Helping Very Low Birth Weight Infants thrive using Near Infrared Spectroscopy and Machine Learning

Diogo Barros

PREEMiE
Preterm Feeding Management System

Coimbra, June 2022

tellspec®
Beam your health up

Diogo Barros Gonçalves

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2014 - 18

2016

2016

PREEMIE
Preterm Feeding Management System

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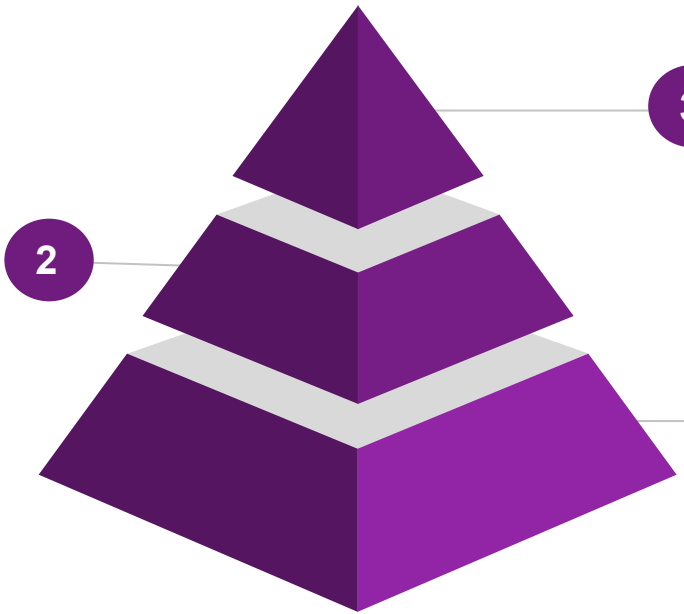
2018 - 2019

Agenda

State of the Art

Medical community approaches to address preterm infants undernourishment and limitations.



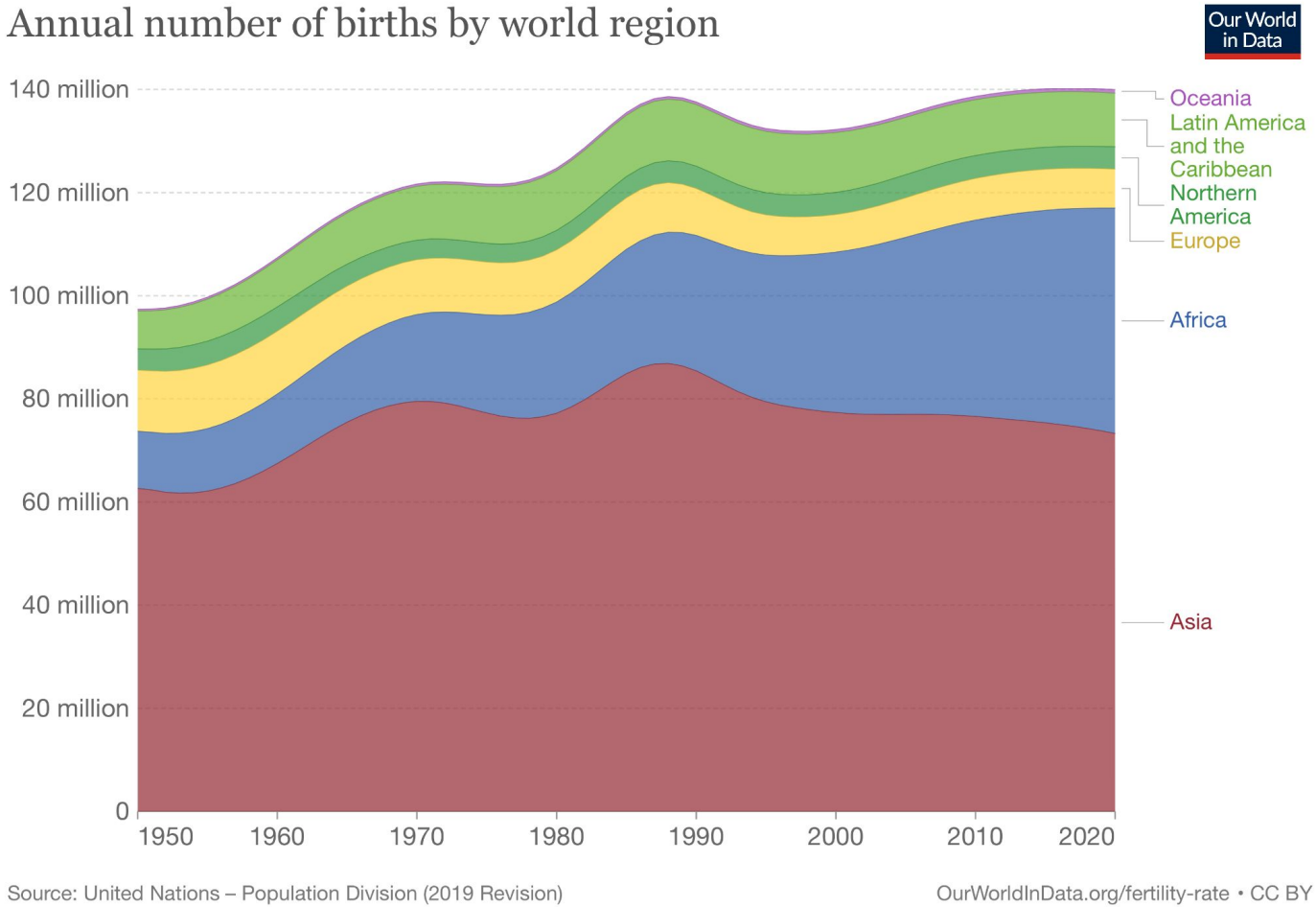
The Preemie System

How NIR Spectroscopy and ML help preterm infants thrive, ML methodology for macronutrient quantification.

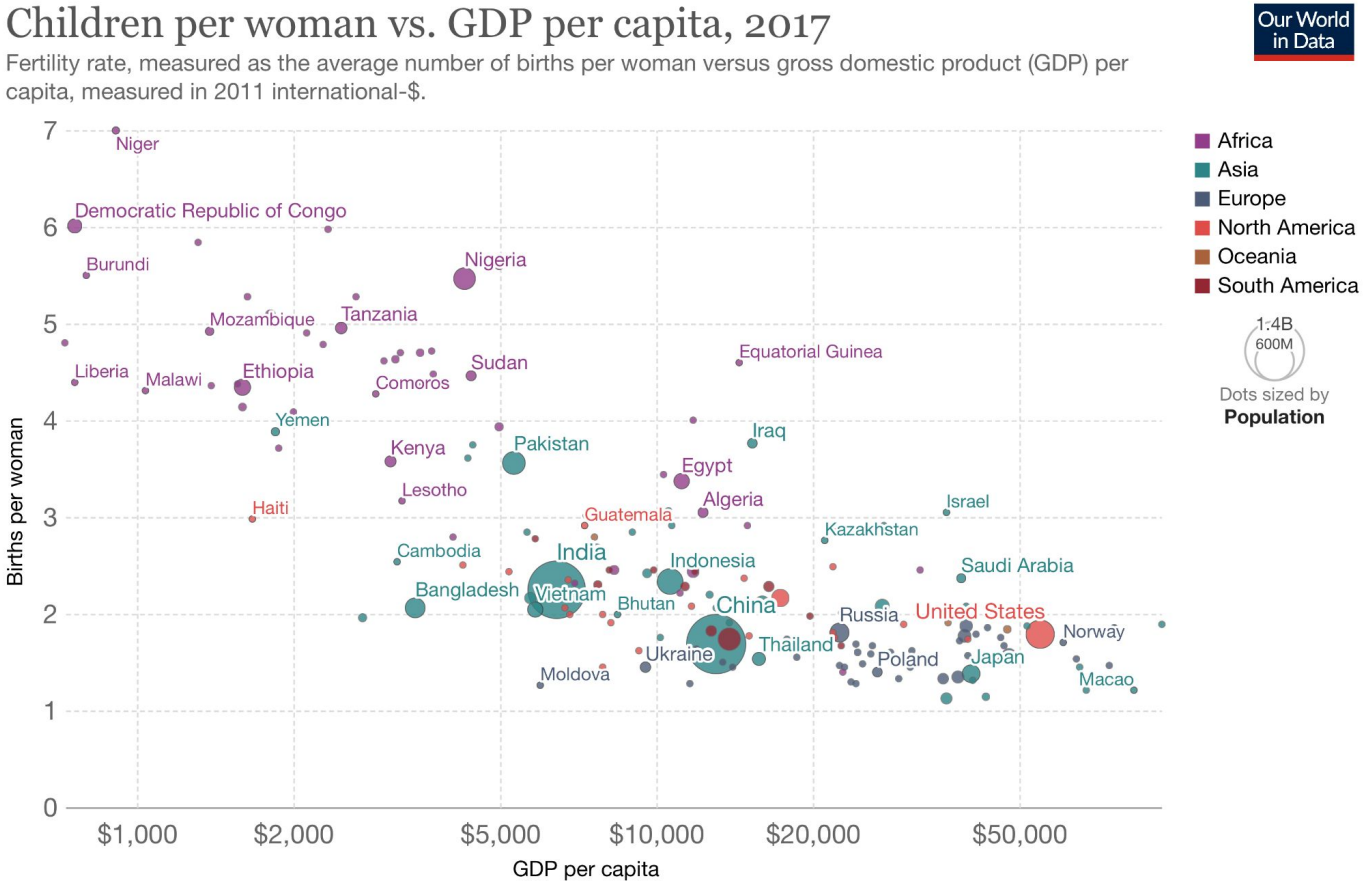
Background

Preterm birth rates worldwide, in the EU and US and its economic cost.

How many infants are born each year?



What's the correlation between #children and GDP per capita?



