Multi-professional training for obstetric emergencies in a US hospital over a 7-year interval: An observational study

Article *in* Journal of perinatology: official journal of the California Perinatal Association · October 2015

DOI: 10.1038/jp.2015.136

CITATIONS
7

READS
190

5 authors, including:

Carl P Weiner
University of Kansas
447 PUBLICATIONS **10,029** CITATIONS

SEE PROFILE

Journal of Perinatology (2015), 1–6

www.nature.com/jp

ORIGINAL ARTICLE

Multi-professional training for obstetric emergencies in a US hospital over a 7-year interval: an observational study

CP Weiner[1], L Collins[2], S Bentley[2], Y Dong[1] and CL Satterwhite[3]

OBJECTIVE: Birth is less safe than it can be. We adapted the UK-developed PROMPT™ (**PR**actical **O**bstetric **M**ulti-**P**rofessional **T**raining) course to local practices and initiated annual training.

STUDY DESIGN: This observational study used quality assurance data from Kansas University Hospital 2 years before and 7 years after intervention encompassing 14 309 consecutive deliveries from January 2006 through December 2014. An events/trials approach was applied to changes in proportions over time.

RESULT: PROMPT™ was associated with progressive decreases in rates ($P < 0.05$) of brachial plexus injury and umbilical artery pH < 7.00 exclusive of catastrophic events. Reduced rates ($P < 0.05$) of cesarean section, episiotomy and higher perception of nurse/physician communication were documented. Hypoxic ischemic encephalopathy (HIE) rates declined progressively by $>50\%$ ($P =$ NS). These improvements occurred despite younger faculty and higher rates of complicated pregnancies ($P < 0.05$). Estimated health-care costs avoided exceeded annual training costs.

CONCLUSION: Local annual multi-professional training as provided by PROMPT™ was temporally associated with improved obstetric outcomes.

Journal of Perinatology (2015) **00,** 1–6. doi:10.1038/jp.2015.136

INTRODUCTION

Background

Multiple health-care organizations recommend simulation training to supplement experiential methods of learning, though the elements critical for a successful program (for example, who should participate, program content and location, frequency of training, high vs low fidelity, and the inclusion of communication and teamwork drills) are unclear.[1] While obstetrical simulation training efforts consistently improve provider knowledge and confidence,[2–8] such gains are not typically associated with improved patient outcomes. In some reports, training was actually associated with an increased rate of cesarean delivery[9] or a worsening of patient outcomes.[10] Nielsen *et al.*[11] observed no improvement in a composite Adverse Outcomes Index after training. Although Phipps *et al.*[12] and Wagner *et al.*[13] reported a modest reduction in the Adverse Outcomes Index after training, neither investigated the impact of training on specific outcomes nor the sustainability of any improvements. We recently reviewed the characteristics of training programs associated with improved obstetric outcomes.[14]

One training program for the management of obstetrical emergencies, PROMPT™ (see www.promptmaternity.org) has been associated with improved perinatal outcomes. Iteratively derived from a randomized controlled trial,[15] PROMPT was developed in the United Kingdom where its implementation has led to improved knowledge[15,16] and clinical management in both simulation[15,17,18] and real life,[19–21] greatly improved team communication and efficiency,[17] retention of knowledge[16] and clinical skills[18] for up to 12 months after training, improved compliance with clinical standards[20,21] and a reduction in clinical errors.[20] There were also statistically significant and clinically important improvements in obstetric outcomes: a 70% reduction in brachial plexus injuries (BPIs),[20] a 50% reduction in encephalopathy,[19] a 50% reduction in the time taken to accomplish delivery after diagnosing umbilical cord prolapse[19] and a reduction in the rate of intensive care admission by 42%.[19]

PROMPT™ is conducted on site and includes didactic sessions and clinical simulations. The didactic sessions are designed to assure that all participants acquire key learning points in a collegial manner. Training occurs in multi-professional teams to reflect workflows. Simulation exercises use patient actors to enhance 360° communication. Throughout the course, PROMPT™ integrates structured communication, teamwork and the concepts of situational awareness and leadership into clinical training to minimize false starts and reduce the potential for hierarchical issues. Finally, training is required annually because the benefits wane after 12 months.[18]

We revised the British version of PROMPT™ (version 1) (see www.promptmaternity.org) to account for differences in health-care team compositions, workflows, medications, and, where relevant, national guidelines. In August 2008, we initiated annual training with the goal of including all health-care workers who might be involved in an obstetrical emergency. Herein, we report the changes in obstetrical outcomes temporally associated with PROMPT™ over a 7-year interval.

