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First-Day Use of the Newborn Weight Loss Tool to Predict Excess Weight Loss in Breastfeeding Newborns

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Abstract

Background and Objectives: Exclusive breastfeeding is recommended for most newborns. However, exclusively breastfed newborns sometimes experience excess weight loss (EWL, loss ≥10% of birth weight) while lactation is being established. Our primary objective was to evaluate the sensitivity and specificity of the Newborn Weight Loss Tool (NEWT) in early identification of exclusively breastfed newborns who develop EWL; and secondarily, identify breastfeeding variables associated with an at-risk NEWT trajectory.
Materials and Methods: We conducted a secondary analysis of prospective data from mother–infant dyads screened for inclusion in the U.S. site of the WHO Growth Reference Study. We excluded records if: NEWT-specific criteria not met, missing key data, or >60 mL formula consumed. We defined NEWT ''test-positive'' based on an in-hospital weight at about 24 hours falling within the NEWT trajectory consistent with eventual EWL. We defined cases as true EWL based on weight measured at home on day of life 4 (DoL4).
Results: Of 280 original records, 60 were excluded ($n = 27$, NEWT-specific exclusion; $n = 15$, missing data; $n = 18$, >60 mL formula), resulting in 220 paired newborn weights measured in-hospital (17 ± 8 hours), and at DoL4 (84 ± 8 hours). NEWT status correctly identified 6/28 EWL cases (21% sensitivity [95% confidence interval, CI, 8–34%]), and 158/192 noncases (82% specificity [95% CI, 75–89%]). NEWT test-positive status was associated with greater weight loss, lower perceived breastfeeding support, and infant less often showing feeding cues on DoL4 ($p < 0.05$).
Conclusion: Sensitivity in predicting EWL is low when applying NEWT at about 24 hours of life; however, early test-positive status is associated with indicators of breastfeeding difficulties on DoL4.

Keywords: newborn, excess weight loss, breastfeeding, NEWT, early discharge

Introduction

Human milk provides powerful nutritional benefits for infant growth, development, and well-being as compared with breast milk substitutes.[1–4] Additionally, exclusive breastfeeding provides long-term benefits to both the lactating mother and her child.[3,4] Thus, it is important that appropriate breastfeeding practices are followed to ensure breastfeeding success for the mother–infant dyad.

Major public health organizations, such as the American Academy of Pediatrics, the World Health Organization, and the Academy of Breastfeeding Medicine, recommend exclusive breastfeeding during the first 6 months of life for optimal growth and development.[1,5,6] Public health initiatives to support exclusive breastfeeding practices in the United States include the Baby-Friendly Hospital Initiative,[7] Baby-Friendly USA,[8] the Centers for Disease Control and Prevention Breastfeeding Report Card,[9] and the Joint Commission tracking of individual maternity hospital exclusive breastfeeding rates.[10]

Unfortunately, exclusively breastfeeding newborns occasionally receive insufficient breast milk, either due to unrecognized suboptimal infant breastfeeding behavior[11,12] or inadequate maternal milk production,[12,13] which can exacerbate infants' physiological weight loss.[14–16] To prevent associated morbidities, such as hyperbilirubinemia,[17,18] hypernatremic

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dehydration,[19–22] and failure to thrive,[23] identification of newborns at risk for excessive weight loss is imperative. A potential solution for detecting newborns who are on a trajectory for excess weight loss (EWL) is the Newborn Weight Loss Tool (NEWT).[24] This tool consists of nomograms that show hour-by-hour weight loss trajectories during birth hospitalization for generally healthy-term newborns. The nomograms were developed from 108,907 newborn weight data points at 6–96 hours of life, extracted from electronic medical records from 14 Kaiser Permanente medical centers in Northern California between January 1, 2009 and December 31, 2013.[24]

