

Systemic Analysis of Socioeconomic Determinants of Health in American Kids with a Behavioral Focus: A Case Study Using the Agent Based Approach (ABA)

Beatriz Carmona^{a,b,c,@}

^a Cornell University

^b Jeb E. Brooks School of Public Policy

^c Cornell Institute for Public Affairs

@ email: bac237@cornell.edu

ABSTRACT: Understanding the relationship between the socioeconomic determinants of health and childhood health outcomes is vitally important to create effective health intervention programs that benefit kids across a variety of socioeconomic contexts. An emphasis on childhood health behaviors within this relationship adds a unique nuance that has not been explored yet systematically but is necessary given that habits and behaviors instilled at an early age are more likely to last later in life. Thus, this map takes a systematic look at the relationships between and amongst these three overarching agents: socioeconomic determinants of health, childhood health behaviors, and childhood health outcomes in American kids aged 5-13. By exploring how each overarching agent relates to the parts of the others and the parts of itself using the “Agent Based Approach”, we are able to come to a more holistic understanding of how health outcomes are shaped by environmental influences, and can subsequently target intervention points by creating systematized recommendations that will have the most widespread and effective impact.

Keywords: health behaviors | socioeconomic determinants of health | children | diet | Agent Based Approach | physical health | nutrition | childhood | self-efficacy

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Introduction

ACCORDING TO THE World Health Organization, health is defined as a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity¹. The comprehensiveness of this definition, which effectively describes the physical foundation for being able to function in and enjoy life, means that the factors leading to “health” are equally, if not more, extensive in number. This myriad of factors requires thorough analysis in order to first understand what systemic issues lie in the health of American citizens, and later to formulate plans to alleviate health issues at a national level. A more pragmatic approach to this systemic issue takes a focus on children, which make up our future and will shape the generations that follow. Understanding the relationship between the socioeconomic determinants of health and childhood health outcomes is critical to create effective health intervention programs that benefit children across a variety of socioeconomic contexts. An

¹ World Health Organization, Constitution of the World Health Organization, , 2021

emphasis on childhood health behaviors within this determinant-outcome relationship adds a unique nuance that has not yet been explored systematically but is necessary given that habits and behaviors instilled at an early age are more likely to last longer in life ². This paper and corresponding map will take a systematic look at the relationships between and amongst these three overarching topics: socioeconomic determinants of health, childhood health behaviors, and childhood health outcomes in American children aged 5-13. By exploring how each overarching topic relates to the part of the others and the parts of itself, we are able to come to a more holistic understanding of how health outcomes are shaped by environmental influences, and can subsequently target intervention points that will have the most widespread and effective impact.

Methods

LIKE A PHYSIOLOGICAL HUMAN DISEASE, any worldly problem can be theoretically broken down into component pieces to first understand the etiology of the complication and later work to build a pragmatic solution. Our world is operated by complex, unpredictable, and non-linear systems. While it is human nature to look at problems with a hyper-focused perspective, only looking at the parts rather than the whole, the field of Systems Thinking attempts to reorganize our thinking models (how we “see” the world) in order to think in a way that better reflects the whole complexity of reality ³. This holistic methodology of looking at reality is able to sidestep our personal biases and biological desire to box ideas into categories we think that they belong in. The reality is that nothing exists in a vacuum, and being cognizant of relationships and themes that tie together our systems and problems within the rich web of reality is extremely beneficial in helping us understand complex problems and formulate solutions. Systems thinking is designed to help us get rid of our innate biases and erroneous thinking patterns to instead look at a whole system that can be broken down and rearranged in order to produce practical, realistic, and effective solutions to our complex problems ⁴.

Systems thinking is largely divided into two methods: Agent Based Modeling (ABM) and Agent Based Approach (ABA) - cut from the same cloth, they are both useful to understand systems, but their utility largely depends on whether they fit the setting in which they are applied. ABM is the more rigorous, powerful version that allows a systems thinker to analyze a Complex Adaptive System (CAS) by explaining the collective behaviors of agents that

follow simple rules in a system with the goal to be able to model their behavior “outputs” depending on different “inputs” (which include an identification of the agents, simple interaction rules, and environment of the system). The implications of this modeling capability are multifold, and quite powerful in a variety of settings, but the field of policy analysis is not often the best place for ABM. This is largely because ABM doesn’t work perfectly when the agents or chosen variables are vague or difficult to identify explicitly, which is often the case in the policy field that deals largely with theoretical social or psychological variables. This is where ABA comes in - it provides an alternative analytical procedure for more vague situations, and still allows the systems thinker to produce a robust and comprehensive overview of the “rules” of a system so as to outcomes⁵.

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In order to best understand my system at a deep level, the Agent Based Approach (ABA) was chosen as the method with which to analyze my socioeconomic determinants of health model. ABA has been specifically designed to better fit the needs of a Complex Adaptive System (CAS) Analysis with the goal to shape policies and systematic interventions, and this succinct purpose in addition to ABA’s ease of use makes it a much better match in this project. ABA can be generally characterized as a “stepwise approach to thinking about CAS with the end goal of coming to some recommendations (and recommendation principles) that will help to change the system from its current undesirable state to some future [more desirable] state”⁶. It is essentially a powerful yet easy to understand tool to help in the process of solving CAS problems to shape policies or guidelines that lead to systemic improvements. The ultimate goal of ABA is to help the user “understand the system” rather than to “solve the problem” outright, since understanding the system is the fundamental key to solve the problem. To give more context as to what the ABA approach looks like, it should be helpful to walk through the preparation and steps of this method. The preparation requires an understanding of the Distinctions, Systems, Relationships and Perspectives (DSRP) theory, which provides a solid theoretical basis for the type of thinking that ABA uses. DSRP, a physio-cognitive theory, prepares the user to understand the CAS and its agents⁷.

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The second preparation step before ABA is to understand that “autonomous agents (multiplied by) simple, local, interaction rules lead to collective dynamics and surprising emergent properties. Knowledge of these can be leveraged to alter the system behavior at the agent and rules level”. The ABA approach itself, once the preparation has been completed, consists of two general steps. The first step is understanding the system, which requires ST/DSRP Loop Analysis, a heuristic that explains how our mental models of reality

need to be tested against actual reality in order to create meaningful, meta-analytical mental models; it involves making a DSRP map of the system and making edits that were cross-checked against reality until it effectively models reality. Another component of the first step is POSIWID differentiation (“The Purpose of a System is What it Does”), which entails understanding the current state of the system and its desired (goal) state. Finally, the last two subparts of the first step are Root Difference Analysis, which builds on POSIWID and requires a description of the differences between the “current state” and the “goal state”; and an identification of agents. All of these procedures should help the user get a sense of how the CAS “functions” - its agents, rules, and emergent properties. The second step would be to make recommendations based on this underlying understanding of the CAS functions. This involves a CAS Analysis table that describes the simple rules that each agent group follows, a recommendations rubric with a few CAS principles that each recommendation should meet (which sets the ground rules) and finally, 3-10 recommendations made that follow the CAS principles⁸.^{8 4}

This is just a general overview of the ABA preparation and steps - in short, ABA helps the user understand its system and agents, identify the current and future state of the system, make rules for the plan, and finally hash out the plan that will help the system transition from its current to future state.

Why an Agent Based Approach (ABA)?

