

National Academies of Science, Engineering, and Medicine
Workshop on Prepregnancy BMI and Gestational Weight Gain:
New Evidence, Emerging Innovations, and Policy Implications
September 4-5, 2025

Using Systems Science to Address Adverse Maternal Health Outcomes

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Disclosures

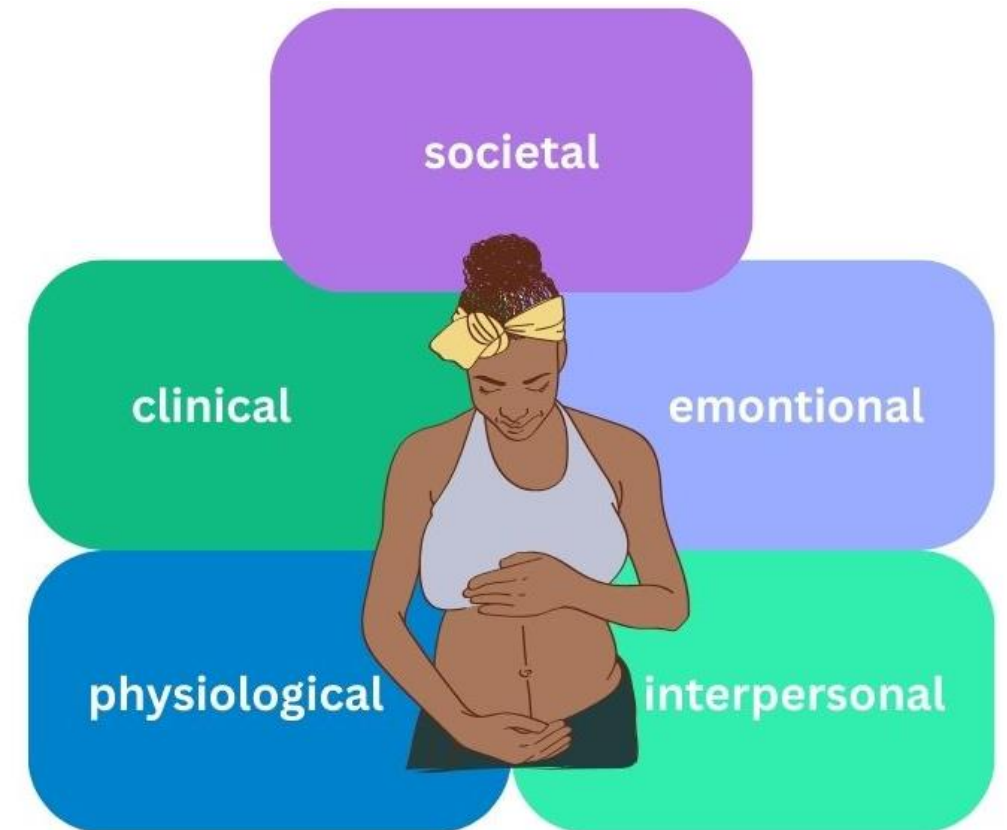
- No conflicts of interest to disclose

Outline

- Complex systems and the childbearing window
- Systems approaches to social context
- Systems Science, Social Context, and Maternal Health Outcomes
 - Gestational Weight Gain
 - Maternal Morbidity
 - Childhood Obesity
- Next Steps and Recommendations

