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Assessment of long-term knowledge retention following single-day simulation training for uncommon but critical obstetrical events

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Abstract

Objective—The objectives were to determine (i) whether simulation training results in short-term and long-term improvement in the management of uncommon but critical obstetrical events and (ii) to determine whether there was additional benefit from annual exposure to the workshop.

Methods—Physicians completed a pretest to measure knowledge and confidence in the management of eclampsia, shoulder dystocia, postpartum hemorrhage and vacuum-assisted vaginal delivery. They then attended a simulation workshop and immediately completed a posttest. Residents completed the same posttests 4 and 12 months later, and attending physicians completed the posttest at 12 months. Physicians participated in the same simulation workshop 1 year later and then completed a final posttest. Scores were compared using paired *t*-tests.

Results—Physicians demonstrated improved knowledge and comfort immediately after simulation. Residents maintained this improvement at 1 year. Attending physicians remained more comfortable managing these scenarios up to 1 year later; however, knowledge retention diminished with time. Repeating the simulation after 1 year brought additional improvement to physicians.

Conclusion—Simulation training can result in short-term and contribute to long-term improvement in objective measures of knowledge and comfort level in managing uncommon but critical obstetrical events. Repeat exposure to simulation training after 1 year can yield additional benefits.

Keywords

Long-term follow up; medical education; obstetric emergencies; simulation

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Introduction

Critical obstetrical conditions such as eclampsia, postpartum hemorrhage, shoulder dystocia and vacuum-assisted vaginal delivery are uncommon, but can result in significant maternal and neonatal morbidity and mortality. Appropriate management of these conditions is essential to providing the highest quality of care and preventing complications. This can only be achieved if obstetricians learn and maintain the necessary knowledge and skills, which can prove difficult when the incidence of the events is low. A single-day simulation workshop is an efficient manner of educating obstetricians in such situations. Simulation exposes physicians to clinical scenarios they may otherwise have never or rarely encountered and offers an opportunity to learn and practice skills in a risk-free environment. This is particularly important when the clinical scenario is rare and associated with significant maternal and neonatal morbidity and mortality.

Successful simulation programs that provide and enhance training for rare and potentially lethal events have been described for many fields, and there is a growing body of literature to support this method [1–5]. In obstetrics, simulated multidisciplinary emergency scenarios have been reported to promote new learning [6] and help identify common clinical management mistakes [7]. Teamwork training integrated with clinical teaching and high-fidelity simulation models has been associated with improved outcomes [8]. Specifically, simulation has been associated with improved management of cord prolapse [9] and can help train clinicians to manage shoulder dystocia [10–12]. Simulation for the management of eclampsia has been demonstrated to be superior to didactic instruction alone [13] and has identified areas for improvement in the management of preeclampsia. In addition, simulation has helped promote systems change to provide safer care for women with eclampsia [14]. However, while studies have demonstrated that simulation for obstetric emergencies can result in more positive attitudes toward competence in handling emergencies, as well as improved individual and team performance, neither long-term benefit nor sustained improvement in knowledge have been demonstrated [15].

It is unclear how long learners maintain some benefit in knowledge, skill or comfort that result from participation in simulation. This issue is particularly important when considering uncommon scenarios, as participants may not have “real-life” opportunity to apply and reinforce their acquired skills, which may result in decreased knowledge retention and comfort level. It also is unclear whether learners continue to benefit from repeated exposure to the same simulation training.

The aim of this study was to determine whether single-day, intensive, multiple-task simulation training results in short-term and long-term improvement in objective measures of knowledge and self-reported comfort level in managing uncommon but critical obstetrical events. In addition, we sought to determine whether additional knowledge and comfort could be gained from a second exposure to the same simulation workshop, 1 year following initial exposure.

