NASEM Workshop on How Nutrition and Health Change over a Person's Life Course

Environmental Influences

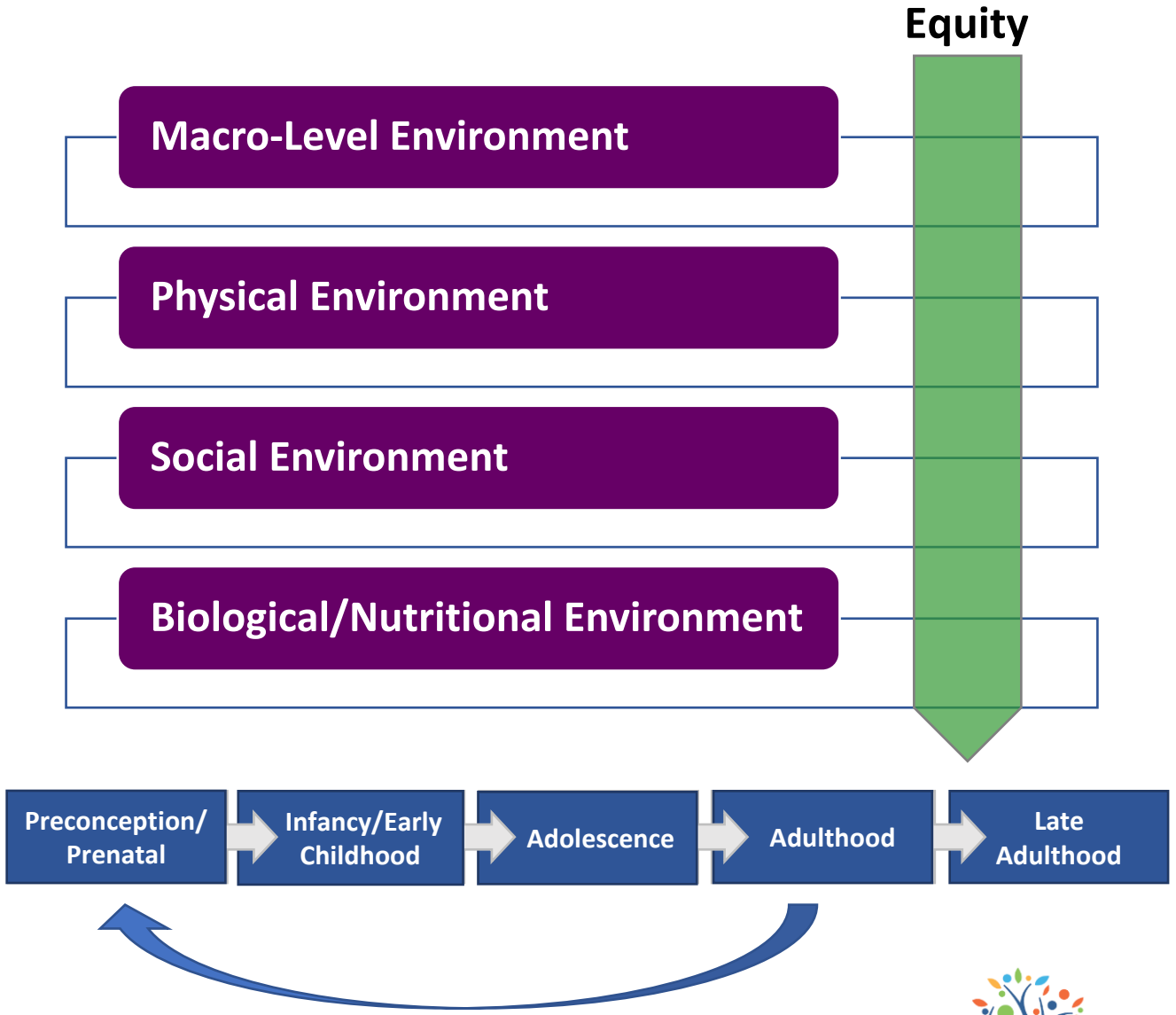
Matthew W. Gillman, MD, SM
Director, Environmental influences on Child Health Outcomes (ECHO)
Office of the Director, NIH
November 16, 2022

The opinions I express are not necessarily those of the NIH.

Influences at many environmental levels affect nutrition of individuals and populations…

…across the life course

Equity is a cross-cutting goal at all levels

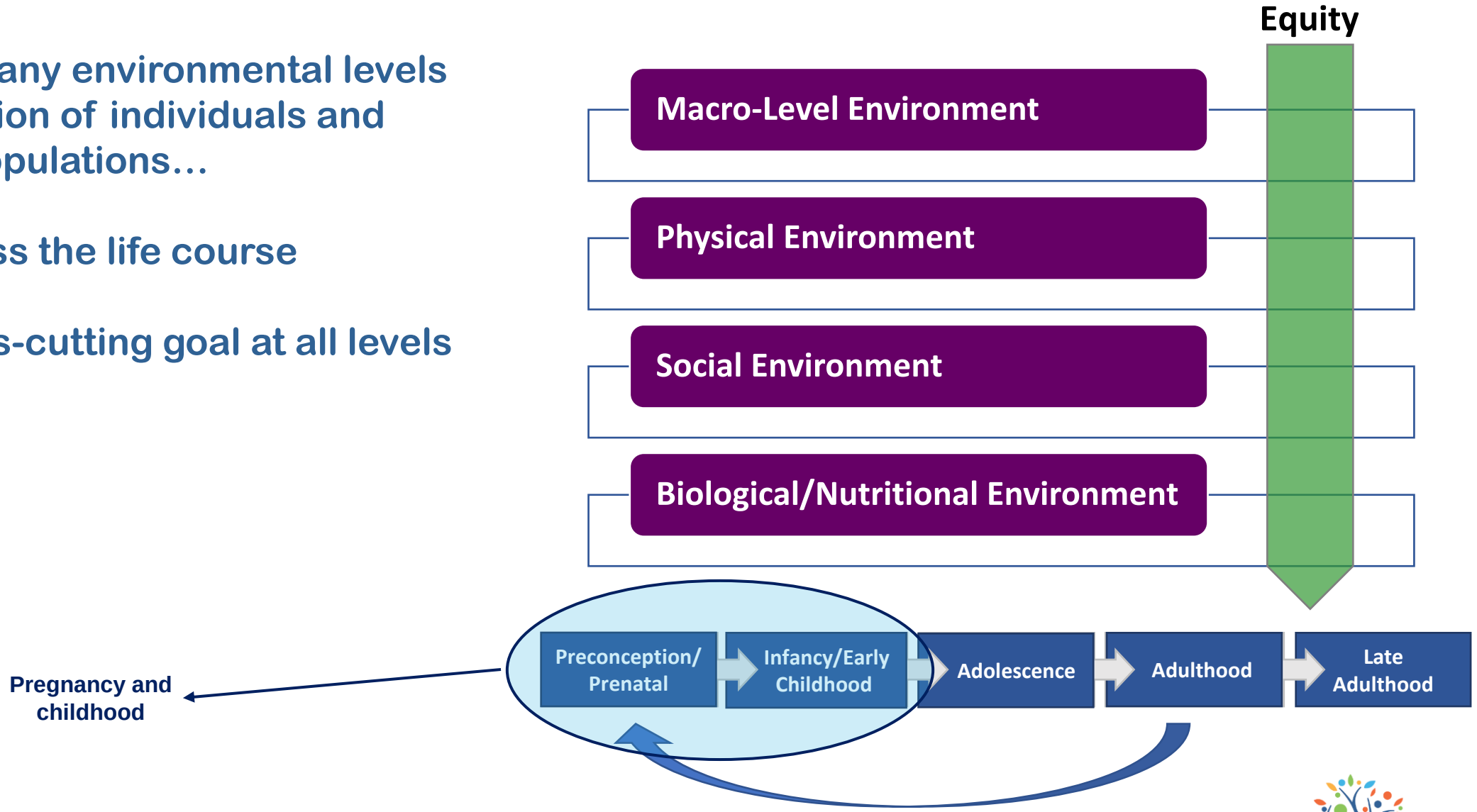


Adapted from Herman et al., Matern Child Health J. 2014;18(2):450-61

Influences at many environmental levels affect nutrition of individuals and populations…