METHODS

This is an observational study of obstetric outcomes before and after the initiation of required annual, multi-professional training at the University of

[1]Department of Obstetrics and Gynecology, University of Kansas School of Medicine, Kansas City, KS, USA; [2]Division of Nursing, University of Kansas Hospital, Kansas City, KS, USA and [3]Preventive Medicine, University of Kansas School of Medicine, Kansas City, KS, USA. Correspondence: Professor C Weiner, Department of Obstetrics and Gynecology, University of Kansas School of Medicine, 3901 Rainbow Boulvard, MS2028, Kansas City 66160, KS, USA.
E-mail: cweiner@kumc.edu

This study was presented in part and the recipient of the Prize Paper, Best Clinical Presentation at the 2014 annual meeting of the Society for Maternal Fetal Medicine.
Received 26 July 2015; revised 13 September 2015; accepted 21 September 2015

Table 1. University of Kansas Hospital obstetricians and PROMPT trainees, 2006–2014

Year	*Obstetrics staff*			*PROMPT trainees*	
	Number of faculty	*Mean faculty age (years)*	*Number of residents*	*Physician*	*Other*
2006	9	57	12	NA	NA
2007	11	54	12	NA	NA
2008	14	50	12	25	74
2009	15	51	12	26	28
2010	15	49	13	28	96
2011	17	47	14	32	111
2012	15	45	15	29	85
2013	18	38	15	33	105
2014	20	38	15	17	112

A significant increase in obstetric faculty number ($P < 0.001$) and a decrease in the mean age of the faculty ($P < 0.001$) were observed.

Kansas Hospital, Kansas City, KS, USA. The delivery population consisted of 14 309 consecutive deliveries after 20 weeks gestation from 1 January 2006 through 31 December 2014.

The original course trainers completed a forerunner of the PROMPT™ 'Train the Trainers Course' under the direction of Professors Timothy Draycott and Dimitrios Siassakos held at the University of Kansas Hospital in 2007. The first PROMPT™ course for physicians and Hospital employees was held in August 2008.

All Hospital personnel assigned to obstetric and nursery units, plus all Obstetrics and Gynecology physician trainees and all obstetrics faculty, were required to complete annual training as a condition of continued access to the Labor Suite. The voluntary participation of Family Medicine, Neonatology and Anesthesia residents and faculty was strongly encouraged. The Family Medicine service was responsible for less than 5% of deliveries.

The 2-day course was held five times per year to avoid unit coverage difficulties. Instructors were uncompensated, and the course was free to all participants.

The curriculum provided from August 2008 through 2012 included modules on fetal heart rate interpretation and management, maternal collapse, eclampsia and hypertensive emergency, maternal hemorrhage, shoulder dystocia (SD), umbilical cord prolapse, forceps use and vaginal breech/twin deliveries. In 2013, we completed and deployed the North American adaptation of PROMPT-2™ that included new modules on sepsis and anesthetic emergencies. All sessions were conducted on campus in multi-professional teams, and woven throughout each were lessons on structured communication, teamwork and situational awareness and leadership. The importance and content of medical record documentation was stressed regularly.

To evaluate the ecological impact of annual PROMPT™ on outcomes, we used 2006 to 2014 Hospital quality assurance data including gestational age, route of delivery, 5-min Apgar score, umbilical artery (UA) pH, episiotomy and the diagnosis of hypoxic ischemic encephalopathy (HIE), SD and transient BPI (even if resolved by discharge). Apgar scores were assigned by Nursery/NICU nurses or pediatricians with few exceptions. Umbilical blood gases (artery and vein) were routinely sent to the Hospital laboratory. SD was diagnosed by the senior physician present and defined as a delivery requiring additional physician maneuvers to effect delivery to the body. There was no relevant missing data. The diagnosis of HIE adhered to standard pediatric definitions;[22] each case was reviewed and confirmed by the Division Head of Neonatology. Finally, the nursing opinion of the quality of nurse/physician communication was quantified using questions from a standard questionnaire administered annually by the University of Kansas Hospital.

Statistical analyses

University of Kansas Hospital employees prospectively collected the data as part of ongoing quality assurance efforts. The first author (CPW) was uninvolved with data collection. Multiple data sources were cross-referenced to assure completeness including hospital and physician discharge diagnoses, written and electronic medical records, handwritten delivery and nursery logs, primary laboratory records, and obstetrical and nursery Quality Assurance records derived from source records to assure all events were identified. The Human Resources Division at University of Kansas Hospital provided the nursing survey results.

Rates are presented as the annual proportion of all eligible deliveries. The number of term deliveries ($\geqslant 37^{0/7}$ weeks) was used to produce annual rates for 5 min Apgar < 7, UA pH < 7.00 and HIE. The number of vaginal deliveries was used as the denominator for the calculation of SD and BPI rates. The total annual rate of cesarean delivery was calculated using the total number of deliveries. Quarterly episiotomy rates were derived from the UHS Clinical Data Base/Resource Manager. All statistical analyses were performed independently by one of the authors (CLS) who applied an events/trials approach to evaluate linear changes in annual proportions over time (SAS, Version 9.1.3, Cary, NC, USA). The first author (CPW) was uninvolved with the performance of any analyses. Differences were considered to be statistically significant at $P < 0.05$.

