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What Are the Effects of the Maternal Voice on Preterm Infants in the NICU?

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ABSTRACT

Background/Significance: Premature infants often experience extended stays in the neonatal intensive care unit (NICU) as opposed to home with parents. This prolonged separation creates a strain for both parents and infants, decreasing attachment and parental caregiving. One strategy to combat this shared stress is increasing parental participation, particularly through the use of their voices whether parents are present or not.

Purpose: This Evidence-Based Practice Brief column explores the connection between mother and child, specifically the effects of maternal voice on infant autonomic stability, weight gain, and behavioral states.

Methods: A systematic search of CINAHL, PubMed, and PsycInfo was used to identify studies involving the use of maternal voice intervention with preterm infants in the NICU.

Results: Fifteen studies were identified. Three intervention categories emerged: (1) live maternal speech, (2) recorded maternal speech (subcategories included whether intervention content was prescribed or not), and (3) recorded maternal speech that was combined with biological maternal sounds (heart rate). Within each category, studies were organized chronologically to reflect how knowledge has changed overtime.

Implications for Practice: Maternal voice has physiological as well as behavioral and emotional effect on preterm infants. Several studies found that maternal voice increased autonomic stability improving (heart rate and respirations) as well as weight gain. No negative effects were identified. Given these findings, incorporating different types of maternal voice into routine care by the bedside nurse can assist the mother in feeling more involved in her infant's care without seemingly being a distraction or obstacle to providers.

Implications for Research: A major limitation for generalizability was sample size; more research is needed with larger sample sizes replicating interventions types to discern best outcomes.

Video Abstract available at https://journals.lww.com/advancesinneonatalcare/Pages/videogallery.aspx?videoId=31&autoPlay=true.

Key Words: biological maternal sounds, live speech, maternal singing, maternal speech, maternal voice, NICU, premature infant, preterm infant, preterm infant outcomes, recorded speech

The early attachment between the mother and the child is one that is recognized by many for its importance to fetal and infant development. While the development of the attachment in utero is vital, that connection does not stop once the neonate is born. In fact, one could argue that the importance of the connection increases as the neonate continues to develop, particularly in relationship to the language, visual, and cognitive development.[1] For neonates born premature or high-risk, admission to the neonatal intensive care unit (NICU) is likely. Within this chaotic and abnormal environment, these high-risk infants are challenged to develop *normally* without constant contact with their parents, particularly their mother, as their primary caregiver. Not only does this separation place more stress on the already physically stressed infant, but it also adds stress for the mother, increasing her feelings of helplessness, particularly because she cannot fully participate in her child's caregiving and development in the way she truly yearns.[2] Mother–infant attachment is well-known to be related to maternal proximity, touch, and voice and each of these characteristics provides support to the infant.[3] In the NICU environment, this attachment is often challenged to fully develop because of obstacles in the environment including limited mother–infant exposure, direct care provided by a nonparent, and other physical limitations (such as being cared for in an incubator or limitations on physical contact between the mother and the child).[4]

To address this issue, much research has occurred related to how to better incorporate mothers into their premature infants' care within the NICU setting; unfortunately, not much research has been completed examining ways to increase father participation. Parents often struggle with coordinating their availability between their personal lives and the predetermined visiting hours set by the hospital, even with open

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visitation many NICUs still have times when parents cannot visit, such as during nursing report or medical rounds. Many parents must continue working and potentially care for other children, so they are unable to be with their newborn infant as often as they would prefer. Given these circumstances, many researchers have examined the feasibility of audio recordings as a source of parental interaction. Two early studies by Lahav and colleagues[5,6] examined the feasibility and potential safety and care issues related to this type of therapy. These feasibility studies showed that audio recordings of voice as well as biological maternal sounds (BMS) were safe to be used in the NICU setting. However, in the preliminary research, the therapeutic window has not been determined, nor the optimal range for this type of therapy, or the short- and long-term effects, both behavioral and physical, that these therapies could have for infants and their mothers.

It is widely accepted that a mother's voice is soothing to her infant, but to what extent or capacity this effect has on the physiological and behavioral responses in the very preterm and moderate to late preterm infant is not well understood. The short- and long-term effects of maternal voice on physiological and behavioral responses were not addressed in these beginning feasibility studies. Increasing our understanding of the connection between mother and preterm infant from a scientific vantage point provides more evidence to support the integration of this intervention into routine caregiving in the NICU. Thus, the purpose of this systematic review is to gain an understanding of what is currently known about the concept of maternal voice as a therapeutic agent for the preterm infant in the NICU.

PURPOSE

This systematic review explores the connection between mother and child, specifically the effects of maternal voice on infant autonomic stability, weight gain, and behavioral states. Given the varied types of interventions, we were unable to complete a meta-analysis; however, we did complete a systematic search and synthesis of the literature using PRISMA to guide our work. A cursory literature search illustrated that the primary source of parental auditory stimulation came from the mother, with little research being conducted with fathers. Why this occurred is unknown, although it may be related to known research on the importance of the mother–infant attachment. Thus, for the review only studies of maternal voice are included.

METHODS

Inclusion and exclusion criteria for study identification are outlined in Table 1. Studies must have met all of the criteria to be included. Studies were identified through a systematic search of CINAHL, PubMed, and its related database MEDLINE, and PsycInfo using the search words as identified in Table 2. Studies were also found through ScienceDirect and Google Scholar.

Cochrane Library was included in our search but not utilized since no reports were found addressing this topic. The initial searches were completed in March 2017 and repeated in April 2018. For specific databases, more intense parameters were included such as the use of MESH term. A PRISMA diagram (Figure 1) was constructed to illustrate this process. After deleting duplicates, a total of 72 articles were found via the database search. With completion of an initial screening, 43 articles were discarded for not meeting parameters: not being available in English; not written in the time frame of the past 15 years; and not occurring within the NICU. Articles were further screened for eligibility regarding the material, such as an intervention study using maternal voice as a therapeutic agent and focusing on preterm infants. Studies were evaluated and grouped on the basis of eligibility and study focus. A total of 15 intervention studies are included in the review. These studies were read in detail and categorized by theme on the basis of maternal voice intervention type into (1) live Maternal Speech or Singing; (2) Recorded Speech or Singing; and then (3) Recorded BMS with Maternal Speech. These categories were further grouped into subsets on the basis of whether the content the mothers spoke and/or sang was prescribed in the study protocol.

TABLE 1. Study Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
• Published in English • Published within the last 15 yr (2003-2018) • Studies examining effects of maternal voice (singing/speech) as an auditory stimulation • Participant sample predominantly preterm infants born between 26 and 38 wk' postmenstrual age (PMA) cared for in the NICU • At the time of the intervention, studies of the preterm infants with not medically complicated conditions	• Studies focused on other auditory stimulation not of maternal nature (music therapy, etc) • Studies with samples that were predominantly full-term infants • Studies of preterm infants with medically complicated conditions (mechanically ventilated, intubated, etc)

TABLE 2. Search Terms Used for Systemically Searching the Literature (PubMed)

Our search strategy for PubMed is included in Table 2. Search strategies used for other databases included the same terms and were loaded separately and together to garner the most possible items for inclusion in the review.

