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Impact of Educational Video on Critical Congenital Heart Disease Screening

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Abstract

Objective: To assess the status of pulse oximetry screening and barriers to implementing screening programs. **Methods:** This was a prospective pre-post intervention survey of nurse managers and medical directors of hospital-based birthing centers in Oregon, Idaho, and Southern Washington. The intervention was a 7-minute video demonstrating and discussing pulse oximetry screening for critical congenital heart disease. **Results:** Analysis of matched pairs showed a significant increase in the use of pulse oximetry screening during the study period from 52% to 73% ($P < .0001$). Following implementation of the video, the perception of all queried potential barriers decreased significantly among individuals from hospitals self-identified as nonscreening at baseline. Viewing the educational video was associated with an increase in the percentage of individuals from nonscreening hospitals that rated screening as "very beneficial" (45% vs 90%, $P = .0001$). **Conclusions:** An educational video was associated with improved opinions of pulse oximetry screening among hospitals not currently screening.

Keywords

pulse oximetry, congenital heart disease/defects, educational intervention

Introduction

Congenital heart disease is the most common birth defect, affecting approximately 81 newborns per 10 000 live births.[1] Critical congenital heart defects (CCHDs), or those requiring surgical or catheter intervention in the first month of life, affect 10 to 18 newborns per 10 000 live births.[1-3] Despite effective treatment, congenital heart disease is responsible for up to 10% of all infant deaths and up to 40% of deaths caused by a congenital malformation.[4] This high mortality rate is in part because of difficulty in diagnosing CCHD in asymptomatic infants. Furthermore, studies have shown that CCHD is diagnosed prenatally by ultrasound in less than half of affected pregnancies.[5-7] Approximately 25% of infants with CCHD leave the hospital undiagnosed, and another 5% are diagnosed at autopsy.[2]

Pulse oximetry is a noninvasive and validated screening strategy for CCHD. In September 2011, the US Health and Human Services Secretary's Advisory Committee on Heritable Disorders in Newborns and Children (SACHDNC) recommended that CCHD be added to the uniform screening panel for newborns.[8] This recommendation was based on the 2009 statement from the American Academy of Pediatrics (AAP) and American Heart Association (AHA), which found evidence supporting pulse oximetry screening in newborns.[9] A large prospective study of nearly 40 000 newborns in Sweden added further support.[10] The SACHDNC in collaboration with the AAP and AHA then outlined implementation strategies for universal pulse oximetry screening.[11] These guidelines recommend that CCHD be excluded via echocardiography—either on-site, via telemedicine, or by transport to another facility—in any newborn who fails pulse oximetry screening "in the absence of other findings to explain the hypoxemia."[11]

Because of these recommendations, there is an interest in large-scale implementation of screening programs. Although many states have proposed and/or have passed legislation mandating screening, a

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thorough understanding of barriers to implementation of screening programs does not exist. Prior to the 2011 endorsement for universal screening, research by Bradshaw et al[12] suggested that implementation of a screening program in a large community hospital was feasible with low barriers and little resource drain. However, immediate access to pediatric cardiologists and on-site echocardiography is not readily available in all birthing facilities. The Pacific Northwest, for example, includes several large states with limited access to pediatric cardiologists. The primary goal of our study was to assess the status of pulse oximetry screening in the Pacific Northwest and the impact of an educational video on that status. Another goal was to understand perceived barriers to screening and the perception of harm and/or benefit of screening. We hypothesized that the frequency of pulse oximetry screening for CCHD in hospitals would increase and the frequency of perceived barriers would decrease following distribution of our educational video.

Methods

Overview

The institutional review board of Oregon Health & Science University approved the study. We conducted a prospective pre-post intervention survey study. Study participants included nurse managers and medical directors of hospital-based birthing centers in Oregon, Idaho, and Southern Washington. Investigators created a list of eligible birthing centers using governmental listings of hospitals providing well-newborn care. The only Pacific Northwest region excluded was Seattle, Washington, because of its role as a distinct catchment area. Freestanding birth centers and practices that included only home births were excluded.

The primary outcome measured in the study was the proportion of hospitals performing pulse oximetry screening on newborns prior to and after the intervention. Secondary outcomes included perceived benefit and/or harm of screening and barriers to screening.

