NICHD Global Health Conference:

Socio-ecological Factors & the Double Burden of Malnutrition among Children & Adolescents in Low- & Middle-Income Countries

The Double Burden of Malnutrition: Targets for Interventions & Future Directions

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Outline

Observational & intervention (RCT) results, with selected results relating to “multiple burden of malnutrition” – Guatemala as a case study

Impact of climate change (heat stress) reproductive outcomes & potential for nutritional mitigation

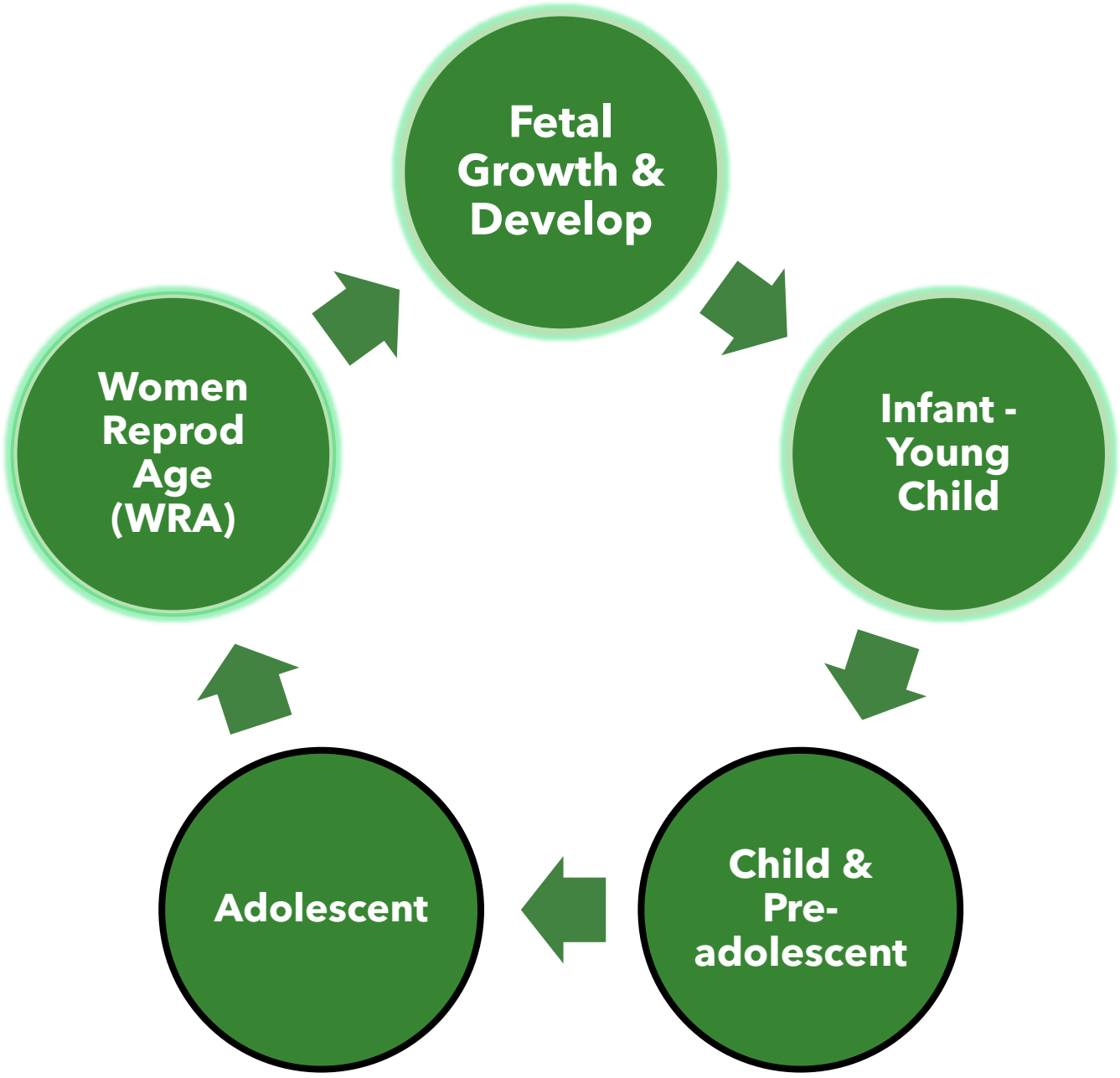
Implications for research agenda and next steps

~~Double~~ Multiple Burden of Malnutrition

aka

*"Global **Syndemic**: Obesity, Undernutrition, Climate Change"**

- Presumes risk "programming"
- "1000 days" set the stage & inform the origins of risk
- Each life-cycle stage gives clues to intervention points



