Systems Thinking in Communities:

Understanding the Causes of Inactivity, Poor Diet/Nutrition, and Childhood Obesity in Caguas, Puerto Rico

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Introduction

Caguas Healthy Kids, Healthy Communities is one of 49 Caguas, Puerto Rico partnerships participating in the national *Healthy Kids, Healthy Communities* program of the Robert Wood Johnson Foundation (www.healthykidshealthycommunities.org). The purpose of this *Caguas Healthy Kids, Healthy Communities* project was to introduce systems thinking at the Caguas, Puerto Rico level by identifying the essential parts of the Caguas Healthy Kids, Healthy Communities system and how the system influences policy and environmental changes to promote healthy eating and active living as well as to prevent childhood obesity. To accomplish this goal, community partners and residents participated in a group model building session and discussions. The group model building exercises were designed by staff from Transtria LLC and the Social System Design Lab at Washington University in St. Louis, Missouri as part of the *Evaluation of Healthy Kids, Healthy Communities* funded by the Robert Wood Johnson Foundation. These exercises actively involved a wide range of participants in modeling complex systems and provided a way for different representatives (e.g., residents, agencies, organizations, businesses, and universities) to better understand the systems (i.e., dynamics and structures) in the Caguas, Puerto Rico (see the *Healthy Kids, Healthy Communities Group Model Building Facilitation Handbook*, www.transtria.com/hkhc). Overall, the evaluation was designed to assess policy, system, and environmental changes as a result of the Caguas, Puerto Rico partnerships' efforts to increase healthy eating and active living in order to reduce childhood obesity.

Caguas, Puerto Rico: Background and Local Participation

In December 2009, the Caguas HKHC partnership received a four-year, $360,000 grant as part of the HKHC national program. This partnership focused on expanding the existing healthy eating and active living efforts throughout Caguas. SANOS was the lead agency.

The municipality of Caguas in Puerto Rico has a population of 142,893 residents and is Puerto Rico's fifth largest municipality. The vast majority of Caguas' population is Hispanic, with Spanish spoken in most households and well over half with limited English proficiency. Over a third of all persons in Caguas had incomes below the U.S. Poverty level and one-fifth of the population is less than 18 years of age.

The current partners had been working together since 2006, however, RWJF funding strengthened and grew the partnership. The Caguas HKHC partnership was established to address the need to reduce the high rate of childhood obesity in Caguas. It started working on healthy eating and active living strategies in preparation for submitting the grant to RWJF, although previous efforts had been more programmatic and promotional. The HKHC grant pushed the Caguas HKHC partnership to work on policy, system, and environmental change approaches.

***Caguas Healthy Kids, Healthy Communities'* Priorities and Strategies**

The partnership and capacity building strategies of *Caguas Healthy Kids, Healthy Communities* included:

- *Agriculture Business:* A non-profit corporation, Youth Corporation for the Development of Sustainable Communities, was developed to promote entrepreneurship in agricultural business for economically disadvantaged communities, including piloting farm technology, serving as a food hub for farmers to prepare food for selling, and reducing energy costs. This was started by the municipal government with collaboration from SANOS.

The healthy eating and active living strategies of *Caguas Healthy Kids, Healthy Communities* included:

- *Active Transportation:* As part of a larger vision to transform Caguas into a Complete Streets community with bike lanes, public transit systems, and pedestrian infrastructure, a CicloRuta event was started which closed the streets to automobiles and opened it to bicyclists to encourage methods of active transportation.
- *School Gardens:* The school garden program started as a pilot program in 3 schools and expanded to include the creation of 17 school gardens in Caguas.
- *Farmers' Markets:* A farmers' market was established in October 2013 in SANOS parking lot held two Fridays and Saturdays each month from 8:00 AM to 2:00 PM.

For more information on the partnership, please refer to the Caguas case report (www.transtria.com/hkhc).

Systems Thinking in Communities: Caguas, Puerto Rico

"Systems thinking" represents a range of methods, tools, and approaches for observing the behaviors of a system (e.g., family, Caguas, Puerto Rico, organization) and how these behaviors change over time; changes may occur in the past, present, or future. Figure 1 illustrates a system of policies, environments, local collaborations, and social determinants in Caguas, Puerto Rico that influence healthy eating, active living, and, ultimately, childhood obesity. This system and the dynamics within the system are complicated with many different elements interacting.

Models, such as Figure 1, provide a way to visualize all the elements of the system and their interactions, with a focus on causal relationships as opposed to associations. Through the model, specific types of causal relationships, or feedback loops, underlying the behavior of the dynamic system, can be identified to provide insights into what is working or not working in the system to support the intended outcomes (in this case, increases in healthy eating and active living, and decreases in childhood overweight and obesity). In system dynamics, the goal is to identify and understand the system feedback loops, or the cause-effect relationships that form a circuit where the effects "feed back" to influence the causes.

