Human Milk Metabolomics Across Lactation: Bioactive Compound Dynamics and Perspectives for Maternal and Infant Health

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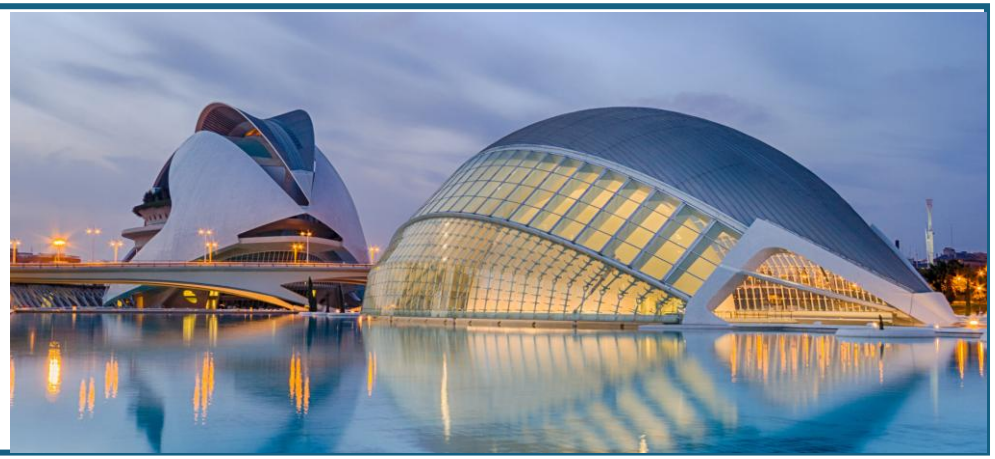

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Women’s Health Research

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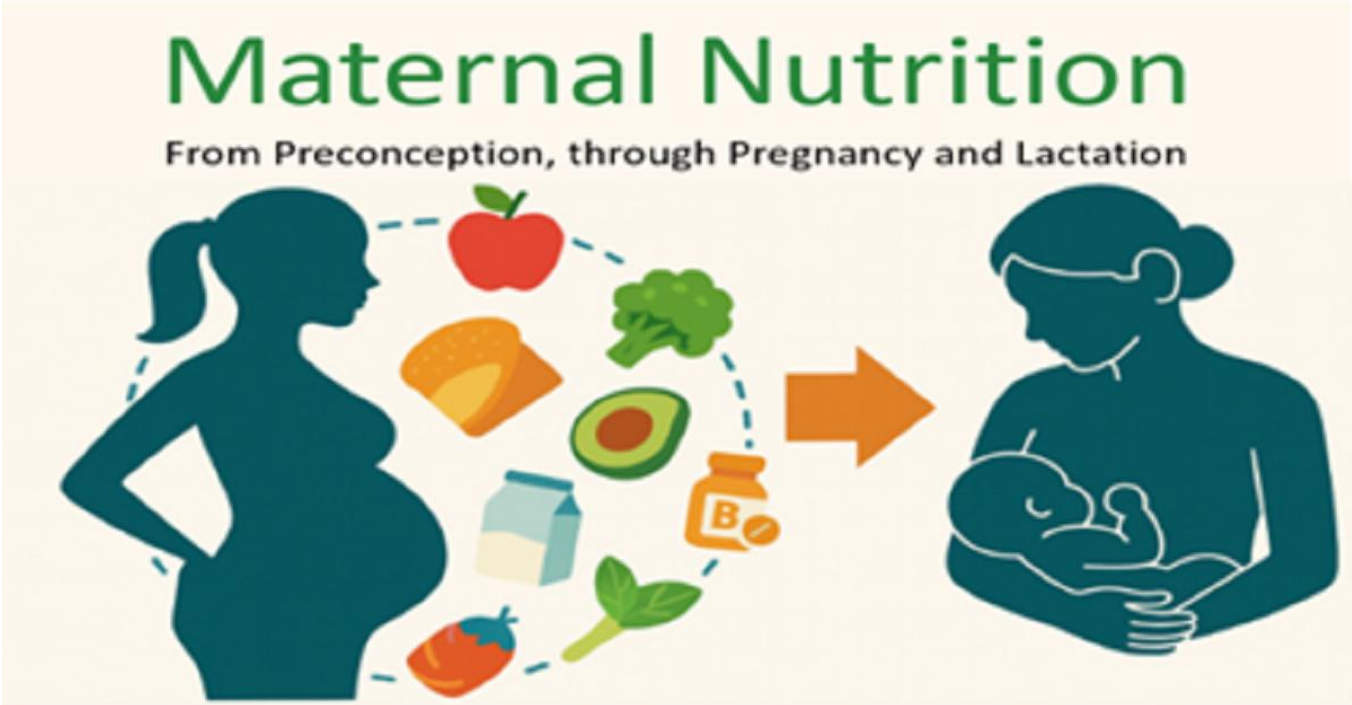
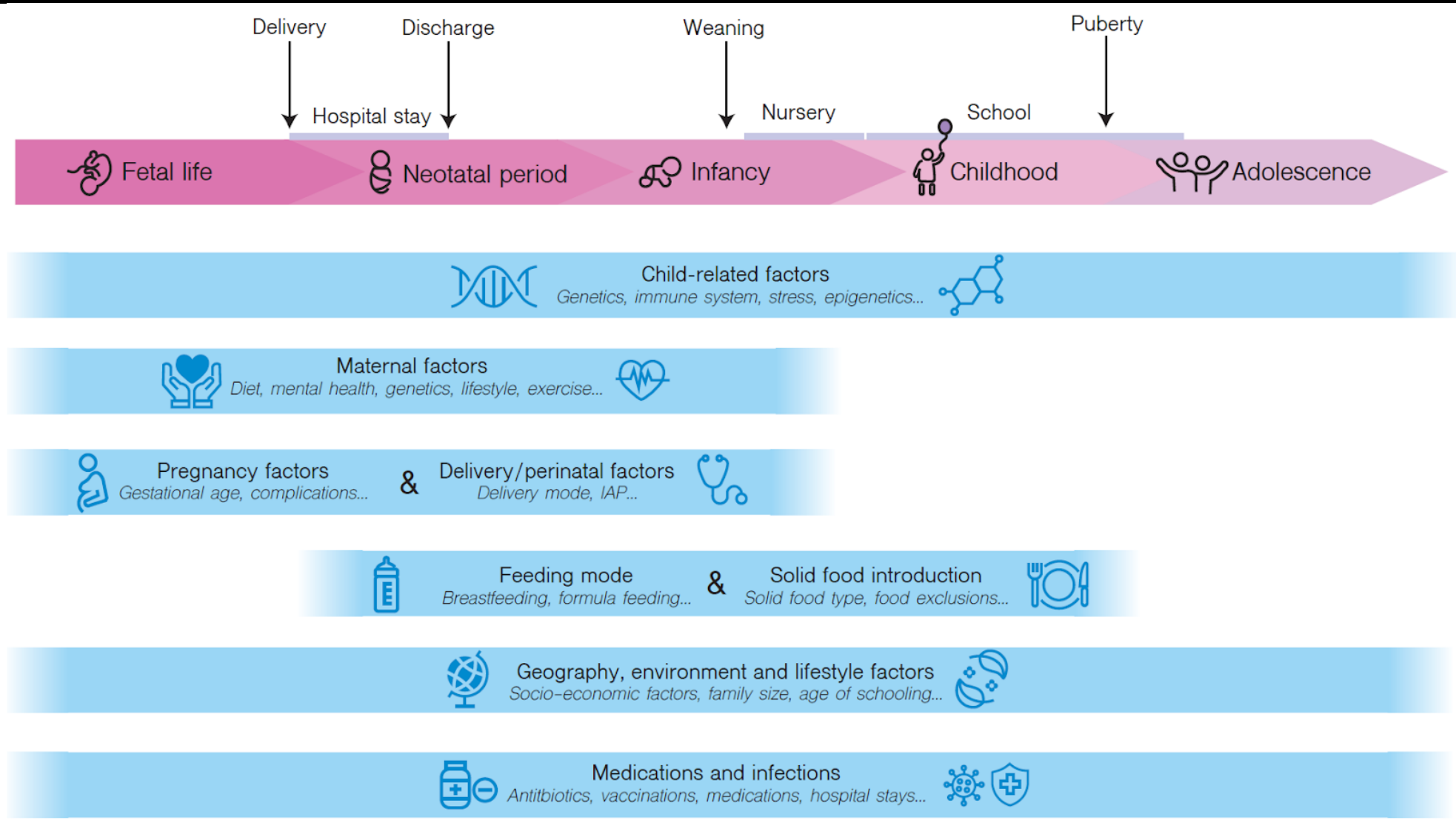