Methods

Resident and attending physicians completed a simulation workshop on the management of eclampsia, shoulder dystocia, postpartum hemorrhage and Kiwi® vacuum-assisted vaginal delivery. The clinical scenarios were identified by the authors in conjunction with members of the Quality Improvement Committee at Beth Israel Deaconess Medical Center (BIDMC). The extent of learning that resulted from the workshop was assessed with a pretest and posttest that included 35 multiple-choice questions designed to evaluate knowledge. All but two of the 35 multiple-choice questions were based on the relevant American Congress of

Obstetricians and Gynecologists practice bulletins [16–19]. The remaining two questions were based on other well-accepted practice guidelines [20,21]. A 10-point Likert scale was used to elicit subjective self-reported comfort level in managing each of the clinical scenarios, with 1 being not at all comfortable and 10 being extremely comfortable. The pretest included one Likert scale question for each of the four clinical scenarios. The posttest was identical to the pretest with the exception of one additional question for each clinical scenario that asked whether learners felt more, equally or less able to manage each scenario after the simulation compared with before.

The pretest was administered immediately before the start of the simulation workshop. Following completion of the pretest, participants attended a 1-hour didactic session that devoted approximately 15 minutes to each clinical scenario and served as an introduction to the simulation topics. This was followed by a simulation training with one station for each of the four clinical scenarios. The simulation was designed so that all four tasks could be completed within 60–90 minutes. Each station was co-led by an attending physician with expertise in the area and a chief resident. Nurses, midlevel providers and scrub techs participated as trainers playing the roles they would play in live situations.

The shoulder dystocia station utilized a partial task trainer mannequin. A labor and delivery nurse was present, and participants communicated the diagnosis and subsequent instructions to the nurse as they would in an actual teamwork situation. The station leader observed as participants described and demonstrated standard, stepwise maneuvers to intervene during an intrapartum crisis and deliver the fetus. Station leaders assisted participants in performing or fine-tuning maneuvers if needed.

The vacuum station also utilized a partial task trainer mannequin. The station leaders provided participants with an obstetric indication for a vacuum delivery and reviewed contraindications. Participants determined the presentation, position and station of the fetus and identified the flexion point on the fetal head. Steps for patient preparation were communicated to the station leaders. Participants then applied the vacuum and appropriate placement was confirmed by the station leader. Vacuum suction and traction were applied under the supervision of the station leaders and the mannequin fetus was delivered.

The eclampsia station utilized a Medical Educational Technologies, Inc. (Sarasota, FL) high-fidelity whole body simulator utilizing the Human Patient Simulator 6 software. A nurse introduced participants to the patient, who reportedly presented to the triage unit complaining of a headache. Elevated blood pressures were displayed on the bedside monitors and a fetal heart rate tracing was available for review. Participants took a history from the patient; questions were answered by the whole body simulator patient that was controlled by station leaders in a neighboring one-way mirrored equipment room. Participants could order specific laboratory tests and medications, including antihypertensive medications and magnesium sulfate. They were required to communicate to the nurse the exact names, doses and routes of administration of medications for the eclampsia scenario. The patient demonstrated seizure activity regardless of previous management; thereafter, the impact of the management was individualized and ranged from improvement to additional seizure activity. Participants were prompted by the patient to discuss timing and method of delivery when the patient regained consciousness.

The postpartum hemorrhage station utilized a uterine model that was not commercially available and was built for the purpose of this workshop. It consisted of a golf club cover as the uterus and a rubber catheter as the uterine vessels. Station leaders described a clinical scenario of postpartum hemorrhage secondary to atony. Participants communicated steps for medical management of atony, including the use of uterotonics (names, doses, maximum

doses and contraindications) and steps for fluid resuscitation and transfusion. Participants then proceeded with laparotomy and surgical management of atony. Station leaders supervised as participants ligated the uterine vessels; placed B lynch sutures and box stitches; and utilized Bakri balloon catheters.