In development of the nomograms, quantile regression was applied separately for vaginal and cesarean deliveries to estimate the 50th, 75th, 90th, and 95th percentiles of weight loss as a function of hours since birth.[24] This tool is publicly accessible online. According to the nomograms, weight loss trajectories at the 90th percentile or more for vaginal deliveries, and at the 75th percentile or more for cesarean deliveries, intersect with weight loss ≥10% of birth weight, which is considered excessive.[15] Before the development of the NEWT, Flaherman et al. reported a significant association between first-day newborn weight loss and the in-hospital weight nadir.[25] However, a limitation of this study is that it is only generalizable to newborns who have not yet been discharged. Notably, the in-hospital weight nadir was the final weight taken for 76% of the sample, indicating that the majority were on a downward weight trajectory at the time of hospital discharge. Although the NEWT nomograms provide a comprehensive picture of weight loss trajectories during the birth hospitalization, NEWT has not been validated in its ability to predict weight loss outcomes posthospital discharge. This is a critical gap, as the NEWT percentiles represent weight loss that occurred in institutionalized settings, where routine care was administered. In contrast, the newborn weight loss nadir often occurs after hospital discharge and before the first pediatric visit.[15,26] Also, even though newborn weights obtained as early as 6 hours of life may be plotted on the NEWT, it is not known if a single early weight is clinically useful for identifying newborns at risk for excessive weight loss once they are discharged to home. This critical need is especially relevant during the current COVID-19 pandemic, when many families are anxious for early discharge and there may be fewer outpatient breastfeeding resources available.

Thus, our primary objective was to evaluate if a single NEWT result obtained in the first 6–48 hours of life is sensitive in identifying exclusively breastfed newborns who will develop true EWL (defined as loss ≥10% of birth weight) once discharged to home, and conversely, its specificity in identifying exclusive breastfeeding newborns who will not develop EWL once discharged to home. Our secondary objective was to determine if this NEWT result is associated with postdischarge breastfeeding variables. In accomplishing our objectives, we will gain insights into the appropriateness of using the NEWT as an early prognostic screening to identify exclusively breastfed infants who are at risk of EWL after they have been discharged to home.

Materials and Methods

Study design

We conducted secondary data analysis using records from the Risk Factors Study (RFS).[12] This community-based cohort included prospectively followed mother–infant dyads who were screened for inclusion in the U.S. site of the World Health Organization Growth Reference Study (Davis, CA). Information was obtained on breastfeeding attitudes and practices, infant feeding patterns, and newborn weights on the first and fourth day of life (and beyond). Research was determined to be nonhuman subjects research by the University of California at Davis IRB as it only involved a deidentified dataset.

Participants

All residents of Davis, California, who gave birth between February and December 1999, were invited to participate in the RFS. Recruitment was coordinated with the five maternity hospitals in the surrounding area. Eligibility was determined by screening mother–infant dyads based on the following criteria: (1) residence in Davis, California, (2) mother willing to attempt exclusive breastfeeding for at least 1 month, (3) singleton infant born ≥37 completed weeks' gestation with no significant perinatal morbidity, (4) mother spoke English, and (5) mother had telephone access. The goal was to screen dyads within the first 24 hours of birth, however, some screenings occurred in the second day of life, resulting in 280 dyads meeting the above criteria and being enrolled within the first 48 hours of birth.

Data relevant to this secondary analysis were collected at the time of enrollment in the maternity unit and at home on day of life 4 (DoL4, defined as 72–96 hours of life). There were a few occasions where the DoL4 visit occurred at the maternity hospital. At both time points, infant weights were measured, infant breastfeeding behavior was observed, and mothers were interviewed regarding infant feeding practices and breastfeeding concerns. The RFS team measured infant weight in duplicate to the nearest 1 g using calibrated electronic infant scales (Tanita, Inc., Arlington Heights, IL) during the birth hospitalization and during study home visits. Hospital infant scales were validated on a quarterly basis and study scales were validated daily.[12]

Analytic dataset

We developed an analytic dataset comprised RFS records that met NEWT selection criteria. All RFS records already met the following NEWT selection criteria: term, singleton birth, biologically plausible weights recorded, and survived discharge to home. We then excluded from our analytic dataset the records that met the following additional NEWT exclusion criteria: (1) newborn admitted to special care nursery (referenced as Level II or Level III care in NEWT study), (2) missing in-hospital weight or data–time of weight, (3) birth weight <2,000 or >5,000 g, or (4) in-hospital weight measured before 6 hours of life. We further excluded records missing home visit weight data and for infants who received more than token amounts of infant formula, which we defined as formula intake >60 mL before the DoL4 home visit. This cutoff is based on our prior analysis in the same cohort, where we observed that a token amount of formula of this nature is well below the threshold for which formula was protective against EWL.[12]