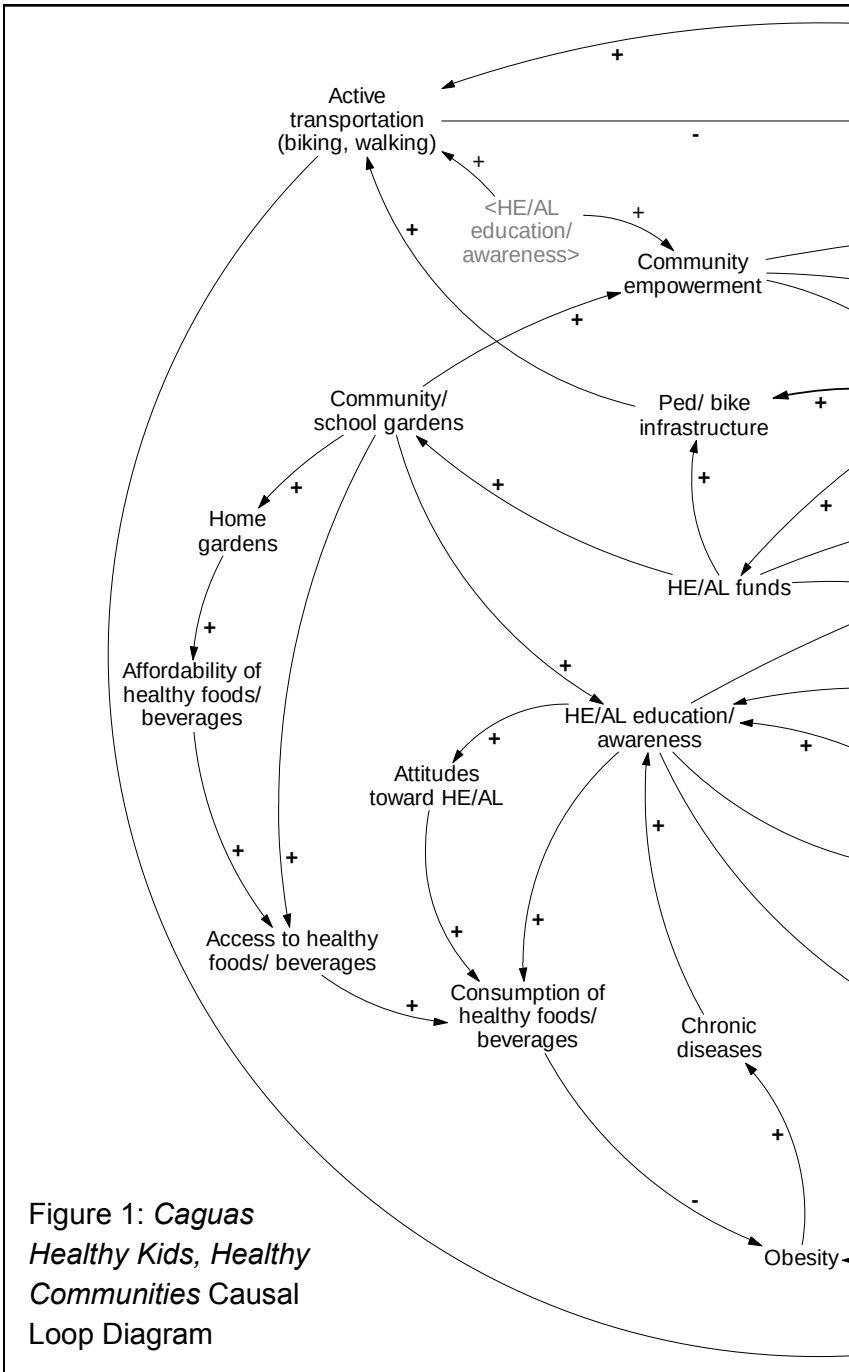


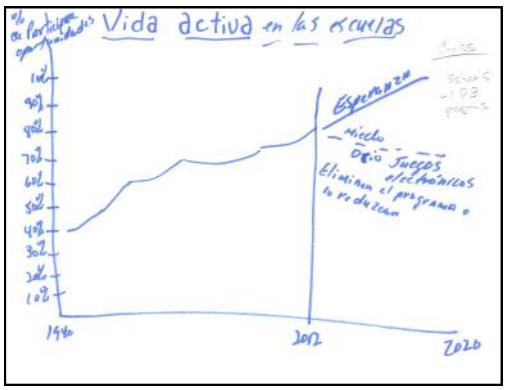
Figure 1: *Caguas Healthy Kids, Healthy Communities* Causal Loop Diagram

Group Model Building

Members of the *Caguas Healthy Kids, Healthy Communities* partnership participated in a group model building session in September, 2012 and generated this system, also referred to as a causal loop diagram (Figure 1). Participants in the group model building session included community partners. The group model building session had two primary activities: 1) a Behavior Over Time Graph exercise; and 2) a Causal Loop Diagram (or structural elicitation) exercise.