…across the life course

Equity is a cross-cutting goal at all levels

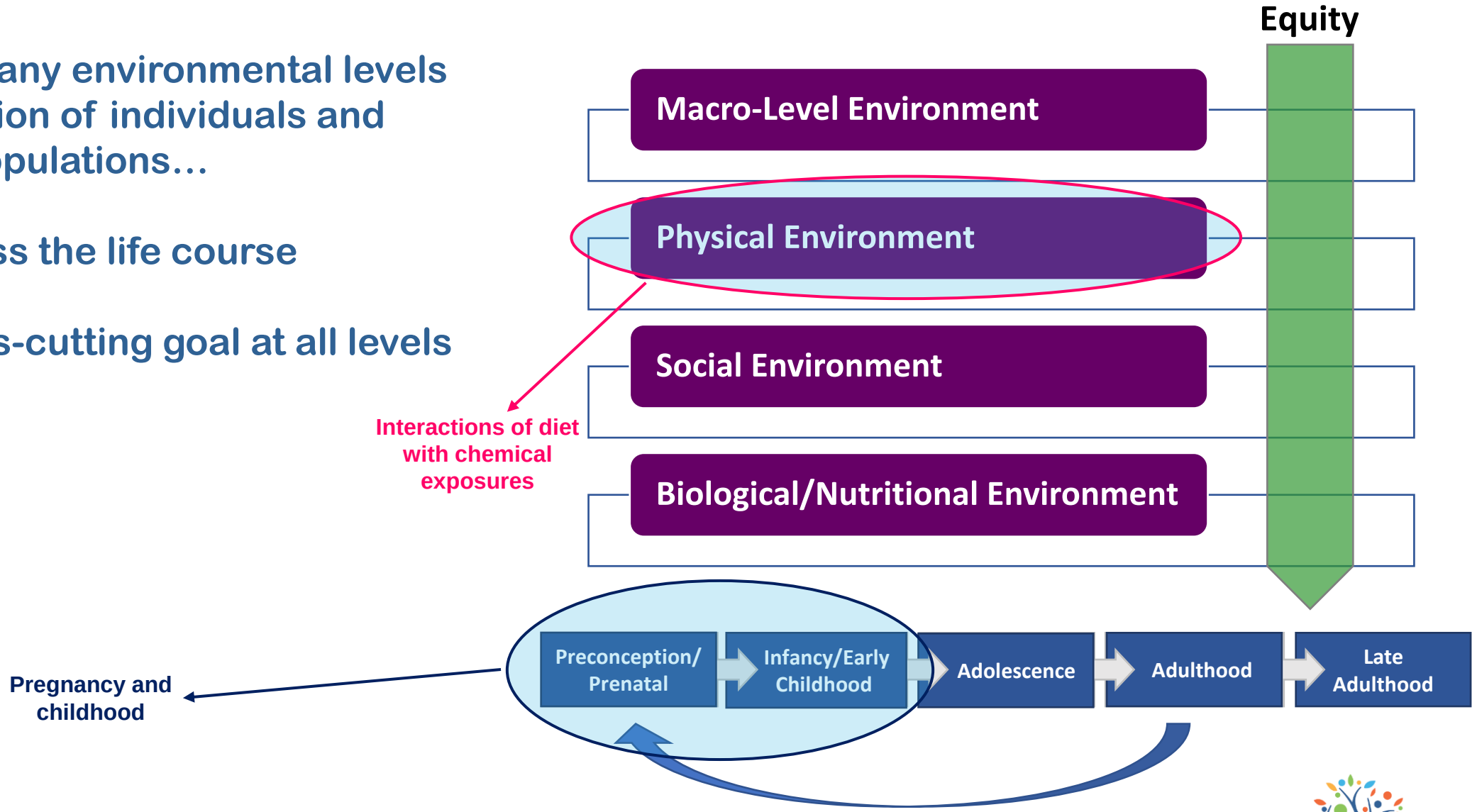


Adapted from Herman et al., Matern Child Health J. 2014;18(2):450-61

Influences at many environmental levels affect nutrition of individuals and populations…

…across the life course

Equity is a cross-cutting goal at all levels

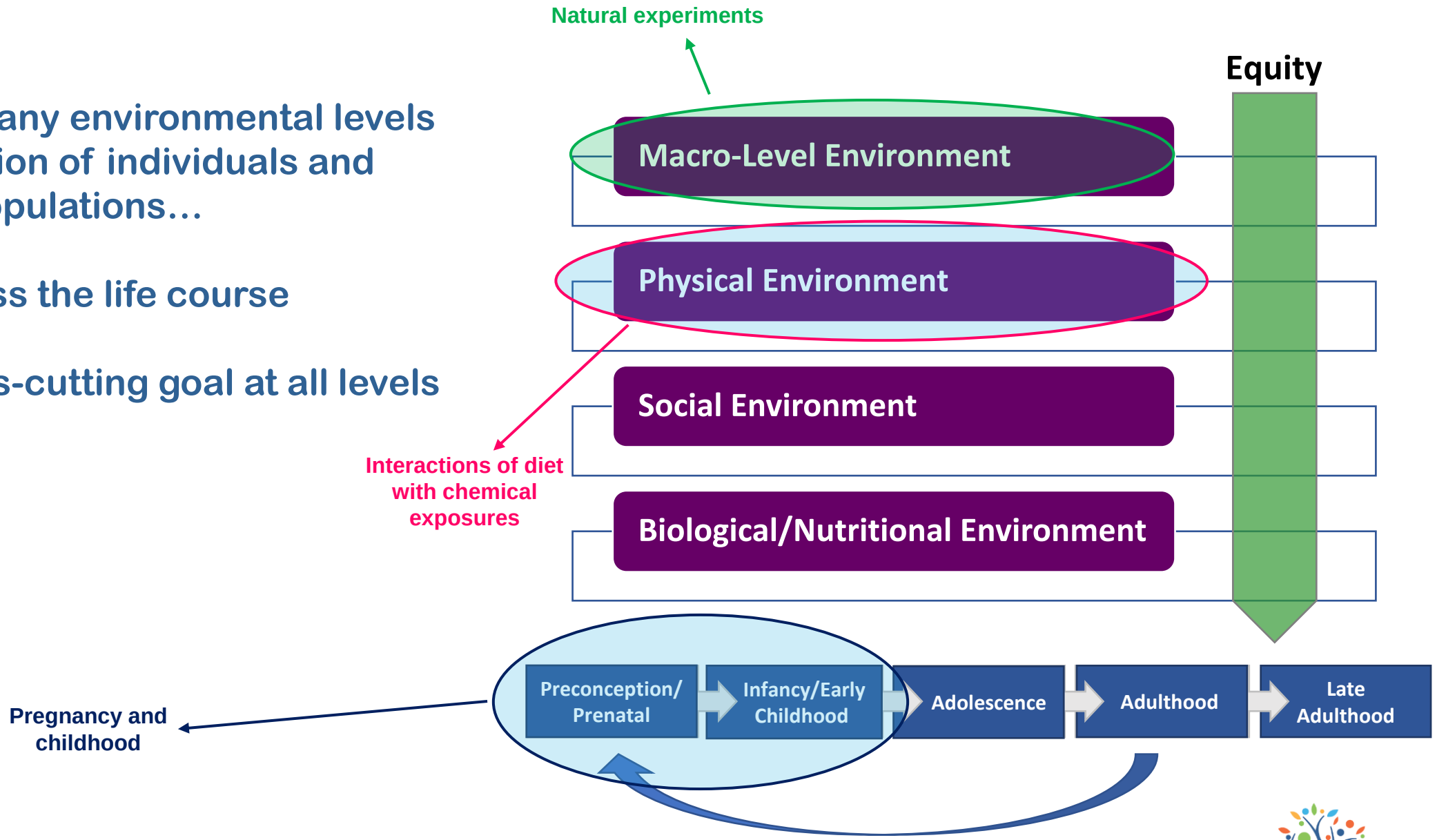


Adapted from Herman et al., Matern Child Health J. 2014;18(2):450-61

Influences at many environmental levels affect nutrition of individuals and populations…