*[Swinburn et al, Lancet 2019]

DBM Case Study: Western HiGuatemala

GN – MNHR: NICHD Global Network – Maternal & Neonatal Health Registry (8 countries)

Women First **(WF)** Preconception Nutrition Trial (4 countries)

Guatemala:

A country of civil war trauma, > 40% total population indigenous, improved economy, impact of climate change, & DBM

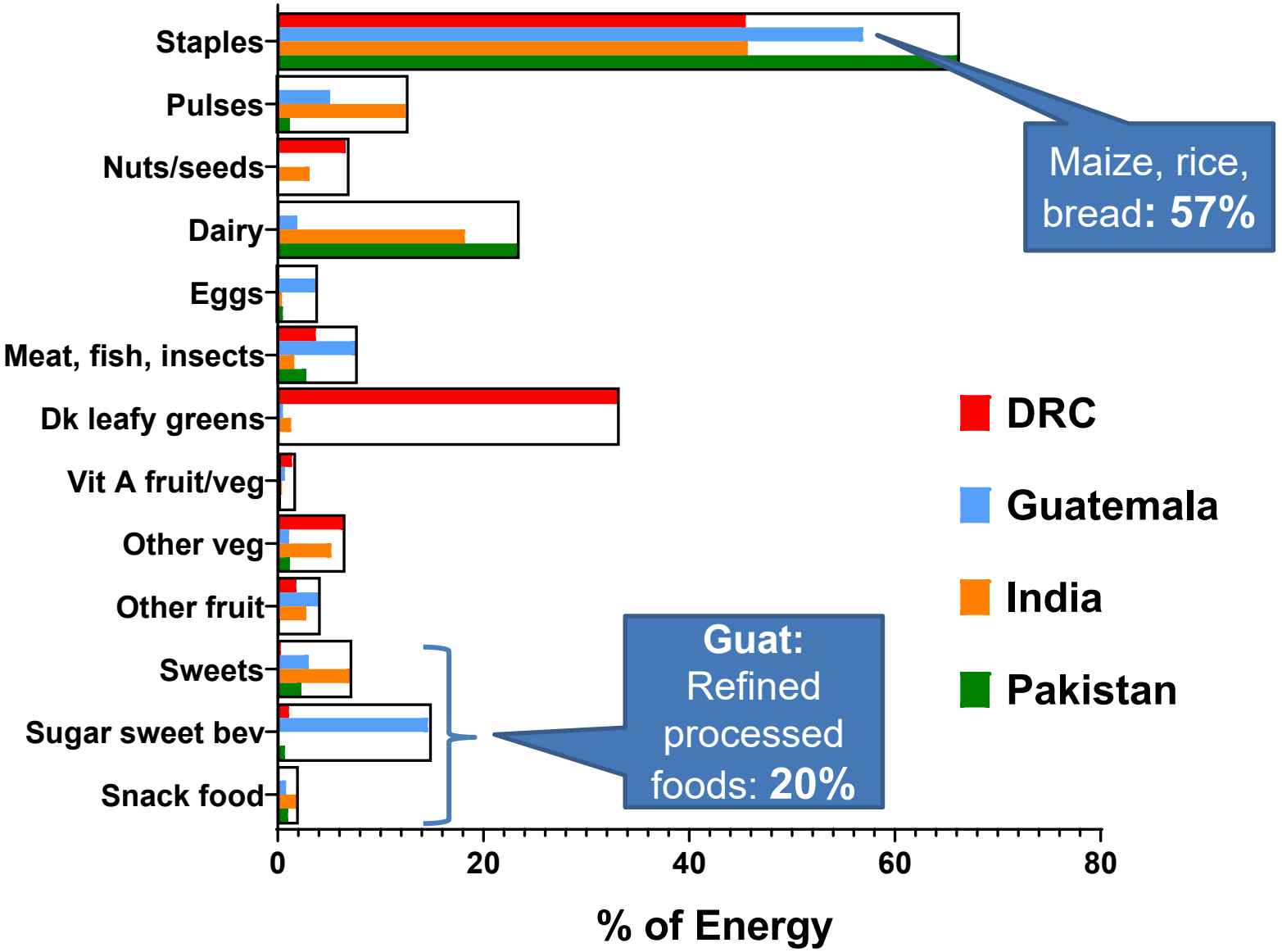
GN-MNHR Data: 2021

- Maternal Ht: 147 cm (70% < 150)
- Maternal Ed: < 7 yr 41%
  7-12 yr 42%
- BMI (pre-PG or 1st Trim)
  < 18.5 2%
  ≥ 25 51%
  Mean: 25.5
- Anemia (pre-PG): < 3%

