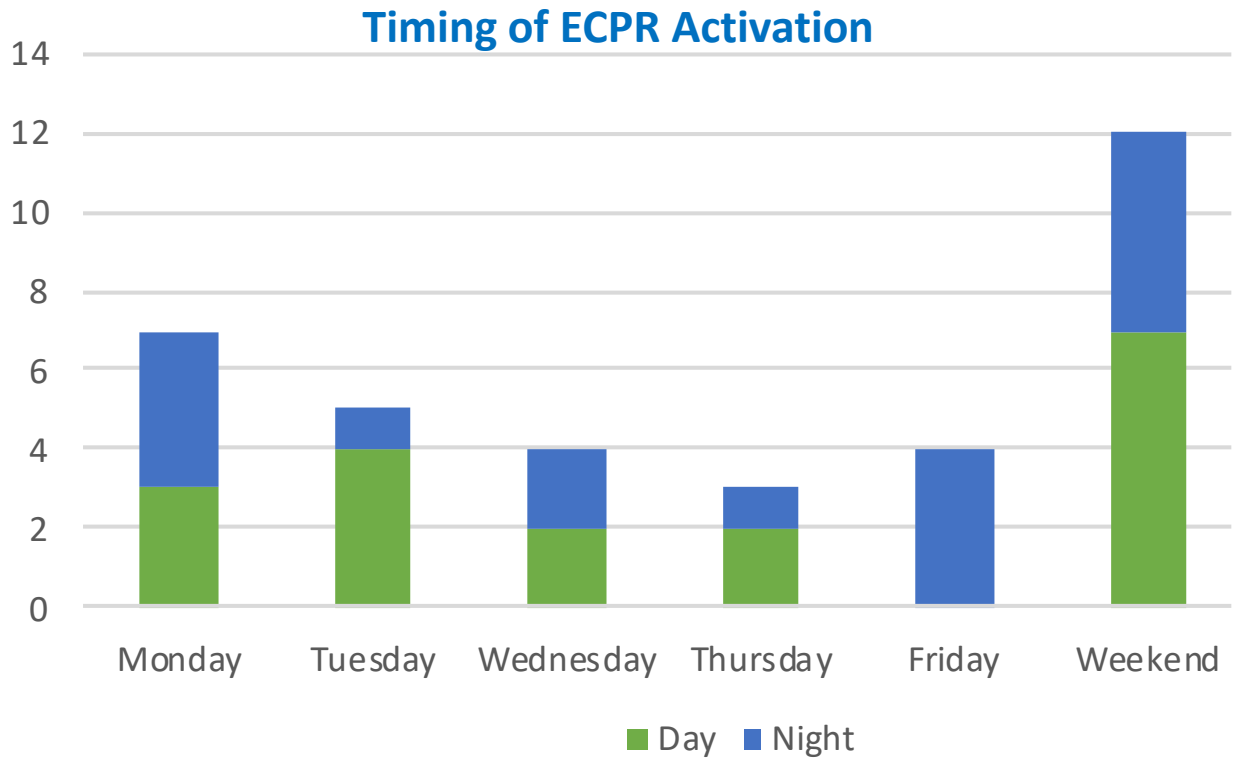
Marissa A. Brunetti, M.D.[1], J. William Gaynor, M.D.[2], Lauren B. Retzloff, M.P.H.[3], Jessica L. Lehrich, M.S.[4], Mousumi Banerjee, Ph.D.[5], Venugopal Amula, M.D.[6], David Bailly, D.O.[6], Darren Klugman, M.D.[7], Josh Koch, M.D.[8], Javier Lasa, M.D.[9], Sara K. Pasquali, M.D.[3], and Michael Gaies, M.D.[3]



- Brunetti et al looked at 449 hospitalizations that included at least 1 ECMO run over a 2-year period in the PC4 registry
  - 32% of surgical and 42% of medical ECMO runs were initiated in a CPR setting
  - There were 642 cardiac arrests during that period
    - ECPR was activated in 24% of surgical cardiac arrests and 16% of medical cardiac arrests
    - Median CPR duration in the ECPR setting was 38min for surgical and 49min for medical arrests
  - Mortality rate after ECPR was 50% in surgical and 83% in medical hospitalizations

The Lurie ECPR Experience

- Study in 2018 of our ECMO outcomes
- Looked at 35 consecutive RR-ECMO or ECPR cannulations over a 5 year period
  - 49 ECPR activations
  - 33 patients ultimately cannulated (2 had more than 1 ECPR episode)
- Of the 33 patients cannulated, 70% survived to decannulation and 46% survived to hospital discharge
- ECPR activation most often occurred outside of “normal business hours”



The Lurie ECPR Experience – Quality & Safety Opportunities

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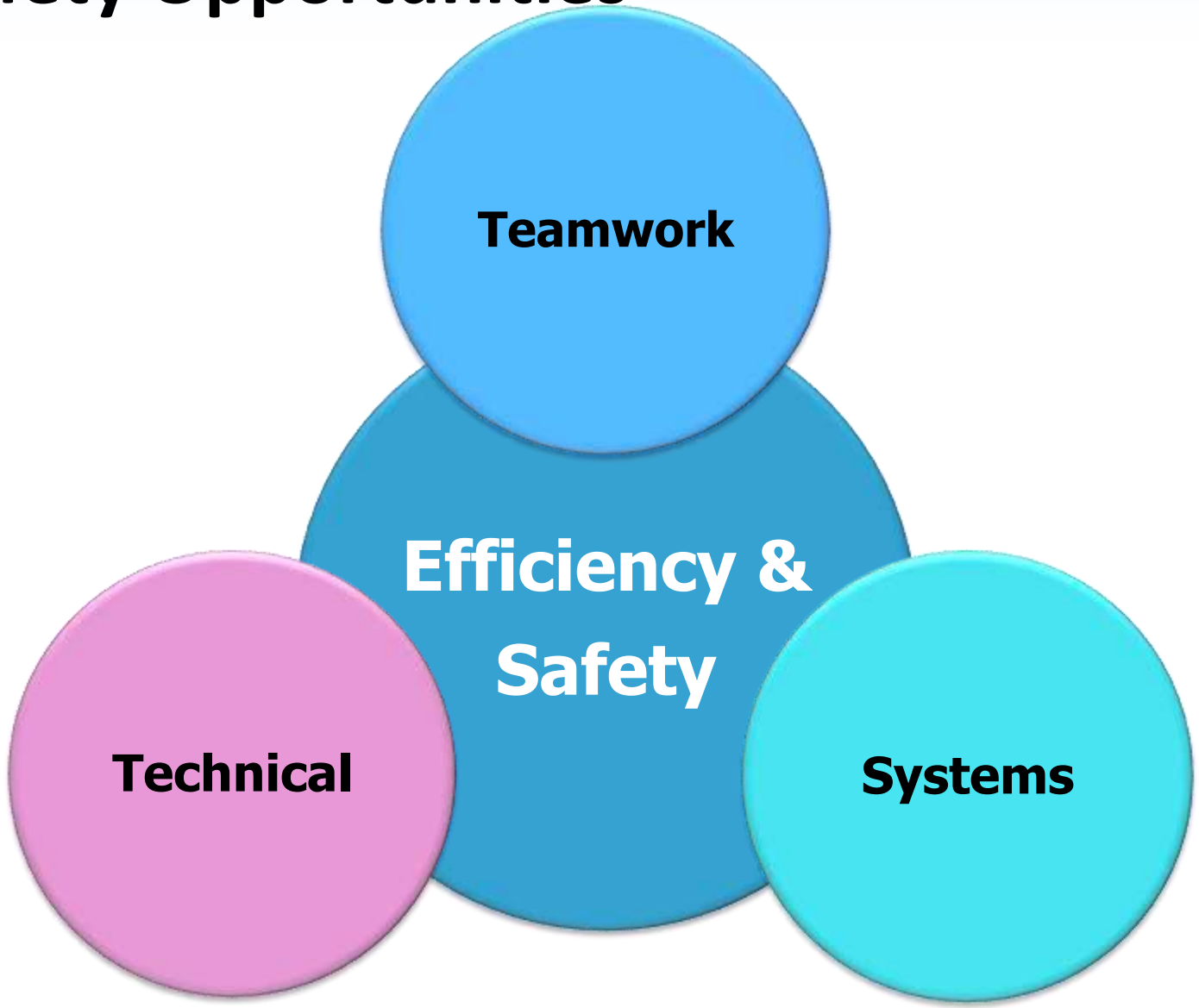