Immediately following the simulation, participants completed the posttest. To examine their experience as co-leaders, chief residents also completed a survey with seven Likert scale questions and one open-ended question. Resident physicians completed additional posttests at 4 and 12 months, and attending physicians completed a posttest at 12 months. After completing the posttest at 12 months, both resident and attending physicians completed the single-day simulation workshop for the second time. Immediately following this repeat simulation workshop, they completed the final posttest.

Data were analyzed with SAS 9.2 (SAS Institute, Cary, North Carolina). All tests were two-sided and p values <0.05 were considered statistically significant. Paired t-tests were used to compare the pretest with each of the posttests. The five chief residents were excluded from this analysis given that they were co-leaders of the simulation stations and had additional exposure to the topics through preparation for their teaching role. Results are reported either for all four clinical scenarios combined or individually and are stratified by level of training. Linear regression was used to evaluate whether knowledge and comfort increased with level of training. Results of the chief resident survey are reported as means with standard deviations.

This study was determined to be a quality improvement activity, and thus not human subjects' research, by the Committee on Clinical Investigations at BIDMC.

Results

The initial simulation workshop was offered to 43 attending obstetricians and all 20 resident physicians in our department; 100% of both the resident and attending physicians participated in the initial workshop and completed all four simulation stations. Fourteen of the fifteen (93%) first-, second- and third-year residents completed the pretest, posttest, 4-month posttest and 12-month posttest. All of the 14 resident physicians also completed the simulation workshop 1 year following the initial workshop and completed the final posttest. Thirty-four (79%) of the 43 attending physicians completed the initial pretest and posttest. Thirty (70%) completed the 12-month posttest, participated in the simulation workshop for a second time and completed a posttest following the second simulation.

Immediately before and after initial simulation

There was a trend towards a higher pretest score with additional years of training as seen in Figure 1. However, a regression model did not show a statistically significant association for overall score by year of training among resident physicians for the pretest ($p = 0.35$), the initial posttest ($p = 0.14$), the 4-month posttest ($p = 0.20$) or the 12-month posttest ($p = 0.07$). The overall score on the first posttest improved significantly compared to pretest scores at all levels of training (all $p \leq 0.005$). Prior to the simulation, resident physicians scored from 48 to 67% on the knowledge components of the pretest; following the simulation, resident scores were from 85 to 95%. Attending scores ranged from 55 to 70% before the simulation and increased to 82 to 93%. As shown in Table I, resident and attending physicians demonstrated statistically significant improvement from the pretest to the immediate posttest both overall and for each clinical scenario (all $p \leq 0.01$).

Similar to physician knowledge, comfort level in managing the clinical scenarios appeared to increase with additional training as shown in Figure 2. Regression models revealed a

significant trend towards increased comfort level with increased level of training among resident physicians for the pretest ($p = 0.008$), the 4-month posttest ($p < 0.001$) and the 12-month posttest ($p = 0.02$), but not the initial posttest ($p = 0.08$). There was a statistically significant improvement in overall comfort level and in each subject area at the first posttest for resident physicians (all $p < 0.01$). Attending physicians also reported an increase in overall comfort level ($p = 0.002$). Following the initial simulation workshop, at least 80% of participants reported that they felt more able to manage postpartum hemorrhage and vacuum delivery, while 72% reported feeling more able to manage eclampsia and 67% reported feeling more able to manage shoulder dystocia. No one reported feeling less able to manage a clinical scenario after the simulation.

Four months after initial simulation

Compared with the pretest the overall 4-month posttest scores were higher at every level of residency (Figure 1); this improvement was statistically significant among second- and third-year residents (both $p \leq 0.04$). In addition, the 4-month posttest results shown in Table I exhibit a statistically significant or borderline significant improvement overall and for each clinical scenario compared to the baseline pretest. There was a significant improvement in overall comfort level at the 4-month posttest compared to the pretest ($p = 0.02$); however, comfort was not reported as high as it was immediately following the simulation workshop (Table II).