Maternal Health and Early-Life Programming

Maternal health during pregnancy and lactation is a critical determinant for infant development and long-term health

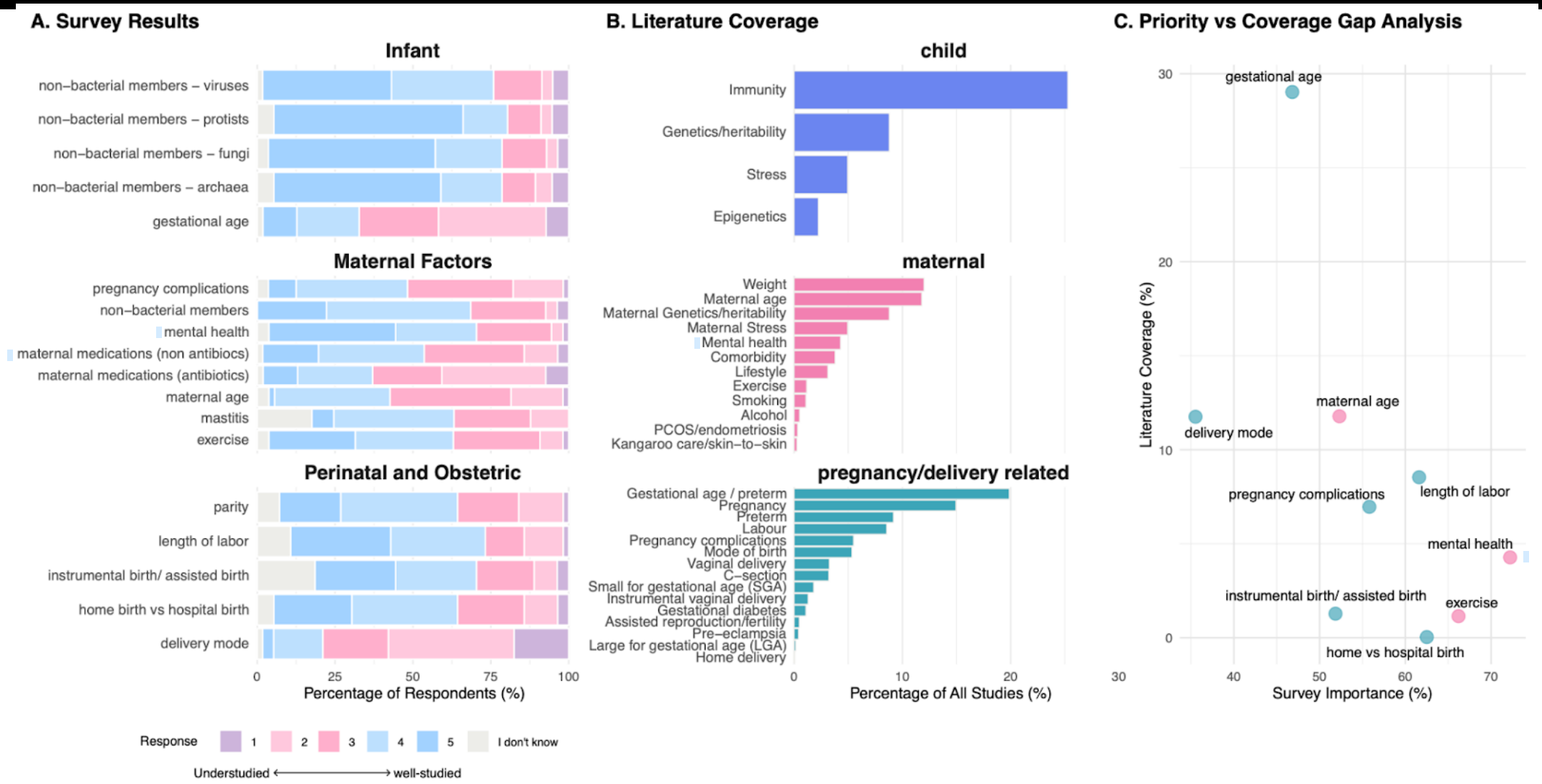
Maternal Health	Infant Development
Malnutrition Anaemia Gestacional diabetes Mental Health disorders	Preterm birth Low birth weight Increased risk of chronic diseases later in life