Lurie ECPR Experience – Quality & Safety Opportunities…

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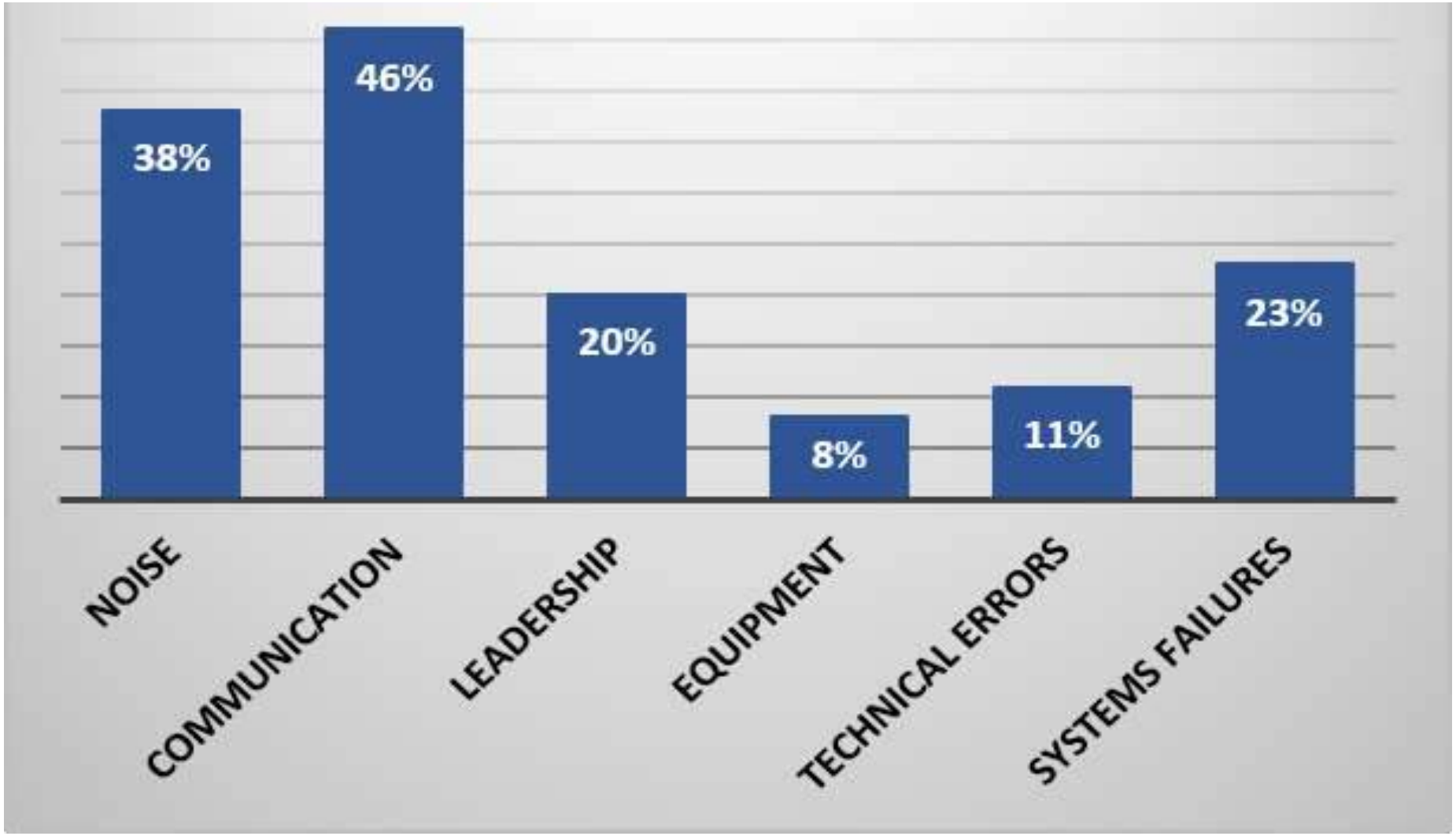
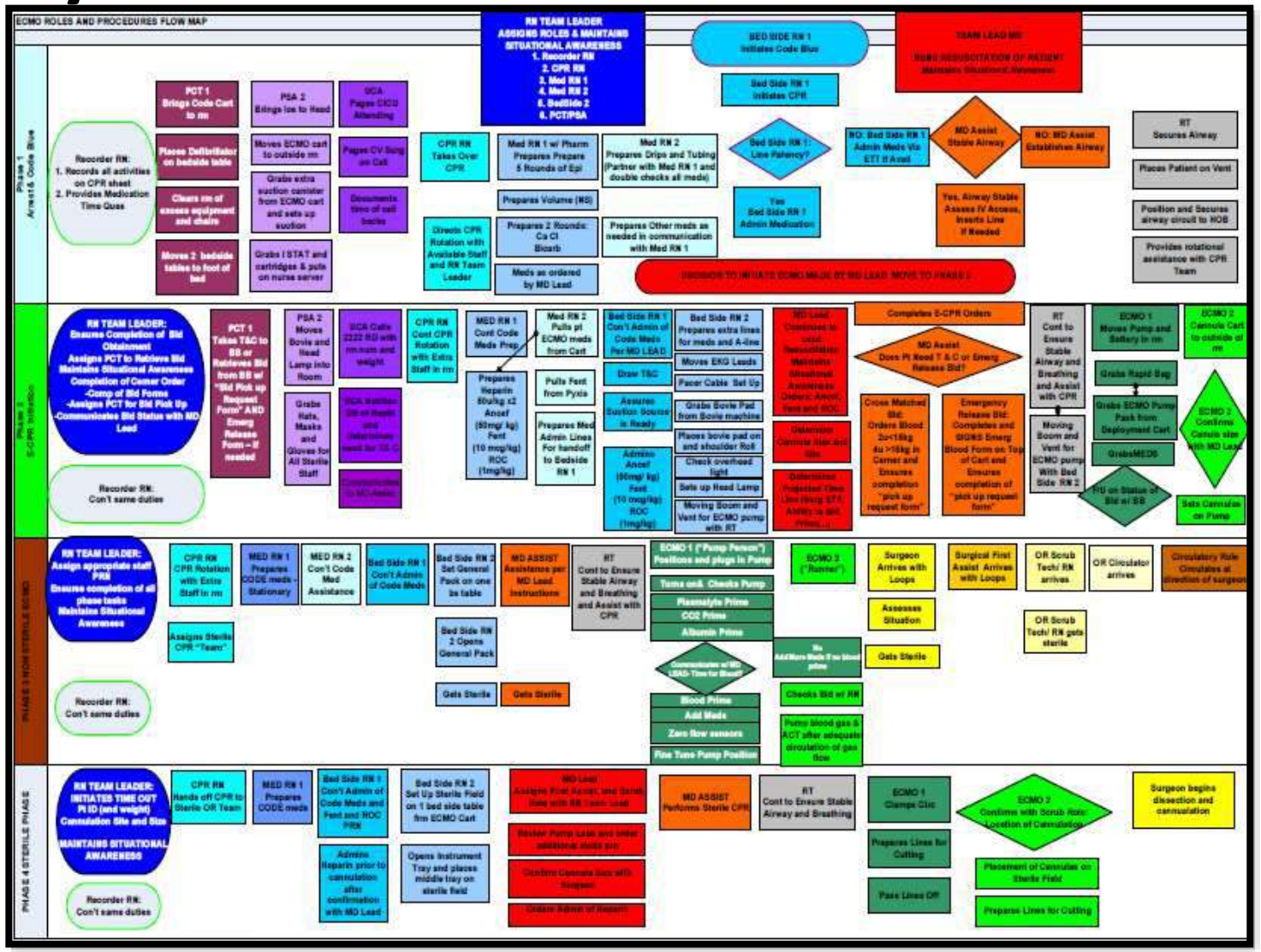


Why so many errors…?