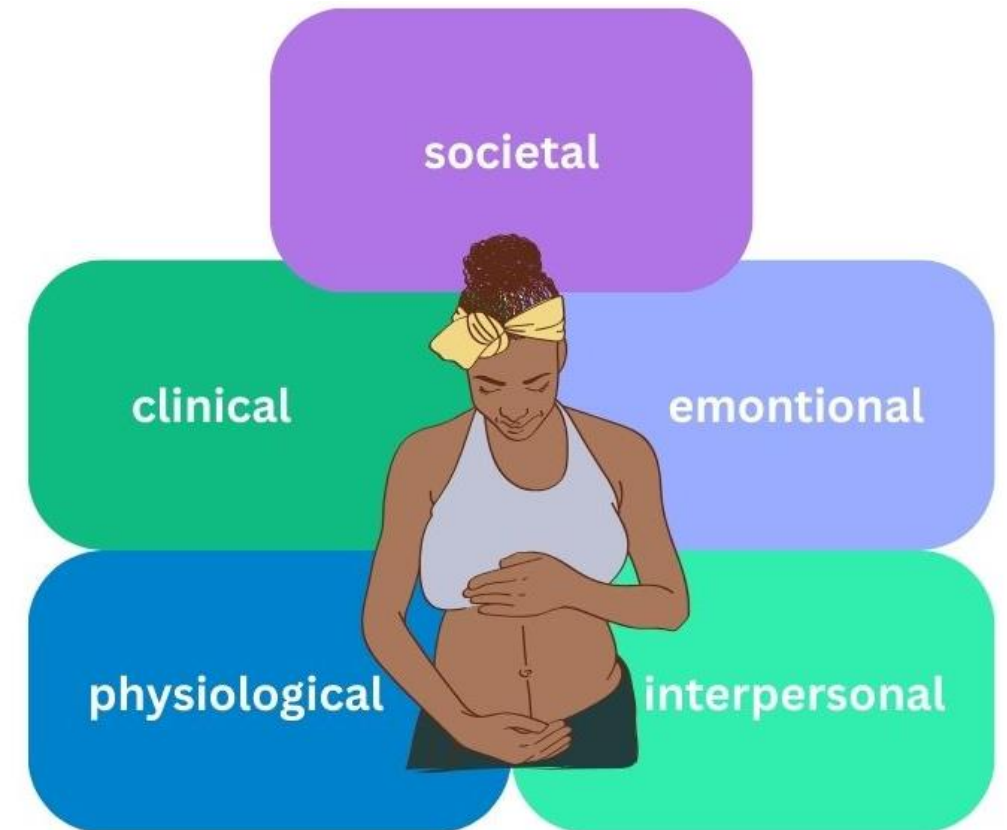
Complex Systems and the Childbearing Window

- Decades of research have identified a wide array of determinants shaping outcomes during the childbearing window
 - Implicit understanding that these determinants are embedded within systems at multiple levels shaping outcomes
 - Childbearing window is also a period of dynamic change across multiple areas



Complex Systems and the Childbearing Window

- Decades of research have identified a wide array of determinants shaping outcomes during the childbearing window
 - Implicit understanding that these determinants are embedded within systems at multiple levels shaping outcomes
 - Childbearing window is also a period of dynamic change across multiple areas
- Traditional epidemiologic approaches do not support the ability to analyze systems



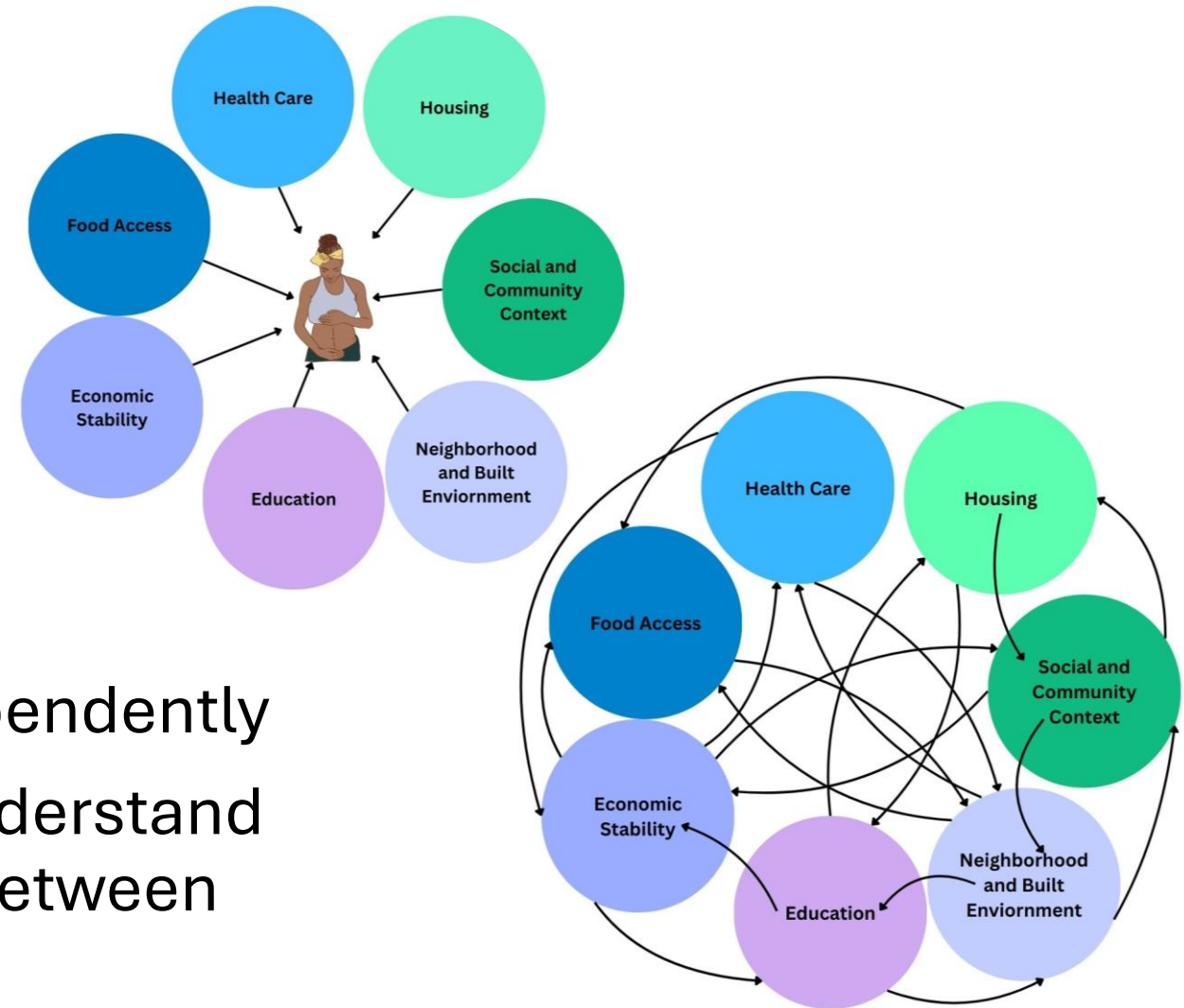
Complex Systems and the Childbearing Window