Factors Shaping Infant Health During Early Life



Petersen et al., 2026 FEMS Microbioogy Reviews (in press)

Gaps in mother-infant research



Petersen et al., 2026 FEMS Microbioogy Reviews (in press)

Maternal–Infant Biological Connection: Human Milk as a Complex Biological System

Nutritional Role

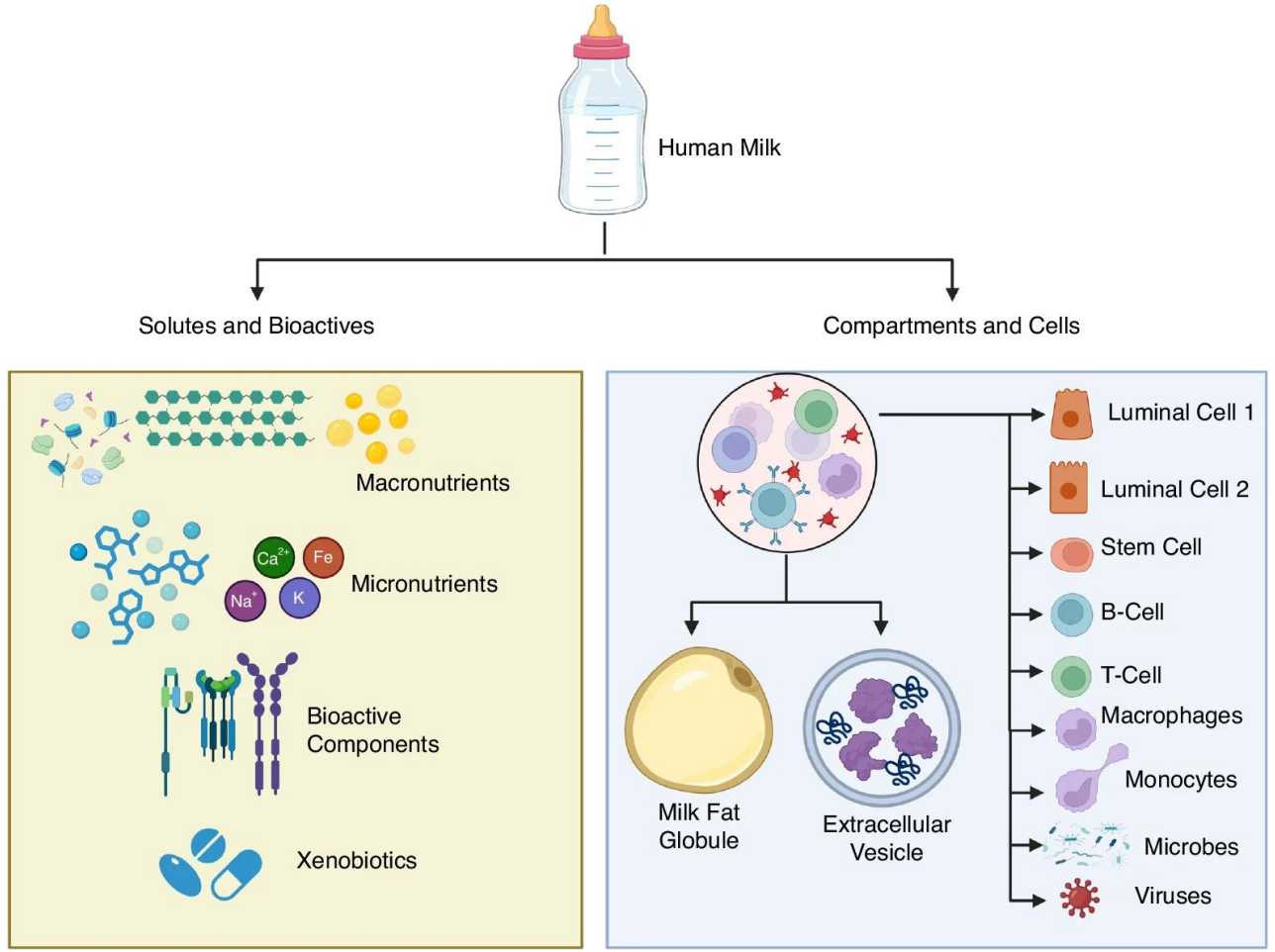
- Human milk provides essential macronutrients and supports infant growth, development, and immune protection.

