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Clinical Focus

Training Students to Evaluate Preterm Infant Feeding Safety Using a Video-Recorded Patient Simulation Approach

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Purpose: The purpose of this study was to determine if brief video-recorded patient simulation training increased students' ability to assess feeding skills in preterm infants.
Method: Baccalaureate-level nursing students (*N* = 52) and graduate-level speech-language pathology students (*N* = 42) were randomized to 1 of 2 groups: didactic training (*N* = 51) or didactic training plus video simulation (*N* = 43). Outcome measures included knowledge test scores, calculated clinical judgment scores, and clinical marker documentation accuracy.
Results: Students' knowledge increased as the result of training, without differences in test scores between the 2 types of training. Students who received video simulation training interpreted simulated feeding behaviors of preterm infants more accurately than students who received didactic training. Infant distress signs were also documented with higher accuracy for students who received video simulation training. After training and regardless of method, participants correctly attributed distress behaviors during bottle-feeding to increased risk for feeding difficulty.
Conclusions: In the current educational environment, training opportunities with high-risk preterm infants are constrained by access to health care settings specializing in care for this population and availability of clinical supervisors with expertise in this area of practice. Patient simulators are expensive; however, video simulation offers inexpensive opportunities for students to effectively gain knowledge and skills for assessing feeding in preterm infants. With video simulation, students effectively apply principles of preterm infant feeding to cases and practice critical thinking skills before entering related clinical practicum placements.

Infants born before 37 weeks' gestation are classified as *preterm*. When infants are born early, biological systems required to sustain life and support development are immature, and physiological function may be subsequently affected. Specifically, preterm infants are at increased risk for prandial aspiration due to inadequate neural integration of sensory and motor pathways that control the suck–swallow–breathe sequence (Kubin, Alheid, Zuperku, & McCrimmon, 2006). Uhm, Yi, Chang, and Kwon (2013) reported that 40% of preterm infants demonstrate some level of dysphagia. In addition, Lee et al. (2011) reported that 26.8% of infants born at very low birth weight have some level of dysphagia. Aspiration of milk into the lungs of preterm infants may acutely trigger life-threatening events. Over time, aspiration may cause chronic pulmonary illnesses (Weir, McMahon, Taylor, & Chang, 2011). Prevention of such illnesses begins with the identification of infants who are at increased risk for aspiration. Identification requires that health care providers understand the pathophysiological and diagnostic properties of preterm birth, integrate these properties with comorbid illnesses, examine precipitating events and, then, act to provide optimal care (Tanner, 2006).

Neonatal nurses are the frontline practitioners who judge preterm infants' risk for aspiration during oral feeding and determine readiness for oral feeding. They use their clinical judgment to determine when preterm infants are physiologically stable, ready to initiate oral feeding, and feeding adequately. Nurses are trained to manage medical needs of preterm infants, but the criteria they use for judging feeding readiness and difficulty feeding vary widely. Currently, no consistent industry standard or widely accepted protocol exists for making such judgments (Breton & Steinwender, 2008). When a preterm infant is identified as having feeding difficulties or judged at increased

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risk for aspiration, speech-language pathologists (SLPs) evaluate their swallow function and work with families, nurses, and team members to implement a care plan that ensures adequate nutrition and airway protection. As with nurses, industry standards for evaluating and judging feeding skills in preterm infants vary across clinicians. It is essential that both nurses and SLPs receive specific training to recognize and accurately interpret approach and avoidance of nonverbal behaviors in infants that signal possible feeding difficulty.

Skill levels for recognizing feeding and swallowing distress on the basis of infants' nonverbal cues likely vary across health care providers because education and training experiences differ. Of concern, academic accrediting bodies for nursing and speech-language pathology students require training in dysphagia, yet requirements for developing competencies related to neonatal feeding and swallowing are not standardized across universities (American Association of Colleges of Nursing, 2008; American Speech-Language-Hearing Association, 2014). Focused training targeted toward preterm infants varies across academic programs on the basis of the curriculum and across students on the basis of clinical training experiences. To provide optimal, evidenced-based care for preterm infants, increased educational opportunities during formal academic training and subsequent postgraduation continuing education are needed.