NEWT status determination

On the publicly accessible website, NEWT displays fields for entering birth weight, birth date–time, and postbirth

weights and timing of these weights, starting at 6 hours of life. The NEWT also includes radio buttons to indicate the mode of delivery (vaginal or cesarean) and mode of feeding (breastfed or formula-fed). Entering these data results in a plotting of the newborn's weight loss percentile relative to the 50th, 75th, 90th, and 95th percentiles as a function of hours since birth, up to 72 hours for vaginal births, and 96 hours for Cesarean births. For vaginal births, if the NEWT-generated weight loss percentile data point was at the 90th percentile or more, we coded this outcome as test positive because the 90th percentile trajectory for vaginal delivery intersects with weight loss of 10% or greater. Conversely, if the data point was less than the 90th percentile (i.e., <50th, 50th–75th, or 75th–90th), we coded this outcome as test negative. Similarly, for all cesarean-delivered infants, if the NEWT-generated weight loss percentile data point was at the 75th percentile or more, we coded this outcome as test positive, because the 75th percentile trajectory for Cesarean-delivered infants intersects with weight loss of 10% or greater; and if the data point was less than the 75th percentile, we coded this outcome as test negative. To minimize bias in coding NEWT status, we used a working database that included only record number and the above NEWT-required variables. Using this approach, the coder was masked to true EWL status at DoL4 while coding NEWT status.

Statistical analysis

We used SAS 9.4 (SAS Institute, Cary, NC) to conduct the data analysis. We generated a flow chart to document the derivation of the final analytic dataset (Fig. 1). We used descriptive statistics (means and proportions) to summarize the characteristics of the mother–infant dyads included in the final analytic dataset, stratified by NEWT test-positive and NEWT test-negative status. We used Student's t test for continuous variables and Chi-Square for categorical variables in determining significant differences ($p < 0.05$) by NEWT status group.

We built 2×2 contingency tables showing the in-hospital NEWT test status cross-classified with true EWL case status. We defined ''cases'' as having weight loss ≥10% of birth weight at DoL4 (72–96 hours of life). This is an optimal timeframe for identifying excess newborn weight loss because it coincides with the time window in which weight

