Received: 5 December 2023 | Revised: 25 July 2024 | Accepted: 29 July 2024

DOI: 10.1002/hsr2.70015

NARRATIVE REVIEW

Health Science Reports Open Access WILEY

The effectiveness of oral motor interventions on the weight gain, independent oral feeding, and length of hospital stay in hospitalized preterm infants: A systematic review and meta-analysis

Ghasem Mahmoodabadi[1] | **Ahmad Bavali-Gazik**[1] | **Fateme Mouhebati**[1] | **Morteza Arab-Zozani**[2] | **Meysamreza Boghrati**[1]

[1]School of Medicine, Birjand University of Medical Sciences, Birjand, Iran

[2]Social Determinants of Health Research Center, Birjand University of Medical Sciences, Birjand, Iran

Correspondence

Morteza Arab-Zozani, Social Determinants of Health Research Center, Birjand University of Medical Sciences, Birjand, Iran.
Email: arab.hta@gmail.com

Meysamreza Boghrati, School of Medicine, Birjand University of Medical Sciences, Birjand, Iran.
Email: boghratimeysamreza@gmail.com

Abstract

Background and Aims: Oral feeding for preterm infants has been a challenging issue globally. In an effort to enhance the effectiveness of oral feeding in preterm infants, oral motor intervention (OMI) was developed. Present systematic review and meta-analysis study aims to examine the impact of various OMI techniques on key outcomes, including body weight at the time of discharge, the duration required to achieve independent oral feeding, and the length of hospital stay for preterm infants.

Methods: A systematic search of the literature was performed across various databases such as PubMed, Scopus, and Web of Science and Google Scholar up to September 28, 2023. Quality assessment was conducted using the Joanna Briggs Institute (JBI) checklist. The overall effect measure was calculated using a random-effects model and was presented as the standard difference of the mean (SDM), accompanied by the standard error and a 95% confidence interval (CI). We used I^2 statistic for investigating the heterogeneity between studies. Data analysis was performed by CMA software (Version 2).

Results: Finally, 22 articles included in this review. The overall effect for body weight at discharge was found to be statistically significant in the prefeeding oral stimulation (PFOS) (SDM = 7.91, 95% CI: 5.62, 10.2, $p = 0.000$, $I^2 = 86.31$) and Premature Infant OMI (PIOMI) (SDM = 3.71, 95% CI: 0.72, 6.69, $p = 0.01$, $I^2 = 96.64$) groups versus control group. The overall effect of independent oral feeding was significant for PFOS-only (SDM = −0.64, 95% CI: −1.1, −0.17, $p = 0.007$, $I^2 = 75.45$), PIOMI only (SDM = −1.48, 95% CI: −2.49, −0.46, $p = 0.004$, $I^2 = 93.73$) and nonnutritive sucking (NNS) only (SDM = −0.53, 95% CI: −0.76, −0.30, $p = 0.001$, $I^2 = 0$) groups versus control groups. The overall effect of length of hospital stay was significant for NNS group (SDM = −0.45, 95% CI: −0.67, −0.23, $p = 0.067$, $I^2 = 0$) and PIOMI group (SDM = −0.42, 95% CI: −0.69, −0.15, $p = 0.002$, $I^2 = 20.18$) versus control group.

Conclusion: Among OMIs, the PIOMI approach generally exhibited a more favorable impact on body weight gain at discharge, the duration required to achieve independent oral feeding, and the length of hospital stay.

KEYWORDS

clinical trials, feeding, independent oral feeding, length of hospital stay, oral motor intervention, premature birth, weight gain

1 | BACKGROUND

Babies who are born before 37 weeks of pregnancy are considered premature and most of these babies have underdeveloped nervous, respiratory, cardiac and muscular systems.[1] Over the past 30 years, the early survival rate of preterm infants has significantly improved as advancements in advances in medical technologies.[2,3] According studies, roughly 15 million preterm births occur worldwide each year, constituting approximately 16% of all births.[4] Nonetheless, the underdeveloped oral feeding ability in preterm infants has had a considerably adverse impact on their overall development, and it has notably contributed to increased morbidity within this specific population.[5] There is substantial evidence indicating that approximately 30–40% of premature infants encounter nutritional challenges.[6]

Low body weight, immature brain development, difficulties sucking and swallowing, problems with breathing, prolonged hospitalization, and diminished oral motor skills are common in preterm infants, all of which have an impact on the healthy development and growth of the child.[7] In premature infants, inadequate coordination of sucking, swallowing, and breathing can lead to oral feeding issues, ineffective oral feeding, extended hospital stays, and ultimately, emotional and financial burdens on families and society.[8] In this regard, the primary criterion for discharging a healthy premature infant from the hospital is the attainment of independent oral feeding.[9]

The development of the oral motor system (Oromotor) is a vital process for these babies because it is directly related to the intake of food, growth and weight gain of the babies and indirectly with the length of their hospitalization in the Neonatal Intensive Care Unit (NICU).[10,11]

Feeding in babies requires a coordinated pattern between the processes of sucking, swallowing and breathing, which usually babies with a birth age of less than 32 weeks, due to the lack of this coordination, need special care and feeding with the help of a tube.[12] To date, many studies have investigated various interventions to establish this coordination as early as possible in premature infants.[13]

Age and gender of babies, weight at birth, gestational age, and Apgar score at birth can be important in the development of the baby and the effectiveness of interventions.[14] The changes in the weight of babies, the time of independent oral feeding, the length of hospitalization and discharge after birth, returning to the hospital (NICU), and the long-term growth or development of babies are among the things that can express the effectiveness of each of these interventions.[15,16]

Given the diversity of intervention methods available, it becomes evident that pinpointing the most suitable technique for infants with specific characteristics can greatly assist the treatment team in optimizing the baby's growth and development. Furthermore, making evidence-based decisions in the treatment process can lead to a reduction in the length of hospitalization, decreased treatment costs, and a lighter workload for the country's healthcare system within the NICU.

During the nonnutritive sucking (NNS) approach, the baby is made to suck by the interventionist gently pressing on his/her palate 5 min a day for 10 consecutive days (either through the use of a pacifier or an expressed breast nipple).[17] Prefeeding oral stimulation (PFOS) consisted of a 15-min program that included 12 min of cheek, lip, gum, and tongue stroking, and 3 min of pacifier sucking, which is often done by the nurse.[18] Premature Infant Oral Motor Intervention (PIOMI) is a globally tested oral motor therapy protocol for preterm infants that has demonstrated good intervention fidelity.[19] The purpose of the targeted 5-min, 8-step PIOMI therapy is to support the functional response of the preterm newborn to pressure and tongue, jaw, and lip movements.[20,21]

Several systematic reviews and meta-analyses have studied the effectiveness of the oral sensory-motor stimulation system in promoting oral feeding.[22–24] For example Grassi et al.[25] studied NNS and nutritive sucking intervention, Rodovanski et al.[26] studied Auditory-tactile-visual-vestibular (ATVV), Tactile/Kinesthetic Stimulation, and Kangaroo mother care (KMC) interventions, Rodriguez Gonzalez et al.[27] studied the PIOMI and the PFOS interventions. Song et al.[28] were evaluated six groups of intervention types: educational and breastfeeding support programs, early discharge, oral stimulation, artificial teats and cups, KMC, and supportive policies within NICUs. Some other reviews determined the effect of one specific intervention method in preterm infants on transition to full oral feeding or discharge time.[29–31] In overall, the existence of a study that reviews and compares the key outcomes, showing the effects of these methods, to revise the existing methods seems necessary. Present systematic review and meta-analysis study aims to examine the impact of various oral motor intervention (OMI) techniques on key outcomes, including body weight at the time of discharge, the duration required to achieve independent oral feeding, and the length of hospital stay for preterm infants.

2 | METHODS

This systematic study was conducted following the guidelines and recommendations outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) checklist/statement.[32]

2.1 | Eligibility criteria

The inclusion criteria for the current systematic review were as follows [population, intervention, comparison and outcomes][33]: (P) Population: only preterm infants born at less than 37 weeks gestation. (I) Intervention: Oral sensory and/or motor interventions. (C) Comparison intervention: Compared against placebo or standard care program. (O) Outcomes: Body weight at discharge, independent oral feeding time, and length of hospital stay. (S) Study design: Randomized or quasi-randomized clinical trials.

The exclusion criteria for the current systematic review were as follows: (a) Studies that failed to provide sufficient details regarding their methods and data analysis. (b) Non-English language publications.