WF at Enrollment (pre-PG)

- Maternal Ht: 145.6 cm (80% < 150)
- Maternal Ed: ≥ 1° 90%
- BMI
  < 18.5 1%
  ≥ 25 49%
  Mean: 25.5
- Waist Hip Ratio, > 0.85: 28%
- Anemia: 12%

Women First: % Energy by Food Groups



Guatemalan WF participants:

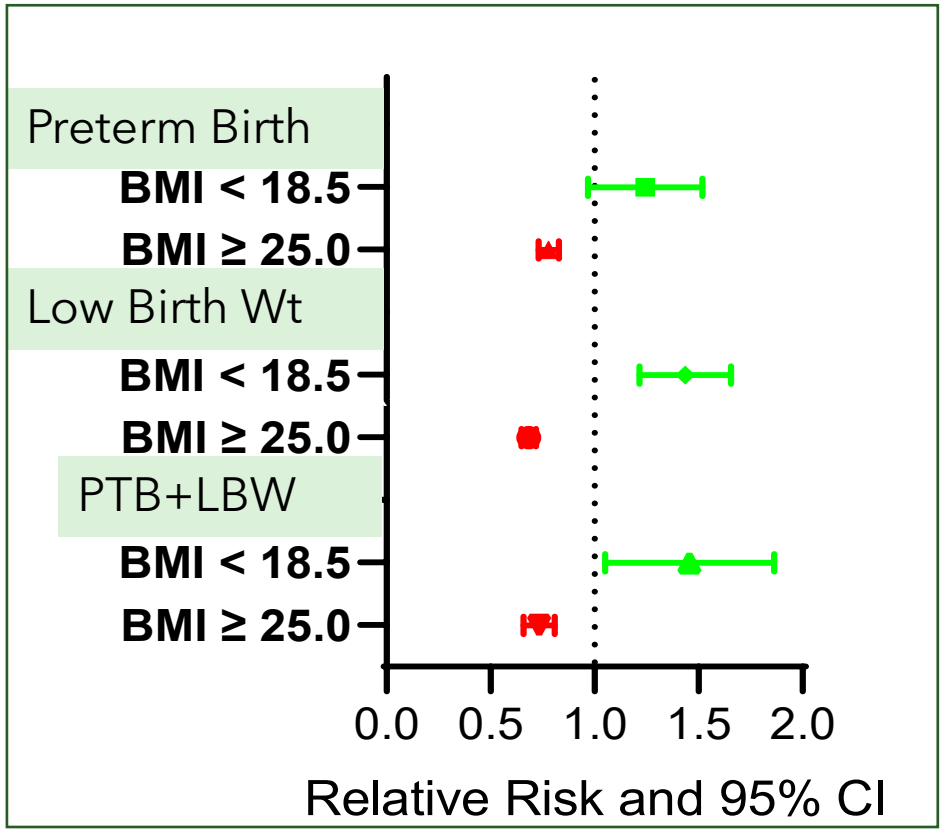
- ~50% had adequate DD
- Highest intakes of processed foods
- Highest caloric & protein intake

Lander et al, Nutrients, 2019

Birth Outcomes: Rates of Preterm Birth (PTB), LBW in Global Network, (2014 - 2018)

[Pusdekar, Reprod Health 2020]

272,192 live births (7 sites) PTB: 12.6% LBW: 13.6% PTB+LBW: 5.5%



Guatemala
(n=52,047)