Bioactive Compounds

- Human Milk contains polyamines, neurotransmitters, vitamins and folates, which affect metabolism, neurodevelopment, and gut health.

Microbiota

- Milk microbiota seed infant gut microbiota



Majood & Rao, 2025. *Pediatric Research*.
https://doi.org/10.1038/s41390-025-04458-3

Objectives of the study

Study Objectives Overview

Our observational study aims to link mother´s health and diet with bioactive compounds dynamics of breast milk and infant health in a small longitudinal mother-infant cohort **(NEMO, n=52)** applying a multi-omics approach.

Maternal Health and Diet Impact

- The study investigates how maternal health and dietary choices affect the bioactive metabolite composition of human milk.

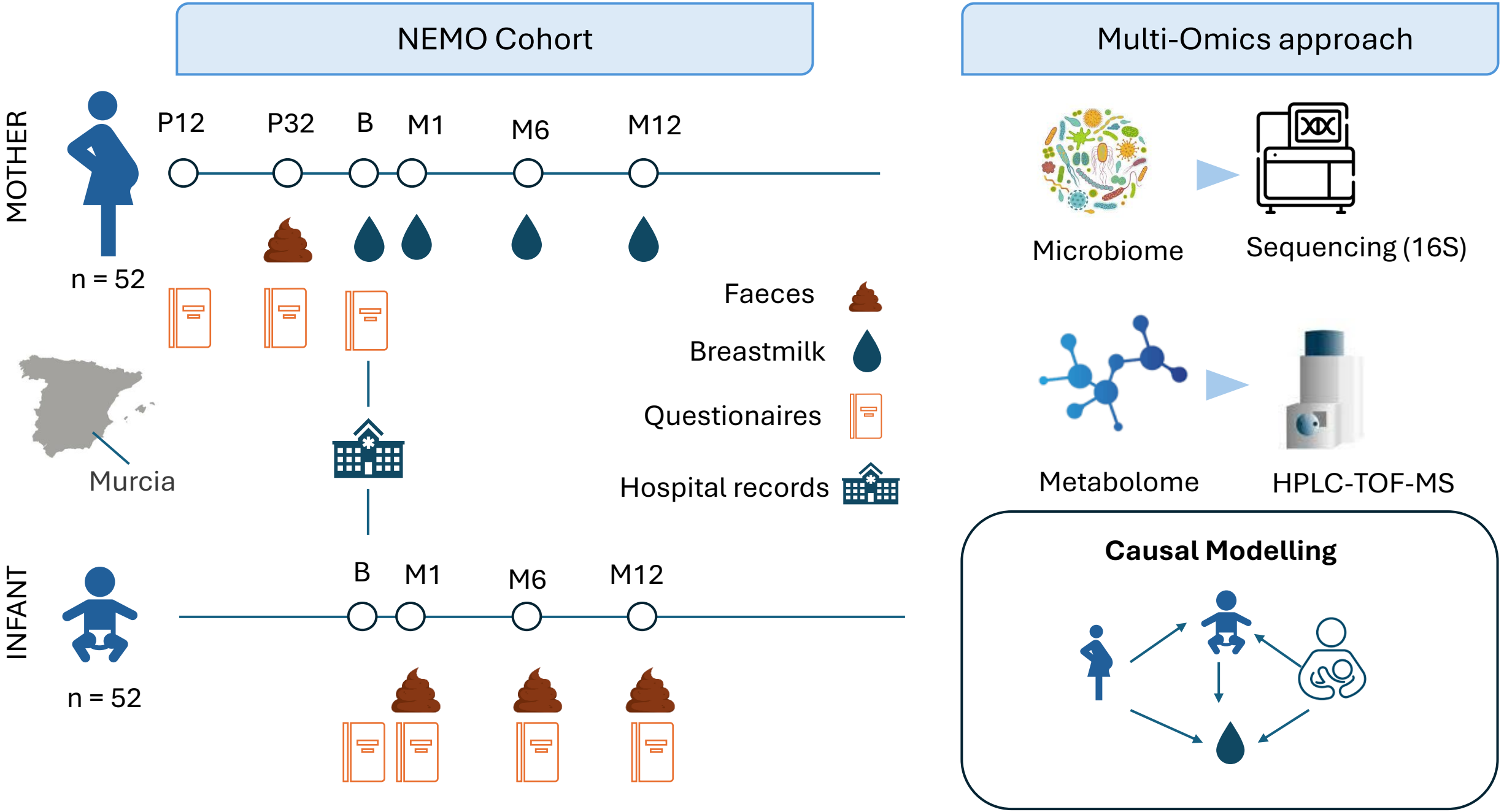
Human Milk Metabolome Characterization

- We aim to characterize the metabolome of human milk throughout lactation, with a focus on bioactive compounds.