Twelve months after initial simulation

Among resident physicians, the overall score was slightly higher at 12 months than at 4 months, though lower than the immediate posttest. Attending physicians scored only slightly better overall at 12 months than they did at the initial pretest, and the difference was not significant ($p = 0.56$). Among resident physicians, comfort level was significantly higher overall at the 12-month follow-up compared to the pretest ($p = 0.001$). While the overall comfort level among attending physicians was also significantly higher at 12 months ($p = 0.005$), this difference seems to be driven by an increased comfort with vacuum delivery ($p < 0.001$). Table I shows results for the 12-month follow-up.

Second simulation

Following the second simulation, resident and attending physicians scored significantly higher overall than they did at the 12-month follow-up immediately preceding the second simulation (both $p < 0.001$). Table III shows resident and attending scores at 12 months and after the second annual simulation exercise. As shown in Table IV, resident and attending physicians were significantly more comfortable immediately following the second simulation that they were at the 12-month follow-up ($p = 0.001$ and 0.02, respectively).

Chief resident survey

Chief residents reported an improved understanding of the scenario they taught that was greater than what they would have expected as a general participant, while also noting that their learning on the other scenarios was more limited than what they would have expected as a general participant. They reported that learning was enhanced by co-leading with an attending physician and that they would feel comfortable leading a similar simulation workshop on their own after graduation. Results of the chief resident survey are displayed in Table V.

Discussion

Our study is one of the first in the obstetric literature to evaluate long-term knowledge retention after a single-day simulation exercise, and shows excellent retention among resident physicians at 4 and 12 months. This suggests that for resident physicians, even a multiple-task simulation of short duration can increase knowledge and contribute to maintaining knowledge over time. In addition, our study demonstrates that for uncommon crises in obstetrics, the benefit of the simulation declined with time and participants benefited from repeating the workshop at 1 year. Resident comfort level in particular benefited from repeat exposure to the simulation workshop.

Among resident physicians, the initial simulation resulted in a significant immediate increase in knowledge and comfort level in all four scenarios. Although knowledge and comfort tended to decline with time, the improvements above the pretest were retained at both 4 and 12 months. Among attending physicians, the overall knowledge retention at 12 months was not significant. We suspect that this may reflect a difference in intervening exposure to other structured learning opportunities on topics; resident physicians have frequent didactics that may contribute to knowledge retention outside of the simulation experience. Attending physicians may not have as much ongoing education on these topics; therefore, their knowledge and comfort may have a more direct relationship with proximity to training. It is possible that resident education alone, without exposure to simulation, would have produced the long-term results seen in this study. We cannot control for resident education and learning opportunities that may influence long-term follow-up scores; however, as simulation currently is utilized as a residency educational tool, our situation reflects the typical resident experience. A randomized controlled trial with long-term follow-up may help differentiate the effects of simulation on long-term knowledge retention and comfort level from other educational experiences. In addition, we did not account for clinical experience which may influence knowledge and comfort.

Following the second annual simulation workshop, both resident and attending physicians scored higher overall than they did on the 12-month follow-up tests, suggesting that repeat exposure to simulation for uncommon events is valuable for both groups. Both groups also reported increased overall comfort following the second simulation above what they reported at 12 months after the first simulation.

While we hoped that participation in the simulation would improve comfort, it has not been determined if comfort correlates with clinical performance. In general, our results showed that comfort increased with additional training among residents. Other studies have reported that simulation can improve comfort levels [22,23] and increase medical student clinical participation [24], but they did not report on the relationship between comfort level and clinical outcomes.

How to maximize the potential of simulation training as an educational tool to foster long-term knowledge retention remains to be determined. Our study suggests that resident and attending obstetricians can benefit from enrollment in a short duration workshop at a simulation center. Our study also suggests that both resident and attending physicians can benefit from participation in both single and repeated simulation workshops for uncommon events. Consideration should be given to the development of a standardized set of scenario scripts, pretests and posttests with long-term follow-up and objective measures of clinical performance that is uniform across obstetrics and gynecology residency programs. For example, Ellis et al. [25] reported time to complete basic tasks in management of an eclampsia scenario; this measure could be incorporated into a variety of simulation scenarios.