((((((((((mother* voice*OR mother*s sound* OR mother* speech OR maternal voice*) AND (NICU OR neonatal intensive care)))) OR ((((“Voice”[MESH]) AND “Acoustic Stimulation” [MESH]) AND “Infant, Newborn” [MeSH Terms]) AND “Infant, Very Low Birth Weight”[Mesh])) OR (((“Acoustic Stimulation” [Mesh]) AND “Intensive Care Units, Neonatal”[MeSH Terms]) AND “Voice” [Mesh])) AND English[lang])) OR (Live[Title] AND maternal[Title] AND effects[Title] AND speech[Title] AND singing[Title] AND beneficial[Title] AND effects[Title] AND hospitalized[Title] AND preterm[Title] AND infants[Title])) OR (((“Singing”[Mesh]) AND “Intensive Care Units, Neonatal”[MeSH Terms]) AND “Intensive Care, Neonatal”[Mesh])))) OR ((((((“Acoustic Stimulation”[Mesh]) AND “Voice”[Mesh]) OR “Speech”[Mesh])) AND ((“Infant, Extremely Premature”[Mesh] OR “Infant, Premature”[Mesh]) OR (“Intensive Care, Neonatal”[Mesh] OR “Intensive Care Units, Neonatal” [Mesh])))) AND English[lang])

Filters: English

Produces 72 documents

Mesh tems:
- Voice
- Acoustic stimulation
- Infant, newborn
- Infant, very low birth weight
- Intensive care units, neonatal
- Singing
- Speech
- Infant, extremely premature
- Infant, premature
- Intensive care, neonatal

Other search terms utilized:
- Mother/mothers/mother’s/mothers’
- Voice/voices
- Speech
- Singing
- Sound
- Maternal
- NICU/neonatal intensive care
- Acoustic stimulation
- Live
- Hospitalized
- Preterm infants/premature infants/newborn infant/very low birth-weight infant

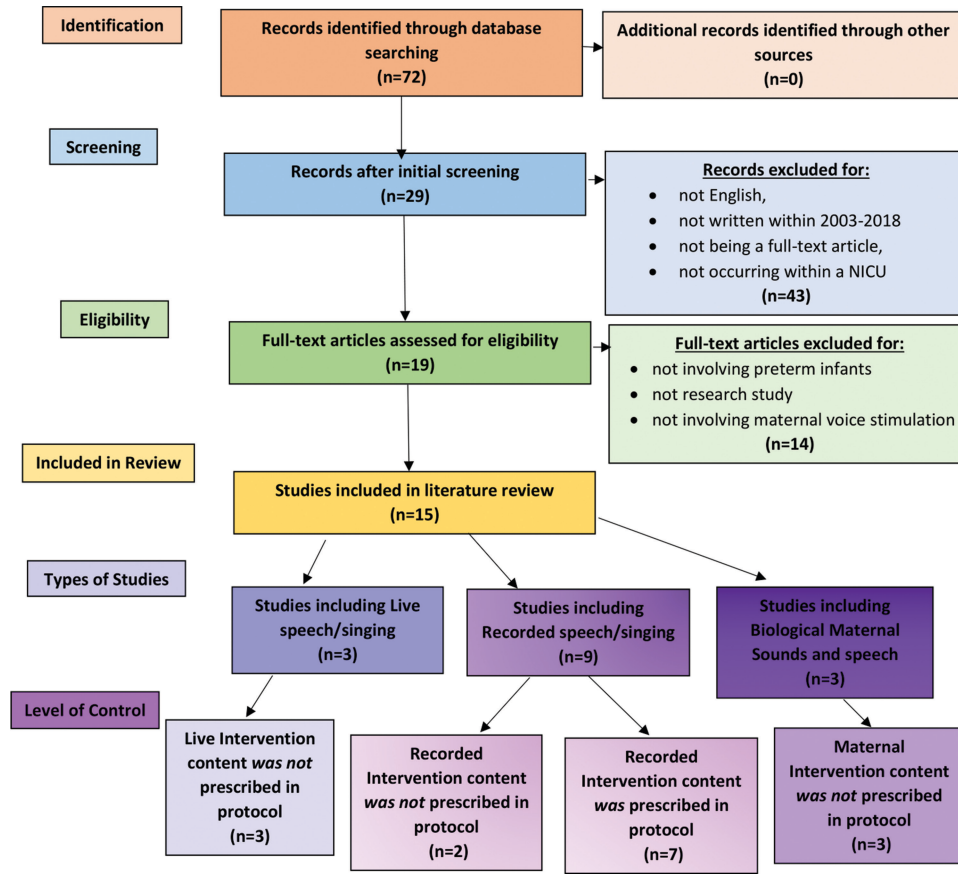
Each reviewer read the final 15 studies and came to consensus to design the matrix table (Table 3). Agreement for inclusion/exclusion of a study in the review was 95%; the only areas where consensus building occurred were (1) whether the study involved predominantly preterm or full-term infants and (2) whether the study was predominately a maternal voice intervention.

Once studies were identified, information from studies was extracted and compiled into a matrix table. The table had the following categories: author, year, title, journal, type of study; purpose (research question, hypotheses); methods (setting/sample design); study variables (independent, dependent); measures (reliability/validity, instruments, data collection methods); results; limitations summary (decision/reservations). Each study was also examined for level of evidence such that comparisons could be made (see Matrix Table 3). The matrix table served as a summary of the studies and aided in further organization of the studies based on similarities and differences in the study content, design, and results (see Table 3).

RESULTS

Of the 15 studies included in the review, 3 involved live speech/singing, 9 with recorded speech/singing, and 3 others with recorded biological maternal sounds and speech. Biological maternal sounds refer

FIGURE 1



PRISMA diagram: Maternal voice effects with Preterm Infants. A PRISMA flow diagram illustrating the screening and organization process used when constructing this review.

to the recording of the mother's heartbeat combined with the mother's vocal recording. Of the 9 studies that used recorded maternal speech/singing, 2 of the studies did not prescribe the intervention content and 7 did (meaning that the participants [mothers] were required to follow a script). Recordings were played for the infant using mp3 players and similar technology. For the studies with live singing and BMS, the mothers could choose the content of their interaction with their infants. Study designs varied and included single subject, within subject, descriptive, quasi-experimental, prospective clinical trial, and longitudinal case study (see Table 3 for more details). Most included studies were conducted within relatively short time frames, a few days to a few weeks, although there are instances of elongated review, such as in one longitudinal study.

Independent variables for studies predominately focused on presence or absence of maternal voice, whether it be live or recorded. Some studies also compared the control (no voice) to maternal voice and additional auditory stimulation, such as music or alternative voice, such as the nurses. Dependent variables extracted from the studies were also similar. Several studies examined infant physiological effects through assessment of heart rate, oxygen saturation, and respiration rate, which we define as *physical effects*. Other studies examined biological measures such as salivary cortisol levels to determine the *biological effects* maternal voice had on the preterm infant. Furthermore, some studies also examined feeding habits, such as volume of formula consumed, days until full oral feedings obtained, and weight gain to address an outcome of *biological effects*. Additional studies also examined behavioral responses, through the use of behavioral observation instruments such as the Blackburn Activity Scale, which we define as *behavioral effects*. The studies included in this review are discussed within these 3 categories to assist clinicians in considering which types of interventions might be most relevant in their caregiving situation. We have also included more detail about the interventions provided in our discussion of study results since the study designs and interventions vary greatly and the detail could be helpful to those considering incorporating these interventions into routine care (Table 4).

