

Clinical Use of the Neonatal Intensive Care Unit Network Neurobehavioral Scale

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ABSTRACT. Features of the Neonatal Intensive Care Unit Network Neurobehavioral Scale that make the examination useful for clinical application are described. Clinical applications in various settings and populations are described. This is followed by a summary of the clinical significance of the examination according to the packages of administration. We then explain how to use the summary scores clinically, writing a clinical summary and the clinical interpretation of the summary scores. Finally, we present a case study with a clinical summary and a work sheet that clinicians may find useful for clinical consultation with caregivers and parents. *Pediatrics* 2004;113:679–689; *neurobehavioral assessment, infants at risk, clinical summary, drug-exposed infants, high-risk infants.*

ABBREVIATIONS. NNNS, Neonatal Intensive Care Unit Network Neurobehavioral Scale; NICU, neonatal intensive care unit.

Earlier articles in this issue provided an overview of the development of the Neonatal Intensive Care Unit Network Neurobehavioral Scale (NNNS) as an assessment for research and provided specific instructions for administration of the items in order, within recommended packages. This article presents clinical applications for the NNNS. At times it may be necessary, depending on the risk status of the infant, to modify the order of administration to accommodate individual differences among infants and caregivers.

The NNNS was developed for assessment of infants at risk. Risk in this context is broadly defined and includes multiple factors. These factors may be characterized as biological risks (eg, prematurity, intrauterine growth restriction), medical risks (eg, illness or injury at birth), or social risks (eg, poor nutrition, inadequate prenatal care, excessive maternal stress, poverty), all of which may have biological and/or neurobehavioral consequences for the infant. The NNNS is applicable to term, normal healthy infants; infants who are at risk as a result of factors such as prenatal substance exposure; and preterm

infants. As such, it provides a useful format for neurodevelopmental and neurobehavioral assessment in clinical settings such as hospital nurseries, including the neonatal intensive care unit (NICU); neonatal follow-up programs; and early intervention programs.

Certain characteristics of the NNNS make it particularly well suited for use in clinical settings:

1. Administration of individual items is state dependent (ie, items are administered only when the infant is in the appropriate state of arousal). The effect of state of arousal on reflex responses, active and passive muscle tone, and orientation abilities is well documented. The NNNS provides a specific range of states for reliable administration of each item to optimize an infant's response and to prevent erroneous clinical impressions. For example, evaluation of the infant's power of active movement can be accomplished only in states 3 (drowsy), 4 (quiet alert), and 5 (active alert). If the infant is sleeping (states 1 or 2), then his or her power of movement will seem to be lower than it is, and if the infant is crying, then power of movement will be artificially increased.
2. The recommended order of administration of individual items (ie, in packages) minimizes handling by the examiner. For example, all observations that should be made in the supine position are completed before changing the infant's position. Not only are these procedures more efficient for the examiner, but also they may be less taxing for the infant.
3. The items within each NNNS package are administered in an order that is relatively invariant. The prescribed sequence for administration is the one that is strongly preferred by experienced examiners. This feature maximizes the amount of information that the examiner is able to obtain in a minimum amount of time. However, the clinical examiner may find it necessary to depart from that sequence to learn more about the infant's neurobehavioral functioning and, when possible, to elicit the infant's best performance. Such variations can be documented in the Order of Administration item, and thus are included in scoring and interpretation.
4. Interpretation of the NNNS does not rely on a total score. On the basis of the examiner's knowledge of the infant's medical history and current status, it is necessary to omit items that may be

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inappropriate or exceedingly stressful. Thus, the NNNS is appropriate for the NICU setting, where energy conservation and maintenance of physiologic stability are of the utmost importance. When using the NNNS in the NICU, the approach to assessment of each infant can be individualized to accommodate his or her medical status and unique thresholds for stimulation.

5. The NNNS items focus on the capacities of the infant for regulation of states of arousal, responsiveness to stimulation, self-soothing, and tolerance of handling. Each of these dimensions has a particular relevance to the care of high-risk infants while hospitalized, in transitional care nurseries, and especially during the transition to home.
6. Observations of the infant's behavior can be done jointly with parents and other caregivers, providing a parent consultation model based on a family-centered approach to evaluation and intervention.
7. The preexamination and postexamination observations ensure that the examiner begins and ends the evaluation with an assessment of the infant's state of arousal. Frequency of changes in state of arousal and duration of states are reflected in the summary scores.
8. The Stress/Abstinence Scale provides medical professionals and other caregivers with a structured framework for documenting the physiologic and behavioral manifestations of drug dependence or environment-related stress.
9. The summary scores are particularly useful for clinicians. The clinician's overall impression of the infant's capacity to habituate and orient to stimuli and respond to handling are recorded. These scores also provide estimates of overall tone and quality of movement, the amount of stress displayed during the assessment, and the number of atypical reflexes demonstrated by the infant during the course of the examination.
10. The NNNS examination can be repeated on a regular basis, without affecting reliability and validity of the scoring. A single examination may not be the most representative evaluation of an infant's underlying neurobehavioral functioning, because of the influence of the infant's state. It also may be useful to repeat the NNNS to document changes in the infant's behavior, which may be reflective of recovery processes and responses to treatment and nursery care. Multiple opportunities for appraisal of an infant's strengths and vulnerabilities form the most reliable basis for recommendations aimed at optimizing behavioral organization and developmental progress.¹ Multiple observations allow clinicians to develop a trajectory of the infant's behavioral and neurodevelopmental progress. Newly emerging behaviors, both positive and negative, can be identified. Infants who show no change or those who demonstrate negative change can receive the necessary intervention or be referred for additional medical/diagnostic evaluation. By repeating the examination over

time, it is also possible to screen infants for new negative findings that may emerge after the immediate postpartum period.