- Birthing people are embedded in multilevel social environments
 - Addressing outcomes during this period requires operating at multiple levels



Complex Systems and the Childbearing Window

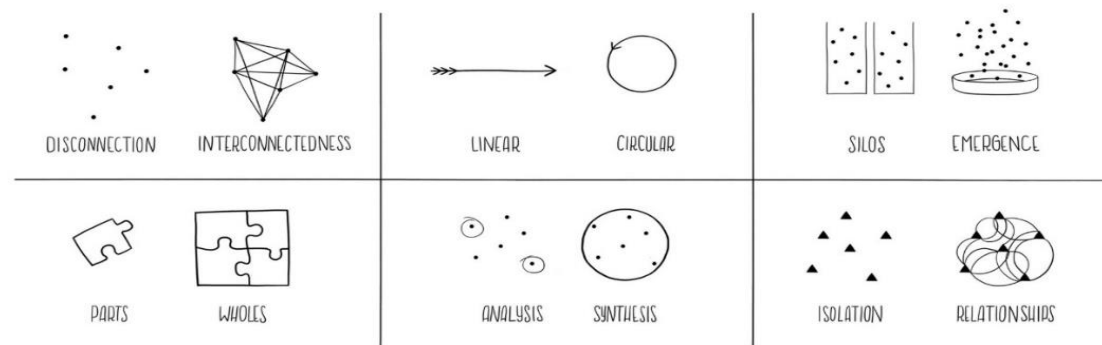
- Birthing people are embedded in multilevel social environments
 - Addressing outcomes during this period requires operating at multiple levels
- However, factors across social environments seldom act independently
- Systems Thinking is a way to understand and analyze interdependence between factors



Systems approach to Social Context

- Systems Science tools support the integration of systems thinking across analytic contexts

