Impact of Virtual Reality Simulation on New Nurses' Assessment of Pediatric Respiratory Distress

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Background Children often experience respiratory illnesses requiring bedside nurses skilled in recognizing respiratory decompensation. Historically, recognizing respiratory distress has relied on teaching during direct patient care. Virtual reality simulation may accelerate such recognition among novice nurses.

Objective To determine whether a virtual reality curriculum improved new nurses' recognition of respiratory distress and impending respiratory failure in pediatric patients based on assessment of physical examination findings and appropriate escalation of care.

Methods New nurses (n = 168) were randomly assigned to complete either an immersive virtual reality curriculum on recognition of respiratory distress (intervention) or the usual orientation curriculum (control). Group differences and changes from 3 months to 6 months after the intervention were examined.

Results Nurses in the intervention group were significantly more likely to correctly recognize impending respiratory failure at both 3 months (23.4% vs 3.0%, $P < .001$) and 6 months (31.9% vs 2.6%, $P < .001$), identify respiratory distress without impending respiratory failure at 3 months (57.8% vs 29.6%, $P = .002$) and 6 months (57.9% vs 17.8%, $P < .001$), and recognize patients' altered mental status at 3 months (51.4% vs 18.2%, $P < .001$) and 6 months (46.8% vs 18.4%, $P = .006$).

Conclusions Implementation of a virtual reality–based training curriculum was associated with improved recognition of pediatric respiratory distress, impending respiratory failure, and altered mental status at 3 and 6 months compared with standard training approaches. Virtual reality may offer a new approach to nurse orientation to enhance training in pediatrics-specific assessment skills. (*American Journal of Critical Care.* 2024;33:115-124)

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The most common cause of pediatric hospitalizations during the first year of life is respiratory distress.[1] Conditions can range from a need for simple supportive care through pediatric acute respiratory distress syndrome, with a mortality rate of more than 30% in those with severe hypoxemia.[2] Bronchiolitis—viral inflammation of the lower airways leading to respiratory distress—is a leading cause of hospitalization and pediatric intensive care unit admission in children younger than 2 years.[3] Respiratory syncytial virus, the most common cause of bronchiolitis in infants and young children, results in approximately 24 hospitalizations per 1000 infants and an estimated 66 000 to 199 000 annual deaths worldwide in children younger than 5 years.[4]

Bronchiolitis has variable presentations, from cough and congestion to respiratory distress or even respiratory failure requiring invasive mechanical ventilation. Although electronic monitoring and laboratory testing can increase recognition of respiratory distress, accurate clinical assessment relies on correct interpretation of physical examination findings and synthesis with vital signs and patient history.

Nurses currently have fewer opportunities to develop the appropriate skills to recognize impending respiratory failure.

Developing skills to recognize respiratory distress, specifically in patients with impending respiratory failure, requires repeated clinical exposure, which historically has relied on direct patient care.[5-8] In the past 2 decades, increased reliance on technology in making diagnostic decisions has resulted in a decline in bedside skills.[9] With even less time spent at the bedside during the COVID-19 pandemic, nurse staffing shortages in critical care units present a challenge to maintaining quality of care and safe practice.[9,10] In the setting of declining bedside teaching with staffing shortages, high turnover, and poor retention, nurses have less opportunity to develop the appropriate skills to recognize impending respiratory failure.[5,6,11,12] The problem is exacerbated for new graduate nurses, who, given a lack of clinical exposure, may not be able to recognize, interpret, and respond to novel acute situations.[13] Novice nurses require additional ways to gain clinical exposure to more efficiently develop the clinical judgment required for successful transition to practice. Simulation training has been proposed as a strategy to cement these core assessment and management skills.[14]

Simulation-based medical education allows nurses to train in safe settings without risk to patients. A frequent approach to simulation-based medical education is computerized mannequin simulators and standardized patients. Currently available simulators cannot fully replicate the subtle physical examination findings critical to early identification of pediatric respiratory distress and failure such as changes in mental status and work of breathing.[5] Additionally, standardized patients—human actors—are not a feasible option for pediatric respiratory distress or failure. Immersive virtual reality (VR) technology using a 3-dimensional, computer-generated environment where users interact with graphical character representations called "avatars" has been increasingly used in medical education. Using immersive VR for training on pediatric respiratory distress allows realistic replication of clinical findings (ie, mental status, work of breathing, perfusion) in a lifelike setting.[5]

