Advances In Pediatric Intensive Care: What Differences Have We Made In The Last Few Decades?

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I would especially commend the physician who, in acute diseases, by which the bulk of mankind are cutoff, conducts the treatment better than others.

Hippocrates
CHANGE IS THE ONLY CONSTANT THING IN LIFE
What is it due to ??

- Advancement in diagnostics & therapeutics secondary to improvement in
  - Understanding of critical illnesses
    - Molecular-level cytokines, biomarkers, etc
    - Influence of genes
  - Biomedical engineering
    - Imaging technologies
    - Information technology
    - Artificial intelligence
  - Multi-disciplinary approach
  - Evidence-based pediatric intensive care
Advances in technology
Advancements in Therapeutic Technologies

- Organ support systems
  - ECMO – V-V, V-A
  - Left ventricular assist devices (LAD)
  - Hemodialysis, CVVH, SLED, etc.
  - MARS, SPAD

- Extra-corporeal therapies – common place and continuously evolving

- Have changed the face of pediatric critical care
ECMO

Is it the panacea we are looking for?

- Indications for ECLS/SCMO – expanding
- Number of ECMO uses in children crossed 16,000 (in 2015)
- Survival rates of 66% for children with refractory hypoxemia and cardiogenic shock with use of ECMO

## Overall Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Total Patients</th>
<th>Survived ECLS</th>
<th>Survived to DC or Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neonatal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>27,728</td>
<td>23,358</td>
<td>20,592</td>
</tr>
<tr>
<td>Cardiac</td>
<td>5,810</td>
<td>3,600</td>
<td>2,389</td>
</tr>
<tr>
<td>ECPR</td>
<td>1,112</td>
<td>712</td>
<td>449</td>
</tr>
<tr>
<td><strong>Pediatric</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>6,569</td>
<td>4,327</td>
<td>3,760</td>
</tr>
<tr>
<td>Cardiac</td>
<td>7,314</td>
<td>4,825</td>
<td>3,679</td>
</tr>
<tr>
<td>ECPR</td>
<td>2,370</td>
<td>1,313</td>
<td>976</td>
</tr>
<tr>
<td><strong>Adult</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>7,008</td>
<td>4,587</td>
<td>4,026</td>
</tr>
<tr>
<td>Cardiac</td>
<td>5,603</td>
<td>3,129</td>
<td>2,294</td>
</tr>
<tr>
<td>ECPR</td>
<td>1,657</td>
<td>639</td>
<td>471</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>65,171</td>
<td>46,490</td>
<td>38,636</td>
</tr>
</tbody>
</table>

Survival rates: Respiratory 84%, Cardiac 62%, ECPR 64% for Neonatal; Respiratory 66%, Cardiac 66%, ECPR 55% for Pediatric; Respiratory 65%, Cardiac 56%, ECPR 39% for Adult; Total Survival: 71%.
Respiratory conditions where ECMO was used

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Total Runs</th>
<th>Average Run Time</th>
<th>Longest Run Time</th>
<th>Survived</th>
<th>% Survived</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viral pneumonia</td>
<td>1,371</td>
<td>320</td>
<td>2,968</td>
<td>884</td>
<td>64%</td>
</tr>
<tr>
<td>Bacterial pneumonia</td>
<td>651</td>
<td>282</td>
<td>1,411</td>
<td>379</td>
<td>58%</td>
</tr>
<tr>
<td>Pneumocystis pneumonia</td>
<td>33</td>
<td>359</td>
<td>1,144</td>
<td>17</td>
<td>52%</td>
</tr>
<tr>
<td>Aspiration pneumonia</td>
<td>293</td>
<td>247</td>
<td>2,437</td>
<td>201</td>
<td>69%</td>
</tr>
<tr>
<td>ARDS, postoperative/trauma</td>
<td>183</td>
<td>248</td>
<td>935</td>
<td>114</td>
<td>62%</td>
</tr>
<tr>
<td>ARDS, not postoperative/trauma</td>
<td>530</td>
<td>305</td>
<td>3,086</td>
<td>285</td>
<td>54%</td>
</tr>
<tr>
<td>Acute respiratory failure, not ARDS</td>
<td>1,101</td>
<td>255</td>
<td>2,429</td>
<td>594</td>
<td>54%</td>
</tr>
<tr>
<td>Other</td>
<td>2,108</td>
<td>217</td>
<td>2,465</td>
<td>1,073</td>
<td>51%</td>
</tr>
</tbody>
</table>

