Variation in Car Seat Tolerance Screen Performance in Newborn Nurseries

Natalie L. Davis, MD, MMSc,[a] Benjamin D. Hoffman, MD,[b] Eric C. Eichenwald, MD[c]

abstract

BACKGROUND: Currently, car seat tolerance screens (CSTSs) are recommended for all infants born prematurely in the United States. Although many late-preterm infants are cared for exclusively in newborn nurseries (NBNs), data on implementation of CSTS in nurseries are limited. Our objective for this study was to determine management strategies and potential variation in practice of CSTS in NBNs across the nation.

METHODS: We surveyed NBNs across 35 states using the Better Outcomes through Research for Newborns (BORN) network to determine what percentage perform CSTSs, inclusion and failure criteria, performance characteristics, follow-up of failed CSTSs including use of car beds, and provider attitudes toward CSTS.

RESULTS: Of the 84 NBNs surveyed, 90.5% performed predischarge CSTSs. The most common failure criteria were saturation <90%, bradycardia <80 beats per minute, and apnea >20 seconds. More than 55% noted hypotonia as an additional inclusion criterion for testing, and >34% tested any infant who had ever required supplemental oxygen. After an initial failed CSTS, >93% of NBNs retested in a car seat at a future time point, whereas only ~1% automatically discharged infants in a car bed. When asked which infants should undergo predischarge CSTS, the most common recommendations by survey respondents included infants with hypotonia (83%), airway malformations (78%), hemodynamically significant congenital heart disease (63%), and prematurity (61%).

CONCLUSIONS: There is a large degree of variability in implementation of CSTS in NBNs across the United States. Further guidance on screening practices and failure criteria is needed to inform future practice and policy.

[a]*Division of Neonatology, Department of Pediatrics, University of Maryland School of Medicine, Baltimore, Baltimore, Maryland;* [b]*Department of Pediatrics, Oregon Health and Science University School of Medicine, Doernbecher Children's Hospital, Portland, Oregon; and* [c]*Division of Neonatology, Department of Pediatrics, University of Pennsylvania Perelman School of Medicine, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania*

Dr Davis assisted in study design, designed the survey tool, assisted in coordination and supervision of data collection, conducted analyses, and drafted the initial manuscript; Drs Hoffman and Eichenwald conceptualized and assisted in study design and assisted in design of the survey; and all authors reviewed and revised the manuscript, approved the final manuscript as submitted, and agree to be accountable for all aspects of the work.

DOI: https://doi.org/10.1542/peds.2019-3593

Accepted for publication May 15, 2020

Address correspondence to Natalie L. Davis, MD, MMSc, Division of Neonatology, Department of Pediatrics, University of Maryland Children's Hospital and School of Medicine, University of Maryland, Baltimore, 110 S Paca St, 8th Floor, Baltimore, MD 21201. E-mail: natalie.davis@som.umaryland.edu

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

WHAT'S KNOWN ON THIS SUBJECT: Data on implementation of car seat tolerance screens (CSTSs) in newborn nurseries (NBNs) are limited. Identifying similarities and differences in CSTS practice across the nation in NBNs will help to inform consensus guidelines and focus future research.

WHAT THIS STUDY ADDS: In a cross section of NBNs in the United States, we found a large degree of variability when it came to implementation of CSTS, inclusion criteria, failure criteria, and follow-up after an initial CSTS failure.

To cite: Davis NL, Hoffman BD, Eichenwald EC. Variation in Car Seat Tolerance Screen Performance in Newborn Nurseries. *Pediatrics.* 2020;146(2):e20193593

The proper use of car safety seats reduces fatal injury in motor vehicle crashes by >70% for infants <1 year of age.[1] However, several studies have revealed that infants born prematurely, low birth weight (BW), and with certain comorbidities are at risk for unstable cardiopulmonary status when positioned in their car seat.[2–8] Given this risk, the American Academy of Pediatrics (AAP) currently recommends that infants born prematurely be observed in their car safety seat before discharge to monitor for clinically significant apnea, bradycardia, and oxygen desaturation.[9] Despite its widespread use, the ability of this test, known as the car seat tolerance screen (CSTS), to identify infants at risk for adverse events while in the semiupright car seat position and demonstrate safety for discharge remains unclear.[10]

Currently, the AAP recommends screening all infants born <37 weeks' gestational age (GA) for a duration of 90 to 120 minutes (or the duration of the ride home, whichever is longer) and repeating a similar period of observation for those infants discharged in car beds (travel devices that allow infants to lay flat).[9] Additional guidelines for critical elements of the test, including failure criteria, test timing, and follow-up after a failed CSTS, remain either vague or nonexistent, leading to significant variability across the nation.[11,12] In recent surveys of NICUs in the United States, it was found that the hemoglobin-oxygen saturation (Spo_2) constituting failure ranged from <80% to <93%, whereas the bradycardia definitions ranged from <70 to <120 beats per minute (bpm).[11,12] This wide variation means that an infant could pass a CSTS at one site while failing at another, based not on differences in the infant, but on differences in the failure criteria chosen at each institution. The lack of guidance on specific performance parameters also makes studying the CSTS difficult because variation in failure criteria makes outcomes less generalizable between institutions. Indeed, this variability and lack of evidence of benefit led the Canadian Paediatric Society to recently rescind their recommendation for routine CSTS.[13]