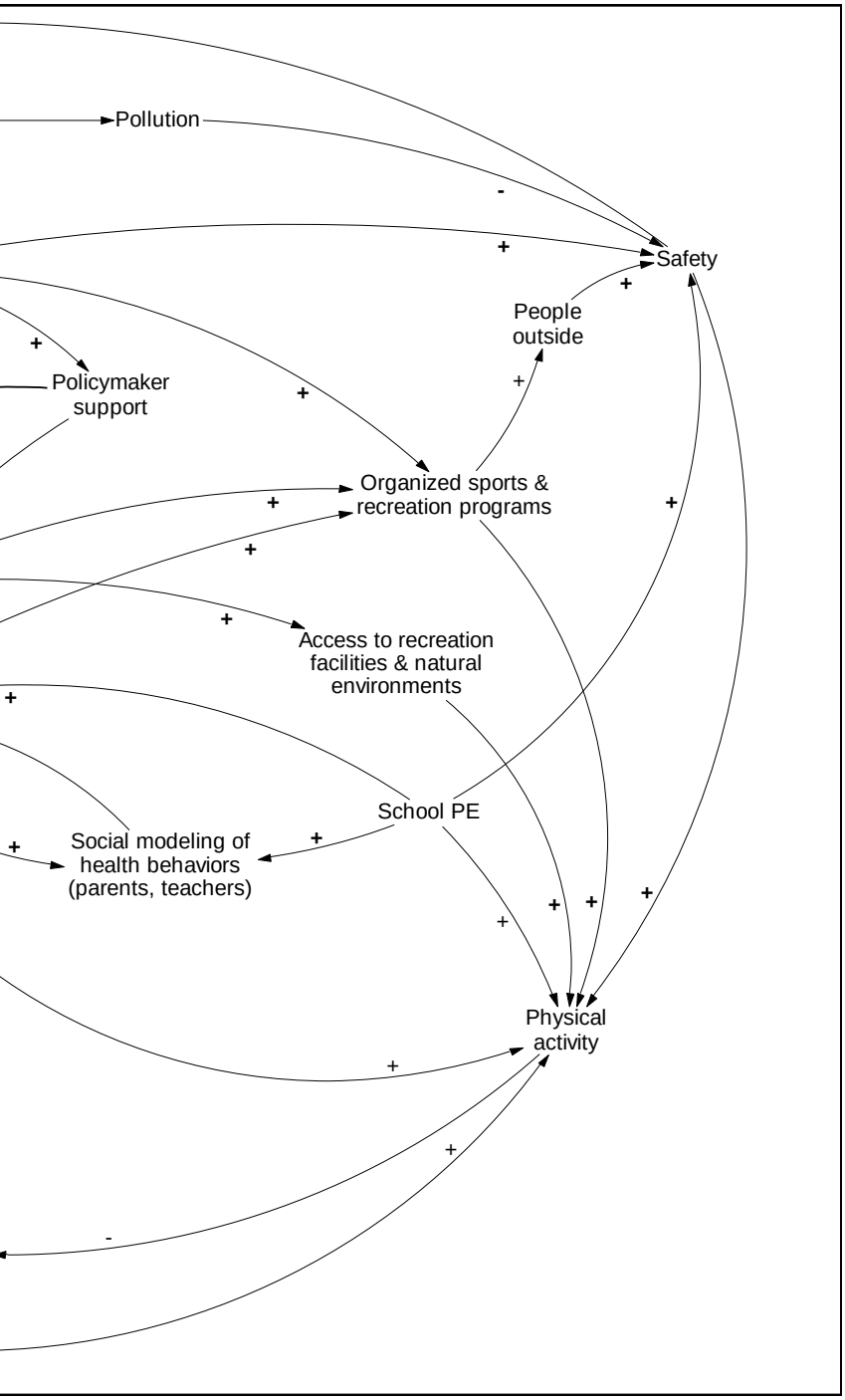
<u>Behavior Over Time Graphs</u>

To identify the range of things that affect or are affected by policy, system, and environmental changes in Caguas related to healthy eating, active living, and childhood obesity, participants designed graphs to name the influences and to illustrate how the influences have changed over time (past, present, and future). In this illustration for schools with physical education (PE) programs, the number of schools has increased from 1940 to 2012 and the participant hopes that this increase will continue into the future.



Schools with PE programs

Each graph is a tool to increase the use of common, specific language to describe *what* is changing in the Caguas, Puerto Rico as well as *when*, *where*, and *how* it is changing. The graphs capture participants' perceptions of the influence, or variable, and through the graph, the participant tells their story. These perceptions are based on actual data or evidence, or they are part of the participants' lived experience.