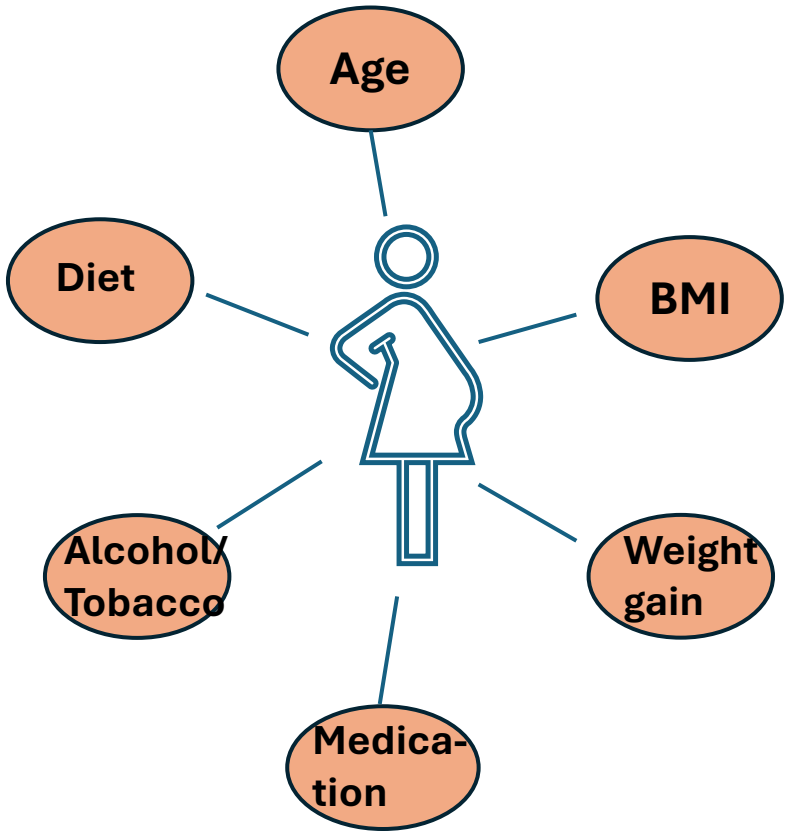
Effects on Infant Health

- This study explores how variations in milk composition influence infant health and development outcomes.

Study design:



Maternal and Infant Characteristics of the NEMO Cohort



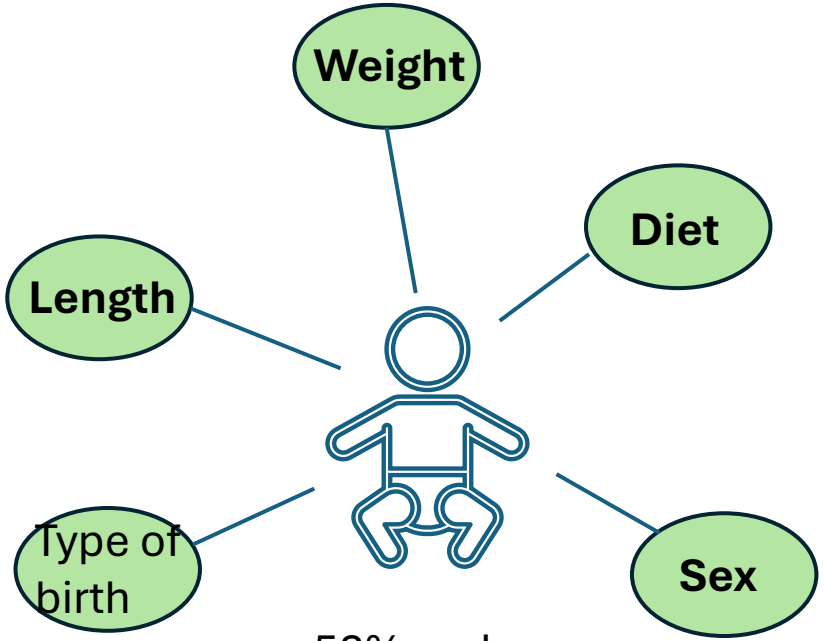
Variable	Value
Sample size (mother–infant pairs)	52
Maternal characteristics	
Maternal age (years)	33.8 ± 4.5
Maternal height (m)	1.64 ± 0.05
Pre-pregnancy weight (kg)	66.0 ± 13.4
Pre-pregnancy BMI	23.9 ± 5.6
Weight in third trimester (kg)	77.8 ± 14.5
Gestational weight gain (kg)	11.4 ± 4.4
Maternal medication during pregnancy	
No medication	29 (55.8%)
Prenatal supplements	11 (21.2%)
Thyroid medication (Eutirox)	6 (11.5%)
Iron supplementation	4 (7.7%)
Insulin (gestational diabetes)	1 (1.9%)
Other medication	1 (1.9%)

Values are expressed as mean ± SD or (%)

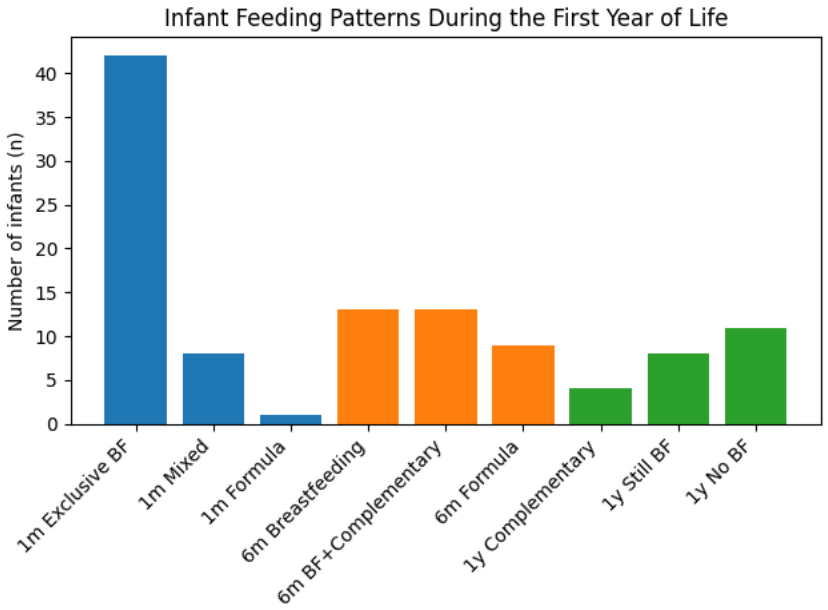
Maternal and Infant Characteristics of the NEMO Cohort