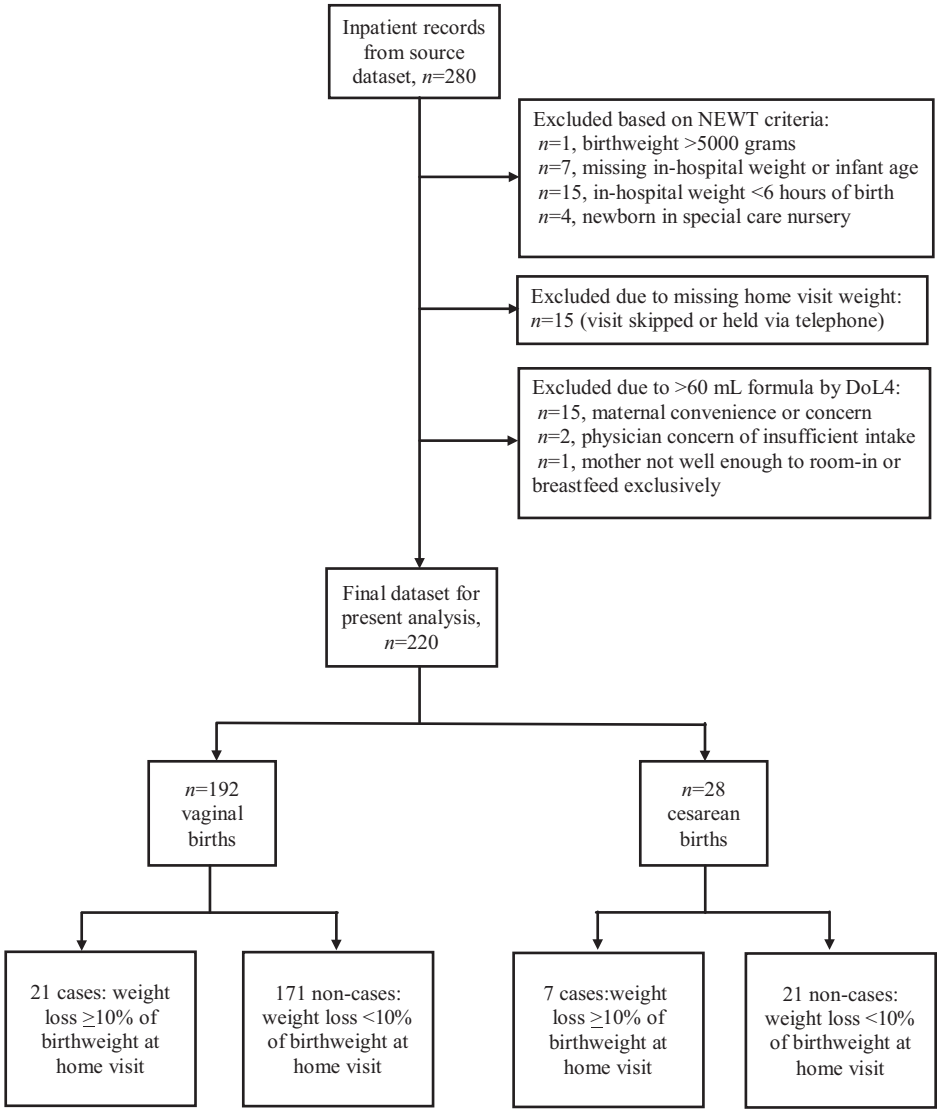

FIG. 1. Flow diagram of record inclusion from the source dataset.

rebound is expected to occur,[14] and often coincides with the first full day or so at home for the breastfeeding dyad. If an infant is on a trajectory for EWL that continues through day 4 without weight rebound, it is often necessary to provide appropriate support to prevent negative sequelae.[15]

Because there are separate NEWT nomograms for vaginal and cesarean deliveries, we constructed a combined contingency table, and tables separated by delivery mode. For each table, we calculated the sensitivity of the NEWT in identifying EWL cases (i.e., percent of true EWL cases that were also NEWT test positive), the specificity of the NEWT in identifying noncases (i.e., percent of non-EWL cases that were also NEWT test negative), NEWT-positive predictive value (percent of true positives out of all NEWT test positives), and NEWT-negative predictive value (percent of true negatives out of all NEWT test negatives). For each estimate, we constructed 95% confidence intervals.[27]

Results

Of the 280 records in the original RFS dataset, 27 (9.6%) were excluded based on NEWT criteria, 15 (5.4%) were excluded due to missing home visit weight data (visit did not occur or was conducted over the telephone), and 18 (8.1%) were excluded due to infant intake of more than 60 mL of formula between birth and the home visit. This resulted in 220 records meeting criteria for inclusion in the final analytic dataset: 192 (87%) records with vaginal births, and 28 (13%) records with cesarean births (Fig. 1).

Overall, mean (standard deviation [SD]) age of the newborn at the in-hospital weight measurement was 17 (8) hours of life, and based on this weight measurement 40 newborns (18%) were categorized as NEWT test positive. Characteristics of the sample, stratified by NEWT test status, are summarized in Table 1. Birth hospitalization variables that were significantly associated with NEWT test status were birth weight category ($p = 0.03$) and infant hour of life at the time of the in-hospital weight measurement ($p = 0.049$).

