# DACLC 2023

Maternal inflammation and human milk composition; maternal predictors and associations with infant outcomes – Results from the MILQ study

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*Department of Nutrition, Exercise and Sports*

*Århus, 9. oktober 2023*

KØBENHAVNS UNIVERSITET

BILL & MELINDA GATES foundation

# OUTLINE

Discussion & conclusion

Other findings from the MILQ study

Findings from PhD study

The MILQ study

Background for research area

1.

2.

3.

4.

5.

**Strengths & limitations**

**Paper I**

**Paper II**

**Paper III**



Obesity and low-grade inflammation during pregnancy and lactation

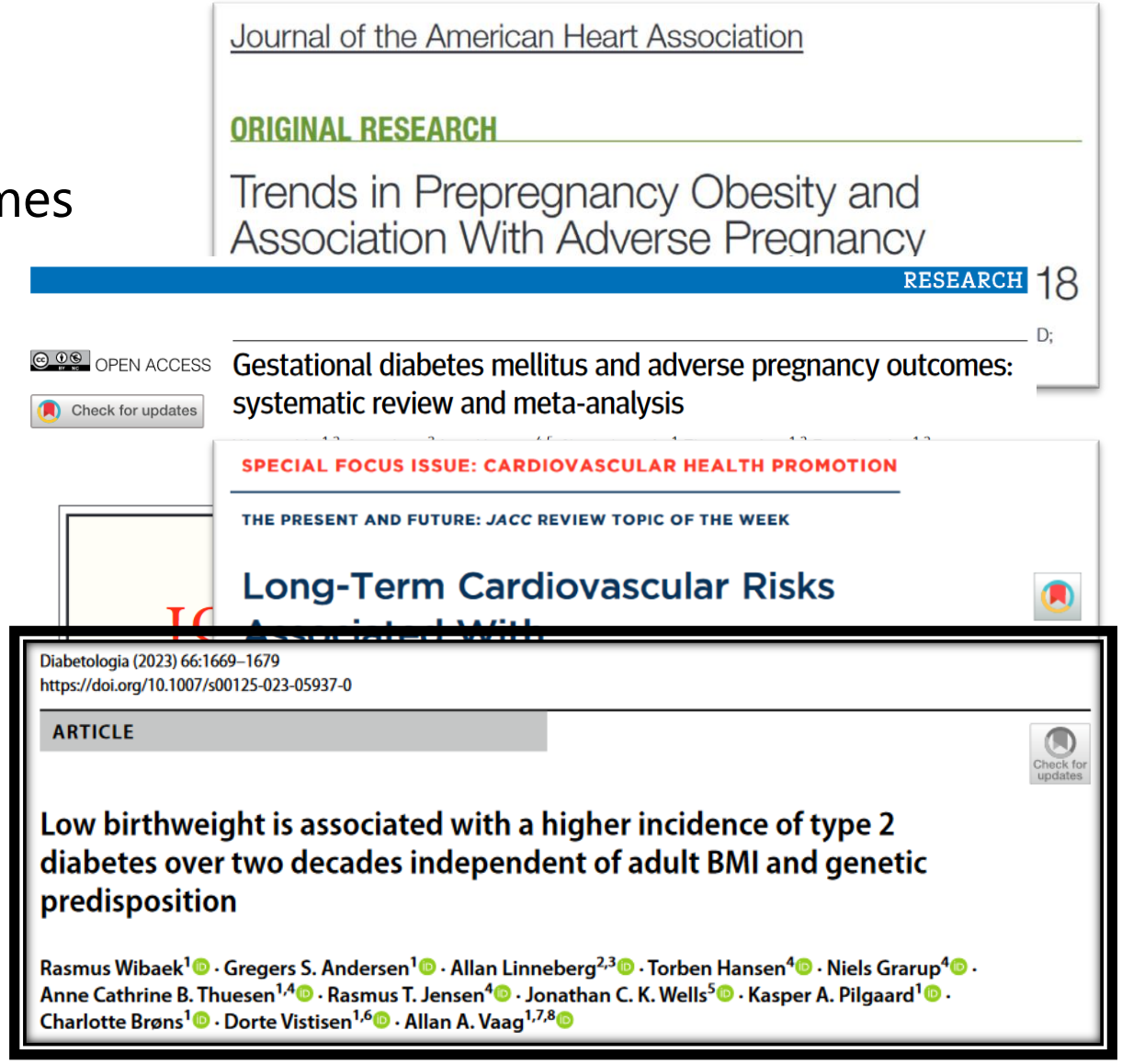
→ Why and how is the evidence lacking?

# OVERWEIGHT AND OBESITY DURING PREGNANCY

Rates of obesity during pregnancy is increasing → adverse pregnancy outcomes

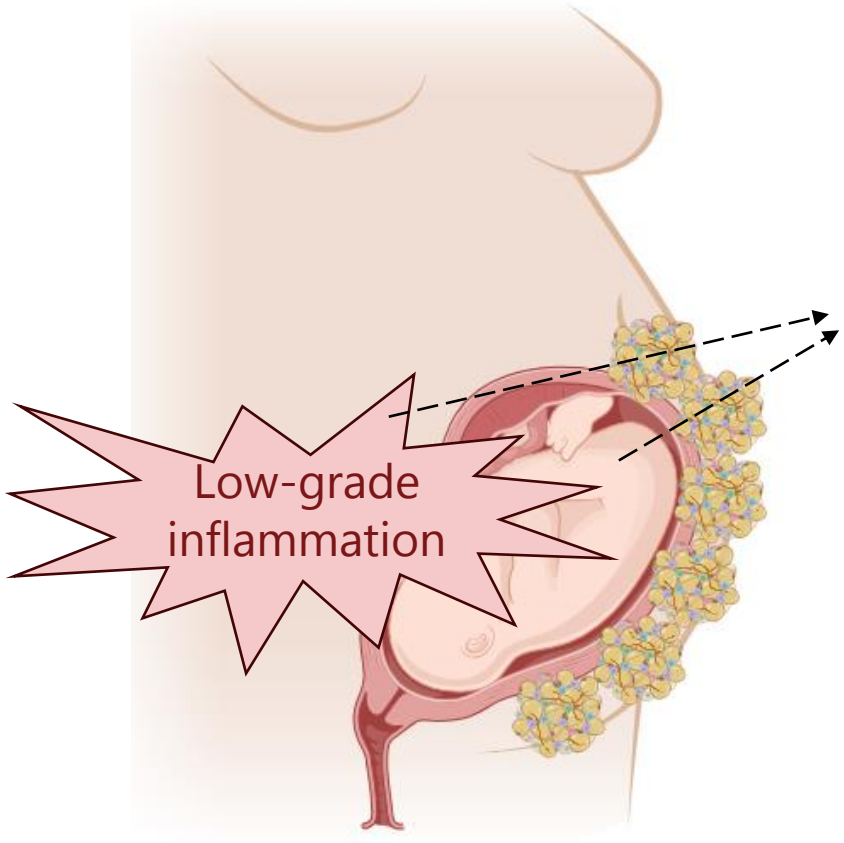
- Obesity increases the risk of
  - ✓ Birth-related complications
  - ✓ Gestational diabetes and preeclampsia
  - ✓ Long-term disease risk (maternal)
  - ✓ Long-term disease risk (infant)