Data adapted from the International Registry of Extracorporeal Life Support Organization, July 2013
ECMO-CPR

- Survival-to-hospital discharge of 38% in whom death was otherwise certain, using E-CPR
- E-CPR may be beneficial for infants and children with cardiac arrest if they have heart disease amenable to recovery or transplantation and the arrest occurs in a highly supervised environment such as an ICU with existing clinical protocols and available expertise and equipment to rapidly initiate ECPR.


*International consensus on CPR. Resuscitation 2010*
Ventricular assist devices in children

- In children with refractory cardiac failure awaiting cardiac transplantation, use of mechanical support in the form of ventricular assist device achieved significantly longer median survival times in comparison to ECMO

Newer advancements in hemodynamic monitoring

- Has become more and more non-invasive
  - LiDCO – Lithium dilution
  - Esophageal Doppler
  - Systolic pressure contour analysis – PiCCO
  - Model-flow pulse contour analysis – Finometer/Portapres
  - Pulse power analysis – LiDCO
  - Arterial pressure waveform analysis without external calibration – FloTrac/ Vigileo
  - Thoracic electrical bio-impedance/ EIT
  - Near-Infrared Spectroscopy (NIRS)
Ultrasonic cardiac output
Estimated Continuous Cardiac Output Monitoring (EsCCO)

- Patented technology
- Nihon Kohden™
- Combination of ECG, NIBP and SpO2 used to predict real time cardiac output in septic shock
- Good correlation with thermodilution techniques*

Newer advancements in neurological monitoring in PICU

- Parenchymal Brain Oxygen Monitoring
- Intracranial pressure monitoring
- Amplitude-integrated EEG monitoring
- Jugular venous saturation
- Cerebral micro dialysis
- Thermal diffusion probes
- Trans cranial Doppler
- Near-Infrared spectroscopy
Parenchymal Brain Oxygen Monitoring in TBI

- Brain tissue oxygen (PbtO\textsubscript{2}) – partial pressure of oxygen in the brain interstitial space
- PbtO\textsubscript{2} = CBF x AVTO\textsubscript{2} = CBF x (PaO\textsubscript{2} – Pv O\textsubscript{2})
- INR > 1.6 or platelet counts < 100,000/cc – Contraindication
- Normal 25-35 mm Hg

BRAIN OXYGEN INDICES:
- PbtO\textsubscript{2} reactivity
- Oxygen reactivity index

Table 1: Licox PbtO\textsubscript{2} values

<table>
<thead>
<tr>
<th>Condition</th>
<th>PbtO\textsubscript{2} Values (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased</td>
<td>&gt;50\textsuperscript{a}</td>
</tr>
<tr>
<td>Normal</td>
<td>25–35</td>
</tr>
<tr>
<td>Compromised; begin treating</td>
<td>20\textsuperscript{b}</td>
</tr>
<tr>
<td>Brain hypoxia</td>
<td>15</td>
</tr>
<tr>
<td>Severe brain hypoxia</td>
<td>10</td>
</tr>
<tr>
<td>Cell death</td>
<td>&lt;5</td>
</tr>
</tbody>
</table>

