Systematic evaluation of machine learning classification models to predict growth failure in preterm infants

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Background

- Growth failure (GF) among preterm infants is associated with clinical disorders and has been shown to adversely affect neurodevelopmental outcomes.
- Machine Learning (ML) methods can be used to integrate and analyze clinical observations, over time, in order to predict the likelihood of GF for preterm infants.
- Goal: Identify those infants that are most at risk for GF and identify changes in the treatment and interventions that could potentially improve the outcome for those at risk.

Objective

- We hypothesized that we could identify infants at risk for GF in the first few weeks of life based on their clinical and feeding data.
- We are interested in deploying and testing ML methods that can both, predict such outcome early on and identify nutritional interventions that could lead to better outcomes.
- Our classification ML models aim to predict GF at discharge, defined as a birth-to-discharge z-score decline of ≥1.2
- We trained three models that differ in the duration of the data they use in order to determine tradeoffs between accuracy and time of predictions: 1) *Birth*, 2) *Two weeks*, and 3) *One month*.

Clinical Data and Classifiers

Figure 1: Overview of Methods

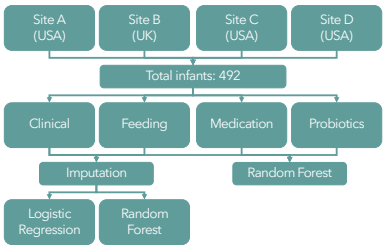


Table 1: Summary of Data Sets

Dataset	# of Infants	
	GF	GN
Training (Sites A,B,C)	91	195
Test (Sites A,B,C)	20	51
Validation (Site D)	81	54

Table 2: List of Features

Feature Name	Weekly?	A	B	C	D
Gestational age		✓	✓	✓	✓
Birth z-score		✓	✓	✓	✓
Gender		✓	✓	✓	✓
Mode of delivery		✓	✓	✓	✓
Multiple gestation?		✓	✓	✓	✓
Maternal age		✓	✓	✓	✓
Post-menstrual age (PMA)	✓	✓	✓	✓	✓
Body weight	✓	✓	✓	✓	✓
Received any medication?	✓	✓	✓	✓	
Quantity of *Ampicillin/Gentamicin*	✓	✓	✓	✓	
Quantity of other antibiotics	✓	✓	✓	✓	
# of days received breastmilk	✓	✓	✓	✓	✓
Quantity of breastmilk	✓	✓	✓	✓	✓
# of days received donated milk	✓	✓	✓	✓	✓
Quantity of donated milk	✓	✓	✓	✓	✓
# of days received formula	✓	✓	✓	✓	✓
Quantity of formula	✓	✓	✓	✓	✓
Received any probiotics?	✓		✓		
Quantity of *Infloran*	✓		✓		
Quantity of *LB2*	✓		✓		

Results

Table 3: Summary of Best Model Performance Across Data Sets

Dataset	Performance Metrics								
	Sensitivity			Accuracy			AUC-ROC		
	Birth	*Two weeks*	*One month*	*Birth*	*Two weeks*	*One month*	*Birth*	*Two weeks*	*One month*
Training	0.68	0.72	0.71	0.61	0.66	0.62	0.64	0.72	0.68
Test	**0.70**	**0.80**	**0.80**	**0.70**	**0.66**	**0.68**	**0.75**	**0.72**	**0.76**
Validation	0.59	0.46	0.76	0.62	0.58	0.66	0.71	0.68	0.70

Table 4: Top 5 Features based on Pearson Correlation Analysis (GF as Positive Label & GN as Negative Label)

Feature Name	Correlation Coefficient (p-value)
# of days received donated milk (week 1)	-0.31 (8.3E-08)
# of days received breastmilk (week 1)	0.25 (2.1E-05)
Quantity of donated milk (week 1)	-0.21 (2.8E-04)
Body weight (Day 29)	-0.16 (6.6E-03)
Birth z-score	0.16 (7.7E-03)

Figure 2: Top 5 Selected Features Across Each Period

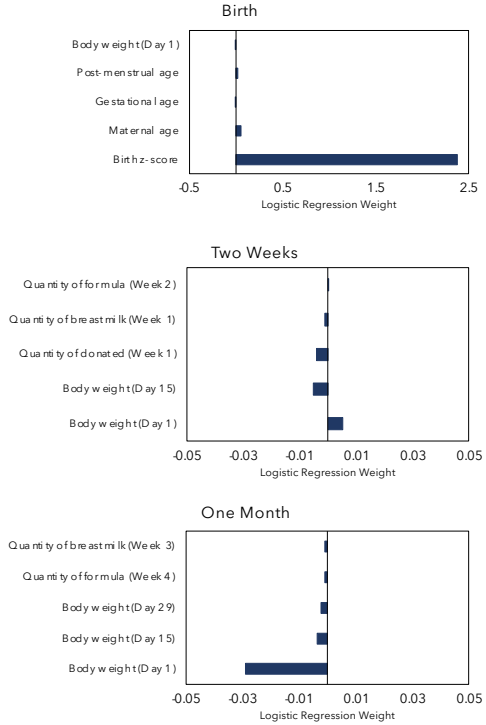
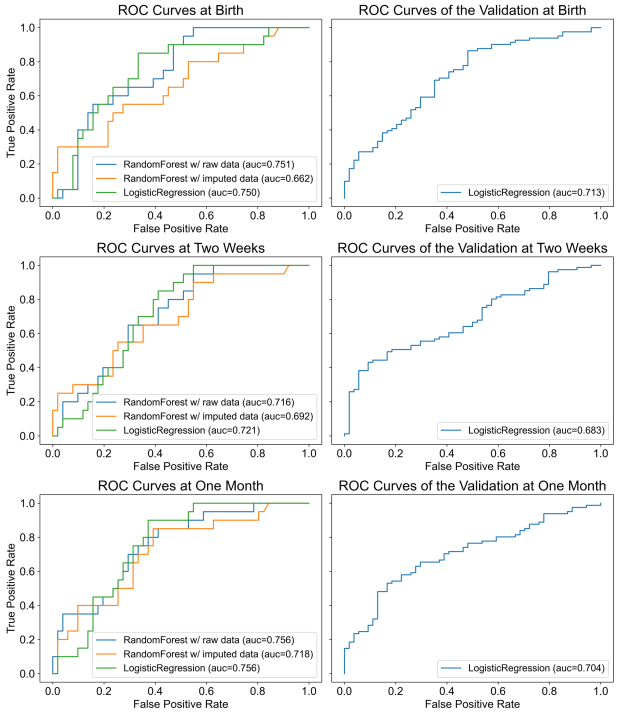


Figure 3: ROC Curves for Test Set and Validation Across Each Period



Conclusions

- We performed a systematic evaluation of ML classifiers to predict GF in preterm infants within the first month of life; Logistic Regression (LR) with imputation performs best and a subset of the features provides adequate accuracy.
- Features related to infant body weight and diet significantly affected the likelihood of GF at discharge.
- To determine generalizability to other preterm patient populations and clinical sites, models were validated on an independent cohort, demonstrating applicability to naïve datasets and patients.

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