Based on principles of developmental care (Als, 1986), clinical practice is moving toward an infant-driven, cue-based feeding culture. With this transition, effective training is needed for health care providers to link infant behavior to physiological functioning and brain development. Neonatal practitioners may learn to appreciate and interpret infants' nonverbal behaviors on the job or through traditional mentoring. However, in the absence of formal training and standardized feeding protocols, neuroprotective care for preterm infants during the transition from tube feeding to oral feeding is unlikely. Efficient, effective, and affordable training approaches are needed to improve short-term and long-term feeding outcomes for preterm infants.

Patient simulation training approaches use innovative, interactive methods for health care providers to practice a variety of procedural tasks. Students and clinicians practice performance skills and judge health statuses using simulated experiences that mimic clinical environments (Beneson & Potter, 2011). Simulated clinical experiences capitalize on repeated experiential learning in an environment that does not risk harming patients (Alinier, Hunt, Gordon, & Harwood, 2006). In the field of adult dysphagia, patient simulation approaches have shown to increase knowledge, critical thinking skills, decision-making skills, communication, and clinical skills performance outcomes (Alinier et al., 2006; Beneson & Potter, 2011; Freeland, Pathak, Garrett, Anderson, & Daniels, 2016; McGaghie, Issenberg, Petrusa, & Scalese, 2010). However, patient simulators are expensive to purchase and require extensive faculty training to effectively utilize the technology. Unlike online pedagogic approaches in which large numbers of students may be trained simultaneously, patient simulation approaches are typically designed to train small groups over an extended period of time. In addition, not all programs have access to patient simulators. As an alternative, principles of patient simulation may be combined with online training models to promote practical application of knowledge within patient clinical scenarios while impacting large numbers of students at a low cost. Video-recorded simulation tasks require less divided attention compared to live simulation tasks. This format may provide added benefits to novice learners and support transfer of concepts to long-term memory, according to cognitive learning theory (van Merrienboer & Sweller, 2010).

Methods of training clinicians to incorporate principles of neurodevelopment in assessing preterm infant feeding readiness and safety have not been studied. Further, the effectiveness of video-recorded simulated patient scenarios in improving detection of preterm infant distress during oral feeding is unknown. The aim of this study was to test video simulation as a method of meeting training needs to develop expertise and clinical skills for accurately evaluating preterm infant feeding safely. Brief video-recorded simulation scenarios in addition to didactic training were used to test the following research questions:

1. Does student knowledge increase with training and differ on the basis of training method: didactic training versus didactic training plus video simulation (DT vs. DTVS)?
   Hypothesis: Knowledge test scores will increase over time for both groups equally.
2. Do students' clinical judgment scores increase with training and differ on the basis of training method (DT vs. DTVS)?
   Hypothesis: Clinical judgment scores will increase over time for both groups with higher increases expected in the DTVS group.
3. Does documentation accuracy for combined clinical markers (CMs) during simulated preterm infant bottle feeding differ on the basis of the method of training?
   Hypothesis: After training, DTVS group will be more accurate in documenting CMs than the DT training group.
4. Do students document physiological CMs more accurately than behavioral CMs after training, and does accuracy differ on the basis of training method (DT vs. DTVS)?
   (a) Hypothesis 1: Physiological CMs will be documented more accurately than behavioral CMs in both pretest and posttest sessions regardless of training method.
   (b) Hypothesis 2: Accuracy of documentation will increase from pretest to posttest conditions for both training methods for physiological and behavioral CMs.

(c) Hypothesis 3: Students who receive DTVS training will demonstrate greater documentation accuracy for physiological and behavioral CMs than those who receive DT training.

Method

Design

A pretraining/posttraining within-participant and between-participants designs was used to compare knowledge and skill acquisition for assessing preterm infant feeding capabilities between participants trained in one of two online pedagogic approaches: DT or DTVS. Outcome measures included a 10-question knowledge test, a calculated clinical judgment score, and a documentation accuracy score. Clinical judgment scores and documentation accuracy scores were based on participant responses to video-simulated feeding scenarios.

Participants

A total of 108 participants took part in this study, including third- and fourth-year undergraduate nursing students (N = 65) and first-year graduate-level, speech-language pathology students (N = 43) from the University of South Alabama and Old Dominion University. The institutional review boards at both institutions approved this study, and all participants provided informed consent.