TABLE 3. Matrix Table: Maternal Voice Effects on Preterm Infants: A Matrix Table Illustrating the Highlights of Each Study Included in This Review[a]

Author, Year, Setting; Level of Evidence (LoE)	Research Question	Study Design Sample	Independent Variables (IV) Dependent Variables (DV) Data Collection Methods (DCM) Instruments	Results	Limitations
Authors: Blumenfeld & Eisenfeld **Year:** 2006 **Setting:** Level II NICU; USA; Hartford, CT LoE: 4	**Research Question:** Can a mother singing to her newborn improve its feeding (more formula eaten, gain weight faster, etc)?	**Design:** Single-subject (infant served as own control) **Sample:** 11 preterm infants beginning to feed on their own (born between 31 and 34 wk' PMA)	**IV:** Singing during feeding content of speech/song were not prescribed; Mother sang during feedings **DV:** Heart rate (HR); Respiration rate (RR); oral feeding volumes **DCM:** Nurses observed of HR, RR, and oral feeding volumes	No differences between HR, respirations, or oral intake with intervention (singing vs nonsinging	**Limitations:** Live singing seemed to cause anxiety for some mothers Results inconclusive; more research is needed to determine relationships Infant stress may have decreased with intervention, more relaxed demeanor and behavior Mothers self-reported time of feedings
Authors: Filippa, Devouche, Arioni, Imberty, & Gratier **Year:** 2013 **Setting:** Level II NICU; Aosta, Italy LoE: 4	**Research Question:** Does live maternal speech and singing have any beneficial effects on preterm infants within the NICU?	**Design:** Single-subject design (infant served as own control) **Sample:** 18 preterm infants 32-38 wk' PMA	**IV:** Testing over 6 days. Data collected on days 1, 3, 5, served as control. Intervention provided days 2, 4, 6; mothers spoke and then sang to child continuously for 5 min each, total 10 min **DV:** HR; Oxygen saturation (O_2 sat); # of critical respiratory events [CRE (hypoxia/bradycardia)]; infant behavioral states **DCM:** Fixed video cameras for facial expressions; Tascam linear PCM recorder (audio); monitors for HR, O_2 sat; CRE **Instruments:** Brazelton—behavioral states—independent raters for infant behavior states (video recording)	HR, O_2 sat, time spent in quiet awake state were increased with speaking/singing intervention Proportion of CRE and time spent in deep sleep were decreased with intervention	**Limitations:** Small sample size; results need to be repeated to confirm More time was spent in quiet and awake states when the infants received the intervention No contact was permitted between mother and child
Authors: Arnon, Diamant, Bauer, Regev, Sirota, & Litmanovitz **Year:** 2014 **Setting:** Level III NICU; Saba, Israel LoE: 4	**Research Question:** Does maternal singing during kangaroo care have added benefits on both preterm infants and mothers?	**Design:** Randomized, within-subject, crossover (infant own control), repeated-measures **Sample:** 86 preterm infants 32-36 wk' PMA	**IV:** Testing occurred over 2 d Intervention consisted of 10 min kangaroo care (KC) no intervention, followed by 20 min KC with live maternal singing content not prescribed, and then 10 min KC no intervention **DV:** HR variability (HRV); Infants'/mothers' HRs, O_2 sat, RR; Infants' behavioral state; Maternal anxiety **DCM:** HRV software analyzed cardiorespiratory information; recorded by a single physician and analyzed by an author blind to the conditions **Instruments:** STAI form Y scale for maternal anxiety	HRV demonstrated autonomic stability with intervention Maternal anxiety also decreased No changes in mean HR, RR, O_2 sat or modified behavioral state criteria	**Limitations:** More testing to confirm observed results of autonomic stability First to focus on maternal anxiety related to providing this type of care Lack of control of timing regarding when intervention was given

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Author, Year, Setting; Level of Evidence (LoE)	Research Question	Study Design Sample	Independent Variables (IV) Dependent Variables (DV) Data Collection Methods (DCM) Instruments	Results	Limitations
Authors: Johnston, Filion, & Nuyt **Year:** 2007 **Setting:** Two university-affiliated Level III, NICUs; Quebec, Canada LoE: 4	**Research Questions:** Does a mother's voice reduce pain felt during her newborn's routine painful procedures? Can it be used as a therapy to reduce the pain/stress during procedures?	**Design:** Crossover design (infants served as own control) **Sample:** 27 preterm infants between 32 and 36 wk' PMA	**IV:** Recording of mother's voice as she spoke soothingly and filtered to mimic conditions of voice heard in womb; baseline recording played via cassette player 3 times daily over a 48-h-period after feedings (total = 6 times) then infant underwent heel lance while recording did or did not play; after 10 d and control condition or intervention was delivered **DV:** HR & O_2 sat; facial expressions; Growth velocity (weight) **DCM:** HR and O_2 sat were recorded by pulse oximeter; nurses recorded weight and volumes of formula/human milk prescribed and consumed Instruments: Panasonic camera to collect facial expressions made during heel lance; pulse oximeter	HR was increased and O_2 sat was decreased in experimental condition Significant weight gain	**Limitations:** Low participation rate related to mothers' lack of comfort Difficult to control other sounds within NICU Results illustrate the importance of observing the infant's reaction to the intervention and adjusting as needed to prevent overstimulation Researchers believe sound level was too high; therefore, the intervention was a noxious stimulus by the infant
Authors: Sajjadian, Mohammadzadeh, Taheri, & Shariat **Year:** 2016 **Setting:** Level III NICU; Tehran, Iran LoE: 4	**Research Question:** Do maternal voice recordings produce any physiological effects on preterm infants?	**Design:** Single-subject (infant served as own control) **Sample Design:** 20 preterm infants between 30 and 34 wk' PMA	**IV:** Intervention 15 min included three 5-min periods (no-sound control, audio recording of mother's voice, and no-sound control following recording). Occurred 3 times daily for 3 consecutive days Recordings played at 8:00 am, 1:00 pm, and 6:00 pm, while infants were awake and alert; not with caregiving. **DV:** HR; RR; O_2 sat **DCM:** Collected by nurses **Instruments:** Auditory tests included both OAE and ABR using Accuscreen	Increase in O_2 sat during voice intervention when compared to prevoice intervention Decrease of HR and RR during voice intervention when compared to prevoice intervention	**Limitations:** Study was done only for 3 d; long-term outcomes need to have further research More data are needed to make further generalizations Maternal voices were recorded using a computer program
Author: Bozzette **Year:** 2008 **Setting:** 2 level II nurseries; USA, Seattle, WA LoE: 4	**Research Question:** What are the immediate effects (physical and behavioral) of the preterm infant in response to maternal voice recordings?	**Design:** Quasi-experimental, repeated-measures design (infants served as own control) **Sample:** 14 preterm infants 31-34 wk' PMA	**IV:** Recordings of each mother reading same story for 3 min. Recording played over a 3-d period, 4X day, total 12 sessions. Sessions consisted of 9 min: 3 min baseline data, 3 min mother's voice recordings, followed by 3 min to observe post behavior. **DV:** HR, RR, O_2 sat; Behavioral responses **DCM:** HR, RR, and O_2 sat recorded by monitor/computer; Mini-camera recorded infants' behavioral reactions to recordings **Instruments:** Blackburn Infant Activity scale	RR decreased significantly during maternal recordings No significant difference in O_2 sat or HR No difference in stress behaviors Stability and Attending behaviors increased during maternal recordings	**Limitations:** Short experimental window; only 3 d Mothers' voice seemed to have a soothing effect (based on observed infant behaviors) Recordings were played 30 min before nursing care.