Causal Loop Diagram

To examine the relationships among the variables from the behavior over time graphs, participants worked together and with facilitators to develop a causal loop diagram. In Figure 1, the words represent variables of quantities that can increase and decrease over time (i.e., the behavior over time graphs). These variables are influenced by other variables as indicated by the lines with arrows. The lines with arrows represent causal relationships - this is what is known about the system and how it behaves.

One feedback loop is: healthy eating (HE) and active living (AL) funds → community/school gardens → community empowerment → policymaker support → HE/AL funds.

What is important to notice in this example is that there are other feedback loops interacting simultaneously to influence or to be influenced by HE/AL funds. Some variables may increase HE/AL funds while other variables limit it. Determining the feedback loop or loops that dominate the system's behavior at any given time is a more challenging problem to figure out, and ultimately, requires the use of computer simulations.

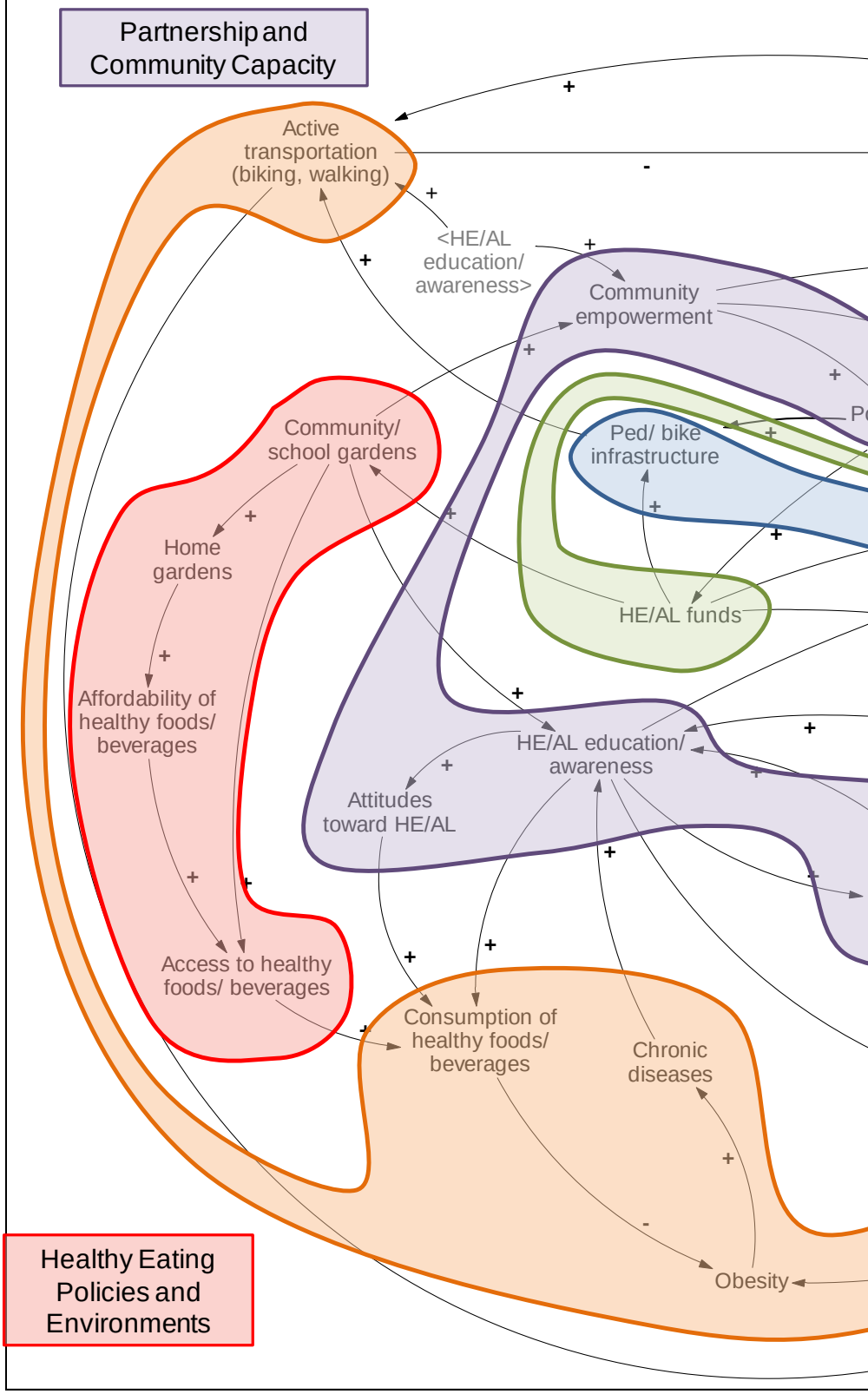
Based on this preliminary work by the *Caguas Healthy Kids, Healthy Communities* partnership, this "storybook" ties together the behavior over time graphs, the participants' stories and dialogue, and feedback loops from the causal loop diagram to understand the behavior of the system affecting health in Caguas, Puerto Rico and to stimulate greater conversation related to Caguas 's theory of change, including places to intervene in the system and opportunities to reinforce what is working. Each section builds on the previous sections by introducing concepts and notation from systems science.