The realities

- ECPR is a low-volume, high-risk procedure that is often used as a last resort
- Stakes are high
- Providers and trainees have limited opportunities to learn and practice
  - (Fortunately) it doesn't happen THAT often
  - That critical situation is not necessarily when you want novice participants trying to expand their skills
- Historically, training has focused on didactic education and "wet labs" that don't necessarily involve real world scenarios – overemphasize cognitive skills, underemphasize technical and behavioral skills
- High fidelity simulation training is increasingly utilized as an educational tool for a variety of scenarios

CAN THE REGULAR USE OF SIMULATION IMPROVE OUR ECPR PERFORMANCE?


FRASCA
FRASCA

Goals of ECMO/ECPR Education

ECMO education needs to address 3 Domains:

- Cognitive Domain
  - Knowledge acquisition
  - Knowledge transfer to the real world
- Psychomotor Domain
  - Technical skills
  - Performance/behaviors
- Affective Domain
  - Attitudes
  - Values
  - Interests

Majority of studies (and didactic teaching) focus primarily on the cognitive domain. Simulation, designed correctly, can address all 3 domains

Goals of ECMO/ECPR Education

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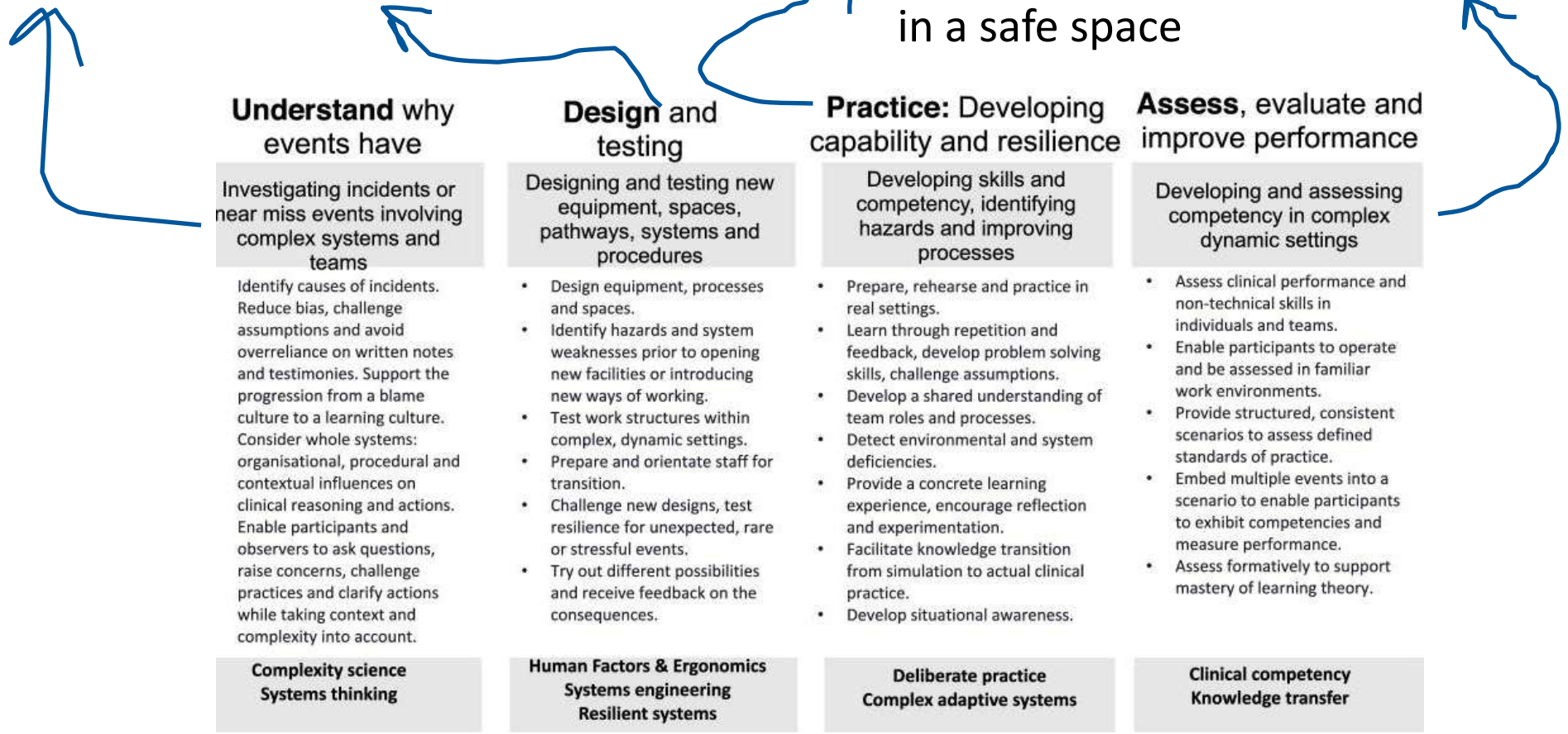
Baxendale *et al. BMC Medical Education* (2022) 22:479
https://doi.org/10.1186/s12909-022-03490-9

Evans *et al. BMC Medical Education* (2022) 22:537
https://doi.org/10.1186/s12909-022-03401-y

To test and retest a new workflow or process to identify and troubleshoot previously unrecognized holes in the proposed workflow

vs.

To provide participants the opportunity to improve their comfort, confidence, teamwork, and ultimately performance by serial repetition in a safe space



Codes in the time of COVID

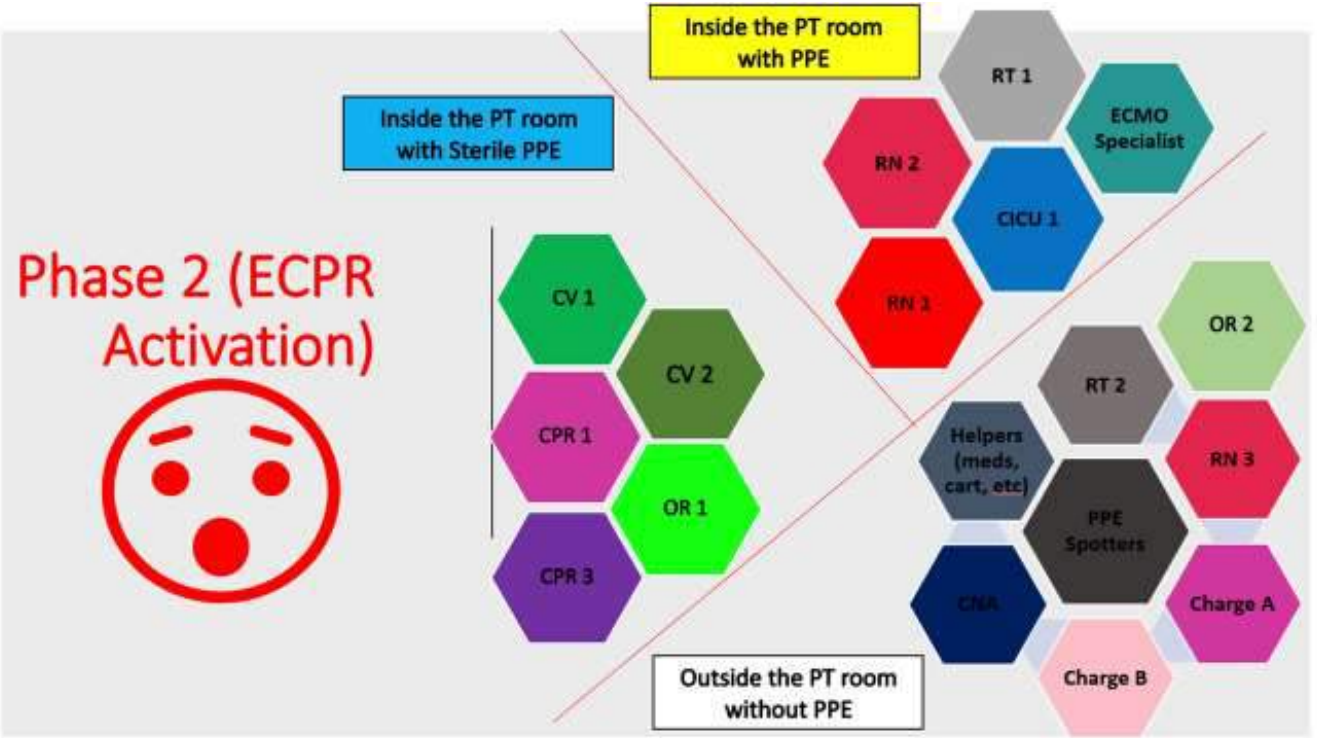
Kiona Allen, MD
Interim Medical Director of the Regenstein CCU
April 20, 2020