Intervention

We created a video highlighting the importance of pulse oximetry screening for CCHD and demonstrating validated screening algorithms, including the 2011 AAP screening algorithm.[11] To address potential barriers to screening, the video highlighted the low false-positive rate and cost-effectiveness of pulse oximetry screening. The video offered strategies for successful implementation, such as clustering screening with routine nursing assessments and using reusable probes. Approximately 7 minutes in duration, the video was available online at http://www.ohsu.edu/medialab/files/beta_pulseOxScr.mov.

Survey Design/Distribution

Because validated instruments to assess newborn screening practices are not readily available, investigators designed an instrument that was pilot tested and reviewed thoroughly by content experts and coinvestigators to ensure content and face validity. The preintervention and postintervention surveys included questions regarding current hospital practices of pulse oximetry screening and questions about opinions and potential barriers to screening. Questions regarding opinions and barriers used a 4-point Likert scale. The postintervention survey questioned the use and impact of our educational video.

We distributed the preintervention survey and video in September 2012. We distributed the postintervention survey in January 2013. Surveys were distributed electronically to potential participants with readily available e-mail addresses, and the rest were mailed. Electronic reminders were distributed in 5 subsequent waves for each survey targeting nonresponders. Telephone reminders were made to nonresponders in 2 waves.

Statistical Analysis

Analyses included comparisons of hospital characteristics at baseline and changes in respondents' opinions before and after viewing the video. All analyses were conducted using Stata 11.2 (StataCorp); $P < .05$ was regarded as statistically significant.

We compared baseline hospital characteristics using t tests for continuous and χ^2 or Fisher's exact test for categorical variables. When examining the relationship between universal screening status at baseline and access to cardiology, echocardiography, and telemedicine, we used exact logistic regression to adjust for hospital size, coded as above or below the median number of labor and delivery beds. To analyze hospital characteristics and practices, we used 1 survey response per hospital. If the nurse manager and medical director for a hospital responded, we used the medical director's responses, supplementing missing items with the nurse manager's responses.

To analyze changes in opinions, we linked prevideo and postvideo responses using unique respondent identifiers, excluding participants who answered only the prevideo ($n = 16$) or postvideo ($n = 10$) survey from matched analysis. We examined changes in opinions and ratings of barriers before and after watching the video using the Wilcoxon signed-rank test.

Table 1. Baseline Descriptive Characteristics of Participating Hospitals.

	Screening Status		
	Yes (n = 39)	No[a] (n = 34)	*P* Value
Labor and delivery beds, mean (SD)	13.1 (11.5)	10.1 (7.0)	.76
Deliveries/year, mean (SD)	839.6 (935.5)	684.1 (611.8)	.77
Access to cardiologist (%)	35 (90)	20 (59)	.003
Type of cardiologist[b] (%)			
Pediatric	6 (15)	2 (6)	.27
Adult	6 (15)	4 (12)	.74
Telephone or telemedicine	27 (69)	15 (44)	.036
Access to echocardiography (%)			
Yes	23 (66)	12 (36)	.004
No	12 (34)	14 (42)	
Sometimes		7 (21)	
Combined access to cardiologist and echocardiography[c] (%)			
Both	23 (66)	13 (39)	.011
Cardiologist only	9 (26)	7 (21)	
Echocardiography only	0 (0)	6 (18)	
Neither	3 (9)	7 (21)	
Telemedicine available (%)	11 (30)	9 (27)	>.99

Abbreviation: SD, standard deviation.
[a]No includes institutions that were planning to screen all newborns, those that were screening some newborns, and those not screening.
[b]Sum of numbers in this category is greater than those that reported "access to cardiologist" because more than 1 option could be selected.
[c]Access to echocardiography includes "sometimes" having access.

Results

Response Rate and Participation

In all, 96 hospitals were contacted (Oregon = 50, Idaho = 27, Southern Washington = 19). Of these, 76% (n = 73) and 70% (n = 67) responded to our preintervention and postintervention survey, respectively; 63% (n = 60) of hospitals responded to both surveys. Both the nurse manager and medical director responded from 10 hospitals; 83% and 80% of responses were from nurse managers during the preintervention and postintervention period, respectively. Also, 93% (n = 62) of responding hospitals had a participant who watched the educational video prior to the postintervention period.