2.2 | Search strategy

A systematic literature search was conducted across multiple databases, including PubMed, Scopus, and Web of Science. In addition to a systematic literature search, manual searching was also carried out on the Google Scholar database. All databases were searched up to September 28, 2023. This search utilized medical subject headings and free terms, applying Boolean operators. The following search terms were employed:

"Infants, Premature," "Premature Infant," "Preterm Infants," "Infant, Preterm," "Infants, Preterm," "Preterm Infant," "Premature Infants," "Neonatal Prematurity," "Prematurity, Neonatal," "sensory-motor-oral stimulation," "Oral Sensorimotor Stimulation Protocol," "Oromotor Stimulation," "Oral Stimulation," "oral motor intervention," "oromuscular stimulation," "Non-nutritive Sucking," "sensorimotor stimulation," "oral motor development," "Oral Sensorimotor Stimulation," "Sensorimotor therapy," "Oral Sensory Motor Stimulation," "Cheek/Jaw support," "Auditory-tactile-visual-vestibular," "Beckman principles," "pre-feeding oral stimulation," "Beckman oral stimulation," "Oromotor exercise," "OMI," "PIOMI," "oral sensorimotor stimulation," "OSMS," "Kangaroo mother care," "Tactile/Kinesthetic Stimulation," "Beckman principles program," "Non-nutritive sucking," and "pre-feeding oral stimulation." No restrictions were imposed regarding the publication date or language. The search was conducted as of 28 September 2023. Additionally, we screened the references of the included studies to identify any additional studies that met our inclusion criteria. The abstracts and titles retrieved from the databases were stored in Endnote reference manager (version X9), with duplicate entries subsequently eliminated.

2.3 | Selection process

Two reviewers (G. M. and F. M.) independently screened the studies based on eligibility criteria and related studies were included based on the title and/or abstract. Subsequently, two reviewers (G. M. and F. M.) independently screened out selected studies that were unrelated by thoroughly reviewing full texts. In cases of discrepancies in the selection process, these were deliberated upon and resolved in consultation with a third colleague.

2.4 | Data extraction and data items

Two investigators (G. M. and F. M.) extracted the following data upon thorough examination of the full text of the selected articles: first author, year of publication, number in each group, experimental intervention, comparator, mean gestational age, mean weight, Apgar score. In instances where discrepancies arose with respect to the selected studies, these were resolved through discussion with a third author.

2.5 | Study risk of bias assessment

The quality of the studies was evaluated independently by two authors (G. M. and F. M.) utilizing the "Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Randomized Controlled Trials."[34] The use of JBI tools is prevalent in academic publications, signifying their established utility for assessing research quality and rigor.[35–37] Finally, the results were scored for better understanding. In this way, the overal score represents the number of positive answers of the reviewer to the questions raised in the standard questionnaire.

2.6 | Synthesis methods

We conducted our analysis for three main outcome of body weight at discharge, independent oral feeding, and length of hospital stay. Also, results were presented in four subgroups, which included PFOS only versus control, PIOMI only versus control, NNS only versus control, and PFOS + NNs versus control. The meta-analysis was conducted using comprehensive meta-analysis software (version 3). The overall effect measure was estimated using a random effect model and represented as standard difference of mean (SDM) and standard error with 95% confidence interval (CI). The between-study heterogeneity was calculated using I^2 statistic. The between-study heterogeneity was calculated using I^2 statistic. We used funnel plot for investigating the publication bias.

3 | RESULTS

3.1 | Study selection

The search strategy yielded a total of 947 publications from the primary databases as well as other Supporting Information sources. Finally, 22 articles included in this systematic review and meta-analysis (Figure 1).

3.2 | Study characteristics

Twenty-two publications were assessed in the current review which involved OMIs from four different intervention methods: NNS (five publications), PFOS (eight publications), the combination of PFOS + NNS interventions (four publications), and PIOMI (eight publications). Publication year of selected studies were from 2002 to 2023 and a total of 1404 preterm infants were evaluated. Mean gestational age reported in most studies (19 publications) and ranged from 28.1 to 33.4 weeks. Mean weight of studied infants, as reported in the majority of studies (22 publications), ranged from 913 to 2590 g. Among eight publications reported Apgar score, the minimum Apgar score was 7.4 and the maximum was 9.36. Detailed characteristics of the eligible publications are provided in Table 1.

3.3 | Risk of bias

Table 2 provides a summary of the results of the risk of bias assessment conducted for the selected studies. Our meta-analysis included a total of 22 publications. Sixteen studies presented moderate risk of bias and six studies showed low risk of bias.

3.4 | Results of individual studies

The NNS intervention demonstrated a reduction in the transition time of independent oral feeding in three publications,[43,45,56] while in one publication,[53] it did not show a significant change. Among the studies that evaluated the NNS intervention, one study[45] reported an increase in body weight at discharge. Furthermore, the length of hospital stay decreased in three publications,[41,45,56] with no significant change observed in one publication.[43]

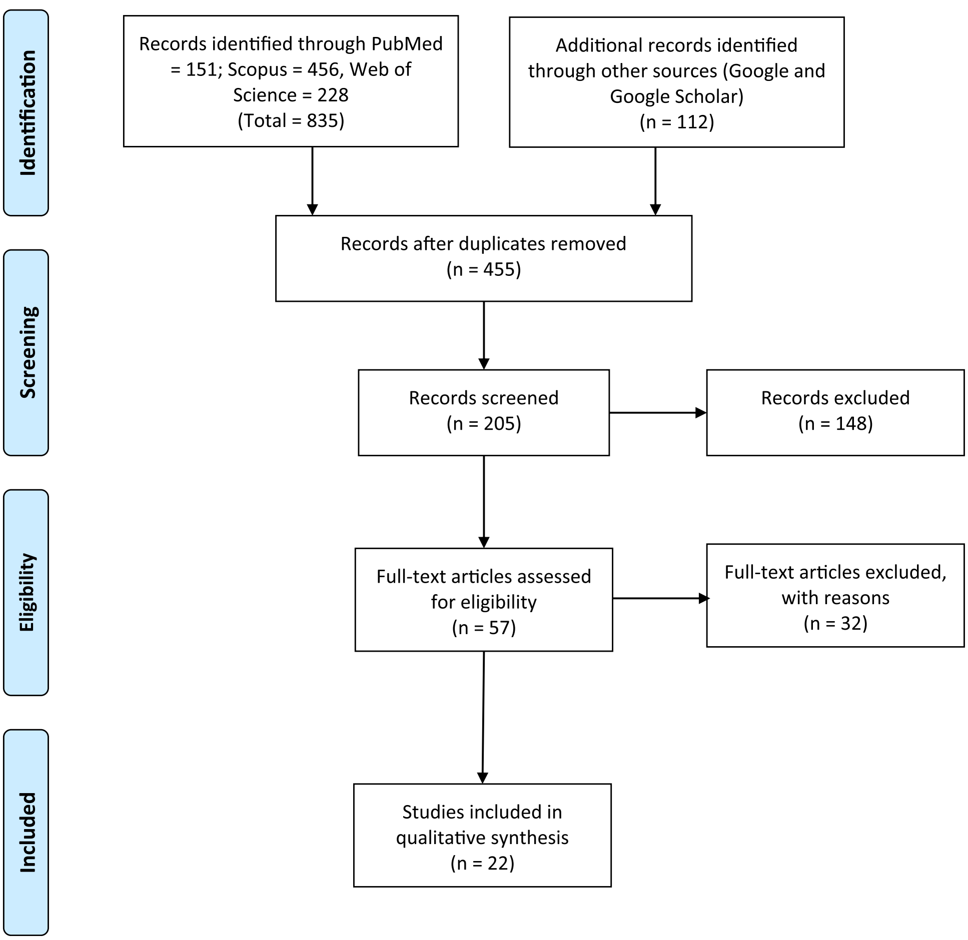

FIGURE 1 PRISMA flow diagram. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analysis.

TABLE 1 Characteristics of Included Trials.