Rates (%)
LBW: 15.6
Term + LBW: 10.7
PTB+ LBW: 5.4

Underweight associated w/ ↑ risk
Overweight associated w/ ↓ risk

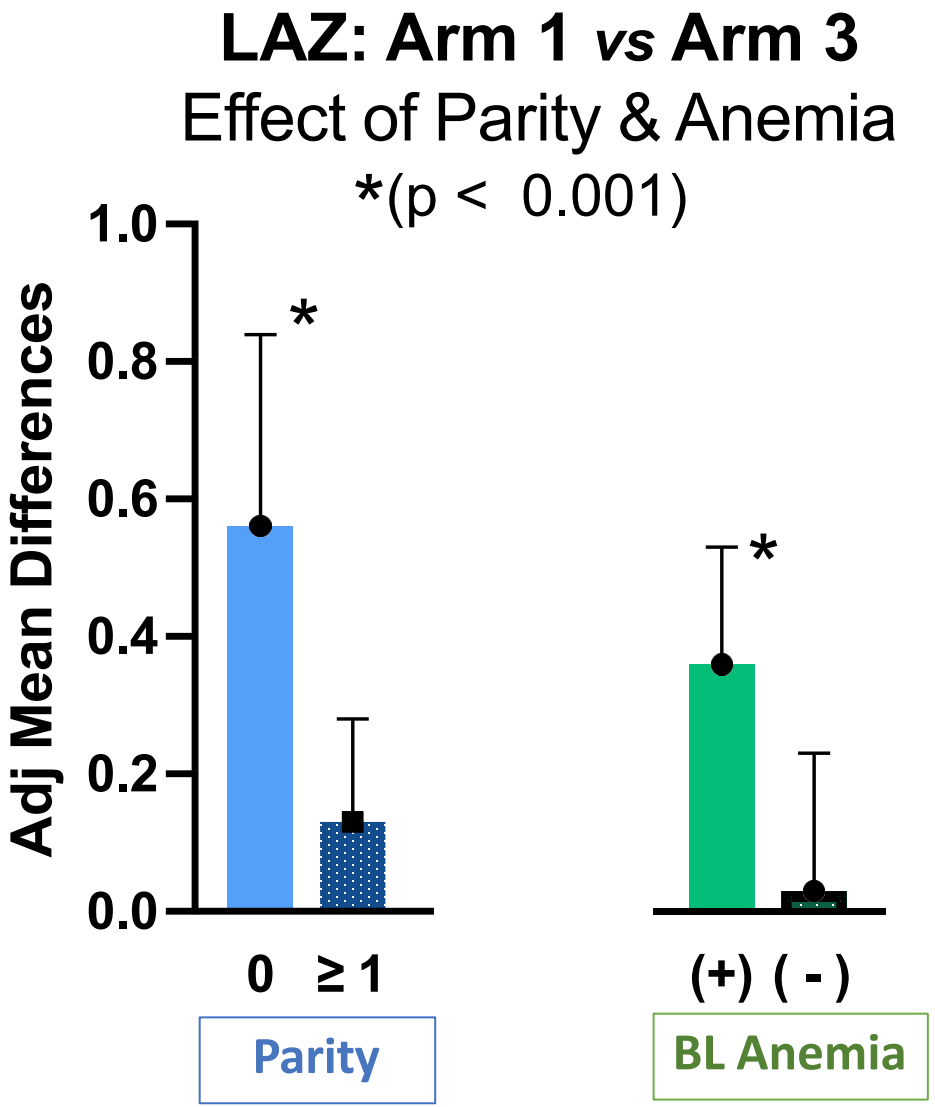
Women First Preconception Nutrition Trial: Key Results

- ↑ Birth length in preconception & early prenatal arms *cf* controls
- ↓ stunting at birth 31%; ↓ LBW; ↓ SGA 22%;
- Gestational weight gain (GWG): **"Adequate" GWG ➔higher birth length & weight** *(p < 0.001) (but 74% of women had "inadequate" GWG)**

- *Guatemala site demonstrated virtually none of the positive effects of the intervention…WHY?*

**[Bauserman, AJCN 2021]*

Effect Modifiers (3 sites w/ GA)



- Parity:
  - 21% nulliparous
  - Guatemala: 6% nulliparous
  - Response to LNS of P_0 = **4.3x** > $P_{\geq 1}$

- Anemia (Hb < 12 g/dL):
  - 59% at baseline
  - Guatemala: ~ 12%
  - Response to LNS ~ **12x** greater women anemic pre-pregnancy

Nutrients, 2019

Double Burden of Malnutrition – Role in Guatemala WF Results?