Source: UN Population Division (Fertility) (2015 revision), Feenstra et al (2015) Penn World Tables 9.1

CC BY

Number of preterm births and preterm birth rates by UN geographical region

Region/subregion[a]	Preterm births		Preterm birth rate	
	No. in 1000s	95% CI[b]	%	95% CI[b]
World total	**12 870**	**12 228–13 511**	**9.6**	**9.1–10.1**
More developed countries	1 014	982–1 046	7.5	7.3–7.8
Less developed countries	7 685	7 109–8 261	8.8	8.1–9.4
Least developed countries	4 171	3 891–4 452	12.5	11.7–13.3
Africa	**4 047**	**3 783–4 311**	**11.9**	**11.1–12.6**
Eastern	1 686	1 481–1 891	14.3	12.5–16.0
Middle	602	535–669	11.6	10.3–12.9
Northern	407	290–523	8.7	6.2–11.2
Southern	228	191–265	17.5	14.6–20.3
Western	1 125	1 036–1 215	10.1	9.3–10.9
Asia	**6 907**	**6 328–7 486**	**9.1**	**8.3–9.8**
Eastern	724	650–798	3.8	3.4–4.1
South-central	4 467	3 944–4 991	11.4	10.0–12.7
South-eastern	1 271	1 062–1 480	11.1	9.3–13.0
Western	396	290–501	7.9	5.8–9.9
Central	49	21–77	3.8	1.6–5.9
Europe	**466**	**434–498**	**6.2**	**5.8–6.7**
LA and the Caribbean	**933**	**858–1 009**	**8.1**	**7.5–8.8**
Caribbean	48	33–63	6.7	4.7–8.8
Central America	295	263–326	9.1	8.2–10.1
South America	591	524–658	7.9	7.0–8.8
North America[d]	**480**	**479–482**	**10.6**	**10.5–10.6**
Oceania				
Australia/New Zealand	20	20–20	6.4	6.3–6.6
Rest of Oceania	16	11–20	6.4	4.6–8.2

Source: S. Becky et al. *Bull World Health Organ* **2010**; 88:31-38

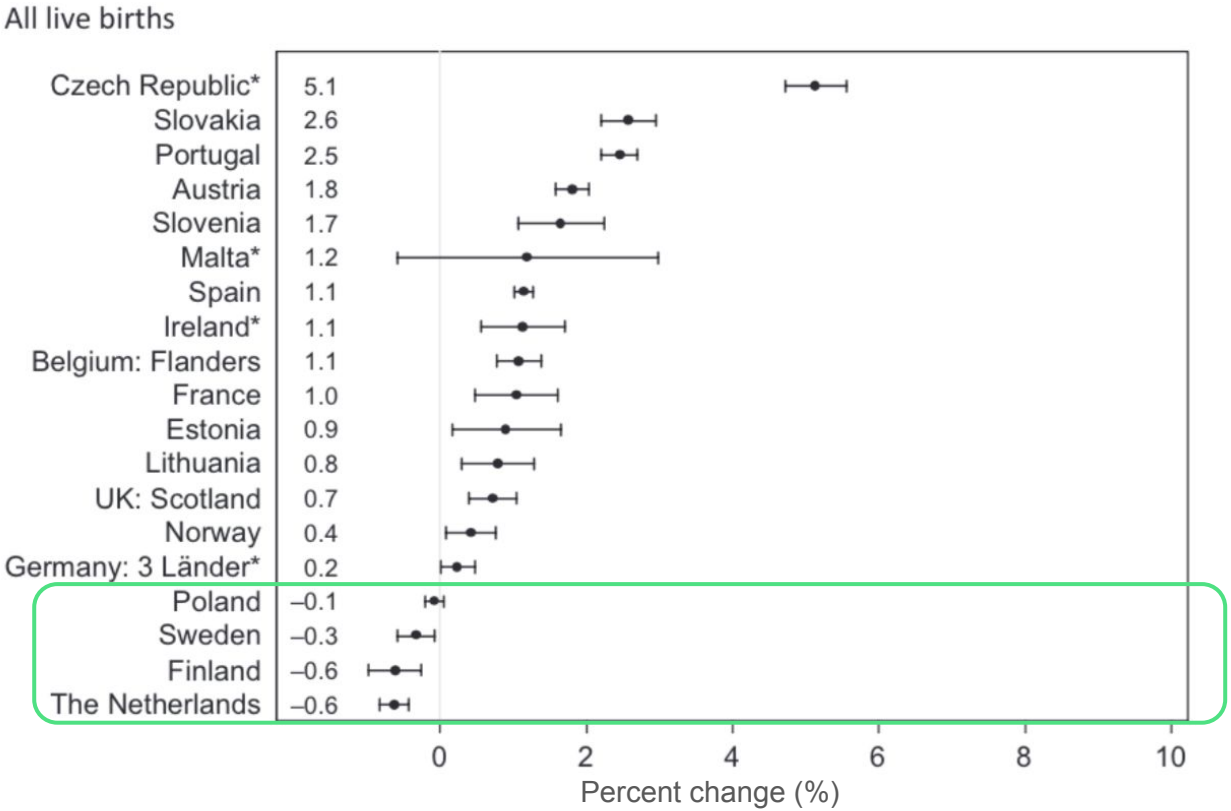
Rates of preterm birth from 1996 to 2008 in 19 European countries

Country: region/ area	All live births					Singleton live births					Multiple live births				
	n (2008)	1996 %	2000 %	2004 %	2008 %	*n* (2008)	1996 %	2000 %	2004 %	2008 %	*n* (2008)	1996 %	2000 %	2004 %	2008 %
Austria	77 720	9.1	10.0	11.4	11.1	75 066	7.9	8.4	9.4	8.7	2654	58.2	67.5	74.6	77.8
Belgium: Flanders	69 187	7.0	7.8	8.1	8.0	66 672	5.2	6.0	6.3	6.2	2515	51.7	55.9	60.4	57.3
Czech Republic	119 455		5.4	7.7	8.3	114 722		4.2	6.0	6.3	4733		42.3	52.7	57.5
Estonia	16 031	5.5	5.9	5.9	6.2	15 506	4.9	5.1	4.9	4.6	525	38.5	46.2	47.6	51.0
Finland	59 486	5.8	6.1	5.6	5.5	57 767	4.5	4.7	4.4	4.3	1719	46.5	49.4	44.5	47.5
France*	14 696	5.4	6.2	6.3	6.6	14 261	4.5	4.7	5.0	5.5	435	40.5	48.2	44.3	42.1
Germany: 3 Länder	215 634		8.8	9.2	9.0	208 383		7.0	7.2	7.0	7251		61.7	61.8	64.2
Ireland	75 246		5.4	5.5	5.9	72 589		4.5	4.4	4.3	2657		41.8	42.3	49.9
Lithuania	31 287	5.3	5.3	5.3	5.9	30 510	4.5	4.6	4.5	4.7	777	41.3	42.6	42.7	49.4
Malta**	4152		6.0	7.2	6.7	4020		5.0	5.8	5.3	132		39.5	51.7	50.0
the Netherlands	175 160	7.8	7.7	7.4	7.4	168 829	6.2	6.0	5.7	5.7	6331	51.1	47.5	48.2	50.6
Norway	60 744	6.4	6.8	7.1	6.7	58 674	5.3	5.4	5.5	5.3	2070	43.4	43.9	49.2	48.3
Poland	414 480	6.8	6.3	6.8	6.6	404 452	6.1	5.5	5.8	5.5	10 028	43.1	44.0	50.2	51.2
Portugal	103 597	7.0	5.9	6.8	9.0	100 705	6.1	4.9	5.4	7.4	2892	45.9	49.6	54.9	63.5
Slovakia	53 624	5.1	5.4	6.3	6.8	52 227	4.4	4.5	5.2	5.6	1397	40.3	46.3	49.8	52.2
Slovenia	21 816	6.0	6.8	7.0	7.4	21 050	4.8	5.1	5.2	5.4	766	54.1	57.4	55.4	62.3
Spain	417 094	7.1	7.7	8.0	8.2	400 474	6.2	6.3	6.4	6.3	16 620	42.2	50.4	53.0	53.9
Sweden**	108 865	6.1	6.4	6.3	5.9	105 799	5.0	5.2	5.2	4.8	3066	44.1	43.4	45.2	43.3
UK: Scotland	58 275	7.0	7.4	7.6	7.7	56 423	5.8	6.1	6.3	6.1	1852	53.1	51.6	55.5	55.0

*Data from France come from a nationally representative sample of births, and the years are 1995, 1998, 2003, and 2010.
**2009, instead of 2008 data.

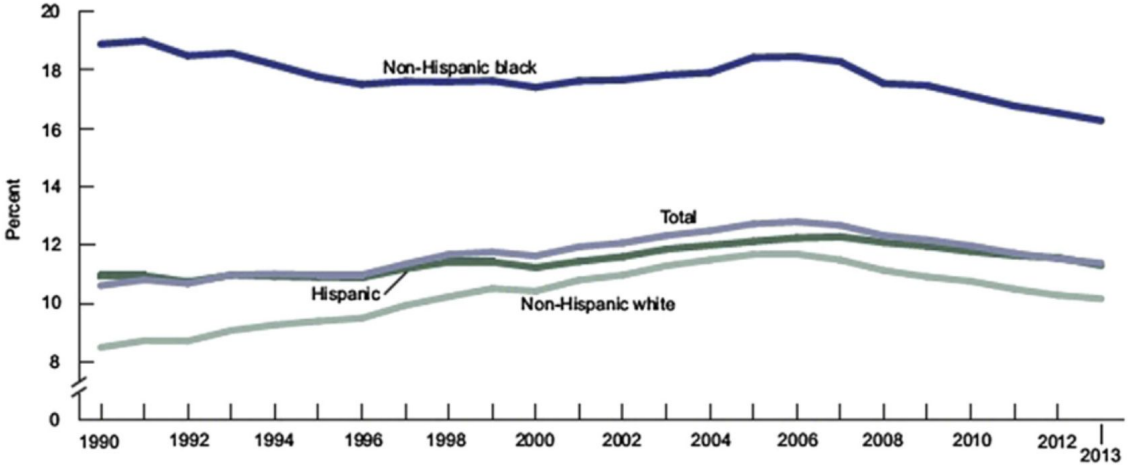
Source: J. Zeitlin et al. *BJOG* **2013**; 120:1356–1365

Average annual percentage change for preterm birth rate by country



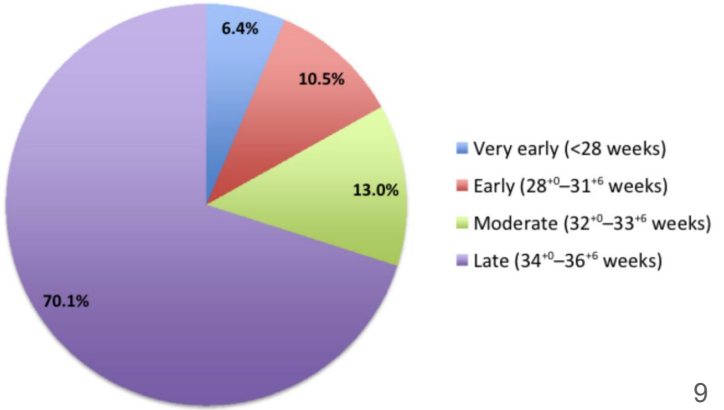
Source: J. Zeitlin et al. *BJOG* **2013**; 120:1356–1365

How does preterm birth rate and distribution look like in the USA?