An opportunity sample of participants was used based on program enrollment at the time of the study. To control for students who learned and tested in an unproctored environment, data for students who spent less than 2 hr and 10 min were excluded. This time limit was based on a pilot study in which students completed components in a proctored environment. Of the 108 participants, 14 (one SLP and 13 registered nurses) were excluded from analyses because they had prior clinical experience in the neonatal intensive care unit (NICU), had children of their own, or did not complete the entire study.

Training

Participants from each discipline were randomly assigned to one of two training groups: DT (N = 51) and DTVS (N = 43). Five to 7 days after participants completed precourse testing, participants completed training and postcourse testing. The minimal amount of time recorded for any one student to complete pretesting, training, and posttesting was 2 hr and 10 min; maximum time recorded was 3.5 hr. Time was recorded using an online timer within the training module and allowed examiners to verify the time required for participants to complete the study components.

Participants in the DT group included 21 SLP and 30 nursing students. Training for DT group occurred 5 to 7 days after precourse testing using a didactic, self-paced, online, voice-over PowerPoint format. Participants accessed training through an online survey platform. Content for DT informed participants about the development of preterm infants' subsystems in the extrauterine environment, behavioral disorganization, physiological distress signs during oral feeding, critical components for assessing preterm infant feeding behaviors on the basis of Als' (1986) synactive theory of neurodevelopment, and the method for calculating the oral feeding skill (OFS) levels described by Lau and Smith (2011). OFS is an objective volume-based tool to triage infants who may benefit from a referral to feeding specialists. Training also reviewed critical components to be documented during a preterm feeding assessment. During training, each sign of behavioral disorganization and physiological distress was operationally defined. Last, an example assessment using PESR method of documentation was presented to the participants. PESR stands for "problem," "etiology," "signs/symptoms," and "recommendations." Participants were provided handouts of the PowerPoint presentation for note taking.

Participants in the DTVS group included 21 SLP and 22 nursing students. Participants in the DTVS group were trained using the same DT as the DT group, but these participants were also provided a video-recorded simulated patient demonstration for each of the behavioral signs of disorganization (muscle tone changes, gulping, and drooling) and physiological distress (apnea, bradycardia, desaturation, coughing, cyanosis, and tachypnea). See Figure 1 for a depiction of the video-recorded simulated demonstration for cyanosis.

Video Simulation Scenarios

Eight, 2-min video-recorded simulated patient scenarios were created based on human preterm infants who were previously assessed and treated in the NICU. These scenarios were created using a high-fidelity, human patient simulation mannequin, HAL® model S3010. Each scenario included infants' birth gestation and weight, current age at the time of the feeding trial, medical history, and feeding performance. Feeding performance data include volume ordered by the physician, volume consumed by

Figure 1. Depiction of video-recorded simulation demonstration for cyanosis.

the infant in the first 5 min, total volume consumed by the infant, and duration of the feeding trial. For each scenario, HAL®'s vital signs were displayed on a cardiopulmonary monitor. Vital signs for this investigation were heart rate, respiratory rate, and oxygen saturation levels. HAL®'s movements and physiological parameters were also manipulated during each video-recorded scenario to simulate preterm behavioral and physiological performance. Parameters included cyanosis, motion, spontaneous breathing, respiratory rate, and depth of respiration. Grunting was programmed into HAL®'s respiratory sounds to simulate gulping in these scenarios.

Each of these eight, 2-min simulated feeding scenarios were video-recorded using a Sony digital video camera, model DCR-SR47. Simulation scenarios were edited into a split screen format using Camtasia software (Camtasia Studio, 2010). Refer to Figure 1 for a depiction. Each split screen video recording visually depicted HAL® bottle-feeding and HAL®'s corresponding vital signs on a cardiopulmonary monitor. Infant coughing was overlaid on three of the videos using the same software.

Outcome Measurements

Participants were scored prior to training and after training on three outcome measurements: knowledge test scores, clinical judgment scores, and accurate documentation of two types of CMs, that is, physiological warning signs and behavioral indicators of disorganization. Scoring was rendered blind to the condition but not for time of testing for each participant. A knowledge test was designed to determine baseline knowledge for underlying pathophysiological components of feeding development in preterm infants, a basic understanding of vital signs, and infant behavior suggesting stability/distress on the basis of Als' (1986) synactive theory of neurodevelopment.