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TABLE 3. Matrix Table: Maternal Voice Effects on Preterm Infants: A Matrix Table Illustrating the Highlights of Each Study Included in This Review[a] (*Continued*)

Author, Year, Setting; Level of Evidence (LoE)	Research Question	Study Design Sample	Independent Variables (IV) Dependent Variables (DV) Data Collection Methods (DCM) Instruments	Results	Limitations
Authors: Saito, Fukuhara, Aoyama, & Toshima **Year:** 2009 **Setting:** Level III NICU; Hiroshima, Japan LoE: 4	**Research Question:** Can neonates differentiate between mother's and nurse's voice? Is there an emotional response related to either?	**Type of Study:** Single-subject (infants served as own control) **Sample:** 26 preterm infants 35-38 wk' PMA	**IV:** Recording of either mother's voice or nurse's voice speaking same phrase (soothing tones) played for infant. White noise used as control. Test divided into 2 blocks and repeated 4 times; each block consisted of 3 instances of recording played for 10 s each time (30 s total). Between block white noise used (to return to baseline) for 20 s. Complete testing took 10 min **DV:** Changes in oxygenated hemoglobin (HGB), deoxygenated HGB, and total HGB in blood in frontal brain area **DCM:** Physiological variables collected while infant was asleep; no visual stimulation could occur since asleep **Instruments:** Double channels of a near-infrared oxygenation monitoring device to detect the tissue oxygenation and therefore activation	Nurse's voice had a greater increase of oxygenated blood at right frontal recording site (mother's voice generated no activation). Left frontal area showed same activation for mother's and nurse's voices, although a slight increase was shown during the mother's recordings.	**Limitations:** Different area activation would suggest that infants can differentiate voices from each other, including random female to mother Right frontal lobe is associated with language development while the left frontal lobe is associated with emotions Nurse's voices might be associated with pain and stress, due to procedures, for the infant, possibly explaining the difference in activation
Authors: Krueger, Parker, Chiu, & Theriaque **Year:** 2010 **Setting:** Level III; USA, southeastern United States LoE: 2	**Research Question:** What short-term outcomes in preterm infants does maternal voice have within the NICU?	**Design:** Comparative; part of larger quasi-experimental study (3 total groups; 2 experimental groups, 1 control group) **Design:** 54 preterm infants 27-28 wk' PMA	**IV:** Mothers spoke in "motherese" or soothing tones during nursery rhyme for recording; recording played twice daily for 45 s each; Group 1 (n = 16) heard recording twice a day 28th-34th week PMA; Group 2 (n = 17) heard recording twice a day 32nd-34th weeks PMA; Group 3 (n = 20) served as control received no recordings. Provided routine care. **DV:** # Days to Discharge; Aver Daily Weight Gain; # Days to Full Enteral Feedings; # Days to Full Oral Feeding; Episodes of Feeding Intolerance; Days NPO; Percent Days Respiratory Support **DCM:** Nurses reported all data **Instruments:** CD players for recordings; Sound level meter (to determine appropriate sound level of ~50 db)	Group 1 experienced significantly fewer episodes of feeding intolerance in comparison to the control group No other major or significant differences or findings between 3 groups	**Limitations:** Decreased feeding intolerance can potentially lead to increased weight gain and velocity in the preterm infant

(continues)

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Author, Year, Setting; Level of Evidence (LoE)	Research Question	Study Design Sample	Independent Variables (IV) Dependent Variables (DV) Data Collection Methods (DCM) Instruments	Results	Limitations
Authors: Dorn, Wirth, Gorbey, Wege, Zemlin, Maier, & Lemmer **Year:** 2014 **Setting:** Newborn intensive care unit (NICU, I7) and the neonatal unit (42); Marburg, Germany LoE: 2	**Research Question:** Does maternal voice influence cortisol stress values and long-term sleep-activity patterns of preterm infants?	**Design:** Block-randomized, prospective clinical trial (3 groups; 2 separate experimental groups, 1 control) **Sample:** 62 preterm infants 30-37 wk' PMA	**IV:** Acoustic stimulation (music, maternal recording) occurred every evening from 8:00 pm to 9:00 pm for 30 min over 2 wk. Maternal recording consisted of mother reading a chapter of "The Little Prince" aloud. Saliva samples were taken 10 min before and 10 min after acoustic stimulation. Saliva samples were taken from control group 7 times over a 24-h period (8:00 pm, 9:00 pm, 1:00 am, 5:00 am, 8:00 am, 1:00 pm, and 5:00 pm) **DV:** Cortisol levels; Sleep-activity patterns **DCM:** Nurses collected saliva samples and sent them to a laboratory for analysis **Instruments:** Voice recorder; audio-player; loudspeaker; ELISA-kit to analyze saliva sample; ACTi graphic monitoring devices to measure rest-activity behavior of infant	No change in circadian rhythm for any infant No significant difference in cortisol levels between acoustic stimulation or control group	**Limitations:** Despite not affecting cortisol levels, maternal voice could still aid in stress reduction in the preterm infant
Authors: Picciolini, Porro, Meazza, Gianni, Rivoli, Lucco, Barretta, Bonzini, & Mosca **Year:** 2014 **Setting:** Level III NICU, Fondazione IRCCS, Ospedale Maggiore; Policlinico, Italy LoE: 3	**Research Question:** Does maternal voice produce an effect on the development of preterm infants?	**Type of Study:** Longitudinal, explorative case control study **Sample Design:** 71 preterm infants, between 30 and 32 wk' PMA. Controls were matched and did not receive any additional treatment/therapy	**IV:** Mothers read passage from "The Little Prince," which were recorded and then filtered. Recordings played via bone conductors to simulate vibrations felt in utero. Intervention occurred daily for 3 wk, every 8 h for a total of 3 times daily. Infants were looked at during testing, at 3 mo and 6 mo. corrected age. **DV:** Vital and neurobehavioral parameters at term; Neurofunctional assessment at 3 and 6 mo of corrected age; HR & O_2 sat; presence of tremors; changes in skin color; quality of spontaneous motor activity **DCM:** Neurobehavioral assessment was carried out by one specialized physician blinded to the intervention **Instruments:** Transducer Oticon model BC461 bone conductor; two equalizers to filter voice recording	Infants who were exposed to maternal voice had lower HRs and more stable skin color at each study point; visual attention and quality of movements were also better in treatment group At 3 mo, treatment group had higher neurofunctional assessment scores; by 6 mo infants in both groups performed similarly	**Limitations:** Filtering maternal voice through bone conductions mimics in utero conditions Long term; first to follow infants after discharge from NICU to see if therapy had lasting effects

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TABLE 3. Matrix Table: Maternal Voice Effects on Preterm Infants: A Matrix Table Illustrating the Highlights of Each Study Included in This Review[a] (*Continued*)