TOOLS OF A SYSTEM THINKER

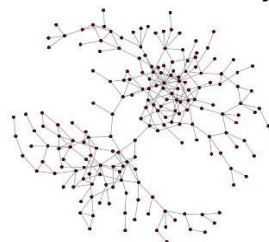


- There are an array of approaches under the systems science umbrella

Agent Based Modeling



Social Network Analysis



System Dynamics

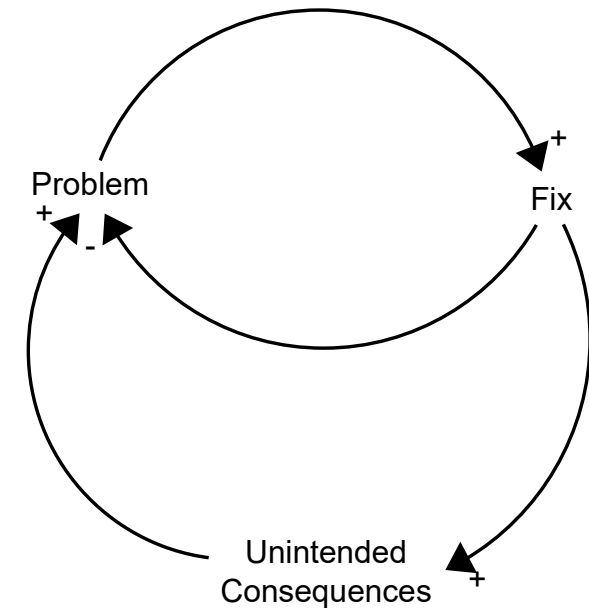


Systems approach to Social Context

- System Dynamics (SD): the use of informal maps and formal models with computer simulation to uncover and understand sources of feedback in systems behavior

Systems approach to Social Context

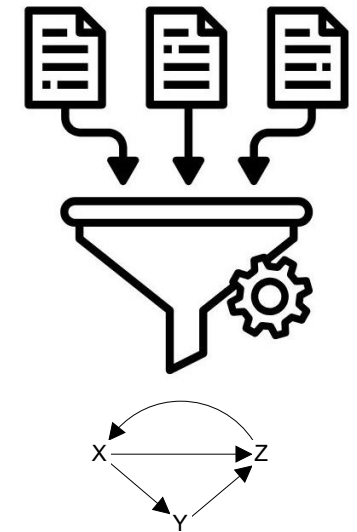
- System Dynamics (SD): the use of informal maps and formal models with computer simulation to uncover and understand sources of feedback in systems behavior
- Qualitative and Quantitative
 - Qualitative approaches use visual diagrams to represent interdependent relationships and feedback
 - Quantitative approaches use mathematical modeling in the form of differential equations to simulate the system of interactions generating behavior over times



*Causal loop diagram:
Fixes that fail archetype*

Systems approach to Social Context

- Participatory and non-participatory SD
 - Participatory approaches blend Community Based Participatory Research and qualitative data collection methods to better understand community perspectives on a problem
 - Non-participatory approaches use a wide array of secondary data including literature reviews, case studies, and expert input



Systems Science and Gestational Weight Gain

- There is a small body of literature that has started to use systems dynamics approaches to better understand pregnancy-related weight

| USING SYSTEMS SCIENCE IN OBESITY RESEARCH |

A Novel System Dynamics Model of Female Obesity and Fertility

| Nasim S. Sabounchi, PhD, Peter S. Hovmand, PhD, MSW, Nathaniel D. Osgood, PhD, Roland F. Dyck, MD, and Emily S. Jungheim, MD, MSCI

Australian and New Zealand Journal of Obstetrics and Gynaecology 2015; 55: 397–400

DOI: 10.1111/ajo.12341

Short Communication

A systems approach to reducing maternal obesity: The Health in Preconception, Pregnancy and Postbirth (HIPPP) Collaborative

Helen SKOUTERIS,¹ Terry HUANG,² Lynne MILLAR,³ Jill KUHMBERG,⁴ Jodie DODD,⁵ Leonie CALLAWAY,⁶ Della FORSTER,^{7,8} Clare COLLINS,⁹ Andrew HILLS,^{10,11} Paul HARRISON,¹² Cate NAGLE,¹³ Marj MOODIE¹⁴ and Helena TEEDE¹⁵

Systems Science and Gestational Weight Gain

- There is a small body of literature that has started to use systems dynamics approaches to better understand pregnancy-related weight
- A lot of the work on social factors however, is in relation to other maternal health outcomes

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ORIGINAL ARTICLE



Complex systems and participatory approaches to address maternal health disparities: Findings from a system dynamics group model building project in North Texas

Michael K. Lemke¹ | Kyrah K. Brown² | Saeideh Fallah-Fini³ | Ariel Hall² | Mercy Obasanya²



ISSN 1746-7233, England, UK
World Journal of Modelling and Simulation
Vol. 7 (2011) No. 3, pp. 163-172

Modeling the dynamics of maternal healthcare in Uganda: a system dynamics approach

Christopher Sooka, Agnes Rwashana-Semwanga*



SUPPLEMENT ARTICLE | Free Access

A systematic review of system dynamics and agent-based obesity models: Evaluating obesity as part of the global syndemic

Alexandra B. Morshed, Matt Kasman, Benjamin Heuberger, Ross A. Hammond, Peter S. Hovmand

First published: 17 July 2019 | <https://doi.org/10.1111/obr.12877> | Citations: 44

