ORIGINAL RESEARCH

Infafeed Monitor Pilot Study: Measuring Ingested Milk Volumes in Neonates

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Received on: 20 January 2025; *Accepted on*: 21 February 2025; *Published on*: 25 March 2025

Abstract

Aim: This study evaluates the technical feasibility of Infafeed, a novel noninvasive prototype for measuring ingested milk volumes in neonates, offering an objective assessment to support breastfeeding.

Materials and methods: A single-center pilot study was conducted. Twenty-four newborn infants (mean gestational age: 37 ± 1 weeks, birth weight: 2.88 ± 0.63 kg) receiving bottle or syringe feeds were recruited. Two cases were excluded due to data-saving errors, and two more were removed due to excessive noise. The Infafeed monitor recorded feeding sounds via a microphone placed on the infant's neck, while a secondary microphone captured background noise for cancellation. Power spectral density analysis was performed to differentiate swallow and nonswallow events, and a linear regression model was used to estimate feed volumes based on 20 recordings.

Results: Spectral analysis revealed a significant difference in swallow vs nonswallow spectral power in bottle-fed infants. Total power in the 400–600 Hz frequency band showed the strongest correlation with milk volume per swallow ($r = 0.94$). The linear regression model achieved a mean absolute error of 6.44 mL for estimated feed volumes.

Conclusion: The Infafeed monitor demonstrated feasibility for neonatal feeding assessment. The observed acoustic differences between swallow and nonswallow periods provide a foundation for automated swallow detection, which can enhance milk volume estimation. Further studies with a larger cohort are required to improve accuracy and evaluate the technical and clinical applicability.

Clinical significance: Maternal concern about insufficient milk supply is a leading cause of premature cessation of exclusive breastfeeding. The Infafeed monitor has the potential to provide a noninvasive, objective tool for assessing neonatal milk intake, reducing unnecessary supplementation, enabling early identification of feeding problems, and supporting breastfeeding continuation. If validated in larger studies, this device could enhance breastfeeding support strategies in both clinical and home settings.

Keywords: Breastfeeding, Infant, Monitor, Neonatal, Nutrition, Swallow.

Newborn (2025): 10.5005/jp-journals-11002-0121

Introduction

The benefits of breastfeeding infants are well documented, and the World Health Organization recommends exclusive breastfeeding for the first 6 months of life.[1] Despite this, globally, fewer than 50% of infants are exclusively breastfed until 6 months of age, with significantly lower rates in higher-income countries.[2,3]

One of the most common reasons for earlier-than-planned cessation of breastfeeding is self-reported maternal concerns around inadequate milk supply and their ability to provide adequate nutrition to their baby through breastfeeding alone.[4–7] This perception of insufficient milk supply is common among women who stop exclusive breastfeeding early; however, primary insufficiency of milk production has been found to affect only 5% of women.[8,9] Many women who report insufficient breastmilk describe infant satiety cues, such as crying as their primary indication of milk supply, despite these having been proven as an unreliable indication of actual milk supply, rather than proven clinical indicators of adequate milk supply, including infant weight gain and growth and urine and stool output.[8,10–12] While weight gain is the primary clinical indicator of adequate milk intake, it does not provide real-time feedback on individual feeding sessions. In cases where feeding adequacy is uncertain—such as

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How to cite this article: Boyd RS, Grooby ES, Bhuiyan H, *et al*. Infafeed Monitor Pilot Study: Measuring Ingested Milk Volumes in Neonates. Newborn 2025;4(1):19–24.

Source of support: This research is supported by a Monash Data Future Institute grant

Conflict of interest: None

Patient consent statement: Informed consent was obtained from the parents or caregivers of all infants Included in this study prior to their inclusion in this study.

in preterm infants transitioning to breastfeeding, neonates with poor weight gain, or infants at risk of dehydration—objective feeding assessments may be beneficial.