First author and publication year	Interventions/ Control	Number in group	Number of male sex in group	Mean gestational age (mean ± SD)	Mean weight (g) (mean ± SD)	Apgar score (mean ± SD)	Comparator	Results
Fucile et al.[18]	PFOS/Control	16/16	7/6	28.2 ± 1.3/ 28.1 ± 1.1	1044 ± 260/ 959 ± 244	NM	Transition time to independent oral feeding	Decreased
							Body weight at discharge	No significant impact
Boiron et al.[38]	PFOS/Control	11/11	4/7	33.4 ± 0.36/ 33.1 ± 1.19	1588 ± 285/ 1556 ± 265	NM	Transition time to independent oral feeding	Decreased
							Sucking parameters	Enhanced
							Body weight at discharge	No significant impact
Rocha et al.[39]	PFOS + NNS/ Control	49/49	NM	30.5 ± 1.7/ 30.2 ± 1.8	1195 ± 221/ 1125 ± 221	NM	Length of hospital stay	Decreased
							Transition time to independent oral feeding	Decreased
							Body weight at discharge	No significant impact
Fucile et al.[40]	PFOS + NNS/ Control	19/20	12/16	29.6 ± 1.5/ 29.4 ± 1.9	1359.7 ± 341.1/ 1346.6 ± 358.3	8.1 ± 0.4/ 8.3 ± 0.5	Test of Infant Motor Performance (TIMP)	No significant impact
							Body weight at discharge	No significant impact
							Length of hospital stay	No significant impact
Lessen et al.[21]	PIOMI/Control	10/9	4/3	NM	1017.3 ± 127.1/ 913.3 ± 87.8	NM	Transition time to independent oral feeding	Decreased
							Length of hospital stay	No significant impact
Harding et al.[41]	NNS (pre-nasogastric tube feeds)/ NNS (on onset nasogastric tube)/Control	19/20/20	12/10/12	32.53 ± 2.67/ 31.6 ± 2.01/ 30.95 ± 3.13	1651.11 ± 403.12/ 1757.9 ± 304.82/ 1670 ± 648.68	NM	Type of feeding on discharge	No significant impact
							Length of hospital stay	Decreased
Lyu et al.[42]	PFOS/Control	32/31	NM	30.87 ± 1.47/ 30.92 ± 1.48	1597.38 ± 264.26/ 1652.5 ± 327.46	8.55 ± 1.92/ 8.45 ± 1.99	Transition time to independent oral feeding	Decreased
							Oral feeding performance	Improved
Zhang et al.[43]	NNS/PFOS/ NNS + PFOS/ Control	25/27/29/27	11/17/ 15/14	30.9 ± 1.7/ 31.1 ± 1.3/ 31 ± 1.4/ 31.3 ± 1.2	1548.2 ± 233.8/ 1541.9 ± 272.5/ 1579.3 ± 280.7/ 1651.5 ± 310.1	8.8 ± 1.3/ 8.5 ± 1.5/ 8.6 ± 1.9/ 8.6 ± 1.7	Transition time of oral feeding	The combined NNS + PFOS intervention decreased the transition time from introduction to independent oral feeding

(Continues)

TABLE 1 (Continued)

First author and publication year	Interventions/ Control	Number in group	Number of male sex in group	Mean gestational age (mean ± SD)	Mean weight (g) (mean ± SD)	Apgar score (mean ± SD)	Comparator	Results
							The milk transfer rate	Enhanced
							Length of hospital stay	No significant impact
Bache et al.[44]	PFOS/Control	40/46	25/25	31.4 ± 1.5/ 31.3 ± 1.7	1560 ± 403.1/ 1582 ± 350.7	8.2 ± 1.2/ 8.3 ± 1.1	Breastfeeding rates	Improved
							Body weight at discharge	No significant impact
							Transition time to independent oral feeding	No significant impact
							Length of hospital stay	No significant impact
Asadollahpour et al.[45]	NNS/PFOS/ Control	11/10/11	6/5/6	30.18 ± 1.77/ 30.01 ± 1.76/ 30.29 ± 1.95	1406.36/1343.01/ 1393.63	7.85 ± 2.17/ 7.55 ± 1.99/ 7.77 ± 2.24	Transition time to independent oral feeding	Decreased
							Body weight at discharge	Increased
							Length of hospital stay	Decreased
Younesian et al.[11]	PFOS/Control	10/10	5/5	31.2 ± 0.78/ 30.9 ± 0.73	1590 ± 0.52/ 1548 ± 0.52	NM	Transition time to independent oral feeding	Decreased
							Length of hospital stay	Decreased
Osman et al.[46]	PIOMI/Control	25/25	16/16	NM	1500 ± 200/ 1500 ± 300	NM	Transition time to independent oral feeding	Decreased
							Length of hospital stay	Decreased
Arora et al.[47]	PIOMI/Control	16/14	8/8	30 ± 0.9/ 30.5 ± 0.6	1040 ± 120.6/ 1063.6 ± 79.5	NM	Transition time to independent oral feeding	Decreased
Thakkar et al.[16]	PIOMI/Control	51/51	28/24	32.1 ± 0.8/ 32.29 ± 0.6	1314.04 ± 105/ 1316.13 ± 80	8.4 ± 0.4/ 8.6 ± 0.4	Feeding performance (overall intake and rate of milk transfer),	Improved
							Transition time to independent oral feeding	Decreased
							Body weight at discharge	Increased
							Length of hospital stay	Decreased
Song et al.[48]	PFOS/Control	109/101	63/48	28.9/28.6	1170/1140	NM	Transition time of independent oral feeding	Decreased
							length of hospital stay	Decreased
Mahmoodi et al.[49]	PIOMI/Control	20/20	8/11	NM	NM	NM	Transition time of independent oral feeding	Decreased
							Length of hospital stay	Decreased

TABLE 1 (Continued)

First author and publication year	Interventions/ Control	Number in group	Number of male sex in group	Mean gestational age (mean ± SD)	Mean weight (g) (mean ± SD)	Apgar score (mean ± SD)	Comparator	Results
Ghomi et al.[50]	PIOMI/Control	15/15	7/8	28.21 ± 1.02/ 28.22 ± 1.01	1275 ± 239.23/ 1220 ± 159.23	NM	Feeding performance	Improved
							Transition time of independent oral feeding	Decreased
							Body weight at discharge	No significant impact
							Length of hospital stay	Decreased
Da Rosa Pereira et al.[51]	PFOS + NNS/ Control	37/37	18/19	30.7 ± 1.4/ 30.8 ± 1.5	1452 ± 330/ 1457 ± 353		Mean proficiency (PRO), transfer rate (RT)	Improved
							Transition time of independent oral feeding	No significant impact
Thabet et al.[52]	PIOMI/Control	30/30	15/9	32.46 ± 1.46/ 33.23 ± 2.68	2490 ± 830/ 2590 ± 660	NM	Transition time of independent oral feeding	Decreased
							Body weight at discharge	Increased
							Length of hospital stay	Decreased
Ostadi et al.[53]	NNS/Control	13/13	7/6	28.5 ± 1.6/ 28.9 ± 2	1165.4 ± 197.7/ 1221.5 ± 231.7	NM	Preterm oral feeding readiness assessment scale (POFRAS)	Increased
							Transition time of independent oral feeding	No significant impact
Le et al.[54]	PIOMI/Control	25/20	15/9	29.96 ± 1.65/ 29.95 ± 1.54	1472.4 ± 235.36/ 1454.5 ± 372.42	7.4 ± 0.91/ 7.45 ± 0.69	Transition time of independent oral feeding	No significant impact
							Length of hospital stay	No significant impact
Guler et al.[55]	PIOMI/Control	30/30	16/15	NM	1267 ± 276.6/ 1266.7 ± 233.6	NM	Sucking capacity	Improved
							Length of hospital stay	No significant impact
Shaki et al.[56]	NNS (with a gloved finger)/ NNS (through an orthodontic pacifier)/ Control	50/50/50	30/26/33	31.76 ± 0.71/ 31.8 ± 0.78/ 31.62 ± 0.6	1644 ± 272.4/ 1639.7 ± 205.89/ 1632.4 ± 215.59	9.15 ± 1.21/ 9.18 ± 0.85/ 9.36 ± 0.87	Transition time of independent oral feeding	Decreased
							Length of hospital stay	Decreased

(Continues)

TABLE 1 (Continued)

First author and publication year	Interventions/ Control	Number in group	Number of male sex in group	Mean gestational age (mean ± SD)	Mean weight (g) (mean ± SD)	Apgar score (mean ± SD)	Comparator	Results
Sasmal et al.[57]	PIOMI/Control	15/14	8/6	30.47 ± 2.09/ 30 ± 1.84	1233.29 ± 201.31/ 1171.86 ± 199.47	NM	Transition time of independent oral feeding	Decreased
							Body weight at discharge	No significant impact
							Length of hospital stay	Decreased

The PFOS intervention decreased the transition time of independent oral feeding in seven publications,[11,18,38,42,43,45,48] while in one publication,[44] it did not produce a significant change. Regarding body weight at discharge, one publication[45] reported an increase, whereas three publications[18,38,44] did not show a significant change. Furthermore, three studies[11,45,48] indicated a decrease in the length of hospital stay as a result of PFOS intervention, while two studies[43,44] did not find a significant change in the length of hospital stay.