Author, Year, Setting; Level of Evidence (LoE)	Research Question	Study Design Sample	Independent Variables (IV) Dependent Variables (DV) Data Collection Methods (DCM) Instruments	Results	Limitations
Authors: Wirth, Dorn, Zemlin, Lemmer, Gorbey, Timmesfeld, & Maier **Year:** 2016 **Setting:** Level III NICU center; Marburg, Germany LoE: 2	**Research Question:** Do recorded lullabies or taped maternal voice produce a reaction in preterm infants?	**Type of Study:** RCT (non-blinded) trial: 3 groups (2 separate experimental groups, 1 control) **Sample Design:** 62 preterm infants, 30-37 wk' PMA	**IV:** Group I received classical melodies sung by females; Group 2 received mother reading a chapter from "*The Little Prince.*" Recordings played for 30 min over 2 wk period, between 8:00 pm and 9:00 pm, 30-60 min after a feeding without parental contact; Group 3 (control group) received normal care without acoustic stimulation **DV:** HR and RR; measurement of activity **DCM:** Collected by cardiorespiratory monitors **Instruments:** Solar 8000i monitors to record heart and respiratory rates; GT3x+ accelerometer to record physical activity; small passive speaker	Both lullaby and maternal voice groups had decrease in HR and RR. Changes were more pronounced in preterm infants of higher gestational age. Activity was lowest in maternal voice group, followed by lullaby group and then control group	**Limitations:** Researchers were able to determine if habituation occurred because of repeated exposure; results showed that this did not occur and that acoustic stimulation can be used as a continuing therapy Lowered HR and RR can be indicative of lower stress
Authors: Chorna, O. D., Slaughter, J. C., Wang, L., Stark, A. R., & Maitre, N. L. **Year:** 2014 **Setting:** Vanderbilt University Medical Center NICU; USA, Nashville, TN LoE: 2	**Research Question:** Does a pacifier-activated music player equipped with the mother's voice improve oral feeding in preterm infants?	**Type of Study:** Random assignment; experimental vs control **Sample Design:** 94 preterm infants between 34 and 35 wk' PMA	**IV:** Pacifier connected to MP3 player (PAM) played lullaby sung by mother once sucking threshold reached. Intervention included 5 daily 15-min sessions of either PAM with mother's recorded voice or no PAM (control) 30-45 min before caregiving/feeding; Recordings were of 2 preselected songs; Baseline data gathered for 3 d prior to protocol **DV:** Oral feeding rate (mL/min); Oral feedings (no. out of 8/d); Oral feed volume (mL/kg/d) **DCM:** Nursing and medical records: Nursing flow sheets **Instruments:** Pacifier-activated music player; MP3 player	PAM group showed improved oral feeding rate, volume of oral intake, and number of oral feedings per day as compared to the control group; PAM group reached full oral feedings ~7 d before control group counterparts No difference in hospital stay or discharge weight	**Limitations:** Significant difference in days full oral feeding was reached; could be used as a therapy to help infants transition from enteral to oral feedings Controlled when recording was played (before care and feeding time) Large study group

(continues)

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Author, Year, Setting; Level of Evidence (LoE)	Research Question	Study Design Sample	Independent Variables (IV) Dependent Variables (DV) Data Collection Methods (DCM) Instruments	Results	Limitations
Authors: Doheny, Hurwitz, Insoft, Ringer, & Lahav **Year:** 2012 **Setting:** NICU at Brigham and Women's Hospital; USA; Boston, MA LoE: 4	**Research Question:** Do biological maternal sounds improve cardiorespiratory regulation in preterm infants?	**Type of Study:** Within-subject design **Sample Design:** 14 preterm infants 26-32 wk's PMA	**IV:** Mothers' voices (reading, singing, and speaking) and heart beat [BMS] recorded; filtered to mimic utero sounds; recording played for 30 min 4 times daily. Began 7 d after birth until NICU discharge. **DV:** # of CREs **DCM:** Nurses collected data **Instruments:** Large-diaphragm condenser microphone; digital stethoscope; MP3 player	Infants who received intervention had lower frequency of CREs Significant difference between control and intervention group at 33-36.6 wk's PMA, as this showed the most difference in number of CREs	**Limitations:** Since some infants received the intervention longer than others, difficult to pinpoint the exact outcomes or therapeutic window Potential therapeutic window could exist at 33-36.6 wk's PMA
Authors: Zimmerman, Keunen, Norton, & Lahav **Year:** 2013 **Setting:** Level III NICU; USA, Boston, MA LoE: 3	**Research Question:** Do BMS cause increased weight gain in preterm infants?	**Design:** Matched-control design **Sample:** Matched control study consisting of 32 VLBW preterm infants (average PMA was 35 wk)	**IV:** Recordings of BMS were played 4 × 24-h for 45 min for 28 d **DV:** Growth velocity; Days to regain BW; duration of no feeding by mouth; days until full enteral feeds; caloric intake; total fluid intake (mL/kg/d) **DCM:** Medical records and nursing flow sheets **Instruments:** Large-diaphragm condenser microphone; digital stethoscope to record BMS; MP3 player	Infants exposed to BMS gained significantly more weight compared with matched controls No other significant differences in nutritional outcomes	**Limitations:** Maternal voice intervention seems to be linked to increased weight gain within the NICU Small sample size so results need to be repeated
Authors: Rand, K., & Lahav, A. **Year:** 2014 **Setting:** Level III NICU; Boston, MA, USA LoE: 4	**Research Question:** Do maternal sounds reduce HR in preterm infants?	**Design:** Single-subject design (infant served as own control) **Sample:** 20 preterm infants, born between 25-32 wk's PMA	**IV:** HR was recorded during 30-min exposure/non-exposure periods within incubator, 4 times daily, 2 times a week, over a 30-min period during 2 feeds with exposure and 2 feeds without on same day. **DV:** HR **DCM:** Nurses recorded times of recordings being played on timesheet; Monitor for cardiac data **Instruments:** Cardiorespiratory monitor for HR	Infants had significantly lower HR during exposure of maternal sounds vs those of controls	**Limitations:** Small sample size Lowered HR could represent development in autonomic stability; this could be very significant, especially in the development of preterm infants

Abbreviation: PMA, postmenstrual age.

[a]Levels of Evidence[7]: 2: one or more randomized controlled trials; 3: controlled trial (no randomization); and 4: case-control or cohort study.

TABLE 4. Evidence-Based Recommendations for Use of Maternal Voice in NICU

**Recommendations are prioritized on the basis of the best evidence with the best choice presented first. REMEMBER—Whenever maternal voice interventions are used modulation of the external environment must be considered such that stress is not increased for the infant. Choosing an intervention must be made in junction with what resources are available to support delivery.