Repeated examinations made jointly by the examiner and the infant's caregivers provide the most realistic view of the infant's developmental needs and behavioral style. Recommendations that emerge from such collaborative evaluations may include modifications to caregiving techniques to be more responsive to the infant's physiologic, developmental, and behavioral characteristics (as well as those that might be contraindicated) and environmental manipulations to accommodate the infant's self-regulatory and behavioral style.

Serial observations using the NNNS also can be useful for infants who have been exposed to illegal substances in utero or who have been sedated for long periods of time and are being weaned from addictive medications. The Stress/Abstinence Scale helps to identify infants who have immediate postpartum effects of drug exposure, who will require medical intervention. Infants who do not initially present with symptoms of neonatal abstinence, such as some opiate-exposed infants, may require repeated observations using the Stress/Abstinence Scale to identify the appropriate timing for initiation of medical and/or behavioral interventions. For example, a change in the infant's performance on the Stress/Abstinence Scale may trigger an alteration in the infant's care plan to include computing Finnegan scores every 3 to 4 hours to determine the need for medication to alleviate symptoms of neonatal abstinence. Repeated observations also help caregivers to identify the most appropriate routines for feeding and handling the infant, as well as strategies for organizing the environment to be most responsive to the infant's changing needs. The Stress/Abstinence Scale and observations made based on the NNNS, with attention to dimensions such as state change, and state control, can provide more information than measures of stress/abstinence and withdrawal on how to stabilize the infant and provide caregiving strategies that optimize positive change.

Infants who are being cared for in the NICU can benefit from repeated observations using the NNNS. The NNNS format (ie, state-dependent items sequenced in packages that reduce unnecessary handling) lends itself to evaluation of fragile, high-risk infants. Preterm infants of early gestation (28–33 weeks) are likely to require considerable modification to the protocol to accommodate their inherent physiologic instability and increased sensitivity to stimulation. With moderate- to high-risk infants, the habituation and orientation items must be presented in an abbreviated format (eg, fewer stimuli, fewer presentations) to conserve the infant's energy and to avoid overstimulation. Some items may be modified, for example, providing additional support to the infant's neck during pull-to-sit. Other items may be omitted (eg, response decrement to tactile stimulation of the foot may be particularly aversive for an infant who is experiencing daily heel sticks; tonic deviation of head and eyes and Moro reflex may be

contraindicated for infants with intraventricular hemorrhage).

The Stress/Abstinence Scale and the summary items provide information that can be of particular benefit to infants who are in hospital nurseries recovering from the effects of prenatal drug exposure or high-risk pregnancy or are stabilizing and growing after preterm delivery. The stress/abstinence items reflect regulation of physiologic and behavioral functioning. The summary items provide a comprehensive view of the infant's capacity for alertness and activity and his or her muscle tone and motor maturity, rapidity of build-up, peak of excitement, irritability, and consolability across the entire examination. As mentioned above, multiple examinations over a period of weeks are recommended, as they provide the examiner and the infant's caregivers with the most accurate view of the infant's neurobehavioral functioning.

Conducting the NNNS with parent or other caregiver participation provides a broader context for observing the infant's functioning and potentially interpreting previous assessment results. Parents are able to observe and appreciate the infant's capacities for protecting his or her sleep, responding to visual and auditory stimuli, and tolerating physical handling. They also are able to witness the infant's response to stressful events and the extent to which the infant is able to assist in his or her own recovery. This increases their understanding of their infant and makes them better able to read their infant's cues and signals. Optimally, parents and other caregivers also participate with the clinician in formulating a plan that will support specific aspects of the infant's behavior and development, including the need for referrals to services such as occupational or physical therapy or neurology. Together, the examiner, the parents, and other caregivers determine positioning, handling, and environmental conditions that are most beneficial for the infant and observe the effect of these changes on the infant's behavior.

Parents' feelings of competence may be increased through these experiences, and this can have a positive effect on the parent-infant attachment relationship. Observing the examination can also bring up specific issues that the parents want to discuss, some of which may be personal. In this context, the examination becomes a clinical "bridge" to parental feelings and reactions that may be important for their relationship with the infant. Parents or other caregivers who participate in the administration of the NNNS will be more informed about individual tolerances of their infant for handling and basic care and will be better prepared to engage in daily routines that are responsive to their infant's cues. Through their participation in the assessment and planning process, caregivers learn additional strategies for interacting sensitively with the infant, and their roles as nurturers and protectors of the infant are reinforced. They will also be more likely to provide appropriate levels and types of stimulation within the home environment.

The NNNS can be used to help determine when the infant is ready for discharge from the hospital.

Infants who meet medical criteria for discharge are not always neurobehaviorally ready for discharge or may have special neurobehavioral issues that need to be taken into account when discharged. Conversely, some infants may not fit the typical medical criteria for discharge, such as weight, and yet may be neurobehaviorally robust. For these infants, the NNNS examination could provide useful information for consideration of an earlier-than-expected discharge.

Discharge planning includes ensuring an adequate home environment for the infant. In addition to determining the infant's tolerances for certain types of stimulation and handling, the NNNS can be used in clinical settings to provide a description of the early personality or temperament of the infant. The infant's pattern of responses during the examination represents the behavioral style of the infant as indicated in summary scales such as arousal, excitability, lethargy, attention, regulation, and handling. Understanding the behavioral style of the infant becomes a key component of the NNNS assessment and forms the basis for many of the recommendations that will result from the examination. When the infant is sensitive to social approaches or when his or her behavior becomes disorganized with handling, these responses can undermine a caregiver's healthy attachment with the infant. Faced with difficult or unpredictable behavior on the part of the infant, family members and other care providers are likely to withdraw from the infant or alter their interactions in ways that can ultimately be detrimental to the infant-caregiver relationship. Conversely, when caregivers are aware of an infant's behavioral characteristics and temperament, they can provide a sensitive environment that is more responsive to the infant's needs.