ABM IS A POWERFUL ANALYTICAL TOOL and has been used to simulate the behavior of a system, its agents and interactions, and capture emergent phenomena with flexibility. Because of its inherent rigor, there are several requirements for the type of CAS that can be modeled with ABM, and specifications for how to do it. Generally speaking, ABM is very specific with regards to the parameters it requires and the construct validity of its results - in other words, the inputs are specific and the outputs are not very generalizable. The general understanding is that, “ABM is a useful tool, but there are still some issues regarding its use, especially in the areas of psychological, social, political, and economic phenomena”⁹. It is difficult to quantify “soft factors” in ABM, which include constructs like irrational or subjective behavior and complex psychology. With this in mind, the CAS discussed in this paper regarding socioeconomic determinants of health works better with ABA, since it includes significant “soft factors”. There are three main reasons for which ABA was preferred over ABM in this context. First, the constituents^{9 4}

of this model are largely intangible, including complex psychological ideas that are not perfect enough to be quantified well in the more rigorous ABM method. Second, the intention of modeling socioeconomic determinants of health with a behavioral focus is to hopefully be able to generalize this model to other similar contexts.

The high specificity requirement of ABM means that generalization isn't often possible, whereas the more forgiving setup of ABA allows us to generalize with more confidence. Lastly, ABM has been hypothesized to potentially lead to a "shoehorning complexity" where the rigid modeling paradigm forces the problem solver to "shoehorn real-world complexities into tightly-defined, discrete variables in order for the model to work"¹⁰. This unintended consequence is dangerous for a number of reasons: it creates the illusion of simplicity, can lead to tunnel-vision in attempting to solve the problem, and prevents effective collaboration by discounting the opportunity for input from outside fields. My CAS is multifactorial, sampling from fields of economics, behavioral psychology, nutrition, healthcare organization, and more. This variety is simply too colorful to be restrained effectively in an ABM model. In the words of statistician George E.P. Box, "All models are wrong, but some are useful"¹¹. The utility with regards to generalizability is greatly increased in this context through the use of ABA, and at the same time the flexibility diminishes some of the potential errors that the model has. There is no such thing as a perfect model, but one that minimizes error is ideal.

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Steps to an Agent Based Approach (ABA)

Step 1: DSRP Analysis of the System

THE "HEART" OF SYSTEMS THINKING, DSRP serves as a construct to establish the skills necessary to understand and effectively map out complex systems. DSRP, which stands for Distinctions, Systems, Relationships, and Perspectives, describes the four simple skills necessary to carry out systems thinking. These four rules work together to help us understand how to identify the mechanism of a system. Distinctions are made up of an "identity" (what the item is) and an "other" (what the item is not)¹². The second component to DSRP, Systems, represents the overarching thought that systems (wholes) can be broken down into parts and parts can be built into systems. Relationships are an intuitive follow-up to the primary distinction methodology, since they represent how you can connect the separate parts of a system. They can be classified as "action" and "reaction" relationships, and can be tangible, conceptual, or

¹² 5

somewhere in the middle. Tangible relationships are pragmatic and visible, such as the scaffolding holding the side of a building as it undergoes repairs - the relationship here is that the scaffolding supports the building (action) and the building receives this support by staying upright (reaction). Conceptual relationships, as the name implies, are not visible. These relationships make up social networks, workplace hierarchies, and even things like international relations - they are intangible, but represent critical bonds between entities, people, or other forms. A relationship in the middle of these two types could be that of a car and its owner. There is a tangible, documented receipt of the owner and the car's relationship, but at the same time their relationship is conceptual since the car and owner have nothing physically connecting them. Perspectives are the last component to the DSRP method - they are a more nuanced representation of how an individual sees a particular item. This item can take any shape, be it the whole world, their community, or a single event in their neighborhood. Perspectives can be extrapolated from a single individual or from a group - at its essence, a perspective is just a representation of how "A" sees "B" within "C", where "C" is the whole and "B" is the part. As we have described, each part of DSRP builds upon the other, and the parts themselves have relationships¹¹. Table 1 gives a summary of the DSRP rules and the parts of each.

Patterns	Elements
Distinctions (<i>D</i>)	identity (<i>i</i>) ↔ other (<i>o</i>)
Systems (<i>S</i>)	part (<i>p</i>) ↔ whole (<i>w</i>)
Relationships (<i>R</i>)	action (<i>a</i>) ↔ reaction (<i>r</i>)
Perspectives (<i>P</i>)	point (<i>ρ</i>) ↔ view (<i>v</i>)

Table 1: DSRP Summary

The fluidity with which DSRP can be described by its own methods serves to explain the power and flexibility of using it to analyze a CAS. Using these four simple rules of systems thinking can help to give the user a deeper and more nuanced understanding of their CAS, and then apply these conclusions into the creation of a realistic solution. It's important to note that in the field of systems thinking, "solutions" to systems are more often represented by the achievement of "understanding" the system, since understanding naturally leads to solving. Using the word "solution" can be too rigid and could shoe-horn its application into not being adaptable since it gives the illusion of being a hard and fast solution. Effective solutions to complex problems are born out of continual trial-and-error modeling and from truly understanding the system that led to the problems themselves. DSRP overall is a truly powerful tool with which to look at complex systems and is an excellent starting point in our analysis

here of socioeconomic determinants of health in American children.

To give a more pragmatic entry point into this DSRP analysis, it's helpful to outline systems mapping to lay the foundation of the analysis. Systems mapping starts with a brainstorm session, as most projects do, which is known as "splat mapping". This splat map is just a regurgitation of everything the systems thinker thinks is included in the system, and is followed up by a Systems distinction that identifies the parts and wholes within this preliminary map. After this comes a Relationships identification, which takes the form of looking at how each part is related to each whole, how each part is related to each part, etc. Lastly, Perspectives in the system should be looked at in order to get an idea of how the major components of the system view themselves and other major components¹³. By applying DSRP step-by-step in this manner, it is possible to methodologically begin to understand a system's innerworkings.

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Step 2: POSIWID and CAS Analysis

A CRITICAL TOOL THAT follows the DSRP foundation, POSIWID ("The Purpose of a System Is What it Does") allows the user to assess the system's real outcome without the bias of what one might want it to do. It's a quick and dirty reality check. One might want a system's outcome to be "A", but POSIWID analysis might reveal to the user that the system's actual outcome is "B", and therefore the system's outcome and purpose are both B. Thus, the POSIWID of a system is a description of the outcome "as is", without any external impact¹⁴. All systems are perfectly designed to create whatever outcome they have, whether the outcome is good or bad, so understanding the POSIWID is essential to understanding the system and identifying what changes should be made to change the system's "perfectly designed" outcome to be what one wants. Essentially, the takeaway from POSIWID is that the user identifies "root differences" between the current and ideal POSIWID and uses these to denote what changes should occur to transform the outcome to that of the ideal system. These changes take the shape of future recommendations, which will be discussed in the next section¹⁵.

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CAS Analysis looks at the CAS and its agents, which follow simple rules to create collective and complex outcomes and emergent behaviors. Though systems are made up of more nuanced pieces and cannot just be described as being "agents + simple rules", this binary simplification is the most effective way to design a system intervention in order to most effectively create change, since agents and simple rules are the heart of a system. By understanding these

and making recommendations tailored to them, one can make the most effective systemic change¹⁶. This is the essence of CAS Analysis; identify the system's agents, their perspectives and simple rules, and emergent behavior. Figure 1 gives a visualization of CAS, showing how individual agents following deceptively simple rules can cause a much more interesting and complex emergent behavior, almost acting as a new individual. This is called system-level behavior, and drawing the distinctions between agent behavior and system-level behavior helps us to understand how a system functions.