…across the life course

Equity is a cross-cutting goal at all levels

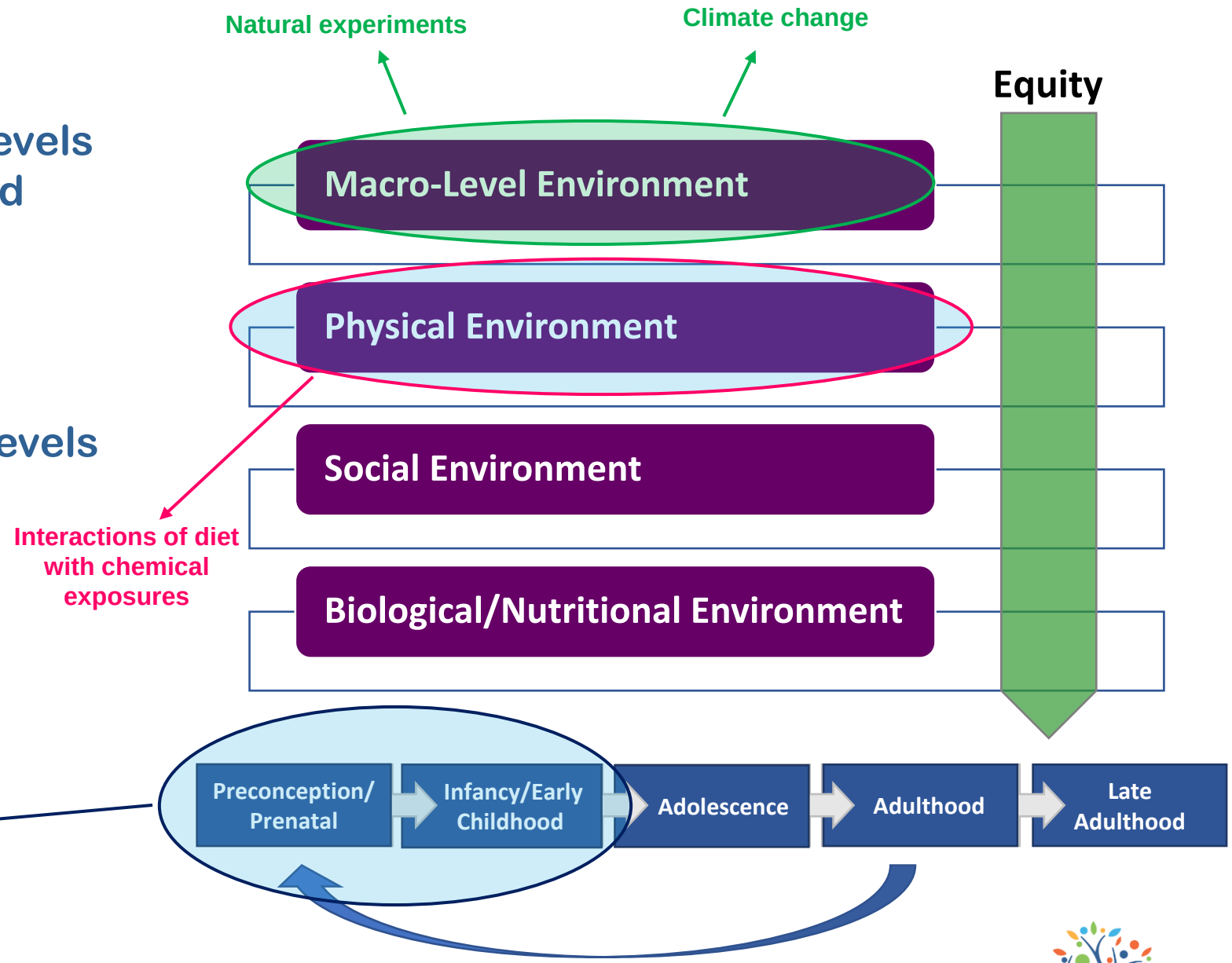


Adapted from Herman et al., Matern Child Health J. 2014;18(2):450-61

Influences at many environmental levels affect nutrition of individuals and populations…

…across the life course

Equity is a cross-cutting goal at all levels

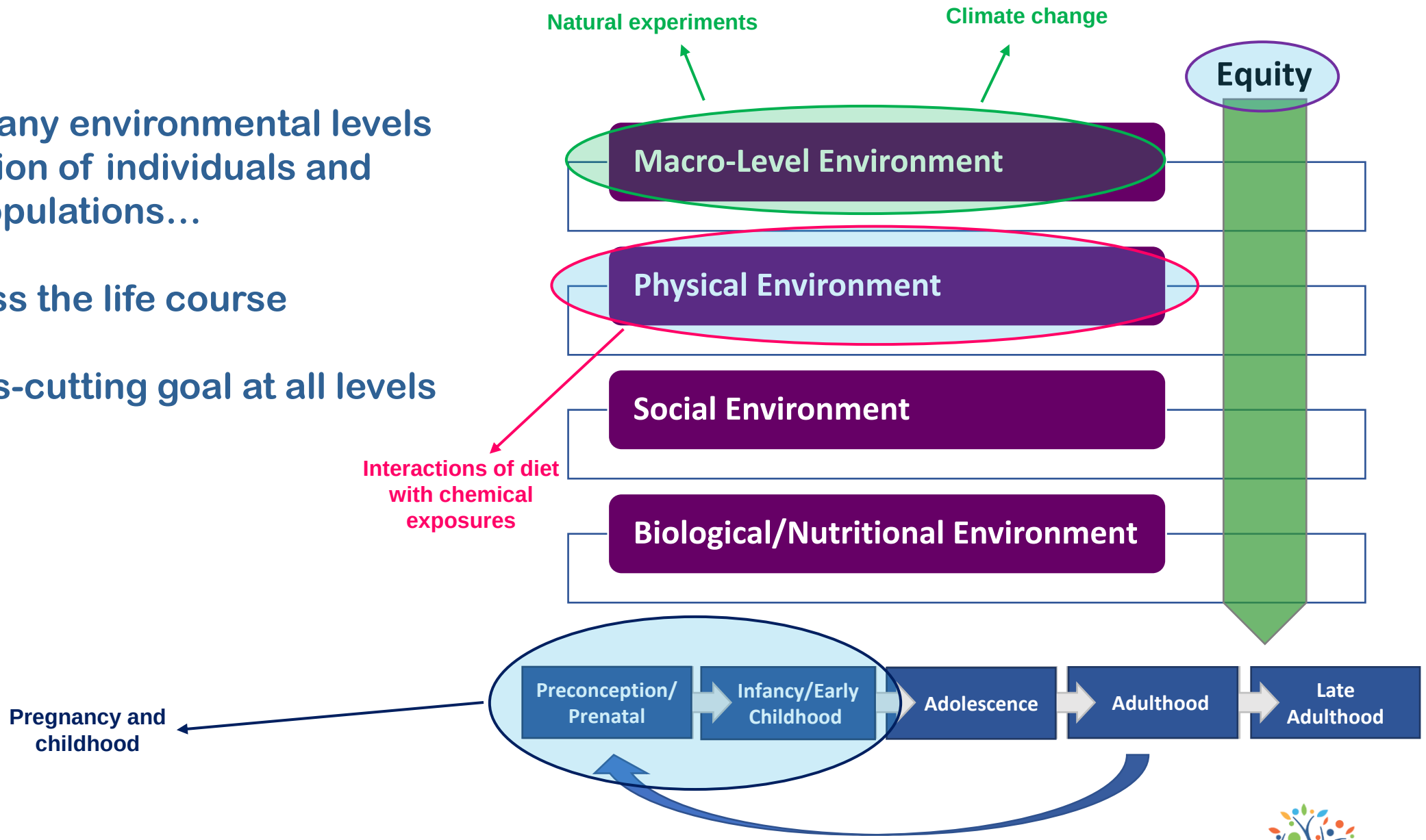


Adapted from Herman et al., Matern Child Health J. 2014;18(2):450-61

Influences at many environmental levels affect nutrition of individuals and populations…