Overall, mean (SD) age of the newborn at the DoL4 weight measurement was 84 (7) hours of life, and based on this weight measurement 28 newborns (12%) were true EWL cases. Table 2 reports sensitivity, specificity, positive predictive value, and negative predictive value for the overall analytic dataset and stratified by delivery mode. Overall, NEWT test-positive status correctly identified 6 of the 28 true EWL cases; and of 40 test-positive records, 6 were true EWL cases. Conversely, NEWT test-negative status correctly identified 158 of 192 noncases; and of 180 test-negative records, 158 were true negatives for EWL. When stratified by delivery mode, NEWT correctly identified 3 of the 21 vaginal birth cases; and of 33 vaginal birth test-positive records, 3 were true EWL cases. Conversely, NEWT correctly identified 141 of 171 vaginal birth noncases; and of 159 test-negative vaginal birth records, 141 were true negatives for EWL. Among cesarean-delivered infants, NEWT correctly identified three of the seven cases; and of seven test-positive cesarean records, three were true EWL cases. Conversely, NEWT correctly identified 17 of 21 cesarean noncases; and of 21 test-negative cesarean records, 17 were true negatives for EWL.

NEWT test-positive status was significantly associated with the following home visit outcomes: greater percentage newborn weight loss ($p = 0.01$), greater absolute newborn weight loss ($p = 0.028$), maternal perception of less breastfeeding support ($p = 0.03$), and less frequent infant cueing of feeding interest ($p = 0.03$) (Table 1).

Discussion

Our primary objective was to evaluate the NEWT sensitivity and specificity in early identification of exclusively breastfed newborns who will lose ≥10% of birth weight once discharged to home. To our knowledge, there is no existing literature that externally validates in-hospital newborn NEWT status in its ability to predict outpatient EWL occurrence. The NEWT was developed entirely with newborn weight data recorded during the birth hospitalization. Based on secondary analysis of the RFS dataset, newborns designated as NEWT test positive did have significantly higher average weight loss at DoL4 (−6.9% versus −5.1%, *t* test *p*-value = 0.01). However, this trend was not apparent when we dichotomized by EWL versus no EWL (Chi-square *p*-value = 0.63), as NEWT test-positive status only identified 6 of the 28 newborns who experienced EWL, resulting in 21% sensitivity. This suggests that a single NEWT result obtained at around the first day of life may not be sensitive enough for clinical usefulness in identifying exclusively breastfed infants at risk for EWL once discharged to home.

The study that is most comparable to our analysis examined first-day weight loss as a predictor of in-hospital EWL.[25] It is notable that this study, which was conducted entirely with data obtained during the birth hospitalization, reported 40% sensitivity of first-day weight loss >4.5% in predicting in-hospital weight loss ≥10%, and they reported 80% specificity. Thus, similar to our analysis, the results are not strong enough to support first-day weight loss being a clinically useful predictor of EWL.

Eighteen records were excluded from our dataset solely because the infant received >60 mL of formula supplement. If the reason for formula use was concern for inadequate infant intake, it could be argued that several of these excluded infants may have become cases if they were not given formula, and thus by excluding them we are diluting the sensitivity of NEWT in predicting EWL. To explore this counterfactual condition, we conducted post hoc analysis. Of the 18 records in question, 3 were NEWT test positive and 15 were NEWT test negative. If we were to assume all 3 test positives, would have developed into cases if it were not for formula use, overall NEWT sensitivity would only increase to 29% (16–42%); and assuming all 15 test negatives would not have become cases even if formula were not used, specificity would only increase to 84% (77–91%). Therefore, exclusion of these records is unlikely to explain the poor prognostic performance of NEWT when applied at around the first day of life. Incidentally, none of these three test-positive records overlapped with the two excluded records, for which the reason for formula use was explicitly stated as due to physician concern for dehydration or inadequate intake (Fig. 1).