The graded format of the NNNS items provides an appropriate context for the examiner to increasingly challenge the infant behaviorally and to elicit the infant's optimal response, with graded assistance (ie, scaffolding) if necessary. The skillful examiner will be able to use the NNNS examination to demonstrate a range of capacities of infants who are at risk, including the ability, however limited, to respond to social approaches and to organize his or her behavior, with or without different types and amounts of assistance. In this context, the examiner may change the order of items within packages to meet his or her estimate of the infant's tolerances or may omit items altogether, in the service of conserving energy. This clinical application of the NNNS represents a departure from its use in research. The research examiner would establish sufficient rapport with the infant to elicit optimal behavior but would not modify the order of items within packages or selectively omit items, to avoid injecting examiner bias into the assessment results. Training in the clinical uses of the NNNS begins with achieving competence and reliability in the administration of the NNNS, with low-to moderate-risk infants, so that as the training advances, the clinician knows the foundation from which they may need to depart to conduct the examination for clinical purposes.

Information from the NNNS examination has been

demonstrated to be useful to social workers in determining the adequacy of the home environment for infants who are neurobehaviorally vulnerable (eg, some drug-exposed infants). Foster parents may find the NNNS examination helpful in learning about the behavior of the infant in their care. For example, in some instances, a foster family's knowledge of the infant's history of prenatal substance exposure has resulted in a view of the infant's potential that is more pessimistic than warranted. Through participating in the NNNS examination, foster families may obtain a heightened appreciation for the infant's abilities, thus dispelling myths and enhancing opportunities for appropriate infant-caregiver interaction.

Adolescent mothers sometimes need help in understanding their infant's behavior. Anticipatory guidance for the parent is an integral component of developmental services for infants of adolescent mothers. Participation in an initial NNNS examination provides these mothers the opportunity to view strengths and vulnerabilities of their infant and to discuss strategies for successful care and handling with the clinician. Participation by adolescent mothers in repeated NNNS examinations provides them with a more accurate view of their infant's changing competencies than they may be able to obtain on their own. Perhaps more important, repeated examinations provide a context in which to provide adolescent mothers with ongoing educational and psychosocial support and, hopefully, affirmation of their competencies in their role as parent.

The NNNS also is useful as a screening to determine the need for follow-up services such as early intervention. In the past, screening criteria for many early intervention programs have used strictly medical risk (eg, birth weight) and/or social risk (eg, poverty) criteria. Screening that includes neurobehavior can target those infants who require modifications to their care routines, to accommodate specific problems with behavioral organization. This approach to screening increases the likelihood of a more positive caregiving environment (ie, one that optimizes the fit between the infant and his or her environment) and provides essential information for initiation of follow-up services in the form of a written evaluation and initial recommendations. The need for follow-up and/or neurologic referral would be indicated in infants with clusters of suboptimal performance, for example, on motor, tone, or reflex items.

OVERVIEW OF THE NNNS FOR CLINICAL ASSESSMENT

The NNNS enables the clinician to do a systematic assessment that includes scoring the infant's response to various administered items or procedures and observing the infant's states; responses to handling; and spontaneous behavior, motor activity, and self-soothing efforts. The assessment includes a variety of indicators of neurobehavioral performance: neurologic and reflex functioning, active and passive muscle tone and quality of movement, signs of stress, abstinence and withdrawal, responses to visual and

auditory stimuli while awake and asleep, and infant state and state changes during the examination.

The complete NNNS examination should be performed only on infants who are medically stable in an open crib or isolette. Although a precise lower gestational age limit cannot be set, the full examination is most appropriate for infants of 33 weeks' gestational age and higher. In the NICU, infants of 28 to 32 weeks' gestational age may benefit from observations during routine caregiving, based on the behavioral and stress/abstinence items, but will probably be too fragile to tolerate the handling involved in administration of the neurologic items. The NNNS will require modification when it is administered to infants who are fragile, secondary to early gestational age or medical condition (eg, administering as much of the examination as possible in the isolette, conducting parts of the examination on different days, omitting certain items). Obviously, the examination should be terminated if the infant seems too stressed as in cases of significant oxygen desaturation and/or cyanosis, persistent tremors, bradycardia, or tachycardia.

The upper age limit for administration may also vary depending on the developmental maturation of the infant. For clinical application, a reasonable upper age limit is 2 months' (48 weeks') corrected age (ie, weeks' gestational age at birth plus weeks since birth). Thus, the NNNS provides a useful bridge in assessment from the early gestation and newborn infant periods to 2 months' corrected age, when other infant assessment tools may be used reliably.

Clinical Significance of NNNS Packages

As indicated elsewhere in the procedures, the NNNS is administered in packages, with each package beginning with a change in focus or in infant position. The packages and the items to be administered within each package are shown in Table 1 of "The Neonatal Intensive Care Unit Network Neurobehavioral Scale Manual" earlier in this issue. The clinical significance of each package is described below.

Preexamination Observation

The infant is observed while asleep and covered. In general, it is expected that the examiner would see the full range of the infant's states during the complete NNNS assessment. A complete assessment should begin with sleep states, moving to a transitional drowsy state with initial handling and progressing to an awake-alert state. Periods of irritability and full-blown crying are expected of term-aged infants as a response to the items, which are packaged to impose increasing amounts of handling and to make varied demands on the infant. The states of arousal reached by the infant, the length of time spent in particular states, and the number of state changes that occur during the NNNS are captured in the summary scores after the assessment.