…across the life course

Equity is a cross-cutting goal at all levels



Herman et al., Matern Child Health J. 2014;18(2):450-61

Why Pregnancy and Early Childhood

Early Exposures Have Lasting Effects

- Development is highly integrated process and sensitive time for exposure
  - Rapid Growth
  - Active and extensive cell differentiation
  - Developing immune system
  - Increased metabolic rate
  - Programming, e.g., via epigenetics

JOURNAL ARTICLE

The Pregnancy and Birth to 24 Months Project: a series of systematic reviews on diet and health FREE

Eve E Stoody ✉, Joanne M Spahn, Kellie O Casavale ✉

The American Journal of Clinical Nutrition, Volume 109, Issue Supplement_1, March 2019, Pages 685S–697S, https://doi.org/10.1093/ajcn/nqy372

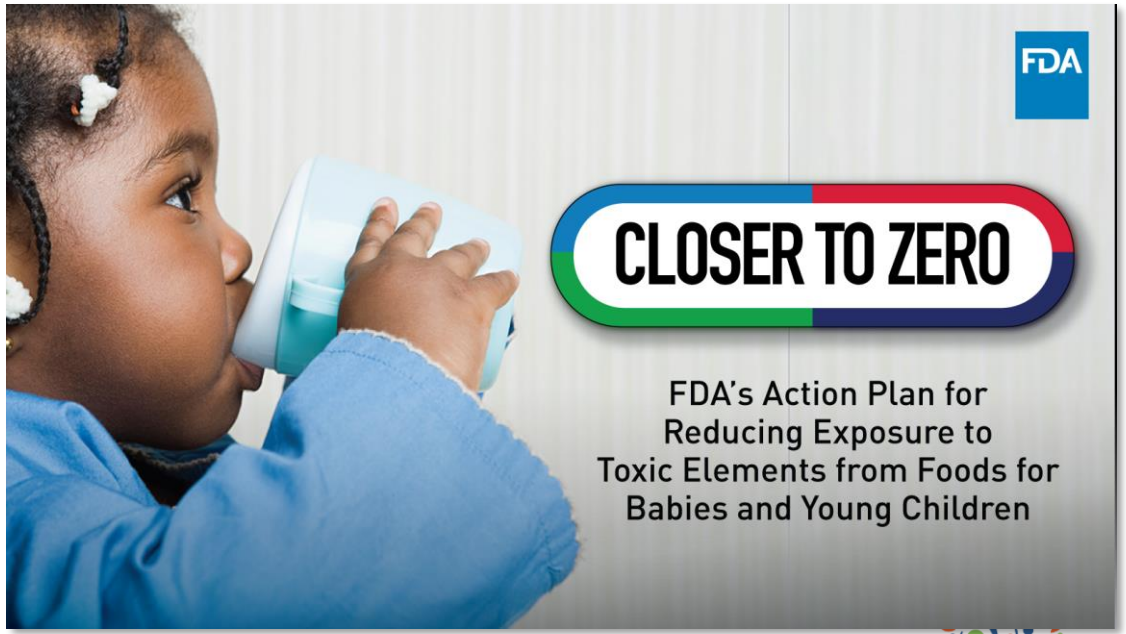
AJPH
A PUBLICATION OF THE AMERICAN PUBLIC HEALTH ASSOCIATION

Home | Articles | Authors

Home » American Journal of Public Health (AJPH) » **October 2022**

Nutrition in the 1000-Day Window: Biden–Harris Administration Setting the Foundation for the Health of Our Nation

Susan RicePhD



Environmental influences on Child Health Outcomes (ECHO)

Enhance the health of children for generations to come

ECHO Overall Scientific Goal

Answer **solution-oriented questions** about effects

of

broad range of **early environmental exposures**

on

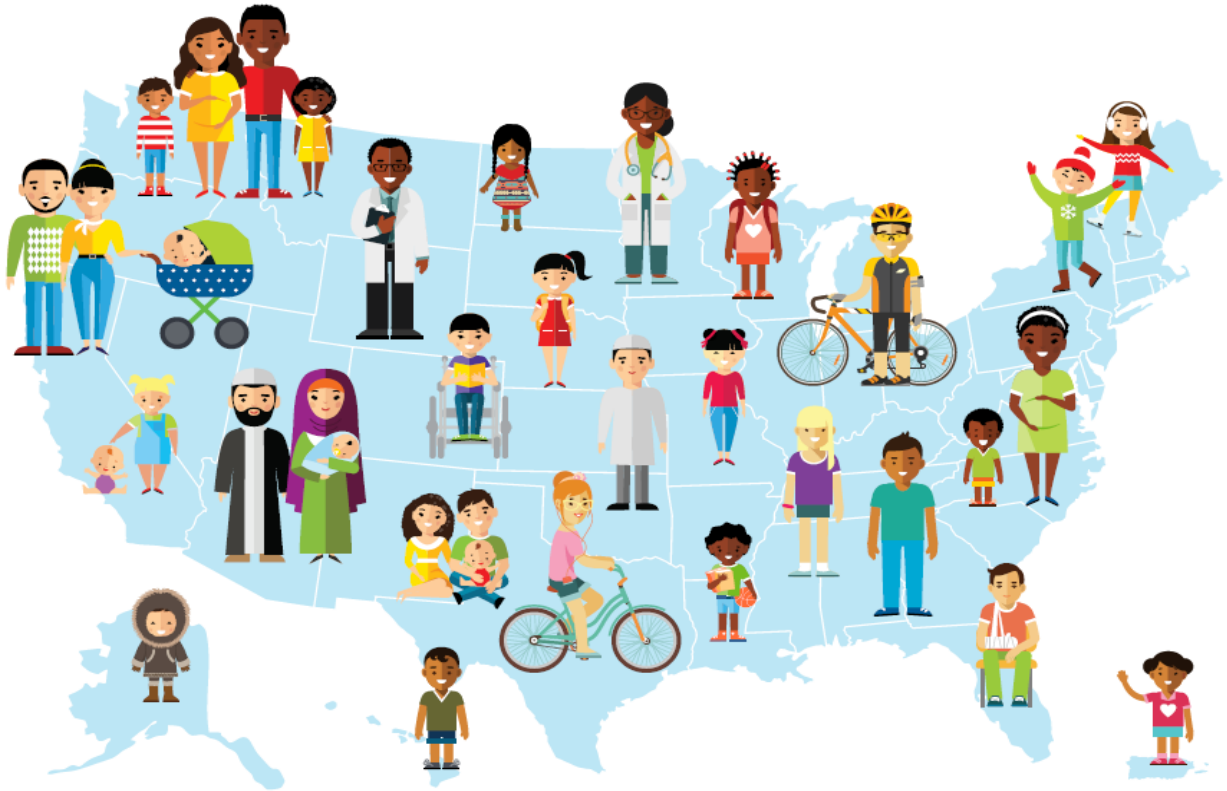
child health and development

ECHO-wide Cohort

Weaving together data from 69 ongoing maternal-child cohort studies

ECHO-wide Cohort

Diverse Geography, Sex, Age, SES, Race/Ethnicity



26% Hispanic
43% White
12% Black
4% Asian
3% AI/AN
4% More than one race
7% Unknown/not reported/other

Interactions of Diet with Chemical Exposures

- Exposure to chemicals via food
- Foods and nutrients as protectors against toxic chemicals