Preterm birth rates, by maternal race in the USA, 1990-2013

Source: J. A. Martin et al. *National Center for Health Statistics* **2015**; 64:1-65



Distribution of preterm births in the USA in 2013

Source: H.A. Frey et al. *Seminars in Fetal & Neonatal Medicine* **2016**; 21:68-73

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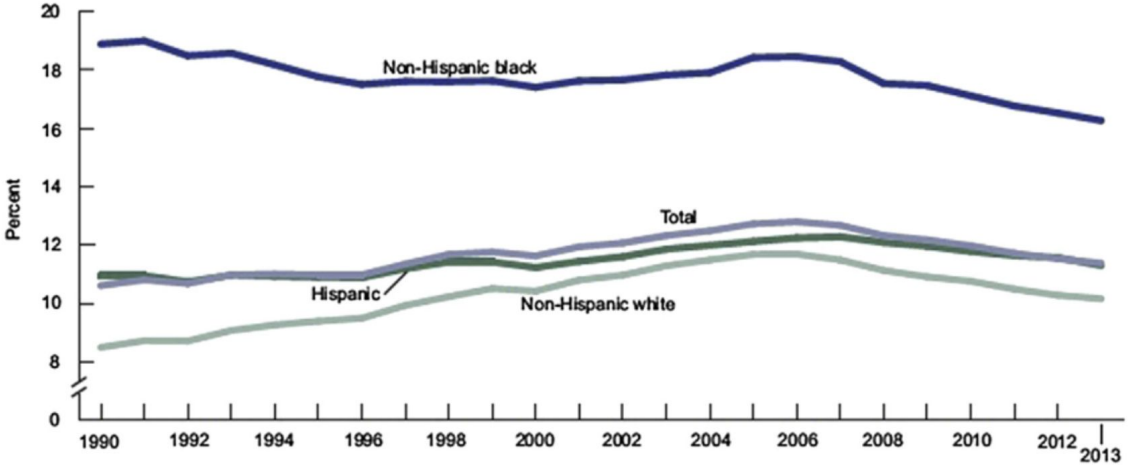

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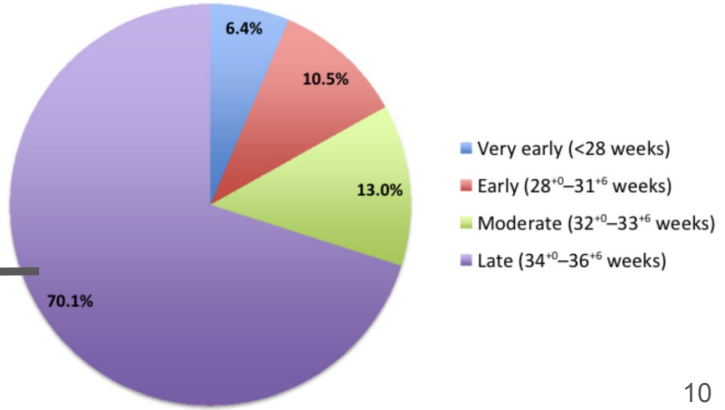

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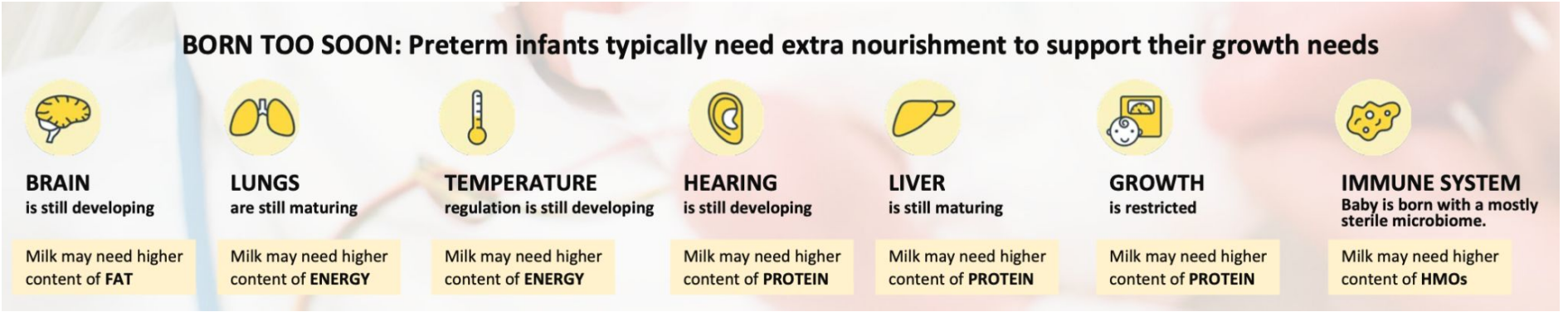
Addressing preemie's extra nourishments needs - Human Milk Fortification



Standard Fortification - "The standard practice [of] **adding a fixed amount of [multicomponent] fortifier** per 100 ml of HM to achieve the recommended nutrient intakes."

Targeted Fortification - "The concept of targeted fortification is to **analyze macronutrient composition of HM** and to fortify it in such a way that **each infant always receives the amount of nutrient that is suggested** in population-based recommendations."

Source: S. Arslanoglu et al. *Front. Pediatr.* **2019**; 7:76

Standard Fortification vs. Targeted Fortification: qualitatively speaking

nutritional quality

milk status

Targeted fortification

Standard fortification

Unfortified milk

Milk fortified with multi-component and modular fortifier(s)

Milk fortified with multi-component fortifier

Initial milk (mom's own milk)

adds to

Modular(s) fortifier *(proteins, lipids, carbs)*

adds to

Multicomponent fortifier (macronutrients, vitamins, co-factors)

chooses

+

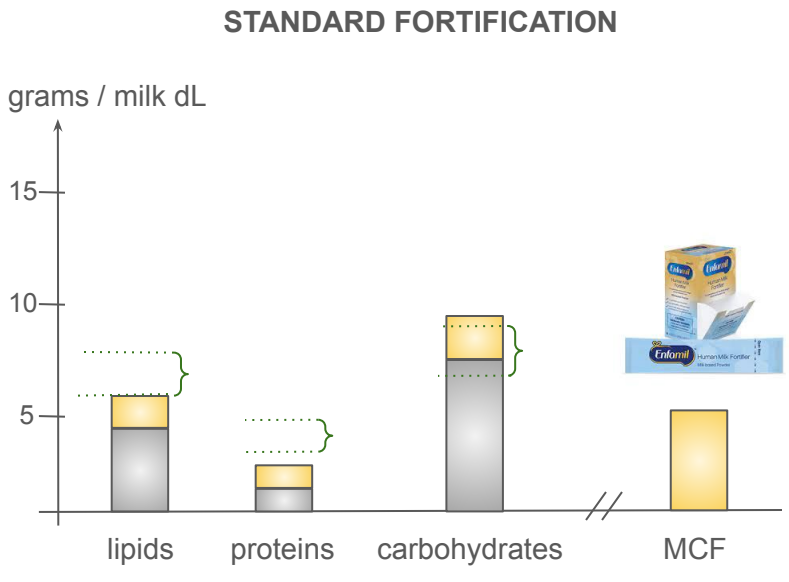
PREEMIE Preterm Feeding Management System

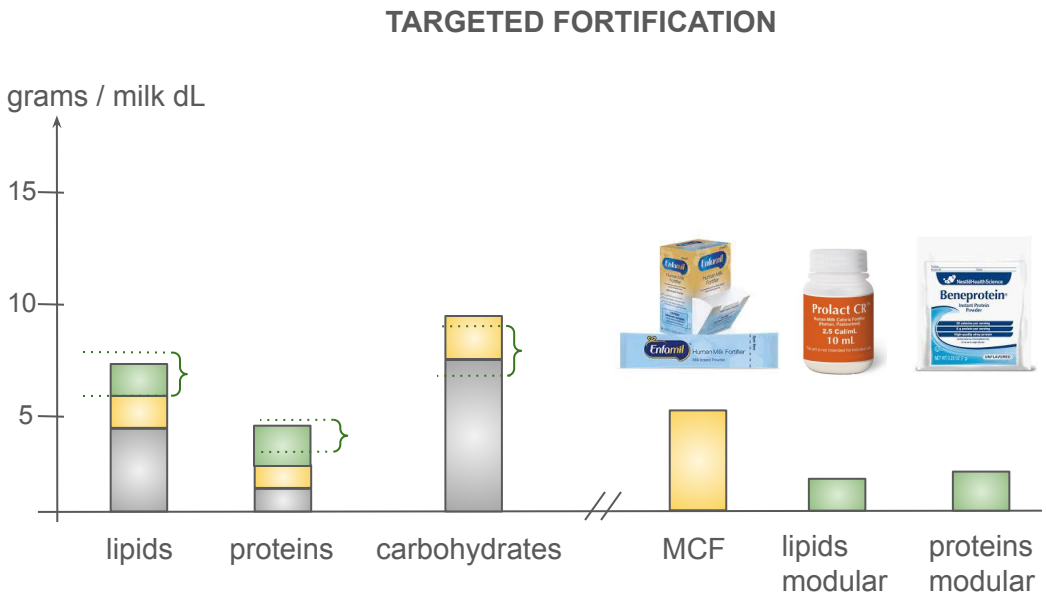
Human milk fortification guidelines

	Munich consensus 2014	ESPGHAN 2010	Ziegler et al.
Energy (kcal/kg/d)	110–130	110–135	105-127
Protein (g/kg/d)	3.5–4.5	4.0–4.5 (<1 kg) 3.5–4.0 (1–1.8 kg)	3.9-4.0
Protein/Energy (g/100 kcal)	3.2–4.1	3.2–4.1	3.1–3.8
Lipids (g/kg/d)	4.8–6.6	4.8–6.6	–
Carbohydrates (g/kg/d)	11.6–13.2	11.6–13.2	–