Although many late-preterm infants are cared for exclusively in the newborn nursery (NBN), data on implementation of the CSTS in NBNs remain even more limited. In one study from 2003, the authors evaluated performance of CSTS in both NBNs and NICUs.[14] Of the 18 NBN sites surveyed, only 22% reported having any CSTS program.[14] No contemporary studies have specifically been focused on CSTS implementation, performance, and follow-up in NBNs. Surveying CSTS protocols across the nation in both NICUs and NBNs will help to evaluate consistency of adherence to current guidelines and focus future research by identifying inconsistencies in CSTS practices across the nation. Our objective for this study was to determine management strategies and potential variation in practice across NBNs surrounding use of the CSTS.

METHODS

The study was performed through the Better Outcomes through Research for Newborns (BORN) network, established by the Academic Pediatric Association in 2010. At the time of the survey, the network included 106 NBN sites at academic and community medical centers across 35 states, with an annual birth rate of >400 000 infants. At each member NBN, the main contact individual was encouraged to forward the survey to the staff member most knowledgeable about CSTS protocols in their nursery. The study was determined to be exempt from human subjects research review by the Institutional Review Board at the University of Maryland, Baltimore.

Survey data were collected and managed by using Research Electronic Data Capture system, a secure Web-based platform for survey design and database management maintained at the University of Maryland, Baltimore.[15,16] The survey was adapted from a previous CSTS survey published in 2013.[11] Between February 2019 and June 2019, an e-mail link to the survey was sent to the designated representative at each BORN center, followed by up to 5 additional e-mail reminders. The survey included questions about location (state), academic affiliation, average annual deliveries, and whether the site routinely performed a predischarge CSTS. For those sites that did perform a CSTS, the survey addressed inclusion and failure criteria, duration, timing, location of testing, follow-up of a failed CSTS, and use of car beds. For those sites that did not perform CSTS, reasons for not performing the test were explored in the survey. All site respondents were also questioned regarding their individual attitudes related to CSTS, including its utility in assessing discharge readiness, optimal duration, and ideal inclusion and failure criteria.

RESULTS

We received responses from 79.2% (*n* = 84) of the BORN sites, representing 35 states. The median (interquartile range [IQR]) annual delivery rate was 3100 (2200–4500) infants, and 84.5% (*n* = 71) of sites were academically affiliated. Respondent training backgrounds included 79.8% in pediatrics (*n* = 67), 17.8% in neonatology (*n* = 15), and 2.4% unknown (*n* = 2). When asked about CSTS performance, 90.5% (*n* = 76) responded that their site did perform a predischarge CSTS, whereas 9.5% (*n* = 8) did not. There were no significant differences in training background, academic affiliation, or annual deliveries between the sites that did and did not perform CSTS.

Inclusion Criteria

Of the 76 nurseries that performed predischarge CSTS, 98.7% (*n* = 75) considered birth GA as an inclusion criterion. Of these, 98.7% (*n* = 74) tested all infants born at <37 weeks, and 1.3% (*n* = 1) only tested those born at <35 weeks. Additionally, 81.6% (*n* = 62) included a minimum BW in addition to birth GA. The most common BW used was <2.5 kg by 82.3% (*n* = 51) of those sites.

When asked about additional inclusion criteria used to determine eligibility for CSTS at their site, 7.6% (*n* = 21) noted no additional factors, although most nurseries did include other diagnoses and comorbidities, as shown in Table 1. Hypotonia, oxygen requirement during admission, and hemodynamically significant congenital heart disease (CHD) were the most common additional factors considered in decisions to perform CSTS.

CSTS Performance

Nurses were responsible for performing the CSTS at all sites, but several also noted the involvement of additional staff (Table 1). Although only 6% specifically noted involvement of trained child passenger safety technicians (CPSTs) in performance of CSTS, 31.6% did have CPSTs available to assist if needed. Most had a staff member position the infant in the car seat for the CSTS, whereas ~8% had the parent or guardian do the positioning while supervised by staff.

When it came to timing of the CSTS in relation to the last feeding, 64.5% (*n* = 49) did not specify timing, 25% (*n* = 19) recommended waiting at least 30 or 60 minutes after the last feeding, 9.2% (*n* = 7) recommended testing within 30 minutes of the last feeding, and 1.3% (*n* = 1) noted they test "between feeds." Timing in relation to discharge was not specified by 78.9% (*n* = 60), whereas the remaining 21.1% (*n* = 16) recommended CSTS performance within 12 hours of anticipated discharge.