Previous research suggests that VR technology can provide nurse educators with novel ways to facilitate learning and complement current educational approaches.[15] A literature review summarizing the results of 23 studies on the role and effectiveness of virtual simulations in nursing education showed that virtual simulation had a positive impact on the skills and affective performance of students while also demonstrating evidence of improving the cognitive

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domain.[16] Improving the cognitive domain results in deeper learning and the ability to transfer and apply new information to new situations to enhance and better retain knowledge. Virtual reality simulation programs provided students with opportunities to develop communication skills by assessing learners' confidence with SBAR (Situation, Background, Assessment, Recommendation) clinical handoffs.[17] During the COVID-19 pandemic, virtual simulation in nursing education became more important when face-to-face learning transitioned to remote learning.[16] Thus, the aim of our study was to assess the efficacy of VR to teach clinical assessment skills to newly graduated nurses—specifically the assessment of pediatric respiratory distress and impending respiratory failure, including recognizing when to escalate care.

Methods

Setting and Study Population

A 2-arm, parallel-group, randomized, controlled, prospective study was conducted at Cincinnati Children's Hospital Medical Center (CCHMC), a large academic children's hospital, from April 1, 2018, to March 30, 2020. Newly hired graduated registered nurses (RNs) who entered the CCHMC RN Transition to Practice program were eligible to participate during the first week of their onboarding process. The study was approved by the CCHMC's institutional review board.

Participation in VR training as part of the study was voluntary. During the orientation process, nurses were informed that their decision of whether or not to participate would not affect their evaluation. Two nurses declined to participate (but received standard training as part of the residency curriculum), and 1 nurse withdrew due to nausea and dizziness. Study data were not collected for these nurses. Nurses were informed that completing the survey indicated consent to participate and were randomly assigned to either VR (intervention group) or standard training (control group) every 2 weeks until the required sample size was achieved. The research team was masked to the randomized assignment. Once a participant was enrolled, a team member disclosed their randomization status to the nurse facilitators. Both groups received standard training during institutional RN orientation, which included verbal instruction on respiratory assessment, hands-on practice with respiratory equipment, and a case study discussion (with no videos of patients or clinical findings). Specific learning objectives focused on assessment of mental status, respiratory effort, and the need for ventilation assistance. Intervention learners received an additional 20-minute VR intervention allowing deliberate practice—an educational training model focused on information processing and improving skill acquisition,[18] with practice focused on the clinical assessment of respiratory distress.

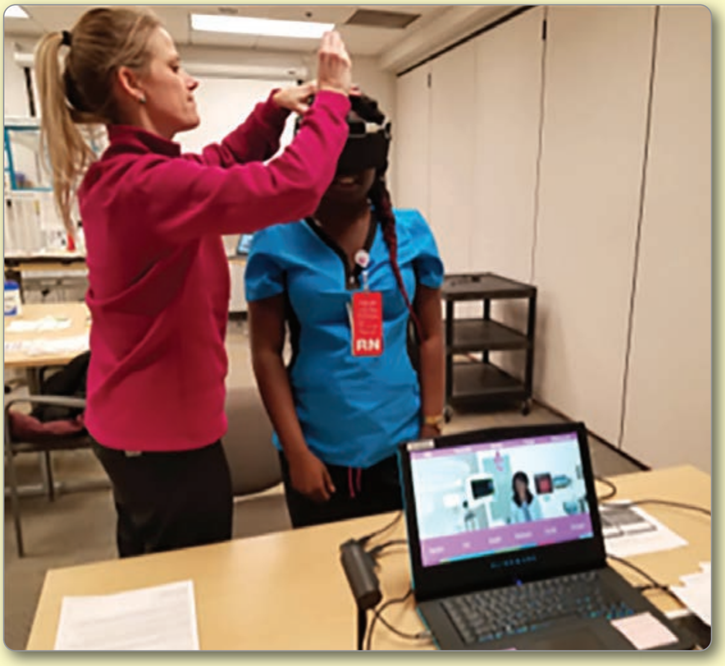

Figure 1 Nurse facilitator prebriefing a learner on the virtual reality experience and fitting the headset.