Phases

- Phase 0 (prior to event)
- Phase 1 (Initial Resuscitation)
- Phase 2 (ECPR Activation)

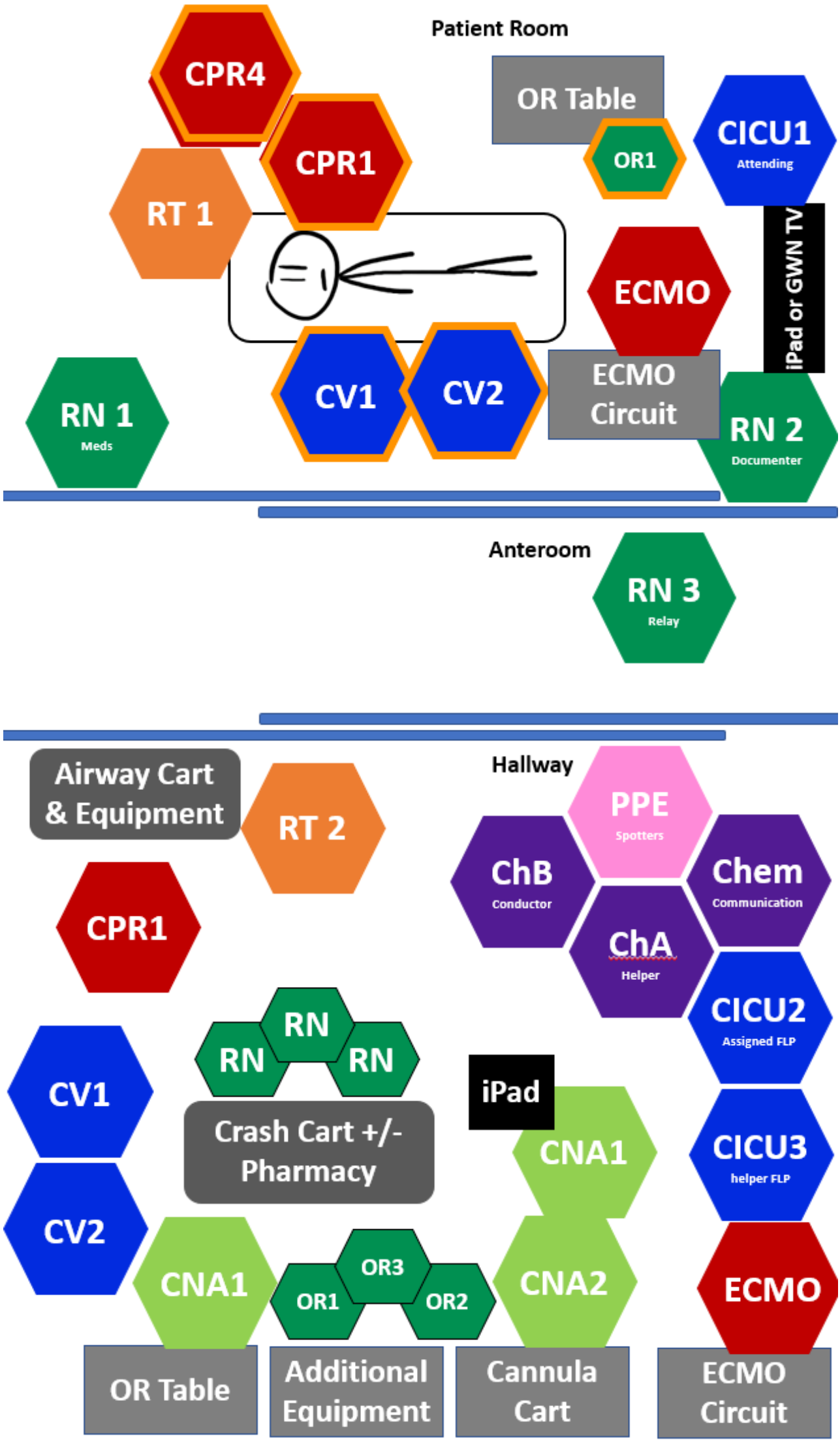
The Facts

- Codes happen in the CICU
- COVID (or COVID rule outs) happen in the CICU
- If codes happen in the CICU and COVID happens in the CICU, eventually these things will overlap…
- Goals
  - Proactively identify patients at risk for decompensation
  - Take aggressive measures to avoid need for staff assist/code
  - If acute decompensation requiring emergent intervention, there are 3 major take home points:
    1. NOBODY ENTERS THE ROOM WITHOUT PPE
    2. Crowd control is critical
    3. Closed loop communication is more important (and more challenging) than ever



Phase 2 (ECPR Activation)

	PPE	PPE	NO PPE	NO PPE	NO PPE	Phase 2 Phase 1	PPE	STERILE PPE	NO PPE	PPE	NO PPE	PPE	NO PPE	PPE	STERILE PPE	NO PPE	STERILE PPE	STERILE PPE	PPE
	RN 1 Bedside RN	RN 2 Relay from outside to inside	RN 3 Documenter	Charge A	Charge B	CPR 1	CPR 2	CPR 3	PPE Spotters	Anesthesia COVID Attending on call	CNA 1	RT 1 Assigned RT	RT 2 Helper RT	CICU 1 Attending	OR 1 OR scrub RN	OR 2 Circulating RN	CV 1 CV Surgeon on call	CV 2 CV Surgery 1st assist	ECMO Specialist
Phase 2	Med person Places shoulder roll under the patient and applies bovi pad Med person	Starts moving equipment out of room (bedside table, chair, etc.) Starts facilitating movement of ECPR equipment into the room Opens sterile items onto the field as needed Continues to act as relay	Documents from outside the room using telemedicine	Activates ECPR using prefix COVID-ECPR Continues roles from phase 1	Continues as helper outside the room	Once OR team is ready to prep, finishes cycle and removes clear plastic drape (Pinch near feet and pull upwards to fold drape into a tent and then fold in half) Discards drape in waste bin Changes into sterile PPE Alternates with CPR 3	Takes over CPR once OR 1 is setting up to prep patient Leaves room and doffs PPE	Dons sterile PPE Waits outside the room Enters the room ready to take over CPR once patient is prepped Alternates with CPR 1	Assist with making sure correct roles have PPE	Brings glidescope when exiting the patient room	Brings ECPR supplies to bedside Runner outside the room	Stays by ventilator monitoring airway and making changes as needed	Stays outside room available to run ABG/VBG as needed	Assists in positioning patient for ECMO Code leader	Dons sterile PPE Starts setting up equipment in the room Starts prepping the patient Acts as circulating RN	Brings additional light source Stays outside the room with supplies and hands off what is needed to RN 2	Dons sterile PPE enters room	Dons sterile PPE enters room	Primes circuit outside the room Dons appropriate PPE enters room with ECMO circuit


Patient Room
CPR4
CPR1
RT 1
OR Table
OR1
CICU1
Attending
iPad or GWN TV
ECMO
ECMO Circuit
CV1
CV2
RN 1
Meds
RN 2
Documenter
Anteroom
RN 3
Relay
Airway Cart & Equipment
RT 2
CPR1
Hallway
PPE
Spotters
ChB
Conductor
Chem
Communication
ChA
Helper
CICU2
Assigned FLP
CV1
RN
RN
RN
Crash Cart +/- Pharmacy
iPad
CNA1
CICU3
helper FLP
CV2
CNA1
OR3
OR1
OR2
CNA2
ECMO
OR Table
Additional Equipment
Cannula Cart
ECMO Circuit

Does simulation improve ECPR outcomes?