+ response in anemic ♀

Ow/Ob→↓ PTB & LBW

Few nulliparous or anemic

Ow/Ob & ↑ WHR

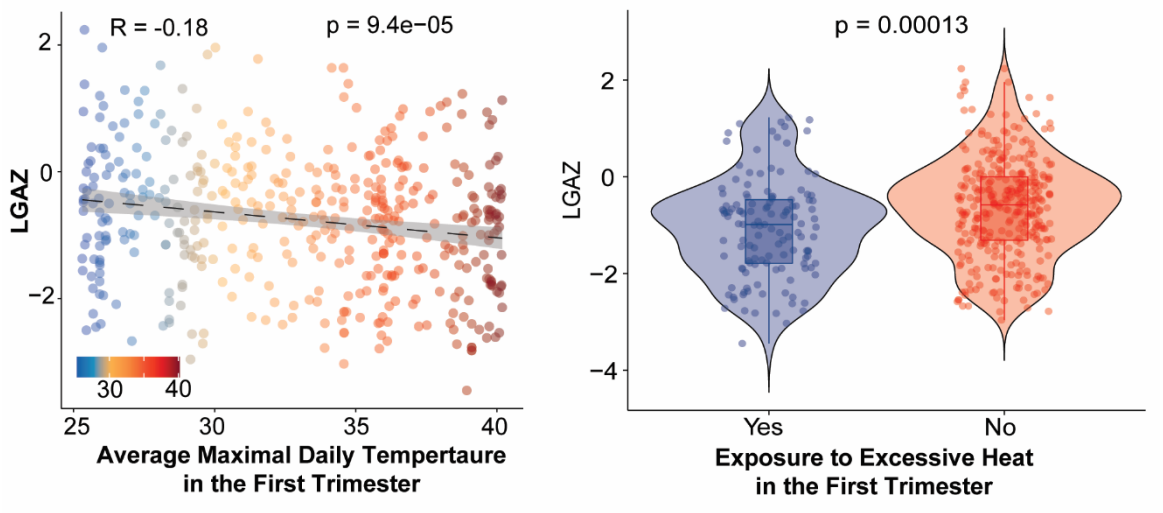
Profound maternal stunting

Diet – ↑ Simple CHO

Inflammation (sys + intest)

Stress/90% indigenous

What about the Syndemic?

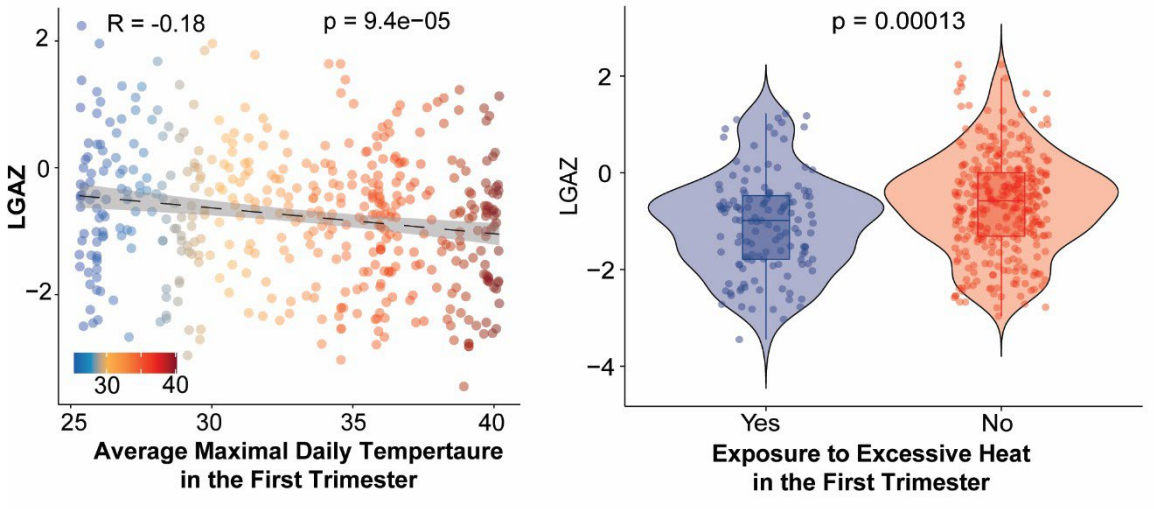


Effect of heat on birth length

- Each 5°C increase in T_{max} in 1st trimester →
  - LAZ ↓ 0.15 z-score
- Excessive heat stress (>20 d of >39ºC) associated with
  - Lower birth length ($p < 0.01$)

[Shankar et al, unpublished data]

Greater Ambient Temp in 1st trimester associated with fetal growth restriction; maternal nutrition may mitigate.