Source: S. Arslanoglu et al. *Front. Pediatr.* **2019**; 7:76

Standard Fortification vs. Targeted Fortification: quantitatively speaking

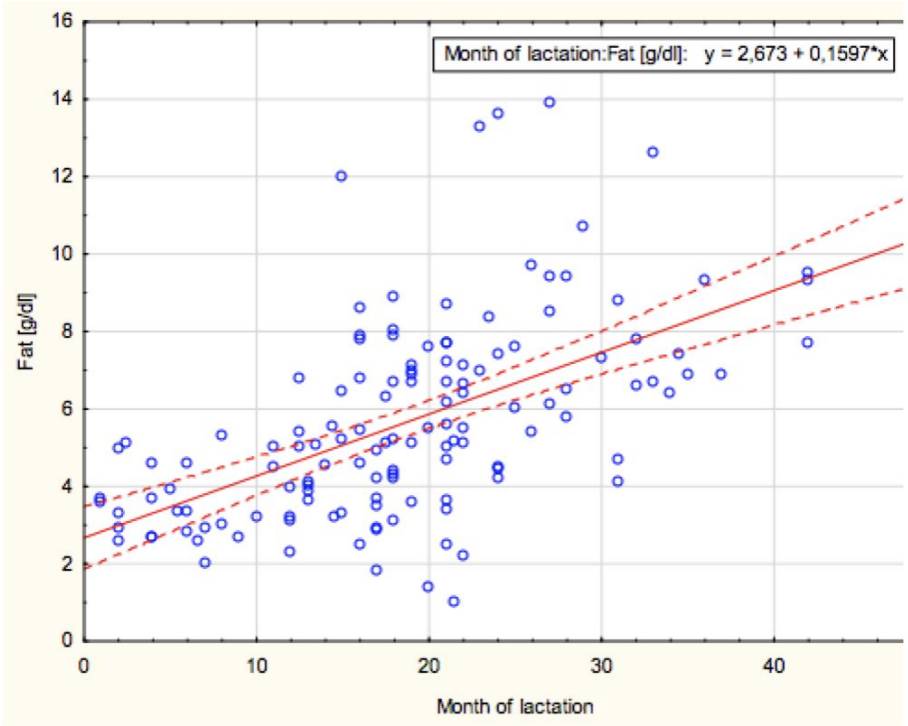




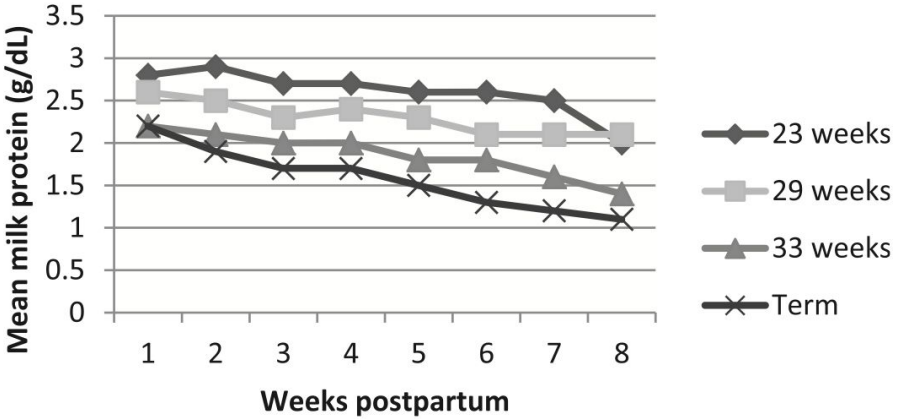
Legend

- Initial milk
- MultiComponent Fortifier (MCF)
- optimal nutrition range according to guideline
- Modular fortifier (lipids, proteins or carbs)

Standard Fortification Limitations: Human milk is a complex, ever-changing food…



Source: M. Czosnykowska-Łukacka et al. *Nutrients* **2018**; 10:1893



Source: O. Ballard et al. *Pediatr Clin N Am* **2013**; 60:49–74

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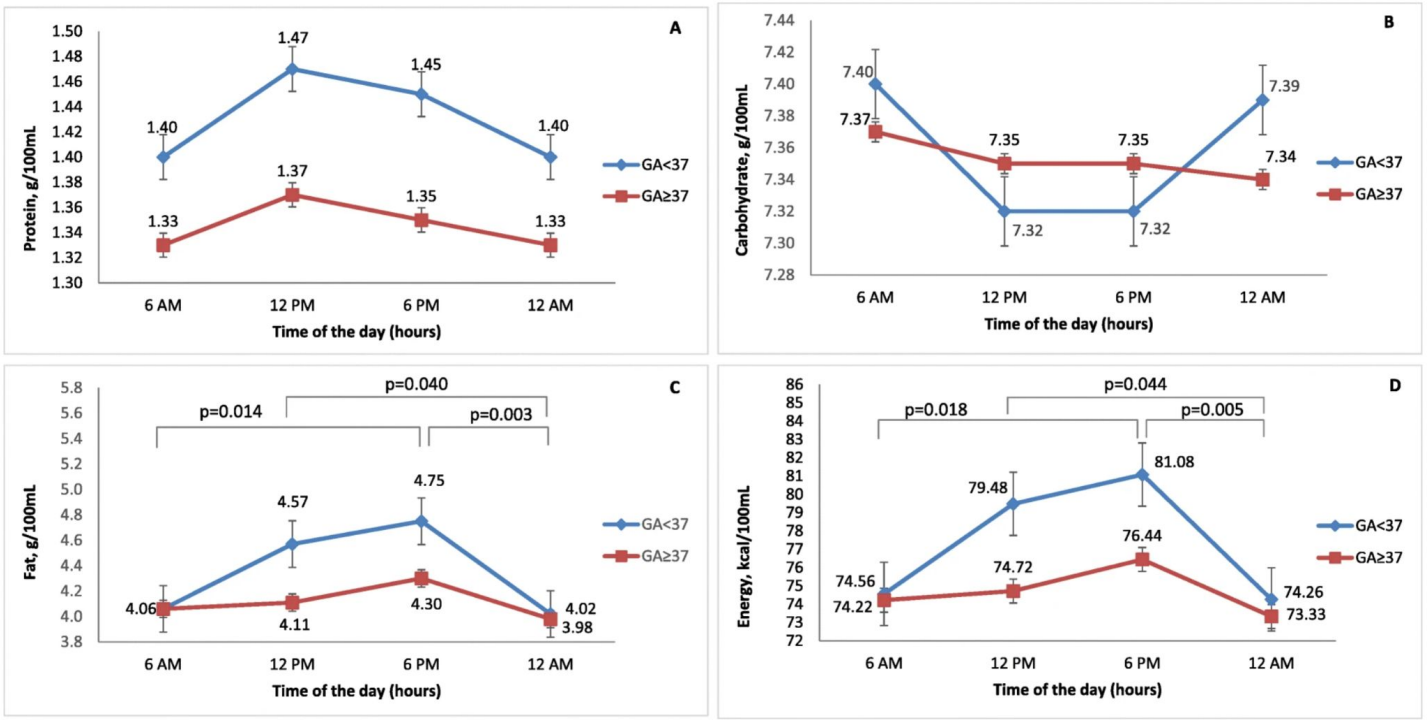
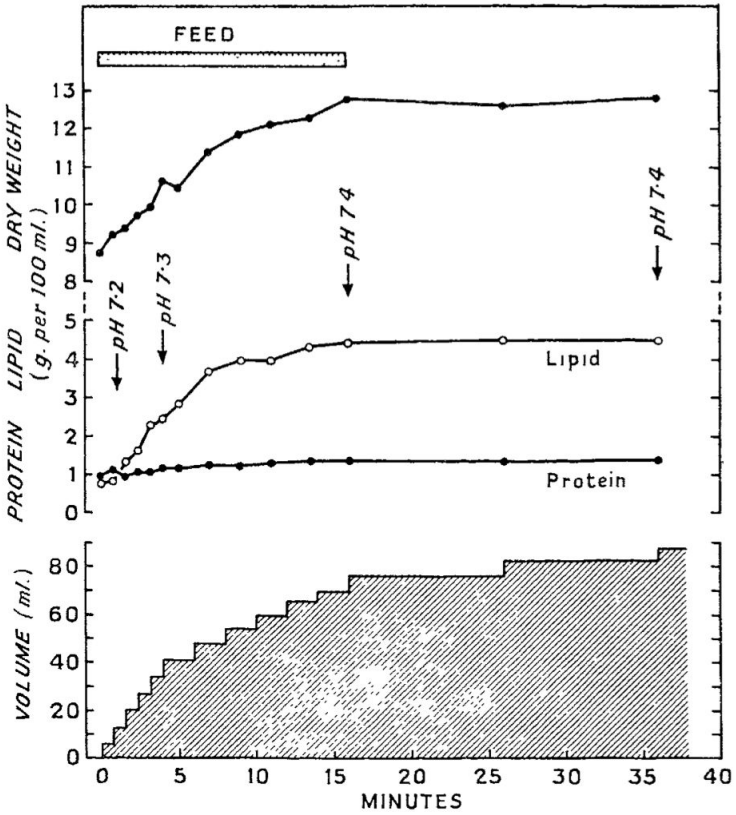


Source: I. Paulaviciene et al. *International Breastfeeding Journal* **2020**; 15:49

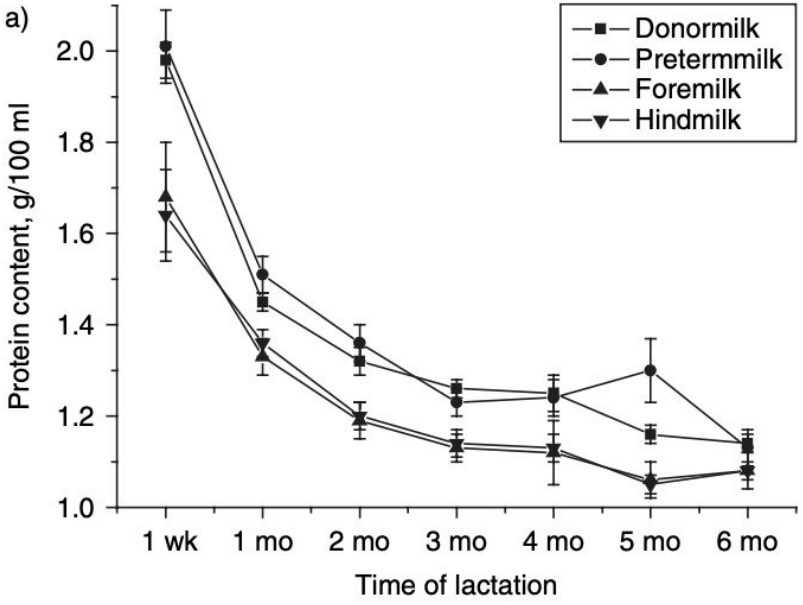
Standard Fortification Limitations: Human milk is a complex, ever-changing food…

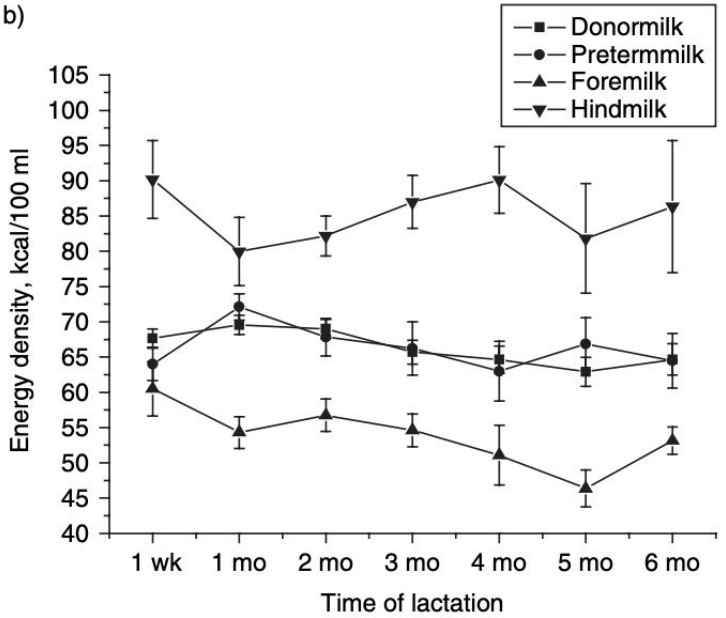


Changes in milk composition during the feed: continuous analysis of milk of one woman.