The clinical judgment score was designed to determine if participants integrated clinical information to make recommendations regarding safe feeding progression for preterm infants. Participants interpreted feeding safety from video-simulated scenarios and medical history, feeding history, and feeding performance parameters. After watching each simulated patient scenario, participants used free response fields to document their clinical judgments and assessment results. Participants were scored for accurate interpretation on six critical performance skills. Critical performance skills were identified based on previous research from the quality of nursing diagnosis scale (Florin, Ehrenberg, & Ehnfors, 2005) and patient safety. The six skills were (a) accurate documentation of the problem, (b) accurate documentation of essential signs of disorganization and distress, (c) documented evidence that supported the initiation of correct interventions, (d) documentation of rationales to support clinical decisions, (e) documentation of the infants' risk for aspiration, and (f) accurate calculation of the OFSs level (Lau & Smith, 2011). Across the eight simulated patient scenarios, accurate documentation for each of these six critical skills was awarded 1 point for a total of 48 points. Higher scores indicated better clinical judgment.

The behavioral and physiological warning signs tracked in this study were based on the previous work of Ferguson, Evans, Estis, Dagenais, and VanHangehan (2015) and included a change in muscle tone (shut down), gulping, and drooling. Physiological signs of distress related directly to hypoventilation and included coughing, apnea, decreased oxygen saturation levels, bradycardia, color changes, and tachypnea. Accurate documentation was measured on two types of CMs: infant-driven behavioral signs of disorganization and physiological signs of distress. There were 23 opportunities to document CMs, 16 opportunities to identify physiological CMs, and seven opportunities for behavioral CMs. Correctly documented signs were tallied across participants in each training group. Twenty percent of responses were coded and reliable based on interrater and intrarater reliability greater than 90% for each of these markers.

Statistical Analyses

Descriptive and analytical statistics were completed to measure outcomes for each of the four research questions using data from the two training groups (DT vs. DTVS) and two levels of time (pretraining and posttraining). Dependent variables were scores from the knowledge test (max score = 10), clinical judgment scores (max score = 48), and combined CM documentation accuracy (physiological markers + behavioral markers; max score = 23). To better understand students' ability to identify specific CMs, the combined CMs were also analyzed separately: physiological marker documentation accuracy (max score = 100% or 16/16) and behavioral marker documentation accuracy (max score = 100% or 7/7). An alpha level of .05 was used to test for significance across all measures. Effect sizes, partial η^2, and Cohen's *d* measure the strength, magnitude, or importance of the relationship between variables. Partial η^2 values were judged small (.01), medium (.06), or large (.14), and Cohen's *d* values were judged small (0.20), medium (0.50), or large (0.80; Tabachnick & Fidell, 2007).

Results

Outcomes Across Disciplines

Nursing and SLP students demonstrated similar scores on all dependent variables. No main effects were found for knowledge, clinical judgment, or documentation CMs. As a result, further analyses did not compare the results between the two disciplines. See Table 1 for means and standard deviations across dependent variables by discipline.

Knowledge Acquisition

Online training improved students' test scores without significant differences between DT and DTVS, indicated by a significant main effect of time (pretest to posttest),

Table 1. Pretest means and standard deviations for nursing and speech-language pathology students on dependent variables: knowledge test, clinical judgment, and documentation of clinical markers.

Pretest scores	Discipline	*N*	*M*	*SD*	Range	
					Minimum	Maximum
Knowledge	SLP	42	1.47	1.35	0.00	7.00
	RN	52	1.38	1.43	0.00	6.00
Clinical judgment	SLP	42	8.95	4.84	0.00	20.00
	RN	52	9.86	4.29	0.00	20.00
CM documentation	SLP	42	5.76	3.71	0.00	14.00
	RN	52	6.54	3.67	0.00	17.00

Note. SLP = speech-language pathologist; RN = registered nurse; CM = clinical marker.

$F(1, 92) = 231.56$, $p < .001$, partial $\eta^2 = .718$. There was no significant main effect of Group or Group × Time interaction. All students increased their knowledge related to preterm infant development, signs of disorganization, and signs of distress following training. See Table 2 for means and standard deviations for dependent variables by training group.

Clinical Judgment

Both training groups showed significantly higher clinical judgment scores after training, but participants in the DTVS group demonstrated significantly higher posttest clinical judgment scores than those receiving DT training. Results are demonstrated by a significant group by time interaction, $F(1, 91) = 7.149$, $p = .009$, partial $\eta^2 = .073$. While both training approaches improved clinical judgment accuracy, video simulation was the most effective training method.