Simulation led by chief residents is a valuable learning tool for both resident and attending physician learners. Chief residents can learn more as a teacher; however, teaching one scenario may compromise learning experiences with other scenarios. Thus, adequate time to participate in other stations should be provided. Leading one simulation workshop can improve chief residents' teaching ability and instill a sense of confidence in their capacity to lead a similar workshop in the future.

Our simulation incorporated nurses in a way that reflects their role in live clinical scenarios. The presence of the nurses was intended to make the simulations more true to life for the physician participants; however simulation is gaining greater acceptance as a valuable teaching tool for nurses [26,27] and ultimately this simulation could be directed at nurses as learners.

The longitudinal follow-up for resident physicians over the course of a full year is a strength of this study. We believe that this workshop contributed to the long-term benefits we observed, but further study is needed to determine whether resident physicians retain the knowledge and comfort beyond 1 year. An additional strength is the inclusion of the repeat simulation and immediate follow up afterwards.

The main limitation of this study is that test performance cannot be correlated with clinical outcomes due to the low incidence of the simulated events or with performance of skills given that we measured knowledge and comfort but not skill performance. As evidenced by the association between training in obstetric emergencies and sustained improvement in perinatal outcomes in the United Kingdom [28], it is likely that increased knowledge of and comfort in managing a difficult and uncommon scenario have a positive impact on live performance. However, while knowledge of these critical scenarios is required for optimal management, in itself, it is not the same as actually managing such a scenario. Future studies should include assessment of hands-on performance during the simulation. A second limitation is that, particularly for the resident physicians with their exposure to additional educational sessions and lack of a control group, we cannot conclude whether the gains in knowledge and comfort are a direct result of the simulation.

Our study demonstrates that single-day simulation training for uncommon but critical obstetric events leads to increased knowledge and comfort immediately following the simulation and may contribute to long-term knowledge retention and increased comfort for residents. In addition, our study suggests that knowledge gained from simulation for uncommon scenarios diminishes with time and long-term gains in knowledge may be minimal, particularly for attending physicians. Finally, this study demonstrates that repeating the same simulation workshop 1 year later results in additional improvements. Future directions for study include determining the ideal frequency of such trainings in order to maintain skill and correlating the benefits of simulation with clinical care.