Additionally, studies have shown that a perception of insufficient milk by a mother does not commonly correlate with an actual insufficiency of milk production, highlighting a need for an objective way to measure breast milk volumes to improve maternal confidence in their ability to feed their infant without requiring supplementary formula.[9,11]

A number of modalities can be used to assess breastfeeds and swallowing. Breastfeeding scoring systems are frequently used, as they are noninvasive and simple to use.[13] However, these are not accurate methods for quantifying feed volumes.[14] Imaging modalities have been studied to visualize swallowing in breast-fed infants, including ultrasound, fiberoptic endoscopic evaluation of swallowing (FEES), and magnetic resonance imaging. These modalities have been shown to be able to visualize milk ingestion and may be able to estimate feed volumes; however, as with breastfeeding scoring systems, they require trained staff, appropriate equipment, and, in the case of FEES, are an invasive procedure.[15–18] They are useful for the evaluation of dysphagia or concerns for aspiration, but are unlikely to be feasible for parents as a tool to evaluate the volume of milk taken by an infant repeatedly over several breastfeeds.[15,17,18] Test weights, which involve weighing a baby before and after a breastfeed, are currently the most accurate noninvasive tool for estimating feed volumes.[11] Test weights have been shown to be effective, but again require staff available to weigh the infant before and after the feed, and have been reported to be perceived negatively by some mothers as it interrupts bonding time and medicalizes breastfeeding.[11,19]

There are currently no commercially available products which have been scientifically proven to accurately provide estimates of ingested breastmilk by an infant. Given that concerns around lack of adequate milk supply is one of the most frequently cited reasons for cessation of exclusive breastfeeding in the first 6 months and the lack of a noninvasive, accurate and easy-to-use bedside method of evaluating milk ingestion from breastfed infants, our goal was to develop a monitor which could easily and noninvasively measure the volume of milk taken by an infant while breastfeeding. The ultimate goal of this device is to improve infant nutrition and breastfeeding rates. Developing this technology requires multiple steps: first, enabling automatic detection and measurement of milk swallows; second, providing real-time feedback to users; and finally, the design must be simple and user friendly, so that it can be used quickly and easily by clinicians and parents without interfering with the infants feeding.

As the first clinical study in the development of this technology, the aim of this project was to assess the technical feasibility of the Infafeed Smart Feeding Monitor, a noninvasive feeding monitoring device. Specifically, this study evaluated the prototype's ability to differentiate acoustic characteristics between swallow and nonswallow periods and to estimate milk intake automatically. It is worth noting that this technology is designed as a noninvasive, supportive tool for specific cases where feeding adequacy is uncertain, such as neonates with poor weight gain, rather than for routine use in all breastfeeding infants. This device aims to complement existing clinical assessments by providing real-time, objective measurements of milk intake, which may be particularly valuable in settings where early identification of feeding difficulties can help guide interventions.

Materials and Methods

Study Design and Data Collection

This was a prospective, single-center, pilot study conducted on the postnatal wards of Monash Medical Center, Melbourne, Australia (a tertiary multispecialty public hospital) and was approved by the Monash Health Human Research Ethics Committee (HREC/89481/MonH-2022-345330). The study population comprised term or late-preterm infants (gestational age: 35–42 weeks) receiving bottle or syringe feeds of expressed breast milk (EBM) or infant formula. Infants were excluded from the study if they were born less than 35 weeks gestation, required nasogastric feeds, had a known major congenital abnormality or genetic condition, or whose parents were unable to give informed consent. Recruitment occurred by informed consent from the parent(s) of infants who had already been born and were admitted to the postnatal ward. All infants recruited were already having a bottle or syringe feed as part of their feeding plan prior to being recruited.

Syringe-fed infants were included to evaluate the feasibility of using the Infafeed monitor in detecting swallows and estimating milk intake at very low volumes. This is particularly relevant as newborns typically consume small quantities of milk in the early stages of breastfeeding. Since the study required a known measure of actual milk intake, only bottle- and syringe-fed infants were included, ensuring accurate volume estimation. The inclusion of syringe-fed infants allowed us to examine the device's performance in detecting swallows at the lowest intake levels.