Why Chemicals Are in What We Eat

Environment & Production
Transfer of Chemicals to Food

Packaging & Processing
Transfer of Chemicals to Food

Global Food Trade

Human Exposure to Chemicals via Food

Adapted from Ng et al., Environ Health Perspect. 2017;125(1):1-7

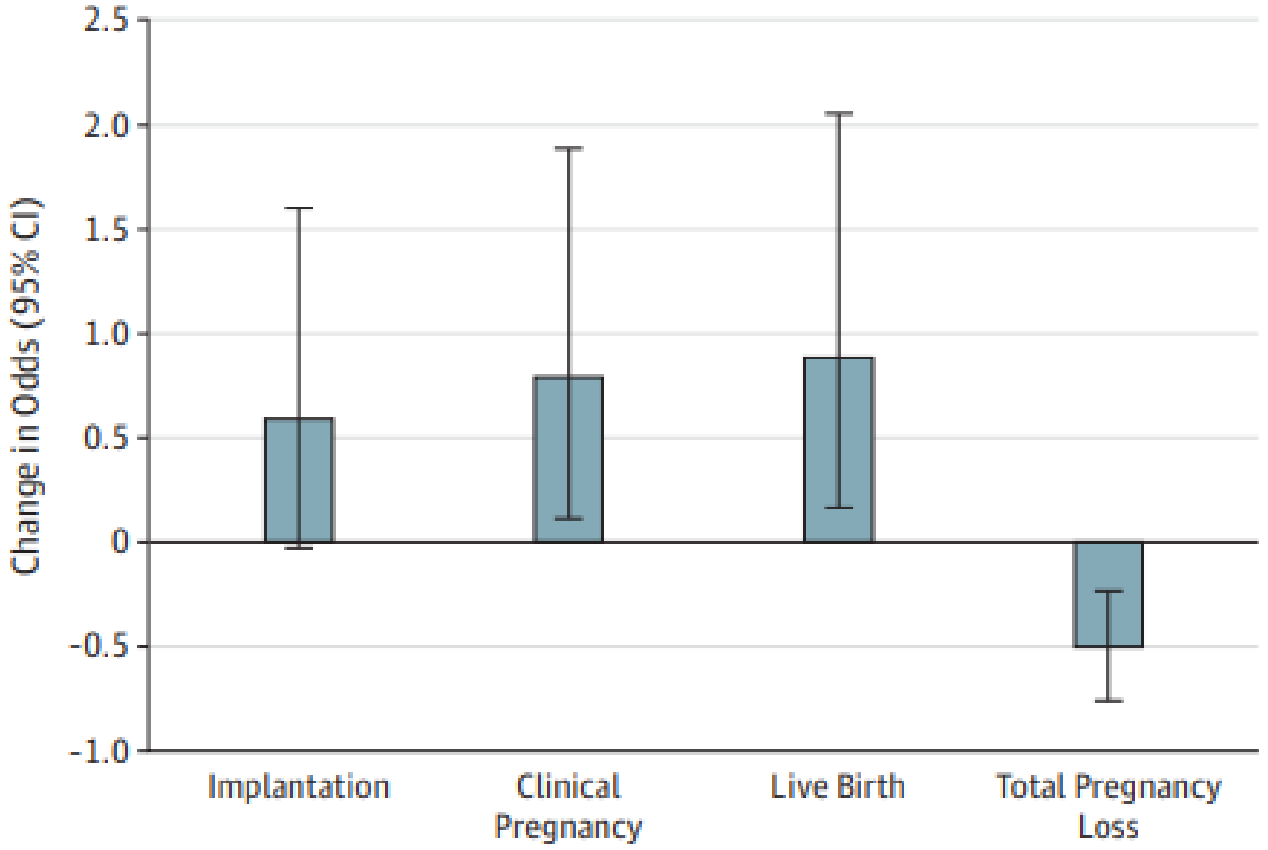
Linking Food and Toxicant Data Bases
Dietary Pesticide Score

- Pesticide Intake From Fruits & Vegetables and Pregnancy Outcomes
- Population
  - Assisted reproductive technology to treat infertility
  - N = 325
- Exposure Measures
  - Food frequency questionnaire
  - US Department of Agriculture Pesticide Data Program to classify fruits & vegetables according to their mean pesticide residue status in US food supply
  - Combine into Pesticide Residue Burden Score
    - For each of 36 fruits and vegetables
    - Categorize into high- and low-residue foods

Chiu et al., JAMA Intern Med. 2018;178(1):17-26

Better pregnancy outcomes by replacing high- with low-pesticide residue fruits & vegetables

Figure 2. Estimated Changes in Odds Ratios of Clinical Outcomes by Replacing 1 Serving/d of High-Pesticide Residue Fruits and Vegetables With 1 Serving/d of Low-Pesticide Residue Fruits and Vegetables



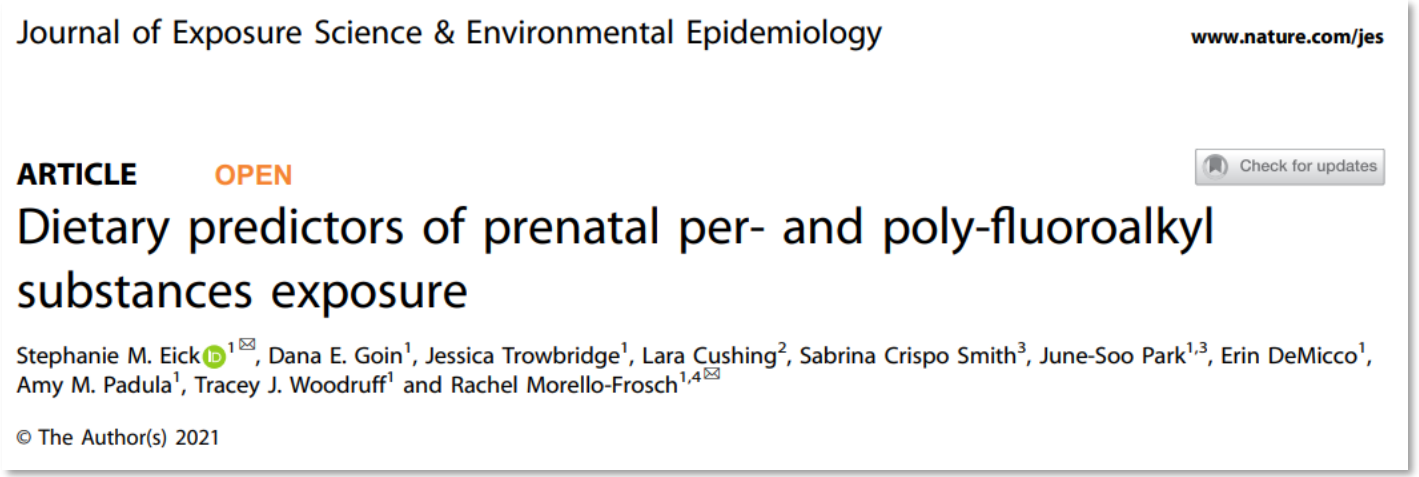
Data were adjusted for age, body mass index, smoking status, race, folate supplementation, organic fruit and vegetable consumption frequency, residential pesticide exposure history, total energy intake, Western and prudent pattern scores, and infertility diagnosis. Error bars indicate 95% confidence interval.

Chiu et al., JAMA Intern Med. 2018;178(1):17-26

“Healthy Diet During Pregnancy
Navigating the Double-edged Sword”

- Weighing harms of toxicants vs. benefits of foods & nutrients

Wang. Am J Clin Nutr 2021;114:414–415



Journal of Exposure Science & Environmental Epidemiology

www.nature.com/jes

ARTICLE OPEN

Check for updates

Dietary predictors of prenatal per- and poly-fluoroalkyl substances exposure

Stephanie M. Eick[1✉], Dana E. Goin[1], Jessica Trowbridge[1], Lara Cushing[2], Sabrina Crispo Smith[3], June-Soo Park[1,3], Erin DeMicco[1], Amy M. Padula[1], Tracey J. Woodruff[1] and Rachel Morello-Frosch[1,4✉]

Animal products eaten during pregnancy —milk, cheese, fish, red meat, poultry— associated with higher PFNA, PFOS, PFDeA, PFUdA

Healthier Diet, but Higher Levels of Arsenic (As) and Mercury (Hg)

TABLE 2 Estimated relative change (%) in median erythrocyte metal concentrations associated with each SD increase in different diet scores for 1196 pregnant women in Project Viva[1]