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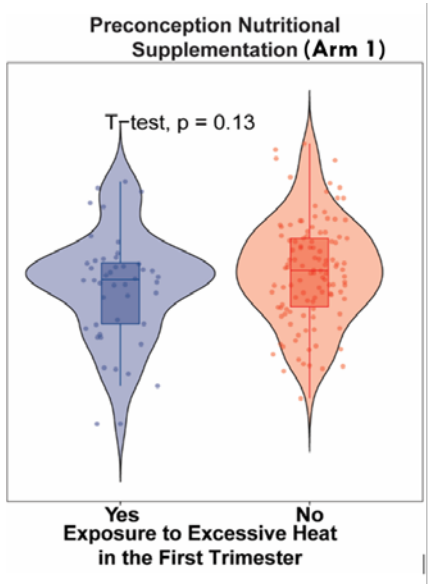
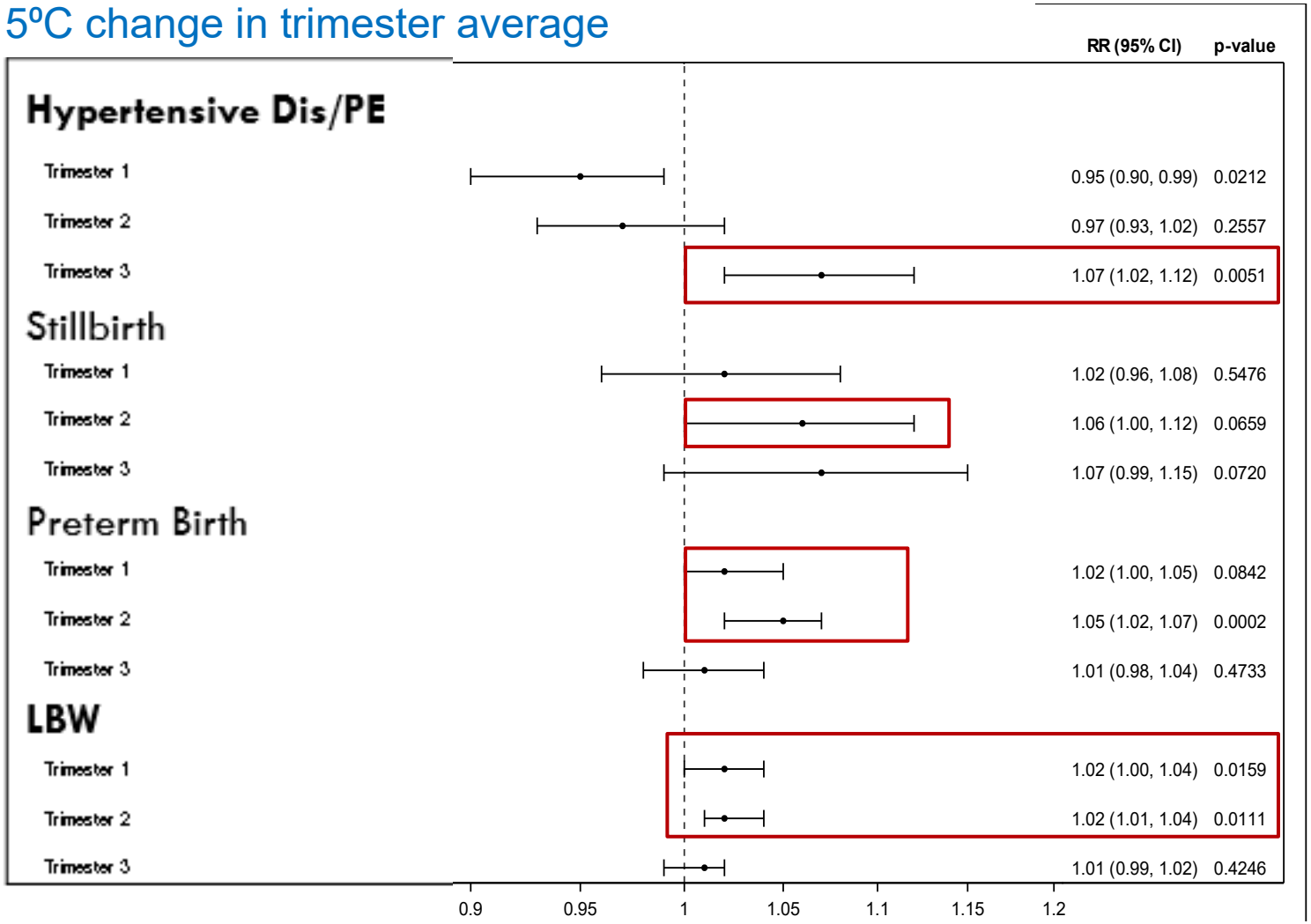


Preconception nutrition supplementation mitigated effect of heat stress

[Shankar et al, unpublished data]

GN-MNHR (So Asia sites, 2014-2020, n > 125,000):
Association of Avg Daily Max Temps by Trimester w/ OB & Fetal Outcomes

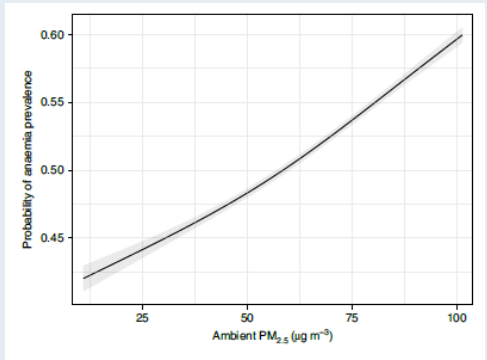
5ºC change in trimester average



[Shankar et al, unpublished data]