Health-care costs avoided were estimated on the basis of annual rate changes from pre-PROMPT™ initiation and estimates of costs per adverse outcome. We used published cost estimates for cesarean delivery and HIE.[23,24]

RESULTS

The total number of course participants rose during 2008 to 2014 before plateauing (Table 1). The number of OB-GYN faculty trained also rose, but their average age declined by almost 20 years ($P < 0.01$).

The number of total deliveries rose ($P < 0.01$, Table 2). The total cesarean delivery rate remained stable from 2006 to 2009, but thereafter declined progressively, reaching a nadir of 21.8% in 2013. The episiotomy rate also declined beginning from the time it was first collated and verified as part of our 2010 QA process (Figure 1).

The annual proportion of a UA pH of < 7.00 among term deliveries uncomplicated by major fetal malformation appeared to decline (Table 2), but did not reach statistical significance. However, we observed that three quarters (9/12) of the low UA pH measurements from 2011 to 2013 were associated with catastrophic events that typically occurred off the Labor floor and all outside the oversight of the obstetric team (maternal respiratory arrest ($n = 1$), $> 50\%$ placental abruption ($n = 5$), uterine rupture ($n = 2$) and umbilical cord prolapse ($n = 1$)). The decline in the rate of metabolic acidemia was significant ($P < 0.01$) when catastrophic events were excluded.

There was a progressive and sustained but statistically insignificant decline in HIE from 2008 to 2014. There was also a stepwise decline in the number of term neonates undergoing whole body cooling, which began at KU Hospital in 2010, from 2.28 to 0.68 per 1000.

We do not have complete, long-term follow-up of cases that were symptomatic at discharge and thus cannot report the permanent BPI rate. Before initiating PROMPT™, the rate of at least transient BPI associated with SD was 10.7%. That rate declined progressively and significantly during 2008 to 2014 ($P < 0.01$, Table 2). Although the proportion of vaginal births complicated by SD increased slightly over time ($P = 0.04$), the proportion of SDs associated with BPI decreased ($P < 0.01$). There was only one transient BPI associated with SD between 2011 and 2014. It occurred in 2014 with a term macrosomic infant; all symptoms resolved during the neonatal period. If we assume all permanent injuries are preceded by a transient injury, then the permanent injury rate for BPI per SD was 0% from 2011 to 2014 *despite* declining cesarean delivery and episiotomy rates, and a younger physician workforce.

Teamwork and communication are central to the PROMPT™. We reasoned that improved interactions among the multi-professional health-care team on the Labor Suite should be associated with a more favorable nursing opinion of their

Table 2. Obstetrical patient outcomes at the University of Kansas Medical Hospital, 2006–2014

Year	*Number of deliveries*	*C/S deliveries (%)*	*Term deliveries (>37 weeks gestation)*				*Vaginal deliveries*		
			5 min Apgar <7 (%)	*UA pH < 7.00 (%)*	*HIE (%)*	*HIE per 1000[a]*	*SD (%)*	*Transient BPI (%)*	*Transient BPI/SD (%)*
2006	1436	423 (29.5)	12 (0.95)	NA	NA	NA	NA	NA	NA
2007	1541	458 (29.7)	25 (1.85)	13 (0.96)	NA	NA	30 (2.77)	NA	NA
2008	1513	467 (30.9)	10 (0.76)	1 (0.08)	2 (0.15)	1.52	28 (2.68)	3 (0.29)	10.7
2009	1587	470 (29.6)	18 (1.34)	0 (0.00)	2 (0.15)	1.48	48 (4.30)	5 (0.45)	10.4
2010	1529	398 (26.0)	5 (0.38)	3 (0.23)	2 (0.15)	1.53	37 (3.27)	2 (0.18)	5.4
2011	1643	368 (22.4)	20 (1.45)	2 (0.15)	1 (0.07)	0.73	45 (3.53)	0 (0.00)	0.0
2012	1720	396 (23.0)	19 (1.30)	6 (0.41)	1 (0.07)	0.68	50 (3.78)	0 (0.00)	0.0
2013	1670	364 (21.8)	25 (1.78)	4 (0.28)	1 (0.07)	0.71	46 (3.52)	0 (0.00)	0.0
2014	1670	397 (23.8)	17 (1.19)	2 (0.14)	1 (0.07)	0.69	5 57 (4.48)	1 (0.07)	1.7
P-value	<0.01↑	<0.01↓	0.42	0.06	0.34	0.12	0.04↑	<0.01↓	<0.01↓

Abbreviations: BPI, at least transient brachial plexus injury; C/S, cesarean section delivery; HIE, hypoxic ischemic encephalopathy; NA, not applicable; SD, shoulder dystocia; UA, umbilical artery. The number of term deliveries with a UA pH of <7.00 decreased significantly between 2007 and 2014 when catastrophic delivery events were excluded ($P < 0.01$) (e.g., maternal collapse, uterine rupture and complete abruption; 9 of the 12 in 2011, 2012 and 2013).
[a]Per 1000 term deliveries.