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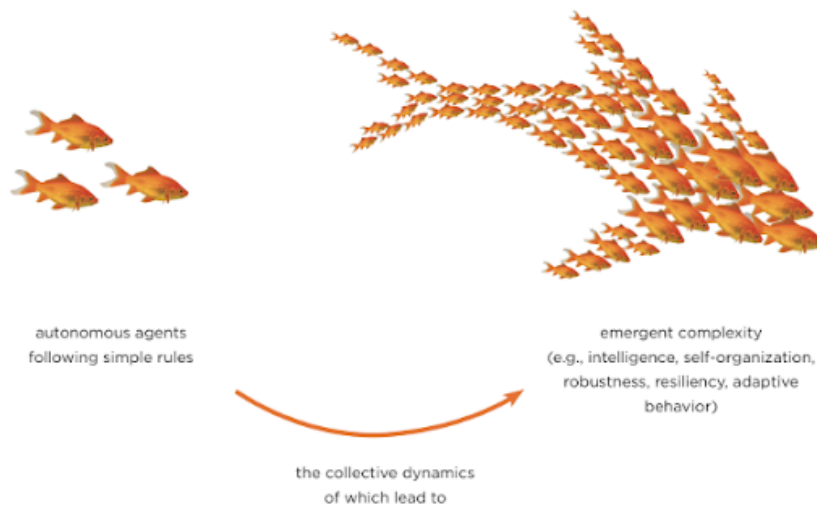


Figure 2.11: The Basic Features of a Complex Adaptive System (CAS)

Figure 1: CAS: Simple Agents and Rules Lead to Emergent Complexity

Giving each agent simple rules and behaviors perfectly complements POSIWID analysis by giving a pragmatic jumping off point for intervention. When POSIWID asks the question “what do we want to do?”, giving the user a description of what changes are needed, CAS Analysis asks “how do we work?”, which tells the user how they can implement these changes¹⁷.

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Step 3: Rubric and Recommendations

ONCE THE WHAT AND HOW of the changes needed to improve a system to achieve the desired outcome are identified, these ideas should be simplified into comprehensive, simple, and easy to implement

recommendations for the system. Since systems thinking is a calculated science, these recommendations are not without structure. Recommendation rubrics are essential to give recommendations a “principle” to follow to ensure that they are standardized and that they consider all important system nuances¹⁸. They make sure that the user keeps the POSIWID root difference results and the CAS Analysis results in the forefront, since they dictate how the system operates, when making recommendations. Recommendations that don’t follow the established principles won’t be considered and should be rejected - this ensures uniformity in recommendations.

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Results

DSRP Analysis of the System

TO SET A SOLID FOUNDATION for ABA analysis, a holistic map of the CAS was created which delineates the major acting agents and relationships in socioeconomic determinants of health. It shows a systematic and agent-based representation of these determinants as they relate to health behaviors in kids aged 5-13 in the United States. Socioeconomic determinants of health (SODH), according to the U.S. Department of Health and Human Services, are the environmental conditions that affect a wide range of health, functioning, and quality-of-life outcomes and risks¹⁹. Broadly, they encapsulate the built and social environments, education and health care access, and economic stability. Understanding the socioeconomic determinants of health across a variety of social contexts in the United States can help policymakers and healthcare providers alike.

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Including a variety of structures is important to create a map with volume, actionable points of intervention, and purposeful layers. This was accomplished by focusing the DSRP Analysis on defining intuitive relationships (such as literacy and individual health behavior patterns), and digging deeper to split these relationships into several layers (in this example, splitting up literacy into four parts: health literacy, technology literacy, numeracy, and reading literacy, and labeling its relationship to individual health behavior patterns with an RDS consisting of Improved Self-Efficacy and Risk Awareness parts). Several acronyms are part of the systems thinking methodology that help to describe specific map structures. One of these is RDS, which here stands for “Relate, Distinguish, and Systematize”²⁰. It essentially represents a systematized and labeled relationship. Figure 2 depicts a straightforward RDS, where the relationship between Numeracy and Health Literacy is systematized

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through three separate properties.



There are lots of “passive” relationships in the system that the map tries to emulate that are characterized largely through “Dio” structures, where identities and others are separated by a labeled, color-coded, relationship arrow. After three ST Loop checks that checked the map against reality, this map had a total of 97 separate identities separated into 4 overarching themed wholes (Individual Characteristics, Individual Health Behavior, Environment, and Health Outcomes). Table 2 shows a summary of the map elements:

DSRP Structures	Number of Times Used
Identities (I)	97
Others (O)	9409
Parts (P)	67
Part-Whole Systems (SPW)	35
Actions (A)	40
Reaction-Action (RAR)	20
Perspectives (p)	9
Views (v)	93
Point-View Perspectives	9
RD	91
P-Circle	93
R-Channel	5

Table 2: DSRP Structures Utilized in Map

An R-Channel is another example of a cognitive channel that builds on an RDS base to where different items in A are able to connect in a systematized way to B. Figure 3 shows an example of an R-Channel, where A is Individual Behavior Motivators and B is Individual Behavior Patterns.