The majority of sites followed the AAP guidelines to test between 90 and 120 minutes (Table 1). Forty-eight sites specified a maximum duration, with the most common being 90 minutes, although the times ranged from 30 minutes to 3 hours. Maximum duration of testing was not specified by 36.8% (*n* = 28), implying that a CSTS is performed for the entire duration of the car ride home, even if >90 to 120 minutes.

Failure Criteria

Of those NBNs that perform CSTS, 74 (97.4%) reported on failure criteria and follow-up of a failed CSTS. Spo_2 constituting failure ranged widely from <85% to <93%, with the most common criterion being <90% (Table 2). The most common minimum duration of desaturation constituting failure of the CSTS was >20 seconds but ranged from any drop below the threshold to >60 seconds.

The minimum heart rate that constituted failure due to bradycardia varied from <60 to <100 bpm, with <80 bpm used most commonly (Table 2). Minimum duration also varied from any drop below the specified threshold to requiring >60 seconds of bradycardia. The most common definition of apnea was a breathing pause >20 seconds.

Follow-up of Failed CSTS

Sites were presented with the case of an infant who failed an initial CSTS but after removal from the car seat was without distress and had complete resolution of abnormal vital signs. In this scenario, most sites would plan to retest in a car seat at a future point (93.2%; *n* = 69). Four (5.4%) automatically admitted to a higher level of care, and 1.4% (*n* = 1) automatically discharged in a car bed. Whereas a majority of sites (70.3%) considered alternative plans for discharge after 2 failed CSTSs, 10.8% continued to repeat CSTS until the infant passed (Table 3).

Use of Car Beds

When queried on the use of car beds after a failed CSTS, 20.3% (*n* = 15) never discharged in a car bed, whereas 1.4% (*n* = 1) automatically discharged in a car bed after 1 failed CSTS (Table 3). Half of the nurseries would consider car beds in the setting of repeated failures but did not routinely use them. For those considering discharge in a car bed (*n* = 59), more than half performed a CSTS in the car bed, 30.5% would discharge an infant in the car bed without testing, and the remaining 15.3% noted that the decision was provider dependent.

When it came to transitioning from a car bed to a car seat, fewer than one-third had the ability to schedule follow-up appointments either in the NBN, NICU, or specialty clinic for repeat CSTS (Table 3). Primary care physician (PCP) appointments were the only follow-up in 67% of sites. Most sites (67.8%) made no recommendations for repeat testing in a car seat to ensure safe transition from a car bed, leaving the decision up to the PCP. The remaining sites used various criteria for retesting, including weight, postmenstrual age ranging from 40 to 44 weeks, and timing after discharge (range of 2–6 weeks). One site did not recommend repeating outpatient CSTS and instead recommended transitioning to a car seat once achieving 40 weeks' postmenstrual age.

Reasons for Not Performing CSTS

For the 8 sites not performing CSTS, 7 noted that this was due to poor data regarding utility and outcomes. Three also noted a lack of staff and/or resources to perform the test. Single sites noted the following reasons: the Canadian Paediatric Society

TABLE 1 CSTS Inclusion Criteria and Performance Characteristics

	n (%)
Additional inclusion criteria	
BW used	
<2.5 kg	51 (67.1)
<5 lb	6 (7.9)
<2 kg	5 (6.6)
Not used	14 (18.4)
Other criteria	
Hypotonia and/or neuromuscular disorder	42 (55.3)
Supplemental oxygen requirement	26 (34.2)
CHD	17 (22.4)
Trisomy 21	8 (10.5)
Cleft palate or micrognathia	7 (9.2)
Physician discretion	7 (9.2)
History of NICU admission for respiratory issues	4 (5.3)
Airway anomalies	3 (3.9)
History of apnea, bradycardia, and/or desaturation events	2 (2.6)
Small for GA or in utero growth restriction	2 (2.6)
Discharged with apnea monitor	2 (2.6)
Orthopedic issues (poor fit risk)	2 (2.6)
Neurologic abnormalities	1 (1.3)
Hydrocephalus	1 (1.3)
Maternal opiate exposure	1 (1.3)
CSTS performance	
Location	
Central location in NBN	62 (81.5)
Patient's room	6 (7.9)
NICU	5 (6.6)
Either patient's room or NBN	3 (3.9)
When performed	
Day shift	2 (2.6)
Night shift	3 (3.9)
When convenient for staff	71 (93.4)
Staff performing CSTS	
Nurse	76 (100)
Medical assistant	8 (9.5)
Child passenger safety tech	5 (6)
Physical and/or occupational therapist	1 (2.1)
Respiratory therapist	1 (2.1)
CPST available to assist	
Yes	24 (31.6)
No	50 (65.8)
Unsure	2 (2.6)
Who places infant into car seat?	
Trained staff	64 (84.2)
Parent or guardian	6 (7.9)
Either staff or parent or guardian	6 (7.9)
CSTS duration	
Minimum duration	
<60 min	2 (2.6)
60–89 min	9 (11.8)
90–120 min	63 (82.9)
Duration of car ride home	2 (2.6)
Maximum duration (*n* = 48)	
30 min	1 (2.1)
60 min	2 (4.2)
90 min	21 (43.8)
2 h	15 (31.3)
2–3 h	1 (2.1)
2.5 h	1 (2.1)
3 h	4 (8.3)
Case-by-case basis	1 (2.1)
Physician discretion	1 (2.1)
Half the time to home	1 (2.1)