Documentation of Combined CMs

After training, the video simulation group showed significantly higher accuracy for documenting CMs than the DT group, $F(1, 90) = 63.79$, $p < .001$, partial $\eta^2 = .415$. Given that pretest scores were covaried, these results revealed that the benefits of video simulation training were greater than online training alone.

Physiological CMs Compared With Behavioral CMs

Multivariate results showed that the difference between DT and DTVS groups on the linear combination of the two dependent variables (physiological and behavioral CM) was different at pretest than it was at posttest ($p < .001$). Further analysis revealed that both groups increased their ability to document both types of CMs after training ($p < .001$). However, video simulation training

Table 2. Means, standard deviations, and ranges for preknowledge and postknowledge test scores, clinical judgment scores, physiological CM, behavioral CM, and total CM scores for DT and DTVS groups.

Outcome measures		DT *N* = 51			DTVS *N* = 43		
		M	*SD*	*Range*	*M*	*SD*	*Range*
Knowledge							
Max = 10	Pretest	1.37	1.49	0 to 7	1.48	1.26	0 to 4
	Posttest	8.78	1.00	6 to 10	8.72	1.22	5 to 10
Clinical judgment							
Max = 48	Pretest	10.01	4.35	0 to 20	8.79	4.72	0 to 20
	Posttest	31.72	6.36	15 to 43	34.09	6.36	16 to 46
Physiological CM*							
Max = 1.0 (16/16)	Pretest	0.38	0.22	0.00 to 0.88	0.35	0.23	0.00 to 1.00
	Posttest	0.72	0.23	0.06 to 1.00	0.89	0.12	0.44 to 1.00
Behavioral CM*							
Max = 1.0 (7/7)	Pretest	0.05	0.11	0.00 to 0.43	0.05	0.10	0.00 to 0.29
	Posttest	0.22	0.19	0.00 to 0.57	0.67	0.22	0.14 to 1.00
Total CM							
Max = 23	Pretest	6.33	3.63	0 to 14	6.02	3.80	0 to 17
	Posttest	13.09	4.32	1 to 20	18.93	2.88	11 to 23

Note. CM = clinical marker; DT = didactic; DTVS = didactic + video simulation.

*Calculated on percent correct to account for difference in opportunities.

resulted in significantly higher posttest accuracy for documentation of physiological CMs compared with the performance of online training along ($p < .001$, partial $\eta^2 = .132$). Similarly, both groups increased their abilities to document behavioral CMs, but the video simulation group's performance was better than the online group ($p = .000$, partial $\eta^2 = .526$).

Learning effects were largest for participants in the DTVS group when documenting behavioral CMs. The ability to identify physiological markers differed in accuracy by 17% between the two training groups (DT = 72%; DTVS = 89%). The ability to identify behavioral markers differed by 46% between the two training groups (DT = 21%; DTVS = 67%). Figures 2 and 3 illustrate the multivariate interaction between group and time for physiological and behavioral CMs.

Conclusion

In this study, online video simulation proved to be a feasible approach for teaching students to use information about the development of preterm infants' subsystems in the extrauterine environment and commonly recognized warning signs to make accurate clinical judgments. Knowledge gains were noted for both groups without group differences. Our data are consistent with other online courses that have yielded knowledge gains across academic topics. Training with video simulation was superior to online training alone for clinical judgment scores and documentation of both behavioral and physiological CMs. Results are consistent with other studies that use case studies and video-recorded, patient-simulated experiences to train clinical judgment (O'Neill & Dluhy, 1997).

The greatest gains were noted when video simulation was used to train students to recognize and document behavioral CMs. Current evidence indicates that while infants use nonverbal behaviors to signal their readiness to feed orally, clinicians and nurses have difficulty identifying and understanding these behaviors (Harding, Bowden, Lima, & Levington, 2016; Thoyre, Shaker, & Pridham, 2005). Behavioral cues are subtle without loud alarms to signal infant distress. After this brief video simulation training, students quickly learned to recognize and document these subtle changes in infant behavior. In fact, the most compelling finding was the degree to which students accurately associated and documented subtle behavioral changes in preterm infants and related these changes to increased risk for swallow dysfunction. Students trained to associate subtle change in infant behavior will be better qualified to intervene before preterm infants experience life-threatening physiological decline.

Figure 2. Percentage of behavioral clinical markers accurately documented across time between groups. Error bars = *SD*; DT = didactic training; DTVS = didactic training with video simulation.