Causal Loop Diagram for the Childhood Obesity System

The causal loop diagram (CLD) represents a holistic system and several subsystems interacting in Caguas, Puerto Rico. In order to digest the depth and complexity of the diagram, it is helpful to examine the CLD in terms of the subsystems of influence. Because of this project's focus on healthy eating, active living, and childhood obesity, this system draws attention to a number of corresponding subsystems, including: healthy eating policies and environments (red), active living policies and environments (blue), health and health behaviors (orange), partnership and Caguas, Puerto Rico capacity (purple), and social determinants (green).

From the group model building exercises, several variables and causal relationships illustrated in Figure 2 were identified within and across subsystems. This section describes the subsystems in the CLD.

Figure 2: Subsystems in the *Caguas Healthy Kids, Healthy Communities* C

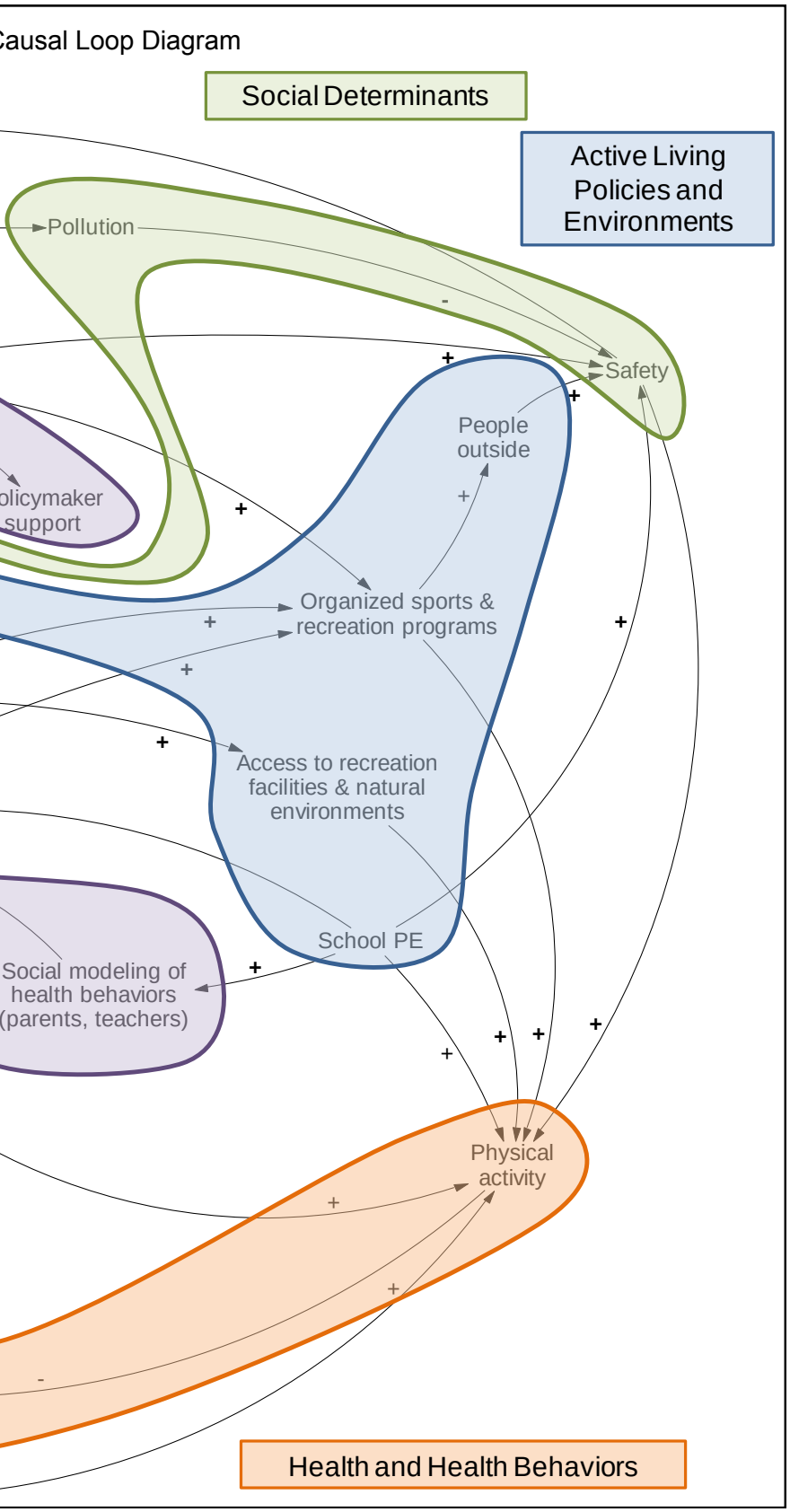


Healthy Eating Policies and Environments (Red)

The healthy eating policy and environmental subsystem includes food production , food distribution and procurement, and food retail. During the behavior over time graphs exercise, the participants generated graphs related to policy or environmental strategies (e.g., community/school gardens) or contexts (e.g., access to healthy foods/ beverages) that affected or were affected by the work of *Caguas Healthy Kids, Healthy Communities*. The variables represent participants' conversations from the behavior over time graph and causal loop diagram exercises.