- Birthweight as main predictor for disease risk



# ADIPOSITY AND LOW-GRADE INFLAMMATION

- Inflammatory biomarkers
- Lipid biomarkers
- Hormones




*Modified from Reynolds & Stirrat 2014*

↑ pro-inflammatory cytokines, hormones and free fatty acids

↓

↑ maternal insulin resistance --> ↑ hyperglycemia

↓

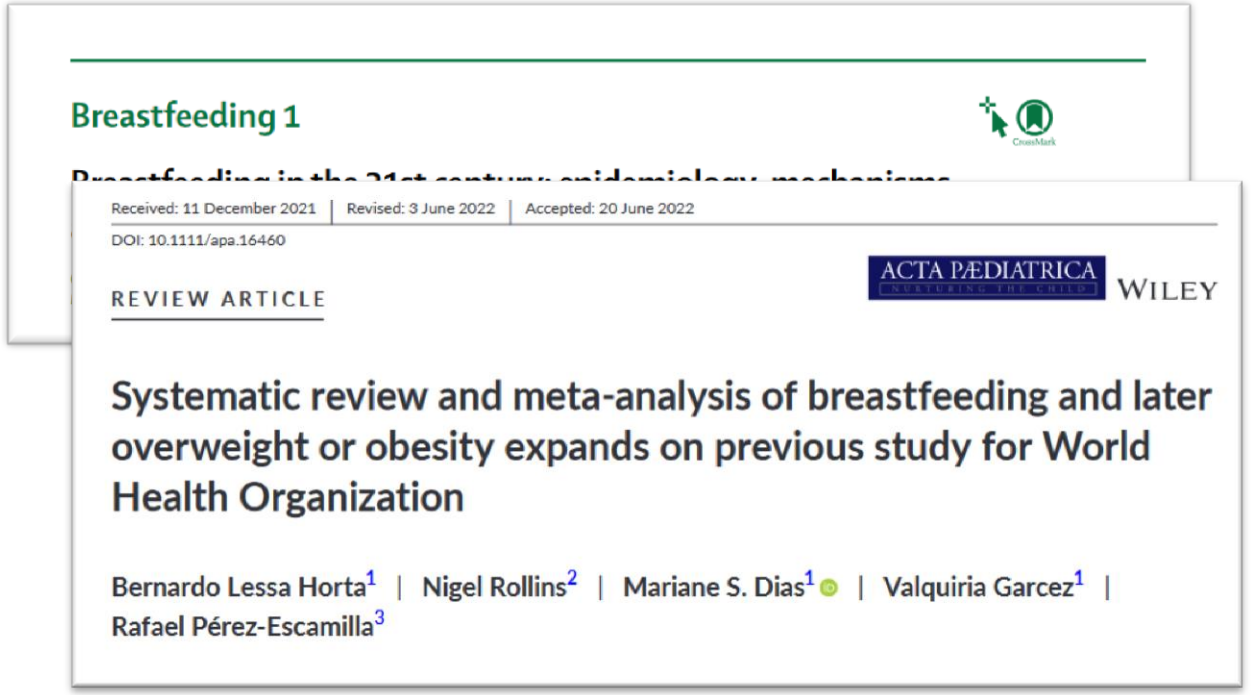
↑ **foetal growth**

# BREASTFEEDING AND LACTATIONAL PROGRAMMING

- Breastfeeding reduces the risk of later overweight in the offspring

- Appetite-regulating hormones
  - Leptin, adiponectin, insulin

… But other mechanisms are likely involved



Breastfeeding 1

Received: 11 December 2021 | Revised: 3 June 2022 | Accepted: 20 June 2022

DOI: 10.1111/apa.16460

ACTA PÆDIATRICA WILEY

REVIEW ARTICLE

Systematic review and meta-analysis of breastfeeding and later overweight or obesity expands on previous study for World Health Organization

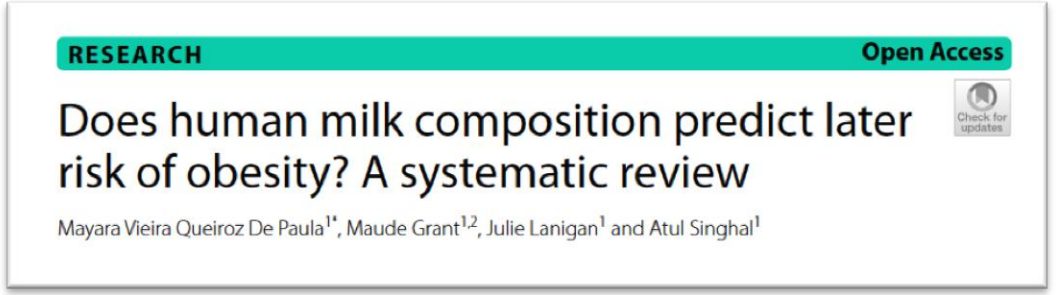
Bernardo Lessa Horta[1] | Nigel Rollins[2] | Mariane S. Dias[1] | Valquiria Garcez[1] | Rafael Pérez-Escamilla[3]

# HUMAN MILK STUDIES

➢ Diverging methodologies

- Study design
- Milk sample collection
- Milk sample analysis
- Outcome of interest

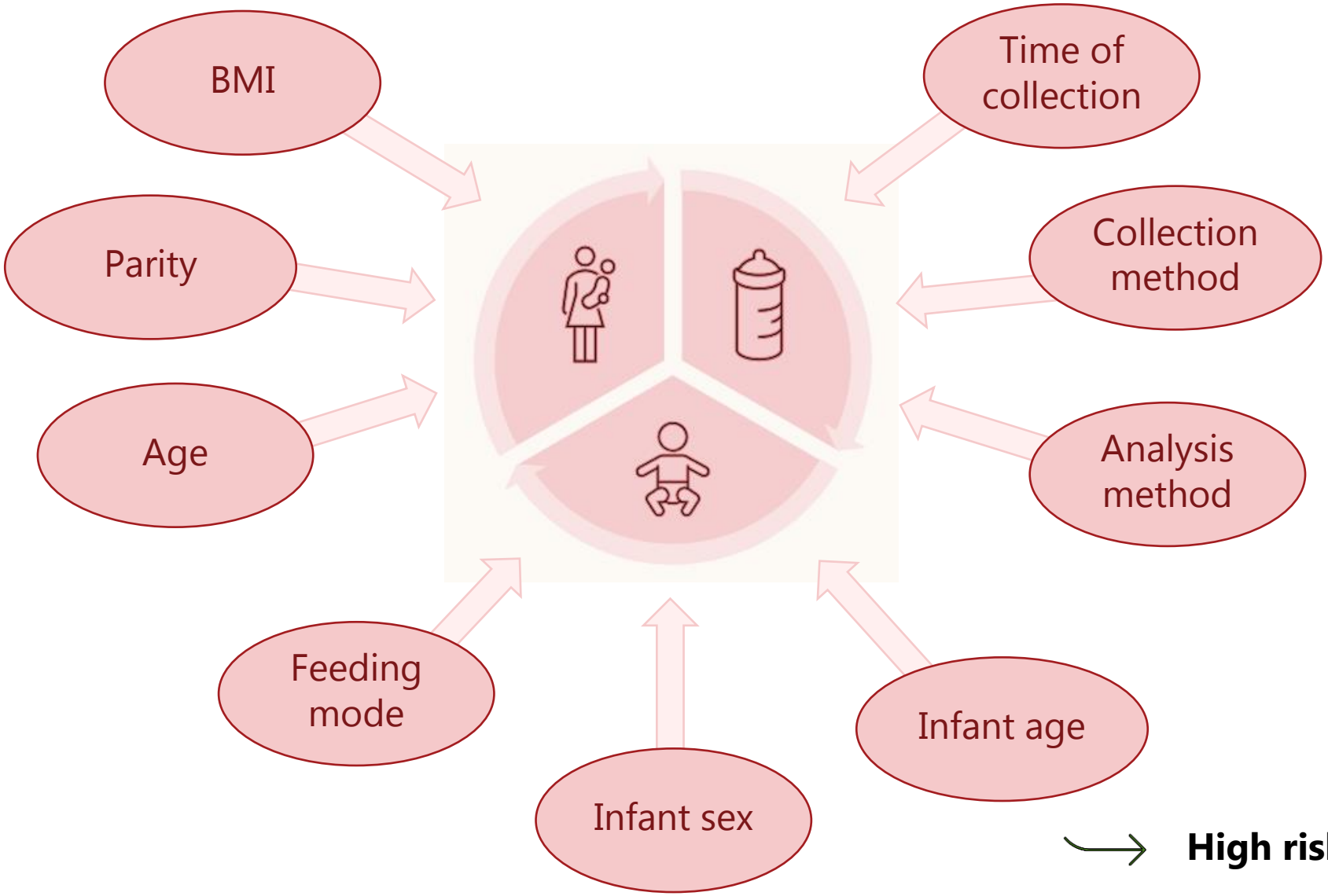
→ **High heterogeneity among studies**


RESEARCH Open Access

Does human milk composition predict later risk of obesity? A systematic review

Mayara Vieira Queiroz De Paula[1*], Maude Grant[1,2], Julie Lanigan[1] and Atul Singhal[1]

# MOTHER-MILK-INFANT TRIAD




**High risk of confounding**

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Obesity and low-grade inflammation during pregnancy and lactation

→ Why and how is the evidence lacking?