statement,[13] which rescinded a recommendation for routine predischarge CSTS; desire to not give the family a false sense of safety from a passed CSTS; and limited availability of car beds, making discharge plans inconsistent.

Provider Attitudes

Eighty-two site respondents answered survey questions on their attitudes regarding CSTS (Table 4). When asked if the CSTS is a "good way to assess cardiorespiratory readiness for discharge in at-risk newborns," 39.2% of those who performed CSTS felt it was, 45.1% were unsure, and 25.7% felt it was not, as did 100% of the sites that did not perform routine CSTS ("no CSTS group"). Survey respondents in the no CSTS group did, however, recommend predischarge CSTS on certain infants, with half recommending testing infants with hypotonia and/or those with hemodynamically significant CHD and more than half recommending testing infants with airway malformations. Overall, the most common recommendations by survey respondents (n = 82) for performing CSTS included screening infants with hypotonia (82.9%; n = 68), airway malformations (78%; n = 64), hemodynamically significant CHD (63.4%; n = 52), and prematurity (61%; n = 50).

Providers were asked, "At what Spo_2 and for what duration would you become clinically concerned enough to continue monitoring and potentially delay discharge?" in the following scenario: "You are observing an otherwise healthy 36-week infant in the nursery who has their pulse ox on after undergoing a predischarge critical cyanotic heart disease screen. The infant is supine in a crib when you notice an oxygen desaturation." There was no difference in the median Spo_2 level between the respondents from programs that did versus those that did not perform routine CSTS (89%

vs 88%, respectively; P = .4). Overall, the median duration of concern was 20 seconds (IQR 20–30) for the entire cohort.

DISCUSSION

We performed a national survey of NBNs via the BORN network to determine management strategies and potential variation in practice of the CSTS. We found that >90% of NBNs did perform a predischarge CSTS and that the vast majority follow AAP recommendations for screening all infants born prematurely and testing duration. As with previous studies in NICUs, we found wide variation in failure criteria cutoffs for Spo_2 and heart rate. Most NBNs did repeat a CSTS after an initial failure, but timing of repeat testing varied. Although discharge in a car bed after CSTS failure was not common, we found that almost half of NBNs did not perform a similar period of observation in a car bed before discharge and that two-thirds of NBNs discharge infants in car beds with only PCP follow-up.

CSTS performance has been widely implemented in US NICUs, with 96.5% performing a CSTS as of 2020.[12] In our study, we found a similar rate in NBNs (90.5%) across 35 states, which is a large increase from the 22% reported in 2003.[14] This is important information because late-preterm infants are often cared for in NBNs to avoid NICU admissions, improve bonding, and facilitate breastfeeding. The sites that did not perform routine CSTS identified the lack of data on utility as the main driver. However, half believed that infants with hypotonia and those with hemodynamically significant CHD should undergo CSTS, whereas almost two-thirds responded that infants with airway malformations should undergo CSTS. Clearly, the usefulness of the CSTS remains unclear to clinicians, which emphasizes the need for rigorous study to determine which, if any, patients would benefit from routine screening.

Although there are no studies evaluating CSTS results and sudden unexplained infant death (SUID), there are data linking car seat position and SUID. In one recent study of SUID with no other known extrinsic risk factors (such as sleeping prone, bed-sharing, soft bedding, or having their head covered) researchers found that 27% of infants had been put to sleep in a semiupright car seat or bouncy seat.[17] In another study evaluating infant deaths in sitting devices, researchers found that 63% occurred in car seats.[18] The association between semiupright car seat positioning and SUID is concerning and requires further study. In a recent study of CSTS in NICU patients, researchers found that although patients who failed had longer lengths of stay, they also had significantly decreased odds of