Curriculum Design

The VR simulation and scenarios used in this study were previously pilot tested and described, and the nurse participants and the facilitators received the same training as previously described.[19] Briefly, the VR environment, experienced through an Oculus Rift headset, replicated an inpatient hospital room at CCHMC containing standard furniture, equipment, and a vital sign monitor. The environment included avatars of a preceptor and a patient, both of which were controlled by a simulation facilitator who underwent formal training on the navigation of 3 simulation scenarios (Figure 1).

> All new nurses (n = 168) completed the usual orientation curriculum on respiratory distress; half were randomized to receive the additional virtual reality training.

The VR curriculum consisted of 3 different scenarios in which participants assessed an infant for respiratory distress. The 3 scenarios portrayed the spectrum of respiratory distress: (1) no distress (used to orient the participant to the VR environment and functionality), (2) respiratory distress, and (3) impending respiratory failure. Before the start of each scenario, the same clinical prompt was used, featuring a previously healthy full-term infant who was now 3 months of age and had been admitted to the inpatient general care unit with bronchiolitis. The participant was instructed to verbally describe their findings to the avatar preceptor while assessing the avatar patient's clinical status. The avatar preceptor, controlled by the facilitator, guided the participant through the simulation with prompting and redirection within the VR environment as needed. Detailed algorithms with appropriate avatar prompts were used to standardize the experience across participants.[19]

Objective Assessment at 3 and 6 Months After Initial Training

The primary outcomes of interest were the impact of the VR curriculum on participant ability to assign an appropriate respiratory status (respiratory distress vs impending respiratory failure), correctly identify key physical examination findings (mental status and work of breathing), and recognize the need for escalation of care for patients with impending respiratory failure. To assess these outcomes, participants (both intervention and control) completed a 15-minute follow-up session at 3 months and 6 months after initial training. This assessment consisted of 3 video vignettes of real pediatric patients (1 in no distress, 1 in respiratory distress, and 1 with impending respiratory failure). Following each vignette (which included video of patient examination findings, vital signs, audio of breath sounds, and clinical history), the participant was asked to complete a free-response questionnaire prompting them to describe their findings, clinical assessment, and next steps (see Appendix). Each 30-second video vignette played on a 5-minute loop to allow adequate time for the nurses to complete the assessment.

> Recognition of impending respiratory failure differed significantly between the VR intervention and control groups at both 3 and 6 months after the initial VR intervention.

Scoring Video Vignette Responses

The 3 video vignettes were designed to emphasize key findings that allow accurate assessment of the patient's clinical status. Participants were assessed using the RIME (Reporter, Interpreter, Manager, Educator) framework, which describes a learner's ability to synthesize knowledge, skills, and attitudes as they progress from novice to competent clinician.[20] The free-response questions prompted participants to report findings that would describe or classify the patient's respiratory status (Reporter stage), assess the patient (Interpreter stage), and manage the patient (Manager stage). Following the study period, using deidentified participant responses, one of the study authors (either K.E., K.I., A.D., or J.S.) scored the responses from the case scenarios using rubrics previously developed through a modified Delphi approach involving 6 clinical experts (emergency medicine and critical care physician faculty), with training on use of the tool consistent with prior work[12] (Figure 2). These rubrics were reviewed by 4 experienced nurse educators before their use in this study to confirm that terminology was consistent with nursing clinical assessments.

Statistical Analysis

Data were summarized as frequency and percentage for categorical variables. To examine group differences and changes from 3 months to 6 months after the intervention, the χ^2 test was used when expected cell frequencies in the contingency table were greater than 5. In instances where expected frequencies fell below 5, the Fisher exact test was applied. Data were analyzed using SAS, version 9.4 (SAS Institute Inc). A 2-sided significance level was set at .05.

Power Analysis

The sample size estimation was based on the primary outcome—the correct recognition of impending respiratory failure. One hundred ninety-seven nurses were required to detect a small to medium effect size (Cramér's V = 0.2) to achieve 80% statistical power at a significance level of .05. To account for a 10% attrition rate, we planned to include 210 nurses in this study.