NeuroSurg Clin N Am 2013
ICP monitoring

- Evolving into a standard of care for children with raised ICP
- Bedside burr hole for ICP monitoring by pediatric intensivist – safe & feasible
- Complications rate – 0.28 per 1000 hours of ICP monitoring
Newer advancements in Respiratory monitoring in PICU

- Continuous intra-arterial blood gas monitoring
- Pediatric continuous oximetry catheter
- Expanding role of capnography – the SIXTH vital sign
  - Cardiac arrest
  - Procedural sedo-analgesia
- Trans-pulmonary & esophageal pressure monitoring
- Lung Ultrasound in critically ill

Hadi-Mohseni-Bod et al. PCCM 2011
Am J Em Med 2014
Talmor D, et al. NEJM 2008
Lung ultrasound in the critically ill

Attractive bedside tool

- Non invasive, no radiation
- However, a scientific assessment of the learning curve remains to be done
- Standardization of views and lung signs in pediatric population - NEEDED
Electrical Impedance tomography

- Principle – based on measuring intra-thoracic impedance distribution

- Monitoring regional lung ventilation in neonates following surfactant
- Assess homogeneity of ventilation following PEEP administration
- Perfusion images – V/Q mismatch

Non-invasive
Radiation-free
Real-time continuous
EAdi monitoring shows an early increase during SBT in patients who failed the trial.

Potential guide to respiratory weaning in difficult-to-wean patients and help to prevent respiratory exhaustion during weaning trials.

Further comparison with other weaning parameters need to be studied.
Newer advancements in molecular monitoring & prognostication

- PERSEVERE pediatric sepsis biomarker risk model may be useful in reliably predicting mortality in pediatric severe sepsis and septic shock
  - Wong HR et al. Crit Care 2012

- Multiple biomarkers like IL-6, IL-8, s-ICAM 1, Ang 2, etc. are being studied in ARDS. They have a role in improving our understanding of the pathophysiology as well as prognostication.
Molecular monitoring in pediatric cardiac arrest & AKI

- The timing, intensity and duration of serum neuron-specific enolase and S-100B biomarker concentration patterns are associated with neurologic and survival outcomes following pediatric cardiac arrest.


- Multiple urinary biomarkers such as N-GAL, KIM-1, L-FABP, IL-18, etc. – for early diagnosis and monitoring of pediatric AKI

  *Devarajan P et al. Biomark Med 2010*
Growth factors in AKI

- An independent risk factor for pediatric intensive care unit mortality, longer length of stay and prolonged mechanical ventilation in critically ill children (Akandari et al. CC 2011)

- Newer growth factors (EGF, IGF-1, MSH, etc.) have been shown to accelerate renal recovery in animal models of AKI (Symons JM. Pediatr Nephrol 2013)
LESS is the ‘new’ more

Simplify yourself as much as possible.
Zen saying

Namasté
Low-tidal volume Ventilation

- Low-tidal volume, lung-protective ventilation strategies have become the norm *(Brower RG et al. N Engl J Med 2000)*

- Pediatric age group still awaits Level 1 evidence on this recommendation, though there is enough consensus among experts on its utility.

- Conducting such a trial in children today, also raises ethical concerns.
Perils of intensive insulin regimens

- Appreciating the poor outcomes associated with and hence avoiding hyperglycemia → standard of care
- Four pediatric RCTs (3288 subjects), when pooled together did not decrease mortality and significantly increased hypoglycemia
- At the same time, lack of clear benefit and problems associated with tight glucose control using intensive insulin regimens have become clearer

Avoiding too much of fluids

- Positive fluid balance: associated with higher mortality and prolonged mechanical ventilation in children with acute lung injury \cite{FloriHR}

- Proven risk factor for AKI in critically ill children.