# THE MILQ STUDY

**Aim** was to develop reference values for macro- and micronutrient concentrations in human milk


RESEARCH METHODOLOGY/STUDY DESIGN

Maternal and Pediatric Nutrition

MiLQ Mothers, Infants and Lactation Quality

CURRENT DEVELOPMENTS IN NUTRITION

**The Mothers, Infants, and Lactation Quality (MILQ) Study: A Multi-Center Collaboration**

Lindsay H Allen,[1,2] Daniela Hampel,[1,2] Setareh Shahab-Ferdows,[1,2] Maria Andersson,[3] Erica Barros,[4] Andrew M Doel,[5] Kamilla Gehrt Eriksen,[6] Sophie Hilario Christensen,[6] Munirul Islam,[7] Gilberto Kac,[4] Farhana Khanam Keya,[7] Kim F Michaelsen,[6] Daniela de Barros Mucci,[4] Fanta Njie,[8] Janet M Peerson,[1] and Sophie E Moore[4,8]

***Why the MILQ study?*** To support WHO breastfeeding guidelines

- Current evidence is limited → few studies, low sample size, low generalisability
- National policies (dietary or supplements) Vit A, B12, iodine
- Method development of analysing the human milk matrix

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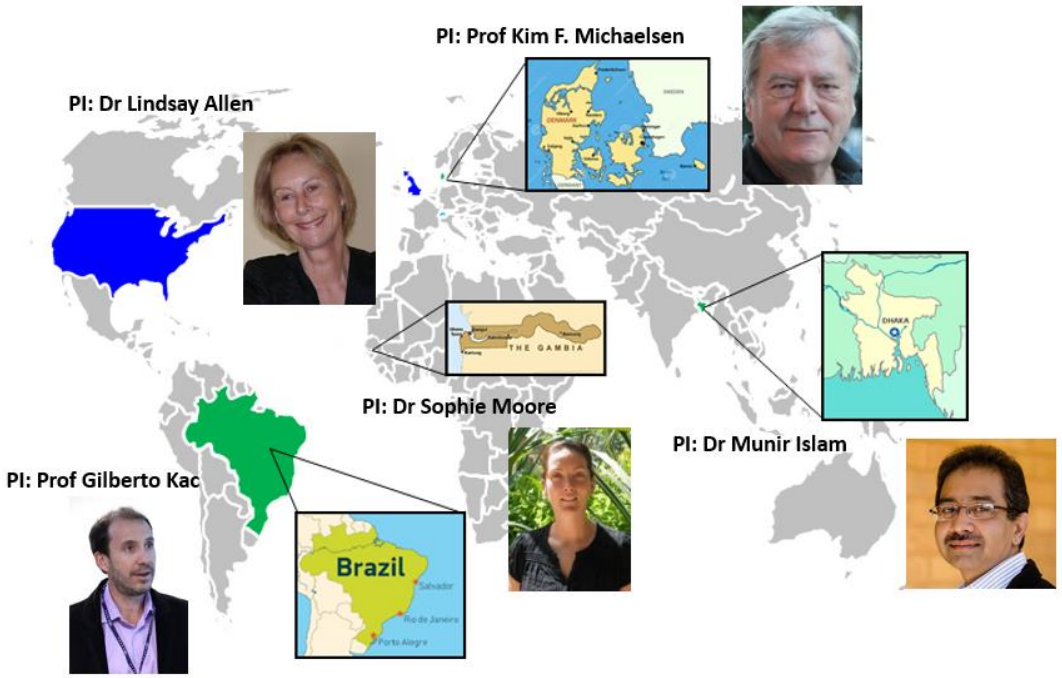
# THE MILQ STUDY




MiLQ
Mothers, Infants and Lactation Quality

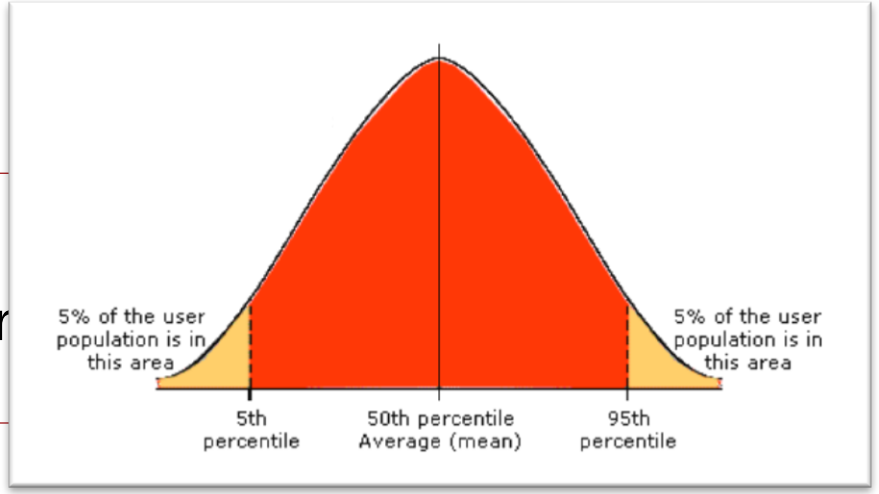
**California, Davis**
Lindsay Allen, PI

- **Bangladesh** *n*=250
- **Brazil** *n*=250
- **Denmark** *n*=250
- **The Gambia** *n*=250

# DEVELOPING REFERENCE VALUES

## *What will be created?*

- Percentiles (5th, 50th, 95th) of human milk concentr




## *How can we use them?*

In the clinic?

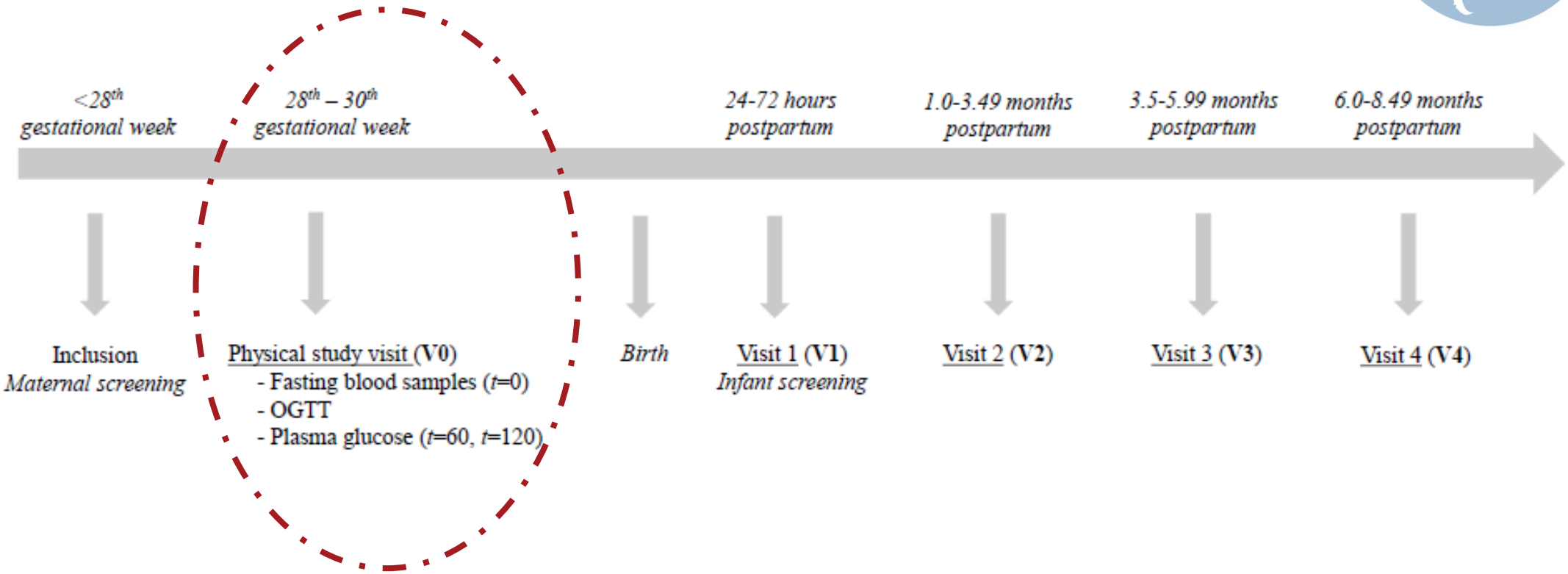
- To estimate adequate intakes (AI) of human milk nutrients
- To identify populations with low human milk concentrations
- To investigate maternal dietary intake → status → human milk conc.