As described in the Materials and Methods section, our main analysis included infants who received token amounts of formula supplement (≤60 mL total). As shown in Table 1, there was no difference in the distribution of newborns who received no formula or token amounts of formula when comparing NEWT test-positive versus test-negative records

Table 1. Maternal and Infant Characteristics Stratified by Early Newborn Weight Loss Tool Status

	NEWT test negative,[a] n = *180, mean (SD) or* N *(%)*	*NEWT test positive,*[b] n = *40, mean (SD) or* N *(%)*	p[c]
Maternal and infant characteristics			
Parity			
Primiparous	98 (54%)	23 (58%)	0.73
Multiparous	82 (46%)	17 (42%)	
Maternal age, years	30.8 (4.6)	30.7 (3.4)	0.87
Body mass index,[d] kg/m^2	25.5 (3.8)	25.6 (3.5)	0.81
Race/ethnicity[e]			
Asian	15 (89%)	2 (5%)	0.19
Black, non-Hispanic	5 (3%)	0 (0%)	
Hispanic	20 (11%)	1 (3%)	
White, non-Hispanic	137 (77%)	35 (92%)	
Maternal education[e]			
No college degree	28 (16%)	6 (16%)	0.99
College degree	149 (84%)	32 (84%)	
Infant sex			
Female	89 (49%)	19 (48%)	0.82
Male	91 (51%)	21 (52%)	
Birth weight (split at median)			
≤3,600 g	79 (44%)	25 (63%)	0.033
>3,600 g	101 (56%)	15 (37%)	
Gestational age, weeks[f]	40.1 (1.2)	39.8 (1.1)	0.10
Delivery mode			
Vaginal	159 (88%)	33 (83%)	0.32
Cesarean	21 (12%)	7 (17%)	
Variables assessed at the birth hospitalization visit			
Infant age at NEWT-assessed weight measurement, hours	17.1 (8.2)	14.8 (6.0)	0.049
Maternal confidence in exclusively breastfeeding for at least 4 weeks			
Less than ''very confident''	44 (24%)	8 (20%)	0.55
Very confident	136 (76%)	32 (80%)	
Infant breastfed in first hour of life			
No	46 (26%)	15 (37%)	0.13
Yes	134 (74%)	25 (63%)	
Maternal perception of infant breastfeeding interest since birth			
Often	117 (65%)	25 (63%)	0.96
Sometimes	59 (33%)	14 (35%)	
Not at all	4 (2%)	1 (2%)	
No. of breastfeeding episodes since birth, adjusted to 24 hours[g]	5.8 (3.3)	4.9 (2.9)	0.10
Infant breastfeeding assessment score[h]	8.7 (3.9)	8.0 (4.3)	0.36
Variables assessed during the home visit			
Infant age at home visit, hours	84.0 (7.5)	82.4 (6.6)	0.20
Current maternal perception of breastfeeding support			
A lot	173 (96)	35 (88)	0.03
None/some	7 (4)	5 (12)	
Maternal perception of infant breastfeeding interest, past 24 hours			
Often	160 (89%)	31 (78%)	0.03
Sometimes	20 (11%)	8 (20%)	
Not at all	0 (0%)	1 (2%)	
Breastfeeding frequency, past 24 hours	10.4 (3.2)	10.5 (3.2)	0.89
Infant breastfeeding assessment score[h]	11.1 (1.6)	10.6 (2.2)	0.15
Delayed lactogenesis[i]			
No	146 (81%)	30 (75%)	0.38
Yes	34 (19%)	10 (25%)	
Formula provided since birth			
None	160 (88%)	36 (90%)	0.98
>0–1 Ounce	10 (6%)	2 (5%)	
1–2 Ounce	10 (6%)	2 (5%)	
Percent weight change between birth and home visit, %	−5.1 (3.9)	−6.9 (3.5)	0.01
Absolute weight change between birth and home visit, g	−189 (147)	−245 (127)	0.03

(*continued*)

TABLE 1. (CONTINUED)

	NEWT test negative,[a] n = *180, mean (SD) or* N *(%)*	*NEWT test positive,*[b] n = *40, mean (SD) or* N *(%)*	p[c]
Weight loss ≥10%			
No	158 (88%)	34 (85%)	0.63
Yes	22 (12%)	6 (15%)	