- Based on 2017 survey, majority of ELSO centers incorporate simulation into their ECMO education
- Simulation education is not explicitly recommended as part of ELSO's guidelines for ECMO specialist training
- There is no good data about the optimal set-up for simulation training (in-situ vs. lab, high vs. low fidelity, debriefing methods) in the literature

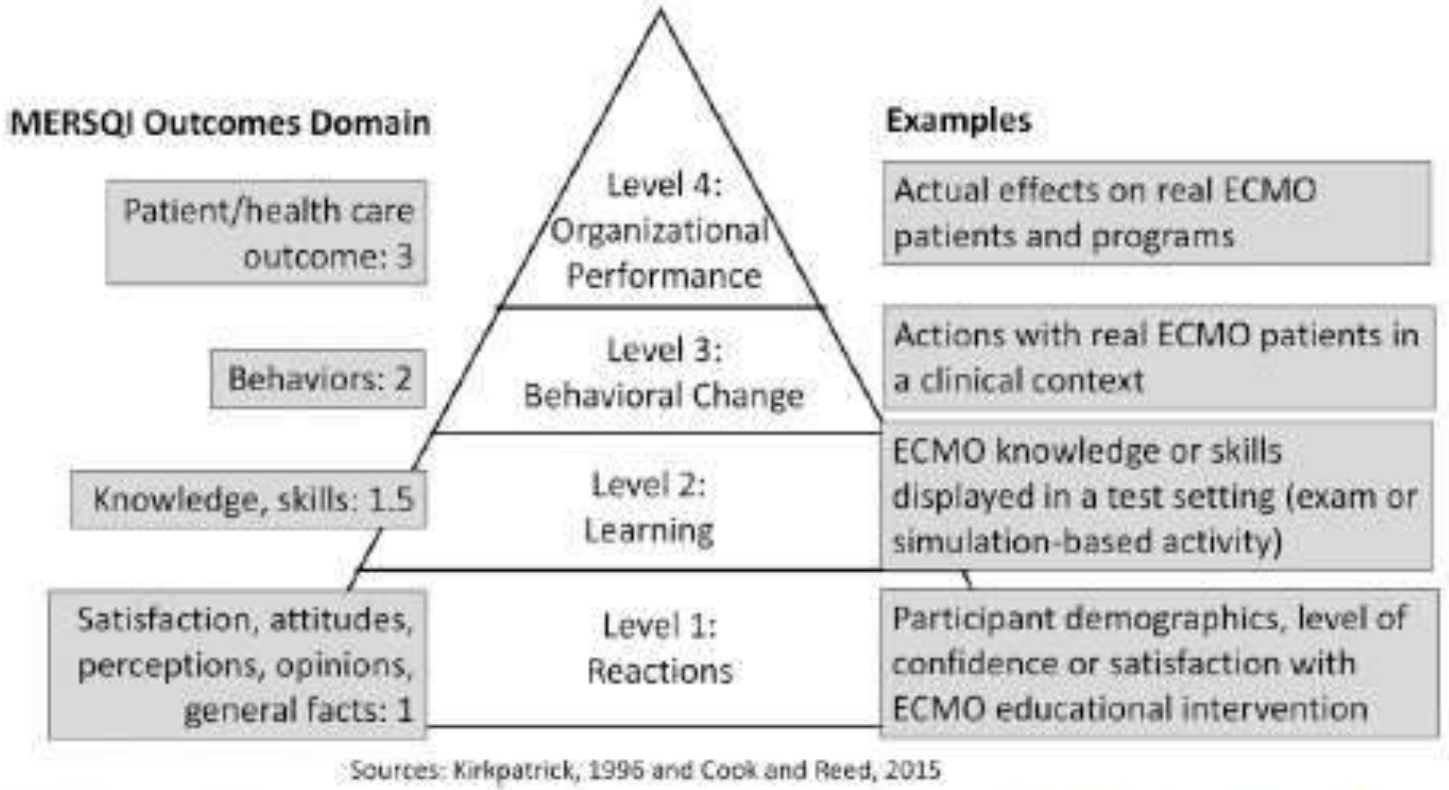


Figure 2. MERSQI outcomes domain reflective of Kirkpatrick's levels of learning evaluation. Numbers in the left column represent the points for each outcomes domain, with higher scores implying more robust outcomes. ECMO = extracorporeal membrane oxygenation; MERSQI = Medical Education Research Study Quality Instrument.

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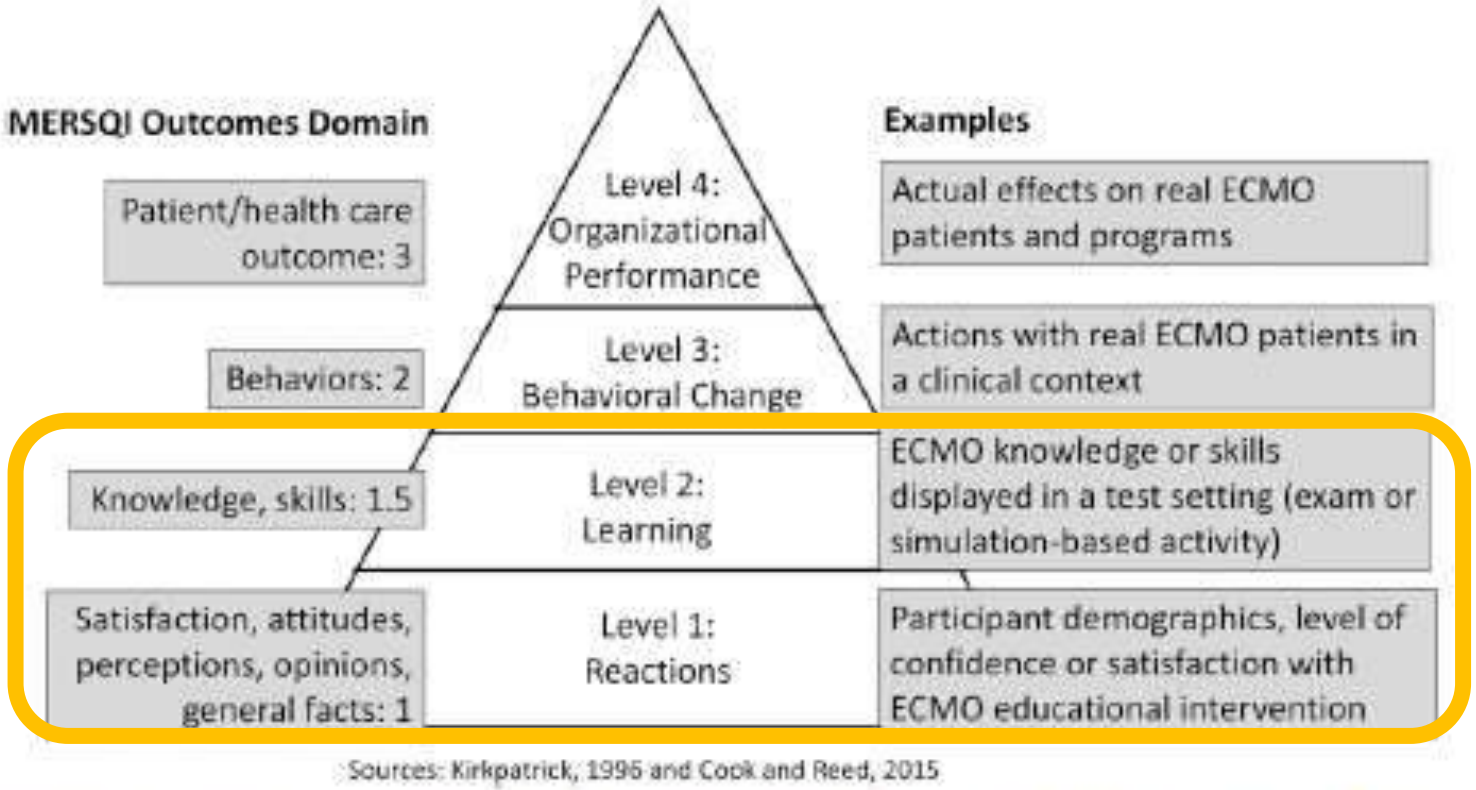
- There is no good data about efficacy in the clinical setting