Preterm infants and other infants at risk may demonstrate significant variability in states achieved, as well as in their ability to maintain periods of quiet alertness. They may also vary in the number of state

changes during the assessment. There is a range of behaviors to observe, which may extend from infants who are hyporesponsive and hard to arouse to infants who are hyperresponsive and irritable. Some infants achieve considerable periods of alertness; others vacillate between drowsiness and irritability, with only brief periods of alertness. The ability to observe and record the amount and rapidity of state change, as well as the quality of states achieved during the assessment, is a clinically useful feature of the NNNS summary scores in documenting the neurobehavioral functioning of the infant at risk.

Preterm infants of 28 to 33 weeks' gestation, as well as infants with medical conditions that prohibit extensive handling, will likely require modifications to the examination and are not expected to demonstrate the full range of states of arousal. Instead, the examiner's focus should be on obtaining information that will be useful to caregivers during handling and routine care, to optimize the infant's responses to his or her environment, and to conserve the infant's energy for growth and improved health.

Response Decrement

The response decrement items indicate an infant's ability to habituate (move from broad, generalized responses such as startles to little or no response over repeated presentations of the stimuli) and provide an indicator of neural processing. The response decrement items also assess for the possibility that the infant may habituate differently to light, sound, or tactile stimuli.

Although there is considerable variation in how infants respond to the response decrement package of the NNNS, the inability to habituate may be an indication of an immature or stressed nervous system. For example, an infant who responds in the same way to every presentation of the stimulus lacks the behavioral accommodation to repeated stimuli that is commonly observed in the healthy newborn. Such a response would be considered "suspect." Thus, information obtained from the response decrement package of the NNNS, coupled with other aspects of the infant's neurobehavioral functioning from other packages, may provide a useful screen for the infant at risk.

The response decrement package of the NNNS may present unique challenges to the examiner when administering the items to preterm or other infants at risk in the NICU. Infants can remain undisturbed on a warmer or in an isolette during administration of these items; however, it is impossible to eliminate competing NICU lighting and noise for the purposes of assessment. Isolettes are generally shaded in the NICU to reduce glare, effectively darkening the sleep space. The flashlight can be used through the open port. In most instances, some decrement in response can be observed after only a few stimuli, obviating the need for repeated stimuli. The bell and rattle provide stimuli at 2 differing sound frequencies. However, the sound of the bell can be similar to some NICU alarms and may be ignored by infants who have already habituated to such sounds. The rattle provides a relatively novel stimulus that may

arouse the infant to a response. When energy conservation is a consideration, it is not necessary to continue repetitions of light or sound stimuli once an initial decrement in response has been observed. Moreover, the examiner should refrain from repeating stimuli if the infant demonstrates an exaggerated response or has a physiologic reaction (eg, oxygen desaturation, apnea, bradycardia) to the stimulus.

Contraindications to administering the response decrement items would include early gestation (28–32 weeks) or extreme sensitivity to environmental stimuli (eg, infants who are physiologically unstable, infants whose eyes have been dilated in preparation for an ophthalmologic examination). In the NICU, it is also important to establish, before the examination, whether the infant is likely to tolerate such stimuli. Reviewing with the bedside nurse the content of the planned assessment and the infant's medical status over the past 24 hours is an essential step in information gathering before beginning the examination.

Unwrap and Supine

This item assesses the infant's initial response to being handled and to being exposed to room-temperature conditions. This maneuver is the first indication of the infant's thermal adaptation, as well as his or her need for containment. The infant's responses may range from remaining relatively stable with little movement or skin color change to increasing movement with marked skin color change. The infant's state of arousal can potentially change to irritability or crying. Drug-exposed infants and other infants at risk may have a pattern of rapid shifts in state or may seem somewhat insulated from early stimulation, only to move rapidly to crying after initial stimulation. At lower gestational ages, infants would not be expected to maintain body temperature without external assists. Because preterm infants have little subcutaneous body fat, they are more susceptible to cold stress than term infants. Term infants with neurologic involvement may have difficulty regulating their body temperature and also may be vulnerable to cold stress. Some infants will be able to be unwrapped for the duration of the examination, whereas some may need to remain inside the warmer or isolette or to be placed under a heat lamp to avoid excessive heat loss. The infant's nurse usually can provide the examiner with appropriate guidelines, based on the infant's previous response to care. However, the examiner should be aware of the signs of cold stress (mottling of the skin, cessation of activity) and should immediately begin to rewarm the infant when these signs appear.

Tactile Stimulation of the Foot

After the infant's response to being unwrapped and uncovered is observed, the tactile stimulation of the foot item is administered. This item indicates the infant's response to having the sole of the foot stimulated by an object and the amount of response decrement over repeated applications of the stimulus. This item can be useful as an additional indicator of the infant's capacity to habituate to noxious stim-

uli but may not be appropriate for infants in the NICU who receive multiple heel sticks.

Reflex Items

These neurologic items assess the neurologic integrity and maturity of the infant. Infant state is specified in the procedures for each reflex. The NNNS identifies normal or best responses, if applicable, but a wide range of normal behavior is usually recognized and the “best” response is meant only as a point of reference. A crucial part of the neurologic assessment is the assessment of muscle tone, which is evaluated under both active and passive conditions. Active tone is assessed while observing spontaneous motor activity, including efforts at self-righting. Passive tone can be assessed during the Posture, Scarf Sign, Popliteal Angle, and Forearm and Leg Recoil items. Both active and passive tone may be influenced by infant state, position (prone, supine, or supported upright), or the effects of postural reflex activity. When assessing muscle tone, both the distribution (proximal versus distal) and the type of tone (extensor versus flexor) should be described because in the developing infant, proximal tone in the neck and trunk may differ from distal tone in the extremities. Another important feature of the NNNS is the scoring of symmetry or asymmetry in reflexes and tone during the assessment. If there is a difference between the 2 sides, then the scoring system records on which side the asymmetry occurred. For accurately assessing symmetry, firm head supports are placed on either side of the infant’s head. (In some nurseries, infection control guidelines may necessitate the use of clean receiving blankets, firmly rolled, versus the props provided in the NNNS kit. The examiner should check with nursery personnel before placing any objects on the infant’s bed linen.) The head is to be maintained in midline during the lower and upper extremity reflexes, as well as during administration of several other reflex items later in the examination. It is expected that with handling, the infant’s arousal will increase. The infant must be in states 3 to 5 for valid administration of these packages.