Systems Science, Social Context, and GWG

- Three ways in which systems tools can advance understanding social context and GWG
 - Understanding
 - Action
 - Evaluation
- Systems tools are great for bridging between these ways as well

Systems Science, Social Context, and GWG: Lessons from other outcomes

- Understanding

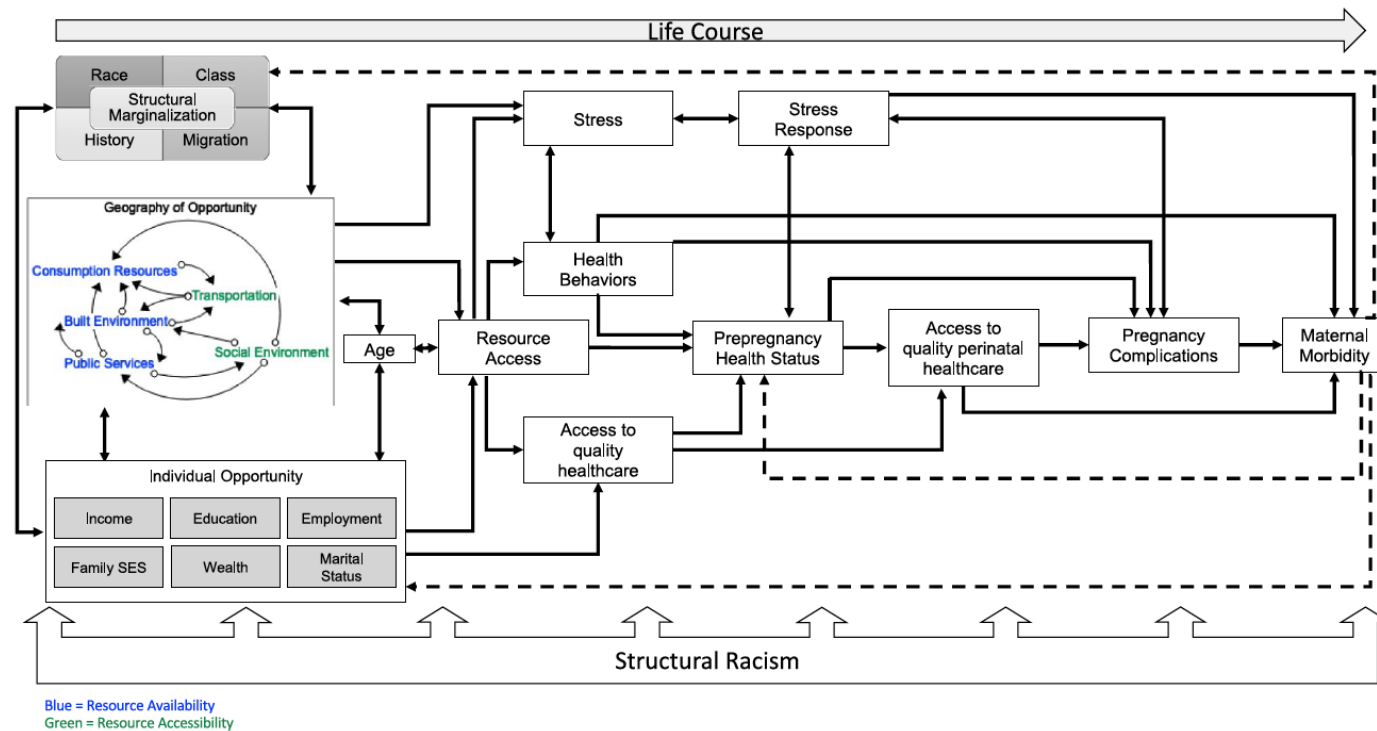


Fig. 1 Conceptual framework of structural marginalization, dynamic neighborhood systems, and racialized maternal morbidity outcomes