- Extravascular lung water (EVLW) correlates with sepsis-induced ALI \cite{KuzkovVV}

- Studied recently in ARDS $\rightarrow$ EVLW may be an independent predictor of survival \cite{BerkowitzDM}

- Increasing fluid balance on day 3 in children with ALI is independently associated with fewer ventilator-free days \cite{ValentineSL}
Conservative PRBC transfusion

- Conservative or restrictive blood transfusion strategy with a hemoglobin threshold of 7 g% as there are no improved outcomes with the liberal transfusion strategies and potential harms exist

No benefit with aggressive targeting of serum albumin levels

- NO pediatric studies
- Adult studies – ALBIOS trial
  - Targeting 3 g% albumin levels
  - Increased costs
  - No benefits in terms of LOS or survival
Treatment of Raised ICP -
Simply keep Blood pressure high

- Simply by keeping Blood pressure at 90-95 centile level using fluids and inotropes
- Mortality in comatose patients with CNS infections could be brought down by 50%

Critical Care Med 2014
Randomized Controlled Trial Comparing Cerebral Perfusion Pressure–Targeted Therapy Versus Intracranial Pressure–Targeted Therapy for Raised Intracranial Pressure due to Acute CNS Infections in Children*

Ramesh Kumar, MD, DM; Sunit Singhi, MD; Pratibha Singhi, MD; Muralidharan Jayashree, MD; Arun Bansal, MD; Anuj Bhatti, MD, DM

**Conclusion:** Cerebral perfusion pressure–targeted therapy, which relied on more frequent use of vasopressors and lesser use of hyperventilation and osmotherapy, was superior to intracranial pressure–targeted therapy for management of raised intracranial pressure in children with acute CNS infection in reducing mortality and morbidity. (*Crit Care Med* 2014; 42:1775–1787)
Advances in therapeutics
Shift towards isotonic fluids as maintenance fluids in critically ill

- Multiple RCTs: lower hyponatremia and better outcomes with isotonic fluids (Choong K et al, ADC 2006)

- In children with severe community-acquired pneumonia, (Singhi S et al)
  - Fluid retention in response to hypoxemia directed towards improving circulating volume
  - Restricting fluids logical only after correction of hypoxemia.

- In the first 48 hours in children with acute CNS infections especially, in settings with high mortality rates, where children present late
  - Maintain intravenous fluids rather than restricting them (Maconochie IK, et al. Cochrane reviews 2011)
Dengue vs. Septic shock – Fluids

- The difference between fluid management strategies for septic shock and dengue shock syndrome has been appreciated better in the last decade.
- The natural history of dengue and our understanding of associated capillary leak has also improved.

Advanced therapies in Sepsis

- Endotheliopathy implicated in the progression from disseminated intravascular coagulation to multiple organ dysfunction syndrome (Vallet B et al)

- No therapy targeting endothelial dysfunction: shown any benefit till date
  - No role for activated protein C (APC) in children with severe sepsis
  - No proven role IVIG or plasma exchange therapy

- In-line filtration may reduce severe complications and LOS in PICU (Jack T, et al. Intensive Care Med 2012)
Immunonutrition

- Immunonutrition to modulate these cytokine biomarkers in pediatric sepsis (CRISIS prevention trial) with zinc, selenium and glutamine conferred no advantage in the immune-competent population of pediatric intensive care unit patients.

Other therapies in ARDS

- Prone ventilation with ARDS: safe and feasible in children, though has not been proven to be of any definitive benefit (Curley MAQ et al. JAMA 2005, Fineman et al. Pediatr Crit Care Med 2006)

- Inhaled Nitric Oxide, surfactant, etc.: Neither survival benefit nor decreased length of mechanical ventilation in children (Wilson et al. PCCM 2013, Medjo et al. Indian Pediatrics 2012, Afshari A et al. Cochrane review 2012)
Spontaneous breathing trial for weaning from mechanical ventilation

- Spontaneous breathing trial (SBT) conducted on pressure support of 10 cm water as effective as a SBT using a T-piece in children (Farias JA et al. ICM 2001)

- Daily evaluation to check readiness for weaning with SBT decreases the risk of remaining on mechanical ventilation by 30% (Foronda FK, et al CCM 2011)