Effects of Heat Exposure on Obstetric & Fetal Outcomes Differ by Trimester

India: Anemia of pregnancy directly associated with air pollution ($PM_{2.5}$)

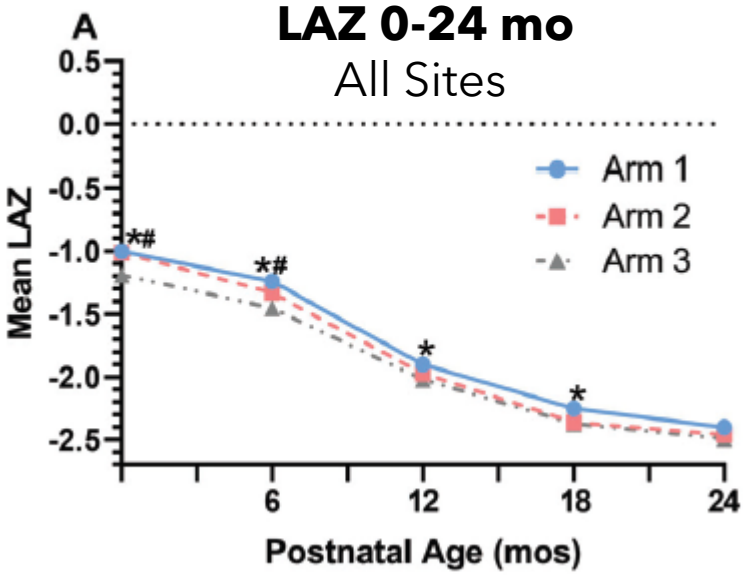


[Chaudhary, Nat Sustain, 2022]

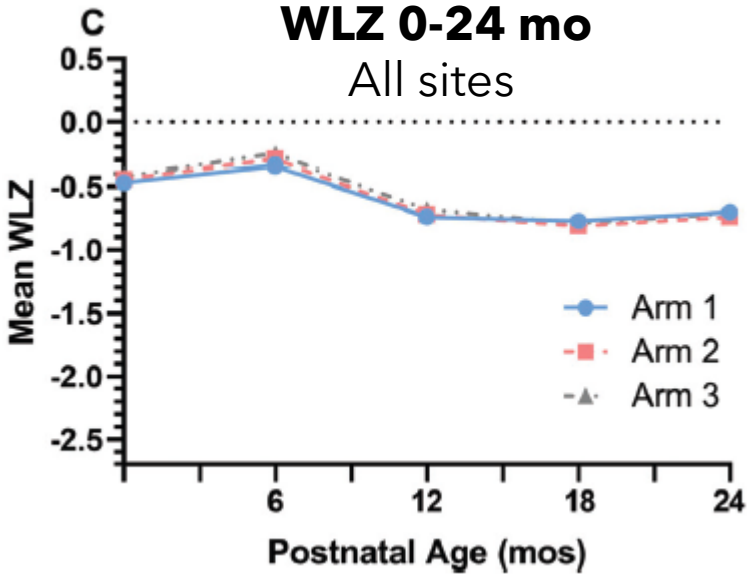
Infant Outcomes – A Link to DBM?

- Postnatal growth + Development

WF Offspring - sharp decline in LAZ after 6 mo; weight/length (WLZ) *lower* in stunted children