Results

Demographics

A total of 168 enrolled participants (85 in the control group and 83 in the intervention group) consented to include their demographic data in the research study. Of the 168 participants, 91 (54.2%) were between 20 and 24 years old, 149 (88.7%) identified as female, and 150 (89.3%) identified as White. Most participants (166 [98.8%]) had worked in their unit for less than 6 months before the VR session (Table 1).

VR Intervention Versus Control Groups at 3 and 6 Months After Initial Training

The results for the VR intervention versus control groups at 3 and 6 months after initial training are shown in Tables 2 through 4.

Scenario component	No distress case	Respiratory distress case	Respiratory failure case
Mental status			
Alertness	☐ Eyes open ☐ Awake AND/OR alert	☐ Eyes open ☐ Awake AND/OR alert	☐ Eyes open ☐ Not awake AND/OR not alert
Activity	☐ Moving extremities AND/OR normal activity	☐ Minimal movement AND/OR decreased activity	☐ No movement AND/OR no activity
Work of breathing			
Head bobbing/flaring Retractions	☐ None present ☐ Minimal to none visible	☐ None present ☐ Suprasternal ☐ Subcostal	☐ Head bobbing ☐ Suprasternal ☐ Subcostal
Belly breathing	☐ Mild belly breathing	☐ Belly breathing	☐ Belly breathing
Breath sounds			
Aeration Inspiratory/expiratory ratio	☐ Audible throughout ☐ No prolonged expiration	☐ Audible throughout ☐ Prolonged expiratory phase	☐ Audible throughout ☐ Prolonged expiratory phase
Quality	☐ Clear or slightly coarse	☐ Coarse	☐ Coarse AND/OR wheezing
Vital signs			
Respiratory rate	☐ ~36/min	☐ ~48/min	☐ ~60/min
O_2 saturation	☐ ~98%	☐ ~96%	☐ ~92%
Heart rate	☐ ~110/min	☐ ~140/min	☐ ~160/min
Expected clinical interpretation and assessment			
Clinical interpretation	☐ Normal mental status ☐ No increased work of breathing ☐ Normal breath sounds/aeration ☐ Normal vital signs	☐ Normal mental status ☐ Increased work of breathing ☐ Abnormal breath sounds/ aeration ☐ Abnormal vital signs	☐ Abnormal mental status ☐ Increased work of breathing ☐ Abnormal breath sounds/ aeration ☐ Abnormal vital signs
Assessment	☐ Patient is not in respiratory distress ☐ No escalation of care warranted	☐ Patient is in respiratory distress ☐ No escalation of care warranted	☐ Patient is in respiratory distress with impending respiratory failure ☐ Warrants escalation of care (call PICU, needs intubation, needs positive pressure)

Figure 2 Rubric to assess participant's description of the expected clinical findings, clinical interpretation, and overall clinical assessment for the 3 video cases.

Abbreviation: PICU, pediatric intensive care unit.

Respiratory Status. A statistically significant difference was found for the recognition of impending respiratory failure between the VR intervention and control groups at both 3 months (24.3% vs 3.0%, $P < .001$) and 6 months (31.9% vs 2.6%, $P < .001$) after the intervention (Table 2). A statistically significant difference was also found for the correct identification of respiratory distress without impending respiratory failure between the VR intervention and control groups at both 3 months (57.8% vs 29.6%, $P = .002$) and 6 months (57.9% vs 17.8%, $P < .001$) after the intervention (Table 3).

Mental Status. For the impending respiratory failure case, participants exposed to the VR intervention were significantly more likely than controls to correctly consider the patient's mental status (ie, stating altered or abnormal mental status) at both 3 months (51.4% vs 18.2%, $P < .001$) and 6 months (46.8% vs 18.4%, $P = .006$) (Table 2). For the respiratory distress

Table 1
Demographic characteristics of 168 study participants

Characteristic	No. (%)
Age, y	
20-24	91 (54.2)
25-29	56 (33.3)
30-34	10 (6.0)
35-39	7 (4.2)
>40	4 (2.4)
Sex	
Female	149 (88.7)
Male	19 (11.3)
Race/ethnicity	
Hispanic or Latino	7 (4.2)
Black or African American	11 (6.5)
White	150 (89.3)
Experience (length of time working in their unit)	
<6 months	166 (98.8)
6 months to 1 year	2 (1.2)