In the evaluation of the combined use of PFOS and NNS interventions on preterm infants, four studies were conducted. Among these studies, two[39,43] reported a decrease in the transition time of independent oral feeding, while one study[51] did not observe a significant change. However, the combination of PFOS and NNS interventions did not appear to affect body weight at discharge, as indicated by two studies.[39,40] Regarding the length of hospital stay, one study[39] reported a decrease, while two studies[40,43] reported no significant change.

The PIOMI was assessed in several publications on preterm infants. Specifically, it was found to decrease the transition time of independent oral feeding in five publications.[16,21,46,49,50,52,57] Among the studies that evaluated body weight at discharge (four in total), two studies showed an increase,[16,52] while two studies reported no significant change.[50,57] Additionally, the length of hospital stay decreased in six publications [16,46,49,50,52,57] but did not show a significant change in three other publications.[21,54,55]

3.5 | Meta-analysis

3.5.1 | Body weight at discharge

Eleven studies reported data related to this outcome and were included in the meta-analysis. Of these, five studies[18,38,44,45,58] compared the PFOS versus control group, three studies[39,40,59] compared the combination of PFOS + NNS versus control group, and three studies[50,52,57] compared the PIOMI versus control group.

The overall SDM were 7.91 (SE = 1.16, 95% CI: 5.62, 10.2, $p = 0.000$, $I^2 = 86.31$), −0.27 (SE = 0.15, 95% CI: −0.57, 0.03, $p = 0.077$, $I^2 = 0$), and 3.71 (SE = 1.52, 95% CI: 0.72, 6.69, $p = 0.01$, $I^2 = 96.64$) for PFOS, PFOS+NNs, and PIOMI versus control groups, respectively. The overall effect was significant for PFOS and PIOMI groups versus control group (Figure 2).

3.6 | Independent oral feeding

Seventeen studies reported data related to this outcome and were included in the meta-analysis. Of these, five studies[11,42,44,48,58] compared the PFOS versus control group, four studies[43,45,53,56] compared the NNS versus control group, two studies[39,59] compared the combination of PFOS + NNS versus control group, and eight studies[16,47,49,50,52,54,55,57] compared the PIOMI versus control group.

The overall SDM were −0.64 (SE = 0.23, 95% CI: −1.1, −0.17, $p = 0.007$, $I^2 = 75.45$), −0.53 (SE = 0.11, 95% CI: −0.76, −0.30, $p = 0.001$,

TABLE 2 Summary of risk of bias assessment.

First name, study year	Quality assessment 1	2	3	4	5	6	7	8	9	10	11	12	13	Overall score
Asadollahpour et al.[45]	Y	U	Y	NA	Y	U	Y	Y	Y	Y	Y	Y	Y	10
Bache et al.[44]	Y	Y	Y	NA	N	N	U	Y	Y	Y	Y	Y	N	8
Boiron et al.[38]	Y	Y	Y	NA	U	U	U	Y	Y	Y	Y	Y	Y	9
da Rosa Pereira et al.[51]	Y	Y	Y	NA	Y	Y	U	Y	Y	Y	Y	Y	Y	11
Fucile et al.[18]	Y	Y	Y	NA	Y	Y	U	Y	Y	Y	Y	Y	Y	11
Fucile et al.[40]	Y	Y	Y	NA	N	N	U	Y	Y	Y	Y	Y	Y	9
Ghomi et al.[50]	Y	Y	Y	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	12
Guler et al.[55]	Y	Y	Y	NA	N	Y	U	Y	Y	Y	N	Y	Y	9
Harding et al.[41]	Y	Y	Y	NA	N	N	U	N	Y	Y	Y	Y	Y	8
Le et al.[54]	Y	Y	Y	NA	N	N	U	N	Y	Y	Y	Y	Y	8
Lessen et al.[21]	Y	Y	Y	NA	Y	Y	U	Y	Y	Y	Y	Y	N	10
Lyu et al.[42]	Y	Y	Y	NA	U	U	Y	Y	Y	Y	Y	Y	Y	10
Mahmoodi et al.[49]	Y	Y	Y	NA	N	N	U	Y	Y	Y	Y	Y	N	8
Ostadi et al.[53]	Y	Y	Y	NA	Y	Y	U	Y	Y	Y	Y	Y	Y	11
Rocha et al.[39]	Y	U	Y	NA	Y	Y	U	Y	Y	Y	Y	Y	Y	10
Shaki et al.[56]	Y	Y	Y	NA	N	Y	U	Y	Y	Y	Y	Y	Y	10
Song et al.[48]	Y	Y	Y	NA	N	Y	U	Y	Y	Y	Y	Y	Y	10
Thabet et al.[52]	Y	N	Y	NA	N	N	Y	Y	Y	Y	Y	Y	Y	9
Thakkar et al.[16]	Y	Y	Y	NA	Y	Y	U	Y	Y	Y	Y	Y	Y	11
Younesian et al.[11]	Y	Y	Y	NA	Y	Y	Y	Y	Y	Y	Y	Y	N	11
Zhang et al.[43]	Y	Y	Y	NA	N	Y	U	Y	Y	Y	Y	Y	Y	10

Study name	Comparison	Statistics for each study: Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Rocha et al. 2007	NNS+PFOS vs Control	-0.336	0.203	0.041	-0.735	0.063	-1.652	0.098
Fucile et al. 2010	NNS+PFOS vs Control	-0.128	0.321	0.103	-0.757	0.500	-0.399	0.690
Fucile et al. 2018	NNS+PFOS vs Control	-0.262	0.361	0.130	-0.970	0.445	-0.727	0.467
		-0.274	0.155	0.024	-0.578	0.030	-1.765	0.077
Fucile et al. 2002	PFOS vs Control	5.900	0.818	0.669	4.297	7.503	7.214	0.000
Fucile et al. 2005	PFOS vs Control	4.706	0.686	0.471	3.361	6.051	6.857	0.000
Boiron et al. 2007	PFOS vs Control	10.114	1.583	2.506	7.011	13.217	6.388	0.000
Bache et al. 2014	PFOS vs Control	8.330	0.671	0.450	7.015	9.645	12.415	0.000
Asadollahpour et al. 2015	PFOS vs Control	13.022	2.056	4.228	8.991	17.052	6.333	0.000
		7.919	1.169	1.366	5.628	10.209	6.774	0.000
Sasmal et al. 2023	PIOMI vs Control	17.296	2.301	5.296	12.786	21.806	7.516	0.000
Ghomi et al. 2019	PIOMI vs Control	-0.425	0.369	0.136	-1.149	0.299	-1.151	0.250
Thabet et al. 2021	PIOMI vs Control	0.631	0.265	0.070	0.112	1.149	2.384	0.017
		3.712	1.524	2.322	0.725	6.698	2.436	0.015

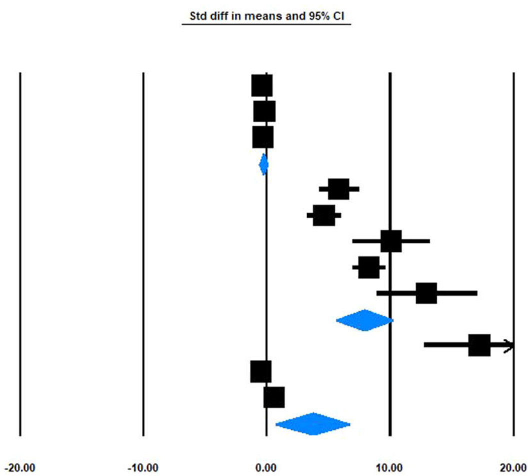

FIGURE 2 meta-analysis of body weight at discharge based on three groups of PFOS, PFOS + NNS, and PIOMI versus control groups. NNS, nonnutritive sucking; PFOS, prefeeding oral stimulation; PIOMI, Premature Infant Oral Motor Intervention.

$I^2 = 0$), −1.68 (SE = 1.21, 95% CI: −4.06, 0.70, $p = 0.16$, $I^2 = 94.74$) and −1.48 (SE = 0.51, 95% CI: −2.49, −0.46, $p = 0.004$, $I^2 = 93.73$) for PFOS, NNS, PFOS + NNS, and PIOMI versus control groups, respectively. The overall effect was significant for PFOS only, PIOMI only, and NNS only groups versus control groups (Figure 3).

3.7 | Length of hospital stay

Eighteen studies reported data related to this outcome and were included in the meta-analysis. Of these, four studies[11,44,45,48] compared the PFOS versus control group, three studies[41,43,56] compared the NNS versus control group, two studies[40,59] compared the combination of PFOS + NNS versus control group, and six studies[21,49,50,52,54,55,57] compared the PIOMI versus control group.