Source: B. Hall. *The Lancet* **1975**; 305:779-781

Standard Fortification Limitations: Human milk is a complex, ever-changing food…





Source: T. Saarela et al. *Acta Pædiatrica* **2005**; 94: 1176–1181

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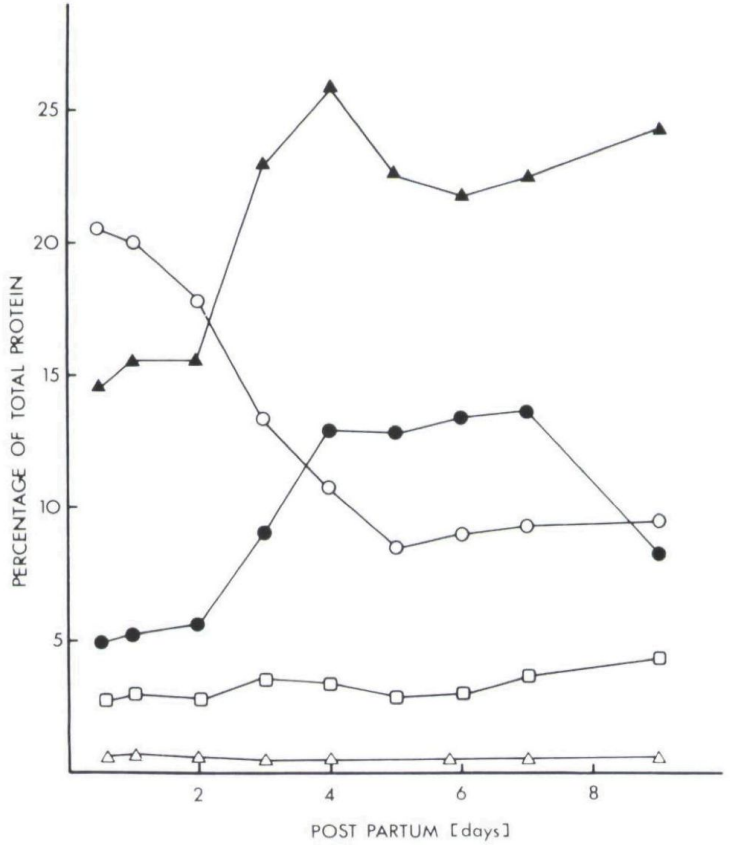
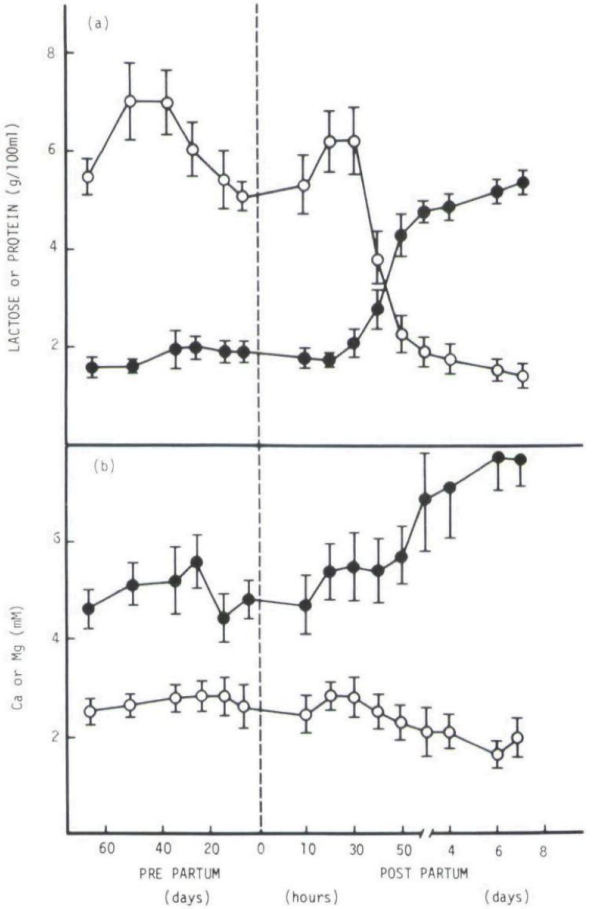


Fig. 5. Changes in lactoferrin, ▲, α-lactalbumin, ●, albumin, □, IgA, ○ and IgG, △, as a percentage of total protein in the mammary secretion during the first 9 days *post-partum* of 4 non-breast feeding women (N1-N4).



Source: J. Kulski et al. *Australian Journal of Experimental Biology and Medical Science* **1981**; 59:101–114

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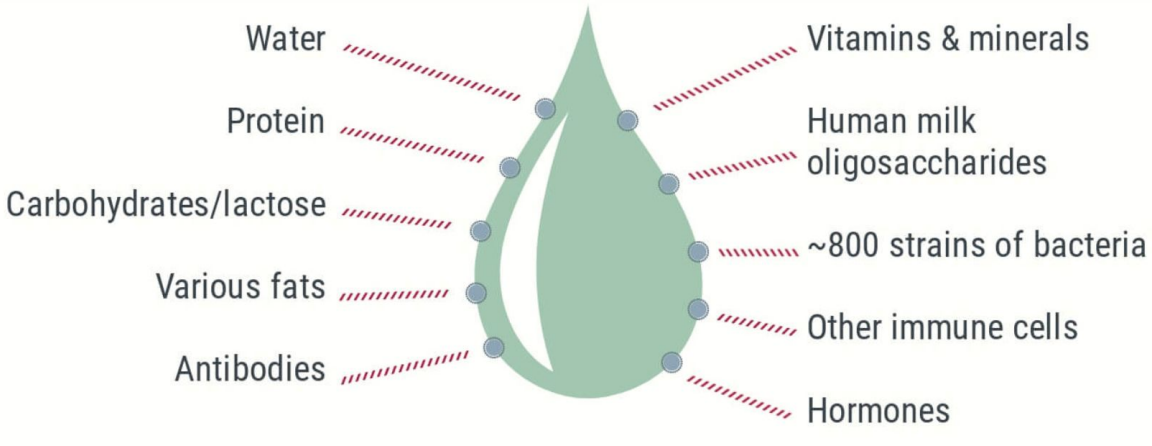
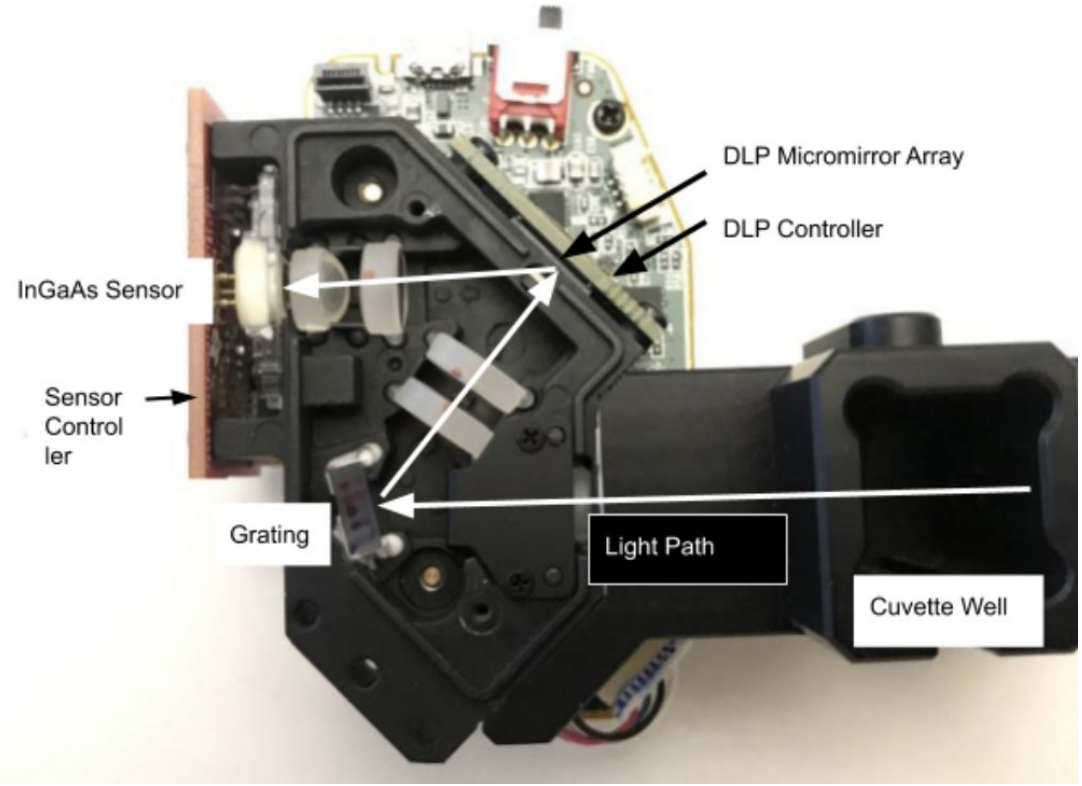


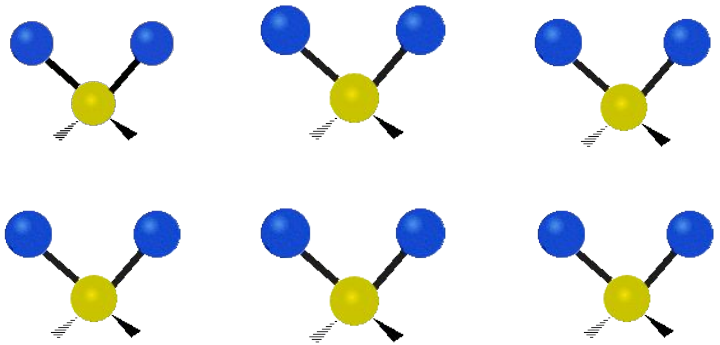
Source: https://familyandconutrition.com/breastmilk/ (adapted)

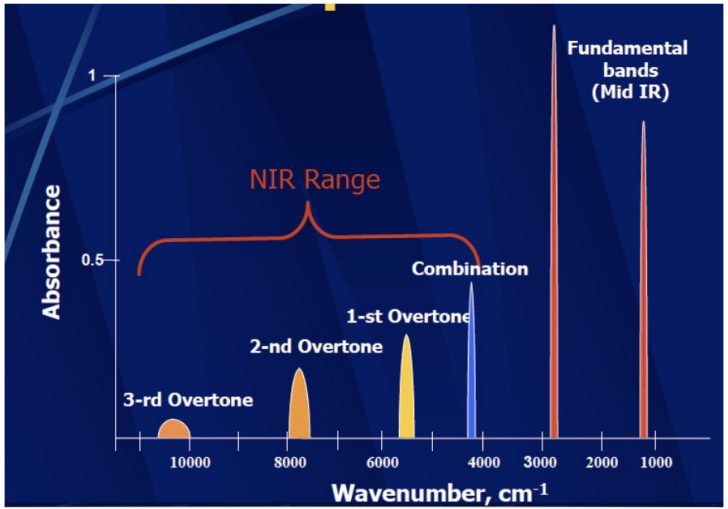
The Preemie System - Leveraging NIR Spectroscopy and AI to help preterm infants thrive

The Preemie ecosystem is composed of the Preemie sensor, supported by cloud-based computation, and a portfolio of four desktop and mobile applications directed to Neonatal Intensive Care Units and Human Milk Banks.