# THE MILQ STUDY

| Maternal inclusion criteria | Infant inclusion criteria |
|---|---|
| Age between 18-40 years old | Term birth (GA 37-42) |
| Pre-pregnancy BMI 18.5-29.9 kg/m2 | Birthweight 2500-4200g |
| No chronic, severe illness<br>No gestational diabetes or preeclampsia | Without any illness possible to affect breastfeeding, growth or development |
| Singleton pregnancy | |
| No intake of multivitamin supplement and low intake of fortified foods | |
| Willing to breastfeed up to 8.5 months (and exclusively up to 3.5) | → Breastfeeding counselling |

*Representing a healthy mother-infant cohort*

# THE MILQ STUDY



# RECRUITMENT AND DATA COLLECTION

## Data collection

- ✓ Maternal and infant anthropometry and body composition
- ✓ Biological samples (human milk, blood, urine, faeces)
- ✓ Dietary intake incl. milk volume (D2O and 24h test weighing)
- ✓ Maternal and infant morbidity
- ✓ Cognitive development

# BREASTFEEDING COUNCELING

- To support WHO recommendations of breastfeeding
  - Breastfeeding counselling was probably one of the main drivers for participation

- Fixed calls with questions
  - 5 days postpartum
  - 4-5 weeks postpartum

- Extra breastfeeding couns
  - For the ones with challenge
  - For the ones with resources

# THE MILQ STUDY

| Primary analysis | Secondary analysis |
|---|---|
| Reference values for macro- and micronutrient concentrations in human milk | Human milk oligosaccharides (HMO) |
| - | Milk RNA (bacteria) |
| - | Milk volume ($D_2O$ and test weighing) |
| - | Inflammatory markers in human milk |
| - | Appetite-regulating hormones |
| - | Differences within infant sex |
| - | Infant growth and body composition |

PhD study

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3. Findings from PhD study

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**Paper II**

**Paper III**

4. Other findings from the MILQ study

5. Discussion & conclusion

**Strengths & limitations**



Obesity and low-grade inflammation during pregnancy and lactation

→ Why and how is the evidence lacking?

# PHD OBJECTIVES

Firstly, to ex
inflamm

Secondly, t

Cytokines and appetite-regulating hormones in human milk and associations with infant growth across four sites: The Mothers, Infants and Lactation Quality Study

Sophie Hilario Christensen[1], Jack Ivor Lewis[1], Hanne Frøkiær[2], Peter Riber Johnsen[2], Janet Peerson[3], Xiuping Tan[4], Setereh Shahab-Ferdows[3], Daniela Hampel[3,4], Munirul Islam[5], Gilberto Kac[6], Daniela de Barros Mucci[7], Amanda C Cunha Figueiredo[6], Sophie E. Moore[8,9], Christian Mølgaard[1], Lindsay H Allen[3,4], Kim F Michaelsen[1]

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SPECIALTY SECTION
This article was submitted to Clinical Nutrition, a section of the journal Frontiers in Nutrition

Associations between m
adiposity and
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through maternal circula
concentrations and migl
infant outcomes

Sophie Hilario Christensen[1]*, Jack Ivor Lewis[1], Anni Larnkjær[1], Hanne Frøkiær[2], Lindsay H. Allen[3], Christian Mølgaard[1] and Kim F. Michaelsen[1]

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associations with birth and breastfeeding outcomes

Sophie Hilario Christensen[1]*, Ane Lilleøre Rom[2,3], Tine Greve[4], Jack Ivor Lewis[1], Hanne Frøkiær[5], Lindsay H. Allen[6], Christian Mølgaard[1], Kristina Martha Renault[2,7†] and Kim F. Michaelsen[1†]

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# MAIN FINDINGS ***Paper I***

- Mediation analyses as a statistical tool


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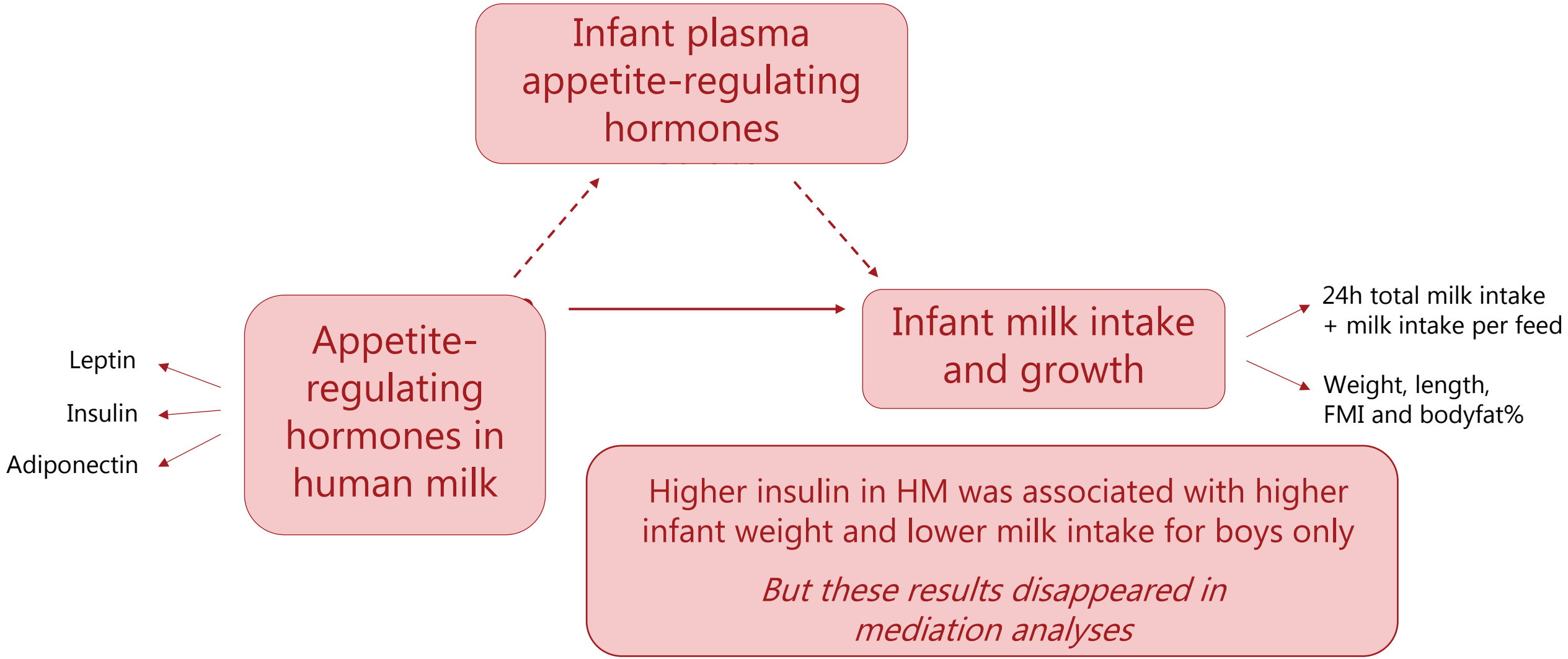
SPECIALTY SECTION
This article was submitted to Clinical Nutrition, a section of the journal Frontiers in Nutrition