Lower and Upper Extremity Reflexes

These packages assess primary reflexes and also allow for evaluation of muscle tone of the extremities (legs, feet, arms, and hands) as well as the trunk. Truncal tone is evaluated by supporting the infant beneath the neck and upper back with one hand and the thighs with the other, then gently lifting and “folding” the infant’s head toward his or her feet. This item is particularly useful for identifying excessively increased or decreased tone. The examiner will feel considerable resistance, sometimes followed by an abrupt release when an infant has emerging spasticity. Resistance may also be felt when there is tightness secondary to prolonged atypical posturing (eg, among infants who have received assisted ventilation for prolonged periods).

The pull-to-sit item is an evaluation of neck and shoulder tone. The infant is raised by the arms to a sitting position, and the infant’s ability to lift his or

her head when the trunk is in an upright position is scored. For small preterm infants or those with excessively decreased tone, this procedure may need to be modified by providing some support for the infant’s head with one hand while the infant is lifted to a sitting position with the other. The examiner then briefly observes the infant’s efforts to balance the head in the assisted sitting position.

A poor response to this item suggests the need for care precautions, including use of added neck support during positioning and handling, particularly when the infant is being fed or positioned in semi-upright in an infant seat. A thin roll behind the neck is sometimes indicated to ensure adequacy of the airway. Lateral head supports help to maintain the infant’s head in midline. (A car seat challenge is a standard of care in most NICUs. This 90-minute observation of the infant while seated in his or her own car seat is done to detect a tendency toward obstructive apnea or bradycardia or oxygen desaturation when placed in a seated position. Infants with excessively weak neck and truncal tone are appropriate candidates for a car seat challenge before discharge from the hospital.)

Upright Responses

This package provides the opportunity to observe the infant’s response to more extensive handling as he or she is moved to a supported upright position. In each of these items, the infant’s postural reaction is scored, along with symmetry and muscle tone during the response.

The stepping reflex and trunk incurvation responses can be particularly revealing of postural asymmetries. During ventral suspension, particular attention is given to the position and the tone of the neck and the shoulders. Excessive extension in ventral suspension indicates increased extensor tone through the neck, shoulders, and trunk and suggests the need for additional assessment and postural interventions. Conversely, the infant whose body drapes in a “rag-doll” manner over the examiner’s hand may have excessively decreased tone. Either extreme warrants additional evaluation, as well as recommendations to caregivers for modifying the positioning and handling of the infant to support a symmetrical, flexed posture.

Prone Responses

For this package, the infant is gently lowered from ventral suspension to the prone position. The quality of the crawling response and the amount of stimulation that may be required to elicit crawling are recorded. The infant’s attempts to raise the head are also evaluated while in prone. This is a particularly meaningful item from a qualitative standpoint for assessment of preterm infants or those who are at risk for neurologic sequelae. When placed directly in prone, most infants of 33 weeks’ gestation or older will turn their head to clear their nose of the surface. Many will also extend the head to lift it briefly from the surface. As infants approach 2 months’ corrected age, they should be expected to lift and turn their head with ease, with extension at least through the

thoracic area, supporting some of their weight on forearms.² Infants who are not able to lift and turn the head sufficiently to clear the supporting surface should never be left unattended in the prone position and are likely to require additional assessment and intervention to enhance extensor tone and shoulder girdle stability.

The NNNS assessment progresses from evaluation of passive tone and reflexes to more active tone and responses. There is also a progression in the amount of handling. At this point, the assessment changes from a primary focus on reflexes, muscle tone, and quality of movement to other aspects of the infant's behavior and functioning.

Cuddling

The infant is picked up and held, and the "cuddliness" of the infant (ie, the infant's participation while being held) is evaluated. While holding the infant, it is possible to assess to what extent the infant relaxes, or decreases in overall muscle tone while being held, and to what extent the infant may actively participate by "nestling" into the arms or into the nape of the examiner's neck while being held upright. Some infants may actively resist being held, and some may be passive, like a "sack of potatoes." Other infants may actively participate and "nestle in." Differences in response to being held in the arms versus upright are evident during this part of the assessment, as is the infant's overall response to being picked up and handled. The information obtained from this item may be particularly useful for infants who are difficult to console, as it provides clues to handling techniques that may be most effective.

Supine on the Examiner's Lap

This is the position for eliciting orientation. Orientation is the ability to actively "alert" and then to coordinate eye and head movement (while staying in an alert state) to visually follow a moving object (eg, ball, rattle, examiner's face) or find a source of sound (eg, rattle, examiner's voice, presented at the side of the head). These items tap information-processing abilities that may represent higher levels of brain function and maturation. Six items are presented for visual and auditory orientation in this package. Three are "inanimate" items (moving ball, moving rattle, and rattle presented as an auditory-only stimulus at the side of the head), and 3 are "animate" items (examiner's face only, face and voice, and examiner's voice only at the side of the infant's head). Each of the 6 items is scored according to the infant's response and ability first to alert and then to track the stimulus. In addition, the different handling procedures that the examiner must use to gain, regain, or maintain alertness are recorded.

The ability to attain or maintain a stable alert state can be variable among infants, particularly infants who are at risk. Some infants (eg, those with functional visual deficits) require a more salient inanimate stimulus to engage the infant visually and to elicit visual tracking. In those cases, a black and

white schematic face can be used as an alternative to the ball and the rattle. Such adaptations to the NNNS procedure should be noted in the clinical summary.