The overall SDM were −0.33 (SE = 0.24, 95% CI: −0.81, 0.15, $p = 0.17$, $I^2 = 68.41$), −0.45 (SE = 0.11, 95% CI: −0.67, −0.23, $p = 0.067$, $I^2 = 0$), −0.18 (SE = 0.24, 95% CI: −0.66, 0.28, $p = 0.43$, $I^2 = 0.04$), and −0.42 (SE = 0.13, 95% CI: −0.69, −0.15, $p = 0.002$, $I^2 = 20.18$) for PFOS, NNS, PFOS + NNS, and PIOMI versus control groups, respectively. The overall effect was significant for NNS only and PIOMI groups versus control group (Figure 4).

3.8 | Publication bias

We investigated the publication bias using funnel plot and visual inspection of it. The results show that there is no publication bias in this study. The funnel plot for LOS was shown in the Figure 5.

4 | DISCUSSION

This study provides evidence supporting the use of OMI as a beneficial intervention for preterm infants hospitalized in the NICU, as it is associated with positive outcomes including higher body weight at discharge, decreased transition time of independent oral feeding, and decreased length of hospitalization. Before this investigation, no studies had explored the effectiveness of different OMI methods based on these three specific characteristics. According to our meta-analysis findings in this study, that utilizing the PIOMI intervention may be a more favorable approach relative to other OMI techniques because the overall effect of this method was significant in all the reviewed outcomes including body weight at discharge, independent oral feeding, and length of hospital stay.

In the context of this systematic review, the majority of studies reviewed reported similar findings, although some clinical trials did not observe a significant difference between the intervention and control groups. Consistent with the current findings, in a study by Bala et al. the impact of oromotor stimulation in combination with routine care, including NNS and KMC, on the time taken to attain partial and complete spoon feeding was investigated in 25 preterm infants. The findings revealed that the intervention group had a significantly reduced median time of gavage tube feeding in comparison to a control group of 26 preterm infants who received routine care only.[60]

Many findings were published about the different effects of NNS, which were reviewed based on the key outcomes of the study. Pimenta et al. evaluated breastfeeding rates in 47 preterm infants who received NNS in combination with oral stimulation programs and

Study name	Comparison	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
		Statistics for each study						
Zhang et al. 2014	NNS vs Control	-0.766	0.288	0.083	-1.330	-0.203	-2.665	0.008
Asadollahpour et al. 2015	NNS vs Control	-0.822	0.444	0.197	-1.692	0.048	-1.852	0.064
Ostadi et al. 2021	NNS vs Control	-0.570	0.400	0.160	-1.354	0.214	-1.425	0.154
Shaki et al. 2022a	NNS vs Control	-0.465	0.203	0.041	-0.862	-0.068	-2.295	0.022
Shaki et al. 2022b	NNS vs Control	-0.429	0.202	0.041	-0.826	-0.033	-2.121	0.034
		-0.538	0.118	0.014	-0.768	-0.307	-4.567	0.000
Fucile et al. 2005	PFOS vs Control	-1.228	0.385	0.149	-1.983	-0.472	-3.186	0.001
Lyu et al. 2014	PFOS vs Control	-0.677	0.259	0.067	-1.185	-0.169	-2.612	0.009
Bache et al. 2014	PFOS vs Control	0.014	0.216	0.047	-0.410	0.438	0.065	0.948
Younesian et al. 2015	PFOS vs Control	-1.749	0.526	0.276	-2.779	-0.718	-3.326	0.001
Song et al. 2019	PFOS vs Control	-0.322	0.139	0.019	-0.594	-0.049	-2.313	0.021
		-0.640	0.237	0.056	-1.105	-0.175	-2.698	0.007
Rocha et al. 2007	PFOS+NNS vs Control	-0.510	0.205	0.042	-0.912	-0.108	-2.484	0.013
Fucile et al. 2018	PFOS+NNS vs Control	-2.943	0.519	0.269	-3.960	-1.927	-5.676	0.000
		-1.680	1.216	1.478	-4.063	0.703	-1.382	0.167
Sasmal et al. 2023	PIOMI vs Control	-1.810	0.441	0.195	-2.675	-0.945	-4.103	0.000
Thakkar et al. 2018	PIOMI vs Control	-5.110	0.688	0.474	-6.459	-3.761	-7.424	0.000
Ghomi et al. 2019	PIOMI vs Control	-1.661	0.423	0.179	-2.491	-0.831	-3.922	0.000
Thabet et al. 2021	PIOMI vs Control	1.087	0.277	0.077	0.545	1.630	3.931	0.000
Le et al. 2022	PIOMI vs Control	-0.583	0.306	0.094	-1.183	0.018	-1.903	0.057
Guler et al. 2022	PIOMI vs Control	-0.728	0.267	0.071	-1.250	-0.205	-2.730	0.006
Mahmoodi et al. 2019	PIOMI vs Control	-0.849	0.330	0.109	-1.496	-0.201	-2.570	0.010
Arora et al. 2018	PIOMI vs Control	-2.894	0.523	0.274	-3.919	-1.869	-5.534	0.000
		-1.477	0.517	0.268	-2.491	-0.463	-2.856	0.004

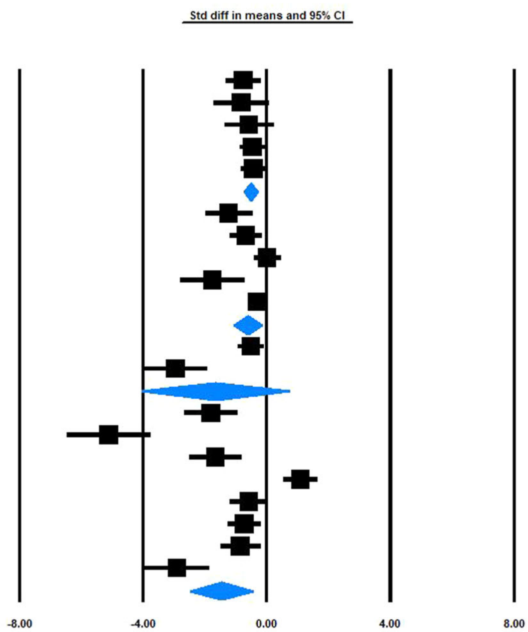

FIGURE 3 meta-analysis of independent oral feeding based on four groups of PFOS, NNS, PFOS + NNS, and PIOMI versus control groups. NNS, nonnutritive sucking; PFOS, prefeeding oral stimulation; PIOMI, Premature Infant Oral Motor Intervention.

Study name	Comparison	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
		Statistics for each study						
Zhang et al. 2014	NNS vs Control	-0.254	0.279	0.078	-0.800	0.292	-0.911	0.362
Harding et al. 2014a	NNS vs Control	-0.600	0.327	0.107	-1.242	0.042	-1.832	0.067
Harding et al. 2014b	NNS vs Control	-0.727	0.331	0.109	-1.375	-0.079	-2.198	0.028
Shaki et al. 2022a	NNS vs Control	-0.529	0.203	0.041	-0.928	-0.130	-2.601	0.009
Shaki et al. 2022b	NNS vs Control	-0.342	0.201	0.041	-0.737	0.053	-1.696	0.090
		-0.458	0.112	0.012	-0.677	-0.239	-4.101	0.000
Bache et al. 2014	PFOS vs Control	0.201	0.217	0.047	-0.224	0.626	0.928	0.353
Asadollahpour et al. 2015	PFOS vs Control	-0.448	0.442	0.196	-1.315	0.419	-1.014	0.311
Younesian et al. 2015	PFOS vs Control	-1.342	0.495	0.245	-2.312	-0.372	-2.711	0.007
Song et al. 2019	PFOS vs Control	-0.300	0.139	0.019	-0.572	-0.028	-2.159	0.031
		-0.331	0.246	0.061	-0.814	0.151	-1.345	0.178
Fucile et al. 2010	PFOS+NNS vs Control	0.023	0.320	0.103	-0.605	0.651	0.072	0.943
Fucile et al. 2018	PFOS+NNS vs Control	-0.462	0.364	0.133	-1.176	0.252	-1.269	0.204
		-0.189	0.241	0.058	-0.660	0.283	-0.784	0.433
Sasmal et al. 2023	PIOMI vs Control	-0.777	0.385	0.149	-1.533	-0.022	-2.017	0.044
Lessen et al. 2011	PIOMI vs Control	0.177	0.460	0.212	-0.725	1.080	0.385	0.700
Mahmoodi et al. 2019	PIOMI vs Control	-0.662	0.325	0.105	-1.299	-0.026	-2.040	0.041
Ghomi et al. 2019	PIOMI vs Control	-0.822	0.380	0.145	-1.567	-0.076	-2.161	0.031
Thabet et al. 2021	PIOMI vs Control	-0.658	0.265	0.070	-1.177	-0.138	-2.480	0.013
Le et al. 2022	PIOMI vs Control	-0.028	0.300	0.090	-0.616	0.560	-0.095	0.924
Guler et al. 2022	PIOMI vs Control	-0.189	0.259	0.067	-0.696	0.318	-0.731	0.465
		-0.427	0.137	0.019	-0.696	-0.157	-3.102	0.002