Variable	Value
Birth weight (kg)	3.28 ± 0.41
Birth length (cm)	50.7 ± 1.7
Head circumference (cm)	34.7 ± 1.4
Weight percentile	50.6 ± 28.0
Length percentile	68.3 ± 22.4
Waist skinfold (cm)	0.38 ± 0.14
Arm skinfold (cm)	0.58 ± 0.15
Leg skinfold (cm)	0.85 ± 1.08

Values are expressed as mean ± SD or (%)



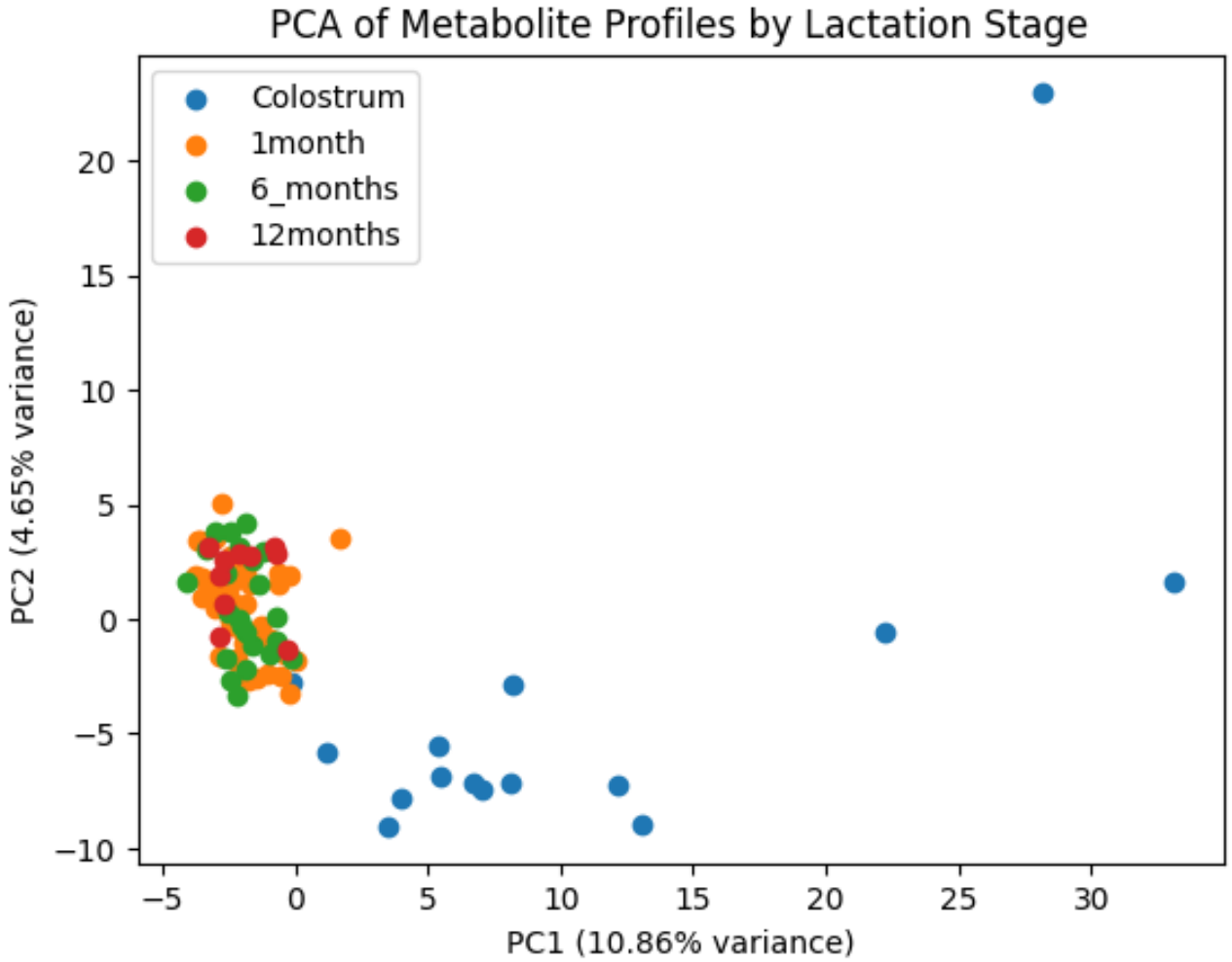
52% male
48% female



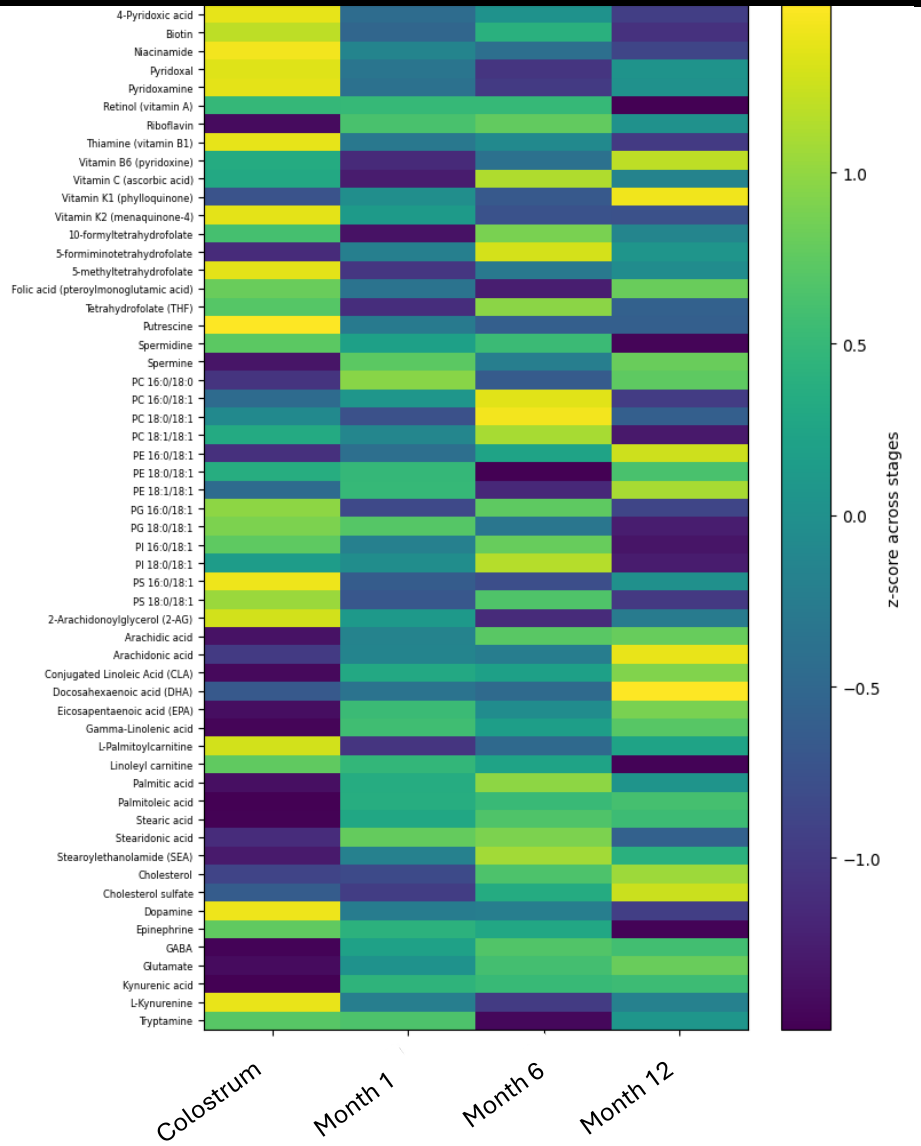