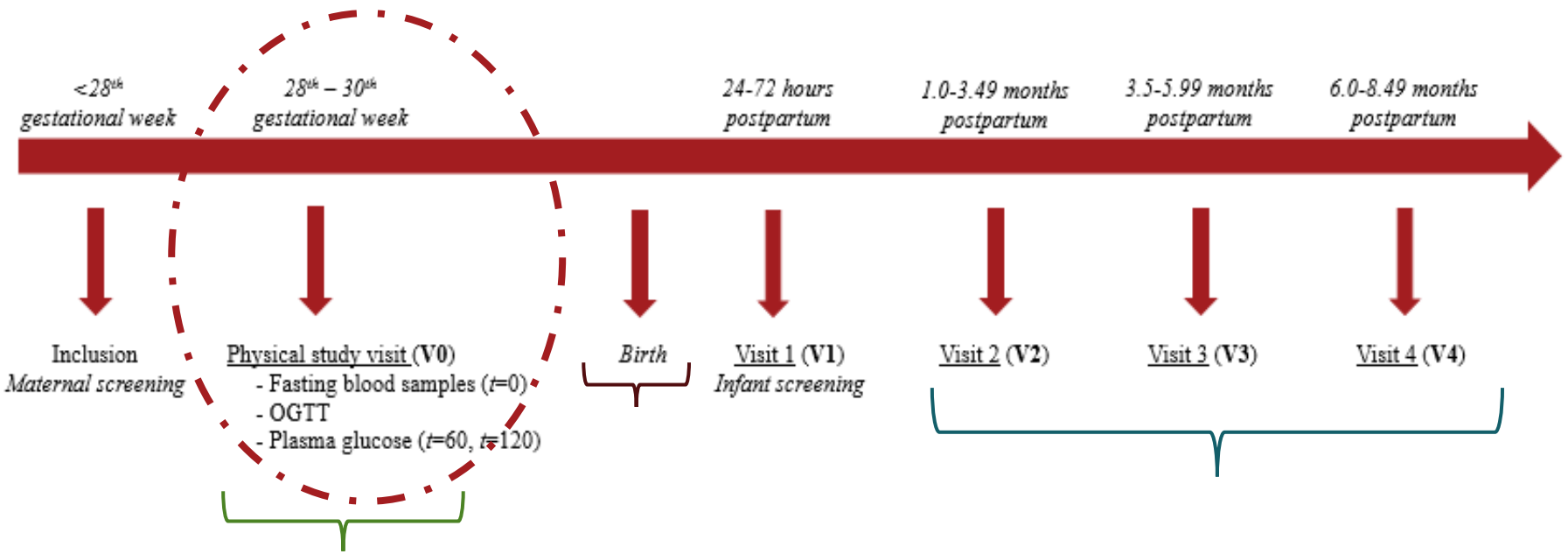
## Associations between maternal adiposity and appetite-regulating hormones in human milk are mediated through maternal circulating concentrations and might affect infant outcomes

Sophie Hilario Christensen[1]*, Jack Ivor Lewis[1], Anni Larnkjær[1], Hanne Frøkiær[2], Lindsay H. Allen[3], Christian Mølgaard[1] and Kim F. Michaelsen[1]

# MAIN FINDINGS ***Paper I***



# MAIN FINDINGS *Paper II*




**Pregnancy biomarkers (exposure)**

*Inflammatory*:
hsCRP, TNF-α, IFN-γ, IL-1β, IL-6, IL-8

*Lipid*:
LDL, VLDL, HDL, triglycerides, total cholesterol

*Metabolic*:
insulin, c-peptide, leptin, adiponectin, glucose ($t$=0, $t$=120, HOMA-IR)

**Birth outcomes**

- ✓ Gestational age at birth
- ✓ Birthweight z-score
- ✓ Placenta weight

**Breastfeeding outcomes**

- ✓ Duration of EBF
- ✓ Human milk intake
- ✓ Human milk concentrations

# *Associations between inflammatory, lipid and metabolic markers and **birth-related outcomes***

**Table 3.** Associations between inflammatory, lipid and metabolic markers measured in maternal plasma at gestational week 28-30 and pregnancy outcomes.

| | a) Gestational age at birth (weeks) | | | b) Birthweight z-score | | | c) Placental weight (g) | | |
|---|---|---|---|---|---|---|---|---|---|
| Gestational markers | β | 95% CI | *p*-value | β | 95% CI | *p*-value | β | 95% CI | *p*-value |
| *Lipid* | | | | | | | | | |
| HDL (mmol/L) | -1.14 | -2.12 – -0.15 | **0.03** | -0.92 | -1.51 – -0.33 | **<0.01** | -52.17 | -144.03 – 39.69 | 0.26 |
| LDL (mmol/L) | 0.06 | -0.32 – 0.44 | 0.76 | -0.01 | -0.24 – 0.22 | 0.93 | 20.23 | -14.54 – 54.99 | 0.25 |
| Log-VLDL | 0.01 | -0.21 – 0.24 | 0.90 | 0.13 | -0.00 – 0.27 | *0.052* | 22.17 | 1.90 – 42.43 | **0.03** |
| Total cholesterol (mmol/L) | 0.00 | -0.40 – 0.41 | 1.00 | -0.06 | -0.30 – 0.18 | 0.63 | 16.32 | -21.73 – 54.36 | 0.39 |
| Triglyceride (mmol/L) | 0.30 | -0.43 – 1.03 | 0.42 | 0.60 | 0.17 – 1.03 | **<0.01** | 98.51 | 36.94 – 160.08 | **<0.01** |
| *Metabolic* | | | | | | | | | |
| Leptin (ng/mL) | 0.00 | -0.03 – 0.04 | 0.77 | 0.01 | -0.01 – 0.03 | 0.49 | 1.18 | -1.82 – 4.18 | 0.44 |
| Adiponectin (µg/mL) | 0.16 | -0.19 – 0.51 | 0.37 | -0.20 | -0.41 – 0.01 | *0.065* | -15.87 | -47.50 – 15.76 | 0.32 |
| Insulin (pmol/L) | -0.00 | -0.02 – 0.01 | 0.73 | 0.00 | -0.01 – 0.01 | 0.73 | 0.10 | -1.63 – 1.83 | 0.91 |
| c-peptide (pmol/L) | 0.00 | -0.00 – 0.00 | 0.61 | 0.00 | -0.00 – 0.00 | 0.21 | 0.11 | -0.14 – 0.36 | 0.39 |
| Glucose (mmol/L) (OGTT, *t*=0) | 0.46 | -0.54 – 1.45 | 0.36 | 0.55 | -0.04 – 1.15 | *0.067* | -2.77 | -91.86 – 86.32 | 0.95 |
| Glucose (mmol/L) (OGTT, *t*=120) | -0.04 | -0.39 – 0.31 | 0.82 | 0.22 | 0.03 – 0.41 | **0.03** | -8.98 | -40.17 – 22.21 | 0.57 |
| HOMA-IR | -0.01 | -0.48 – 0.46 | 0.97 | 0.11 | -0.23 – 0.45 | 0.51 | 4.62 | -45.48 – 54.73 | 0.85 |

*Models were adjusted for the following covariates: a) maternal pre-pregnancy BMI, age and parity; b) maternal pre-pregnancy BMI, age, parity and infant sex; and c) maternal pre-pregnancy BMI, age and parity. p-values in bold indicate significance (p<0.05), and p-values in italic indicate borderline significance (p<0.1).*
*HDL = High-Density Lipoprotein; HOMA-IR = Homeostasis Model Assessment of Insulin Resistance; hsCRP = high-sensitive C-Reactive Protein ; IFNγ = Interferon-γ; IL = Interleukin; LDL = Low-Density Lipoprotein; OGTT = Oral Glucose Tolerance Test; TNFα = Tumor-Necrosis Factor-α; VLDL = Very Low-Density Lipoprotein*

# *Associations between inflammatory, lipid and metabolic markers and **breastfeeding outcomes***

**Table 4.** Associations between inflammatory, lipid and metabolic markers measured in maternal plasma at gestational week 28-30 and breastfeeding outcomes.