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Simulating Extracorporeal Membrane Oxygenation Emergencies to Improve Human Performance. Part I: Methodologic and Technologic Innovations

JoDee M. Anderson, MD; Kristine B. Boyle, RNC, MS, NNP; Allison A. Murphy, MD; Kim A. Yaeger, RN; Judy LeFlore, PhD, RNC, NNP, CPNP-PC&AC; and Louis P. Halamek, MD

Ann & Robert H. Lurie Children's Hospital of Chicago®

- Rolled out an ECMO simulation program to 25 physicians and nurses who take care of ECMO patients in the NICU
- Combined traditional didactic teaching with high fidelity simulation
- Rated a more effective learning strategy by participants re: relevance to practice and transferability of skillset to real world

- Substantially more time spent in active learning

TABLE 5. Percentage of Total Course Time Spent in Different Activities in ECMO Sim and Traditional ECMO Training

Activity	ECMO Sim	Traditional ECMO Training	*P* Value*
Active learning (eg, hands-on)	78%	14%	<0.001
Passive learning (eg, lecture)	22%	86%	<0.001

**P* value determined using a Student's *t* test.

- Did not assess objective performance improvement

TABLE 4. Mean Rating (+ SD) of ECMO Sim and Traditional ECMO Training as Scored on a 5-point Likert Scale (1 = Poor to 5 = Excellent)

Question	ECMO Sim	Traditional ECMO Training	*P* Value*
Relevance to my practice in the hospital	5.0 + 0.0	3.1 + 0.6	
Ability to engage my intellect	5.0 + 0.0	3.6 + 0.7	
Ability to develop my behavioral skills	4.9 + 0.4	2.6 + 0.7	
Ability to transfer learned behavioral skills to the real environment	4.9 + 0.5	2.5 + 0.8	
Ability to develop my technical skills	4.8 + 0.5	2.6 + 0.7	
Ability to transfer learned technical skills to the real environment	4.9 + 0.4	2.4 + 0.5	
Ability to develop my critical thinking skills	5.0 + 0.0	3.0 + 0.9	
Ability to transfer learned critical thinking skills to the real environment	5.0 + 0.0	2.9 + 0.7	
Builds my confidence in handling ECMO emergencies	4.9 + 0.4	2.9 + 0.6	
Total score	44.4 ± 0.5 (4.93 ± 0.07)	25.6 ± 0.7 (2.84 ± 0.37)	<0.001

FIGURE 1. The ECMO Sim physical environment at the Center for Advanced Pediatric Education.

FIGURE 2. ECMO cannula entering the manikin's thoracic cavity, prior to suturing.

PERIOPERATIVE MANAGEMENT

Simulation-based training delivered directly to the pediatric cardiac intensive care unit engenders preparedness, comfort, and decreased anxiety among multidisciplinary resuscitation teams

Catherine K. Allan, MD,[a,b] Ravi R. Thiagarajan, MBBS, MPH,[a,b] Dorothy Beke, RN, MS, PNP,[e] Annette Imprescia, RN, CCRN,[e] Liana J. Kappus, Med,[c,d] Alexander Garden, MBChB, PhD,[f,g] Gavin Hayes, BS,[c,d] Peter C. Laussen, MBBS,[a,b,h] Emile Bacha, MD,[b,i] and Peter H. Weinstock, MD, PhD[b,c,d]

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- Course rolled out to 182 multidisciplinary providers (MD, RN, RT, APN, etc) in the CICU
- Pediatric CICU scenarios were enacted in-situ on the unit (including ECMO activation) using high fidelity simulation
- Participants replicated the composition of a clinical team
- All participants felt program and scenarios were useful
- Improvement in participants' perceived ability to function as a team member, ability to speak up, and self-confidence during a code scenario
- Did not objectively measure improvement in team performance

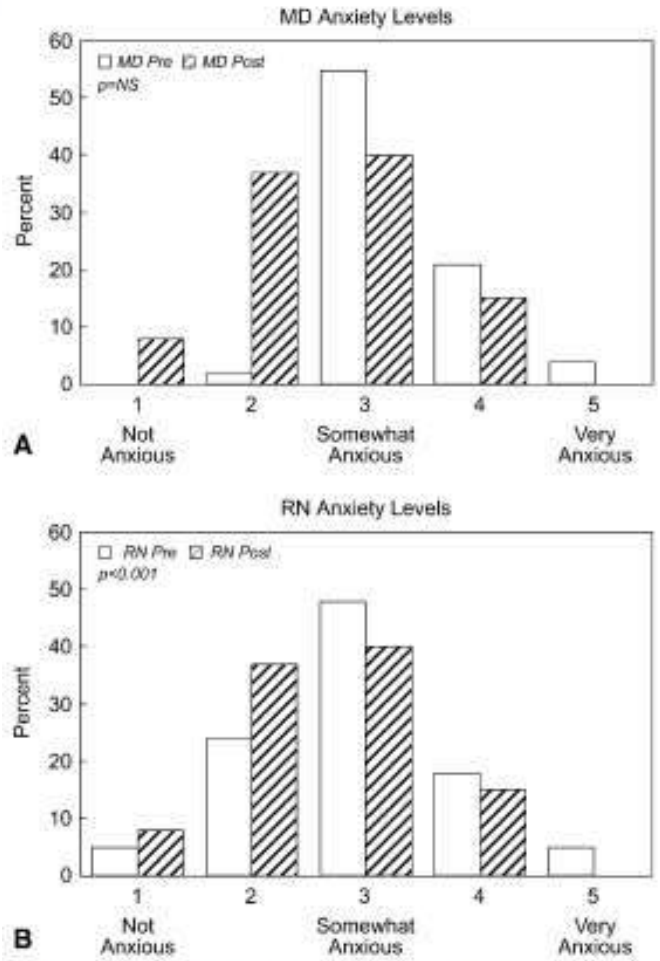

FIGURE 4. Nurses' and physicians' assessment of their anxiety regarding participation in a future cardiopulmonary resuscitation event before and after participation in pCICU–CRM training program. *pCICU*, Pediatric cardiac intensive care unit; *CRM*, Crisis Resource Management.

EMPIRICAL INVESTIGATIONS

An Extracorporeal Membrane Oxygenation Cannulation Curriculum Featuring a Novel Integrated Skills Trainer Leads to Improved Performance Among Pediatric Cardiac Surgery Trainees

Allan, Catherine K. MD; Pigula, Frank MD; Bacha, Emile A. MD; Emani, Sitaram MD; Fynn-Thompson, Francis MD; Thiagarajan, Ravi R. MBBS, MPH; Imprescia, Annette RN; Hayes, Gavin BS; Weinstock, Peter MD, PhD

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Simulation in Healthcare

Journal of the Society for Simulation in Healthcare®

- 10 cardiac surgical trainees participated in high-fidelity simulation using a surgical neck cannulation trainer
- CICU team collaborated to run the preceding code event
- Performance rated by attending CV surgeons
- Trainer was rated as authentic and sessions as useful by the trainees
- Median time to cannulation decreased over serial exposures and was sustained at 3 months
- Participants ranked the 1:1 performance evaluation from the attending surgeon as the most helpful element of the program