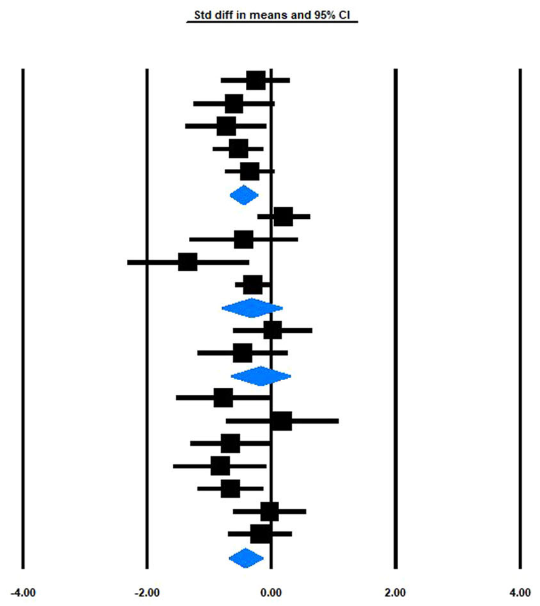

FIGURE 4 meta-analysis of length of hospital stay based on four groups of PFOS, NNS, PFOS + NNS, and PIOMI versus control groups. NNS, nonnutritive sucking; PFOS, prefeeding oral stimulation; PIOMI, Premature Infant Oral Motor Intervention.

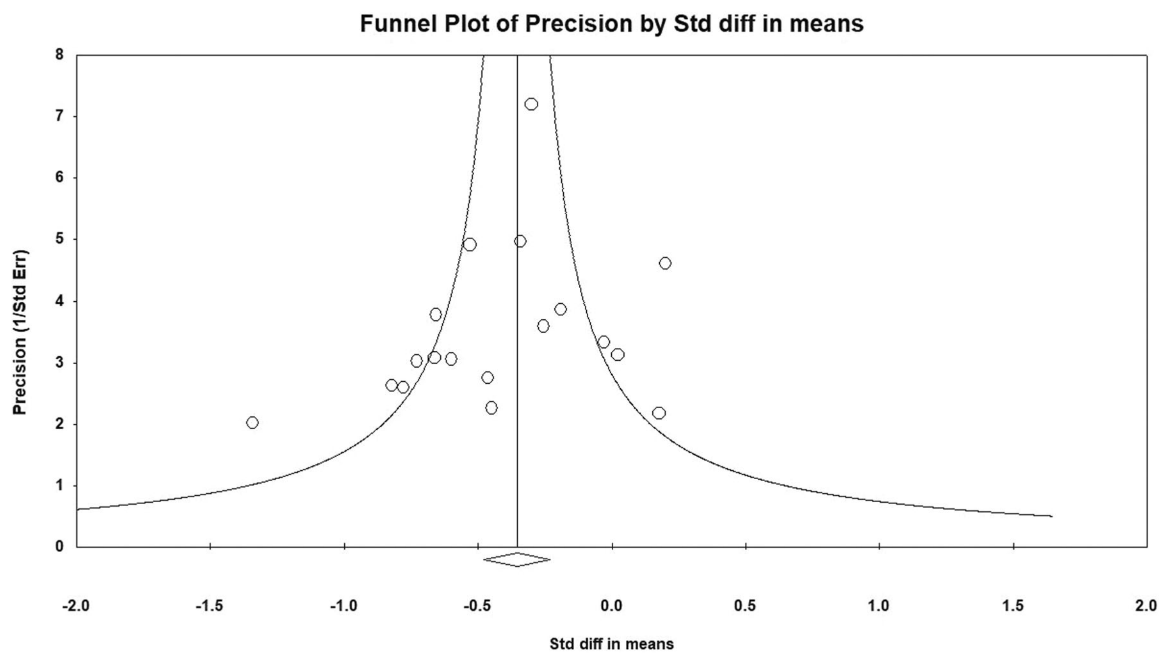

FIGURE 5 Funnel plot for LOS outcome.

compared them to a control group of 49 preterm infants who did not receive the intervention. The results showed that the intervention group had a significantly elevated breastfeeding rate.[61] Moreover, Kamhawy et al. demonstrated that NNS technique during nasogastric tube feeding led to elevated oxygen saturation levels, hastened advancement to breastfeeding, increased weight gain, and early hospital discharge in 23 preterm infants compared to a control group (24 preterm infants). Additionally, there were no significant variations in heart rate among the study groups.[62] In contrast to these findings, Valizadeh et al. performed a study to compare the effects of oral massage and NNS on preterm infants in three groups of 24 infants each. The results showed that both intervention groups had a significantly shorter duration of oral intake in comparison with the control group. However, the three study groups did not differ significantly in the time to attain independent oral feeding ability and length of hospitalization.[63]

In relation to the impacts of PFOS intervention, key outcomes have been reviewed in different studies. Amer et al. demonstrated that PFOS intervention improved feeding performance in 27 preterm infants by significantly increasing the total oral consumption rate, reducing net leakage, and shortening oral feeding period compared to a control group of 28 preterm infants.[64] Furthermore, in a study by Mashad et al., the impact of PFOS intervention on oral feeding period and body weight alteration was investigated in 25 preterm infants. The findings revealed a significant decrease in oral feeding time and a significant increase in weight variation percentage in the intervention group compared to a control group of 25 preterm infants.[65] In conflict with these data, Hwang et al. indicated no statistically significant differences in feeding performance (the amount of milk consumed per suck and mean rate of suckling), physiological changes (oxygen saturation in peripheral blood and heart rate), and behavioral states between PFOS group and a control group of 19 preterm infants.[66] Besides, Khalasi et al. conducted a study to assess the impact of administering PFOS and NNS on the weight of preterm infants. The study involved three groups of 15 preterm infants each, with one group receiving PFOS and NNS once a day for ten days, another group receiving PFOS and NNS two times a day for 5 days, and a control group receiving routine nursing care only. The findings revealed that the infants in the first group had significantly increased body weights at reaching eight and four oral feedings per day, as well as at discharge, compared to the second group and the control group.[67]

In accordance with the present study's conclusions, Thakkar et al. found that PIOMI intervention had improved feeding performance including milk transfer rate and overall intake, augmented weight gain, reduced duration of transition to independent oral feeding as well as decreased length of hospitalization in a sample of 51 preterm infants compared to a control group who received routine nursing care only (51 preterm infants).[16] In addition, Mahmoodi et al. determined that PIOMI intervention reduced hospital stay duration in 20 preterm infants compared to a control group (20 preterm infants).[68] Moreover, it is important to mention that Bandyopadhyay et al. reported a significantly accelerated progression from tube to complete spoon feeds in 16 preterm infants who underwent PIOMI technique compared to a control group (16 preterm infants). The result of this study showed although the mean (SD) time to transition was attained significantly earlier in the PIOMI group than the control group, there was no significant difference between the two groups in terms of the duration of hospital stay.[69]

Several potential explanations have been put forth to account for the different efficacy of OMIs training in promoting body weight at discharge, independent oral feeding time, and length of hospital stay in preterm infants. At the participating institutions, there is no standardized protocol for initiating and progressing oral feedings, despite the availability of general guidelines for their management. Of course, standard feeding protocols such as implementing the Infant Driven Feeding, and a Cue-Based feeding programs can be considered more carefully in this field.[70,71] The decision to advance the number of daily oral feedings in preterm infants may be based on criteria such as successful completion of all feedings by mouth and/or appropriate daily weight gain, as determined by certain healthcare providers. Furthermore, while there are established criteria for discharging infants from the hospital, there is no standardized timeline for initiating discharge planning. Additionally, failure to evaluate staffing patterns may result in nurses choosing to forego oral feedings in favor of gavage feedings due to time constraints, potentially leading to delays in feeding progression. Moreover, not assessing the use of human milk versus formula in bottle feeding may serve as a confounding variable with regard to the achievement of successful feeding.

5 | LIMITATIONS

One limitation of this meta-analysis is that some studies were excluded due to low quality, such as those not reporting prevalence or having small sample sizes.