Metal	AHEI-P, % (95% CI)	Mediterranean diet, % (95% CI)	Western diet, % (95% CI)	Prudent diet, % (95% CI)
As	5.8 (−0.2, 12.2)	24.3 (16.9, 32.3)[2]	−9.4 (−16.0, −2.2)	21.2 (13.9, 29.1)[2]
Ba	0.2 (−4.8, 5.5)	1.4 (−4.0, 7.2)	5.0 (−1.8, 12.3)	1.9 (−3.6, 7.7)
Cd	0.9 (−2.3, 4.2)	0.9 (−2.7, 4.5)	1.8 (−2.3, 6.2)	4.2 (0.7, 7.9)
Cs	3.4 (1.4, 5.5)[2]	6.2 (4.0, 8.6)[2]	−6.5 (−8.9, −4.1)[2]	4.0 (1.7, 6.3)[2]
Cu	−0.3 (−1.3, 0.7)	−0.5 (−1.6, 0.6)	0.5 (−0.9, 1.8)	−1.3 (−2.3, −0.2)
Hg[3]	12.7 (4.7, 21.3)[2]	32.6 (22.7, 43.3)[2]	−17.3 (−24.9, −9.1)[2]	31.1 (21.2, 41.7)[2]

Lin et al., Am J Clin Nutr. 2021 Aug 2;114(2):414-415

FDA/EPA Advice on Which Fish to Eat

This chart can help you choose which fish to eat, and how often to eat them, based on their mercury levels.

Best Choices

- Anchovy
- Atlantic croaker
- Atlantic mackerel
- Black sea bass
- Butterfish
- Catfish
- Clam
- Cod
- Crab
- Crawfish
- Flounder
- Haddock
- Hake
- Herring
- Lobster, American and spiny
- Mullet
- Oyster
- Pacific chub mackerel
- Perch, freshwater and ocean
- Pickerel
- Plaice
- Pollock
- Salmon
- Sardine
- Scallop
- Shad
- Shrimp
- Skate
- Smelt
- Sole
- Squid
- Tilapia
- Trout, freshwater
- Tuna, canned light (includes skipjack)
- Whitefish
- Whiting

Good Choices

- Bluefish
- Buffalofish
- Carp
- Chilean sea bass/ Patagonian toothfish
- Grouper
- Halibut
- Mahi mahi/dolphinfish
- Monkfish
- Rockfish
- Sablefish
- Sheepshead
- Snapper
- Spanish mackerel
- Striped bass (ocean)
- Tilefish (Atlantic Ocean)
- Tuna, albacore/ white tuna, canned and fresh/frozen
- Tuna, yellowfin
- Weakfish/seatrout
- White croaker/ Pacific croaker

Choices to Avoid HIGHEST MERCURY LEVELS

- King mackerel
- Marlin
- Orange roughy
- Shark
- Swordfish
- Tilefish (Gulf of Mexico)
- Tuna, bigeye

Less N-3 LCPUFA

More N-3 LCPUFA

"Healthy Diet During Pregnancy
Navigating the Double-edged Sword"

- Weighing harms of toxicants vs. benefits of foods & nutrients

→Dietary scores

→e.g., pesticides in fruits & vegetables

→Mixture models

→Exposome approaches

→ e.g., untargeted metabolomics including nutrients and toxicants

Wang. Am J Clin Nutr 2021;114:414–415

Putting it all Together for Personal Recommendations
Which Fish to Eat?

Weighing not only

- Toxicological hazards
  - e.g., MeHg, PCBs, pesticides, and
- Nutritional benefits
  - e.g., N-3 LCPUFA, vitamin D, I, Se

But also

- Environmental sustainability
  - e.g., overfishing, habitat destruction, aquaculture, and
- Economic influences
  - e.g., consumer choice, industry stakeholders, fisheries management

→Decision analysis?

Oken et al. Environ Health Perspect 2012;120:790–798

Foods & Nutrients as Protectors
E.g., neurodevelopment

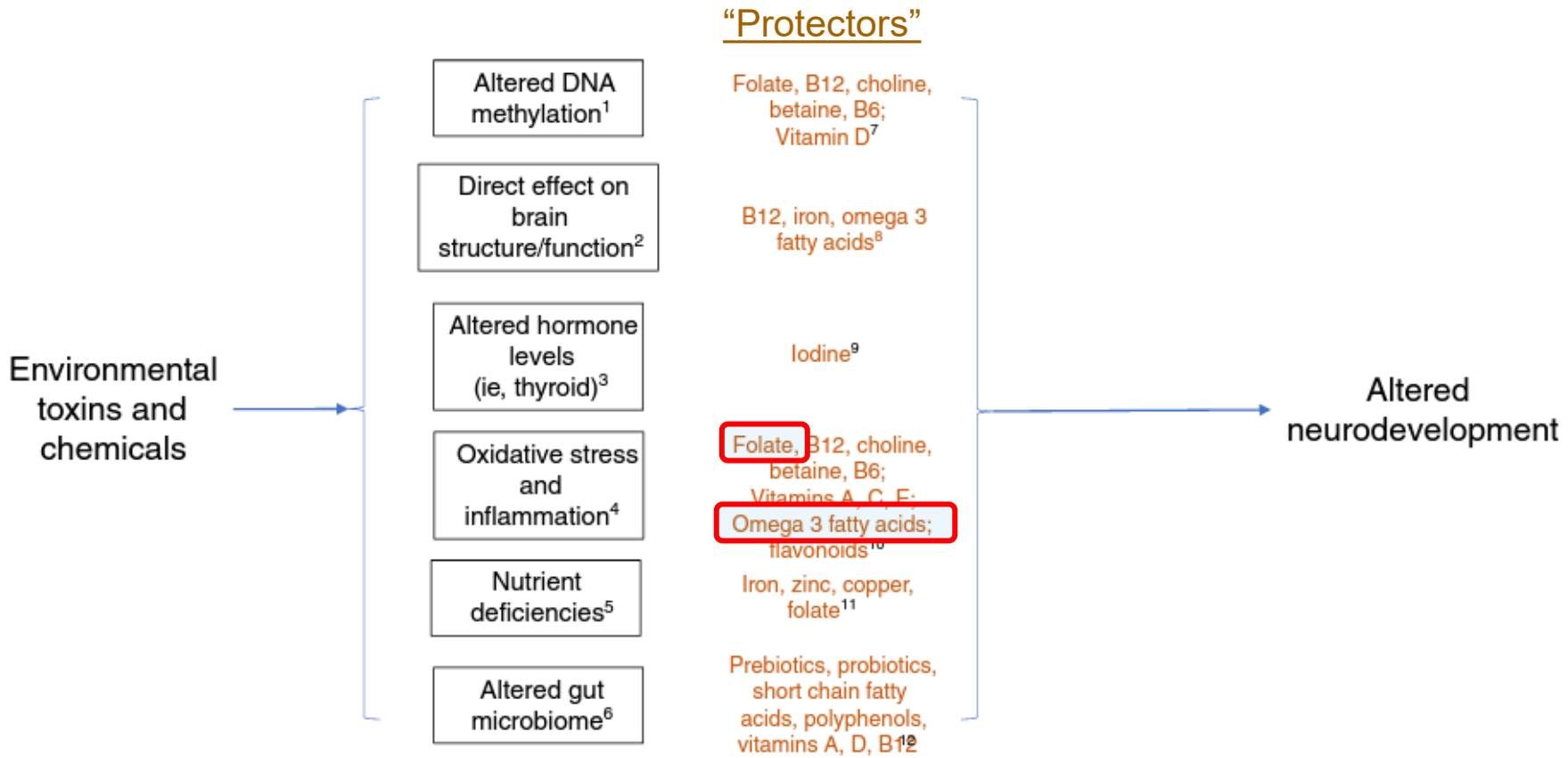


Fig. 1 Key pathways that may link environmental exposures, nutrients, and neurodevelopmental outcomes