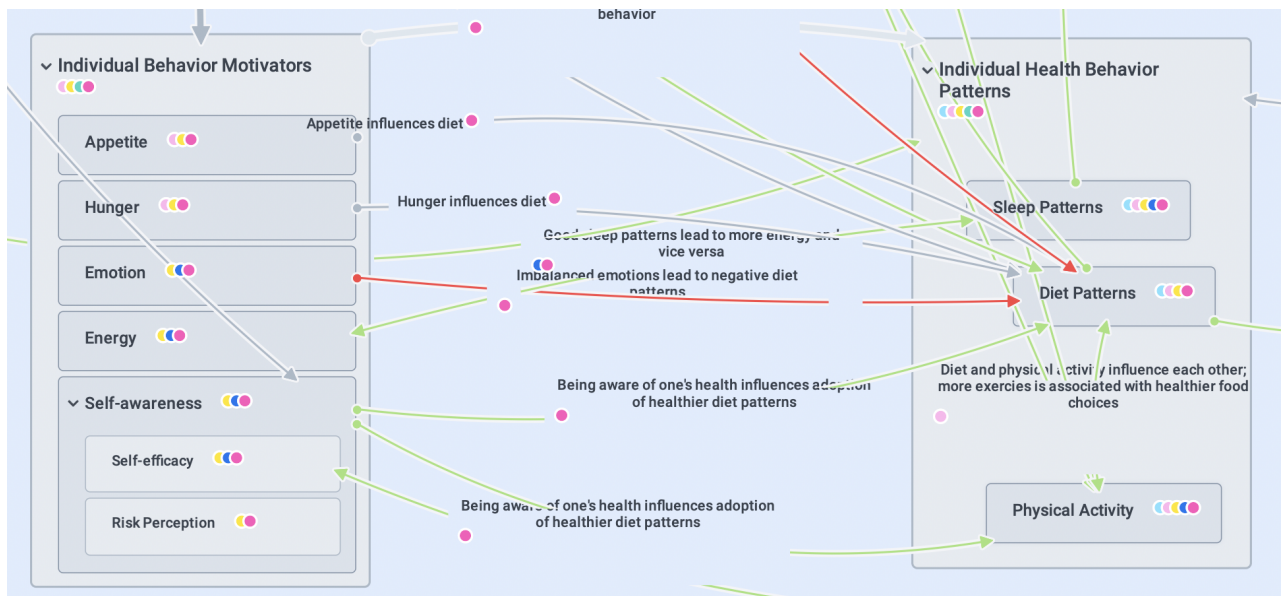
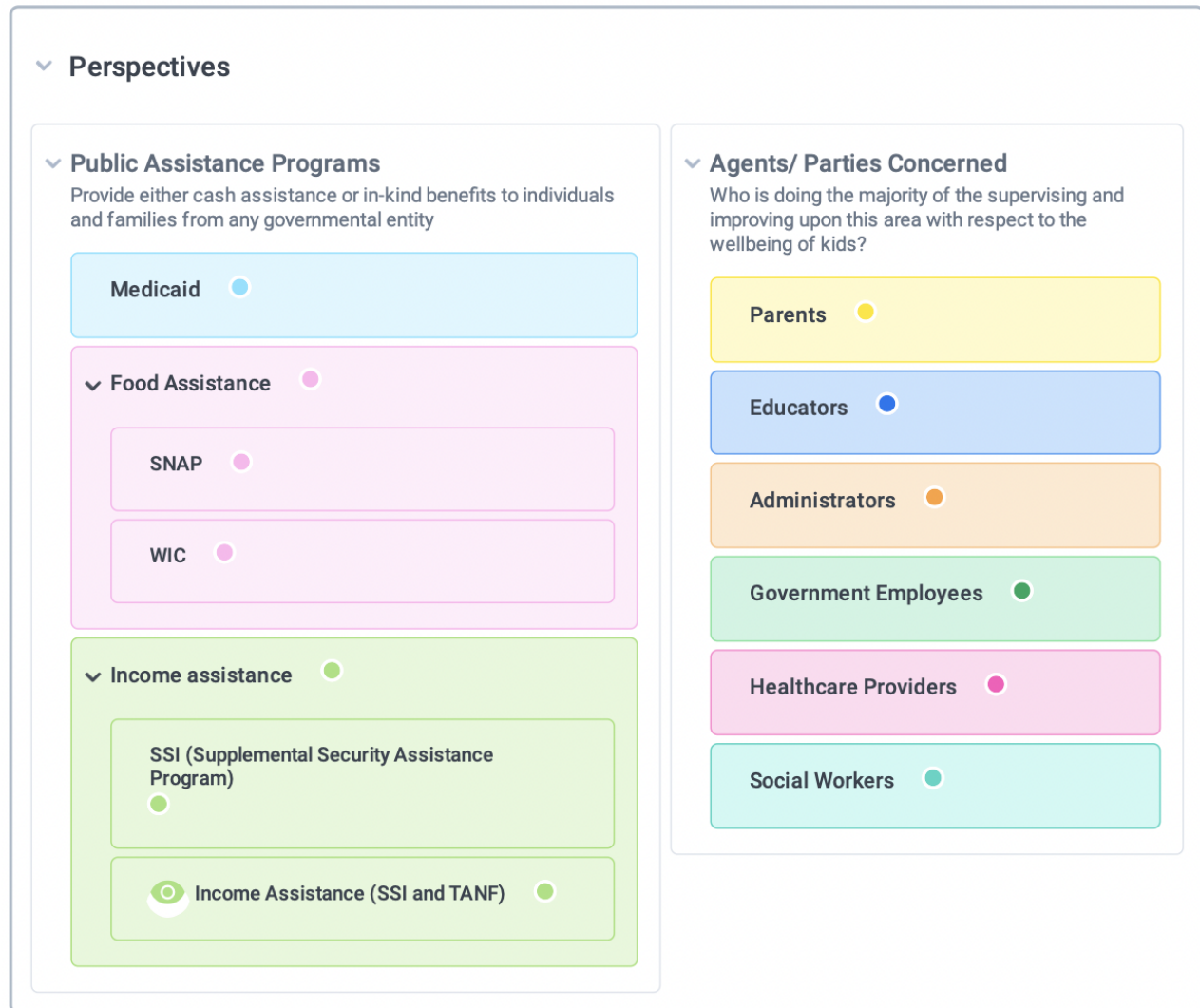


Figure 3: Example of R-Channel

There are many other cognitive jigs in DSRP, but for the purposes of this paper they are not necessary to break down in detail. There were 40 actions in the map (20 of these were bidirectional arrows characterized as reactions) and 9 total perspectives. Since there are so many agents and important programs in the field of health outcomes, these 9 perspectives were split into 2 wholes/groups (Public Assistance Programs and Agents/Parties concerned), with the inclusion criteria of “Is this an improvement program?” or “Is this a supervisor/benefactor of an improvement program?” Adding these two layers to the perspectives allowed for a richer understanding of how involved these programs are in shaping the 93 “views” they look at, and who are the primary agents that create and improve them. Figure 4 shows the 9 perspectives broken down into 2 wholes.

An important tool to fine-tune a map is the application of “Fropping Rules” (Framing and Stopping rules) to help define what is included in DSRP analysis and what isn’t. These rules included the demographics (kids ages 5-13 in America), influence (health behaviors and outcomes resulting from socioeconomic determinants), and desired output (the recommendation should be innovative and new). In checking this mental model against reality, experts in the field and resources with validated data were both used. The resources are cited within this paper, and experts that looked at this map included two Postdoctoral Associates in a Nutrition Graduate Research lab (which specialized in Health Behaviors) and a colleague PhD student in this same lab. This cross-checking against reality and experts helps to ensure that the map is sound and represents its contents as accurately as possible.

Figure 4: Perspectives in the Map.



The following excerpts describe the map through an SPW (Part-Whole Systems) which is essentially the idea that a relationship between two parts can itself have several parts.

Primary Input: Individual Health Behavior

IF ONE WERE TO DRAW A LINE through this map reaching only the most important pieces to (the run-down), the system would have three inputs (as SPW's) and one main output. The three inputs can be organized into primary, secondary, and tertiary on a basis of decreasing changeability moving from primary to tertiary. The

primary input is the most changeable, since it encapsulates individual health behavior. Figure 5 shows this RDS whole, with two pieces of individual behavior motivators and individual health behavior patterns interacting with each other. The two contain their own items that work with items in the other to create behavior outcomes. The relationship labels here help to distinguish the nuances that exist within this RDS.

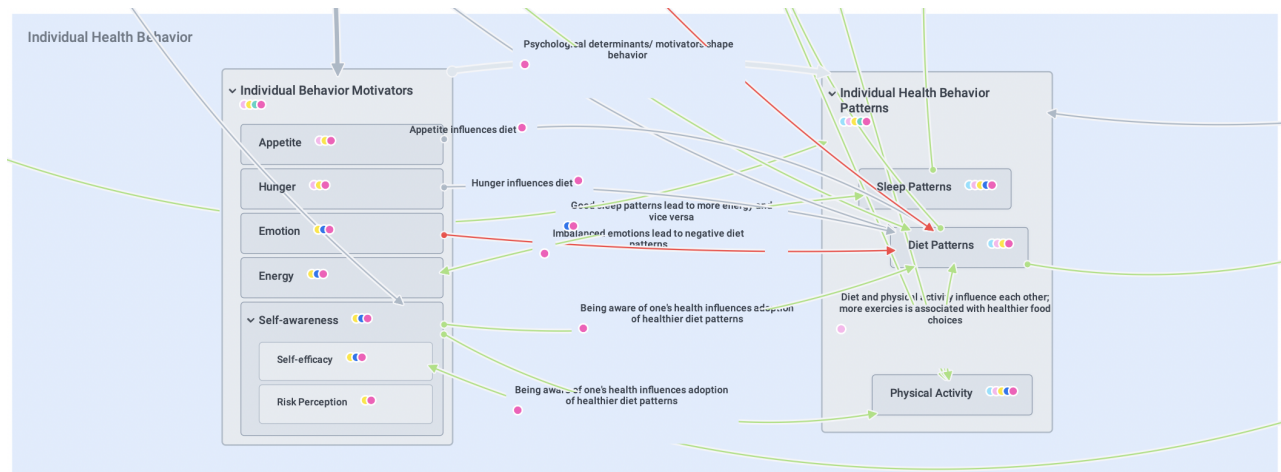


Figure 5: Individual Health Behavior (as Primary Input).