The Preemie System - Leveraging NIR Spectroscopy and AI to help preterm infants thrive







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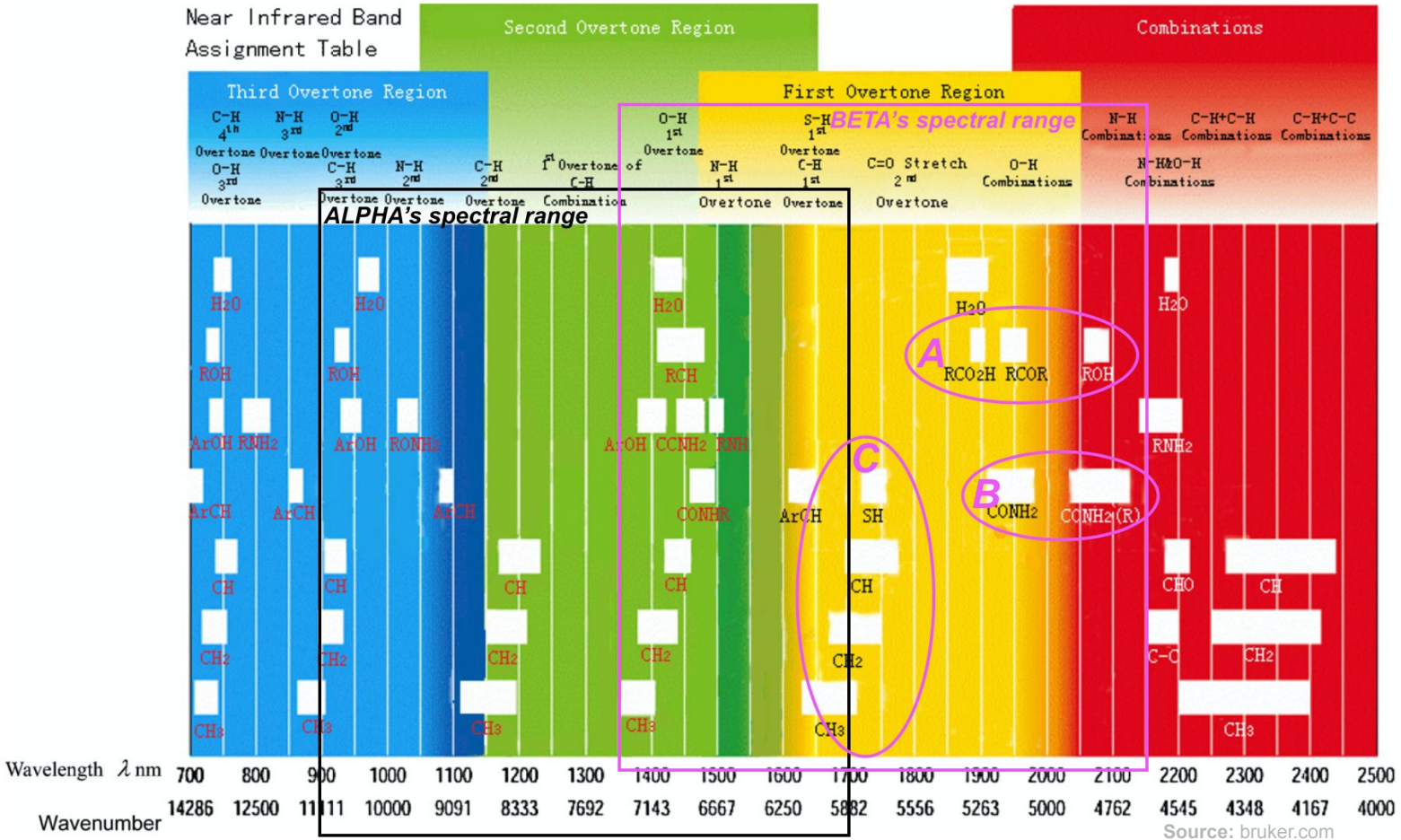

Source: bruker.com

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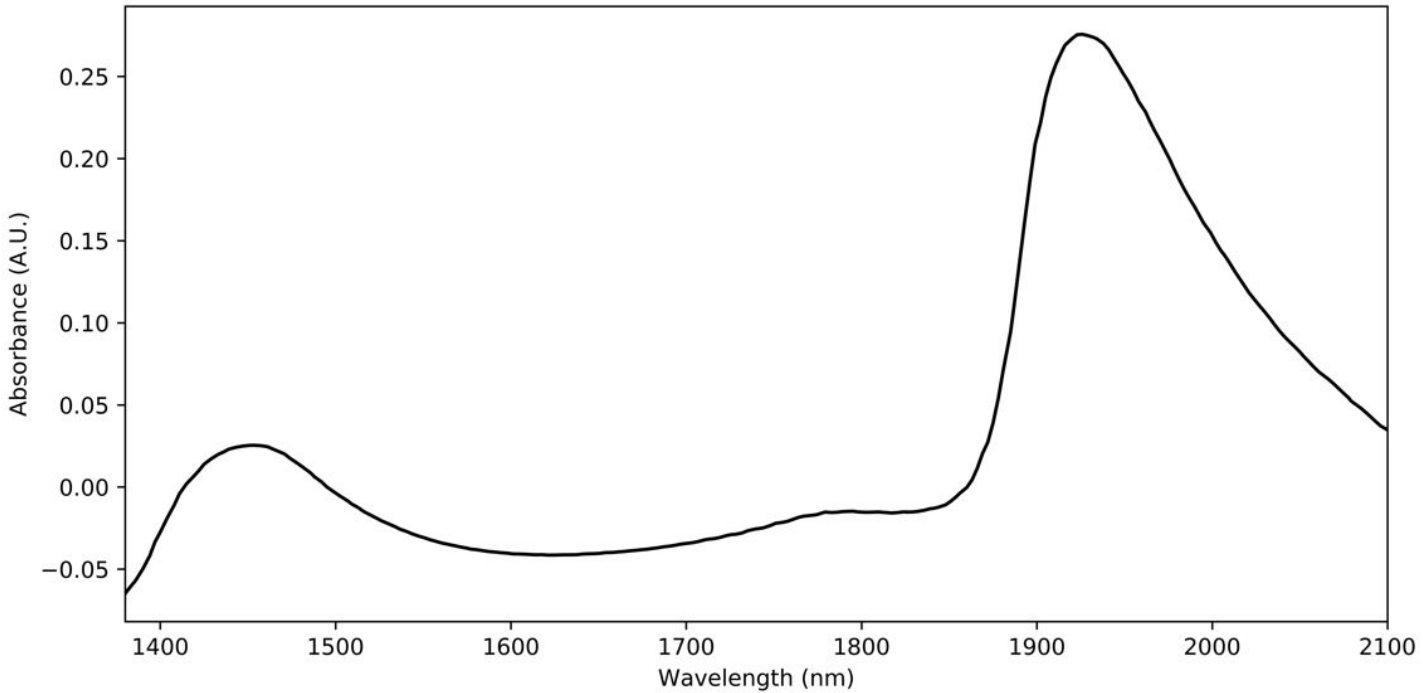


Human milk spectrum acquired with the Preemie Sensor.

The Preemie System - Leveraging NIR Spectroscopy and AI to help preterm infants thrive

Protein (grams/100 mL)
Protein is the value contributing the most to the infant's growth.

Total Lipids (grams/100 mL)
Fat is crucial for the development of the infant's neurological system.

Carbs (grams/100 mL)
Crucial for energy intake and infant growth, they protect against pathogens and diseases.

Lactose (grams/100 mL)
The main sugar in milk, it provides most of the energy needed by the growing infant.

HMOs (grams/100 mL)
Oligosaccharides are unique to human milk, and serve to feed the gut microbiome.