TABLE 2 CSTS Failure Criteria

	n = 74, n (%)
Spo_2 failure criteria	
<93%	4 (5.4)
<92%	2 (2.7)
<91%	1 (1.4)
<90%	45 (60.8)
<89%	1 (1.4)
<88%	8 (10.8)
<85%	10 (13.5)
Varies by birth GA	2 (2.7)
Not specified in policy	1 (1.4)
Desaturation duration	
Any drop below threshold	12 (16.2)
>5 s	2 (2.7)
>10 s	14 (18.9)
>15 s	6 (8.1)
>20 s	28 (37.8)
>30 s	6 (8.1)
>60 s	1 (1.4)
Not specified	5 (6.8)
Bradycardia failure criteria	
<100 bpm	6 (8.1)
<90 bpm	11 (14.9)
<80 bpm	48 (64.9)
<60 bpm	1 (1.3)
Not specified in policy	8 (10.8)
Bradycardia duration	
Any drop below threshold	20 (27)
>5 s	3 (4.1)
>10 s	22 (29.7)
>15 s	5 (6.8)
>20 s	14 (18.9)
>30 s	1 (1.4)
>60 s	1 (1.4)
Not specified	8 (10.8)
Apnea definition	
>20 s	62 (83.8)
>15 s	1 (1.3)
>10 s	2 (2.7)
Not specified	9 (12.2)
Additional failure definitions	
Respiratory distress	25 (33.8)
Tachypnea	9 (12.2)
Cyanosis or color change	4 (5.4)

TABLE 3 Follow-up of a Failed CSTS and Use of Car Beds

	n (%)
Follow-up of failed CSTS (*n* = 74)	
Duration between repeat CSTS?	
Not specified	3 (4.1)
Can repeat immediately	6 (8.1)
Minimum 6 h	14 (18.9)
Minimum 12 h	21 (28.4)
Minimum 24 h	1 (1.4)
Minimum 72 h	2 (2.7)
Minimum 7 d	22 (29.7)
Varies on the basis of how quickly infant failed CSTS	3 (4.1)
NICU team decides	2 (2.7)
How many repeat CSTSs before alternative discharge plans (NICU, car bed, etc)?	
Do not repeat CSTS	4 (5.4)
After 2 failed CSTSs	52 (70.3)
After ≥3 failed CSTSs	10 (13.5)
Unlimited (repeat until pass)	8 (10.8)
Consideration of a sleep study for failed CSTS?	
Never	68 (91.8)
After 2 failed CSTS	3 (4.1)
After ≥3 failed CSTS	3 (4.1)
Use of car beds at discharge	
Policy for use of car beds after failed CSTS (*n* = 74)	
Never discharge in car bed	15 (20.3)
Routinely used after 1 failed CSTS	1 (1.4)
Routinely used after ≥2 failed CSTSs	21 (28.4)
Occasionally use after repeated failed CSTSs	37 (50)
Are car bed tests performed? (*n* = 59)	
Always	32 (54.2)
Never	18 (30.5)
Unsure or provider dependent	9 (15.3)
How do families obtain car beds? (*n* = 59)	
Purchase on own	7 (11.8)
Available for purchase at hospital	6 (10.2)
Rental through hospital	27 (45.8)
Loaned (no cost) through hospital	19 (32.2)
What follow-up is established to transition back to a car seat? (*n* = 57)	
PCP only	38 (66.7)
Subspecialist appointment made	3 (5.3)
Appointment in specialty clinic to repeat CSTS	10 (17.5)
Return to NICU or nursery to repeat CSTS	6 (10.5)
When is a repeat CSTS recommended after discharge? (*n* = 59)	
Unsure or per the PCP	40 (67.8)
Repeat CSTS at specific chronological age	10 (16.9)
Repeat CSTS at specific corrected GA	4 (6.8)
Repeat CSTS at specific wt	2 (3.4)
Varies by patient	2 (3.4)
Transition at term without repeating CSTS	1 (1.7)

readmission within 30 days.[19] In a study focused exclusively on NBN infants who were automatically admitted to the NICU for continuous monitoring after one failed CSTS, researchers found that 39% had ongoing apneic events while supine.[7] And in a study evaluating late-preterm infants, researchers found that 21% of those who failed >1 CSTS from the NBN ultimately required NICU admission for significant hypoxia and that two-thirds subsequently required supplemental oxygen for safe discharge.[20] It remains unclear whether CSTS failure unnecessarily prolongs inpatient admission or properly identifies infants at risk for unstable cardiorespiratory status before discharge, thereby preventing adverse postdischarge outcomes, which is why more research is needed.

The AAP and the Committee on Fetus and Newborn both state that infants are not safe for hospital discharge until "physiologically mature and stable cardiorespiratory function has been documented for a sufficient duration."[21,22] This must apply not only while supine in a crib but also while semiupright in a car seat. However, in the absence of standardized screening and failure criteria, each institution has been left to determine which vital signs are clinically concerning for unstable cardiorespiratory function, leading to variation in CSTS practice. Since the 1980s, Spo_2 constituting failure in the literature has ranged from <85% to <95%.[23] In 2 recent surveys of NICUs, the Spo_2 and duration constituting failure ranged widely from <80% to <93% and from any drop below the threshold to requiring >60 seconds, respectively.[11,12] Similarly, we found that NBNs also have a wide range of Spo_2 failure cutoffs, with values ranging from <85% to <93% and a similar duration range.