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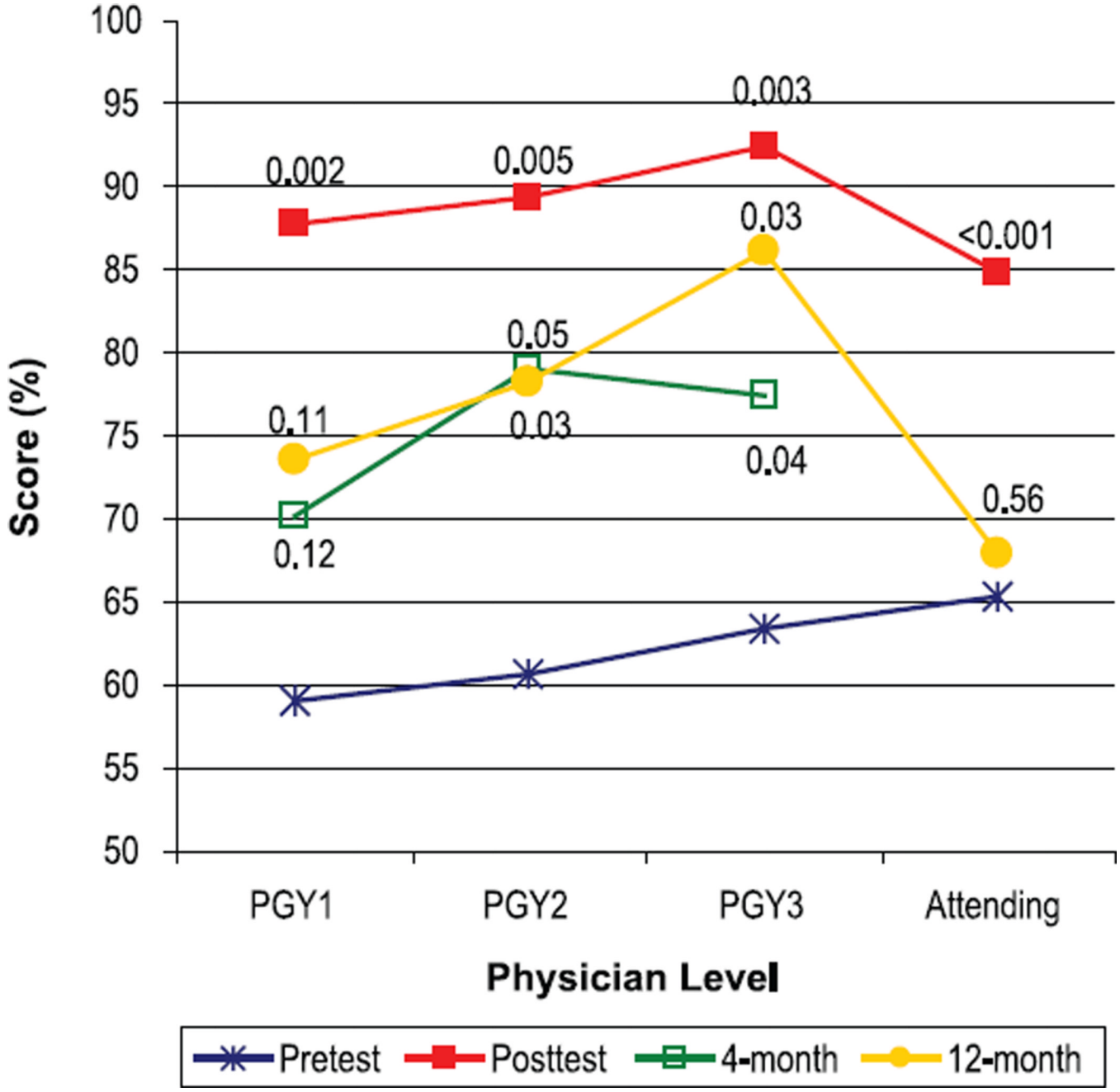

Figure 1.
Mean overall knowledge score stratified by level of physician training.