- Live maternal voice is best.
  - Use of "*motherese*"/mother speaking tone for interaction
    - Requires presence and confidence in mother for best delivery
    - Often better controlled for mother through reading a script/book
  - Skin-skin contact can be a good venue for provision of maternal voice
- Recorded maternal voice via audio player
  - Use engaging "*motherese*" tone for recording
  - Use recordings during periods of no parental contact (rounds, report)
  - Use recordings during feedings and caregiving activities
  - Use recordings before, during, and after painful procedures (heel lance, surgeries)
  - Do not choose all of the above; target intervention choice to best support the individual needs of infant
- Add-ons to the vocal recording that can also be employed
  - Consider the use of biological maternal sounds (heart rate) linked to voice
  - Consider the use of pacifier-activated music players that use recordings of maternal voice are played once a sucking threshold is met by the infant (measured by the pacifier)
  - Consider the use of any other additional filtering to mimic the sounds heard from the womb (vibrations, bone conduction); however, consider stress of infant and whether the additional noise is age-appropriate

Abbreviation: NICU, neonatal intensive care unit.

Live Maternal Speech or Singing

This independent variable included in this category of studies was live maternal speech or singing. Blumenfeld and Eisenfeld[8] were the first to investigate the potential therapeutic effects of live maternal voice with preterm infants. They examined the effects of mothers singing to their preterm infants during feedings and measured the infant's heart rate, respiration rate, and volume of formula taken orally (n = 11 mother–neonate pairs). Neonates served as their own controls and no significant differences were identified in relationship to the intervention. Although behavior measures were not obtained, the researchers noted that the neonates were more relaxed with the intervention. Filippa and colleagues (2013) used a single-subject design with 18 mothers and their infants[2]; this study differed from Blumenfeld and Eisenfeld's in that the singing/speech condition did not occur during feedings. The sing/speech condition was delivered by mothers on an every-other day basis; on odd days control data were collected. Results showed that critical respiratory events were significantly lower in the maternal voice condition, and that heart rate and oxygen saturation were significantly higher. Despite having a relatively small sample size, their results illustrated both positive physical and behavioral/emotional effects of maternal voice with the preterm infant, demonstrating its potential use as a therapeutic agent. Similarly, Arnon and associates[3] used a randomized within-subject crossover design with 86 preterm infants born between 32 and 36 weeks' gestation. Mothers sang to their infants during skin-to-skin care. Measurements included infant's state, infant heart rate variability, as well as physiological parameters (respiratory rate, heart rate, and oxygen saturation) for both mothers and infants and maternal anxiety. Results demonstrated increased autonomic and physiological stability for the infant regarding heart rate variability with the intervention. Maternal anxiety was also decreased. This was one of the few studies to examine both infants and maternal outcomes. This study also had the largest sample size by far among all the included studies.

Recordings of Maternal Voice (Uncontrolled Content)

Two groups of researchers used maternal voice recordings (no control of content during recordings) to perform their trials. In 2007, Johnston and colleagues[9] completed a crossover design study, using the mother's voice as a distracting and soothing element during heel lance procedures. The intervention included maternal voice recordings provided after feedings 3 times daily over a 2-day period, and then the same recordings were played during the heel-lance procedure. Ten days after this first trial, the trial was repeated; however, the recordings were not played during this second heel lance to examine differences related to the use of the recordings during the procedure. Results were inconclusive for most variables. However, infants exposed to the maternal sounds gained significantly more weight than their matched controls who did not receive the

intervention. In the second study, Sajjadian and associates[10] used a single-subject design, where the infants served as their own controls. Twenty neonates received the intervention every day for 3 days, 3 times a day. The intervention consisted of three 5-minute intervals: the first 5 minutes were the control period, where no sound was played, followed by a 5-minute interval of the mother's recording, and followed by another 5-minute interval of silence again. Neonates' heart rate, respiration rate, and oxygen saturation rate were recorded during these sessions. Neonates' oxygen saturation increased during the intervention as compared with the control conditions, while heart rate and respiration rate decreased, illustrating autonomic stabilization. No long-term outcomes were measured.

Recordings of Maternal Voice (Controlled Content)

This group of studies used recordings of the mothers' voices and further controlled the content of the speech during the intervention. Study protocols had the mothers speak the same phrase, or choose from a list of a selected nursery rhymes, read from a passage from a book, or sing the same songs. Surprisingly, many of these studies choose the same book, *The Little Prince* by Antoine de Saint-Exupéry. There was no explanation for choosing this book particularly, however it may, because of the novel's rhythmic pace and popularity among parents at the time.

Saito et al[4] used a single-subject design with 26 preterm infants to examine infants' responses when listening to their mothers' voice as compared with listening to a nurse's voice. Testing consisted of playing the recording of the same phrases by either the nurse or the mother for 10 seconds and followed by white noise (control) for 20 seconds; this sequence was repeated 2 more times to complete a "block." These blocks were repeated 4 times, so that the total amount of time of intervention sessions was 10 minutes. Each infant completed a session with the mother's recording and the nurse's recording; infants randomly received either the mother's or the nurse's recording first in the protocol sequence. Near-infrared technology was used to examine changes in infants' oxygenated hemoglobin, deoxygenated hemoglobin, and total hemoglobin in blood from the brain frontal area to determine where activation of certain lobes occurred across the intervention sequence. Different areas of the brain were activated; during the nurse's recording, both the infant's right and left frontal lobes were activated, whereas during the mother's recording, only the infant's left frontal lobe was activated, and the activity level was increased as compared with the nurse's recording. These results demonstrated the infant's ability to differentiate between voices they hear and potentially identify their mother's voices from another female's voice. The researchers suggest that during the intervention the infants' brains made a connection with the nurse's voice and pain, as this was the voice they heard during procedures and care, whereas the area activated more by the mother's voice was connected to more positive emotions and could increase emotional attachment. However, these outcomes are speculative; more research is needed to better understand these relationships.

Bozzette[11] recruited 14 preterm infants to participate in a quasi-experimental study. Mothers were each asked to record themselves for 3 minutes reading the same script, a nursery rhyme. The experimental sessions consisted of 3 minutes of baseline conditions, 3 minutes of the mother's voice recording, followed by another 3 minutes to return to baseline. Recording was played 4 times a day for 3 days. Infants' physiological responses—heart rate, respiration rate, and oxygen saturation as well as the infants' behavioral responses—were measured throughout the protocol. Results showed that infants' respiration rates decreased, stability behaviors (foot clasp, handclasp, sigh, ooh face, open face, flexion, grasping, and smile) were increased as well as attending behavior (eyes wide, eyes brightening, eyes toward source, suckling, stilling, visual locking, hand to face/mouth) was increased during the maternal recordings. Similarly in 2010, Krueger and colleagues[12] conducted a comparative quasi-experimental study with 54 preterm infants.[12] Infants were divided into 3 groups: group 1 (n = 16) received a recording of their mother's voice reciting nursery rhymes twice a day from week 28 to 34 PMA (postmenstrual age); group 2 (n = 17) received a recording of their mother reciting nursery rhymes twice a day during weeks 32 to 34 PMA; group 3 (n = 20) served as a control and did not receive any recording. Recordings were played for a total of 45 seconds each session. Short-term outcomes measures included the number of days to discharge, average daily weight gain, the number of days to full enteral feedings, number of days to full oral feeding, the number of episodes of feeding intolerance, days NPO, and percentage of days on respiratory support. Group 1 experienced fewer episodes of feeding intolerance in comparison with group 2 and the control group. These results suggest that the earlier use of maternal voice as a therapeutic intervention may aid in increasing the rate at which preterm infants become tolerant to oral feedings and move from enteral feedings to oral feedings, which aids in increased weight velocity.