Variable	1 month	6 months	1 year
Weight (kg)	4.60 ± 0.76	7.66 ± 0.82	9.82 ± 1.56
Length (cm)	55.7 ± 2.6	67.4 ± 3.7	74.9 ± 3.1
Head circumference (cm)	37.6 ± 1.4	43.5 ± 1.4	46.7 ± 1.9

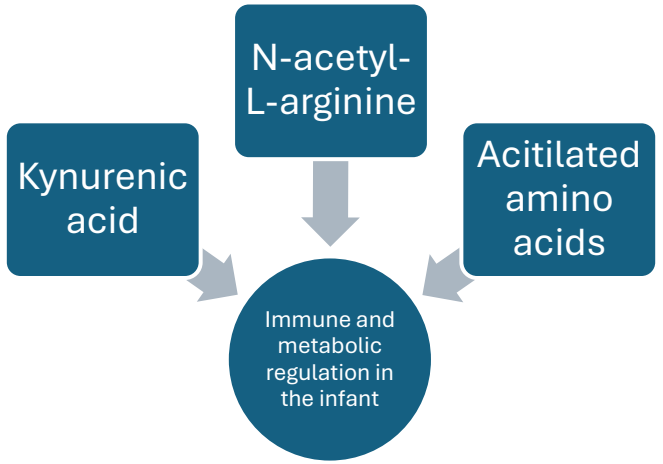
Values are expressed as mean ± SD

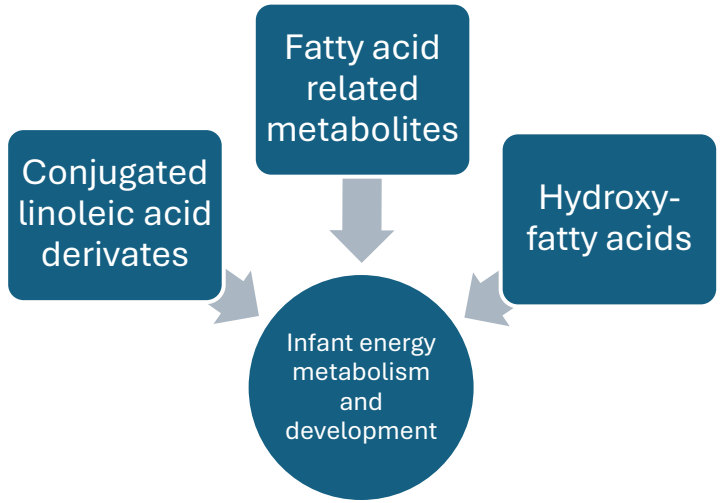
Main metabolic changes occur between colostrum and later stages of lactation