Table 2

Intervention vs control participants' ability to assess pediatric respiratory status and correctly recognize impending respiratory failure and the need for escalation of care at 3 and 6 months after initial training

Assessment	No. (%) of participants				*P* values with *P*<.10			
	VR intervention group		Control group		3 vs 6 months		VR vs control	
	3 months (n=74)	6 months (n=47)	3 months (n=66)	6 months (n=38)	VR	Control	3 months	6 months
Mental status								
Considers mental status	38 (51.4)	22 (46.8)	12 (18.2)	7 (18.4)			<.001[a]	.006[a]
Comments on eyes being closed	2 (2.7)	1 (2.1)	0	0				
Comments on patient being not awake and/or alert	5 (6.8)	3 (6.4)	3 (4.5)	2 (5.3)				
Comments on no movement and/or activity status	4 (5.4)	1 (2.1)	0	0				
Interprets mental status as altered	17 (23.0)	8 (17.0)	1 (1.5)	2 (5.3)			<.001[b]	
Interprets mental status as lethargic	10 (13.5)	8 (17.0)	5 (7.6)	2 (5.3)				
Work of breathing								
Considers work of breathing	72 (97.3)	46 (97.9)	56 (84.8)	36 (94.7)			.01[b]	
Comments on head bobbing	19 (25.7)	12 (25.5)	15 (22.7)	11 (28.9)				
Comments on suprasternal	12 (16.2)	3 (6.4)	7 (10.6)	1 (2.6)				
Comments on subcostal	25 (33.8)	15 (31.9)	19 (28.8)	10 (26.3)				
Comments on belly breathing	11 (14.9)	3 (6.4)	9 (13.6)	3 (7.9)				
Interprets work of breathing increased	39 (52.7)	18 (38.3)	34 (51.5)	14 (36.8)				
Breath sounds								
Considers breath sounds	43 (58.1)	37 (78.7)	48 (72.7)	27 (71.1)	.02[a]		.07[a]	
Comments on audible throughout	1 (1.4)	3 (6.4)	6 (9.1)	2 (5.3)				
Comments on prolonged expiratory phase	4 (5.4)	2 (4.3)	0	0				
Comments on coarse and/or wheezing	42 (56.8)	26 (55.3)	41 (62.1)	20 (52.6)				
Interprets obstructive lung disease	0	0	0	0				
Interprets abnormal breathing	0	1 (2.1)	4 (6.1)	2 (5.3)				
Vital signs								
Considers vital signs	68 (91.9)	46 (97.9)	56 (84.8)	35 (92.1)				
Comments on 50 breaths per minute	11 (14.9)	7 (14.9)	22 (33.3)	10 (26.3)			.01[a]	
Comments on use of supplemental oxygen	31 (41.9)	31 (66.0)	33 (50.0)	19 (50.0)				
Comments on 150 beats per minute	8 (10.8)	2 (4.3)	9 (13.6)	2 (5.3)				
Interprets tachypnea and/or fast	29 (39.2)	14 (29.8)	20 (30.3)	19 (50.0)				.06[a]
Interprets hypoxemia and/or low	26 (35.1)	9 (19.1)	19 (28.8)	9 (23.7)				
Interprets tachycardia and/or fast	14 (18.9)	11 (23.4)	12 (18.2)	7 (18.4)				
Interprets respiratory distress with impending respiratory failure	18 (24.3)	15 (31.9)	2 (3.03)	1 (2.6)			<.001[b]	<.001[b]
Recognizes need for escalation of care	53 (71.6)	20 (42.6)	39 (59.1)	9 (23.7)	.001[a]	<.001[a]		.07[a]

[a] χ^2 test.
[b] Fisher exact test.

without impending respiratory failure case (ie, considers normal mental status), a significant difference was found at 3 months (37.5% vs 14.8%, *P* = .006) but not at 6 months (35.1% vs 28.9%, *P* = .51) (Table 3).

Work of Breathing. Overall, rates of correctly considering work of breathing by the VR intervention and control groups were high for all cases at both 3 and 6 months after initial training. A significant difference was found for the impending respiratory failure case at the 3-month assessment (97.3% vs 84.8%, *P* = .01) (Table 2).