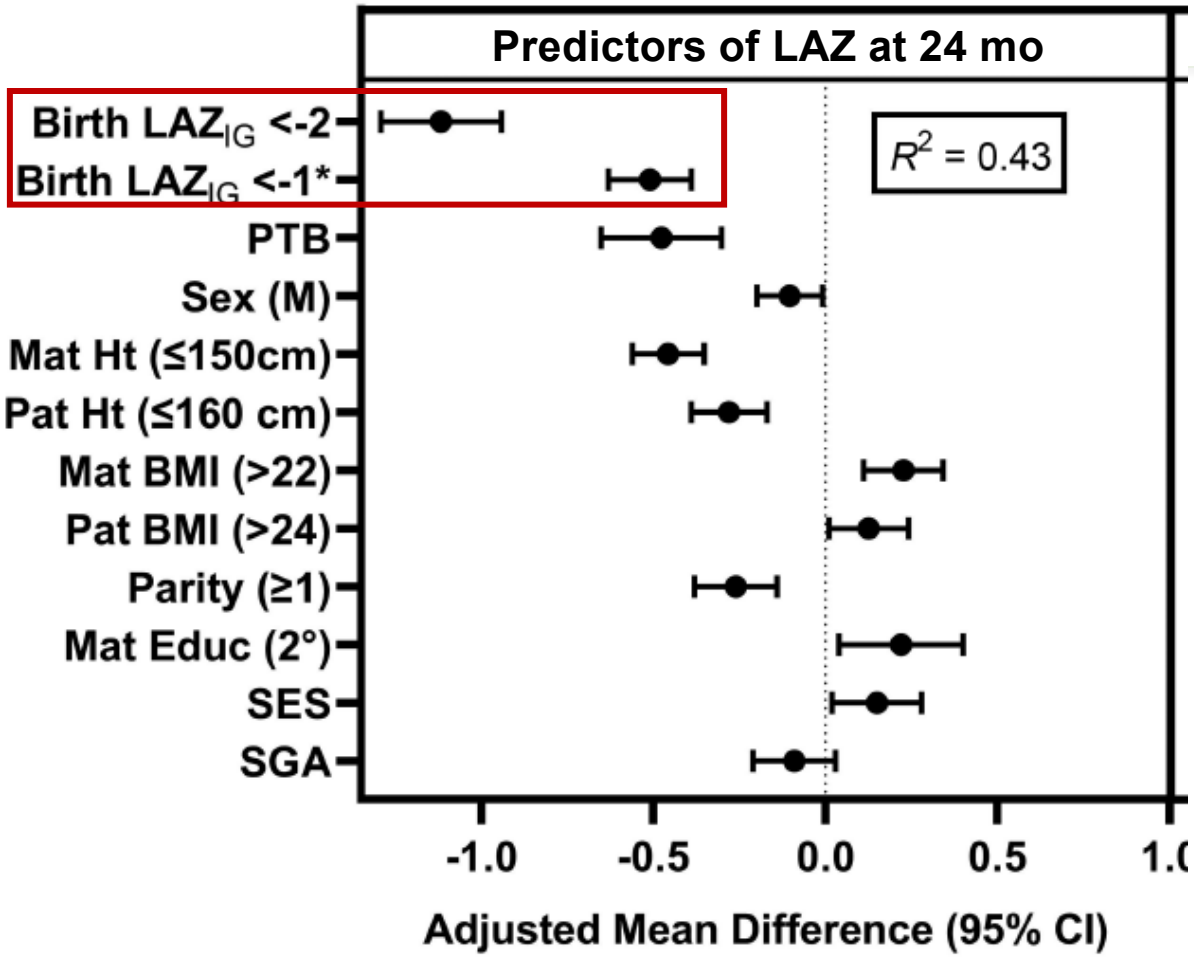
Stunting at 24 mo > 60%
(Guatemala 66%)



W/L > 95th: 1.07%
$WLZ_{24\ mo}$:
Stunting at 0,12 & 24 mo:
WLZ stunted < non-stunted

[Krebs, AJCN, 2022]

Predictors of LAZ & Stunting at 24 mo:
Birth LAZ , PTB & maternal height



[Krebs, AJCN, 2022]

DBM Perspective:

Maternal BMI & Education:
(+) assoc with LAZ (& ↓ stunting)

Neurodevelopment at 24 mo

- **4 variables** assoc w/ **all** domains:
  - Mat Educ
  - Δ $LAZ_{6\text{-}24\ mo}$
  - BW > 2500 g
  - FCI (play materials)

[Krebs, Curr Dev Nutr, 2022]

Evidence-Based Strategies to Address Global Syndemic

↑ PC nutrition of nullips**
Target GWG
(WASH)
↓ Heat Stress*

Fetal Growth & Develop

↑ Birth length**
↓ LBW / SGA
↓ PTB

Infant - Young Child

BF & CF**
(WASH)
Maternal Educ
Play materials

Child & Pre-adolescent

WASH, Diets, Education
↑ Growth (& pelvic diameter)*

Adolescent

↑ Education
↓ Anemia
↑ Growth*

Women Reprod Age (WRA)

↓ Anemia (↓PM2.5)
Improve diets*

* Research Topics
(** synergistic?)

Next steps

- Invest in longitudinal cohorts in LMIC to identify critical periods and conditions that drive development of DBM
- Apply multiple data sets to refine links of exposures & outcome
- Think holistically & multi-sectorally:
  → Biomedical *and* socioenvironmental

Acknowledgements:
NIH NICHD + ODS | Bill & Melinda Gates Foundation
Thrasher Research Foundation

Thank You!