The Infafeed monitor (first prototype, not yet commercialized) is being developed as a wearable device for accurate feed volume measurement. It uses two microphones: one placed on the infant's neck to record swallowing sounds, and another within the main unit to capture background noise.

After informed consent was obtained, a recording of the feed from a bottle or syringe was made. The Infafeed sensor was placed on the right or left lateral neck surface of the infant and adhered to the skin using a small amount of DuoDerm (Convatec Inc., Victoria, Australia) adhesive dressing (Fig. 1). A note of the volume taken by the baby during the feed was made at the end of the feed, and during any interruptions to the feed. To identify swallow events, a noise was made by the investigator each time the baby swallowed; for the initial 12 recordings, this was done using verbal cues each time the baby swallowed and picked up

Fig. 1: Infafeed sensor applied to lateral neck of infant mannequin

by the background microphone in the Infafeed sensor head. To improve swallow recognition, from the 13th recording onward, a clicking noise was made by the investigator using a click noise on their phone; this clicking was recorded separately and saved, to synchronize with the audio recorded by the Infafeed microphone. The clicker was pressed every time the investigator saw the use of swallowing muscles in the infant's neck. This clicker was introduced as a reference to assist in locating swallow events for spectral analysis. However, the clicker data was not used in the automated volume estimation process, ensuring that the estimation model does not depend on any manual cues.

The medical records were accessed for each infant to document demographic data, including gestational age, chronological age, birth weight, sex, mode of delivery, the type of milk being fed, and the total volume of milk taken by the infant during the feed. Infant characteristics were assessed for normality and the mean and standard deviation (SD) or median and interquartile range (IQR) were calculated for each domain.

Preprocessing

Following the collection of all data, the sensor data was processed. This included noise removal and spectral analysis of milk swallows. To obtain power spectral density (PSD) plots, primary and background microphones were sampled at 5,000 Hz. Background noise cancellation was achieved by spectral oversubtraction of the secondary background microphone, which picks up background noise, from the primary microphone, as described by Emmanouilidou et al.[20]

Spectral Analysis

Primary microphone data was broken up into swallow and nonswallow periods. Swallow periods were defined as the entire region in which feeding associated with swallows occurred. Power spectral density was then calculated. The difference between swallow and nonswallow periods was also calculated for different power bands from 0 to 2,500 Hz and the total power. Significance testing was performed using two-sided paired Wilcoxon signed rank test.

Milk Intake Volume Estimation

A linear regression model was trained with feed volume as the target variable and total power of the sound, age, and delivery mode as independent variables. The model was trained iteratively on subsets of the dataset, with one infant's recording reserved for testing in each iteration, while the remaining data was used for training. This iterative leave-one (infant)-out validation process ensures a reliable and unbiased evaluation of the model's ability to generalize across different infants.

Results

Infant Recruitment

The parents of 24 infants receiving bottle or syringe feeds provided consent for their participation in this study. One recording of a bottle or syringe feed was made for each infant. None of the infants in the study received feeds from a cup or other alternative feeding methods. Of the 24 recordings, two were excluded from the analysis due to errors in saving the data (in one case, the device was turned off before the recording was saved, and in the second, the device was not turned on to record correctly). Two further recordings were significantly corrupted by noise and were excluded. Final analysis was performed on the remaining 20 recordings. Recordings took place over a 6-month period from December 2022 to May 2023.

Table 1: Demographic data

Demographic variables	*Infants (n = 24)*
Gestational age (week), mean (SD)	37 (1)
Birth weight (kg), mean (SD)	2.88 (0.63)
Female	13 (54%)
Male	11 (46%)
Mode of delivery	
Vaginal	10 (42%)
Cesarean section	14 (58%)
Type of feed	
Bottle	17 (71%)
Syringe	7 (29%)
Milk type	
EBM	12 (50%)
Formula	12 (50%)
Feed volume (mL), median (IQR)	
Bottle	20 (15)
Syringe	2.5 (0.5)