Baseline Characteristics of Participating Hospitals

Baseline characteristics for participating hospitals are shown in Table 1. A higher percentage of screening institutions at baseline had access to a cardiologist (90% vs 59%, $P = .003$) and echocardiography (66% vs 36%, $P = .004$) compared with nonscreening institutions. There were no differences in mean number of labor and delivery beds, mean number of deliveries per year, or access to telemedicine. When hospitals were divided at the median number of beds, larger nurseries were significantly more likely to have access to echocardiography (75% vs 25%, $P < .001$) and on-site cardiology (37% vs 9%, $P = .005$). After adjusting for the number of labor and delivery beds, access to cardiology and echocardiography remained significantly associated with screening, though all the nurseries with access to echocardiography also had access to cardiology. The type of access to cardiology—on-site or by telemedicine—was not statistically significantly different. Screening and nonscreening hospitals reported similar telemedicine access (30% vs 27%, $p>0.99$).

Baseline Characteristics of Pulse Oximetry Screening Programs

Baseline characteristics of screening programs are shown in Table 2. Preductal and postductal saturations were obtained on all newborns by 80% (n = 31) of screening institutions. Thirty-six percent (n = 14) were using a reusable probe the majority of the time; 38% (n = 13) had a system for tracking results for quality assurance. One-third of screening programs (33%) obtained an echocardiogram on all positive screens. Additional characteristics including cutoff values used and timing of pulse oximetry screening are shown in Table 2.

Table 2. Baseline Characteristics of Pulse Oximetry Screening Programs.

	Screening Institutions (n = 39)
Written guideline for screening (%)	
Yes	33 (85)
Creating one	4 (10)
No	2 (5)
Probe type most often used (%)	
Reusable	14 (36)
Disposable	24 (62)
Both equally	1 (3)
Preductal and/or postductal saturation obtained (%)	
Both preductal and postductal saturation obtained	31 (80)
Postductal only	4 (10)
Preductal only	4 (10)
Preductal and postductal gradient calculated (%)	
Yes, on all newborns	30 (77)
As a supplement test only	2 (5)
No	7 (18)
Cutoff value used to repeat screening[a] (%)	
Using AAP value of <95%	23 (62)
Value less than AAP recommended	11 (30)
Cutoff value used to act on immediately[a] (%)	
Using AAP value of <90%	26 (76)
Value less than AAP recommended	2 (6)
Timing of pulse oximetry screening (%)	
After 24 hours or prior to discharge	34 (87)
Before 24 hours	5 (13)
Quality assurance tracking in place (%)	13 (38)
Obtain echocardiogram[b] (%)	
On all positive screens	13 (33)
Positive screens without other cause identified	9 (23)
If signs of congenital heart disease present	10 (26)
Cannot obtain echocardiogram	9 (23)

Abbreviation: AAP, American Academy of Pediatrics.
[a]Numbers in the group do not sum to total because they did not include those that were using a value higher than the AAP recommendation or those who did not know their institution's value.
[b]Sum of numbers in the group is greater than total because respondents could select more than 1 response for this question.

Primary Outcome: Impact of Educational Video on Status of Pulse Oximetry Screening

Analysis of matched pairs for the 60 hospitals that responded to both surveys showed a statistically significant increase in the status of pulse oximetry screening after the intervention ($P < .0001$; Table 3). Of these 60 hospitals, at baseline, 52% (n = 31) were performing pulse oximetry screening on all newborns, whereas 17% (n = 10) were planning to start screening. Following the intervention, 73% (n = 44) were performing pulse oximetry screening on all newborns, and 12% (n = 7) were planning to start screening (Table 3).

To determine whether the educational video affected pulse oximetry screening practices in the preintervention versus postintervention period, we asked if institutions changed practice or protocol as a result of the video. We found that 21% of institutions that were not screening at baseline (n = 6) reported that they implemented a pulse oximetry screening program in response to the video; 47% (n = 8) of nonscreening institutions during the postintervention period reported that they were considering implementing a screening protocol as a result of the video. Respondents reported that a total of 21 protocol modifications were made to existing programs as a result of the video. Described modifications included changing to a reusable probe, changing the time the test is performed, and adjustment of cutoff values used to identify a positive screen. Others stated that they established quality assurance tracking and changed criteria for obtaining an echocardiogram.