Systems Science, Social Context, and GWG: Lessons from other outcomes

- Understanding

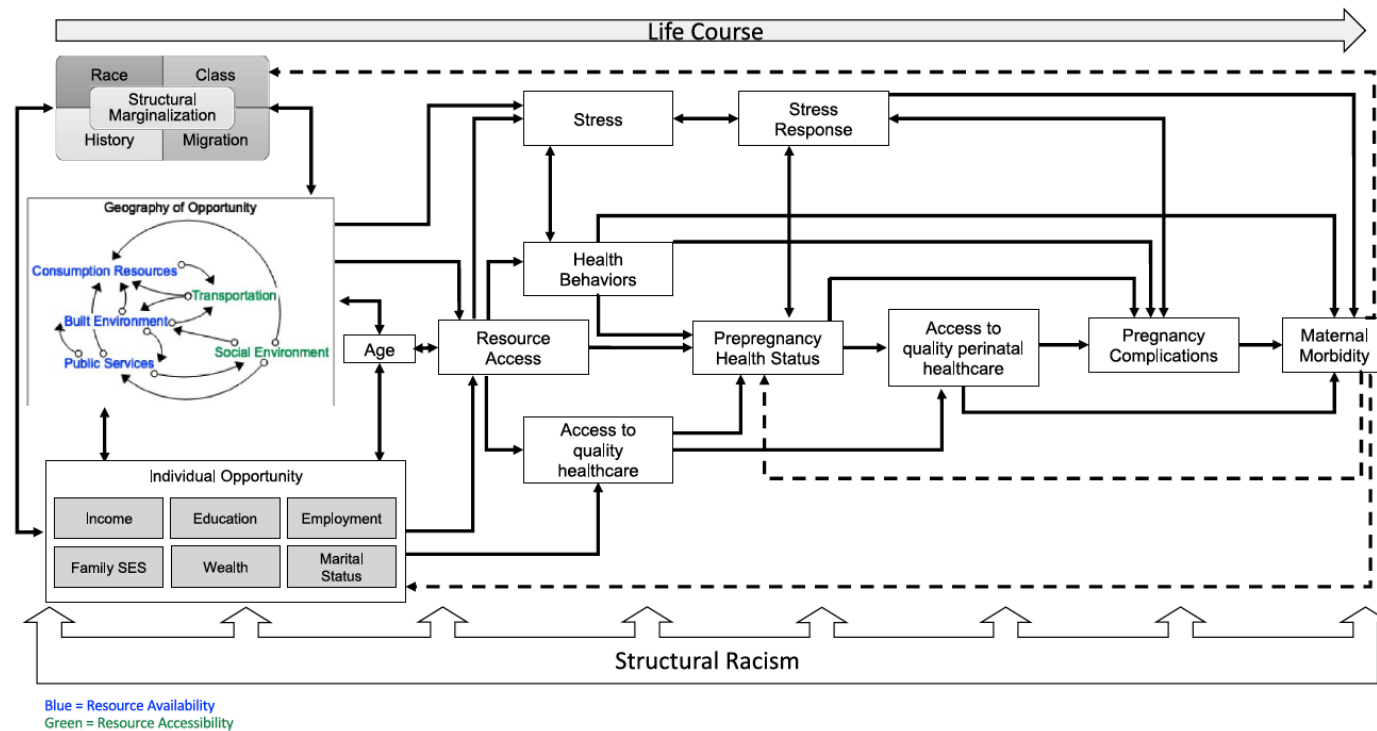


Fig. 1 Conceptual framework of structural marginalization, dynamic neighborhood systems, and racialized maternal morbidity outcomes

Headen, Irene. "Structural Racism, Geographies of Opportunity, and Maternal Health Inequities: A Dynamic Conceptual Framework." *Journal of racial and ethnic health disparities* (2025): 1-18.

Systems Science, Social Context, and GWG: Lessons from other outcomes

- Evaluation

Using system dynamics mapping to explore synergy in an equity-focused obesity prevention framework

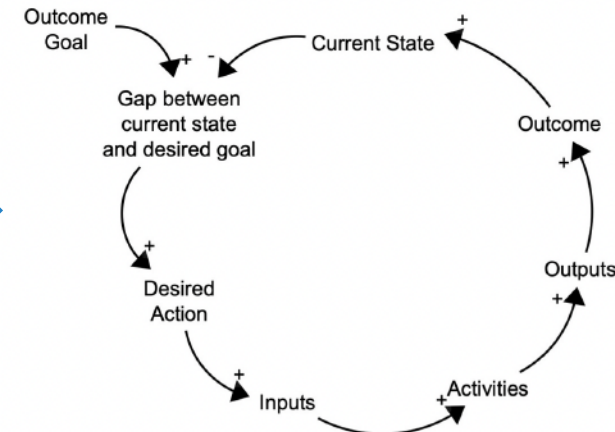
Irene E. Headen^{1*}, Tiffany M. Eaton² and Shiriki K. Kumanyika^{1,2}

