Improving Patient Safety by Predicting Early Deterioration in the Pediatric Pulmonary Population

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Background

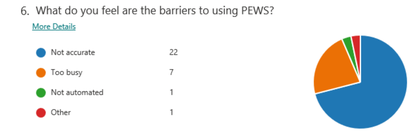
- Acute care services (ACS) utilize a modified Pediatric Early Warning Score (PEWS) including the inpatient pulmonary unit
- Review of medical emergency team (MET) activations and code events showed inaccuracies with PEWS documentation
- Pulmonary nurses were interviewed and surveyed regarding PEWS; feedback themes:
  - Inaccuracy for patient population
  - False highs for patient's baseline
  - Does not alert RN to patient deterioration
- Historical cycle of re-education, learning opportunities, and redundant feedback has yielded similar results

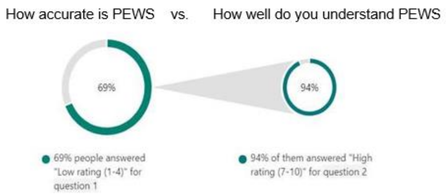
- Focused surveys of pediatric pulmonary staff reflected the themes mentioned above.
- Strong consensus that chronic pulmonary patients need scoring tool that factors the "abnormal normal" or the patient's baseline vitals and respiratory support

- Practice Questions:
  - Does the Children's Hospital Early Warning Score (CHEWS) tool have more accurate scoring and determination of early deterioration in pediatric patients that are dependent on tracheostomy, oxygen, or invasive or non-invasive ventilation than the current modified Pediatric Early Warning Score (PEWS) tool?
  - Do nursing staff perceive the CHEWS tool is accurate for this population?

- This pilot was completed as part of the TCU Evidence Based Practice Fellowship program

Pulmonary Nurses PEWS survey





Literature Review

- Literature search showed no pre-existing pulmonary specific early warning tool
- Search expanded to pediatric early warning tools that had been validated with consideration to abnormal baseline vitals or oxygen use
- A total of 17 articles were reviewed and 5 articles selected pertaining to CHEWS
- The CHEWS (Children's Hospital Early Warning Score) was chosen due to:
  - Sensitivity of 84% and specificity of 81%
  - Score calculates from baseline vital signs or oxygen usage
  - Tool was originally developed and validated for pediatric cardiac patients a chronic population with abnormal baselines similar to pulmonary
  - Validation expanded to all pediatrics and externally validated
- Qualitative article reviewed barriers/enablers to CHEWS implementation

Current PEWS vs. CHEWS

PEWS Scoring Table

	0	1	2	3
Behavior	• Playing • Appropriate • Normal sleep	• Irritable, but consolable	• Irritable not consolable • Abnormally sleepy	• Lethargic • Confused • Reduced response to pain
Cardiovascular	• Pink • Capillary refill 1-2 seconds	• Pale • Capillary refill 3 seconds	• Grey • Capillary refill 4 seconds • Tachycardia 20 above normal for age	• Grey • Mottled • Capillary refill 5 seconds or greater • Tachycardia 30 above normal for age • Bradycardia • Confirmed hypotension based on Systolic BP
Respiratory	• Within normal parameters for age • No retractions	Respiratory Triggers A • > 10 above normal for age • >30% FiO2 • >3 L/min of oxygen • Increased retractions	Respiratory Triggers B • > 20 above normal for age • >40 % FiO2 • >6 L/min oxygen • Any combination of 2 or more from Respiratory Triggers A	• 5 below normal for age • Retractions • Grunting • >/=50% FiO2 • >/=8 L/min oxygen • Any combination of 2 or more from Respiratory Triggers B
Additional Points: (Add additional point for each category of the following, if applicable) MAX 2 points		• Difficult airway designation OR Tracheostomy OR Positive pressure ventilation (CPAP, BiPAP) OR Home ventilator dependence • Seizure disorder		

Children's Hospital Early Warning Score

	0	1	2	3
Behavior/Neuro	* Playing/sleeping appropriately * Alert, at patient's baseline	* Sleepy, sominolent when not disturbed	* Irritable, difficult to console * Increase in patient's baseline seizure activity	* Lethargic, confused, floppy * Reduced response to pain * Prolonged or frequent seizures * Pupils asymmetric or sluggish
Cardiovascular	* Skin tone appropriate for patient * Capillary refill ≤ 2 seconds	* Pale * Capillary refill 3-4 seconds * Mild* tachycardia * Intermittent ectopy or irregular HR(not new)	* Grey * Capillary refill 4-6 seconds * Moderate* tachycardia	* Grey and mottled * Capillary refill >5 seconds * Severe* tachycardia * New onset bradycardia * New onset/increase in ectopy, irregular HR or heart block
Respiratory	* Within normal parameters * no retractions	* Mild* tachypnea/ increased WOB (flaring, retracting) * Up to 40% supplemental oxygen * Up to 1L NC > patient's baseline need * Mild desaturations < patient's baseline * Intermittent apnea self-resolving	* Moderate* tachypnea/increased WOB (flaring, retracting, grunting, use of accessory muscles) * 40-60 % oxygen via mask * 1-2 L NC > patient's baseline need * Nebs q 1-2 hr * Moderate desaturations < patient's baseline * Apnea requiring repositioning or stimulation	* Severe* tachypnea * RR < normal for age * Severe increased WOB (i.e. head bobbing, paradoxical breathing) * >60 % oxygen via mask * > 2 L NC > patient's baseline need * Nebs q 30 minutes – 1 hr * Severe desaturations < patient's baseline * Apnea requiring interventions other than repositioning or stimulation
Staff Concern		Concerned		
Family Concern		Concerned or absent		