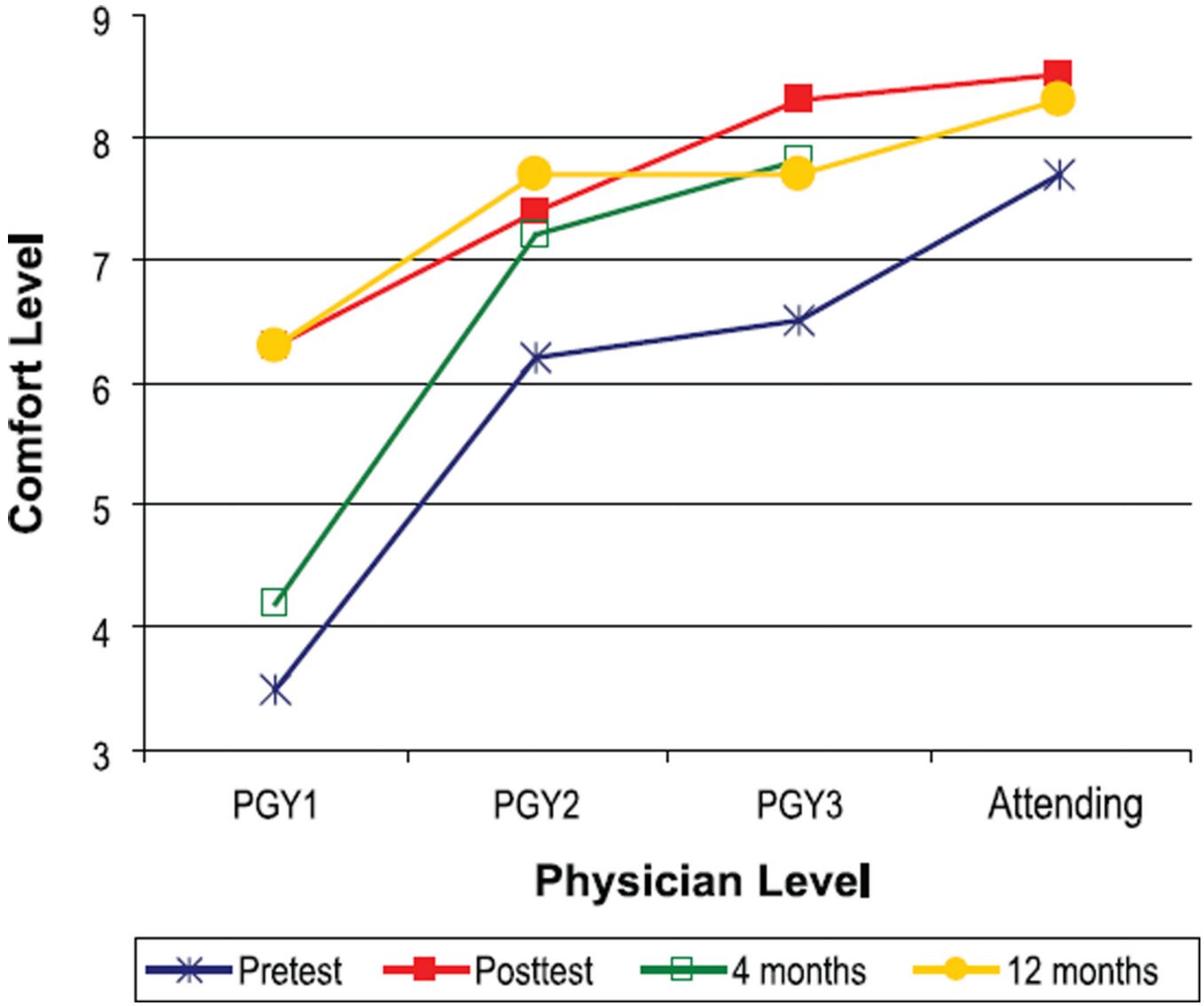

Figure 2.
Mean comfort level stratified by level of physician training.

Table I

Mean knowledge scores and mean change from pretest to immediate posttest, 4-month follow-up and 12-month follow-up.

	Initial simulation				4 Months			12 Months		
	Pre	**Post**	**Change**	***p***	**4 mo**	**Change**	***p***	**12 mo**	**Change**	***p***
Resident physicians n =14										
Overall	60.8	89.8	28.9	<0.001	75.4	14.6	<0.001	78.8	17.9	<0.001
Kiwi vacuum	67.0	94.6	27.7	<0.001	91.1	24.1	<0.001	90.2	23.2	<0.001
Eclampsia	48.4	92.9	44.4	<0.001	60.3	11.9	0.06	65.9	17.5	0.04
Hemorrhage	61.9	84.9	23.0	<0.001	75.4	13.5	0.03	84.9	23.0	<0.001
Dystocia	66.1	86.6	20.5	<0.001	75.0	8.9	0.03	74.1	8.0	0.12
Attending physicians n = 30										
Overall	65.3	84.8	19.5	<0.001	–	–	–	67.9	2.6	0.56
Kiwi vacuum	68.3	92.9	24.6	<0.001	–	–	–	78.3	10.0	0.05
Eclampsia	55.2	82.2	27.0	<0.001	–	–	–	64.1	8.9	0.09
Hemorrhage	67.4	79.3	11.9	0.01	–	–	–	69.6	2.2	0.69
Dystocia	70.4	85.0	14.6	<0.001	–	–	–	59.6	−10.8	0.06

mo, months.