Secondary Input: Environment

A LITTLE LESS CHANGEABLE than health behavior, the environment can be categorized as a secondary input in this map since it often can't be helped but also is not completely rigid. Figure 6 shows this whole, which contains the parts physical environment and social environment which both contain their own RDS's. Physical environment contains "location", "transportation", and "access", while the social environment contains "cultural environment" as well as "quality of connections". The latter piece is important to help contextualize the impact of a person's social environment on their wellbeing. Thus, the whole of the environment has tangible and intangible items that connect through relationships of quality and strength of influence.

Tertiary Input: Individual Characteristics

THE LAST OUTPUT is the least changeable - individual characteristics, which are fairly rigid in regards to how they shape a person's response to their health. Thus, this is the last input category. Figure 7 showcases

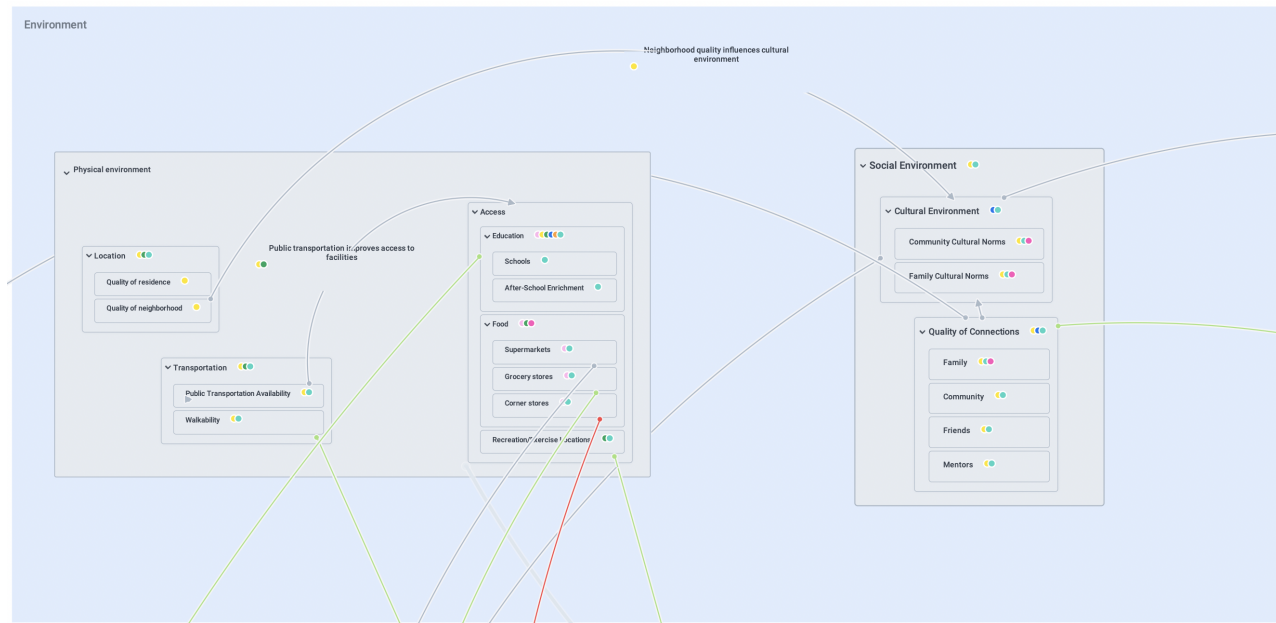


Figure 6: Environment (as Secondary Input).

the individual characteristics portion of the map, which is largely divided into two categories: predetermined biological risk factors (such as race, family history, epigenetic factors, and genetic factors) and human capital (containing “literacy” and “income level”). The latter has several subdivisions that help to explain the details of human capital and its relation to the other inputs and output in this map. The right side of Figure 7 shows the whole of individual risk factors, and the left side shows the human capital whole divided into literacy and income level.

Main Outcomes: Body Conditions

SINCE THE MAP ANALYZED in this study looks at health, the major overall outcome is body conditions, representing the status or absence of any body ailments. This “body conditions” whole is divided into 2 parts: short-term and long-term body conditions. The former represents acute conditions, such as infection, cold/flu, or malnutrition, which is the medical diagnosis for an acute (short-term) period of low nutrition. The long-term conditions represent chronic conditions such as obesity, cardiovascular disease, diabetes, arthritis, osteoporosis, and hypertension. Another very important piece within long-term health outcomes is “epigenetic changes” which stems from recent research findings that suggest that certain diets are able to change genes in the epigenome, which means they will be passed down bearing these lifestyle-induced changes. Epigenetic changes can be

good or bad depending on the individual's lifestyle - bad habits lead to poor epigenetic changes that will complicate health outcomes for future generations, which is even more reason to take health behaviors seriously as an adult. Overall, this main outcome directly reflects the inputs, both environmental and individual, that occurred before them. These are not always directly changeable - to affect any of them, one must intervene at an earlier stage. This step-wise perspective, from environment to behavior to outcome, is a helpful way to look at how changes at any step in the process affect outcomes, and posit how interventions may improve outcomes. Figure 8 shows this outcome.

POSIWID Analysis

THIS MAP'S POSIWID ANALYSIS required stepping back to look at the big-picture and cross-referencing against reality to identify the system's main emergent behaviors. Then, an identification of what they look like today versus what the intended future system's emergent behaviors would look like ideally was carried out. The table below summarizes the conclusion from the POSIWID Analysis. The problem statement describes the overall CAS situation through its outcomes, the current POSIWID describes the current system's emergent behaviors, and the future POSIWID describes how these emergent behaviors would be in an ideal setting after the application of our recommendations. Because the "problem statement" highlights the current systemic outcomes of poor health behaviors and poor health outcomes, the current POSIWID explains how the underlying structure of the system sets American children up for these emergent outcomes of poor health behavior habits and poor health outcomes. Since our goal is to improve overall health outcomes, the future POSIWID alters the former statement into one that explains how the underlying structure of the system sets American children up for good health behavior habits and good health outcomes. By combing through all of the systemic differences in these two hypothetical systems - the current versus future POSIWIDs - it is possible to identify key "root differences" that characterize why and how each system produces its emergent outcomes. There were three root differences. The first is that in the current POSIWID, curative methodologies prevail over preventive methodologies of healthcare. A large portion of the outcomes outlined in the CAS Analysis are attributable to the "preventive healthcare" category - health behavior habituation, nutrition education, physical activity, etc. Today, the healthcare field is largely skewed to its complement, curative healthcare, which

simply treats pre-existing morbid conditions but does not do any work on the front-end to prevent the development of these in upcoming generations. In other words, the field of healthcare right now focuses on treating older adults for their heart disease, renal failure, and other chronic conditions, but does not allocate many resources to helping the children of these older adults (hypothetically speaking) adopt healthful behaviors so as to prevent these morbid conditions later on in their own life. It's been estimated that shifting the focus of healthcare from curative to 90% preventive would result in total savings of \$3.7 billion nationwide through reduced loss of labor, reduced cost of treatment and emergency care, and a greater proportion of healthy adults that are able to grow the economy²¹.