One of the main barriers to further research is the heterogeneity of CSTS protocols in NICUs and NBNs. Consensus on failure criteria across the nation is important not only to encourage standardization of care but also to allow the performance of large multicenter trials to determine the utility of the CSTS. This remains challenging because data are limited on what constitutes a safe lower Spo_2 in high-risk infants near the time of discharge. Interestingly, a recent review of CSTS literature,[24] as well as both the NICU surveys[11,12] and our NBN survey, revealed that the most commonly used Spo_2 failure cutoff was <90%. When providers in our study were asked what Spo_2 would cause enough clinical concern to potentially delay a discharge from the NBN, the median value we found was

TABLE 4 Provider Attitudes Regarding CSTS in NBN Patients

	Perform Routine CSTS (n = 74)	Do Not Perform Routine CSTS (n = 8)	P
Is the CSTS a good way to assess cardiorespiratory readiness for discharge in at-risk infants? n (%)			.0001
Yes	29 (39.2)	0	
No	19 (25.7)	8 (100)	
Unsure	26 (45.1)	0	
Under what birth GA should neonates be screened with CSTS before discharge? n (%)			<.0001
N/A (should not be considered)	8 (10.8)	5 (62.5)	
<37 wk	47 (63.5)	0	
<36 wk	8 (10.8)	0	
<35 wk	7 (9.5)	1 (12.5)	
<34 wk	3 (4)	1 (12.5)	
<33 wk	0	0	
<32 wk	0	1 (12.5)	
All neonates should be tested	1 (1.4)	0	
Under what BW should neonates be screened with CSTS before discharge? n (%)			.0089
N/A (should not be considered)	13 (17.6)	5 (62.5)	
<2500 g	39 (52.7)	0	
<2000 g	14 (18.9)	2 (25)	
<1500 g	2 (2.7)	1 (12.5)	
<5 lb	1 (1.4)	0	
Unsure	5 (6.8)	0	
Which infants should be screened with CSTS before discharge? n (%)			
Hemodynamically significant CHD	48 (63.2)	4 (50)	.4660
Hypotonia	64 (84.2)	4 (50)	.0191
Hypertonia	7 (9.2)	0	.3700
In utero opiate exposure	9 (11.8)	0	.3030
Airway malformations	59 (77.6)	5 (62.5)	.3392
Born at <37 wk GA	50 (65.8)	0	.0003
Small for GA or in utero growth restriction	22 (29)	0	.0765
All infants	1 (1.3)	0	.7441
No infants	5 (6.6)	2 (25)	.1312
Which Spo_2 and for what duration would clinically concern you enough to continue monitoring and potentially delay discharge in a 36-wk-old infant who is desaturating while supine? Median (IQR)			
Spo_2	89% (85%–90%)	88% (83%–89.5%)	.3979
Duration, s	20 (15–21)	55 (30–60)	.0014

N/A, not applicable.

89%. Because Spo_2 <90% is the most commonly used criteria in the NICU literature as well as in our NBN study, this value could be used to standardize CSTS failure criteria via expert consensus. Early-preterm infants with Spo_2 target values <90% had increased inpatient mortality compared with those with Spo_2 target values >90% during their hospitalization,[25] although it is unclear how applicable these data are to otherwise healthy late-preterm infants in NBNs. However, there is a precedent for using Spo_2 <90% as a screening cutoff, namely in the CCHD screen. When performing routine critical CHD screens, the AAP and American Heart Association recommend that any infant found to have Spo_2 <90% requires a "comprehensive evaluation for causes of hypoxemia."[26] Therefore, applying this value to CSTS as identifying unstable cardiorespiratory status in the car seat seems reasonable.

Less variation exists for the definitions of clinically concerning apnea and bradycardia. More than 83% of NBNs defined apnea as a breathing pause lasting >20 seconds. The most common criterion to define bradycardia was a heart rate <80 bpm, used by 65% of NBNs in our study and, similarly, by 70% of NICUs.[11]