[a]NEWT Test Negative: For vaginally delivered infants, newborn weight data point <90th percentile on the NEWT nomogram; For cesarean-delivered infants, newborn weight data point <75th percentile on the NEWT nomogram; Test negative represents infants not at risk for eventual excess weight loss.
[b]NEWT Test-Positive: newborn weight data point ≥cutoffs described above; Test positive represents infants at risk for eventual excess weight loss.
[c]Statistical significance in comparing NEWT test positive and NEWT test negative groups based on Student's *t* test for continuous variables and Chi-square for categorical variables.
[d]Missing, $n = 21$.
[e]Missing, $n = 5$.
[f]Missing, $n = 1$.
[g]Missing, $n = 2$.
[h]IBFAT, score ranges from 0 to 12.
[i]Maternal perception of the onset of noticeable breast fullness beyond 72 hours postpartum.
IBFAT, Infant Breastfeeding Assessment Tool; NEWT, Newborn Weight Loss Tool; SD, standard deviation.

($p = 0.98$). Also, in post hoc analysis where we excluded token formula use, there was not an appreciable difference in the results (except that with a smaller sample size, the confidence intervals were wider, data not shown).

NEWT test-positive status was significantly associated with two birth hospitalization variables. Infants whose birth weight was below the cohort's median (3,600 g) were more likely to be classified as NEWT test positive. Also, the average age of newborns at the time of the birth/hospitalization weight measurement was significantly lower for newborns classified as test positive. These associations suggest that there may be misclassification bias in the NEWT result based on the context of the weight measurement.

Despite low sensitivity in predicting EWL, NEWT test-positive status was significantly associated with indicators of breastfeeding difficulties as assessed at the DoL4 home visit.

TABLE 2. CONTINGENCY TABLE FOR PREDICTING EXCESS WEIGHT LOSS AMONG ALL NEWBORNS, AND STRATIFIED BY MODE OF DELIVERY

	All newborns[a]			*Vaginally delivered newborns*[b]			*Cesarean delivered newborns*[c]		
	Cases, weight loss ≥10% of birth weight	*Noncases, weight loss <10% of birth weight*	*Total*	*Cases, weight loss ≥10% of birth weight*	*Noncases, weight loss <10% of birth weight*	*Total*	*Cases, weight loss ≥10% of birth weight*	*Noncases, weight loss <10% of birth weight*	*Total*
Test outcome									
NEWT test-positive[d]	6	34	40	3	30	33	3	4	7
NEWT test-negative[e]	22	158	180	18	141	159	4	17	21
Total	28	192	220	21	171	192	7	21	28
Prediction									
Se[f]	21% (16–27%)			14% (9–19%)			43% (25–61%)		
Sp[g]	82% (77–87%)			82% (77–88%)			81% (66–95%)		
PPV[h]	15% (10–20%)			9% (5–13%)			43% (25–61%)		
NPV[i]	88% (83–92%)			89% (84–93%)			81% (66–95%)		

[a]Chi-square p-value = 0.63.
[b]Chi-square p-value = 0.71.
[c]Chi-square p-value = 0.21.
[d]NEWT Test Negative: For vaginal delivery, newborn weight data point <90th percentile on the NEWT nomogram; For cesarean delivery, newborn weight data point <75th percentile on the NEWT nomogram; Test negative represents infants not at risk for eventual excess weight loss.
[e]NEWT Test Positive: For vaginal delivery, newborn weight data point ≥90th percentile on the NEWT nomogram; For cesarean delivery, newborn weight data point ≥75th percentile on the NEWT nomogram; Test positive represents infants at risk for eventual excess weight loss.
[f]Se: cases that are NEWT test positive/all cases of weight loss ≥10% of birth weight; percentage (95% confidence interval).
[g]Sp: noncases that are NEWT test negative /all noncases; percentage (95% confidence interval).
[h]PPV: cases that are NEWT test positive/all NEWT test positives; percentage (95% confidence interval).
[i]NPV: noncases that are NEWT test negative/all NEWT test negatives; percentage (95% confidence interval).
NPV, negative predictive value; PPV, positive predictive value; Se, sensitivity; Sp, specificity.