Table 3. Change in Frequency of Newborn Pulse Oximetry Screening Among Matched Responding Hospitals.

Screening Status	Prevideo (n = 60)	Postvideo (n = 60)	*P* Value
Yes, on all newborns (%)	31 (52)	44 (73)	<.0001
Planning to perform on all newborns (%)	10 (17)	7 (12)	
Yes, on some newborns (%)	11 (18)	7 (12)	
No (%)	8 (13)	2 (3)	

Secondary Outcome: Perceived Benefit/Harm of Pulse Oximetry Screening

Respondents rated opinions of pulse oximetry screening on a 4-point Likert scale (very harmful, somewhat harmful, somewhat beneficial, or very beneficial). At baseline, 84% (n = 32) of individuals from screening institutions compared with 45% (n = 15) of individuals from nonscreening institutions rated screening as "very beneficial" ($P < .0001$). Viewing of the educational video was associated with an increased percentage of individuals from nonscreening hospitals rating screening as "very beneficial" (45% vs 90%, $P = .0001$; Figure 1). When asked if the video affected participants' opinions, 31% (n = 18) reported that they now consider screening as "more beneficial" than previously. No respondent rated screening as "less beneficial" after the intervention.

Secondary Outcome: Barriers to Pulse Oximetry Screening

Using a 4-point Likert scale, survey respondents rated the degree to which they perceived factors as barriers to screening during both periods (not at all a barrier, mild barrier, moderate barrier, or major barrier). Matched-pair analysis of individuals from nonscreening hospitals at baseline showed a significant reduction in perceived barriers for all queried potential barriers following implementation of the intervention (Figure 2). During the postintervention period, the item most frequently rated as a barrier among respondents from nonscreening hospitals was lack of access to cardiology (45%, n = 14). Among respondents from screening hospitals, the items most frequently rated as barriers during the postintervention period were concerns for false positives and lack of access to cardiology, with 48% of respondents for each (n = 16).

Participants selected 1 potential barrier as the greatest barrier to implementing a screening program. The factors most frequently selected among individuals from nonscreening institutions were concerns for false positives (26%, n = 9) and lack of access to cardiology (18%, n = 6). Individuals from screening institutions most frequently reported time to train staff (27%, n = 10) and nursing time to perform pulse oximetry (16%, n = 6).

Discussion

About three-quarters (73%) of responding hospital-based nurseries in the Pacific Northwest are performing universal pulse oximetry screening for CCHD. Increased rates of screening during the postintervention period appeared to be directly related, at least in part, to viewing of our educational video. The overall perceived benefit of screening improved among nonscreening institutions following our intervention. The results of this study show that several barriers to screening exist, which may contribute to poor opinion of screening or hinder development of screening programs. The negative perception of these barriers decreased among nonscreening institutions following the intervention. Nearly half of nurseries regardless of screening status continued to consider limited access to cardiology as a barrier to screening.

Other projects to encourage large-scale implementation of pulse oximetry screening have been successful. The most successful projects coincided with legislative mandates; however, in our study, none of the included states passed legislation mandating screening during the study period. New Jersey was one of the first states to mandate screening for CCHD. The educational approach in New Jersey included a team of content experts that created and conducted a series of Web-based lectures.[13,14] During the first 3 months following implementation of the mandate, preliminary data showed that more than 98% of newborns in New Jersey were screened.[15] Hospitals reported that implementation of pulse oximetry screening posed minimal burden to their nursing staff.[15] However, this report was based on a sample of 11 of the 52 birthing facilities in New Jersey.