²¹ 9

A second root difference looks at the status of nutrition education - that of "memorizing" versus "evaluating" being the primary focus of this field in the current versus future POSIWID, respectively. In the current system, "memorizing" simply refers to the rote memorization that is applied in today's nutrition education programs. This rote memorization tactic does not give students of nutrition education programs the analytical skills to make the critical thinking decisions required to be a health-conscious consumer. Critical thinking is essential today for a variety of reasons: the market is flush with "customer centered" (processed, fatty, sugary) foods that people need to be able to reject, the current built environment doesn't naturally lead to exercise (so movement needs to be a conscious decision), and people need to be aware of how to apply health behaviors in their own environments despite what their cultural norms may be, which also requires critical thinking. Thus, the future POSIWID in which good health behaviors are the emergent outcome requires a stronger "critical thinking" curriculum in nutrition education programs so as to prepare consumers with the ability to make good health decisions for themselves in the face of a food market and cultural environment saying otherwise. The current POSIWID nutrition education norm, which is the rote memorization of health facts, does not provide people with this skill.

The last root difference between the current and future POSIWID is the culture of health behavior motivation - the drive that motivates people to consistently maintain habits of health-promoting behaviors in their life. In the current POSIWID system, this culture is characterized by "help-dependency", where consumers are accustomed to the "curative" healthcare philosophy and simply ask for help when their own health is at stake. Help is good inherently, but a reliance on this "band-aid" type of approach to health overlooks the value that a preventive philosophy has on maximizing health outcomes. To best ensure adherence to a preventive philosophy, "self-efficacy"

should be emphasized - this means an individual's belief in their ability to perform the necessary behaviors for a specific outcome (in this case, health). By considering the value of prioritizing self-efficacy on behavior, it's easy to see how long-term health outcomes in the future POSIWID would be possible through this shift from "help-dependency" to "self-efficacy" healthcare culture²². Overall, this POSIWID analysis was invaluable in helping to define what the recommendation goals are contextualized by the specific differences that should be addressed between the current and goal state. The following table summarizes the POSIWID Analysis findings. With these four difference-derived goal themes in mind, CAS Analysis can be carried out next.

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Problem Statement	Current POSIWID	Future POSIWID	Root Difference
Current American children display poor health behaviors and have poor health outcomes.	The socioeconomic environment of American kids is exceptionally well designed and good at its purpose of creating habits of poor health behaviors that lead to poor health outcomes in kids.	The socioeconomic environment of American kids is exceptionally well designed and good at its purpose of creating habits of good health behaviors that lead to good health outcomes in kids.	At its core, POSIWID difference is 1. Curative vs preventive healthcare. 2. Memorizing vs evaluating nutrition education. 3. Help-dependent vs self-efficacy culture of health behavior motivation.

Table 3: POSIWID Analysis

CAS Analysis

THE CAS ANALYSIS focuses on identifying the major agents in the system. These major agents are American children ages 5-13, Health Behavior-Facilitation programs, and Health Behavior-Motivation programs. The distinction between Health-Behavior-Facilitation and Motivation was made because of the important gap between the "ability" to do something versus actually doing that action. Despite most socioeconomic health interventions focusing on increasing "ability", a lot of this newly granted access to health promoting resources remains to be unfruitful in terms of producing actual long-standing positive health outcomes in the population. Health Behavior-Facilitation programs are centered around the axis of "access" and "ability" - these include the Environment region in my map, made up of the parts Physical Environment (location, transportation, and access), and Social Environment (cultural environment, quality of connections). This physical environment lays the foundation for a motivated individual to carry out health-promoting behaviors,

but they have to be motivated. The interplay between motivation and access/ facilitation is critical when addressing health improvement policies. An unmotivated individual with access to health-improving behaviors will produce the same outcome as a motivated individual without access to health-improving behaviors; both will not succeed in creating healthy long-term behavior habits. Thus, the Health-Behavior-Motivation agent is the third critical salient agent in this CAS Analysis. It has parts that focus on improving the motivation for health-promoting behaviors in the focal agent of the CAS - the children. These motivation-improving parts in the map are the “Human Capital” region that includes Income Level and Literacy, and of course the “Individual Health Behavior” region with the parts Individual Behavior Motivators and Individual Health Behavior Patterns. Essentially, the parts of the map that directly address motivation deal with intangible knowledge or behavioral items, whereas the parts of the map that address behavior facilitation are more tangible. The table below summarizes the three critical map agents with their individual simple rules as well as the emergent system-level behavior they produce.

List of Salient Agents	Current Simple Rules	Current System Level Behavior
American children ages 5-13	• Rely on their caregivers for sustenance, care, and access to resources • Adopt behaviors from their environment when the resources are available • Incorporate behaviors into long-term habits	• Accept sustenance, care, and access to resources to grow and thrive • Display behaviors from their environment when the resources and motivation is available • Display and pass on long-term habitual behaviors learned from their environment
Health Behavior- Facilitation Programs	• Provide food and health resources to American children • Facilitate the adoption of behaviors for motivated individuals	• Help to nourish and care for American children through healthcare services • Help motivated individuals adopt behaviors
Health Behavior- Motivation Programs	• Establish the protocol for teaching health-promoting behaviors • Facilitate the adoption of behaviors for motivated individuals	• Educate individuals about health-promoting behaviors • Help motivate prepared individuals to adopt behaviors

Table 4: CAS Analysis

Rubric and Recommendations

ANY RECOMMENDATIONS made should not violate the current simple rules described in this section's recommendation rubric. There are three major recommendations for this system, and they all incorporate allocation of "Health Behavior-Facilitation Programs" for disadvantaged populations and "Health Behavior-Motivation Programs" for all.

Recommendation Rubric

No specific recommendation should violate these rules:

1. The recommendation must proactively establish resource allocation before all else - either confirm resource availability or create a path for it.
2. The recommendation considers "resources" as being continual access to whole foods, open spaces for exercise, and the ability to safely and knowledgeably access healthcare providers.
3. The recommendation must establish behavior motivation (the first step after resource allocation confirmation) through education before all else.
4. The recommendation must be focused on children, and strive to proactively and continually meet both them and their families where they are in terms of resources and motivation.

Specific Recommendations

1. Intervention/Recommendation 1: Establish a yearly baseline understanding of the resources available to American children ages 5-13 through a public school enrollment survey.
2. Intervention/Recommendation 2: Ensure social workers allocate appropriate resources for families of children ages 5-13 so as to confirm that every year, families of children ages 5-13 are able to have access to whole foods, open spaces for exercise, and the ability to safely and knowledgeably access healthcare providers.
3. Intervention/Recommendation 3: Create flexible and adaptive health-behavior motivation programs for resource-established families that start by establishing a foundational health education knowledge base and build towards self-efficacy.