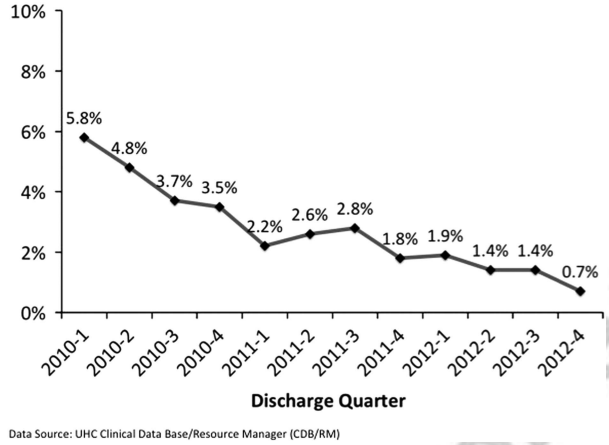

Figure 1. Episiotomy rate, University of Kansas Hospital, 2010 to 2012. The quarterly rate of episiotomy for vaginal deliveries. *Metric Definition*: The numerator includes vaginal deliveries without instrumentation discharges (MS-DRGs 774, 775, 767 and 768) with an ICD-9 procedure code indicating an episiotomy of 73.6. The denominator includes all vaginal deliveries without instrumentation discharges (MS-DRGs 774, 775, 767 and 768). Deliveries coded with a shoulder dystocia (ICD-9 diagnosis codes: 660.40 and 660.41) or with an ICD-9 procedure code indicating instrument-assisted delivery (72.0, 72.1, 72.21, 72.29, 72.31, 72.39, 72.4, 72.51, 72.53, 72.6, 72.71, 72.79, 72.8 and 72.9) are excluded from both the numerator and the denominator. Data on non-viable neonates and hospice discharges are excluded.

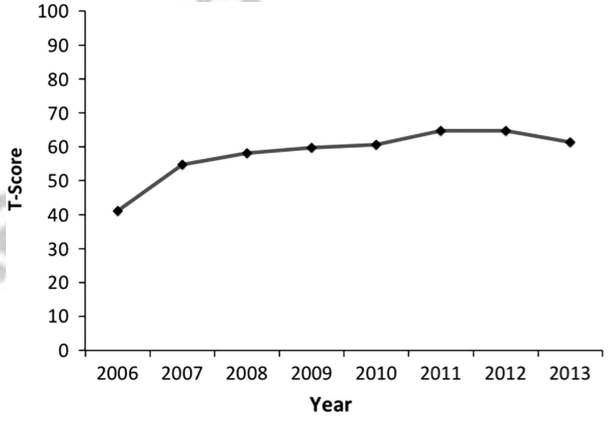

Figure 2. Obstetric nursing satisfaction with physician interactions, University of Kansas Hospital, 2006 to 2013. **T*-score scale: <40 = low satisfaction, 40–60 = moderate satisfaction, >60 = high satisfaction. Data demonstrate a significant increase in satisfaction ($P < 0.001$).

communications with the physician staff. To test that hypothesis, we reviewed the results of a standardized questionnaire administered each Spring by the University of Kansas Hospital to all nursing staff, and compared obstetric nurse scores for RN–MD interactions during the 2-year period before and the 6-year period after the PROMPT™ was initiated (2014 not available at submission). There was a significant improvement in the nurses' perception of their interactions with the physician staff (Figure 2).