Table II

Mean comfort and mean change from pretest to immediate posttest, 4-month follow-up and 12-month follow-up.

	Resident physicians $n = 14$									
	Initial simulation				4 Months			12 Months[a]		
	Pre	Post	Change	*p*	4 mo	Change	*p*	12 mo	Change	*p*
Overall	5.4	7.3	1.9	0.002	6.4	1.0	0.02	7.3	1.8	0.001
Kiwi vacuum	4.9	7.6	2.7	0.006	6.5	1.6	0.02	7.7	2.8	0.005
Eclampsia	5.2	7.2	2.1	0.01	6.0	0.8	0.22	6.4	1.2	0.05
Hemorrhage	6.0	7.2	1.2	0.007	7.2	1.2	0.01	7.9	1.9	<0.001
Dystocia	5.7	7.2	1.5	0.001	6.1	0.4	0.34	6.9	1.2	0.003
	Attending physicians $n = 21$									
	Initial simulation				4 Months			12 Months		
	Pre	Post	Change	*p*	4 mo	Change	*p*	12 mo	Change	*p*
Overall	7.7	8.5	0.7	0.002	–	–	–	8.3	0.6	0.005
Kiwi vacuum	5.8	7.9	2.0	0.003	–	–	–	8.3	2.5	<0.001
Eclampsia	7.9	8.5	0.6	0.03	–	–	–	7.9	0.0	0.86
Hemorrhage	8.5	8.6	0.1	0.45	–	–	–	8.7	0.2	0.36
Dystocia	8.7	8.8	0.1	0.54	–	–	–	8.6	−0.1	0.54

[a] $n = 13$; one resident did not complete the comfort questions for the 12-month follow-up.

mo, months.

Table III

Mean knowledge scores and change from 12-month follow-up to final posttest.

	12-mo	Final	Change	*p*
Resident physicians $n = 14$				
Overall	78.8	89.9	11.1	<0.001
Kiwi vacuum	90.2	95.5	7.9	0.05
Eclampsia	65.9	92.9	27.0	0.001
Hemorrhage	84.9	88.9	4.0	0.21
Dystocia	74.1	82.1	8.0	0.06
Attending physicians $n = 30$				
Overall	67.9	83.0	15.1	<0.001
Kiwi vacuum	78.3	95.4	17.1	0.001
Eclampsia	64.1	83.7	19.6	<0.001
Hemorrhage	69.6	78.9	9.3	0.03
Dystocia	59.6	74.2	14.6	<0.001

Table IV

Mean comfort level and change from 12-month follow-up to final posttest.

	12-mo	Final	Change	*p*
Resident physicians $n = 14$				
Overall	7.3	7.7	0.4	0.001
Kiwi vacuum	7.7	8.2	0.5	0.08
Eclampsia	6.4	7.2	0.8	0.003
Hemorrhage	7.9	7.8	−0.2	0.50
Dystocia	6.9	7.4	0.5	0.03
Attending physicians $n = 30$				
Overall	8.3	8.7	0.4	0.02
Kiwi vacuum	8.3	8.7	0.4	0.06
Eclampsia	7.9	8.5	0.6	0.03
Hemorrhage	8.7	8.8	0.1	0.33
Dystocia	8.6	8.9	0.3	0.07

Table V

Chief resident experience.

Question (1 = not at all, 5 = a great deal)	Mean ± SD *n* = 5
Improved understanding of topic taught	4.6 ± 0.5
Learned more because you were a leader	5.0 ± 0.0
Learning limited on other topics	3.8 ± 0.4
Learning enhanced by pairing with attending	3.0 ± 1.6
Felt comfortable leading without an attending	4.4 ± 0.9
Experience enhanced your teaching abilities	4.2 ± 0.8
Capable of leading workshop after graduating	4.8 ± 0.4