6 | CONCLUSION

The findings of this systematic review suggest that, among OMIs, the PIOMI approach generally had a more advantageous impact on body weight gain at discharge, duration of independent oral feeding, and length of hospital stay. Despite ongoing research, the conclusion regarding the efficacy of PIOMI for premature infants remains controversial due to certain limitations, including small sample sizes that may result in low statistical power and the potential for false-negative outcomes.

Notably, among OMIs the cost of implementing PIOMI intervention program is low, as it does not require the use of specific devices, but rather relies on the expertize of a physiotherapist. The integration of this intervention into standard care protocols would enhance the quality of care for this patient population, with minimal economic impact on NICU, provided that the necessary healthcare professionals are already on staff. We encourage researchers to undertake additional studies to establish more standardized, scientifically rigorous, and rational approaches for clinical implementation.

AUTHOR CONTRIBUTIONS

Ghasem Mahmoodabadi: Writing—original draft; methodology. **Ahmad Bavali-Gazik**: Methodology; writing—review and editing; software; formal analysis. **Fateme Mouhebati**: Investigation; writing—original draft. **Morteza Arab-Zozani**: Conceptualization; writing—original draft; methodology; software; formal analysis. **Meysamreza Boghrati**: Conceptualization; writing—original draft; methodology; funding acquisition.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, [M. A.], upon reasonable request.

TRANSPARENCY STATEMENT

The lead author Morteza Arab-Zozani, Meysamreza Boghrati affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

ORCID

Morteza Arab-Zozani http://orcid.org/0000-0001-7223-6707
Meysamreza Boghrati http://orcid.org/0009-0005-1698-6913

REFERENCES

1. Salt A, Redshaw M. Neurodevelopmental follow-up after preterm birth: follow up after two years. *Early Hum Dev*. 2006;82(3):185-197.
2. Kelly MM. The medically complex premature infant in primary care. *J Pediatr Health Care*. 2006;20(6):367-373.
3. Kramer MS. The contribution of mild and moderate preterm birth to infant mortality. *JAMA*. 2000;284(7):843-849.
4. Walani SR. Global burden of preterm birth. *Int J Gynaecol Obst*. 2020;150(1):31-33.
5. Howe T-H, Sheu C-F, Hinojosa J, Lin J, Holzman IR. Multiple factors related to bottle-feeding performance in preterm infants. *Nurs Res*. 2007;56(5):307-311.
6. Behnam Vashani H, Abolfazli M, Boskabadi H. The effect of non-nutritive sucking on weight gain and length of stay in preterm infants. *Evid Based Care*. 2013;3(3):43-50.
7. Bryant-Waugh R, Markham L, Kreipe RE, Walsh BT. Feeding and eating disorders in childhood. *Int J Eat Disord*. 2010;43(2):98-111.
8. Kung H-C, Hoyert DL, Xu J, Murphy SL. Deaths: final data for 2005. 2008.
9. Lubbe W. Clinicians guide for cue-based transition to oral feeding in preterm infants: an easy-to-use clinical guide. *J Eval Clin Pract*. 2018;24(1):80-88.
10. Sampallo-Pedroza RM, Cardona Lopez LF, Ramirez Gomez KE. Description of oral-motor development from birth to six years of age. *Revista de la Facultad de Medicina*. 2015;62(4):593-604.
11. Younesian S, Yadegari F, Soleimani F. Impact of oral sensory motor stimulation on feeding performance, length of hospital stay, and weight gain of preterm infants in NICU. *Iran Red Crescent Med J*. 2015;17(7):e13515.
12. da Costa SP, van Den Engel–Hoek L, Bos AF. Sucking and swallowing in infants and diagnostic tools. *J Perinatol*. 2008;28(4):247-257.
13. Gaebler CP, Hanzlik JR. The effects of a prefeeding stimulation program on preterm infants. *Am J Occup Ther*. 1996;50(3):184-192.
14. Neiva FCB, Leone CR, Leone C, et al. Non-nutritive sucking evaluation in preterm newborns and the start of oral feeding: a multicenter study. *Clinics*. 2014;69:393-397.
15. Sasmal S, Shetty AP, Saha B. Effect of prefeeding oromotor stimulation on preterm infants: a systematic review. *Int J Health Sci Res*. 2020;10(12):93-104.
16. Thakkar PA, Rohit H, Ranjan Das R, Thakkar UP, Singh A. Effect of oral stimulation on feeding performance and weight gain in preterm neonates: a randomised controlled trial. *Paed Int Child Health*. 2018;38(3):181-186.
17. Harding C. An evaluation of the benefits of non-nutritive sucking for premature infants as described in the literature. *Arch Dis Child*. 2009;94(8):636-640.
18. Fucile S, Gisel E, Lau C. Oral stimulation accelerates the transition from tube to oral feeding in preterm infants. *J Pediatr*. 2002;141(2):230-236.
19. Lessen BS, Morello CA, Williams LJ. Establishing intervention fidelity of an oral motor intervention for preterm infants. *Neonatal Netw*. 2015;34(2):72-82.
20. Huang C-C, Hwang Y-S, Lin Y-C, Huang M-C. Effects of oral stimulation on feeding readiness of preterm infants: a randomized controlled study. *J Neon Nurs*. 2024;30(2):160-164.
21. Lessen BS. Effect of the premature infant oral motor intervention on feeding progression and length of stay in preterm infants. *Advan Neon care*. 2011;11(2):129-139.
22. Arvedson J, Clark H, Lazarus C, Schooling T, Frymark T. Evidence-based systematic review: effects of oral motor interventions on feeding and swallowing in preterm infants. 2010.
23. Daley HK, Kennedy CM. Meta analysis: effects of interventions on premature infants feeding. *J Perinat Neonatal Nurs*. 2000;14(3):62-77.
24. Pinelli J, Symington AJ. Non-nutritive sucking for promoting physiologic stability and nutrition in preterm infants. *Cochrane Database Syst Rev*. 2005;19(4):CD001071.
25. Grassi* A, Sgherri* G, Chorna O, et al. Early intervention to improve sucking in preterm newborns: a systematic review of quantitative studies. *Adva Neon Care*. 2019;19(2):97-109.
26. Rodovanski GP, Réus BAB, Dos Santos AN. The effects of multisensory stimulation on the length of hospital stay and weight gain in hospitalized preterm infants: a systematic review with meta-analysis. *Braz J Phys Ther*. 2022;27(1):100468.
27. Rodriguez Gonzalez P, Perez-Cabezas V, Chamorro-Moriana G, Ruiz Molinero C, Vazquez-Casares AM, Gonzalez-Medina G. Effectiveness of oral sensory-motor stimulation in premature infants in the neonatal intensive care unit (NICU) systematic review. *Children*. 2021;8(9):758.
28. Song JT, Kinshella M-LW, Kawaza K, Goldfarb DM. Neonatal intensive care unit interventions to improve breastfeeding rates at discharge among preterm and low birth weight infants: a systematic review and meta-analysis. *Breastfeed Med*. 2023;18(2):97-106.
29. Greene Z, O'Donnell CP, Walshe M. Oral stimulation for promoting oral feeding in preterm infants. *Cochrane Database Syst Rev*. 2023;6(6):CD009720.
30. Jyoti SM, Kodi S, Deol R. Effect of premature infant oral motor intervention on oral feeding and weight gain: aA systematic review and Meta-Analysis. *Iran J Nurs Midwifery Res*. 2023;28(3):225-234.
31. Tian X, Yi L-J, Zhang L, et al. Oral motor intervention improved the oral feeding in preterm infants: evidence based on a meta-analysis with trial sequential analysis. *Medicine*. 2015;94(31):e1310.
32. Moher D. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Intern Med*. 2009;151(4):264-269.
33. Santos CMC, Pimenta CAM, Nobre MRC. The PICO strategy for the research question construction and evidence search. *Rev Lat Am Enfermagem*. 2007;15:508-511.
34. Tufanaru C, Munn Z, Aromataris E, Campbell J, Hopp L. Explanation for the critical appraisal tool for RCTs with individual participants in parallel groups. *Joanna Briggs Institute Reviewer's Manual The Joanna Briggs Institute*, 2017:1-9.
35. Munn Z, Moola S, Lisy K, Riitano D, Tufanaru C. Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and cumulative incidence data. *Int J Evid Based Health*. 2015;13(3):147-153.
36. Mahumud RA, Kamara JK, Renzaho AMN. The epidemiological burden and overall distribution of chronic comorbidities in