Although intensive interventions have been effective at increasing screening rates, the comparative potential impact of brief educational interventions is less understood. For example, in an effort to encourage universal pulse oximetry screening, a team at Children's National Medical Center created a "toolkit."[16] This toolkit, which has been distributed to more than 200 hospitals, contains

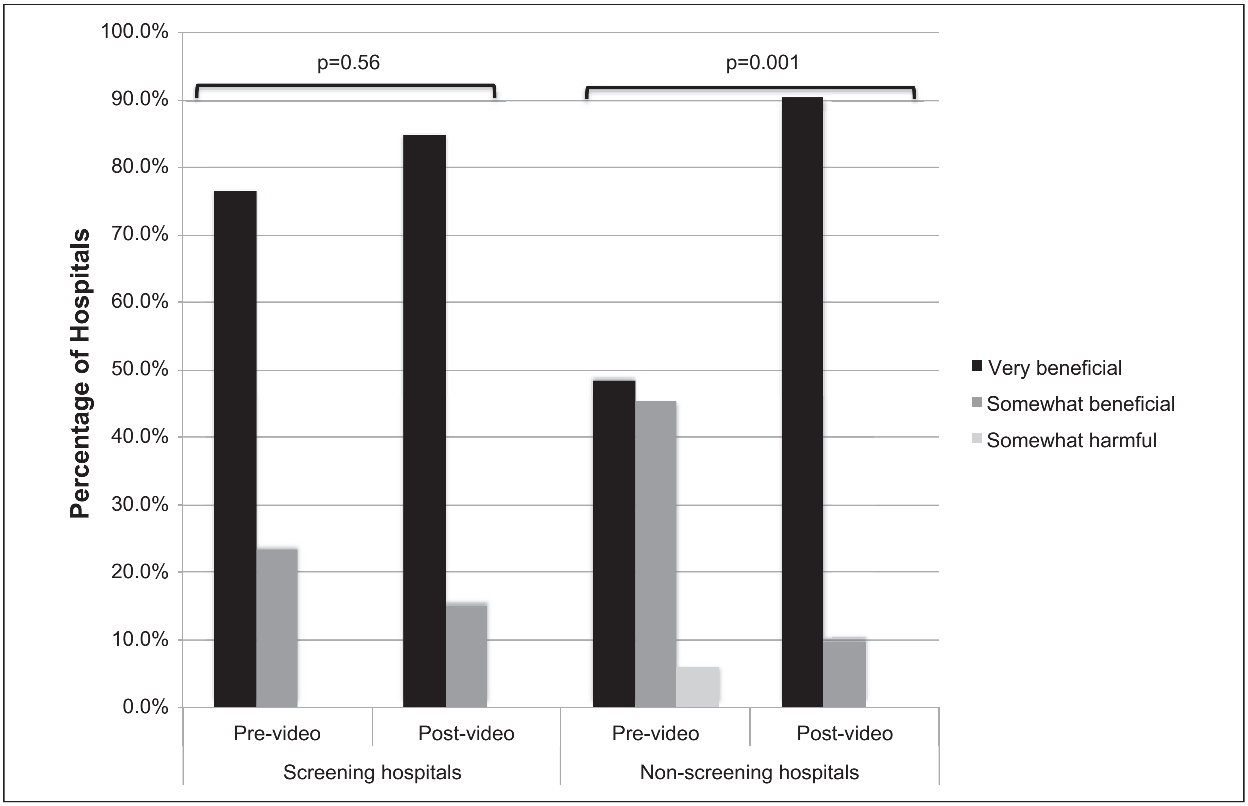

Figure 1. Impact of educational video on overall opinion of pulse oximetry screening among screening[a] and nonscreening[b] hospitals.

[a]Screening hospitals include those that were performing pulse oximetry on all newborns during the preintervention period.

[b]Nonscreening hospitals include those that were planning to perform pulse oximetry on all newborns, those performing it on some, and those performing on none during the preintervention period.

materials that include recommended steps to implement a CCHD screening program, resources for training staff, resources for educating families, and advocacy information.[16,17] Children's National also collaborated with the Health Authority of Abu Dhabi to conduct large-scale implementation of pulse oximetry screening, which consisted of on-site workshops in Abu Dhabi to train individuals that were then responsible for using the toolkit to train their staff.[13] Our educational approach, though more limited, was also associated with significant reductions in perceived barriers to screening and increased frequency of screening.