In 2014, Dorn and colleagues[13] conducted a prospective clinical trial with block randomization (n = 62 neonates).[13] Neonates were split into multiple groups: group 1 (n = 20) received a recording of music, group 2 (n = 20) received a recording of their

mother reciting passages from *The Little Prince*, and group 3 (n = 22) was a matched control group of infants who received no recordings. Recordings were played during a specific time period for 30 minutes every day for 2 weeks. Salivary cortisol levels were measured 10 minutes before recordings and 10 minutes after the recordings were played. As a baseline, salivary cortisol levels were also collected 7 times over a 24-hour period before initiating the intervention. Study results were inconclusive; no significant differences were noted in salivary cortisol levels across the measurement events; no other parameters were measured during this study. Picciolini et al[14] conducted a trial that utilized recordings of maternal readings of *The Little Prince* as well. Within this longitudinal explorative case study, 71 preterm infants were compared with matched controls. Voice recordings were played via bone conductors to mimic the vibrations the infant felt while in utero when their mother spoke. The recordings were played 3 times daily for 3 weeks. The infants were observed during testing, and at 3-month corrected age, and 6-month corrected age. Measurements included vital and neurobehavioral parameters at term, neurofunctional assessment at 3 and 6 months of corrected age, heart rate, oxygen saturation, presence of tremors, changes in skin color, and quality of spontaneous motor activity. At each study point, the group that received the maternal voice recordings had lower heart rates and more stable skin color as well as higher scores for visual attention and quality of movements as compared with the matched control group. At 3 months, the intervention group had higher scores for the neurofunctional assessment; however, by month 6 the 2 groups performed similarly in all the tests. This study was interesting because it was the only one to use a vibratory element in their delivery of the maternal voice to the infant, attempting to mimic the type of environment the infant first heard his or her mother's voice. It also was one of the only studies to examine the therapeutic effects for a long term. In 2016, Wirth and colleagues[15] conducted a randomized, controlled nonblind study with 62 infants. Twenty infants received recordings of classical lullabies, 20 others received recordings of their mother's voice reading from *The Little Prince*, and 22 infants were in the control group. The recordings were played for 30 minutes daily for a 2-week period, between 8:00 and 9:00 in the evening, 30 to 60 minutes after a feeding and parental contact. Measurements included examining differences in mean heart rate during stimulation compared with baseline; difference in mean heart rate before and after stimulation; difference in mean respiratory rate before, during, and after stimulation; and physical activity of the infant during the stimulation. Both groups that received the recordings (lullaby and maternal recordings) had a lower heart and respiratory rate than the control group. Physical activity was lowest in the maternal voice recording group, followed by the lullaby group, and then the control group.

In 2014, Chorna and associates[16] conducted a randomized trial with 94 preterm infants, examining whether maternal voice would improve infant feeding behaviors. Forty-six were in the experimental group, while 48 were in the control group. The experimental group received a pacifier-activated music (PAM) player equipped with a recording of the infant's mother's voice; the recording was automatically played once a sucking threshold was reached via the pacifier. Recordings consisted of the mothers singing 2 preselected songs. The intervention period occurred for 15 minutes for 5 days, 30 TO 45 minutes before scheduled care and feedings. Baseline data for the experimental group were collected the previous 72 hours before the experimental protocol started. Measurements included the infant's oral feeding rate, the number of oral feedings, and oral feed volume consumed. Infants who received the PAM intervention had an increased oral feeding rate, volume of oral intake, as well as the number of oral feedings per day when compared to the control group. The experimental group reached full oral feedings an average of 7 days before their control group counterparts. This difference could be credited to the PAM player; if the infant sucked harder and more frequently on the pacifier, they heard their mother's voice possibly providing more incentive (the soothing voice of their mother) to practice their sucking motions and allowed them to master this skill quicker, allowing for the results of quicker oral feeding rates. More research is needed to better understand this mechanism.

Recordings of Maternal Voice and Biological Maternal Sounds

These studies examined the relationship between maternal voice, biological sounds, and infant responses. In 2012, Doheny and associates[17] conducted their study with 14 preterm infants where infants served as their own controls. Infants were played a recording of their mother reading and singing as well as the mother's heartbeat; the sounds were filtered together to mimic how they would sound in the womb. The recordings were played for 30 minutes 4 times a day, beginning a week after the infant's birth until the infant was discharged from the NICU. Thus, some infants received the intervention for a longer duration than others. The control group did not receive any recordings. Measurements included the number of critical respiratory events (CREs) each infant experienced. Results showed that the infants receiving the intervention experienced a lower number of CREs than their control counterparts. It was also determined that the

intervention proved most significant (most difference in frequency of CREs) for infants during weeks 33 to 36.6 PMA, demonstrating a potential window for therapeutic effectiveness for the use of maternal voice.

Similarly in 2013, Zimmerman et al[18] conducted a study with a matched control design with 32 preterm infants. Sixteen infants in the experimental group received recordings of their mother's speech and heartbeat, while the control group (16 infants) received standard care. The recordings were played for 45 minutes 4 times a day for 28 days. Measurements included the infant's growth velocity (the days to regain their predicted birth weight had they been born full-term), duration of no feeding by mouth, days until full enteral feedings (defined as 140 mL/kg/day), caloric intake, and total fluid intake. Results showed that infants who received the BMS gained weight significantly faster than controls over time. Lastly in 2014, Rand and Lahav[19] completed a single-subject design trial with 20 preterm infants. The infants' heart rate was measured during 30-minute increments of exposure to BMS (similar to those provided in the previous study) 4 times a day, between caregiving and parental visits, compared with nonexposure events twice each week during the infant's first month of life. The researchers found that the infants' heart rates during the exposure periods were lower than those during the nonexposure periods.

DISCUSSION

The main findings of these studies support the use of maternal voice as a therapeutic agent in the preterm infant's care within the NICU. Overall, the studies showed that autonomic stability improved in the presence of maternal voice (form did not seem to matter) and increased weight velocity was also noted. The use of maternal voice did not appear to produce any negative effects of outcomes for the preterm infants; even in the cases where the interventions did not produce significant results, no harm or increased stress was noted in study findings. These are important and significant effects, as many infants born premature are severely underweight and have major difficulties controlling their heart and respiration rates (autonomic control), as these systems are often immature and underdeveloped.

Also, important to note is the reduction of maternal anxiety and stress regarding caregiving within the NICU due to the intervention. Often, mothers feel unable to truly parent in the open environments of many NICUs for fear of judgment. Some parents have reported "stage fright"; not many individuals would feel comfortable talking, let alone singing in an environment surrounded by so many others. The recordings serve as a parenting participation strategy that the mothers can control, reducing not only their anxiety but also reinforcing their attachment to their child and alleviating their fear or discomfort of not being able to more fully participate in the care of their child. Yet, it is also important to note that none of the researchers reported attempts to control the external environment stimuli as an aspect of their study protocols that must be considered a limitation of their findings. Not having information on the external environment or other noise exposure limits recommendations for use. Within the NICU, there are many noxious stimuli, such as harsh lights, sounds, and various people talking and performing tasks that could add to the stress experienced by both infants and their mothers.