The orientation package challenges the infant to maintain an alert state and to attend to visual stimuli while shutting out competing stimulation. This task also places demands on the infant's ability to maintain physiologic stability and motor organization; thus, with smaller and more fragile preterm infants, it may be advisable to limit the number of stimuli presented. Training in the clinical uses of the NNNS is particularly important with the administration of the orientation items, to learn what actual items to use in response to the at-risk infant's more variable states of alertness.

Infant Spin

This item involves evaluation of tonic deviation of the head and the eyes in response to stimulation of the labyrinths in the inner ear. The examiner holds the infant upright in space with hands around the infant's shoulders and the infant's head supported with the fingers, and then spins in a full circle, observing for the presence and the direction of eye movements. The typical newborn response is movement of the eyes and head in the direction of the spin. Nystagmus (rhythmic saccades) are rarely present in newborns. An exaggerated or prolonged nystagmus response can be indicative of a stressed or atypically functioning nervous system. This item should be administered only to medically stable infants as vestibular stimulation has the potential to induce autonomic responses.

Supine in Crib

The defensive responsive, asymmetrical tonic neck reflex and Moro reflex tend to be the most aversive and thus are placed at the end of the assessment. The infant may respond to elicitation of these reflexes with higher arousal and irritability. In some instances, eliciting the Moro reflex will contribute comparatively little to the information obtained from the NNNS evaluation and may potentially stress the infant unnecessarily. The examiner should be judicious in estimating the potential physiologic and behavioral "cost" of administering individual items before including them in the evaluation. Throughout administration of the NNNS, the infant's own attempts at self-soothing and the efforts of the examiner to soothe the infant are observed and recorded.

Postexamination Observation of Infant State

The infant's final state is one indication of the infant's ability to tolerate the overall handling and procedures during the examination. When evaluating fragile infants, it is recommended that the examiner remain at the bedside for a minimum of 10 minutes after completion of the assessment to obtain an adequate picture of the infant's ability to recover and to regain physiologic and behavioral organization.³

SUMMARIZING THE NNNS FOR CLINICAL PURPOSES

There are several ways in which the NNNS can be summarized for clinical purposes. First, the examination is scored and summary scores are calculated as described in the procedures ("The Neonatal Intensive Care Unit Network Neurobehavioral Scale Procedures" earlier in this issue). Scores for an individual infant can be compared with the percentile scores to determine how an infant compares with an at-risk sample ("Summary Statistics of Neonatal Intensive Care Unit Network Neurobehavioral Scale Scores from the Maternal Lifestyle Study: A Quasinormative Sample" earlier in this issue) and a normative sample ("Normative Neurobehavioral Performance of Healthy Infants on the Neonatal Intensive Care Unit Network Neurobehavioral Scale" earlier in this issue). This method can identify domains (summary scores) in which the infant deviates from the larger population. However, these percentiles should be used with caution as they are based on samples of infants at different ages (1–2 days for nonrisk infants and 1 month for at-risk infants).

The second way to summarize the examination is through interpretation of the computed summary scores (see Appendix 2 later in this issue). This includes interpretation of the construct measured by the summary score as well the individual items that compose the summary score.

A third approach is to write a clinical summary using the constructs of the summary scales but without actually scoring the individual items. For some clinical purposes, there may not be time or resources for scoring the examination and computing the summary scores. The clinician can move from assessing the infant to writing up a clinical summary based on a working knowledge of the summary scales without actually scoring the examination. Interpretation of each summary score is described below. This is followed by a case study with a clinical summary and a work sheet that clinicians may find useful for clinical consultation with caregivers and parents.

Summary Scores

Habituation

This scale measures the capacity of the infant to "protect" his or her sleep by progressively "tuning out" a stimulus, after an initial response. Higher scores are indicative of better (more rapid) habituation. Low scores indicate the infant's failure to inhibit the response or long delays in inhibiting the response, either of which may result in irritability or disturbed sleep.

Nonoptimal Reflexes

The NNNS scores not only the presence of newborn reflexes but also the strength of the response. However, reflexes differ with regard to the criterion for an optimal response. A brisk response may be desirable for some reflexes; for others, a more moderate response is considered optimal. For each reflex item in the NNNS examination, the optimal response

is described. Any other response is considered non-optimal. The number of nonoptimal responses is potentially more important than performance on any single reflex. Therefore, this score is a count of the number of nonoptimal scores. In addition, the clinician should make note of worrisome performance on individual reflexes.

Asymmetrical Reflexes

This is a count of the number of times that the reflex on one side of the body is stronger or weaker than on the other side. As with the nonoptimal reflex score, the number of asymmetric responses is probably more important than isolated asymmetries on specific reflexes. Some asymmetric responses are typical among newborns (eg, a rightward asymmetry of the Moro and asymmetric tonic neck reflex⁴). However, multiple asymmetries, particularly when they are consistently detected on one side, may represent a clinically significant finding. This is not reflected in the NNNS score and should be noted separately.

Hypertonicity

This scale indicates increased muscle tone in the arms, legs, and trunk. It is based on specific items that measure active and passive tone as well as overall summary scores of tone and movement seen throughout the examination. A high score describes an infant whose overall tone is consistently hypertonic (ie, increased tone in arms, legs, trunk, neck, and shoulders).

Hypotonicity

This scale uses the same items as the Hypertonicity scale to measure decreased or low muscle tone. A high score on this scale describes an infant who was consistently hypotonic in arms, legs, trunk, neck, and shoulders during active and passive assessment of tone and overall tone and during motor activity. Some infants show marked fluctuations in overall tone or are hypertonic on some items and hypotonic on others. There are provisions for this in the scoring, but it may be important to make a special note of this observation.