Discussion

DSRP Analysis of the System

THE DETERMINANTS, or most of the pieces in this map, were “splat mapped” using inspiration from the classical pentivariate SODH model (Economic Stability, Education Access and Quality, Health Care Access and Quality, Neighborhood and Built Environment, and Social and Community Context) to create a more precise 2-factor and 2-outcome model²³. With only 2 broad “factor groups” (Individual Characteristics and Environment), it is easier to look at how these variables shape the 2 sequential “outcome groups” (Individual Health Behavior and Health Outcomes). One way to look at the distinction between these two identities (factors vs outcomes) is asking the questions “What is already established for the individual?”, which relates to the factors, and “What is the individual doing or causing?”, which relates to the outcomes²⁴. The factors are what shape the individual’s health behaviors and outcomes, and are where interventions should be targeted for the most effective remediation.

The overarching conclusion from this DSRP analysis is that interventions are only as feasible as the input that they affect. By organizing the map into three inputs that vary by changeability, it is easier to see that some parts of the event sequence from individual to outcome are more rigid than others. For example, it is unfeasible to think that intervening at the income level would realistically be able to yield a predictable amount of significant change in health outcomes. A more realistic intervention point would be “self-awareness” in the individual behavior motivators whole since the relationships between this and health outcomes and health behaviors are numerous and substantiated. Using this philosophy, the main takeaways from this map and DSRP analysis are that the points of access (within “physical environment”), literacy (within “individual characteristics”), and self-awareness (within “individual health behaviors”) are the most feasible to intervene within the three previously described “inputs” for the health outcome output. This information is valuable in the next steps of the ABA approach where it is more clearly defined how these points should be intervened.

POSIWID Analysis

APPLYING POSIWID ANALYSIS may have been the most rewarding part of the ABA approach in helping to conceptualize what the actual problem with the CAS was. Before writing down the system emergent behaviors, it’s easy to talk oneself into confusion by just describing what the system appears to do without any real structure. Following the POSIWID protocol, one can identify the root differences as being (1) curative versus preventive healthcare, (2) memorization

versus evaluation nutrition education, and (3) help-dependent versus self-efficacy culture of health behavior motivation. The former in each of these root differences represents the current status of the CAS, whereas the latter describes the goal situation. An intuitive connection can be made between the DSRP Analysis and POSIWID Analysis, where the main hypothesized intervention points correspond largely with the root differences. The “access” intervention point within the physical environment relates to the health-care environment (which we ideally want to be preventive). The “literacy” intervention point within the individual characteristics relates to the evaluation nutrition education goal, and finally, the “self-awareness” piece relates to the self-efficacy culture of health behavior motivation goal.

Identifying these root differences was monumental for helping to create a plan for improving the current system. Half of these root differences can be categorized into individual health behavior “facilitators” (health-centered food market and preventive healthcare) and the other half into individual health behavior “motivators” (evaluating nutrition education and self-efficacy culture of health behavior motivation). Ultimately, the most effective differences to improve within the map are those of individual behavior motivators and facilitators, and this insight can help to format our recommendations.

CAS Analysis

THE CAS ANALYSIS tied all previous findings together beautifully. It helped to contextualize the concept that the two major categories of factors that lead to behavior change are “individual behavior motivators” and “individual behavior facilitators”. Treating these two factors as agents in the map and identifying their rules and behaviors at the system level gleaned information as to how to best intervene. Thus, the first two agents were these two factors, and the third agent within this CAS Analysis was American children ages 5-13. This analysis showed that there are two real ways to cause behavior change in American children - by changing aspects that affect individual behavior facilitation, or by changing aspects that affect their individual behavior motivation. Adding research findings to this baseline conclusion gave a new layer of information to any potential interventions. Knowing that behavior motivators have no effect on individuals without pre-existing behavior facilitators (things like access, environment, etc) means that any behavioral motivation interventions that exist in isolation of behavioral facilitation are not worthwhile. These two behavioral factors co-exist and work with each other to lead to behavior change. This was the main takeaway

from CAS analysis - that American children display behaviors from their environment when the resources and motivation is available. Thus, any recommendations made to improve this system must consider both resources (behavior “facilitators”) and motivation in order to affect any significant change.

Rubric and Recommendations

IN PRAGMATIC TERMS, the most pivotal aspect of this map is a bipartite factor focus that shapes the focus of the recommendations. The bipartite factors, representing what lead to health behaviors and ultimately long-term health outcomes, are the “Environment” and “Individual Characteristics” regions that harbor an individual’s physical/social environment and human capital/ literacy level, respectively. These regions correspond with the “two-fold” recommendations - first the establishment of Health-Behavior-Facilitation programs (which correspond with the “Environment” piece) and then supplementing with Health-Behavior-Motivation programs that focus on building an individual’s interest and ability to adopt health behavior habits (that focus on the “Individual Characteristics” factor).

This recommendation theme, which considers the individual’s existing resource access before the consideration of motivation programs, stems from the system level behaviors that behavior adoption only occurs when the resources are available. This sedimentary characterization of behavior adoption, where the resources should first exist and be accessible for the individual before motivation is feasible to cause behavior change, stems from Maslow’s Hierarchy of Needs, where “resource”-adjacent needs such as Physiological Needs (air, water, food, shelter, sleep, clothing. etc) and Safety Needs (personal security, employment, resources, health, and property) are a requirement before any of the higher-level cognitive needs like Esteem (respect, self-esteem, status, recognition, strength, and freedom) as well as Self-Actualization (desire to become the best one can be, which relates heavily to self-efficacy in health) can be fulfilled. Thus, emphasizing Health-Behavior Motivation programs without considering the resources that are available to individuals is not going to be effective according to Maslow - individuals simply aren’t able to focus on behavioral intricacies when their basic needs haven’t been met²⁵. Conversely, it is also not appropriate to completely ignore Health-Behavior Motivation programs and only focus on resources, since this would lead to a half-finished pyramid (using Maslow’s visual) with individuals lacking the education, motivation, and self-efficacy needed to turn their vast resources into positive

²⁵ 11

health outcomes through behaviors and lifestyle habits.

The first recommendation, to establish a yearly baseline understanding of the resources available to American children ages 5-13 through a public school enrollment survey, creates the knowledge base for which to guide any interventions. It follows all of the rules and maintains an “agent-based” approach. The second recommendation, which similarly follows all of the rules, is to ensure that social workers allocate appropriate resources for families of children ages 5-13 so as to confirm that every year, families of children ages 5-13 are able to have access to whole foods, open spaces for exercise, and the ability to safely and knowledgeably access healthcare providers. This goes a step-up from the knowledge base to establish a baseline resource level with regards to the individual’s environment so that they have the ability to do any behavior change. Once this baseline resource is established, the third recommendation comes into play: create flexible and adaptive health-behavior motivation programs for resource-established families that start by establishing a foundational health education knowledge base and build towards self-efficacy. This, again, maintains an “agent-based” approach and follows the recommendation rubric rules. All of the recommendations are “agent-based”, which matches the “Agent Based Approach” method and provides an actionable item list with which to intervene in the system. As with all solutions, it’s important to maintain a feedback loop to make edits to the recommendations. Overall, this final recommendation list is a standardized, agent-based approach to create positive change in the current system of socioeconomic determinants of health in American children, bringing the system from its current status of a curative healthcare philosophy, a memorization approach to evaluate nutrition education, and a help-dependent health behavior motivation culture, to one of preventive healthcare, evaluation-focused nutrition education, and self-efficacy culture of health behavior motivation. The ultimate outcome, improved long-term health outcomes in American children, should be a natural result of these small agent-based changes based on our DSRP analysis.