DISCUSSION

The present experience suggests that PROMPT™ is exportable to the United States and applicable to a hospital with a delivery volume of 1200 to 2000. Annual PROMPT™ participation after adaptation to North American workflows and practices duplicated many of the results achieved by the original UK-based PROMPT™ program. There were significant and progressive declines in the annual rates of BPI as a proportion of both those complicated by SD and all vaginal deliveries, and a decline in the rate of fetal acidemia in otherwise healthy term neonates despite significant decreases in obstetric interventions such as cesarean delivery and episiotomy. The sustained decline in the rates of HIE and neonates undergoing total body cooling paralleled a significant decline in acidemia at birth, but did not reach statistical significance, perhaps because of the delivery volume. However, the annual rate of HIE achieved happens to be the same reduction reported in the RCT that served as the foundation for PROMPT™.[15]

In 2007, the SD rate at the University of Kansas Hospital and its associated rate of at least transient BPI mirrored the published literature.[25] After the initiation of PROMPT™, the rate of BPI declined progressively. Assuming a 10.7% baseline rate of BPI per SD as documented when the PROMPT™ intervention was initiated, we should have had at least 26 to 30 BPIs during the

Table 3. Costs avoided by improved outcomes ecologically associated with the PROMPT™ University of Kansas Hospital, 2008–2014

Year	*C/S prevented (31% rate)*	*C/S $ saved*[22]	*HIE prevented (0.15% rate)*	*HIE $ saved*[23]	*BPI prevented (0.29% rate)*	*BPI $ savings (estimate)*
2008	1	6886	0	0	0	0
2009	21	144 606	0	0	0	0
2010	75	516 450	0	0	1	500 000
2011	140	964 040	1	6 700 000	3	1 500 000
2012	136	936 496	1	6 700 000	3	1 500 000
2013	153	1 053 558	1	6 700 000	3	1 500 000
2014	121	833 206	1	6 700 000	5	2 500 000
Total	647	4 455 242	4	26 800 000	15	7 500 000

Abbreviations: BPI, transient/permanent brachial plexus injury; C/S, cesarean section delivery; HIE, hypoxic ischemic encephalopathy. Total potential cost savings: $38 755 242.

7 years. Instead, there were only 11, and no permanent injuries during 2011 to 2014. This reduction in BPI contrasts with the experience of Mackenzie *et al.*,[10] who found the BPI rate increased after the introducing a different simulation training technique for SD. This suggests that all training is not the same.

Medical negligence costs for BPI are among the highest obstetric liabilities in the United States, with settlements often exceeding $10 million. We could not locate an estimate for the average medical costs of either a transient or a permanent BPI associated with SD, nor for the average total liability cost (cost of legal proceedings and settlement) for a permanent BPI. However, another neurologic damage disorder with a wide range of health and negligence impact, spina bifida, has an estimated average excess health-care cost of $850 000 (excludes liability costs) for the first 65 years of life.[26] For illustrative purposes, we assumed the average total lifetime cost of a BPI in the United States (combined transient and permanent, medical and liability costs) was $500 000. Using this figure as a placeholder, our 7-year experience with PROMPT™ was ecologically associated with an avoidance of $7.5 million dollars US (Table 3). Whether the actual costs of BPI are more or less, it is clear that the savings to society are significant.

The incidence of HIE in developed countries approximates 1.5 per 1000 live births,[24] which was similar to the pre-PROMPT™ rate at the University of Kansas Hospital. It has been estimated the excess lifetime medical cost of HIE approximates $6.7 million in 2003 US dollars (excludes any associated negligence costs).[24] Over the 7 years PROMPT™ has been required at the University of Kansas Hospital, the HIE rate declined progressively by 54.6%. Though the decline did not achieve statistical significance, the 50% reduction is similar to that observed in the UK PROMPT-RCT[19] and correlates with the decline in high cord lactate rates observed following the Australian deployment of PROMPT™.[27] Considering the significant and progressive declines in the rates of non-catastrophic UA pH <7.00 at term (where the health-care team had the opportunity to intervene) (Table 2) coupled to the parallel decrease in the rate of neonatal head cooling, it is reasonable to consider the decline in HIE as biologically plausible and estimate the potential costs avoided at $26 800 000 US (Table 3).

In light of the $>80\%$ decrease in non-catastrophic UA pH <7.00 at term, we were surprised that there was no corresponding decrease in the rate of low 5-min Apgar scores at term. This was consistent with the Australian experience with initiating the PROMPT™ program.[3] We were surprised to discover our average low 5-min Apgar rate in term newborns (1.03%) was higher than that reported in the literature (0.45 to 0.76%[28]). We confirmed how our nursery staff assigns scores, and that the guidelines for their assignment had not changed over the time period studied. However, we learned that in contrast to the 1-min Apgar score, which was assigned contemporaneously in the delivery room, the 5-min score was typically assigned after the newborn transferred to the nursery and often many hours after birth. It is possible that this practice leads to some recall bias, and we now stress contemporaneous assignment of the 5-min Apgar score.