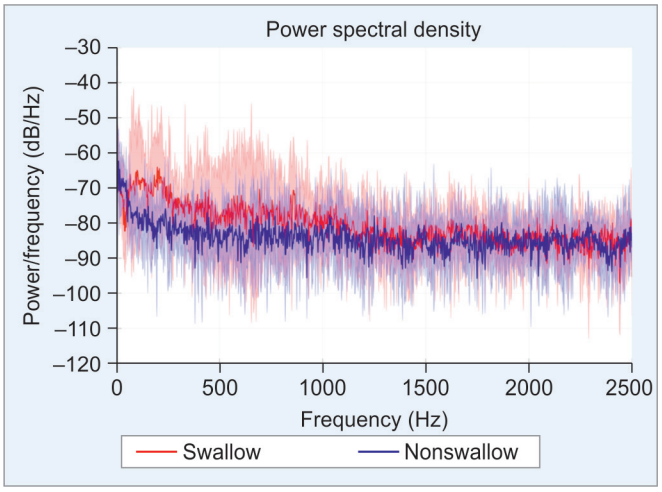

Fig. 2: Overall PSD plot for bottle feeds. Solid lines represent median value and shaded regions represent first quartile to third quartile values

Demographic Information

The infants had a mean (SD) gestational age of 37 (1) completed weeks. The mean (SD) birth weight was 2.88 (0.63) kg, and 13 (54%) of the infants were female. The feed volume taken by bottle [median (IQR)] was 20 (15) mL, and volume taken by syringe [median (IQR)] was 2.5 (0.5) mL; 12 (50%) of the infants took EBM, and 17 (71%) took their feed from a bottle. Demographic data is shown in Table 1.

Spectral Analysis Results

Power spectral density plots were created for seven sample recordings of bottle feeds, which were of the highest quality. The overall PSD is shown in Figure 2. There was a significant difference in power between the swallow and nonswallow periods in the total

Table 2: Difference in power between swallow and nonswallow events for bottle feeds and correlation coefficient of power band with feed volume per swallow

Power band (Hz)	*Median difference (dB/Hz)*	*p-value*	*Correlation coefficient*
Total power	2.51	0.02	0.8508
Power 0–200 Hz	1.42	0.02	0.6793
Power 200–400 Hz	6.90	0.08	0.4315
Power 400–600 Hz	10.46	0.22	0.9360
Power 600–800 Hz	6.17	0.16	0.6182
Power 800–1000 Hz	6.80	0.11	0.6374
Power 1000–1200 Hz	1.32	0.58	0.5949
Power 1200–1400 Hz	0.93	0.38	0.5138
Power 1400–1600 Hz	1.78	0.38	0.2153
Power 1600–1800 Hz	2.10	0.22	0.7640
Power 1800–2000 Hz	0.37	1	0.7191
Power 2000–2500 Hz	1.62	0.02	0.4240

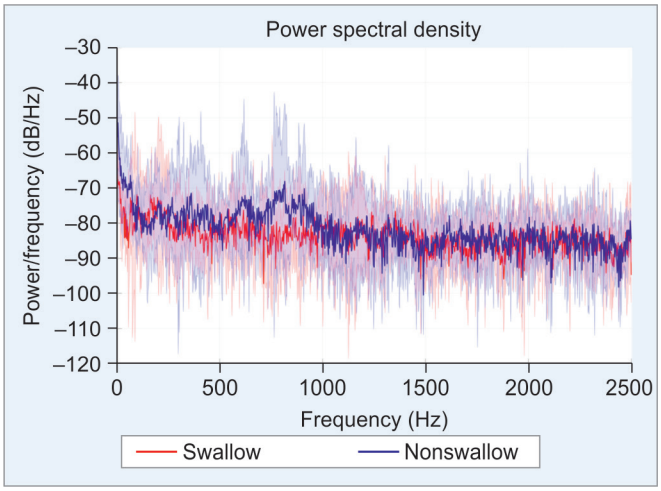

Fig. 3: Overall PSD chart for syringe feeds. Solid lines represent median value and shaded regions represent first quartile to third quartile values

power, and in the range of 0–200 Hz (Table 2). A high correlation was seen with the feed volume per swallow in the 400–600 Hz range and in the total power, with a correlation coefficient of 0.94 and 0.85, respectively (Table 2).