Active Living Policies and Environments (Blue)

The active living policy and environmental subsystem includes design, planning, construction, and enforcement or maintenance related to access to opportunities for active transportation and recreation. For this topic, the group model building participants also developed graphs related to policy or environmental strategies (e.g., school physical education) or contexts (e.g., access to recreation facilities and natural environments) that affected or were affected by the partnership's work.



Health and Health Behaviors (Orange)

The subsystem for health and health behaviors includes health outcomes (e.g., obesity), health behaviors (e.g., healthy eating, physical activity), and behavioral proxies or context-specific behaviors (e.g., active transportation).

Partnership and Community Capacity

The partnership and community capacity subsystem refers to the ways communities organized and rallied for changes to the healthy eating and active living subsystems. For instance, *Caguas Healthy Kids, Healthy Communities* used approaches to increase community empowerment. This subsystem also includes Caguas, Puerto Rico factors outside the partnership that may influence or be influenced by their efforts, such as policymaker support.

Social Determinants

Finally, the social determinants subsystem denotes societal conditions (e.g., HE/AL funds) and psychosocial influences in the Caguas, Puerto Rico that impact health beyond the healthy eating and active living subsystems. In order to achieve health equity, populations and subgroups within the Caguas, Puerto Rico must have equitable access to these resources and services.

Each one of these subsystems has many more variables, causal relationships (arrows), and feedback loops that can be explored in greater depth by the *Caguas Healthy Kids, Healthy Communities* partners or by other representatives in Caguas, Puerto Rico. Using this CLD as a starting place, Caguas, Puerto Rico conversations about different theories of change within subsystems may continue to take place.

The next sections begin to examine the feedback loops central to the work of *Caguas Healthy Kids, Healthy Communities*. In these sections, causal relationships and notations (i.e., arrows, “+” signs, “-” signs) from Figure 2 will be described to increase understanding about how systems thinking and modeling tools can work in communities to increase understanding of complex problems that are continuously changing over time, such as childhood obesity. At the end of this CLD storybook, references to other resources will be provided for those interested in more advanced systems science methods and analytic approaches.

School Garden Feedback Loop

To simplify the discussion about feedback loops, several loops drawn from the Caguas Healthy Kids, Healthy Communities CLD (see Figures 1 and 2) are highlighted in Figures 3-5. While the CLD provides a theory of change for the childhood obesity prevention movement in Caguas, Puerto Rico, each feedback loop tells a story about a more specific change process.