IMPLICATIONS FOR PRACTICE

Based on these findings, several different strategies using maternal voice recordings could be easily implemented into routine nursing care with preterm infants. The primary recommendation for care providers would be to play recordings of maternal voice during times when the mother and the father are unable to visit.[9] Finding times to use maternal voice interventions to augment care could be beneficial to the infant and maximize the effects of the maternal voice while in the NICU. These recordings could be played during feedings as well as during nursing care; however, care must be taken to modulate the external environment and observe the infant's cues and behaviors so that the stimulation does not add stress for the infant.[9] This may mean modulating the volume of the recordings or more likely modulating the other noise and chaos in the environment. Other recommendations, given their feasibility in individual units and environments, might include (1) linking the recordings to PAM players,[16] (2) filtering recordings through a program to better simulate the womb-like environment to be more like what the infant originally heard his or her mother's voice through,[14] (3) as well as linking the vocal recording to a recording of the mother's biological sounds, such as her heartbeat.[19] The infant PMA must also be considered when choosing the intervention for the infant, adding maternal womb sounds to the maternal voice intervention may not be appropriate for all infants particularly those of a later PMA and when they have been experiencing the external environment for a longer period of time.

Linking maternal voice to feedings has been shown to increase weight gain in preterm infants,[16] whereas linking maternal voice to caregiving has led to overall autonomic stability in preterm infants' heart rate, respirations, as well as a reduction of respiratory events.[14,19] However, all interventions that increase stimulation for the preterm infant must be administered with attention to individual

responses of the infant. Care must be taken to make sure that the stimulation does not add stress for an infant who is already easily overstimulated.

For mothers, the primary recommendations would likely be related to the content of the recordings. Mothers are advised to speak in soothing tones as if they were speaking to their child directly, a tone dubbed by professionals as "motherese" or "mother speak" as most appropriate.[4] While there is no clear consensus over whether reading from a script or adlibbing is more beneficial, the tone can be better controlled if the mother is reading from a book or lullaby.[15] What's most important is maintaining the tone throughout the recording, as it is this maternal tone rather than that of any female that is more beneficial for the infant.[12] If feasible, connecting the recording to BMS[17] or skin to skin holding (kangaroo care)[3] has proven to be most effective in aiding the infant in maintaining autonomic stability and weight gain. Last, there are some beginning recommendations for utilizing these recordings during procedures. Maternal recordings can be played to the infant before beginning the procedure[9]; while there has not been research completed on what the optimal amount of time is, a recommendation can be made for 10 to 15 minutes before the procedure, as this will allow proper time for the infant's heart rate and respiration rate to stabilize.[9] If feasible, the maternal voice recordings can be played during the procedure itself, as the infant would still be able to hear whether awake or under anesthesia.[9] Last, the recordings could be played directly after and during the healing process for the infant.[9] Using maternal voice during procedures is an area where more research is needed. However, understanding how best to interpret the infant's cues and behaviors during the intervention will be important to guiding both short- and long-term outcomes. Additional stress must always be considered when adding intervention strategies since the other stressors in the environment must be considered and modulated or eliminated whenever possible.

LIMITATIONS

Several limitations must be considered. Generalization can only be made with great caution because the studied intervention protocols vary greatly across studies and most of the sample sizes were quite small. Not only is the population itself small (preterm infant in the NICU), but research is difficult to conduct with this high-risk population. Studying high-risk infants in the NICU is limited by with many challenges including (1) many healthcare needs limiting stability for research protocols, (2) limited time to perform study protocols, and importantly (3) limited access due to parental fear of research. Parents are reluctant to include their children in research protocols for fear that they will add to the stress their infants already encounter in the NICU. Several of the researchers reported maternal discomfort with participating (performing) in the study themselves, because speech and/or singing is such a vulnerable action, let alone allowing their children who often have more complex health needs to participate in such studies. These types of studies can also be time-consuming; some parents are not able to dedicate the required time for involvement. Several of the studies reported difficulty in retaining subjects, some participants dropped out due to anxiety and other factors, some infants were discharged home prior to study completion, some infants were transferred to other units/hospitals, and unfortunately some infants died. These sampling issues limit generalizability of the results.

IMPLICATIONS FOR FUTURE RESEARCH

Future research might examine the therapeutic window surrounding maternal voice recordings used as an intervention strategy with preterm infants. Questions could include determining if there is a particular time of day or particular point in time within the infant's caregiving schedule that proves to be more therapeutic. For example, delivering the intervention with feeding or during particular caregiving activities might increase intervention effectiveness. Also, more research is needed to better understand whether mimicking the environment of the uterus during recordings is truly significant or should only be considered for a particular population of infants (possibly those born extremely premature). Perhaps these types of recordings could be more therapeutic during stressful procedures; however, no research exists on the use of this intervention in this way, with this population. A study in progress is examining the potential effects of maternal voice on sleep patterns; although preliminary results look exciting, final results are unavailable at the time of this review.[20]

Further research could also examine whether there are any marked differences between maternal and paternal voices as a therapeutic intervention. Only one study was found using paternal voice as an intervention with preterm infants. Lee and White-Traut[21] examined the effects of male recorded lullabies on preterm infants in the NICU and found the intervention reduced heart rate and increased blood oxygen saturation. While their study was aimed at introducing music into evidence-based practice, it brings up an interesting question. This type of intervention could be a positive way to incorporate the father into caregiving by providing his voice recordings in addition to the mother's. This would allow for even greater parental involvement in the premature infant's care, not only potentially improving the child's care, but also improving the relationship between father and child and the father's emotional

Summary of Recommendations for Practice and Research	
What we know:	• Maternal voice exposure positively affects autonomic stability in preterm infants (heart rate, respirations) • Potentially maternal voice exposure decreases frequency and severity of critical respiratory events • Maternal voice when heard during feedings potentially leads to increased weight gain by preterm infants • Maternal voice exposure has been associated with increased behavioral stability in preterm infants
What needs to be studied:	• Replication of the existing research is needed to substantiate results as well as additional randomized controlled trials • Therapeutic window for maternal voice intervention with regard to infant caregiving schedule • Optimal time exposure of maternal voice to achieve physical and behavioral effects • Physical and behavioral effects of paternal voice (increasing the father involvement in the intervention)
What we can do today:	• Encourage mothers to speak to their infants frequently during visits • Employ maternal voice recordings when the mother cannot be with the infant, provided it does not disrupt the infant's schedule and does not cause excess stimulation • Modulate the environment so maternal voice can be more easily identified by the infant

status regarding his involvement in his child's care, a relationship that is not as stressed in our society.

In conclusion, promoting the use of "live" mother's voice is always the best strategy for supporting the infant. Helping the mother to understand her infant's cues and speak in "motherese" to her infant on a regular basis when she is with her infant is important to mother–infant attachment and other long-term outcomes. Nurses need to find ways to help the mother to feel more comfortable in providing this support to her infant in the environment of the NICU, since the hospital environment can be an obstacle for delivering this interaction. Provision of single rooms can help but having the available environment is just not enough. Mothers need to feel supported and believe they will not be judged on the basis of their performance (how they speak to their infant); few of us would want to perform parenting acts in the "bubble" of the NICU environment. Moreover, when it is not feasible for the mother to provide "live" speech and recorded speech and/or singing can be beneficial for infant outcomes, particularly the effects related to autonomic stability and supporting weight gain.

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Instructions:

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