| | a) Duration of EBF (months) | | | b) Human milk intake (mL/kg) | | | c) Human milk marker (conc.) | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Gestational markers*** | β | 95% CI | *p*-value | β | 95% CI | *p*-value | β | 95% CI | *p*-value |
| *Inflammatory* | | | | | | | | | |
| Log-hsCRP | 0.21 | -0.38 – 0.79 | 0.48 | -6.81 | -19.70 – 6.07 | 0.30 | - | - | - |
| Log-TNFα | -0.06 | -0.51 – 0.39 | 0.80 | -1.58 | -10.86 – 7.69 | 0.74 | -0.04 | -0.32 – 0.25 | 0.80 |
| Log-IFNγ | 0.06 | -0.23 – 0.35 | 0.70 | 1.18 | -4.80 – 7.16 | 0.70 | -0.23 | -0.53 – 0.06 | 0.12 |
| Log-IL6 | -0.15 | -0.56 – 0.26 | 0.46 | 0.63 | -8.71 – 9.96 | 0.90 | -0.09 | -0.46 – 0.28 | 0.63 |
| Log-IL8 | -0.08 | -0.43 – 0.27 | 0.64 | -3.06 | -10.77 – 4.65 | 0.43 | -0.21 | -0.77 – 0.34 | 0.45 |
| *Lipid* | | | | | | | | | |
| HDL (mmol/L) | 1.03 | 0.07 – 2.00 | **0.04** | 19.47 | -1.81 – 40.75 | *0.07* | - | - | - |
| LDL (mmol/L) | 0.06 | -0.26 – 0.38 | 0.70 | 5.44 | -1.31 – 12.20 | 0.11 | - | - | - |
| Log-VLDL | 0.11 | -0.10 – 0.32 | 0.31 | 2.38 | -2.13 – 6.89 | 0.30 | - | - | - |
| Total cholesterol (mmol/L) | 0.20 | -0.16 – 0.55 | 0.27 | 11.17 | 2.35 – 19.98 | **0.01** | - | - | - |
| Triglyceride (mmol/L) | 0.36 | -0.33 – 1.05 | 0.29 | 2.48 | -13.15 – 18.10 | 0.75 | - | - | - |
| *Metabolic* | | | | | | | | | |
| Leptin (ng/mL) | 0.03 | 0.00 – 0.06 | **0.048** | -0.01 | -0.70 – 0.67 | 1.0 | 0.03 | 0.00 – 0.06 | **0.031** |
| Adiponectin (µg/mL) | -0.08 | -0.37 – 0.22 | 0.60 | 1.46 | -4.85 – 7.77 | 0.65 | 0.18 | 0.06 – 0.30 | **<0.01** |
| Insulin (pmol/L) | 0.02 | 0.00 – 0.04 | **0.03** | -0.44 | -0.87 – -0.02 | **0.04** | 0.00 | -0.01 – 0.01 | 0.92 |
| c-peptide (pmol/L) | 0.00 | 0.00 – 0.00 | 0.12 | -0.03 | -0.08 – 0.02 | 0.27 | - | - | - |
| Glucose (mmol/L) (OGTT, t=0) | 0.50 | -0.43 – 1.42 | 0.29 | 14.44 | -4.10 – 32.99 | 0.13 | - | - | - |
| Glucose (mmol/L) (OGTT, t=120) | -0.24 | -0.52 – 0.03 | 0.08 | 0.13 | -5.81 – 6.07 | 0.97 | - | - | - |
| HOMA-IR | 0.68 | 0.17 – 1.20 | **0.01** | -1.34 | -11.97 – 9.28 | 0.80 | - | - | - |

*IFNγ = Interferon-γ; IL = Interleukin; LDL = Low-Density Lipoprotein; OGTT = Oral Glucose Tolerance Test; TNFα = Tumor-Necrosis Factor-α; VLDL = Very Low-Density Lipoprotein*

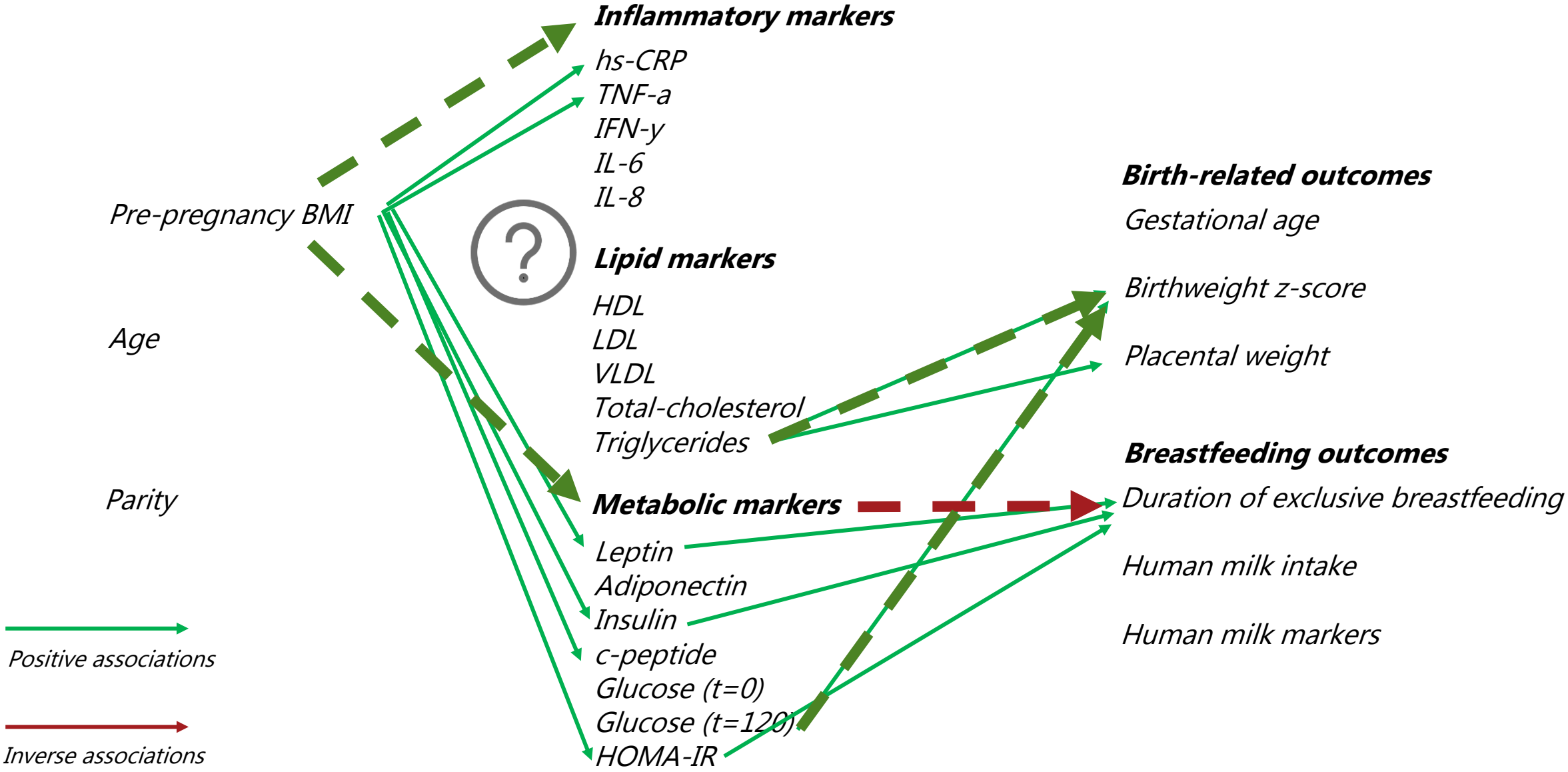
# ***Predictors*** *of inflammatory, lipid and metabolic markers in pregnancy*

**Table 5.** Maternal predictors of inflammatory, lipid and metabolic markers measured at gestational week 28-30.

| | Maternal pre-pregnancy BMI | | | Maternal age | | | Parity | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Gestational markers*** | β | 95% CI | *p*-value | β | 95% CI | *p*-value | β | 95% CI | *p*-value |
| *Inflammatory* | | | | | | | | | |
| Log-hsCRP | 0.10 | 0.04 – 0.16 | **<0.01** | -0.00 | -0.05 – 0.04 | 0.90 | 0.36 | -0.04 – 0.76 | *0.076* |
| Log-TNFα | 0.10 | 0.01 – 0.18 | **0.03** | 0.00 | -0.05 – 0.06 | 0.88 | 0.41 | -0.16 – 0.97 | 0.15 |
| Log-IFNγ | 0.10 | -0.01 – 0.21 | *0.068* | -0.00 | -0.08 – 0.07 | 0.95 | -0.07 | -0.80 – 0.66 | 0.85 |
| Log-IL6 | 0.07 | -0.01 – 0.16 | *0.076* | -0.03 | -0.08 – 0.03 | 0.38 | 0.09 | -0.46 – 0.65 | 0.73 |
| Log-IL8 | 0.04 | -0.05 – 0.12 | 0.40 | -0.04 | -0.10 – 0.02 | 0.24 | 0.21 | -0.36 – 0.79 | 0.47 |
| *Lipid* | | | | | | | | | |
| HDL (mmol/L) | -0.02 | -0.05 – 0.01 | 0.24 | -0.00 | -0.03 – 0.02 | 0.82 | 0.05 | -0.17 – 0.28 | 0.63 |
| LDL (mmol/L) | -0.03 | -0.12 – 0.07 | 0.57 | 0.00 | -0.06 – 0.07 | 0.93 | 0.01 | -0.60 – 0.62 | 0.98 |
| *Metabolic* | | | | | | | | | |
| Leptin (ng/mL) | 2.41 | 1.31 – 3.51 | **<0.001** | -1.26 | -2.02 – -0.50 | **<0.01** | 5.42 | -1.78 – 12.61 | 0.14 |
| Adiponectin (µg/mL) | -0.09 | -0.19 – 0.01 | *0.089* | 0.00 | -0.06 – 0.07 | 0.90 | 0.07 | -0.58 – 0.72 | 0.84 |
| Insulin (pmol/L) | 5.04 | 2.95 – 7.13 | **<0.001** | -1.74 | -3.20 – -0.28 | **0.02** | -4.65 | -18.72 – 9.43 | 0.51 |
| c-peptide (pmol/L) | 33.25 | 20.38 – 46.12 | **<0.001** | -7.15 | -16.07 – 1.77 | 0.11 | -14.39 | -98.98 – 70.20 | 0.74 |
| Glucose (mmol/L) (OGTT, *t*=0) | 0.02 | -0.02 – 0.05 | 0.35 | 0.03 | 0.01 – 0.06 | **0.02** | -0.03 | -0.26 – 0.21 | 0.83 |
| Glucose (mmol/L) (OGTT, *t*=120) | 0.07 | -0.04 – 0.17 | 0.24 | -0.00 | -0.08 – 0.07 | 0.92 | -0.19 | -0.85 – 0.48 | 0.58 |
| HOMA-IR | 0.16 | 0.09 – 0.24 | **<0.001** | -0.03 | -0.08 – 0.02 | 0.21 | -0.17 | -0.68 – 0.33 | 0.49 |