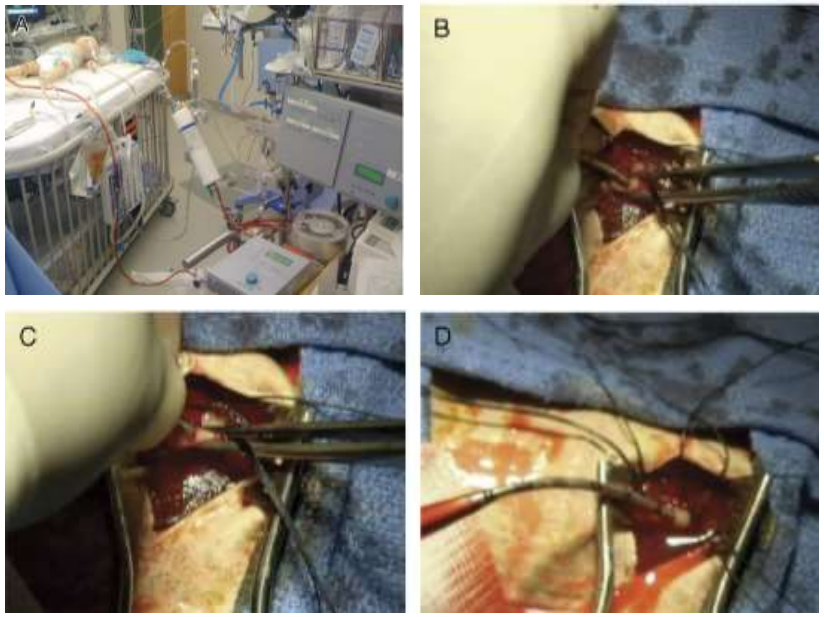

FIGURE 2

Embedded high-fidelity ECMO skills trainer. A, A simulated trainer with the look, feel, and anatomy of the actual tissue is embedded in the mannequin within the high-fidelity environment at the point of clinical care. B and C, Cannulation is performed with authentic "blood" flow rates in "vessels," as well as risks of "oozing" and bleeding from the operative site (D).

Source

An Extracorporeal Membrane Oxygenation Cannulation Curriculum Featuring a Novel Integrated Skills Trainer Leads to Improved Performance Among Pediatric Cardiac Surgery Trainees

Simulation in Healthcare8(4):221-228, August 2013.

Impacts of a Pediatric Extracorporeal Cardiopulmonary Resuscitation (ECPR) Simulation Training Program

Taylor Sawyer, DO, MEd; Christopher Burke, MD; D. Michael McMullan, MD; Titus Chan, MD; Hector Valdivia, RN; Larissa Yalon, RN; Joan Roberts, MD

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- 2-hour high-fidelity in-situ ECPR simulations were held monthly in the CICU, PICU, and NICU
  - 30 minute introduction
  - 30 minute simulation
  - 60 minute postevent debriefing
- Each simulation included an average of 11 healthcare professionals (RN, MD, RT, perfusionists, etc)
- Utilized specially developed "neck patch" with simulated skin, tissue, and vessels.
  - Vessels within the patch were connected to a bladder system that provided realistic circulation of artificial blood within the ECMO circuit
  - Surgical team could perform a lifelike cannulation during CPR

Impacts of a Pediatric Extracorporeal Cardiopulmonary Resuscitation (ECPR) Simulation Training Program

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- Predetermined learning objectives included:
  1. Accurately identify ECPR candidates
  2. Activate the ECPR system in accordance with hospital policy
  3. Provide effective CPR
  4. Demonstrate good teamwork and communication

Table 1. Outcome Measures of ECPR Simulation Training

Kirkpatrick Level	Outcome Metric	How Measured
1. Reactions	Self-perceived value of the simulations training	Surveys of participants
2. Learning	Self-perceived knowledge gains	Surveys of participants
3. Behaviors	CPR coordination	Facilitator observation
	Dawning sterile attire for chest compressions	Semi-structured interviews
4. Results	Appropriate ECPR activation	Analysis of hospital "code blue" and ELSO data
	Time to ECPR cannulation	
	Duration of cannulation procedure	
	Survival outcomes	

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- Applied cognitive task analysis demonstrated issues with CPR coordination with surgical cannulation and performing sterile compressions that were targeted for further training

Table 2. Cognitive Demands Table Developed Using ACTA From Observations Made During ECPR Simulations

Difficult Cognitive Element	Why Difficult?	Common Errors	Strategies Developed Through ACTA
How to coordinate chest compressions during surgical procedure	Unclear who coordinates the pauses in compressions Lack of clinical experience	Long pauses in compressions Frequent interruptions of compressions Poor-quality CPR	Surgeon instructs compressor to pause compressions based on surgical needs. Instruct compressor to count seconds out loud in 15-second intervals from the stop of compressions. Surgeon instructs compressor to restart compressions with goal of <1-minute pause in compressions
How to put on sterile gown for chest compressions during ECPR	Multiple steps Lack of nurse training in donning sterile attire	Delays in start of sterile compressions OR techs tasked to help nurses don sterile attire Violations of sterile precautions	All ICU nurses received education on donning sterile attire during nursing skill days Area established in room for sterile compressors to stand to avoid contamination

ACTA indicates applied cognitive task analysis; ECPR, extracorporeal cardiopulmonary resuscitation; CPR, cardiopulmonary resuscitation; OR, operating room; and ICU, intensive care unit.

Current State of ECMO Education

- Based on 2017 survey, majority of ELSO centers incorporate simulation into their ECMO education
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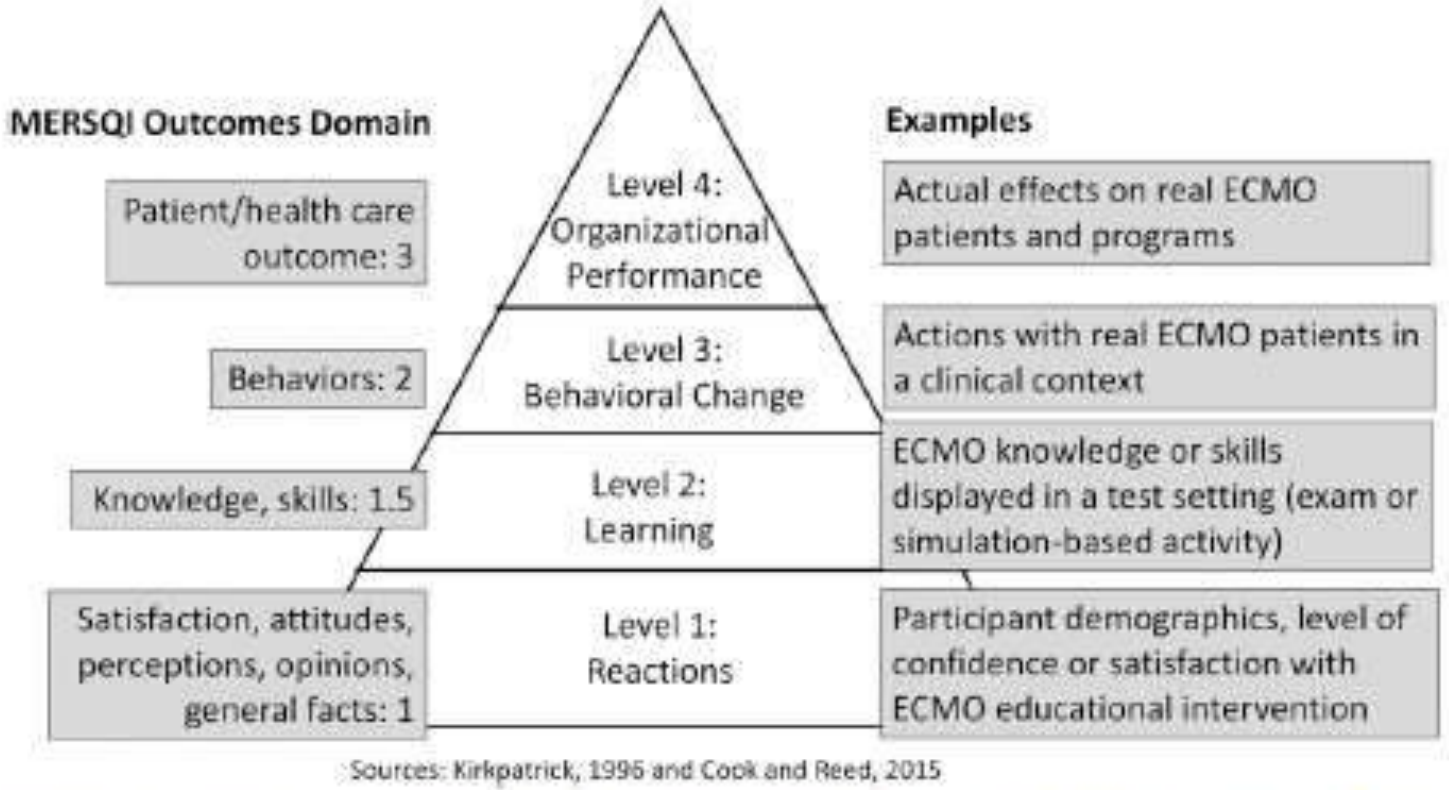