Recordings of syringe feeds were analyzed separately. Of the seven recordings of syringe feeds, four with the highest quality were used for analysis. The overall PSD chart for syringe feeds is shown in Figure 3. Unlike bottle-fed infants, there was not a noticeable dominant power peak for milk swallows taken from a syringe (Table 3).

Milk Intake Volume Estimation Results

Figure 4 shows the line of best fit for the actual and estimated swallow volumes for all 20 recordings of bottle and syringe feeds. The overall root mean squared error was 6.44 mL and overall mean absolute error was also 6.44 mL.

Table 3: Difference in power between swallow and nonswallow events for syringe feeds

Power band (Hz)	*Median difference (dB/Hz)*	*p-value*
Total power	−0.96	0.13
Power 0–200 Hz	0.17	0.88
Power 200–400 Hz	−7.93	0.63
Power 400–600 Hz	−5.80	0.38
Power 600–800 Hz	−12.92	0.25
Power 800–1000 Hz	−9.25	0.38
Power 1000–1200 Hz	−0.84	1
Power 1200–1400 Hz	−0.99	1
Power 1400–1600 Hz	1.20	0.63
Power 1600–1800 Hz	−1.46	0.63
Power 1800–2000 Hz	−0.35	0.88
Power 2000–2500 Hz	0.48	0.25

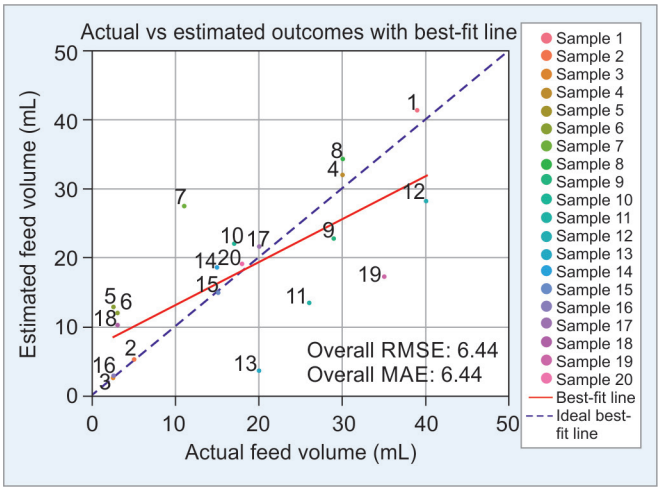

Fig. 4: Line of best fit for actual vs estimated swallow volumes from the linear regression model

Discussion

This is the first study of the use of a feeding monitor to assess feed volumes in bottle- or syringe-fed newborn infants. The Infafeed Smart Feeding Monitor is being developed as an automated technology to assist in determining milk volumes taken by breastfeeding infants to improve breastfeeding rates and long-term nutrition. This first step in its development aimed to test the monitor's ability to estimate the volume of milk intake, with the goal for the software to automatically measure milk intake for each swallow in real time when correctly placed on the infant's neck. This was the first study of this device conducted on infants and utilized an initial prototype model of the sensor. Use of the monitor was feasible, did not interfere with feeding, and parents were generally accepting of the device.

This study represents an initial step toward developing a noninvasive, user-friendly device for assessing neonatal milk intake. While the current prototype requires manual placement and monitoring, the ultimate goal is a small, lightweight, and wearable device that seamlessly integrates into breastfeeding

without requiring continuous supervision. This final design is intended for specific cases where parents or healthcare providers are concerned about feeding adequacy, such as dehydrated infants, those with poor weight gain, or preterm infants transitioning to breastfeeding. At this early stage, our focus is on validating the technology's ability to differentiate swallows and estimate milk intake, with future studies addressing usability, placement, and potential impact on bonding.