- Protocol-directed weaning of children from mechanical ventilation leads to shorter weaning time than physician-directed weaning (Schultz TB et al. Respir Care 2001)
Traumatic Brain Injury in Children

- Evaluation of Traumatic brain injury in children in the emergency room has improved (*PECARN* study)
- Hypothermia initiated within 8 hours and continued for 24 hours does not improve neurological outcomes and may increase mortality in children with traumatic brain injury (*Hutchison JS, et al. NEJM 2008*)
- It is not clear if a more prolonged duration (48 hours) or adjustment of degree and depth according to intracranial pressure helps (*MacIntyre LA, et al. JAMA 2003*)
Hypertonic saline is better than Mannitol and that, cerebral-perfusion pressure-targeted therapy is better than intracranial-pressure-targeted therapy among children with central nervous system infections with raised intracranial pressure

International consensus (2010) states that therapeutic hypothermia (32-34°C) may be beneficial for adolescents who remain comatose following resuscitation from sudden witnessed out-of-hospital VF cardiac arrest.

Does not matter if you do something or not...
What matters is when you do it.

Timing is of the essence
Timing of ‘First-dose’ antibiotics

- Early first-dose antibiotics can go a long way in saving lives
- Delayed antibiotic administration translates to lives lost

Early Goal-directed therapy

- Importance of early and adequate fluid resuscitation within the first hour has been established.
- Studies have clearly demonstrated that Early goal-directed therapy (EGDT) of pediatric septic shock can save lives.
- There is no evidence to support the routine use of albumin for fluid resuscitation.

Early enteral nutrition

- Initiation of enteral nutrition early – the KEY consensus – Do not keep NPO unnecessarily
- Hyper-metabolic response apparent in adults, is not very evident in critically ill children.
- Currently available predictive equations cannot substitute for indirect calorimetry
- High incidence of overfeeding in critically ill children assessed using indirect calorimetry

Advances in ‘PIC’ delivery
The ‘new’ PICU Culture

- Safety Checklists
- Care bundles
- Critical Incident reporting
- Computer-based physician orders
- Quality improvement initiatives
- Audits of every aspect of PICU care
- Parental participation in PICU administration
  - Ethics
  - End of life care
Repackaging as ‘SSC’ guidelines

- Newer sepsis guidelines (structured resuscitation) improved the outcomes of severe sepsis globally.
- Data from the US: mortality reduction of 1.5% (Texas) and, 57% shorter hospital stay in Boston (Cruz et al. 2011, Paul R et al 2012).
- In Rotterdam, deaths decreased from 20% to 1% after implementation of guideline-based therapy for severe sepsis and purpura (Verbruggen et al 2006).
- Developing world (Brazil) has shown mortality reduction of 27% with ScvO$_2$-guided fluids, inotropes and blood (de Oliviera CF et al, 2008).
- In Thailand, a mortality reduction of 23% with implementation of SSC guidelines over a 3-year period (Samransamruajkit R et al 2014).
Interventions to reduce healthcare-associated infections when combined as bundles can make significant impact (Pronovost P et al. NEJM 2006)

Similarly, protocol-based interventions and evidence-based guidelines make a difference to clinically relevant outcomes in many aspects of pediatric critical care such as traumatic brain injury, sedo-analgesia, prevention of HCAIs, resuscitation of septic shock, etc. (Kochanek P et al. PCCM 2012)
Improving quality of care using evidence-based medicine
Shift to EBM from empirical medicine

- Growing clinical research
- Reliance on data and interpretations
  - Global data
  - Local unit’s data
- Evidence-based guidelines on every aspect
  - Assessing utility of diagnostic tools, therapeutic options as well as monitoring tools
- Putting together complex patient data to identify meaningful trends. The new arena of research

Randolph AG. 2007
Shifting focus from mortality to morbidity

- Studies focused on predicting intact survival and survival with disabilities in children