When we initiated PROMPT™ in August 2008, the cesarean section rate of 31% approximated the national average. Though PROMPT™ does not include a specific module on indications for cesarean delivery, it is clear that a previously stable cesarean section rate declined progressively after the initiation of PROMPT™, reaching a nadir of 21.8% in 2013. We suspect that the previously demonstrated improvements in teamwork, communication and clinical knowledge from PROMPT™ participation are responsible for the decline.[15–21] Regardless of the explanation for the decline in cesarean deliveries, the costs avoided are substantial. Using an incremental direct cost for cesarean delivery over vaginal delivery of $6886 (2011 US dollars, excluding costs of surgical complications and any additional charge by obstetric or anesthesia providers or the hospital for newborn care),[23] annual PROMPT™ participation was associated with a cost avoidance of more than $4.4 million (Table 3).

In aggregate, annual PROMPT™ participation of obstetric staff at the University of Kansas Hospital was ecologically associated with an estimated cost avoidance of more than $30 million US *excluding* the estimated cost of BPI. It is unfortunate that there is no standard in the United States for the costs to be included in such determinations. However, there are population-wide data available for England, where the UK National Health Service reported the total cost of clinical negligence for maternity care in England during the decade of 2000 to 2009.[29] The average total negligence cost per delivery approximated £600 Sterling (or about $900 to $1000 US). In contrast, the average negligence cost per delivery at the Southmead Hospital, Bristol, where PROMPT™ originated and has been an annual requirement for more than a decade, was a tenth of the national average. Clearly, improving patient outcome presents an incredible opportunity to maximize the return on the health-care dollar.

This is the first report of PROMPT™, a program of annual local multi-professional training in the United States, whose health-care system is fundamentally different from that of the United Kingdom. The period of study (7 years) exceeds the duration for all PROMPT sites with the exception of Bristol, UK. The intervention was deployed over a 4-month interval, and discrete obstetric outcomes compared before and after the intervention. Our experience indicates that the core themes of PROMPT™ are exportable to other health-care systems and to hospitals with a considerably lower delivery census than the 6500 annual deliveries at Southmead Hospital, Bristol, UK.

This was not a randomized trial and thus subject to all flaws of any observational study. While the improvements were temporally associated with PROMPT™, and the types and magnitude of improvements mirrored the experiences of hospitals outside

North America who initiated PROMPT™, we cannot make causal conclusions.

We have actively sought other events occurring during the same period of time that might have contributed to the improved outcomes independent of PROMPT™. In 2006, we initiated weekly sessions where obstetric physician trainees interpreted fetal heart rate tracings blind to any clinical information with the goal of predicting the umbilical cord blood gases at birth. This practice continues today, and we cannot exclude the possibility such drills contributed to lower rates of fetal acidemia and cesarean delivery. However, those rates did not even begin to decline until 2009, more than 3 years after training started and 1 year after the initiation of PROMPT™. In 2011, the University of Kansas Hospital initiated the portion of TeamSTEPPS[30] associated with structured patient handoffs and periodic updates. As this activity is integral to PROMPT™, the Hospital-wide initiative had no impact on practices in the Labor Suite.

As it relates to the significant decline in the rate of cesarean delivery, the rate of operative vaginal delivery has not changed appreciably and the rate of episiotomy continued to decline. We have historically encouraged vaginal birth after cesarean, but there is no evidence the vaginal birth after cesarean rate has increased. In 2007, we initiated a daytime laborist model of care whereby one faculty member staffed the Labor Suite during the day for a week at a time, an action that reduced the number of patient handoffs. However, the cesarean section rate did not begin to decline until 2010, 3 years after the addition of the laborist. In 2013, we expanded the laborist model to the night by hiring a faculty member to work from 1700 to 0800 hours from Sunday through Thursday. While 2013 coincides with our lowest annual cesarean delivery rate, the cesarean rates were similar when we compared the four nights staffed by our nocturnist to the three nights staffed by rotating obstetrical faculty. Finally, the decline in cesarean delivery was not the result of fewer complicated deliveries, as the associated Case Mix Index actually increased 9%, indicating that the obstetric patients cared for during the PROMPT™ period were actually more complicated than pre PROMPT™. One potential explanation for the continued decline in cesarean delivery is that after successive years of a decreasing primary cesarean rate, the number of repeated cesarean deliveries was declining. We have refined our documentation to make such study possible in the future. We can say now that the primary cesarean section rate from July 2014 through June 2015 was 10.6%.

We made several mistakes when initiating PROMPT™ at the University of Kansas Hospital. The greatest among them was not prospectively setting up a real-time monitoring system for patient outcomes. Ideally, such a system would be built into the electronic medical record system for contemporaneous entry and designed for easy extraction. An example of the current University of Kansas Hospital Obstetric Dashboard is shown in Supplementary information.

The originators of PROMPT™ studied the contributions of training components extensively (summarized in Siassakos *et al.*[1] and Collins *et al.*[14]). PROMPT™ involves multi-professional teams to reflect actual practice patterns. The beneficial impact of training on team knowledge and performance is well documented, but declines after 12 months. Training is conducted locally, which allows all health-care personnel to train together at the lowest cost, facilitating the identification of local issues that might interfere with effective patient care. Throughout the program, PROMPT™ combines teamwork and structured communication while encouraging situational awareness and leadership.