Recognition of Need for Escalation of Care. For the impending respiratory failure case, the VR intervention group had a higher percentage of participants recognizing the need for escalation of care than the control group at 6 months after initial training (42.6% vs 23.7%, *P* = .07), but this difference did not reach statistical significance (Table 2).

Performance at 3 Months Versus 6 Months for VR Intervention and Control Groups

The significant results for the 3-month versus 6-month performance for the VR intervention and control groups in the case of impending respiratory failure are shown in Table 2. For the other 2 scenarios, no statistically significant performance

Table 3
Intervention vs control participants' ability to assess pediatric respiratory status and correctly recognize respiratory distress without impending respiratory failure at 3 and 6 months after initial training

	No. (%) of participants				*P* values with *P* < .10	
	VR intervention group		Control group		VR vs control	
Assessment	3 months (n = 64)	6 months (n = 57)	3 months (n = 54)	6 months (n = 45)	3 months	6 months
Mental status						
Considers mental status	24 (37.5)	20 (35.1)	8 (14.8)	13 (28.9)	.006[a]	
Comments on eyes being open	0	1 (1.8)	0	1 (2.2)		
Comments on patient being awake and/or alert	12 (18.8)	10 (17.5)	2 (3.7)	4 (8.9)	.02[b]	
Comments on minimal movement and/or decreased activity	3 (4.7)	3 (5.3)	1 (1.9)	1 (2.2)		
Interprets appropriate/normal mental status with decreased activity level	5 (7.8)	0	1 (1.9)	0		
Work of breathing						
Considers work of breathing	52 (81.2)	46 (80.7)	42 (77.8)	35 (77.8)		
Comments on none present	0	0	0	0		
Comments on suprasternal	4 (6.2)	2 (3.5)	2 (3.7)	2 (4.4)		
Comments on subcostal	8 (12.5)	9 (15.8)	7 (13.0)	4 (8.9)		
Comments on belly breathing	26 (40.6)	15 (26.3)	13 (24.1)	12 (26.7)	.06[a]	
Interprets work of breathing increased	21 (32.8)	21 (36.8)	13 (24.1)	8 (17.8)		.05[b]
Breath sounds						
Considers breath sounds	52 (81.2)	47 (82.5)	48 (88.9)	36 (80.0)		
Comments on audible throughout	1 (1.6)	0	2 (3.7)	0		
Comments on prolonged expiratory phase	0	0	0	0		
Comments on coarse	20 (31.2)	20 (35.1)	16 (29.6)	15 (33.3)		
Interprets obstructive lung disease and/or abnormal	3 (4.7)	3 (5.3)	2 (3.7)	1 (2.2)		
Vital signs						
Considers vital signs	57 (89.1)	51 (89.5)	47 (87.0)	37 (82.2)		
Comments on 48 breaths per minute	13 (20.3)	9 (15.8)	13 (24.1)	6 (13.3)		
Comments on use of supplemental oxygen	34 (53.1)	36 (63.2)	32 (59.3)	21 (46.7)		
Comments on 130 beats per minute	8 (12.5)	4 (7.0)	10 (18.5)	2 (4.4)		
Interprets tachypnea and/or fast	32 (50.0)	27 (47.4)	31 (57.4)	25 (55.6)		
Interprets hypoxemia and/or low	5 (7.8)	4 (7.0)	7 (13.0)	4 (8.9)		
Interprets tachycardia and/or fast	25 (39.1)	18 (31.6)	21 (38.9)	14 (31.1)		
Interprets respiratory distress without impending respiratory failure	37 (57.8)	33 (57.9)	16 (29.6)	8 (17.8)	.002[a]	<.001[a]

[a] χ^2 test.
[b] Fisher exact test.

differences were found between 3 and 6 months for either group.

Respiratory Status, Mental Status, and Work of Breathing. In the impending respiratory failure (Table 2) and respiratory distress without impending respiratory failure (Table 3) cases, no significant differences were found in the correct identification of the patient's respiratory status, mental status, or work of breathing between the 3- and 6-month assessments for both the VR intervention and control groups.

Escalation of Care. In the impending respiratory failure case, significant differences were found in the recognition of the need for escalation of care between the 3- and 6-month assessments for both groups, with significant declines from 3 months to 6 months for both the VR (71.6% vs 42.6%, $P = .001$) and control (59.1% vs 23.7%, $P < .001$) groups (Table 2).