We observed significant differences in the power spectrum between swallow and nonswallow regions in bottle feed recordings. This information can inform future models for automatic swallow detection. There was a strong correlation with the total power, especially in the 400–600 Hz band range and the quantity of milk per swallow, which may be helpful in future to improve the milk intake quantification. In this study, we identified total power as the most effective feature for estimating milk intake volume. Previous studies of cervical auscultation in adults have shown differences in the peak frequency recorded based on the swallowed volume, though this was not consistent across males and females, and the effect size was small in both studies.[21,22] It is difficult to know how these results would translate to the neonatal swallow, though highlights the need for further assessment on a larger number of infants. The four recordings of feeds taken by a syringe did not show a statistically significant difference in the power peak. This may be due to the smaller volume taken being a lot quieter and not being picked up as easily on this prototype, with limited denoising and amplification; however, recordings of these smaller volumes will be important in future studies of the device.

Few studies have characterized cervical auscultation for infant swallowing analysis, primarily focusing on dysphagia evaluation rather than feed volume measurement or automated swallow detection.[23,24] As the first study of this unique monitor in infants, we were able to identify differences in the acoustic characteristics of swallow and nonswallow periods, which may be a key to further develop this as an automated technology to detect swallowing. Difficulties encountered in the use of this prototype device during the study were mostly related to the design of the sensor head, which was large and heavy, meaning that the researcher had to hold the sensor in place and affected its ability to have contact with the skin at all times. A new flexible probe is currently being designed as our second prototype, which has a lower profile and would allow more constant contact with the skin.

There were also difficulties in identifying swallows for spectral analysis. This was initially done by the investigator making a noise to be picked up by the background microphone in the sensor head. In subsequent recordings, a clicker noise was used and recorded separately, requiring the recording from the Infafeed device to be synchronized with the recording of clicking for each swallow. Due to challenges in capturing and synchronizing verbal cues for each swallow on the background microphone, some recordings were excluded from the spectral analysis. However, since the milk intake measurement did not rely on the number or timing of swallows, all 20 recordings were included for this analysis. To allow for better swallow detection, the next prototype will include an inbuilt clicker so that the investigator can more accurately time each swallow. The integrated clicker would also enable synchronizing the click information with recordings from the microphones and other sensors. Importantly, the clicker will only be required during algorithm training and will not be needed in the final product used by end users.

Due to differences in the sound quality between infants taking larger volumes of feed from a bottle and smaller volumes from a syringe, we analyzed these data sets separately. Smaller feed volumes taken by a syringe were more difficult to analyze and did not show a significant difference between swallow and nonswallow periods. Future versions of this device should include enhanced noise removal and sound amplification. This will make the device more useful for detecting and analyzing smaller swallow volumes in infants receiving smaller amounts of milk.

A key limitation of this study is the small sample size, which may limit the generalizability of the findings. Future studies with a larger and more diverse cohort are necessary to validate the accuracy of the Infafeed monitor and establish more robust conclusions. Expanding the study population will also allow for improved statistical power and a better understanding of interindividual variability in feeding characteristics. The exclusion of four recordings due to technical and data quality issues, may also impact the generalizability of the findings. Our result suggests a potential regression to the mean effect, where lower volumes appear to be overestimated. Future work will refine the model to address this, particularly by incorporating a larger dataset and optimizing the training of the volume estimation algorithm.

Another limitation of this study is the exclusion of breastfeeding. While this does not fully replicate all aspects of breastfeeding, it provided a controlled environment for initial feasibility testing. The device successfully identified distinct acoustic features during bottle and syringe feeding; however, the absence of breastfeeding data means that additional validation is required to confirm its ability to differentiate true swallows in natural breastfeeding scenarios. Unlike bottle and syringe feeding, breastfeeding involves complex dynamics which may influence the acoustic profile of swallows, which will be investigated in future studies to refine swallow detection accuracy in breastfeeding infants. The technical feasibility demonstrated in this study—such as the ability to distinguish swallows from nonswallow events and estimate intake volume—suggests that further development toward a fully functional device for breastfeeding infants is warranted rather than dismissed. Future studies will focus on evaluating the device in breastfeeding infants, considering additional variables such as infant positioning, milk flow, and natural feeding behaviors.