Quality of Movement

This scale is a measure of motor control, including smoothness, maturity, modulation of movement of the arms and legs, and startles and tremors. High scores (good quality of movement) on this scale indicate infants who show smooth movement with little or no jitteriness, tremors, or startles and average amounts of spontaneous and elicited motor activity. Low scores (poor quality of movement) indicate infants who are predominantly jittery with little or no smooth movement of the arms and legs and with considerable tremors, startles, and a high overall activity level.

Attention

This scale indicates an infant's response to the auditory and visual stimulation during the orientation package. Infants with high scores on this scale

TABLE 1. NNNS Consultation Sheet

Patient's Name: Baby K

Date: _____

Reason for Consultation: Brief summary of case and questions to be answered (*prenatal substance exposure; how to manage care—consult with parents*)

Report of Consultation: To be written in the following manner

1. List of findings
2. Summary of findings
3. Recommendations

Assessment Conducted by: _____ Date of Consultation: _____
Time of Consultation: _____

1. List of Findings
Stress Abstinence Signs (list those observed)
Yawning, Startles, Hypertonia, Back Arching, Fisting, Cortical Thumb, Gaze Version, Fuss/Cry During Orientation, High-Pitch Cry, Extreme Irritability, Abrupt State Changes
Nonoptimal Reflexes (list those observed)
Popliteal Angle, Scarf Sign, Hand Grasp, Truncal Tone, Stepping, Ventral Suspension, Crawling, Tonic Deviation of Head and Eyes
Attention (describe)
4 of 6 items could not be administered (98), many handling procedures required (6).
Motor (describe)
Hypertonic motor tone (7), poor motor maturity (2), high activity (spontaneous, 4; elicited, 4).
Arousal/Excitability (describe)
High irritability (7), rapidity of build-up early to reflexes (8), high activity (spontaneous, 4; elicited, 4), high lability of states (7), several startles (8), consolability with pick up and hold (3).
Regulation (describe)
High irritability (7), consolability with pick up and hold (3), able to self-quiet (8), hand to mouth (7)
Habituation (describe)
Decrement after 5 stimuli to light (7), decrement after 6 stimuli to sound (7), localized to foot after 3 stimuli (6).
2. Summary of Findings
Stress/Abstinence: Baby K showed 11 stress/abstinence signs.
Nonoptimal Reflexes: Baby K showed 8 nonoptimal reflexes. However, none of the reflexes was asymmetrical.
Attention: Baby K was fussy during orientation despite many handling maneuvers used to try to keep the infant in a state 4/5. Four of the 6 items could not be administered because the infant was not in state 4/5. However, there was a stable alert state for the auditory items (inanimate, score of 8 and animate, score of 6).
Motor: General Tone/Predominant Tone was hypertonic 50% of the time. Motor Maturity showed jerky movements with mild overshooting, with much Spontaneous Activity and Elicited Activity. There was no hypotonia.
Arousal/Excitability: Baby K was irritable throughout the exam and became irritable early, during the lower extremity reflexes, and showed much activity, a high number of state changes, and several startles. He could be soothed by being picked up and held in the examiner's arms.
Regulation: Baby K was irritable but could be soothed by being picked up and held. The infant was able to self-quiet and showed hand-to-mouth ability.
Habituation: While asleep, Baby K stopped response decrement light and sound after 5 or 6 stimuli and localized stimulation of the foot after 3 presentations.
3. Recommendations
1. Allow Baby K to sleep in a quiet place.
2. Swaddle Baby K during feeds; low key, quiet voice, don't have several sensory inputs (talking, facial demands, rocking) at the same time. Frequent breaks for sucking; burp in upright position over shoulder every 1 ounce.
3. Interact quietly, direct face alone, or face and quiet voice, when Baby K is awake.
4. Consult with physical/occupational therapy to examine for tone issues, number of nonoptimal reflexes (see consultant for complete scored NNNS exam), recheck quality of sucking, coordination of sucking, and swallowing.
5. Will do repeat examination in 2–3 days. Will focus on alertness, range of states, irritability, signs of stress, motor tone/motor control, ability to self-soothe.
6. Instruct Boarder Baby volunteers on holding, interacting with infant when awake.
7. Consultant will meet with parents and do parent–infant consult with NNNS.
8. Referral to the Vulnerable Infants Program.

show good turning and following on the orientation items and show sustained alertness. Low scores indicate minimal turning and following and brief pe-

riods of alertness during the presentation of the orientation items, with a poor quality of response. A low attention score may reflect a low threshold for