Specifically, NEWT test-positive status was predictive of maternal perception of less breastfeeding support and of the infant less often showing interest in breastfeeding in the past 24 hours. This result is consistent with Flaherman et al., who reported that percent weight loss at discharge was significantly associated with cessation of exclusive breastfeeding within the first month.[17] Taken together, these results suggest that there may be an underlying link between an early at-risk weight loss trajectory and subsequent challenges with successfully establishing exclusive breastfeeding once at home. Nonetheless, the association does not appear to be sufficiently strong enough to be clinically useful in predicting mother–infant dyads who are at high risk of breastfeeding difficulties.

A limitation of our analysis is that we based NEWT status on only one in-hospital infant weight, recorded at an average of 17 hours of life, which is likely generalizable to circumstances where infants are discharged early. It is possible that an additional in-hospital weight during the second day of life may be more sensitive to detecting true EWL. Further research is warranted using later or multiple in-hospital weights. Another potential limitation is that our source dataset comprises infants born to residents of Davis, California, where best practices for breastfeeding management and exclusive breastfeeding rates are relatively high compared with other regions of the United States.[28] Also, the Davis cohort is predominantly white and college educated. Further research is warranted in more diverse settings. Finally, we defined ''test-positive'' based on the NEWT weight loss percentile trajectories that intersected with weight loss of >10% of birth weight, but this definition may not optimize the prognostic ability of NEWT.

The major strength of our design is examining NEWT sensitivity and specificity using an external source of infant weight data obtained in the home at about the time of the expected weight nadir. Newborns who are still in the hospital at DoL4 may be inherently different in their weight loss trajectory as compared with newborns who are at home. Another strength of our study is reduction of misclassification bias as researchers were masked to true EWL status at the time of determining the NEWT-generated percentiles.

Conclusion

In conclusion, the NEWT, when applied at around the first day of life, demonstrated poor sensitivity in identifying eventual EWL in exclusively breastfed infants. This finding is most applicable to circumstances where infants are discharged early, because there is typically only one additional weight taken after the initial birth weight in these situations. When multiple weights are available, the NEWT may be useful for contextualizing the weight loss trajectory relative to in-hospital weights for other term newborns. For instance, a steep crossing of percentiles could represent emerging breastfeeding difficulties amenable to intervention before hospital discharge. Alternatively, the NEWT might provide reassurance to families who are distressed to hear that their newborn is losing weight if they see that their newborn's weight loss trajectory is following the expected pattern. However, it is important to recognize that the NEWT is merely a single tool that is not intended to be used in isolation of other indicators of healthy progress, such as stool output and adequacy of latch. It is also important to recognize that the NEWT does not account for maternal contribution to excess newborn weight loss through delayed and/or failed lactogenesis, which often does not manifest until the dyad is at home.

To illustrate the above point, our pediatric coauthor (L.P.W.) offers a cautionary tale of a recently encountered case in which a full-term, appropriate-for-gestational-age infant was readmitted on DoL5 after presenting to the emergency department with respiratory distress, poor feeding, decreased output, and weight loss of 25%. The newborn had a profound metabolic acidosis and hypernatremia from severe dehydration. In reviewing the birth hospitalization course, there were no concerns noted by the caregivers of this exclusively breastfed infant leading up to discharge at 60 hours of life. In a retrospective review of this case, the newborn's in-hospital weight loss had an appropriate NEWT trajectory ($\sim$50th percentile). However, there were several maternal risk factors for delayed lactogenesis and/or insufficient milk production, including gestational diabetes, morbid obesity, primiparity, and delivery by cesarean after failed induction. Although the potential for excessive weight loss could have been anticipated based on the maternal risk factors, most pediatricians are trained to focus on the baby when evaluating readiness for discharge, and the NEWT was deceivingly reassuring in this case.

The above case also highlights the critical gap in clinical algorithms for identifying mothers at risk for insufficient milk production, as their infants comprise the large majority of newborns who will experience EWL.[12] Even though the mother in the above case exhibited several risk factors that have been identified in epidemiologic studies, no clinically validated tools are currently available to evaluate postdischarge breastfeeding failure risk based on the specific risk profile of each mother–newborn dyad. Given the current maternal obesity epidemic in many regions of the United States and elsewhere, there is an urgent need for further research across diverse settings to improve identification of mother–infant dyads who should be prioritized for close follow-up postdischarge.

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