The AAP clinical report recommends "interventions to reduce the frequency of desaturation and episodes of apnea and bradycardia" when significant cardiorespiratory events occur in the car seat.[9] Examples include employing certified CPSTs to optimize positioning, use of car beds, supplemental oxygen, continued hospitalization, and further medical assessment. The AAP clinical report states that infants with cardiorespiratory events in the semiupright position "should travel in a supine or prone position in an…approved car bed after an observation period" similar to the CSTS.[9] We found that ~5% of sites routinely admit to a higher level of care and that ~1% routinely discharge in a car bed after an initial failed CSTS. Despite no specific mention in the clinical report, we found that the most common practice in NBNs is to retest in a car seat at a future point with the goal of sending the infant home in a rear-facing car seat in a semiupright position. The avoidance of car beds for discharge despite the AAP report is likely due to multiple factors, including greater complexity in their use and the cost to families. In addition, rear-facing car safety seats have been more extensively crash tested and therefore have better documentation of protection than car beds.[27] Studies of preterm and term infants have revealed similar rates of desaturation and bradycardic events in both devices,[28–31] indicating that car beds are not necessarily a safer choice for all infants who fail their initial CSTS, especially when a car bed observation screen is not routinely performed, as was the case in ~45% of NBNs surveyed. As recommended by the AAP,[9] if discharge is planned in a car bed, a similar period of observation (ie, car bed screen) should be performed given the risk of unstable cardiorespiratory status in NBN patients that has also been demonstrated in car beds.[32] Infants for whom a car bed might be beneficial will be better identified by performing such a car bed screen. If an infant is discharged in a car bed, a plan should be established, by the time of discharge, to evaluate the infant's safety for transitioning to a rear-facing car seat. The PCP should be contacted before discharge and should be involved in all follow-up planning. PCPs may not have the resources to perform a period of observation to assess cardiorespiratory safety in the outpatient setting, so leaving follow-up decisions only to the PCP is not always appropriate. Additional consultations may be required to safely transition to a rear-facing car seat, such as performing polysomnography or repeating a CSTS in a specialty clinic.

Strengths of our study include the use of the BORN network, which provided a large, diverse, nationally representative sample of NBNs. We had a strong survey response rate (79%), representing NBNs from 35 states, making these data widely generalizable. We were able to obtain data on CSTS practice as well as data on newborn providers' attitudes toward CSTS performance. These data will help identify focus areas for future research on this controversial topic. One limitation is that data were based on survey response by an assigned site representative rather than direct observation of the written CSTS protocol, so any differences between the practice and survey response could not be assessed. In this survey, we did not address whether the car seat used during the CSTS was the same one used at discharge or whether the sites had an established policy in place for education of caregivers regarding car safety seat use,[33] which would be important for future studies. In addition, data on providers' attitudes were based solely on the specific respondent and were not necessarily representative of all newborn providers at their institution.

CONCLUSIONS

Although we found a large degree of variability in implementation of CSTS in a cross section of NBNs across the United States, we observed trends regarding screening practices and failure criteria that can inform future practice and policy. This variability suggests the need for more specific guidance by the AAP if the CSTS is to be reproducible across sites, and to help in understanding if this test is clinically important in the detection of cardiorespiratory instability in the semiupright position in at-risk infants.

ACKNOWLEDGMENTS

We thank the members of the BORN network for their participation in this study and specifically Beth King for her invaluable assistance throughout the study.

ABBREVIATIONS

AAP: American Academy of Pediatrics
BORN: Better Outcomes through Research for Newborns
BW: birth weight
CHD: congenital heart disease
CPST: child passenger safety technician
CSTS: car seat tolerance screen or screening
GA: gestational age
IQR: interquartile range
NBN: newborn nursery
PCP: primary care physician
Spo_2: hemoglobin-oxygen saturation
SUID: sudden unexplained infant death

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: No external funding.