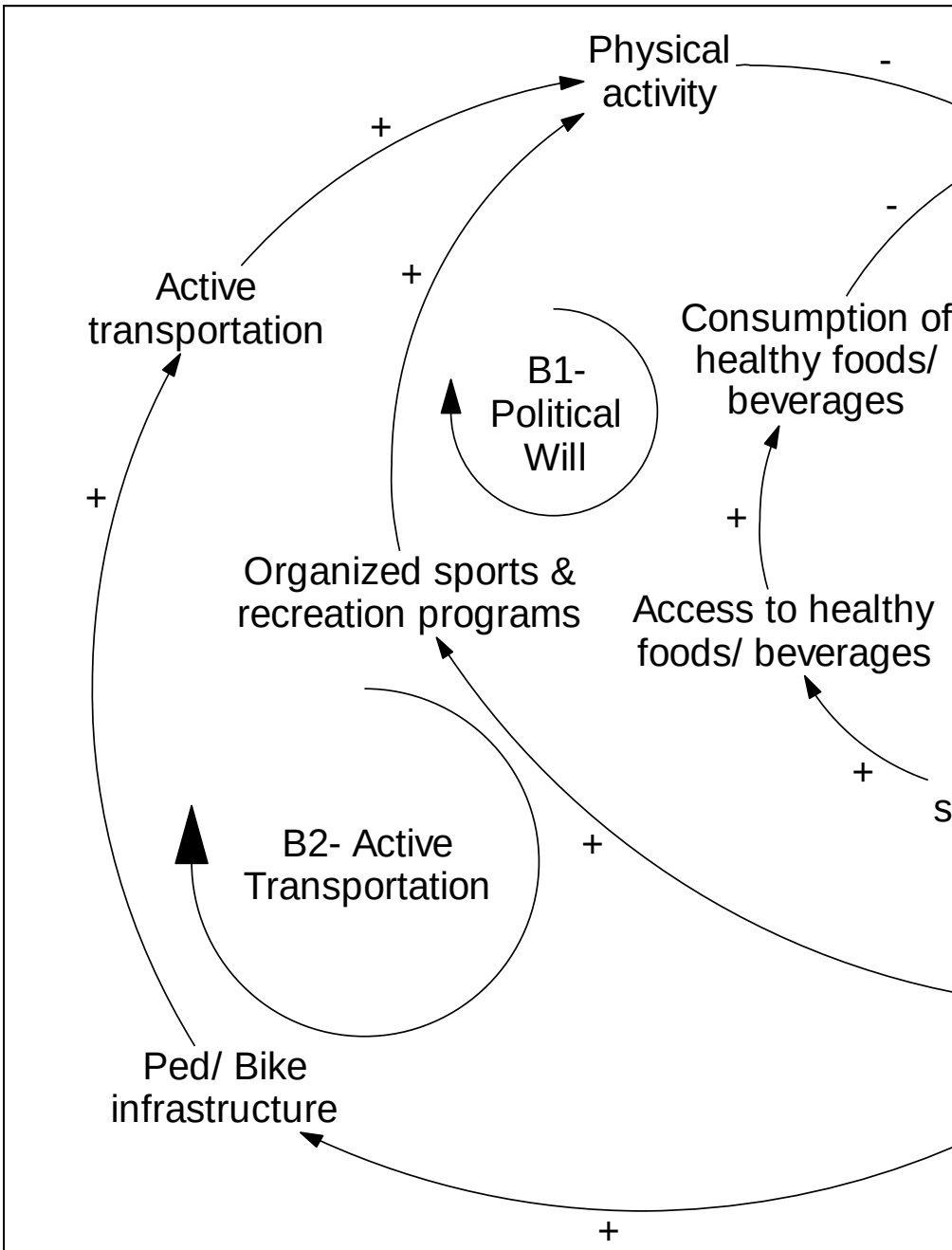


Figure 3: Caguas, Puerto Rico Gardens Feedback Loop

Causal Story for Feedback Loop

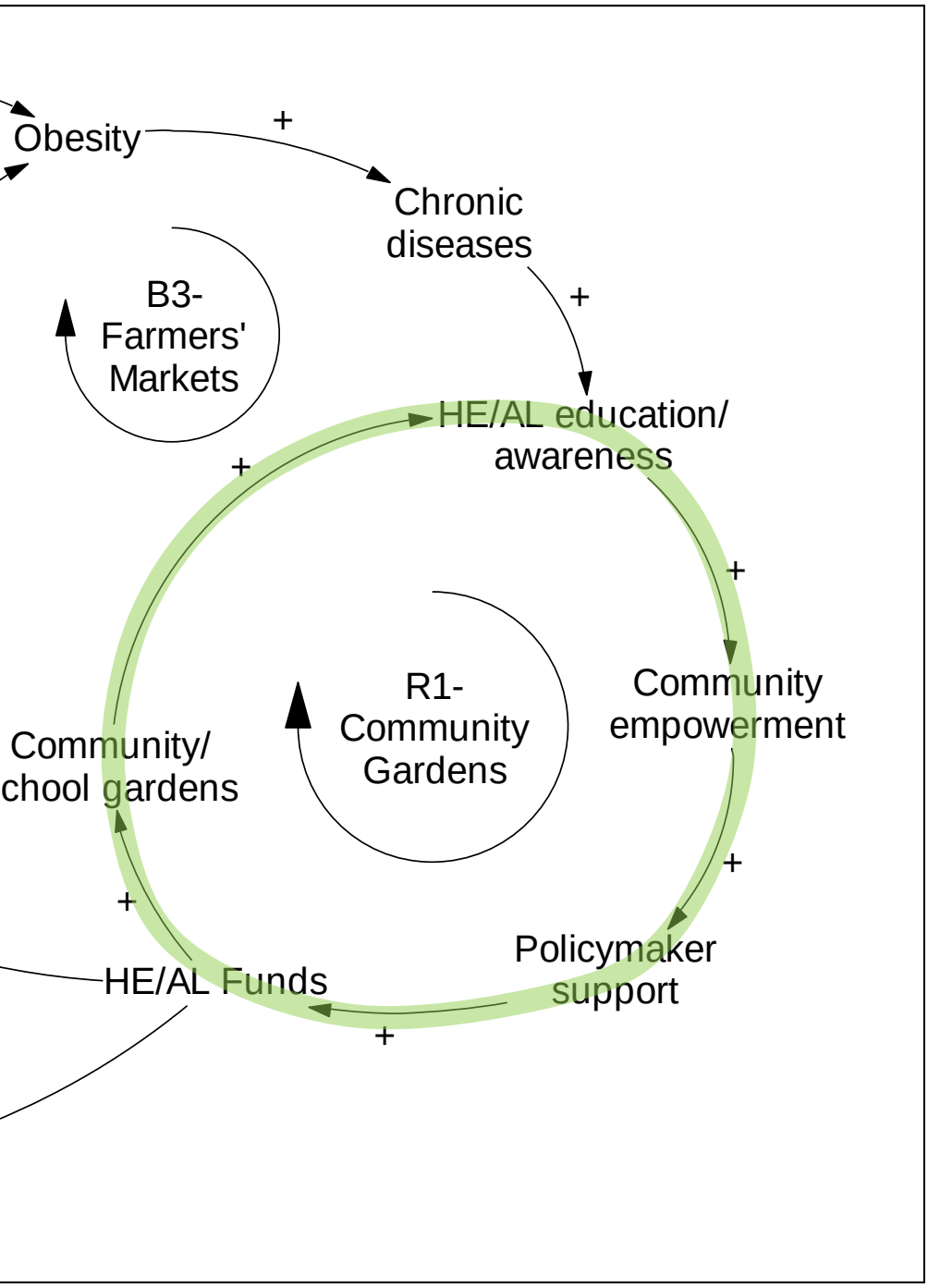
Story A: In this case, the story is about school gardens (green highlighted loop in Figure 3). Caguas, Puerto Rico partners created 17 school gardens. Participants described how school gardens increase education and awareness of the importance of healthy eating. In turn, this awareness empowers communities to gain support from policy-makers, including funding, to support further development and maintenance of school gardens.