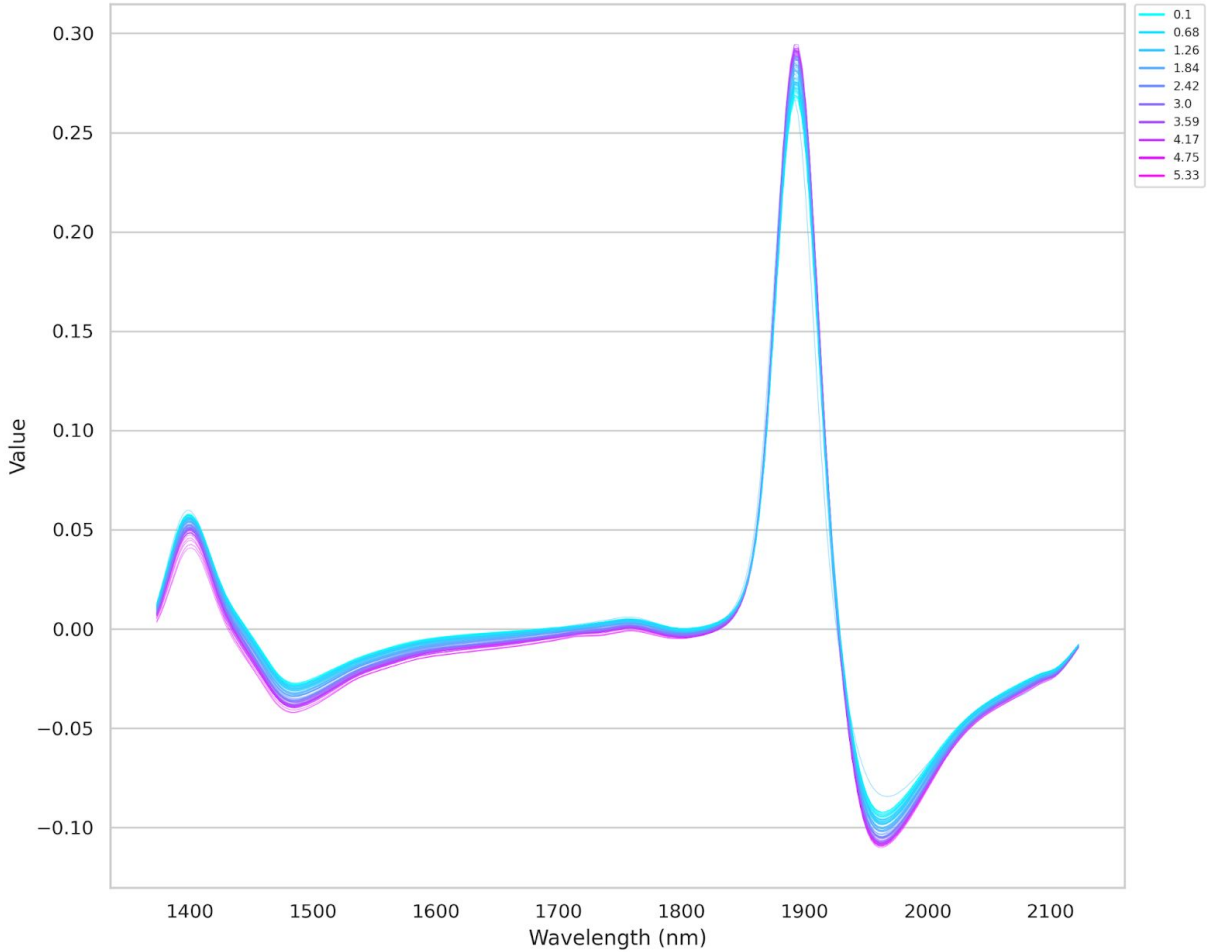
Energy (kcal/100 mL)
Calculated from other parameters, caloric intake is key for infant development.

Somatic Cells (Low/High count)
High levels of somatic cells can be used to study breast health and prevent mastitis.

Freshness (Fresh/Spoiled)
Total aerobic bacteria count determines the freshness and acceptability of the milk.

The Preemie System - Leveraging NIR Spectroscopy and AI to help preterm infants thrive

Human milk spectrum gby
Lipids content



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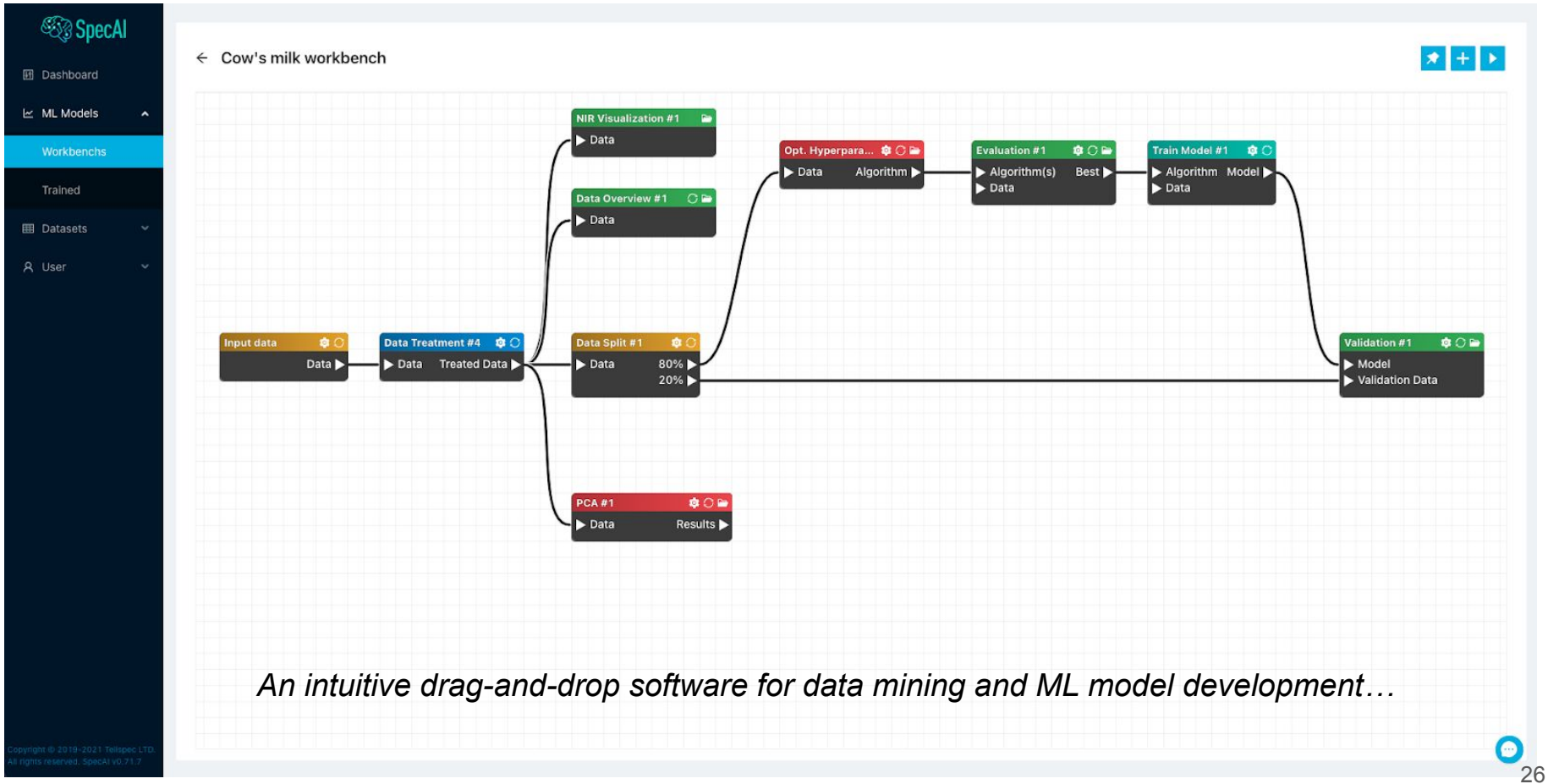
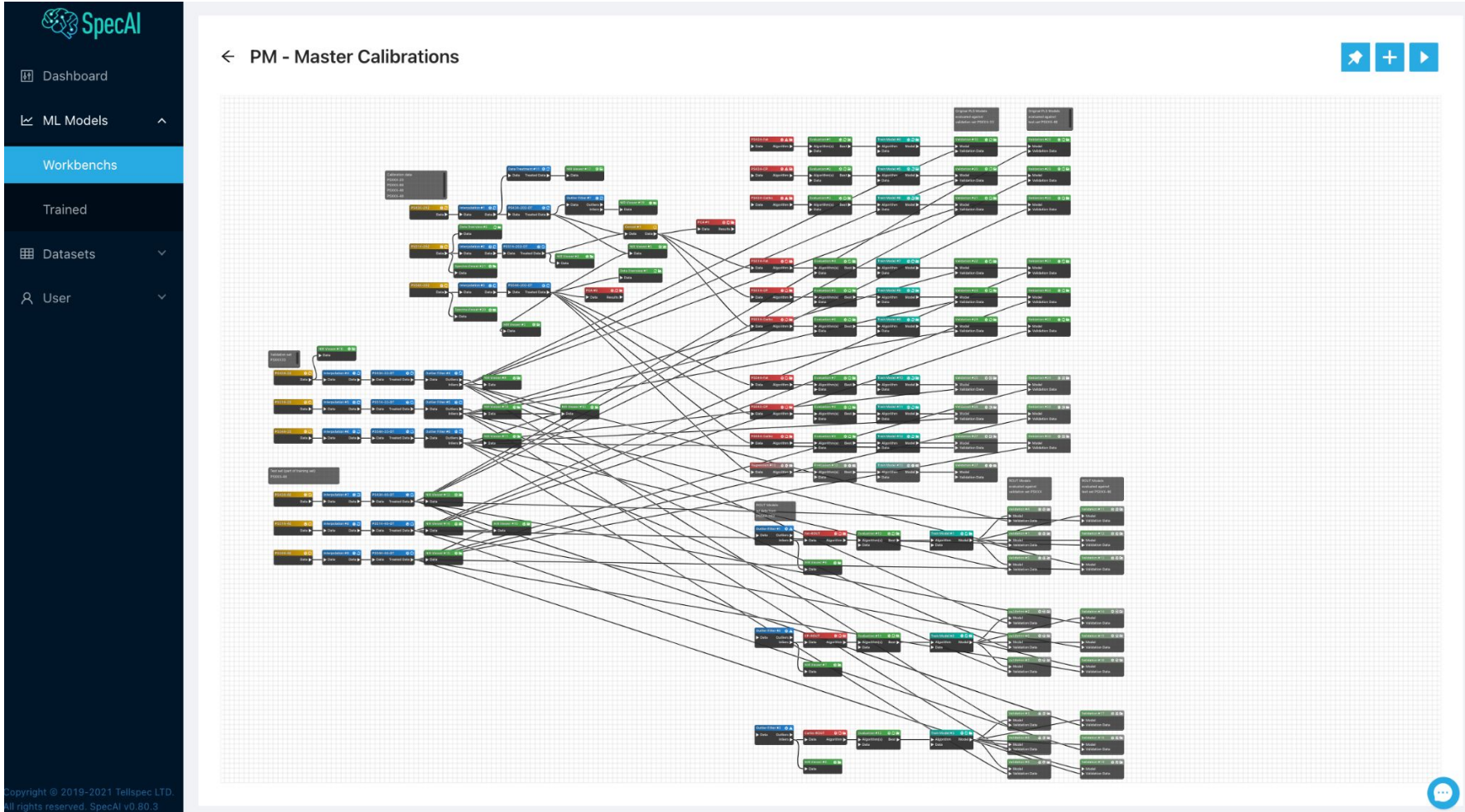


An intuitive drag-and-drop software for data mining and ML model development…

The Preemie System - Leveraging NIR Spectroscopy and AI to help preterm infants thrive