- Focus on safety culture & quality of care in pediatric intensive care
  - Newer improved assessment scales (COMFORT-B) and bispectral index for sedation & comfort levels
  - Characterizing sedation-related adverse events using RESTORE definitions

Ista E, et al. PCCM 2005
Twite MD, et al. PCCM 2007
Gupta K, et al. PCCM 2009
Grant MJC et al. Heart & Lung 2013
Immunocompromised child in the PICU

- PICU increasingly handles
  - Children with malignancies
  - Stem-cell Transplant recipients
  - Organ transplant recipients
  - Children with primary/secondary immune deficiencies
- A new sub-specialty of ‘PICU for children with compromised immune status’ may evolve
- Needs of this sub-group are specific
- Need to generate data for improving outcomes
Computerized physician order entry
Does it improve clinical outcomes??

- 12 observational studies – 4 pediatric
- Meta-analysis:
  - Significant decreased risk of medication prescription errors
  - No significant reduction in ADR or mortality rates
- Implementation process of computerized physician order entry software as a critical factor for outcome

Van Rosse F et al. Pediatrics 2009
Simulation Technology in PIC

High fidelity patient simulation as an educational tool in pediatric intensive care: A systematic review.


- High-fidelity patient simulation (HFPS) in pediatric intensive care nursing education
- 8 papers in the period 2000-2015
  - Improved short-term outcomes
  - Improved learner outcomes following HFPS training
  - No evidence of negative effects
- HFPS – useful tool in education of PICU nurses
The impact of a lean rounding process in a pediatric intensive care unit

Atlanta, Georgia

- Initial descriptive study – PCCM 2011
  - Poor workflow associated with physician rounding
  - Large variations in rounding process present
- ‘Standardized lean rounding process’
  - Decreased time for rounds (157 to 121 minutes)
  - Discharges were 58 minutes sooner
  - Increased staff & patient satisfaction
  - Clearer understanding of processes by staff
Meeting the Challenges:
Reaching out to underserved
LOW-COST High-yield interventions
Mitigating the climbing costs of PIC

- In 1999,
  - Total cost for PICU care was $16,983,323
  - Average cost per admission: $12,342 +/- $22,313
  - Average cost per patient day was $2,264 +/- $868

- In 2015,
  - Presence of HCAIs alone increases the cost of PICU care by $30,791.4
  - Exponential increase in costs/ expenditure

- Need to make PICU care more cost-effective

Morillo-Garcia A et al. Gac Sanit 2015
Bridging the resource-gap

- >90% of world’s children reside in the under-developed and developing economies
- PIC in these regions – ‘WAY-BEHIND’
- Low-cost, innovative technologies to improve penetration into these pockets of need
- Improving outcomes for every child on the planet – ‘The ultimate GOAL’

Basnet S et al. Pediatrics 2011
Jeena PM et al. J Med Ethics 2005
Causes of Mortality under 5

Infection, poor nutrition and sanitation, and lack of primary health care and immunizations are the primary causes of death in resource-poor countries.
Oral Rehydration Solution

- The British medical journal The Lancet has described ORS as "potentially the most important medical advance of this century."
Hand hygiene

- The WHO Multimodal hand hygiene improvement strategy:
  - system change: alcohol-based handrub at the point of care; access to a safe, continuous water supply, soap and towels;
  - training and education;
  - evaluation and feedback;
  - reminders in the workplace; and
  - institutional safety climate.
Neonatal cooling

- Reduction in cerebral metabolism that reduces accumulation of excitotoxins, and suppresses oxygen free radical

- Suppresses apoptotic (i.e. programmed cell death) processes in the developing brain

- Suppresses the release of pro-inflammatory cytokines and interleukins, reducing direct neurotoxicity

Low-cost and Low-energy Therapeutic Hypothermia Device

A non-invasive hypothermia indicator for Newborns, Infants and Children

“We conclude that the ThermoSpot ™ device is a simple accurate device allowing continuous thermal monitoring of low birth weight infants, especially in resource poor setting. Mothers quickly understood how the device worked and responded appropriately when warned of hypothermia”.