	Mild*	Moderate*	Severe*
Infant	≥10% ↑ for age	≥ 15% ↑ for age	≥ 25% ↑ for age
Toddler and Older	≥ 10% ↑ for age	≥ 25% ↑ for age	≥ 50% ↑ for age

Methodology

- Iowa Model for EBP utilized for project methodology
- Inclusion criteria for patients:
  - Baseline ventilatory requirement (invasive or non-invasive)
  - OR Tracheostomy dependence
  - OR Baseline oxygen dependence

- Retrospective patient data reviewed for METs, Codes, ICU transfers (2020- July 2021)
- A total of 99 patient deterioration events reviewed and 38 met inclusion criteria, these served as the case group
- Nurses recorded CHEWS scores for 47 patients; these served as the control group
  - Scores for both tools near time of deterioration and scores 4-6 hours prior to deterioration were reviewed
  - Scores were corrected if scored inaccurately to ensure inter-rater reliability

• Each of the tools was evaluated using sensitivity, specificity and Area under the receiver operating characteristic (AUROC) curve
• The sensitivity and specificity were calculated to measure the validity of the tools and the most predictive score for a deterioration event requiring ICU transfer
• The comparison of the AUROC for each tool determined the ability to discriminate between cases (children who suffered an impending or actual deterioration event) and controls (children who did not have an impending or actual deterioration event).

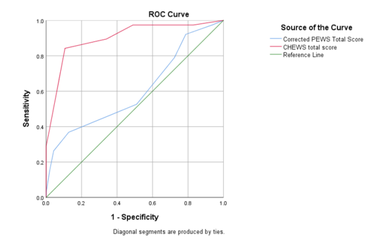
Outcomes

- CHEWS demonstrated 84% sensitivity and 89% specificity (score ≥ 4) for the pediatric pulmonary population while PEWS had 79% sensitivity and 28% specificity (score ≥ 4)
- CHEWS further detected patient's declining clinical status up to 4-6 hours prior to acute event leading to transfer to the ICU

What does this mean?

- The CHEWS score increasing is a more accurate indicator of patient deterioration. Early escalation to ICU means acute respiratory compromise and cardiopulmonary arrest on the floor can be prevented!

Score	PEWS		CHEWS	
	Sensitivity	Specificity	Sensitivity	Specificity
≥2	97.4%	6.4%	97.4%	51.1%
≥3	92.1%	21.3%	89.5%	66.0%
≥4	78.9%	27.7%	84.2%	89.4%
≥5	52.6%	48.9%	39.5%	97.9%



AUROC shows how accurate the tool is at predicting deterioration

ROC score	Evaluation
0.9 < AUC ≤ 1.0	Excellent
0.8 < AUC ≤ 0.9	Good
0.7 < AUC ≤ 0.8	Fair
0.6 < AUC ≤ 0.7	Poor
AUC ≤ 0.6	Fail

At time of deterioration

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval Lower Bound	Asymptotic 95% Confidence Interval Upper Bound
Corrected PEWS Total Score	.603	.063	.103	.480	.727
CHEWS total score	.902	.035	.000	.833	.971

The test result variable(s): Corrected PEWS Total Score, CHEWS total score has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.
a. Under the nonparametric assumption
b. Null hypothesis: true area = 0.5

CHEWS AUROC was .9 (P<.05) demonstrating "excellent" ability to predict deterioration

4-6 hours prior to deterioration

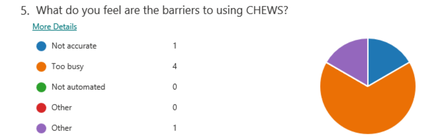
Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval Lower Bound	Asymptotic 95% Confidence Interval Upper Bound
Corrected Previous PEWS Score	.568	.066	.297	.439	.698
Previous CHEWS score (4-6hrs)	.720	.061	.001	.601	.839

The test result variable(s): Corrected Previous PEWS Score, Previous CHEWS score (4-6hrs) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.
a. Under the nonparametric assumption
b. Null hypothesis: true area = 0.5

CHEWS AUROC was .72 (P<.05) demonstrating "fair" ability to predict patient deterioration 4-6 hours prior to decompensation event

Pulmonary Nurses CHEWS survey



How accurate is CHEWS?
83% of nurses answered **high** rating of 8-10

How well do you understand CHEWS?
83% of nurses answered **high** rating of 8-10

Current state and next steps

- Data analysis shared at system-wide task force evaluating current PEWS
- CHEWS pilot **expanding** to include additional staff, floors, and campuses to validate CHEWS in the larger population
- If further validation is consistent with data from this pilot, then the system level task force will move towards **implementation of CHEWS at Children's Health System of Texas**.

Literature references here!

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