TABLE 2. Summary of NNNS Examination

1. State/State Changes
 - Overall State Changes*
 - a. Summarize the number and type of state changes during the exam.
 - b. Describe what events, types of handling, infant physical movement, etc caused the infant to change state.
 - Detail: State Changes During the Exam*
 - c. Habituation. Describe infant's response to light, rattle, and bell.
 - d. State During Reflex/Motor Items. (Lower/Upper Extremity, Upright Responses).
 - e. Describe infant's state during reflex items, what state changes occurred, what caused the state changes, what did the examiner do, what self-soothing behavior did the infant do?
 - f. State During Orientation. Was the infant able to reach a stable alert state? If so, what did the examiner do to maintain or recover an alert state (examiner facilitation items)? What did the infant do to maintain or recover an alert state?
 - g. State at End of the Exam (spin, defensive maneuvers, TNR, Moro). Describe the infant's state during the final times, including what state changes occurred, what caused these state changes, what the examiner did, and what the infant did.
2. Crying/Soothing
 - a. Describe when the infant cried or fussed during the exam.
 - b. Describe what the examiner did to soothe the infant.
 - Summary of Soothing Techniques*
 - c. Describe which methods of soothing were most effective in helping the infant to achieve a state 4 or lower (refer to Examiner Facilitation).
3. Infant's Self-Soothing/Regulatory Behavior
 - a. Describe hand to mouth, visual fixation, leg crossing, foot bracing, etc, and the changes of state that occurred when the infant performed these behaviors.
 - Summary of Self-Soothing/Regulatory Behavior*
4. Infant's Response to Orientation
 - a. Describe the infant's response to each of the 6 Orientation items.
 - b. Describe how the infant responded, possibly differently, to animate versus inanimate items.
 - c. Describe how the infant responded, again possibly differently, to auditory versus visual stimulation.
 - d. During orientation, describe what helped the infant to achieve or to maintain, an alert state.
 - e. Describe which behaviors (or signs) the infant could achieve or maintain in an alert state.
5. Infant's Response to Cuddliness Items
 - a. Describe the infant's response to cuddliness (In Arms, Upright on Shoulder).
 - b. Describe how the infant's responses were different or similar to in Arms versus Upright on Shoulder.
6. Infant's Signs of Stress
 - a. Describe the signs of stress the infant showed during the exam (Stress/Abstinence Scale items).
 - b. Describe what caused or preceded the onset of these signs of stress.
 - c. Describe how each stress sign was correlated with state and motor behavior.
 - d. Describe what followed the onset of each sign of stress (on the examiner's and the infant's part).
7. Motor Behavior, Motor Movement, and Motor Coordination
 - a. Describe the infant's overall motor tone (summary scale).
 - b. Describe the infant's overall quality of movement (summary scale).
 - c. Describe the amount of startles during the exam.
 - d. Describe significant reflex responses, those that were under- or overresponsive.
 - e. Describe the quality of sucking.

stimulation and is often seen in infants who are physiologically unstable.

Handling

This score is specific to the orientation package and describes the number and the type of maneuvers that were necessary to keep the infant in the appropriate state to administer the orientation items. These include the amount and the type of handling needed to arouse the infant from a drowsy to an alert state or to soothe the infant from an irritable or crying state to an alert state. High scores indicate infants who need substantial input from the examiner to elicit orientation; infants with low scores require minimal input from the examiner.

Arousal

This score indicates the infant's overall level of arousal during the examination. This includes states

of arousal reached and associated motor activity, as well as how quickly the infant becomes irritable and the infant's overall activity in response to handling. A high score indicates an infant who is easily aroused to fuss and cry during the examination, predominantly fussing and crying during the examination, and highly active while being handled and while left alone.

Excitability

This scale is a measure of high levels of motor, state, and physiologic reactivity. Like the Arousal scale, it includes how irritable the infant was in response to handling. Although the Arousal scale focuses primarily on the level of arousal, the Excitability scale includes associated changes in physiologic and motor activity and signs of stress such as color changes, startles, and tremors. Excitability also in-

cludes how the infant responds to efforts by the examiner to soothe him or her. A high excitability score identifies infants who become irritable during the examination, as well as those who remain irritable despite repeated attempts by the examiner to soothe them. Infants who have a high number of state changes, become persistently red in color with handling, and have a high number of tremors and startles, especially while being handled, obtain a high excitability score. Infants who remain physiologically stable in response to handling with little irritability, few state changes, and few startles obtain a low excitability score. This score is especially pertinent to the care of infants in the NICU or those with prenatal drug exposure.

Lethargy

This scale is a measure of low levels of motor, state, and physiologic reactivity. It is the converse of the Excitability score and is meant to identify infants who are extremely underaroused. This summary scale captures an infant who may remain in a lower drowsy state despite the necessary handling during the examination. A high Lethargy score is reflective of the examiner's efforts to bring the infant to a stable alert state to evaluate his or her response to visual and auditory stimulation. Such findings suggest the need for a careful review of any medications that are being administered to the infant, as well as the infant's sleep schedule, as each may contribute to a high Lethargy score.

Regulation

This score combines physiologic, motor, and attentional activation with the ease or difficulty, on the part of the examiner, of soothing the infant. It also incorporates the infant's capacity to soothe him- or herself. It is probably the most general of the summary scores and indicates how the infant copes with the demands of the examination, with higher scores indicating better regulation.

Stress/Abstinence

This scale includes an overall score as well as scores by organ system. Although a high overall score is worrisome because it indicates that the infant showed many stress/abstinence signs, it is important to note whether they were generalized and distributed throughout the various organ systems or were

localized to specific organ systems. A low number of stress signs scattered over many organ systems may have a different meaning than if they cluster in the same area. Five stress signs all in the central nervous system area, for example, or those that describe drug withdrawal might have clinical significance. Finally, some stress signs, such as myoclonic jerks, are important when they are observed because they are rarely seen.

Case Study

Infant K was a white male infant born at 38 weeks' gestational age by spontaneous vaginal delivery and had birth weight 2655 g and Apgar scores of 8 (1 minute) and 9 (5 minutes). The infant's urine toxicology screen was positive for marijuana. The mother was in a methadone treatment program with a daily dose of methadone of 90 mg in the last trimester of pregnancy. The infant was being treated with deodorized tincture of opium, which had been started on the fifth day of life, after increased signs of withdrawal. The infant was examined on the seventh day of life. Finnegan scores of withdrawal for 12 hours preceding the NNNS examination ranged between 4 and 6.

The findings, using the NNNS Summary Scores, are indicated on the NNNS Consultation Sheet (Table 1) for an in-hospital consultation. When appropriate, the actual NNNS score for the item is indicated. An additional form for providing feedback to caregivers or parents is also provided (Table 2).

NNNS Summary Form

This form is used as a guide to provide a written summary to give feedback to caregivers or parents. It is useful both in situations in which the parents observed the examination and when they did not observe the examination.

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