coronavirus disease-2019 among 202,005 infected patients: evidence from a systematic review and meta-analysis. *Infection*. 2020;48:813-833.
37. Porto De Toledo I, Stefani FM, Porporatti AL, et al. Prevalence of otologic signs and symptoms in adult patients with temporomandibular disorders: a systematic review and meta-analysis. *Clin Oral Investig*. 2017;21:597-605.
38. Boiron M, Da Nobrega L, Roux S, Henrot A, Saliba E. Effects of oral stimulation and oral support on non-nutritive sucking and feeding performance in preterm infants. *Dev Med Child Neurol*. 2007;49(6):439-444.
39. Rocha AD, Moreira MEL, Pimenta HP, Ramos JRM, Lucena SL. A randomized study of the efficacy of sensory-motor-oral stimulation and non-nutritive sucking in very low birthweight infant. *Early Hum Dev*. 2007;83(6):385-388.
40. Fucile S, Gisel E. Sensorimotor interventions improve growth and motor function in preterm infants. *Neonatal Netw*. 2010;29(6):359-366.
41. Harding C, Frank L, Van Someren V, Hilari K, Botting N. How does non-nutritive sucking support infant feeding? *Infant Behav Develop*. 2014;37(4):457-464.
42. Lyu T, Zhang Y, Hu X, Cao Y, Ren P, Wang Y. The effect of an early oral stimulation program on oral feeding of preterm infants. *Int J Nurs Sci*. 2014;1(1):42-47.
43. Zhang Y, Lyu T, Hu X, Shi P, Cao Y, Latour JM. Effect of nonnutritive sucking and oral stimulation on feeding performance in preterm infants: a randomized controlled trial. *Ped Crit Care Med*. 2014;15(7):608-614.
44. Bache M, Pizon E, Jacobs J, Vaillant M, Lecomte A. Effects of pre-feeding oral stimulation on oral feeding in preterm infants: a randomized clinical trial. *Early Hum Dev*. 2014;90(3):125-129.
45. Asadollahpour F, Yadegari F, Soleimani F, Khalesi N. The effects of non-nutritive sucking and pre-feeding oral stimulation on time to achieve independent oral feeding for preterm infants. *Iran J Ped*. 2015;25(3):e809.
46. Osman A, Ahmed E, Mohamed H, Hassanein F, Brandon D. Oral motor intervention accelerates time to full oral feeding and discharge. *Int J Advan Nurs Stud*. 2016;5(2):228.
47. Arora K, Goel S, Manerkar S, et al. Prefeeding oromotor stimulation program for improving oromotor function in preterm infants—a randomized controlled trial. *Indian Pediatr*. 2018;55:675-678.
48. Song D, Jegatheesan P, Nafday S, et al. Patterned frequency-modulated oral stimulation in preterm infants: a multicenter randomized controlled trial. *PLoS One*. 2019;14(2):e0212675.
49. Mahmoodi N, Knoll BL, Keykha R, Jalalodini A, Ghaljaei F. The effect of oral motor intervention on oral feeding readiness and feeding progression in preterm infants. *Iranian J Neonatol* 2019;10(3):58-63.
50. Ghomi H, Yadegari F, Soleimani F, Knoll BL, Noroozi M, Mazouri A. The effects of premature infant oral motor intervention (PIOMI) on oral feeding of preterm infants: a randomized clinical trial. *Int J Pediatr Otorhinolaryngol*. 2019;120:202-209.
51. da Rosa Pereira K, Levy DS, Procianoy RS, Silveira RC. Impact of a pre-feeding oral stimulation program on first feed attempt in preterm infants: double-blind controlled clinical trial. *PLoS One*. 2020;15(9):e0237915.
52. Thabet AM, Sayed ZA. Effectiveness of the premature infant oral motor intervention on feeding performance, duration of hospital stay, and weight of preterm neonates in neonatal intensive care unit: results from a randomized controlled trial. *Dimens Crit Care Nurs*. 2021;40(4):257-265.
53. Ostadi M, Jokar F, Armanian AM, Namnabati M, Kazemi Y, Poorjavad M. The effects of swallowing exercise and non-nutritive sucking exercise on oral feeding readiness in preterm infants: a randomized controlled trial. *Int J Pediatr Otorhinolaryngol*. 2021;142:110602.
54. Le Q, Zheng S, Zhang L, et al. Effects of oral stimulation with breast milk in preterm infants oral feeding: a randomized clinical trial. *J Perinat Med*. 2022;50(4):486-492.
55. Guler S, Cigdem Z, Lessen Knoll BS, Ortabag T, Yakut Y. Effect of the premature infant oral motor intervention on sucking capacity in preterm infants in Turkey: a randomized controlled trial. *Advan Neon Care*. 2022;22(6):E196-E206.
56. Shaki F, Aziznejadroshan P, Rad ZA, Chehrazi M, Arzani A. Comparison of the effect of two methods of sucking on pacifier and mother's finger on oral feeding behavior in preterm infants: a randomized clinical trial. *BMC Pediatr*. 2022;22(1):292.
57. Sasmal S, Shetty AP, Saha B, Knoll B, Mukherjee S. Effect of pre-feeding oromotor stimulation on oral feeding performance of preterm neonates during hospitalization and at corrected one month of age at a tertiary neonatal care unit of India: a randomized controlled trial. *J Neonatol*. 2023;37:09732179221143185.
58. Fucile S, Gisel E, Lau C. Effect of an oral stimulation program on sucking skill maturation of preterm infants. *Develop Med Child Neurol*. 2005;47(3):158-162.
59. Fucile S, Milutinov M, Timmons K, Dow K. Oral sensorimotor intervention enhances breastfeeding establishment in preterm infants. *Breastfeed Med*. 2018;13(7):473-478.
60. Bala P, Kaur R, Mukhopadhyay K, Kaur S. Oromotor stimulation for transition from gavage to full oral feeding in preterm neonates: a randomized controlled trial. *Indian Pediatr*. 2016;53:36-38.
61. Pimenta HP, Moreira MEL, Rocha AD, Junior Junior SCG, Pinto LW, Lucena SL. Effects of non-nutritive sucking and oral stimulation on breastfeeding rates for preterm, low birth weight infants: a randomized clinical trial. *J Pediatr*. 2008;84:423-427.
62. Kamhawy H, Holditch-Davis D, Al-Sharkawy S, Alrafay S, Corazzini K. Non-nutritive sucking for preterm infants in Egypt. *J Obstet Gynecol Neon Nurs*. 2014;43(3):330-340.
63. Valizadeh S, Hosseini MB, Karimijavan G, Amirteimori I. Effect of oral massage vs. non-nutritive sucking on attainment of independent oral feeding and duration of hospitalization in NICU: a randomized trial. *HAYAT*. 2014;20(1):38-47.
64. Amer HW, Rashad HM, Dabash SAE, El Din ZME. Effect of prefeeding oral stimulation program on preterm infants' feeding performance. *J Biol Agricult Healthcare*. 2015;5(16):14-19.
65. El Mashad G, El Saied H, Mekawy N. Effect of an early oral stimulation program on oral feeding in preterm neonates. *Menoufia Med J*. 2021;34(1):226.
66. Hwang Y-S, Vergara E, Lin C-H, Coster WJ, Bigsby R, Tsai W-H. Effects of prefeeding oral stimulation on feeding performance of preterm infants. *Indian J Ped*. 2010;77:869-873.
67. Khalessi N, Nazi S, Shariat M, Saboteh M, Farahani Z. The effects of pre-feeding oral stimulations and non-nutritive sucking on physical growth and independent oral feeding of preterm infants. *Iranian J Neonatol*. 2015;6(4):25-29.
68. Mahmoodi N, Zareii K, Mohagheghi P, Eimani M, Rezaei-Pour M. Evaluation of the effect of the oral motor interventions on reducing hospital stay in preterm infants. *Alborz Univer Med J*. 2013;2(3):163-166.
69. Bandyopadhyay T, Maria A, Vallamkonda N. Pre-feeding premature infant oral motor intervention (PIOMI) for transition from gavage to oral feeding: A randomised controlled trial. *J Ped Rehabilit Med*. 2023;16(2):361-367.
70. Fry TJ, Marfurt S, Wengier S. Systematic review of quality improvement initiatives related to cue-based feeding in preterm infants. *Nurs Womens Health*. 2018;22(5):401-410.

71. Osman A, Ibrahim M, Saunders J, et al. Effects of implementation of Infant-Driven oral feeding guideline on preterm infants' abilities to achieve oral feeding milestones, in a tertiary neonatal intensive care unit. *Nutr Clin Pract*. 2021;36(6):1262-1269.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Mahmoodabadi G, Bavali-Gazik A, Mouhebati F, Arab-Zozani M, Boghrati M. The effectiveness of oral motor interventions on the weight gain, independent oral feeding, and length of hospital stay in hospitalized preterm infants: a systematic review and meta-analysis. *Health Sci Rep*. 2024;7:e70015. doi:10.1002/hsr2.70015