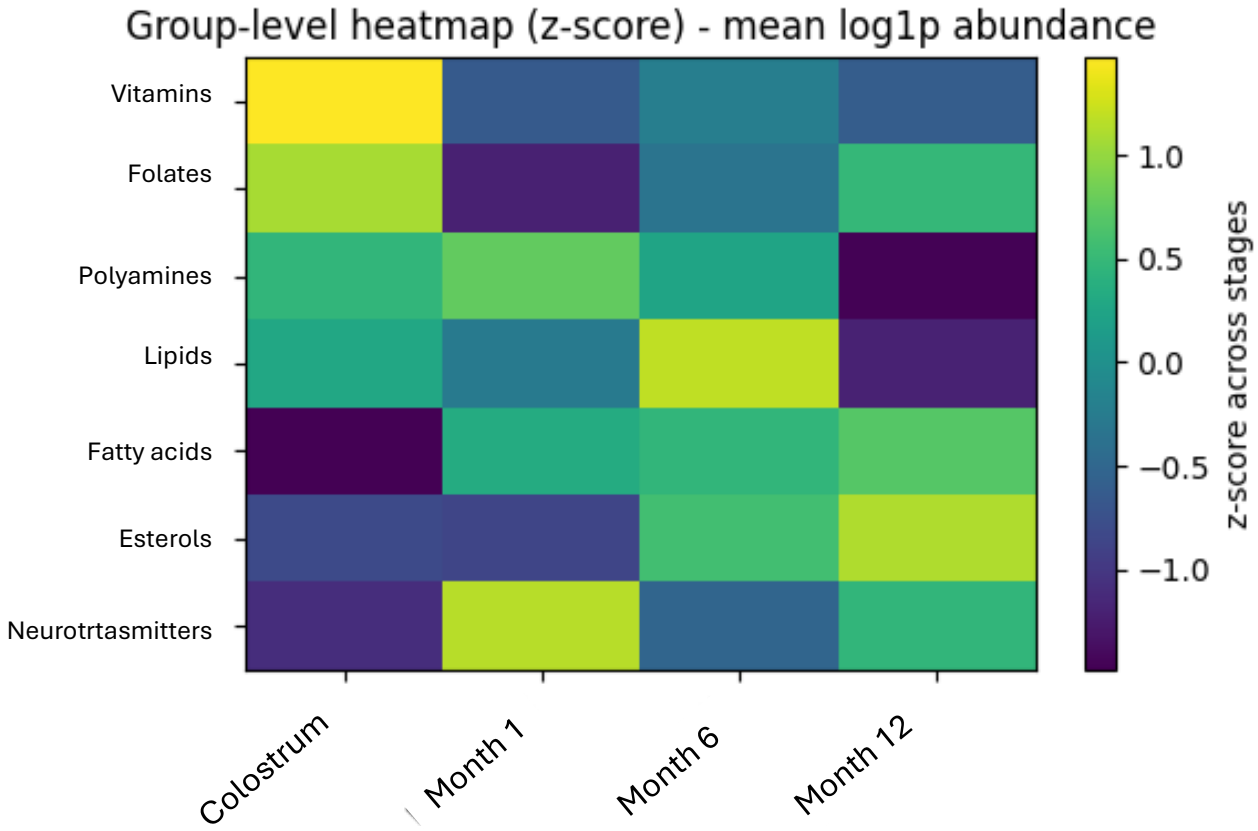
Top Metabolomic Changes in Human Milk Across Lactation







Dynamic Changes in Bioactive Compound Classes Across Lactation

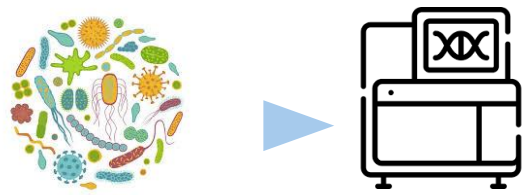


Colostrum is enriched in micronutrients and bioactive signaling molecules, while later milk stages are enriched in lipids and energy-related metabolites.

Conclusions and Future Perspectives

Our results highlight significant metabolic differences between colostrum and later lactation stages, reflecting the adaptation of milk composition to infant needs

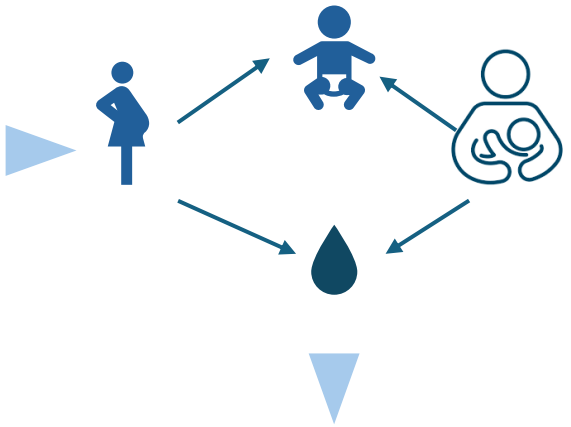
There are significant differences of relevant metabolites as neurotrasnmitters that can shape infant reprogramming



Metabolome

HPLC-TOF-MS

Mother-infant correlations



Nutritional interventions

Acknowledgments

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Prof. Maria Esteban Torres
Prof. María José Esteve
Prof. Jesús Blesa
Prof. Alessandra Cimbalo
Prof. Giuseppe Meca
Prof. Carlos Luz
Ana Moreno

RYC2023-045839-I, funded by MICIU/AEI/10.13039/501100011033 and FSE+.

Dr. María A. Nuñez Sánchez
Prof. Antonio J. Ruiz Alcaraz
María Suárez Cortes
Alonso Molina Rodríguez
María Ángeles Castaño Molina

HR EXCELLENCE IN RESEARCH

European Union

Ref: 22080/JLI/22 de la Fundación Séneca y CP23/00051 del Instituto de Salud Carlos III (Programa Miguel Servet)