We found that PROMPT™ was adaptable to North American practices and associated with improvements in diverse patient outcomes. The experience indicates that the core themes of PROMPT™ are exportable to health-care systems different from the United Kingdom and to hospitals with <2000 deliveries per annum.

CONFLICT OF INTEREST

Dr Weiner has directed without compensation PROMPT™ North America, a licensee of PROMPT Maternity, providing postgraduate multi-professional training to hospitals in the United States for obstetrical emergencies since April 2013. He has received less than $5000 per year serving as an instructor for PROMPT™ Train the Trainer courses.

ACKNOWLEDGEMENTS

We are grateful to all the obstetrical staff who have annually contributed their time to PROMPT and the University of Kansas Hospital leadership for their public and financial support of PROMPT. We wish to thank Dr Prabhu Parimi, Professor and Division Head of Neonatology at the University of Kansas, for reviewing each patient with a diagnosis of HIE. Finally, we thank the team at PROMPT Maternity, Bristol, UK, a registered UK charity for all of their assistance over the last decade. This project was a product of annual Quality Assessment activities conducted by the University of Kansas Hospital. Quality Assessment activities such as these are generally considered exempt from Human Subjects Committee approval.

AUTHOR CONTRIBUTIONS

CPW directs the PROMPT™ program at the University of Kansas Hospital. He conceived of the study and is the primary author of the manuscript. He was intentionally excluded from data collection and analyses. LC is the Nurse Manager of the University of Kansas Labor Suite. She participated in data collection, and has read, edited and approved the content of the final manuscript. SB is a nurse midwife who was responsible for the Quality Assessment of obstetrics at the University of Kansas Hospital. She participated in data collection, and read, edited and approved the content of the final manuscript. YD is the Division Director of Research at the University of Kansas. He offered suggestions on the approach taken, and read, edited and approved the content of the final manuscript. CS is a faculty member in the Department of Preventative Medicine at the University of Kansas. She performed all the statistical analyses, provided interpretation of the results, and read, edited and approved the content of the final manuscript.

REFERENCES

1 Siassakos D, Crofts JF, Winter C, Weiner CP, Draycott TJ. The active components of effective training in obstetric emergencies. *BJOG* 2009; **116**: 1028–1032.
2 Walker LJ, Fetherston CM, McMurray A. Perceived changes in the knowledge and confidence of doctors and midwives to manage obstetric emergencies following completion of an Advanced Life Support in Obstetrics course in Australia. *Aust NZ J Obstet Gynaecol* 2013; **53**: 525–531.
3 Woiski MD, Hermens RP, Middeldorp JM, Kremer JA, Marcus MA, Wouters MG *et al.* Haemorrhagia post partum; an implementation study on the evidence-based guideline of the Dutch Society of Obstetrics and Gynaecology (NVOG) and the MOET (Managing Obstetric Emergencies and Trauma-course) instructions; the Fluxim study. *BMC Pregnancy Childbirth* 2010; **10**: 5.
4 Gardner R, Walzer TB, Simon R, Raemer DB. Obstetric simulation as a risk control strategy: course design and evaluation. *Simul Healthc* 2008; **3**: 119–127.
5 Thanh NX, Jacobs P, Wanke MI, Hense A, Sauve R. Outcomes of the introduction of the MOREOB continuing education program in Alberta. *J Obstet Gynaecol Can* 2010; **32**: 749–755.
6 Robertson B, Schumacher L, Gosman G, Kanfer R, Kelley M, DeVita M. Simulation-based crisis team training for multidisciplinary obstetric providers. *Simul Healthc* 2009; **4**: 77–83.
7 MacEachin SR, Lopez CM, Powell KJ, Corbett NL. The fetal heart rate collaborative practice project: situational awareness in electronic fetal monitoring-a Kaiser Permanente Perinatal Patient Safety Program Initiative. *J Perinat Neonatal Nurs* 2009; **23**: 314–323.
8 Sørensen JL, Løkkegaard E, Johansen M, Ringsted C, Kreiner S, McAleer S. The implementation and evaluation of a mandatory multi-professional obstetric skills training program. *Acta Obstet Gynecol Scand* 2009; **88**: 1107–1117.
9 Inglis SR, Feier N, Chetiyaar JB, Naylor MH, Sumersille M, Cervellione KL *et al.* Effects of shoulder dystocia training on the incidence of brachial plexus injury. *Am J Obstet Gynecol* 2011; **204**: 322.e1–6.