→ More & better observational studies

Bragg et al., Curr Environ Health Rep 2022 Jun;9(2):324-338

Few Diet Interventions to Block Endocrine Disruption

- 16 studies
  - Many age groups
- Most small
- Many non-randomized
- Interventions
  - Folate, I, Vitamin C
  - Organic foods
  - Avoiding plastic and cans
- Most with intermediate outcomes
  - Chemicals


International Journal of GYNECOLOGY & OBSTETRICS

REVIEW ARTICLE | Open Access

Nutritional interventions to ameliorate the effect of endocrine disruptors on human reproductive health: A semi-structured review from FIGO

Gillian A. Corbett, Sadhbh Lee, Tracey J. Woodruff, Mark Hanson, Moshe Hod, Anne Marie Charlesworth, Linda Giudice, Jeanne Conry, Fionnuala M. McAuliffe ... See all authors

First published: 04 February 2022 | https://doi.org/10.1002/ijgo.14126

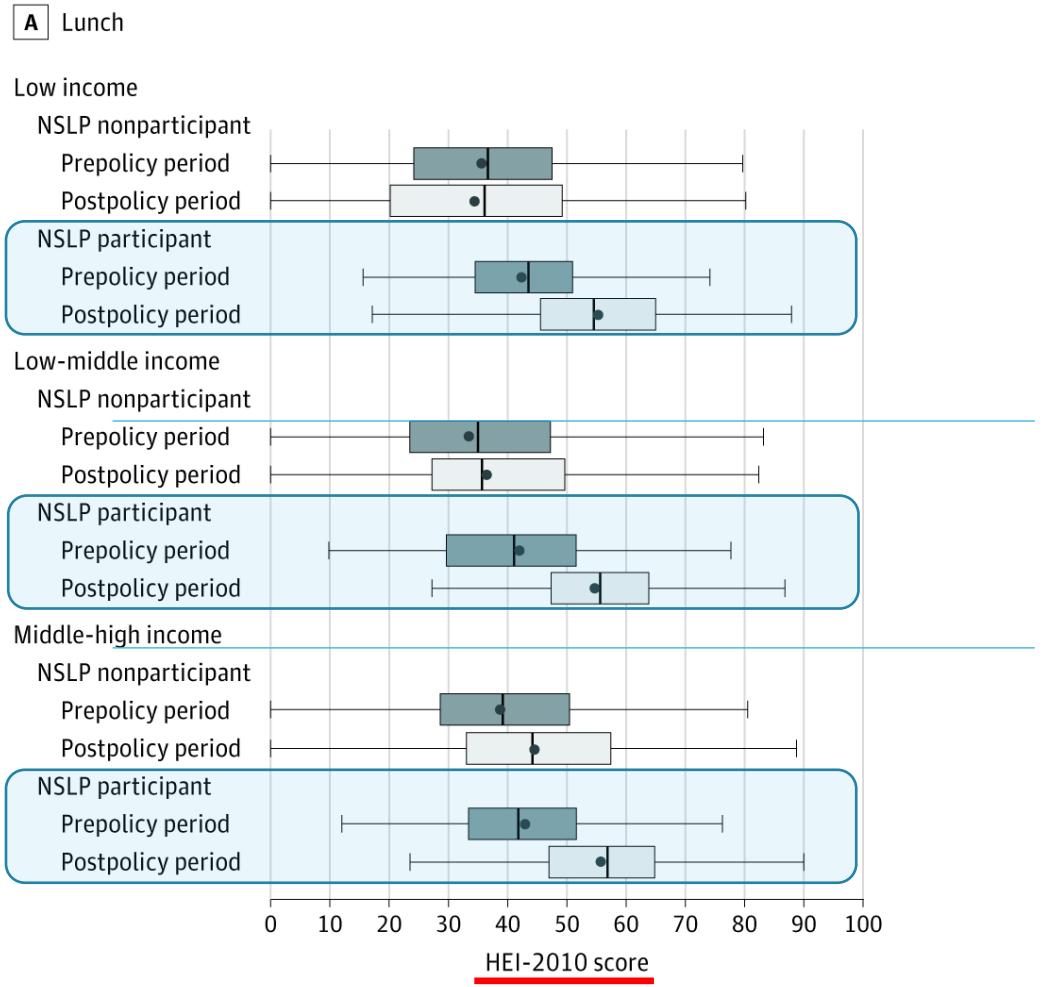
→Judicious intervention studies with clinical endpoints

Natural Experiments

- Healthy, Hunger-Free Kids Act 2010
  - Nutrition standards National School Lunch, Breakfast, and Smart Snacks Programs
    - 50m children at 99,000 schools
- COVID-19
  - Non-nutritional natural experiment with nutritional impact

Healthy, Hunger-Free Kids Act Associated with Higher Dietary Quality Among Children in US National School Lunch Program

Similar results across 3 income levels



Kinderknecht et al., JAMA. 2020;324(4):359-368; NHANES

Removed paper in press

Change in BMI larger during COVID-19 than pre-pandemic

38 ECHO Cohorts

- Pre-pandemic
  - 10/2017 - 02/2020
    - 29 mo.
- During Pandemic
  - 03/2020 - 05/2021
    - 15 mo.

Change in BMI		
Pre-pandemic change in BMI per year	Nearly flat	–0.04 (–0.15, 0.07)
Excess change in BMI during pandemic	Increase	0.24 (0.02, 0.45)

Knapp et al., Pediatrics 2022 Sep 1; 150(3); e2022056552

Increase in BMI During COVID-19 Pandemic Summary

- Increase in BMI during pandemic vs. ~no change pre-pandemic
- Predictors of pandemic-related increase
  - Obesity larger than overweight
  - Higher income smaller
  - Black race probably larger
- Prevention implications
  - What changes in obesity-related behaviors could explain the BMI increase?

Knapp et al., Pediatrics 2022 Sep 1; 150(3); e2022056552

Screen time increased from pre-pandemic to during pandemic

4 ECHO Cohorts

- Both educational and recreational screen time increased
  - Most owing to increases in recreational
  - Black and Hispanic children had larger increases