Results of previous studies assessing state resources and status of pulse oximetry screening differ from our results. For example, a survey of Wisconsin hospitals in 2011 found that 28% of hospitals were routinely using pulse oximetry screening for CCHD.[18] In June 2012, and a few months prior to the start of our study, Clark et al[19] conducted a survey that revealed that 31% of hospitals in Georgia were performing pulse oximetry screening, with another 28% planning to start screening in 2012. Both these states had lower frequencies of screening than that found in our study, which may in part be a result of the later date of our study. Both states' findings differed from ours in regard to status of screening and access to echocardiography. Screening and nonscreening hospitals had similar access to echocardiography and cardiologists in Georgia, whereas we found less access to cardiologists and echocardiography among nonscreening hospitals.[19] Wisconsin did not directly measure the relationship between screening status and access to echocardiography, but 13.6% of hospitals did not have access to echocardiography, representing only 3.4% of births in the surveyed hospitals.[18] These differences are likely related to the higher population density in Georgia and Wisconsin. In 2010, their population densities were more than 100 per square mile, whereas Oregon and Idaho, which made up the majority of the hospitals in our study, had densities of <40.[20]

According to AAP recommendations, if a newborn has a positive screen and an etiology for the hypoxemia cannot be readily determined, then CCHD must be excluded with the use of echocardiography, which may

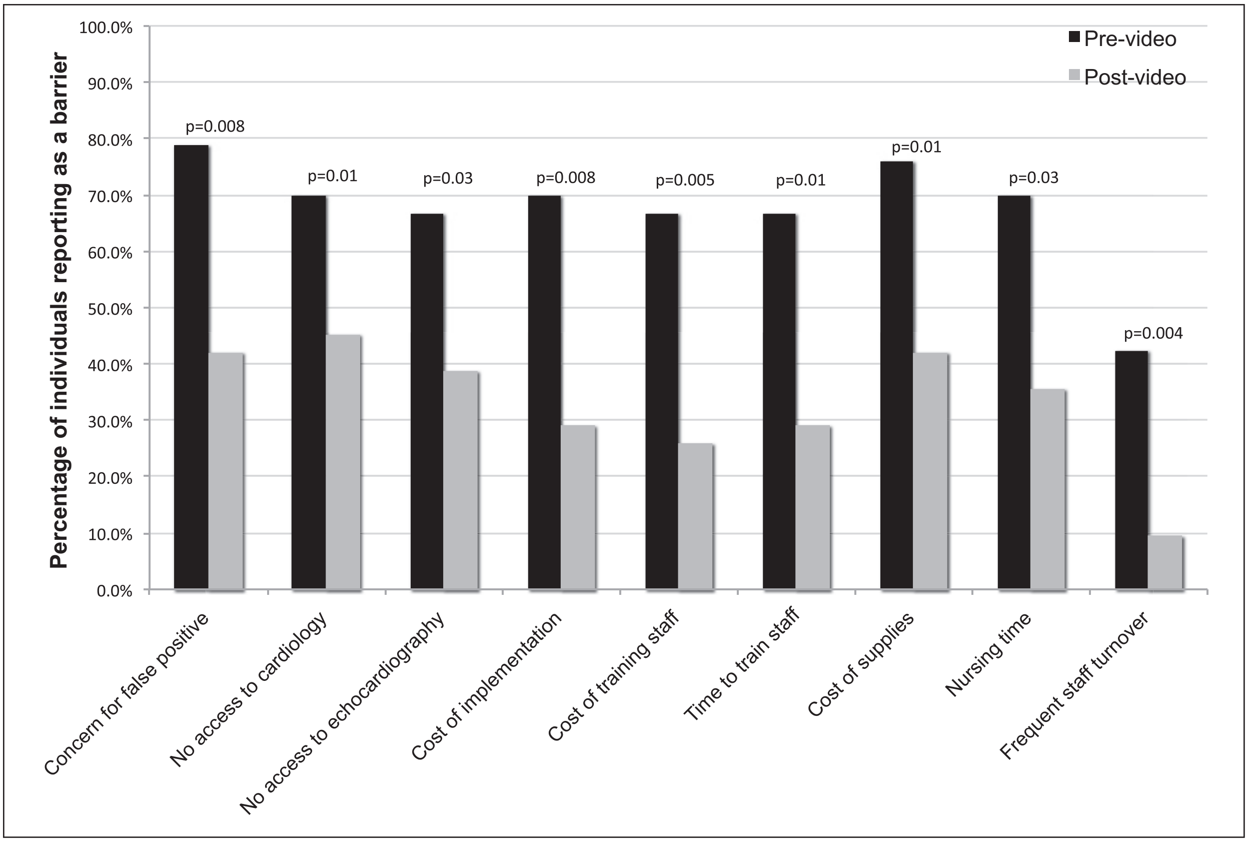

Figure 2. Impact of educational video on perceived barriers to screening among nonscreening hospitals.[a]
[a]Nonscreening hospitals include institutions that were planning to screen all newborns, those that were screening some newborns, and those not screening during the preintervention period.