Traditional Theory of Change Framework

Inputs → Activities → Outputs → Outcomes → Impact



(A) Logic Model Theory of Change Modified to Illustrate Dynamic Feedback



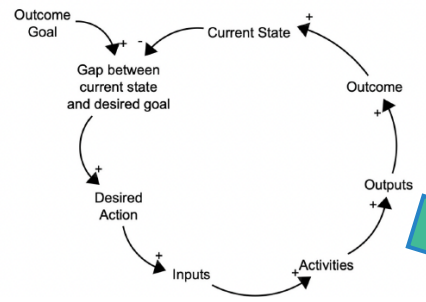
Systems Science, Social Context, and GWG: Lessons from other outcomes

- Evaluation

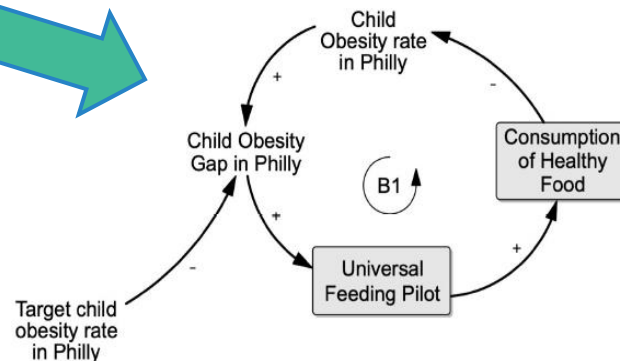
Using system dynamics mapping to explore synergy in an equity-focused obesity prevention framework

Irene E. Headen^{1*}, Tiffany M. Eaton² and Shiriki K. Kumanyika^{1,2}

(A) Logic Model Theory of Change Modified to Illustrate Dynamic Feedback



(A) Intervention promoting healthy options through universal feeding



(B) Intervention promoting healthy options and the deterrents to implementation and success