Discussion

This study demonstrates successful implementation of VR-based training on assessment of pediatric respiratory distress and failure with nurse participants. The intervention group recognized impending respiratory failure at a higher rate than the control group at 3 months after training, and that difference was maintained at 6 months after training. For the impending respiratory failure case, intervention participants were also significantly more likely than control participants to correctly recognize mental status, a key indicator of a patient's risk for clinical decompensation. Additionally, participants in both groups demonstrated a significant decline in correctly recognizing

Table 4
Intervention vs control participants' ability to assess pediatric respiratory status and correctly recognize no respiratory distress at 3 and 6 months after initial training

	No. (%) of participants				P values with $P<.10$	
	VR intervention group		Control group		VR vs control	
Assessment	3 months (n=64)	6 months (n=47)	3 months (n=55)	6 months (n=37)	3 months	6 months
Mental status						
Considers mental status	41 (64.1)	22 (46.8)	31 (56.4)	25 (67.6)		.06[a]
Comments on eyes being open	1 (1.6)	0	0	0		
Comments on patient being awake and/or alert	17 (26.6)	7 (14.9)	5 (9.1)	2 (5.4)	.02[b]	.08[b]
Comments on normal movement and/or normal activity	1 (1.6)	0	0	0		
Interprets appropriate/normal mental status	4 (6.2)	1 (2.1)	0	1 (2.7)		
Work of breathing						
Considers work of breathing	51 (79.7)	31 (66.0)	43 (78.2)	23 (62.2)		
Comments on none present	2 (3.1)	2 (4.3)	0	2 (5.4)		
Comments on none visible	9 (14.1)	4 (8.5)	9 (16.4)	2 (5.4)		
Comments on mild belly breathing	4 (6.2)	2 (4.3)	3 (5.5)	1 (2.7)		
Interprets mild to no increased work of breathing	25 (39.1)	13 (27.7)	10 (18.2)	12 (32.4)	.01[a]	
Breath sounds						
Considers breath sounds	45 (70.3)	31 (66.0)	36 (65.5)	27 (73.0)		
Comments on audible throughout	0	0	3 (5.5)	0		
Comments on no prolonged expiration	0	0	0	0		
Comments on clear	26 (40.6)	27 (57.4)	18 (32.7)	17 (46.0)		
Interprets normal breathing	2 (3.1)	0	1 (1.8)	1 (2.7)		
Vital signs						
Considers vital signs	60 (93.8)	41 (87.2)	50 (90.9)	29 (78.4)		.09[a]
Comments on 36 breaths per minute	12 (18.8)	8 (17.0)	13 (23.6)	6 (16.2)		
Comments on use of supplemental oxygen	39 (60.9)	19 (40.4)	31 (56.4)	15 (40.5)		
Comments on 110 beats per minute	10 (15.6)	2 (4.3)	10 (18.2)	2 (5.4)		
Interprets tachypnea and/or fast	14 (21.9)	15 (31.9)	15 (27.3)	11 (29.7)		
Interprets hypoxemia and/or low	0	3 (6.4)	0	2 (5.4)		
Interprets tachycardia and/or fast	3 (4.7)	5 (10.6)	6 (10.9)	6 (16.2)		
Interprets mild to no increased work of breathing with no signs of distress	15 (23.4)	17 (36.2)	10 (18.2)	8 (21.6)		

[a] χ^2 test.
[b] Fisher exact test.

that the patient with impending respiratory failure required an escalation of care at 6 months compared with their 3-month performance.

Our findings suggest that exposure to a VR curriculum may have accelerated new nurse transition to practice by enhancing their recognition and interpretation of assessment findings for pediatric patients with respiratory distress and impending respiratory failure. These results may be due to the unique ability of VR, as compared with standard training modalities, to create a safe environment for deliberate practice in the assessment of realistically portrayed clinical findings.In this environment, the nurse could see changes in mental status; assess the patient's work of breathing with realistically portrayed nasal flaring, belly breathing, and retractions; and hear breath sounds. This hypothesis is further supported by the fact that skills gained during the VR intervention were maintained over time for several aspects of the curriculum.