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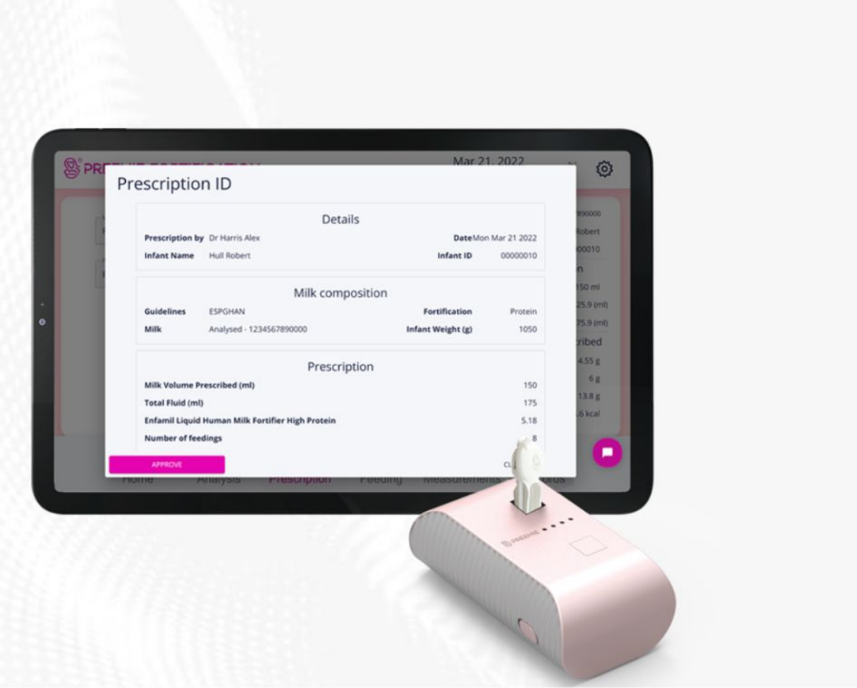
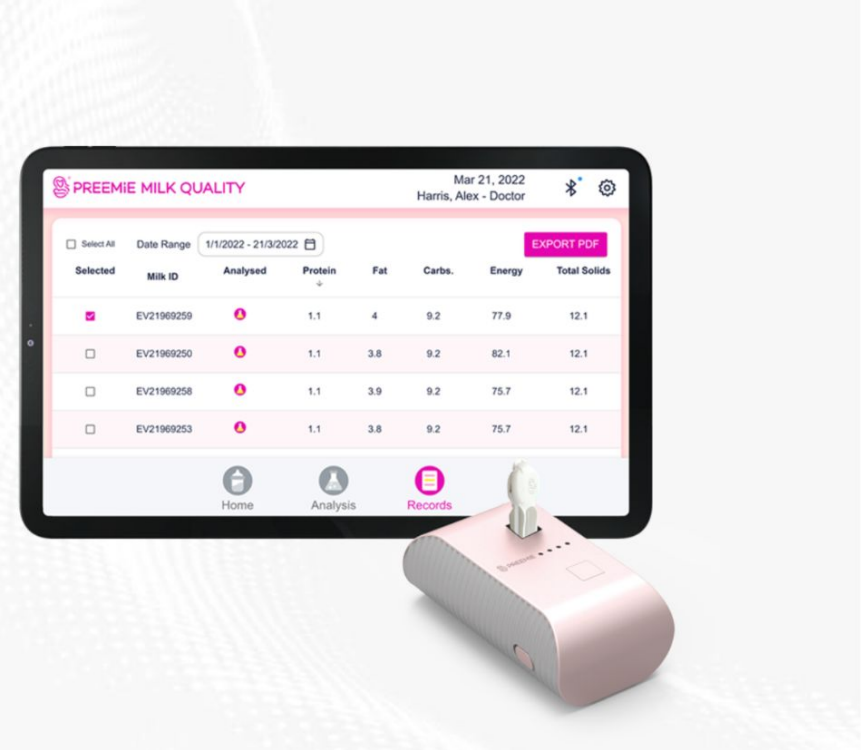


PREEMiE FORTIFICATION

This software app is designed to only work with the Preemie sensor and to be used to test milk composition at the NICU.

- Designed to meet the needs of Neonatal Intensive Care Units for targeted fortification;
- Analysis of the composition of human milk for nutrition, freshness, and safety;
- Parameters measured: Total Protein, Total Lipids, Lactose, Total HMOs, Energy, Freshness, Somatic Cell Count;
- Automatic calculation of the suggested fortification;
- Customization of fortification guidelines and fortifiers used;
- Storage of relevant data about infant nutrition and growth in compliance with GDPR;
- Produces, exports, and saves reports.

The Preemie System - Leveraging NIR Spectroscopy and AI to help preterm infants thrive



PREEMiE MILK QUALITY

This software app is designed to only work with the Preemie sensor and to be used to test milk composition, freshness, and safety at the HMB.

- Designed for Human Milk Banks;
- This software works with the Preemie sensor;
- Analysis of the composition of human milk for nutrition, freshness, and safety;
- Parameters measured: Total Protein, Total Lipids, Lactose, Total HMOs, Energy, Freshness, Somatic Cell Count;
- Storage of relevant data about donor milk in compliance with GDPR;
- Produces, exports, and saves reports.

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The Preemie Milk Quality software will be launched in the spring of 2021.
Add your name to our list to keep informed of our progress

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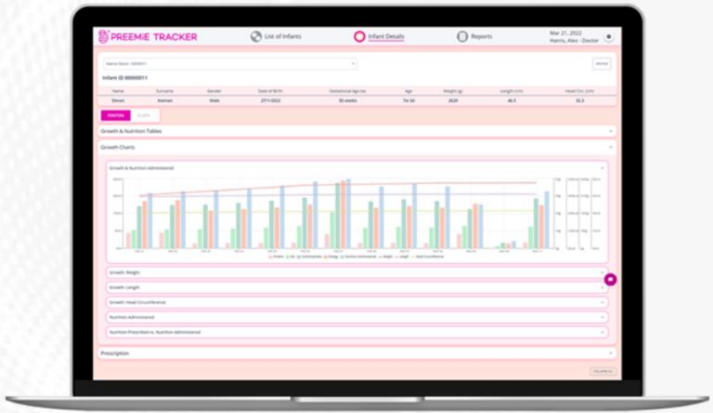

PREEMIE TRACKER

This software is designed to work with or without the Preemie sensor and to be used to track the infant's nutritional intake and correlate it with the infant's growth at the NICU.

- Designed for Neonatal Intensive Care Units;
- Stand-alone desktop software (does not require the use of the Preemie sensor);
- Comprehensive management of the infant's nutritional intake overtime;
- Correlation of the infant's nutritional intake with growth indicators such as weight, length, and head circumference;
- Allows digital prescription of fortification on a daily basis;
- Customization of fortification guidelines and of fortifiers used;
- Personalized introduction to fortification;
- Also works with Fortification app to enable personalized and tracked nutritional intake;
- Produces, exports, and saves reports;
- Key insights based on metadata.

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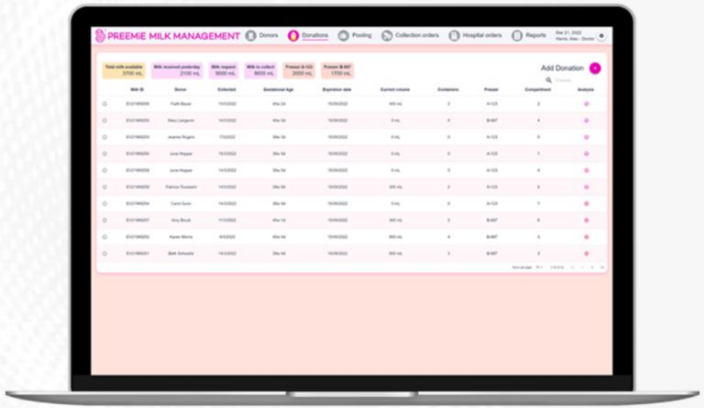

PREEMIE MILK MANAGEMENT

This software is designed to work with or without the Preemie sensor and to be used to manage the donor milk at the HMB.

- Designed for Human Milk Banks;
- Stand-alone desktop software (does not require the use of the Preemie sensor);
- Comprehensive management of the donor milk received;
- Stores key data about the donor milk encompassing all the key steps, from reception to storage, up to processing and delivery;
- Suggestion of the best donor milk to be pooled in order to achieve the highest milk quality;
- Generation of nutritional labels for each donor and pooled milk bag;
- Also works with Milk Quality app.

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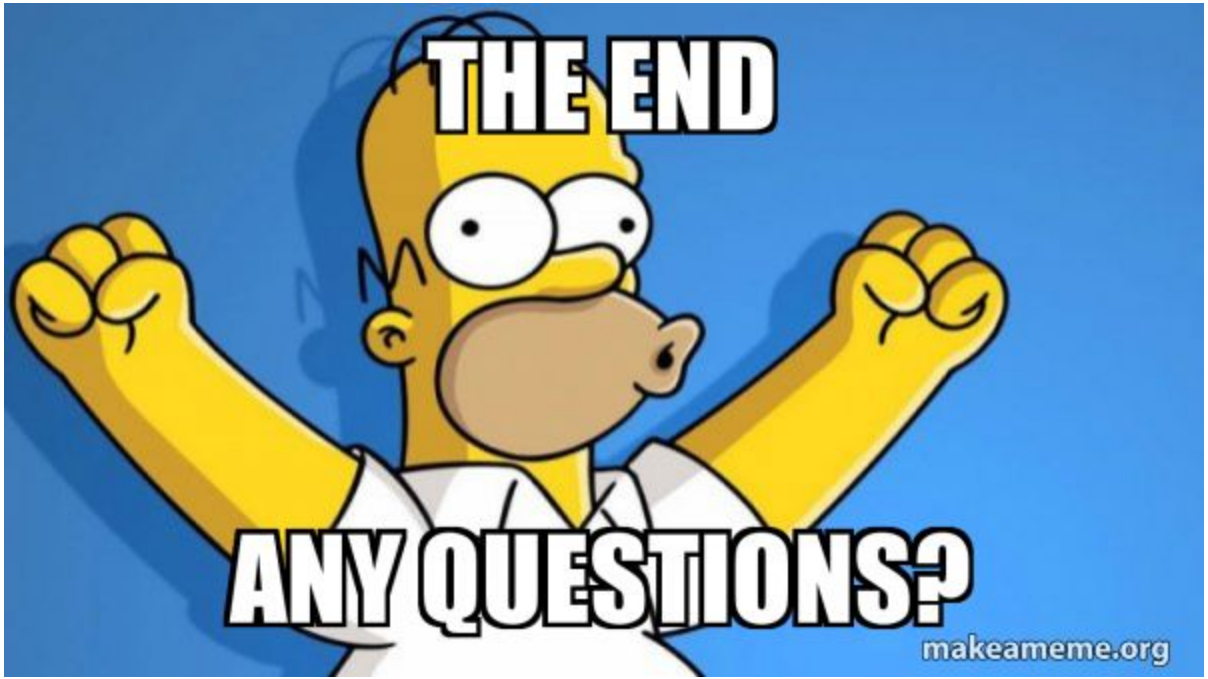
The Preemie Milk Tracker software will be launched in the spring of 2021.
Add your name to our list to keep informed of our progress

THANK YOU FOR YOUR ATTENTION!



you can reach out to me at diogo@tellspec.com
... or at a local craft brewery