require transport to another institution if echocardiography is not available.[11] The need to arrange transport to another institution may be significant, considering that a third of screening institutions in our region did not report access to echocardiography on-site. Access to echocardiography was closely related to access to cardiologists, with all hospitals with access to echocardiography also having access to cardiologists. Therefore, telemedicine may provide an option to address this barrier by improving access to both echocardiography and cardiologists and preventing unnecessary transfers. One study evaluating the impact of telemedicine on pediatric cardiology practice showed that telemedicine transmission of echocardiography substantially altered patient care and prevented unnecessary transfers.[21] Unfortunately, our study suggests that only about one-third of hospital-based nurseries in our region currently have access to telemedicine.

The AAP-recommended algorithm from 2011 includes oximetry screening for both preductal and postductal saturations.[11] The majority of institutions (80%) in our study are performing both preductal and postductal screening on all newborns. In June 2012, after the publication of the AAP-recommended algorithm, Thangaratinam et al[22] performed a meta-analysis that evaluated the difference between postductal saturation alone and preductal and postductal saturations. In this study, the false-positive rate and sensitivity were not statistically significantly different between the 2 methods but did trend toward a reduced false-positive rate and improved sensitivity with postductal screening alone.[22] Given these findings and our finding that the greatest barriers to screening include concerns for false positives, time to train staff, and nursing time, we propose that postductal oximetry screening alone should be further evaluated in order to simplify the process and potentially lower the false-positive rate. Additional research by Kochilas et al[23] suggests a more simplified algorithm, and education may be useful. After evaluating the compliance of pulse oximetry screening in Minnesota in 2012, Kochilas et al found that 21 newborns were incorrectly determined as "passes" or "failures" because of misinterpretation of the algorithm. Furthermore, we do not have information regarding current practice of or barriers to pulse oximetry screening in freestanding birthing centers or home births, and a simplified process would likely make implementing pulse oximetry for this population more feasible.

Martin et al[24] developed recommendations to address current challenges and areas of focus regarding pulse oximetry screening for CCHD, which included reporting standards for public health monitoring. Our study highlights this need as less than half of screening hospitals track quality outcomes. Quality assurance should be implemented to evaluate if pulse oximetry screening leads to improved outcomes and to further assess the impact of single postductal oximetry screening.

There are limitations to our approach. The lack of randomization or control institutions limit the ability to determine if the increase in screening institutions was a result of trend or an effect of our video. However, we attempted to directly assess the impact of our intervention with questions that specifically asked if changes in practice occurred in response to our video. More than 20% of hospitals that were not screening at baseline reported that they started a program in response to our video. In addition, nearly half of the hospitals that were not screening following the intervention reported that they were considering implementing a screening program because of our video. This may reflect response bias if respondents were hesitant to be critical of the educational video. Furthermore, the lack of an impact rating scale of the video may have skewed responses to an all-or-nothing impact. As with all survey studies, there is potential for selection bias: respondents may have different perceptions of pulse oximetry screening compared to nonrespondents. Some readers may suggest that we should have classified hospitals planning to screen as screening hospitals as opposed to nonscreening. However, in our experience, some hospitals planning to screen have yet to start a screening program, and therefore, their perceptions of and barriers to screening are likely to be more similar to that of nonscreening hospitals. Non–hospital-associated birthing centers and home births provide areas for future study.

Conclusion

In summary, this study shows that distribution of a brief educational video may be an effective way to help increase the proportion of hospital nurseries performing pulse oximetry screening for CCHD in the absence of legislative mandates. Distribution of an educational video may be a reasonable approach to change practice and perceptions for other medical practices. Although implementation of our educational video was associated with improved opinion of benefit and fewer perceived barriers to screening, barriers still exist. Improved access to cardiology and echocardiography may reduce these barriers further.

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Declaration of Conflicting Interests

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