Bubble CPAP
Brown J et al. PLOS One 2013

- Cost of stand-alone bubble CPAP – 6000 $
- Indigenous CPAP - $350 , Replacement cost of <1$ /year
High-flow nasal prong oxygen

*Brink Fia ten et al. PCCM 2013*

- Safe form of support for children with moderate to severe respiratory distress
- Works across a large range of diagnoses
- Especially useful where work of breathing or hypoxemia is not sufficiently relieved by standard oxygen therapy
- Lower need for escalation of respiratory support in comparison to NP CPAP
High Flow Nasal Cannula
Inter-hospital transport

*Schlapbach L J et al. Intensive Care Med 2014*

- Optimal respiratory support for inter-hospital transport of critically ill children??
  - Transport ventilators may not be available
- Significant reduction in need for invasive ventilation or intubation after introduction of HFNC (OR =0.51; 95% CI- 0.27-0.95)
- Not inferior to low-flow oxygen or NIV
N-CPAP

- nCPAP – replaces invasive mechanical ventilation in many settings
- Bronchiolitis *(Essouri S et al. ICM 2014)*
  - Significant decrease in length of ventilation, LOS PICU and hospital LOS
  - Significantly lesser complications
  - Lower cost – 17,451 EUROS to 11,205 EUROS
  - Total cost reduction of 715,000 EUROS
Mobile technology
how has it changed PIC?
Mobile phone interventions in community settings

- Zanzibar – Pragmatic, cluster-randomized controlled trial
- 2550 pregnant women – antenatal care; 2482 babies
- Followed until 42 days of delivery
- Intervention: MOBILE TEXT MESSAGE & voucher
- 24 primary health care facilities randomized
- Perinatal mortality rates – Significant lower in intervention group (17/1000 vs 26/1000) OR 0.50 (0.27-0.90)
Improving pharmacist workflow

Using mobility technology to improve pharmacist workflow in the PICU rounding process.


- Comparative workflow study
- Impact of a mobility computing solution using Motion C5 mobile clinical assistant
- Increasing pharmacist time with PICU rounding team to 98.9%
- Increased pharmacist satisfaction with rounding workflow
Impact of ‘smart’ technologies in PIC
Smart Pump technology


Implementing smart pump technology in a pediatric intensive care unit: a cost-effective approach

- Smart pumps with drug library loaded
- Adverse effects and preventable adverse effects monitored
- Profitable in PICU – ability to intercept potentially serious medication errors and reduce costs associated with such errors

Ohashi K et al. Drug Saf. 2014
Standard drug concentrations and smart-pump technology reduce continuous-medication-infusion errors in pediatric patients.


- Smart ‘syringe’ pumps & Human engineered medication label
- Number of errors dropped by 73%
  - Absolute risk reduction of 3.1 to 0.8 per 1000 doses
  - Preparation errors decreased: 0.66-0.16 per 1000
  - Significantly reduced errors associated with continuous medication infusions
Simulated pediatric emergency

Use of drugs calculator on a smartphone compared with use of British national formulary for children (BNFC)

More accurate – 28.6% accuracy in BNFC vs 100% in smart phone group

Quicker – 376 % faster results than BNFC

Improved confidence in the smart phone group
What should we do and where are we..? In resource limited settings

- Every society has the obligation to ensure that children are not dying from lack of a minimum level of care regardless of their socioeconomic status. Though every child does not receive the best of everything that a country has to offer.

- What is appropriate intensive care in the Global context?

- Should we remain satisfied with what has been done, what challenges do we face??

- Should we allow the gap between the haves and have-nots to protect their right to live widen further?....