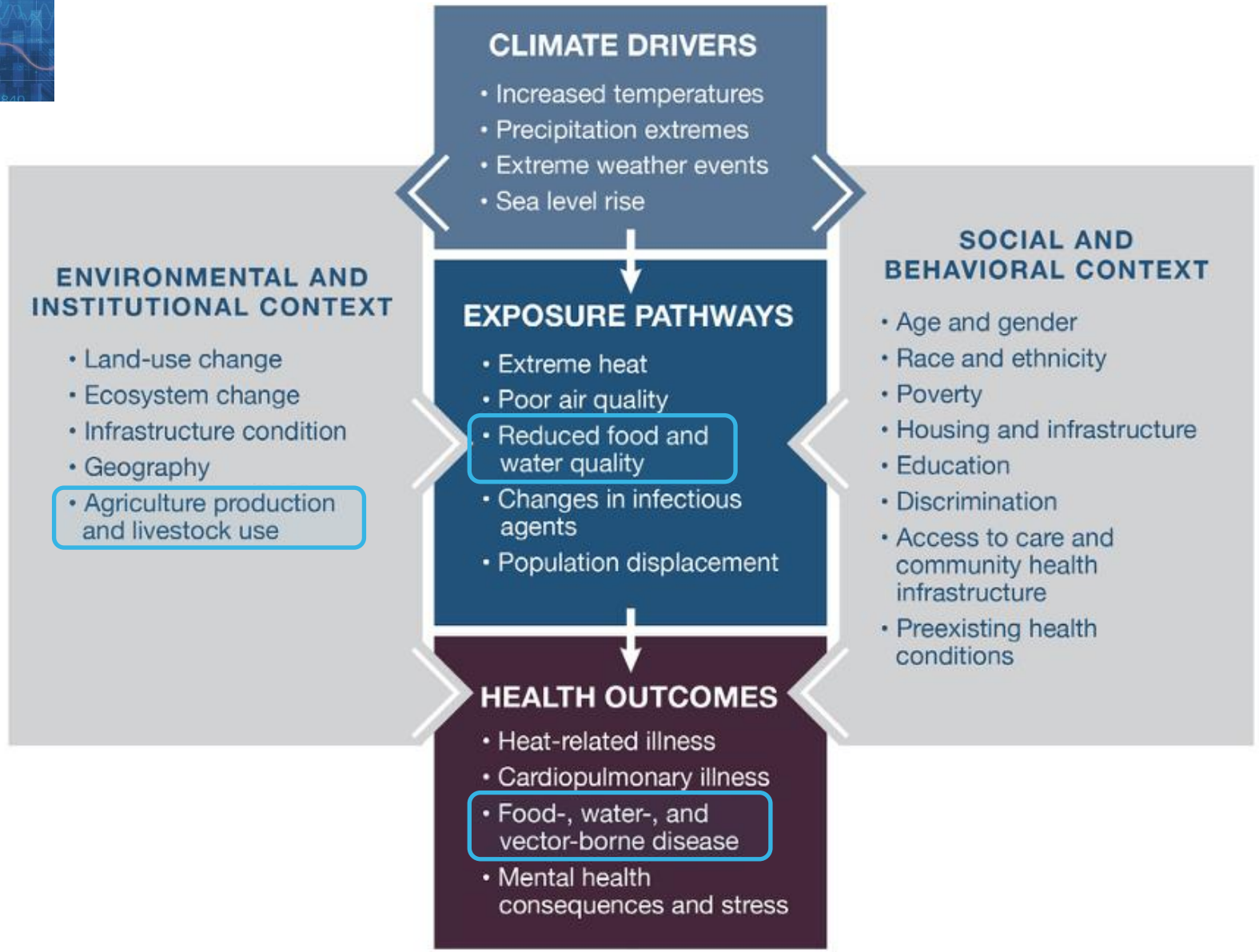
Outcomes	Pre-Pandemic [1]	Pandemic [2]	*p* Value
Screen time, h/day, median [IQR]	**211**		
Total weekday duration	3.0 (1.8, 5.2)	5.4 (3.6, 8.9)	<0.001
Total weekend duration	2.5 (1.5, 4.5)	5.3 (3.0, 8.7)	<0.001
Total averaged duration	4.0 (2.5, 6.3)	5.6 (3.6, 8.2)	<0.001
Weekday, educational	0.0 (0.0, 0.5)	1.0 (0.0, 3.0)	<0.001
Weekend, educational	0.0 (0.0, 0.2)	0.0 (0.0, 0.5)	0.011
Weekday recreational	2.2 (1.2, 4.3)	3.6 (2.2, 6.4)	<0.001
Weekend, recreational	3.5 (2.2, 6.0)	5.3 (3.0, 8.0)	<0.001

Bekelman et al., Int J Environ Res Public Health 2022; 19:9220

Climate Change

NIH National Institutes of Health

Climate Change and Health Initiative Strategic Framework



Woychik et al., Lancet. 2022 Nov 4:S0140-6736(22)02163-8
https://www.nih.gov/climateandhealth

Maternal-child Effects of Climate Change

- Unpredictable rainfall & higher temperature
  - Decrease farmers' ability to reliably supply food
    - Food insecurity
    - Women and children often eat last in many parts of world
- Extreme weather events decrease
  - Crop yields
  - Supply of essential nutrients, e.g., Ca, folate, thiamine, pyridoxine
- Higher atmospheric CO_2 affects
  - Nutritional composition of plants
    - Higher production of carbon-dense micronutrients, e.g., vitamin C
    - Lower production of essential nutrients for pregnancy, e.g., protein, Fe, Zn

Giudice et al., Int J Gynaecol Obstet. 2021 Dec;155(3):345-356
Roos et al., Acta Obstet Gynecol Scand. 2021 Apr;100(4): 566-570

Maternal-child Effects of Climate Change

- Malnutrition → infectious diseases
- Deteriorating water quality → food-borne illness, contaminants
- Unintended consequences of climate action
  - e.g., reducing animal-source food to reduce greenhouse gases
    - But nutrient rich
    - Equity for pregnant/lactating women, and children

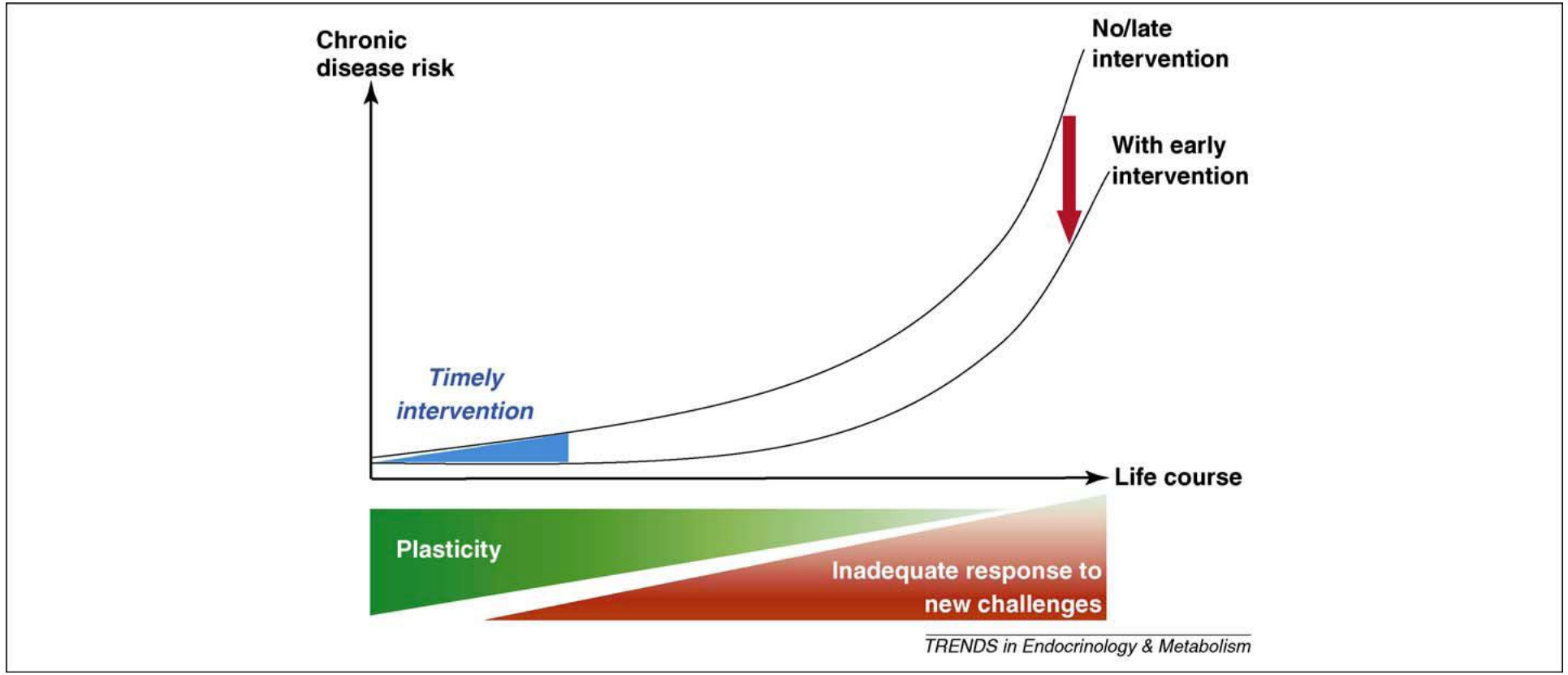
Giudice et al., Int J Gynaecol Obstet. 2021 Dec;155(3):345-356
Roos et al., Acta Obstet Gynecol Scand. 2021 Apr;100(4): 566-570

Summary

- Early developmental periods are critical for long-term health
- What we eat can contain harmful toxicants
  - Balance of benefits and harms
- Foods and nutrients may mitigate harmful effects of toxicants
- Natural experiments can offer convenient approach to evaluate policies, pandemics, etc.
- Climate change may have far-reaching effects on nutrition during pregnancy and childhood
- Disparities, challenges to equity

Extra slide

Early intervention → Healthy trajectory



Godfrey et al., Trends Endocrinol Metab 2010 ; 21:199-205