*Models included all three covariates: maternal pre-pregnancy BMI (kg/m$^2$), age (years) and parity (nulliparous vs. multiparous). p-values in bold indicate significance (p<0.05), and p-values in italic indicate borderline significance (p<0.1).HDL = High-Density Lipoprotein; HOMA-IR = Homeostasis Model Assessment of Insulin Resistance; hsCRP = high-sensitive C-Reactive Protein ; IFNγ = Interferon-γ; IL = Interleukin; LDL = Low-Density Lipoprotein; OGTT = Oral Glucose Tolerance Test; TNFα = Tumor-Necrosis Factor-α; VLDL = Very Low-Density Lipoprotein*

# Conclusion & Discussion



# MAIN FINDINGS *Paper III*

Cytokines and appetite-regulating hormones in human milk and associations with infant growth across four sites: The Mothers, Infants and Lactation Quality Study

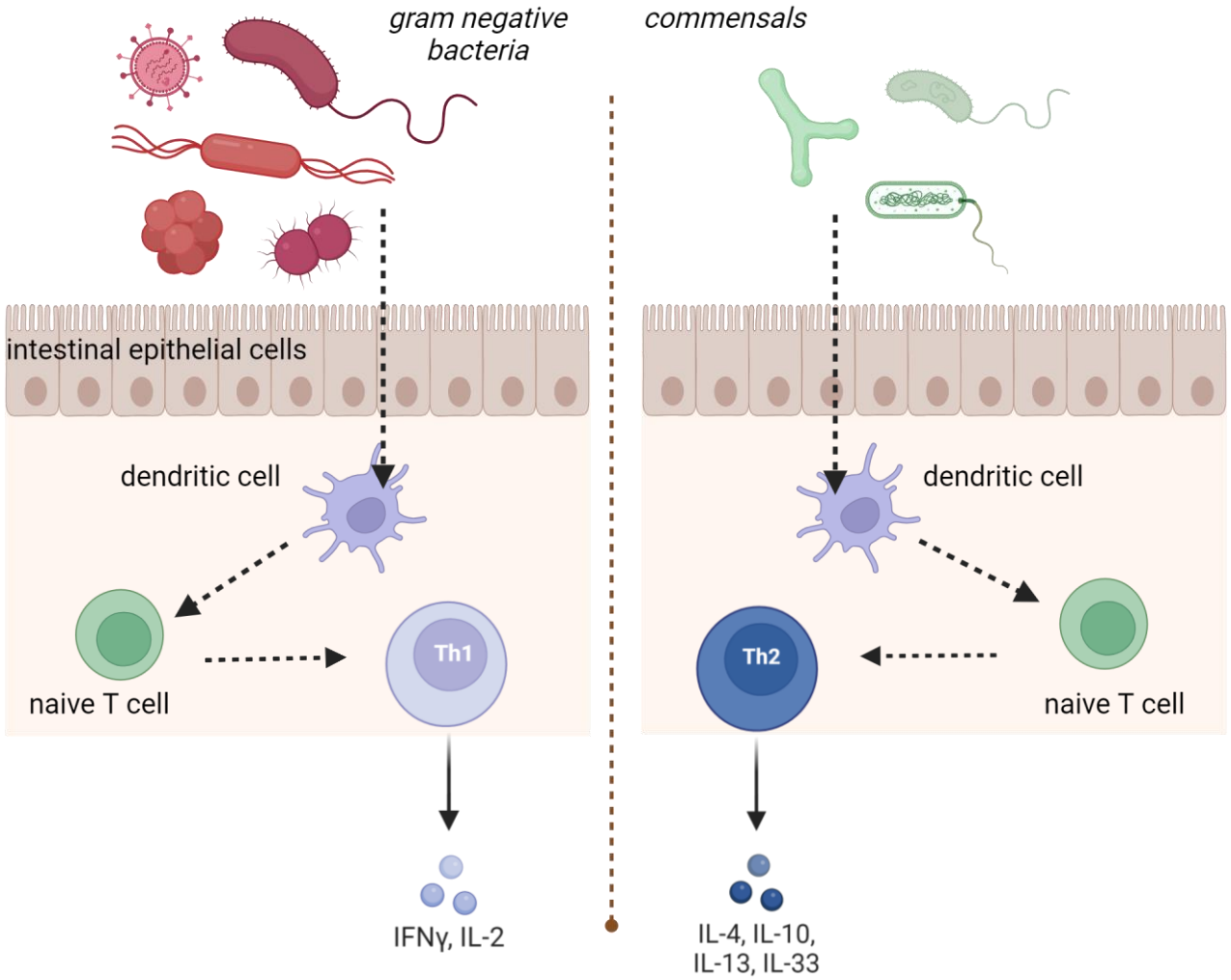
Sophie Hilario Christensen[1], Jack Ivor Lewis[1], Hanne Frøkiær[2], Peter Riber Johnsen[2], Janet Peerson[3], Xiuping Tan[4], Setereh Shahab-Ferdows[3], Daniela Hampel[3,4], Munirul Islam[5], Gilberto Kac[6], Daniela de Barros Mucci[7], Amanda C Cunha Figueiredo[6], Sophie E. Moore[8,9], Christian Mølgaard[1], Lindsay H Allen[3,4], Kim F Michaelsen[1]

**Aim**

1. To compare HM composition between sites
2. To associate HM composition with infant growth

- Human milk samples collected at 1-3.5 months (*n*=820) from all sites

# MAIN FINDINGS ***Paper III***






*Adapted from Zhang et al. 2022 & Jahnavi Konduru 2022*

# OUTLINE

Discussion & conclusion

Other findings from the MILQ study

Findings from PhD study

The MILQ study

Background for research area

1.

2.

3.

4.

5.

**Strengths & limitations**

**Paper I**

**Paper II**

**Paper III**



Obesity and low-grade inflammation during pregnancy and lactation

→ Why and how is the evidence lacking?