Of note, neither group of participants increased their ability to correctly recognize respiratory failure by the 6-month assessment, demonstrating that these skills are not being gained through clinical exposure alone. The finding that recognition of a need for escalation of care for the patient with impending respiratory failure worsened over time is also concerning. A potential explanation for these findings is that they reflect differences in ongoing clinical exposure based on the participant's unit. Many participants came from subspecialized acute care units, so they may not have had the opportunity to care for patients admitted with respiratory illnesses and thus gain those skills through clinical exposure. Further, a lack of clinical exposure to decompensating patients may have led to a loss of skills over time, specifically in recognizing patients who require an escalation of care. Deliberate practice-based simulation training has been associated with improved learner skills and less skill decay and could be leveraged to address this potential gap in exposure.[18] An alternative hypothesis is that participants gained a false sense of confidence through increasing experience during this early stage of their nursing career—inappropriately believing that the patient's needs could be met in the general care unit because of their increasing comfort with an inpatient clinical environment. Finally, although nurses are taught to communicate abnormal assessment findings using a communication framework (SBAR), this does not necessarily include a synthesis of those findings that conveys the overall severity of the presentation or significance of the concern, making it more difficult for the physician to identify the needed intervention. Although use of SBAR may promote rapid nurse-physician communication, its effectiveness may be limited by how the information is interpreted by the recipient.[21] A key point of emphasis in the deliberate practice experience was that although listing the findings of tachypnea, increased work of breathing, lethargy, and tachycardia is accurate in conveying the bedside assessment, starting with a summary synthesis using terms that convey severity and urgency is key for priming the recipient. Stating the actual words *respiratory distress* or *respiratory failure* conveys the patient presentation and acuity, as opposed to what many nurses perceive to be a diagnosis. The persistent perception that stating these terms constitutes diagnosing the patient, which is outside the nursing scope of practice, may explain some of our findings.

Key next steps include the systematic rollout of this VR curriculum as part of a broad institution-wide focus on the recognition and management of clinical deterioration. In addition, tracking clinical exposure will help answer questions about maintenance of skills and need for additional booster training over time. Last, ongoing work to make this training platform autonomous (ie, no need for a human facilitator) will further expand its reach and utility.

Limitations

This study has several limitations. First, it was conducted at a single site for only new graduate nurses, thus limiting its generalizability. However, these participants may be representative of incoming nurses at most large academic pediatric medical centers. Second, there was no direct observation of nurse performance with actual patients, so we are unable to determine whether skills learned during the VR curriculum were applied at the bedside. Third, because we did not track clinical exposure between assessments, we cannot account for the number of patients with respiratory complaints cared for by each nurse during the study period. Last, not all institutions have access to VR-based training. However, as costs of VR equipment continue to decrease with increasing development of curricula such as this one, implementing this type of training should become increasingly feasible for most institutions.

Conclusion

This study demonstrates the successful implementation of a VR-based training curriculum that showed an association with improved recognition of pediatric respiratory distress and impending respiratory failure at 3 and 6 months compared with standard training approaches. However, there was a concurrent decline in the recognition of the need for escalation of care in the impending respiratory failure case from the 3- to 6-month assessments for both groups. This finding illuminates the need for additional exploration regarding potential skill decay versus gain of false reassurance with clinical experience and communication practices between nurses and physicians. Our findings suggest that VR training may be an effective method of teaching clinical assessment skills and may represent a new approach to onboarding new graduate nurses to help them more effectively transition to practice.

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Appendix
Respiratory Distress/Failure Study Video-Based Assessment: Free-Response Questionnaire

The 3- and 6-month questionnaires were administered through REDCap. For each of the 3 videos/cases, we asked the participants the following questions at 3 and 6 months:

1. Please describe your examination findings that allow you to assess the patient's respiratory status.
2. How would you classify this patient's respiratory status?
3. What would be your next steps following assessment of this patient?
4. Please describe in further detail your rationale for your assessment of the patient's respiratory status as well as your proposed next steps in management.

We also asked participants to self-identify whether they participated in VR training with this question:

- Did you participate in the initial VR simulation training?

SEE ALSO
For more about simulation training, visit the *AACN Advanced Critical Care* website, **www.aacnacconline.org**, and read the article by Hernandez and Casida, "Acute Care Nurse Practitioner-Led Extracorporeal Membrane Oxygenation Simulation Training" (Winter 2021).

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