Conclusions

Use of the Infafeed Smart Feeding Monitor during bottle or syringe feeds was feasible. We were able to demonstrate the technical feasibility of automated milk intake estimation and a noticeable difference in the acoustic characteristics between swallow and nonswallow periods of the recordings, which will be useful in further studies of this monitor, and to develop automatic detection of swallows. Further studies with a larger cohort of infants consuming varying milk volumes are needed to enhance swallow detection and milk intake estimation accuracy over a wide range of volumes.

Clinical Significance

One of the primary reasons for early cessation of exclusive breastfeeding is maternal concern over insufficient milk supply, despite actual milk insufficiency being rare.[4–7] This perception often leads to unnecessary formula supplementation, which in turn can reduce breastfeeding frequency and milk production, ultimately contributing to early weaning.

The feasibility study conducted in bottle- and syringe-fed neonates demonstrated the potential of Infafeed to differentiate swallow vs nonswallow events. The strong correlation between acoustic features and milk volume per swallow, and the estimation of milk intake volume using linear regression, demonstrated the feasibility of Infafeed for automated monitoring of breastfeeding. By providing quantifiable, immediate feedback on neonatal milk intake, Infafeed has the potential to:

- Empower mothers by increasing breastfeeding confidence through objective milk intake measurements.
- Reduce unnecessary formula supplementation, thereby supporting exclusive breastfeeding continuation.
- Enable early identification of feeding difficulties, particularly in preterm or at-risk neonates, thereby improving neonatal nutrition, reducing the risk of dehydration and growth stunting.

If validated in larger studies, Infafeed could transform breastfeeding support strategies in both clinical and home settings, offering an accessible, low-cost tool to improve breastfeeding rates and long-term infant health outcomes globally.

Data Availability Statement

Data is available upon reasonable request to the corresponding author.

Ethical Approval

This study was approved by the Monash Health Human Research Ethics Committee (HREC/89481/MonH-2022-345330).