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

REFERENCES

1. National Highway Traffic Safety Administration. *Traffic Safety Facts 2012 Data*. Washington, DC: US Department of Transportation; 2014
2. Willett LD, Leuschen MP, Nelson LS, Nelson RM Jr. Ventilatory changes in convalescent infants positioned in car seats. *J Pediatr*. 1989;115(3):451–455
3. Willett LD, Leuschen MP, Nelson LS, Nelson RM Jr. Risk of hypoventilation in premature infants in car seats. *J Pediatr*. 1986;109(2):245–248
4. Davis NL. Car seat screening for low birth weight term neonates. *Pediatrics*. 2015;136(1):89–96
5. Merchant JR, Worwa C, Porter S, Coleman JM, deRegnier RA. Respiratory instability of term and near-term healthy newborn infants in car safety seats. *Pediatrics*. 2001;108(3):647–652
6. Smith RW, Mohamed A, Young J, Jefferies A, Shah V. Factors associated with car seat test failure in late preterm infants: a retrospective chart review. *Paediatr Child Health*. 2016;21(1):16–20
7. Shah MD, Dookeran KA, Khan JY. Clinical outcomes associated with a failed infant car seat challenge. *J Pediatr*. 2017;180:130–134
8. Ojadi VC, Petrova A, Mehta R, Hegyi T. Risk of cardio-respiratory abnormalities in preterm infants placed in car seats: a cross-sectional study. *BMC Pediatr*. 2005;5:28
9. Bull MJ, Engle WA; Committee on Injury, Violence, and Poison Prevention; Committee on Fetus and Newborn; American Academy of Pediatrics. Safe transportation of preterm and low birth weight infants at hospital discharge. *Pediatrics*. 2009;123(5):1424–1429
10. Pilley E, McGuire W. Pre-discharge “car seat challenge” for preventing morbidity and mortality in preterm infants. *Cochrane Database Syst Rev*. 2006;(1):CD005386
11. Davis NL, Zenchenko Y, Lever A, Rhein L. Car seat safety for preterm neonates: implementation and testing parameters of the infant car seat challenge. *Acad Pediatr*. 2013;13(3):272–277
12. Davis NL, Cheo S. A national survey of car seat tolerance screening protocols in neonatal intensive care units [published online ahead of print February 7, 2020]. *Acad Pediatr*. doi:10.1016/j.acap.2020.02.004
13. Narvey MR; Canadian Paediatric Society, Fetus and Newborn Committee. Assessment of cardiorespiratory stability using the infant car seat challenge before discharge in preterm infants (<37 weeks' gestational age). *Paediatr Child Health*. 2016;21(3):155–162
14. Williams LE, Martin JE. Car seat challenges: where are we in implementation of these programs? *J Perinat Neonatal Nurs*. 2003;17(2):158–163
15. Harris PA, Taylor R, Minor BL, et al; REDCap Consortium. The REDCap consortium: building an international community of software platform partners. *J Biomed Inform*. 2019;95:103208
16. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform*. 2009;42(2):377–381
17. Trachtenberg FL, Haas EA, Kinney HC, Stanley C, Krous HF. Risk factor changes for sudden infant death syndrome after initiation of Back-to-Sleep campaign. *Pediatrics*. 2012;129(4):630–638
18. Liaw P, Moon RY, Han A, Colvin JD. Infant deaths in sitting devices. *Pediatrics*. 2019;144(1):e20182576
19. Jensen EA, Foglia EE, Dysart KC, et al. Car seat tolerance screening in the neonatal intensive care unit: failure rates, risk factors, and adverse outcomes. *J Pediatr*. 2018;194:60–66.e1
20. Magnarelli A, Shah Solanki N, Davis NL. Car seat tolerance screening for late-preterm infants. *Pediatrics*. 2020;145(1):e20191703
21. AAP Committee on Fetus and Newborn; ACOG Committee on Obstetric Practice. In: Kilpatrick SJ, Papile LA, Macones GA, eds. *Guidelines for Perinatal Care*, 8th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2017
22. American Academy of Pediatrics Committee on Fetus and Newborn. Hospital discharge of the high-risk neonate. *Pediatrics*. 2008;122(5):1119–1126. Reaffirmed November 2018
23. Bass JL. The infant car seat challenge: determining and managing an “abnormal” result. *Pediatrics*. 2010;125(3):597–598
24. Davis NL. Screening for cardiopulmonary events in neonates: a review of the infant car seat challenge. *J Perinatol*. 2015;35(4):235–240
25. Askie LM, Darlow BA, Davis PG, et al. Effects of targeting lower versus higher arterial oxygen saturations on death or disability in preterm infants. *Cochrane Database Syst Rev*. 2017;(4):CD011190
26. Kemper AR, Mahle WT, Martin GR, et al. Strategies for implementing screening for critical congenital heart disease. *Pediatrics*. 2011;128(5). Available at: www.pediatrics.org/cgi/content/full/128/5/e1259
27. Weber K. Crash protection for child passengers: a review of best practice. *UMTRI Research Review*. 2000;31(3):1–28
28. Kornhauser Cerar L, Scirica CV, Stucin Gantar I, Osredkar D, Neubauer D, Kinane TB. A comparison of respiratory patterns in healthy term infants placed in car safety seats and beds. *Pediatrics*. 2009;124(3). Available at: www.pediatrics.org/cgi/content/full/124/3/e396
29. Kinane TB, Murphy J, Bass JL, Corwin MJ. Comparison of respiratory physiologic features when infants are placed in car safety seats or car beds. *Pediatrics*. 2006;118(2):522–527
30. Salhab WA, Khattak A, Tyson JE, et al. Car seat or car bed for very low birth weight infants at discharge home. *J Pediatr*. 2007;150(3):224–228

31. Davis NL, Shah N. Use of car beds for infant travel: a review of the literature. *J Perinatol*. 2018;38(10):1287–1294
32. Wilker RE, Cotoni BJ, Mirando CS, Bass JL. Newborn car bed testing in a community hospital: implementing the American Academy of Pediatrics recommendations. *Am J Perinatol*. 2014;31(8):677–682
33. National Highway Traffic Safety Administration. *Hospital Discharge Recommendations for Safe Transportation of Children: Best Practice Recommendations Developed By an Expert Working Group Convened by the National Highway Traffic Safety Administration*. Washington, DC: US Department of Transportation; 2015