The recommendation rubric used to develop the recommendations is valuable in itself, and can be used to develop new recommendations in a similar system, or can be adapted to fit other systems. The final 3 recommendations capture the goal of ensuring long-term health outcomes in American children while following all of the established recommendation rubric rules, guiding the system into an emergent behavior much closer to one in an ideal setting that leads to positive long-term health outcomes.

A major benefit of an ABA analysis regarding health behaviors in children is that behavior change is generational. Thus, any work

done in this area is likely to extend to future generations. Future research should focus on applying these recommendations in home-school settings, as well as other cultures outside of America. Another straight-forward jumping off point from this analysis would be to include other age groups in the future.

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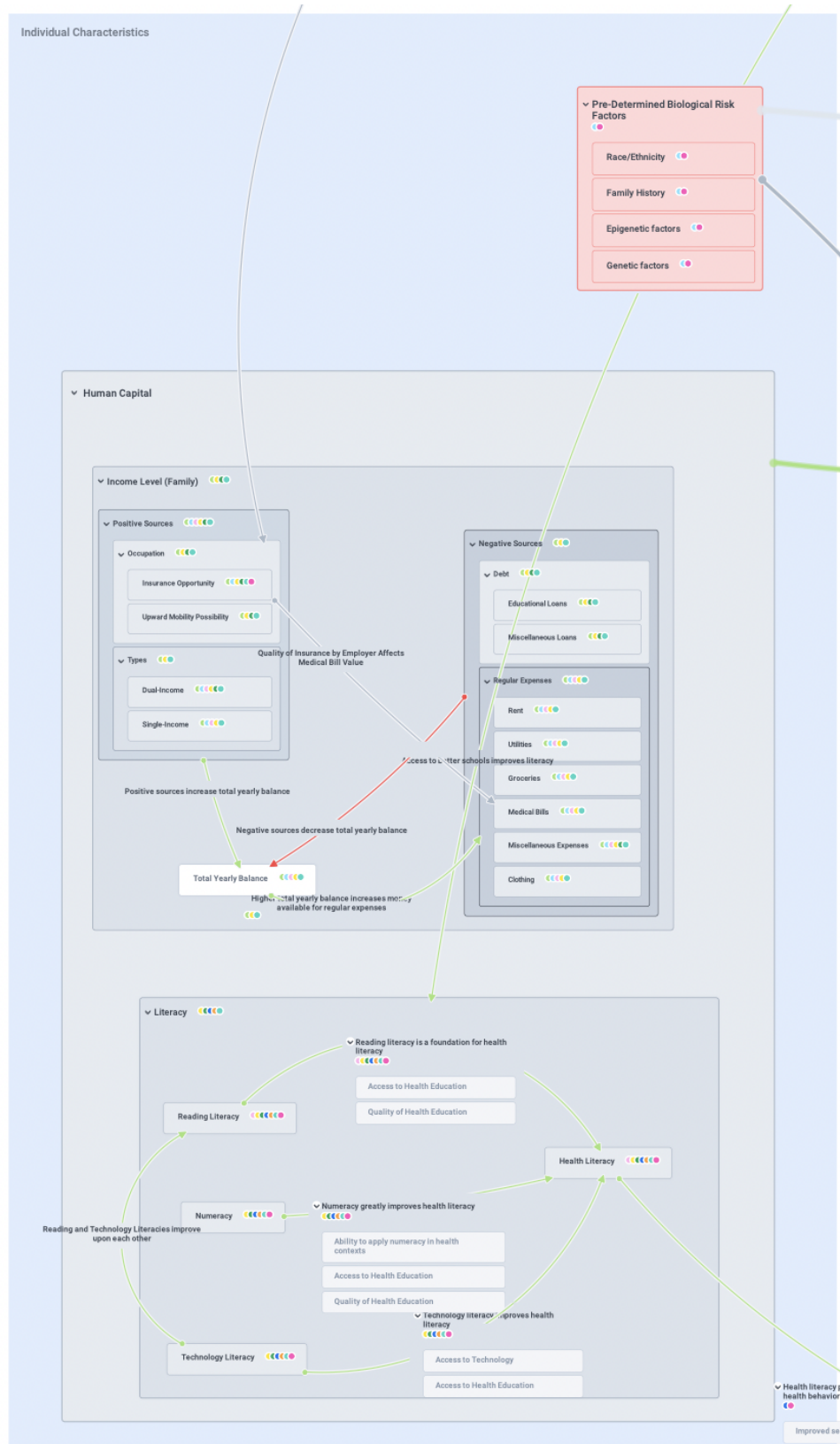


Figure 7: Individual Characteristics (as Tertiary Input).

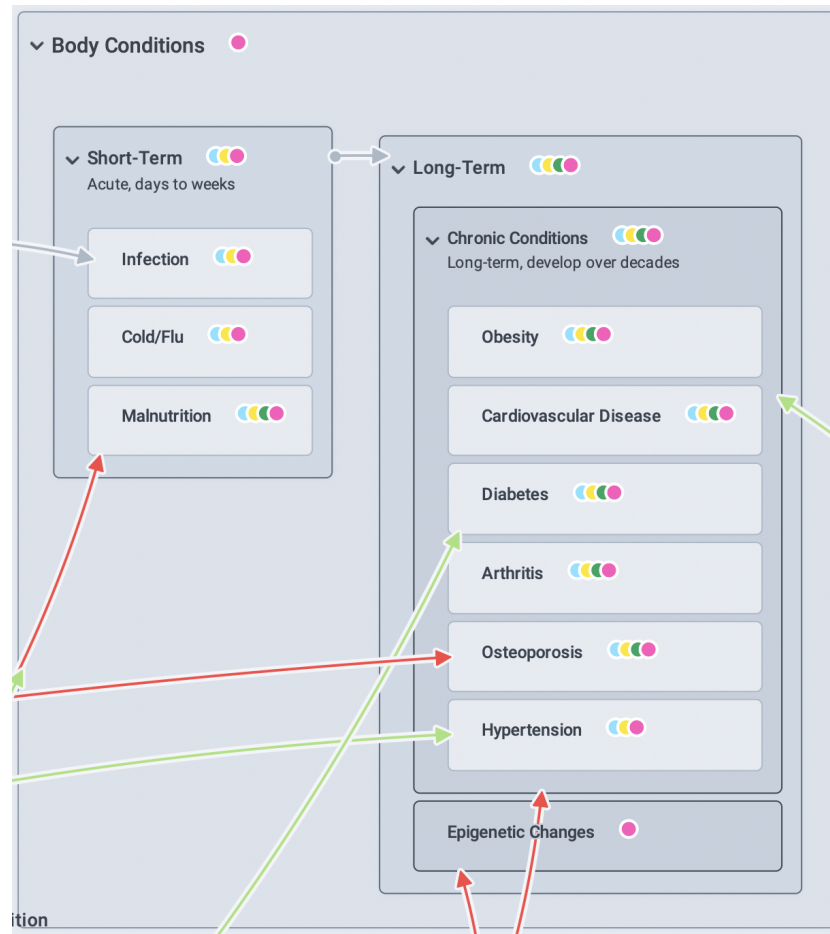


Figure 8: Body Conditions (as Main Outcome).