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References

1. World Health Organization. Exclusive breastfeeding for six months best for babies everywhere [Internet]. 2011. Available from: https://www.who.int/news/item/15-01-2011-exclusive-breastfeeding-for-six-months-best-for-babies-everywhere.
2. Victora CGP, Bahl RMD, Barros AJDP, et al. Breastfeeding in the 21st century: Epidemiology, mechanisms, and lifelong effect. Lancet 2016;387(10017):475–490. DOI: 10.1016/S0140-6736(15)01024-7.
3. Balogun OO, Dagvadorj A, Anigo KM, et al. Factors influencing breastfeeding exclusivity during the first 6 months of life in developing countries: A quantitative and qualitative systematic review. Matern Child Nutr 2015;11(4):433–451. DOI: 10.1111/mcn.12180.
4. Gianni ML, Bettinelli ME, Manfra P, et al. Breastfeeding difficulties and risk for early breastfeeding cessation. Nutrients 2019;11(10):2266. DOI: 10.3390/nu11102266.
5. Li R, Fein SB, Chen J, et al. Why mothers stop breastfeeding: Mothers' self-reported reasons for stopping during the first year. Pediatrics 2008;122(Suppl 2):S69–S76. DOI: 10.1542/peds.2008-1315i.
6. Brown CRL, Dodds L, Legge A, et al. Factors influencing the reasons why mothers stop breastfeeding. Can J Public Health 2014;105(3):e179–e185. DOI: 10.17269/cjph.105.4244.
7. Odom EC, Li R, Scanlon KS, et al. Reasons for earlier than desired cessation of breastfeeding. Pediatrics 2013;131(3):e726–e732. DOI: 10.1542/peds.2012-1295.
8. Kent JC, Prime DK, Garbin CP. Principles for maintaining or increasing breast milk production. J Obstet Gynecol Neonatal Nurs 2012;41(1):114–121. DOI: 10.1111/j.1552-6909.2011.01313.x.
9. Galipeau R, Dumas L, Lepage M. Perception of not having enough milk and actual milk production of first-time breastfeeding mothers: Is there a difference? Breastfeed Med 2017;12:210–217. DOI: 10.1089/bfm.2016.0183.
10. Kent JC, Ashton E, Hardwick CM, et al. Causes of perception of insufficient milk supply in Western Australian mothers. Matern Child Nutr 2021;17(1):e13080. DOI: 10.1111/mcn.13080.
11. Kent JC, Hepworth AR, Langton DB, et al. Impact of measuring milk production by test weighing on breastfeeding confidence in mothers of term infants. Breastfeed Med 2015;10(6):318–325. DOI: 10.1089/bfm.2015.0025.
12. Sacco LM, Caulfield LE, Gittelsohn J, et al. The conceptualization of perceived insufficient milk among Mexican mothers. J Hum Lact 2006;22(3):277–286. DOI: 10.1177/0890334406287817.
13. Pados BF, Park J, Estrem H, et al. Assessment tools for evaluation of oral feeding in infants younger than 6 months. Adv Neonatal Care 2016;16(2):143–150. DOI: 10.1097/ANC.0000000000000255.
14. Altuntas N, Kocak M, Akkurt S, et al. LATCH scores and milk intake in preterm and term infants: A prospective comparative study. Breastfeed Med 2015;10(2):96–101. DOI: 10.1089/bfm.2014.0042.
15. Torabinia M, Rosenblatt SD, Mosadegh B. A review of quantitative instruments for understanding breastfeeding dynamics. Glob Chall 2021;5(10):2100019. DOI: 10.1002/gch2.202100019.
16. Vetter-Laracy S, Osona B, Roca A, et al. Neonatal swallowing assessment using fiberoptic endoscopic evaluation of swallowing (FEES). Pediatr Pulmonol 2018;53(4):437–442. DOI: 10.1002/ppul.23946.
17. Reynolds J, Carroll S, Sturdivant C. Fiberoptic endoscopic evaluation of swallowing: A multidisciplinary alternative for assessment of infants with dysphagia in the neonatal intensive care unit. Adv Neonatal Care 2016;16(1):37–43. DOI: 10.1097/ANC.0000000000000245.
18. Mills N, Lydon AM, Davies-Payne D, et al. Imaging the breastfeeding swallow: Pilot study utilizing real-time MRI. Laryngoscope Investig Otolaryngol 2020;5(3):572–579. DOI: 10.1002/lio2.397.
19. Perrella SL, Nancarrow K, Rea A, et al. Estimates of preterm infants' breastfeeding transfer volumes are not reliably accurate. Adv Neonatal Care 2020;20(5):E93–E99. DOI: 10.1097/ANC.0000000000000721.
20. Emmanouilidou D, McCollum ED, Park DE, et al. Adaptive noise suppression of pediatric lung auscultations with real applications to noisy clinical settings in developing countries. IEEE Trans Biomed Eng 2015;62(9):2279–2288. DOI: 10.1109/TBME.2015.2422698.
21. Cichero JAY, Murdoch BE. Acoustic signature of the normal swallow: Characterization by age, gender, and bolus volume. Ann Otol Rhinol Laryngol 2002;111(7):623–632. DOI: 10.1177/000348940211100710.
22. Youmans SR, Stierwalt JAG. Normal swallowing acoustics across age, gender, bolus viscosity, and bolus volume. Dysphagia 2011;26(4):374–384. DOI: 10.1007/s00455-010-9323-z.
23. Vice FL, Heinz JM, Giuriati G, et al. Cervical auscultation of suckle feeding in newborn infants. Dev Med Child Neurol 1990;32(9):760–768. DOI: 10.1111/j.1469-8749.1990.tb08479.x.
24. Vice FL, Bamford O, Heinz JM, et al. Correlation of cervical auscultation with physiological recording during suckle-feeding in newborn infants. Dev Med Child Neurol 1995;37(2):167–179. DOI: 10.1111/j.1469-8749.1995.tb11986.x.