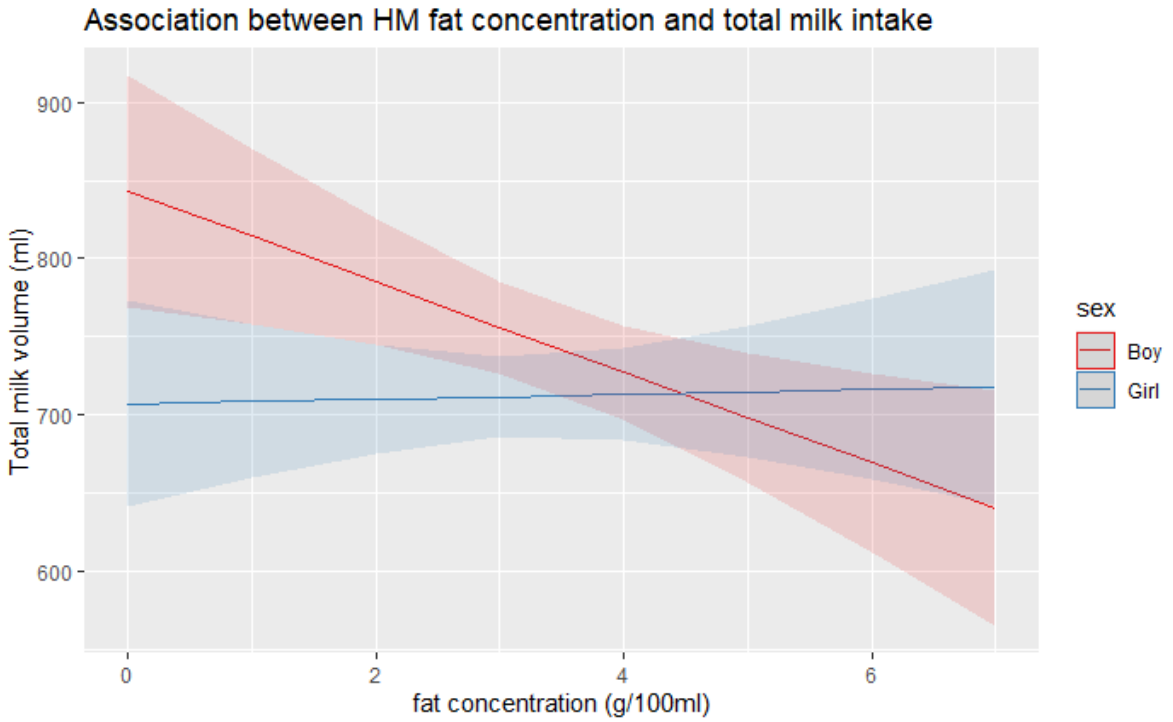
# OTHER FINDINGS FROM THE MILQ STUDY

- Subclinical mastitis → *does SCM affect HM volume or composition?*

# OTHER FINDINGS FROM THE MILQ STUDY

- Subclinical mastitis → *does SCM affect HM volume or composition?*
- HM macronutrients → *do concentrations affect infant growth?*
- HM volume → *do volumes affect infant growth? or HM macros?*

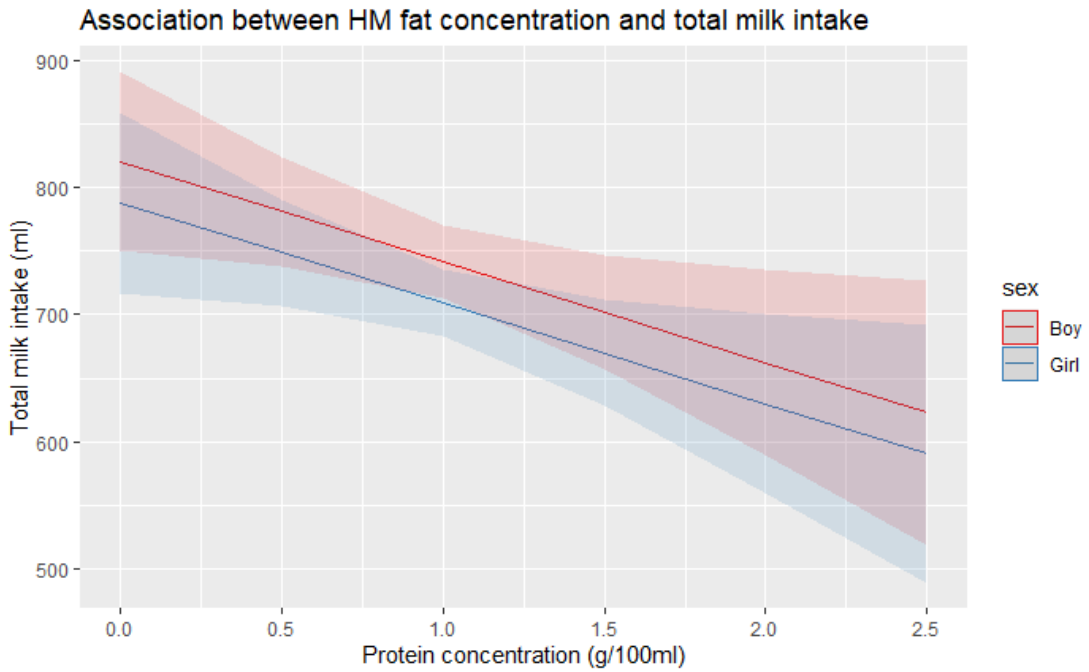
# HUMAN MILK VOLUME AND MACRONUTRIENTS




***Boys**:-30.7 ml per g fat per 100 ml (p=0.002)*

***Girls**: 3.1 ml per g fat per 100 ml (p=0.8)*

# HUMAN MILK VOLUME AND MACRONUTRIENTS




*-78.7 ml per g protein per 100 ml (p=0.012)*

# OTHER FINDINGS FROM THE MILQ STUDY

- Subclinical mastitis → *does SCM affect HM volume or composition?*
- HM macronutrients → *do concentrations affect infant growth?*
- Milk volume → *do concentrations affect infant growth? or milk volume?*
- HMO → *do concentrations affect infant growth?*

# HUMAN MILK OLIGOSACCHARIDES

To be continued...

# OTHER FINDINGS FROM THE MILQ STUDY

- Subclinical mastitis → *does SCM affect HM volume or composition?*
- HM macronutrients → *do concentrations affect infant growth?*
- Milk volume → *do concentrations affect infant growth? or milk volume?*
- HMO → *do concentrations affect infant growth?*
- Iodine → *iodine excretion through HM*

# OTHER FINDINGS FROM THE MILQ STUDY

- Subclinical mastitis → *does SCM affect HM volume or composition?*
- HM macronutrients → *do concentrations affect infant growth?*
- Milk volume → *do concentrations affect infant growth? or milk volume?*
- HMO → *do concentrations affect infant growth?*
- Iodine → *iodine excretion through urine vs. HM*
- Milk RNA → *characterizing the interplay between HM bacteria, HM cytokines, morbidity incl. SCM, milk volume and breastfeeding outcomes*

# OUTLINE

Discussion & conclusion

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**Strengths & limitations**

**Paper I**

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**Paper III**



Obesity and low-grade inflammation during pregnancy and lactation

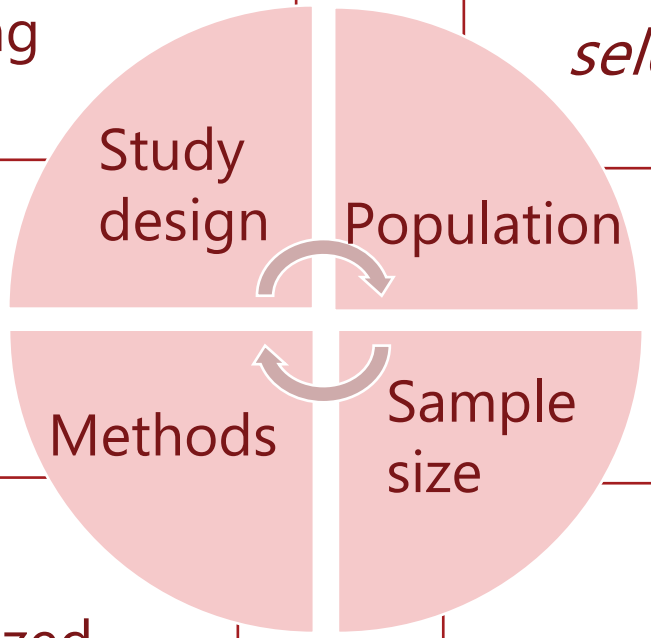
→ Why and how is the evidence lacking?

# STRENGHTS & LIMITATIONS

Strong longitudinal design – but still a risk of confounding

A healthy population

*selection bias?*




Standardized protocols

**Paper III**

**Paper II**

# TAKE HOME MESSAGE

- Overweight and/or inflammation in pregnancy and lactation may affect birth outcomes and HM composition → e
- Implications for the infant are challenging
  - Absorption of components in the infant gut –
  - Infant's own production of appetite-regulating
  - Interplay between the above?
- Generalisability of results → very selected

TABLE 1 Participant characteristics at inclusion.

| Maternal characteristics | All ($n$ = 223) |
|---|---|
| Pre-pregnancy BMI (kg/m$^2$) | 22.5 (2.5) |
| BMI ≥ 25 kg/m$^2$ | 32 (14) |
| Gestational weight gain (kg) | 13.4 (4.4) |
| Age (years) | 31.5 (3.4) |
| **Higher education** | |
| Short (<3 years) | 15 (7) |
| Medium (3–4 years) | 51 (22) |
| Long (>4 years) | 161 (71) |
| **Household income (DKK**)** | |
| <500,000 | 34 (15) |
| 500,000–799,999 | 74 (33) |
| 800,000–999,999 | 71 (31) |
| >1,000,000 | 48 (21) |

# THANK YOU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**The MILQ families**
**The MILQ breastfeeding counsellors**

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