10 MacKenzie IZ, Shah M, Lean K, Dutton S, Newdick H, Tucker DE. Management of shoulder dystocia: trends in incidence and maternal and neonatal morbidity. *Obstet Gynecol* 2007; **110**: 1059–1068.
11 Nielsen PE, Goldman MB, Mann S, Shapiro DE, Marcus RG, Pratt SD *et al.* Effects of teamwork training on adverse outcomes and process of care in labor and delivery: a randomized controlled trial. *Obstet Gynecol* 2007; **109**: 48–55.
12 Phipps MG, Lindquist DG, McConaughey E, O'Brien JA, Raker CA, Paglia MJ. Outcomes from a labor and delivery team-training program with simulation component. *Am J Obstet Gynecol* 2012; **206**: 3–9.
13 Wagner B, Meirowitz N, Shah J, Nanda D, Reggio L, Cohen P *et al.* Comprehensive perinatal safety initiative to reduce adverse obstetric events. *J Healthc Qual* 2012; **34**: 6–15.
14 Collins K, Draycott TJ, Crofts JF, Siassakos D, Winter C, Weiner CP *et al.* Myths and realities of training for obstetric emergencies. *Best Pract Res Clin Obstet Gynecol* 2015; **S1521-6934**(15): 00127–00310.
15 Crofts JF, Ellis D, Draycott TJ, Winter C, Hunt LP, Akande VA. Change in knowledge of midwives and obstetricians following obstetric emergency training: a randomised controlled trial of local hospital, simulation centre and teamwork training. *BJOG* 2007; **114**: 1534–1541.
16 Crofts JF, Fox R, Draycott TJ, Winter C, Hunt LP, Akande VA. Retention of factual knowledge after practical training for intrapartum emergencies. *Int J Gynaecol Obstet* 2013; **123**: 83–85.
17 Ellis D, Crofts JF, Hunt LP, Read M, Fox R, James M. Hospital, simulation center, and teamwork training for eclampsia management: a randomized controlled trial. *Obstet Gynecol* 2008; **111**: 723–731.
18 Crofts JF, Bartlett C, Ellis D, Hunt LP, Fox R, Draycott TJ. Management of shoulder dystocia: skill retention 6 and 12 months after training. *Obstet Gynecol* 2007; **110**: 1069–1074.
19 Draycott T, Sibanda T, Owen L, Akande V, Winter C, Reading S *et al.* Does training in obstetric emergencies improve neonatal outcome? *BJOG* 2006; **113**: 177–182.
20 Draycott TJ, Crofts JF, Ash JP, Wilson LV, Yard E, Sibanda T *et al.* Improving neonatal outcome through practical shoulder dystocia training. *Obstet Gynecol* 2008; **112**: 14–20.
21 Siassakos D, Hasafa Z, Sibanda T, Fox R, Donald F, Winter C *et al.* Retrospective cohort study of diagnosis-delivery interval with umbilical cord prolapse: the effect of team training. *BJOG* 2009; **116**: 1089–1096.
22 Use and abuse of the APGAR score. Committee on fetus and Newborn, American Academy of Pediatrics, and Committee on Obstetric Practice, American College of Obstetrics and Gynecology. *Pediatrics* 1996; **98**: 141–142.
23 US Agency for Healthcare Research and Quality, HCUPnet, Healthcare Cost and Utilization Project. Rockville, MD: AHRQ. Available at http://hcupnet.ahrq.gov/.
24 Centers for Disease Control and Prevention. Economic costs associated with mental retardation, cerebral palsy, hearing loss, and vision impairment—United States, 2003. *MMWR Morb Mortal Wkly Rep* 2004; **53**: 57–59.
25 Grobman W. Shoulder dystocia. *Obstet Gynecol Clin North Am* 2013; **40**: 59–67.
26 Ouyang L, Grosse SD, Armour BS, Waitzman NJ. Health care expenditures of children and adults with spina bifida in a privately insured U.S. population. *Birth Defects Res A Clin Mol Teratol* 2007; **79**: 552–558.
27 Shoushtarian M, Barnett M, McMahon F, Ferris J. Impact of introducing Practical Obstetric Multi-Professional Training (PROMPT) into Maternity Units in Victoria, Australia. *BJOG* 2014; **121**: 1710–1718.
28 Thorngren-Jerneck K, Herbst A. Low 5-minute Apgar score: a population-based register study of 1 million term births. *Obstet Gynecol* 2001; **98**: 65–70.
29 NHSLA Report – An analysis of NHS Litigation, October 2012.
30 Stead K, Kumar S, Schultz TJ, Tiver S, Pirone CJ, Adams RJ *et al.* Teams communicating through STEPPS. *Med J Aust* 2009; **190**(11 Suppl): S128–S132.

Q9

Supplementary Information accompanies the paper on the Journal of Perinatology website (http://www.nature.com/jp)