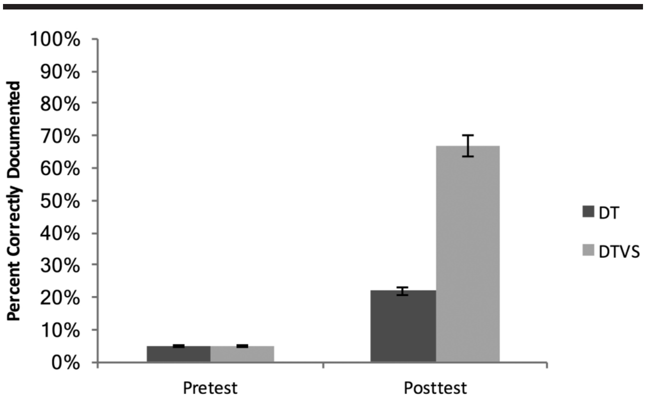
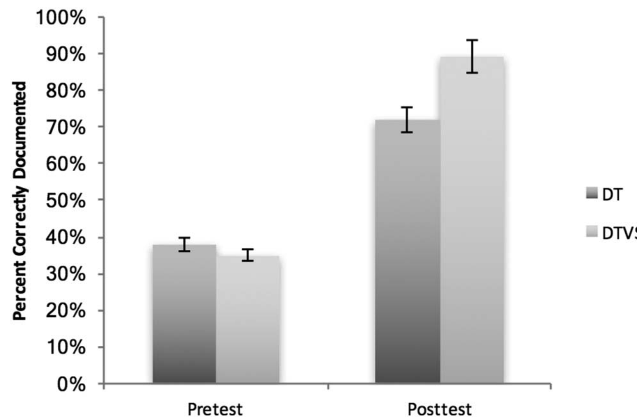


Figure 3. Percentage of physiological clinical markers accurately across time between groups. Error bars = *SD*; DT = didactic training; DTVS = didactic training with video simulation.



Access to external clinical placements that offer students the opportunities to assess swallow function in medically fragile infants is constrained. We set out to determine if a brief online didactic training with integrated, video-recorded, simulated patient training could be used to train students to recognize and interpret infant behaviors that help guide clinical practice decisions about readiness and poor readiness to feed orally. Given these favorable outcomes, it may be beneficial to distribute this cost-effective, web-based laboratory experience for use with novel students to increase their exposure to feeding and swallowing function and dysfunction in high-risk medically fragile infants.

Using an online didactic training with integrated, video-recorded, simulated scenarios has limitations. Students learn using focused attention and integrate new knowledge with practical scenarios; students do not gain hands-on experience. Clinical practice requires high levels of alternating sustained and divided attention, which was not necessary for video-recorded, simulated patient scenarios. The ability to practice in vivo with high-fidelity patient simulators may be used to further develop skills performance for assessing feeding abilities in medically complex infants. In addition, students used notes during post-course testing, which may have inflated the knowledge test scores in this investigation. Although the same limitation may be argued for the clinical judgment scores, the clinical judgment assessment required participants to analyze information from multiple sources, integrate that information, and make inferences about causality to rationalize their clinical recommendations. Therefore, the clinical judgment assessment was a higher measure of cognitive learning; scores were less susceptible to inflation.

Our training is not comprehensive nor designed to prepare students to work independently in a NICU. However, students trained in the art of interpreting infant behavior will be better prepared to enter the NICU environment and learn with supervision. Students may find that they are better prepared for the transition to patient care because they have practiced recognizing signs of distress and recommending strategies for a safer transition to full oral feeding in video-recorded, simulated, preterm infants.

The design of this laboratory training program provides opportunities for large numbers of students to be introduced to specific principles germane to fragile neonates, developing physiological subsystems and physiologically based warning signs that are associated with increased risk for feeding challenges and aspiration. Evidence-based, objective criteria were provided to guide students' ability to rationalize neuroprotective treatment methods and recommendations that will improve short- and long-term outcomes for preterm infants. Our training provided brief, inexpensive, and effective scenario-based exercises for which students practiced making clinical judgments and recommendations without harming medically fragile preterm infants. Educators who seek to introduce novice students to preterm infant feeding behaviors but who do not have access to human infants or patient simulators may benefit from using this video simulation training approach.

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