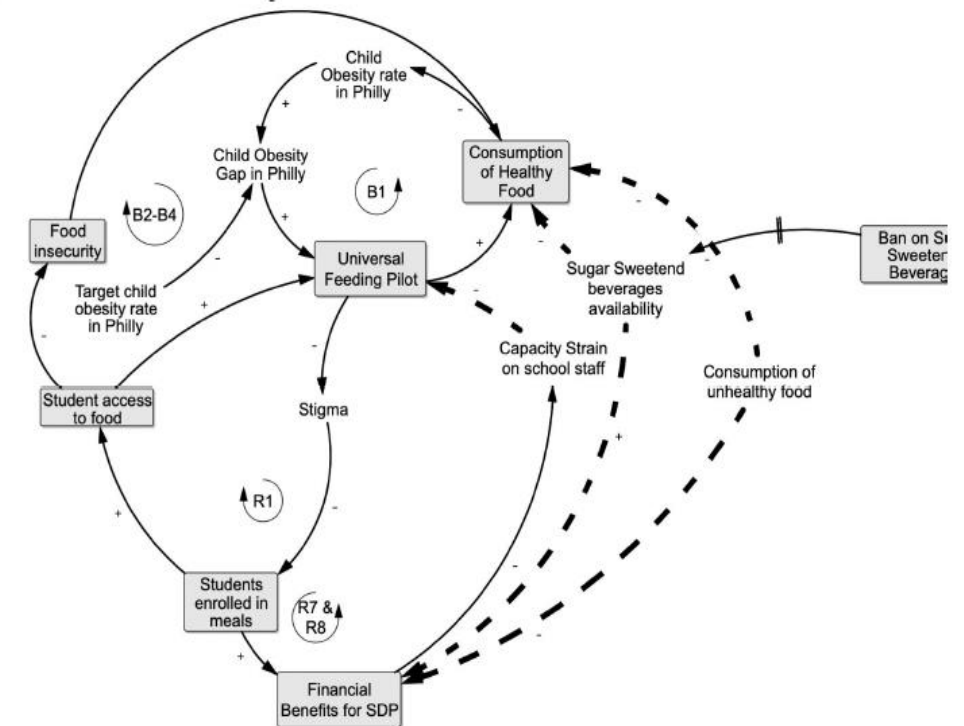
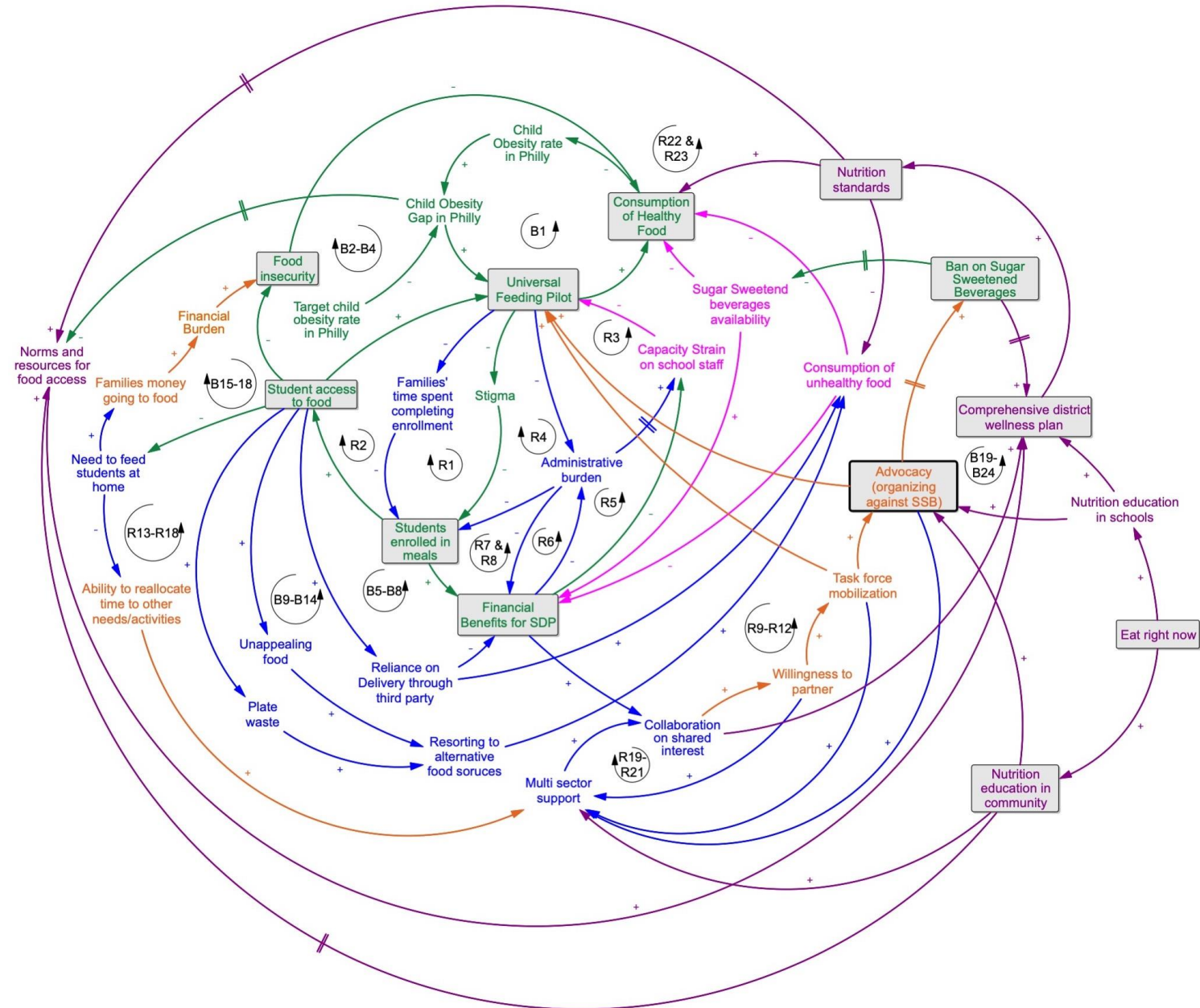


FIGURE 4

Systems Science, Social Context, and GWG:

Lessons from other outcomes

- Evaluation



Next Steps: Setting the Stage for Innovation

- Remaining research gaps:
 - Better operationalizing the social and structural drivers of GWG
 - Provide insight on different tailoring of intervention approaches in different populations
 - Bridges with Implementation Science
- Using systems approaches to develop “flight-simulators” for intervention development
- Better understanding of how to use big data and large, linked data sets to improve both qualitative and quantitative systems development

Next Steps: Challenges and Considerations for Committee in Revising GWG Recommendations

Challenges

- Skill development/Sustainability of method
- Computational Complexity
- Availability of data

Considerations

- Systems science tools can be important bridging tools from understanding to action and action to evaluation, especially for socially marginalized populations
- Building an infrastructure for promoting cross-disciplinary collaborations that can incorporate the use of these and other innovative methods

Thank you!