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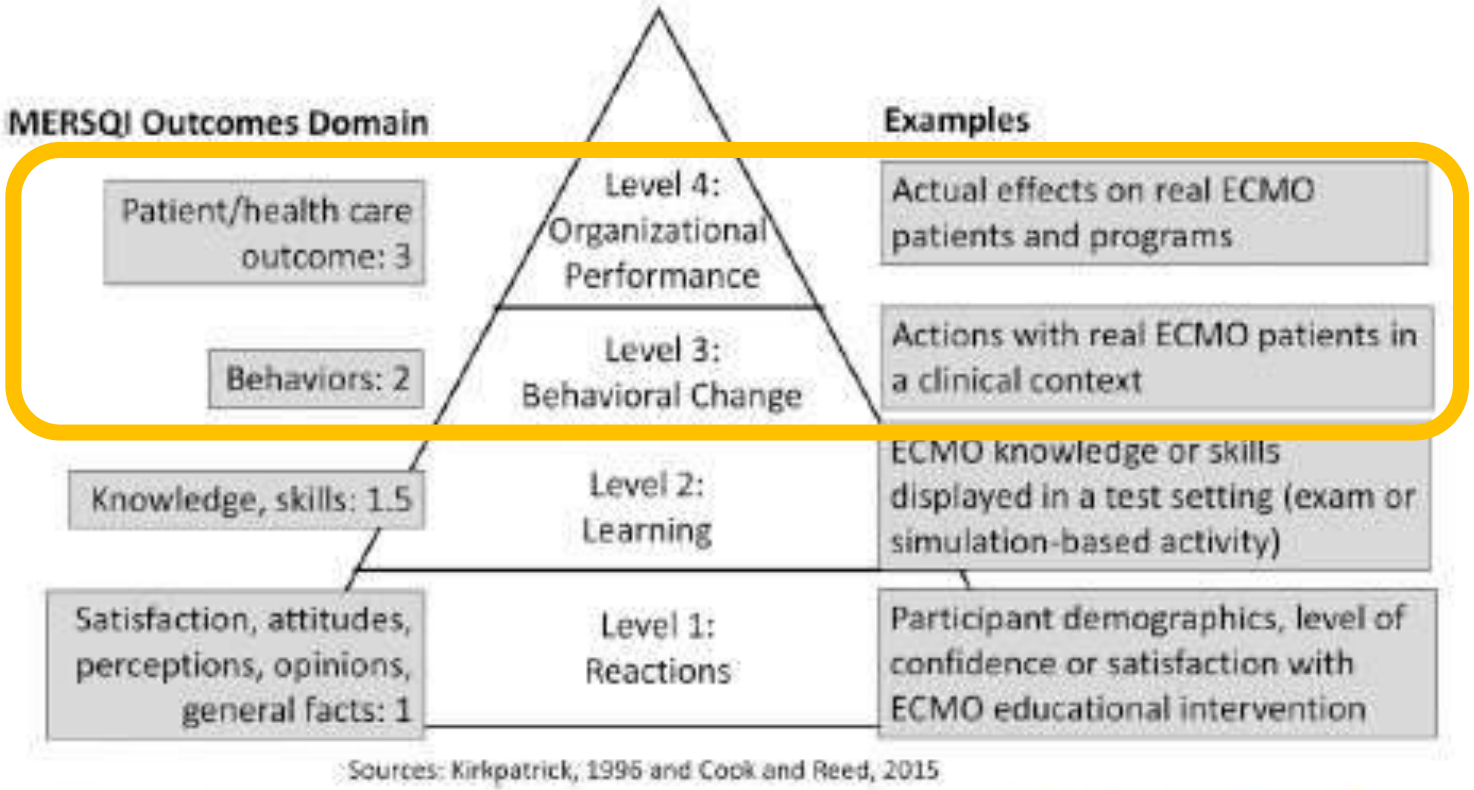

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- Adherence to ECPR activation protocol improved from 83% to 95% and ECPR activation time decreased from 7 min to 2 min (p <0.01)

Table 3. Clinical Outcomes of ECPR Before and After Simulation Training

Demographics and Outcomes	Before Simulation (n = 11)	After Simulation (n = 16)	*P* Value
Age, mo, median (IQR)	7 (3.25–15.75)	6 (1.625–78.5)	.83
Weight, kg, median (IQR)	6.3 (4.45–8.1)	6.4 (3.2–12.25)	.88
Female sex, n (%)	4 (36)	7 (43)	.72
Location, n (%)			
CICU	9 (82)	12 (75)	.66
PICU	2 (18)	3 (19)	
NICU	0 (0)	1 (6)	
ECPR activation time, min, median (IQR)	7 (4–9)	2 (1–4)	<.01
ECPR response time, min, median (IQR)	18.5 (15–23)	25 (18.5–27.75)	.36
ECPR deployment time, min, median (IQR)	37 (30.75–41.25)	46 (39.5–49.75)	.52
Nighttime or weekend deployment, min, n (%)	7 (64)	14 (88)	.25
Surgical cannulation time, min, median (IQR)	17 (15–21)	22 (14.5–27.5)	.65
ECLS 24-h survival, n (%)	5 (45)	9 (56)	.56
Survival to discharge, n (%)	3 (27)	6 (38)	.38

ECPR indicates extracorporeal cardiopulmonary resuscitation; IQR, interquartile range; CICU, cardiac intensive care unit; PICU, pediatric intensive care unit; NICU, neonatal intensive care unit; and ECLS, extracorporeal life support.

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PICU	2 (18)	3 (19)	
NICU	0 (0)	1 (6)	
ECPR activation time, min, median (IQR)	7 (4–9)	2 (1–4)	<.01
ECPR response time, min, median (IQR)	18.5 (15–23)	25 (18.5–27.75)	.36
ECPR deployment time, min, median (IQR)	37 (30.75–41.25)	46 (39.5–49.75)	.52
Nighttime or weekend deployment, min, n (%)	7 (64)	14 (88)	.25
Surgical cannulation time, min, median (IQR)	17 (15–21)	22 (14.5–27.5)	.65
ECLS 24-h survival, n (%)	5 (45)	9 (56)	.56
Survival to discharge, n (%)	3 (27)	6 (38)	.38

ECPR indicates extracorporeal cardiopulmonary resuscitation; IQR, interquartile range; CICU, cardiac intensive care unit; PICU, pediatric intensive care unit; NICU, neonatal intensive care unit; and ECLS, extracorporeal life support.

Prior Extracorporeal Membrane Oxygenation (ECMO) Experience and Performance in High-Fidelity Simulation Scenarios

Prichard E, Staudt A M, Garcia-Choudary T, et al. (September 18, 2022) Prior Extracorporeal Membrane Oxygenation (ECMO) Experience and Performance in High-Fidelity Simulation Scenarios. Cureus 14(9): e29301. DOI 10.7759/cureus.29301

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- 51 providers participated in a study comparing animal model vs. sim-based ECMO education
- Task completion times and performance were measured using a validated ECMO skills assessment tool
- After the training there was no significant difference in the performance between those with substantial prior ECMO experience vs. those considered "novice"
- Potentially highlights the efficacy of "just-in-time" training to rapidly achieve proficiency even for those without prior experience

Conclusion

- ECPR is a high-risk, low-frequency event, which makes it difficult to achieve and maintain competency
- Simulation has been shown to improve confidence and some aspects of teamwork but there is not robust data on how it impacts patient clinical outcomes
- Simulation is most helpful when it incorporates the validated principles of adult learning
- It can be useful both for maintenance of skillset and to help operationalize a new aspect of the workflow (new personnel, new equipment, new situation)
- Even if you can't do high-fidelity simulation, it offers an opportunity for more active learning that may better engage the participants

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And it's fun!

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