Story B: While the preceding story reflected a positive scenario for Caguas, Puerto Rico, the same feedback loop also tells the opposite story. The absence of school gardens limits opportunities for education and awareness of the importance of healthy eating. As a consequence, community residents may be less empowered to work with policy-makers to increase funding for healthy eating initiatives, such as school gardens.

Reinforcing Loop and Notation

These stories represent a reinforcing loop, and the notation in the feedback loop identifies it as a reinforcing loop (see "R1 — Community Gardens" and green highlighted loop in Figure 3). The words represent variables of quantities that increase and decrease as illustrated in the stories above. These variables change over time and are influenced by other variables as indicated by the arrows. Each arrow represents a causal relationship, and the plus and minus signs on the arrows indicate whether or not the influence of one variable on another variable (1) increases/adds to (plus or "+" sign), or (2) decreases/ removes from the other variable (minus or "-" sign). These signs are referred to as polarities. In a reinforcing loop, the effect of an increase or decrease in a variable continues through the cycle and returns an increase or decrease to the same variable, respectively. Looking specifically at the "+" or "-" notation, a feedback loop that has zero or an even number of "-" signs, or polarities, is considered a reinforcing loop. Balancing loops, with an odd number of "-" signs in the loop, are another type of feedback loop.

In isolation, this reinforcing loop represents a virtuous cycle in Story A as these assets positively support one another, or a vicious cycle in Story B as these challenges perpetuate a downward spiral. Yet, the influence of school gardens likely levels off at some point when, for instance, each school has a garden. To understand what



Number of planting areas in schools of the municipality of Caguas

specifically leads to the leveling off of school gardens, it may be helpful for the partners in Caguas, Puerto Rico to consider other variables that influence or are influenced by school gardens (e.g., personnel and funds to support maintenance of the gardens). In addition, it is important to remember that this reinforcing loop is only one part of the larger CLD (see Figures 1 and 2), and the other loops and causal relationships can have an impact on the variables in this loop.

<u>System Insights for *Caguas Healthy Kids, Healthy Communities*</u>

Participants also identified a steady increase in the number of planting areas in schools in Caguas, Puerto Rico (see behavior over time graph).

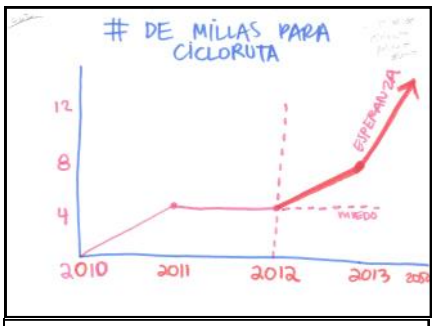
From the systems thinking exercises, several insights can inform ongoing efforts to develop and maintain school gardens, such as enlisting community residents to work in the gardens in order to generate greater awareness of the gardens and to increase community and political support for school gardens and healthy eating opportunities in Caguas.

In addition to these insights, systems thinking can also help to pose key questions for assessment and evaluation, including assessment of community residents' and policy-makers' awareness and support for school gardens as well as funds needed to support and maintain the school gardens over time.

Active Transportation (CicloRuta) Feedback Loop

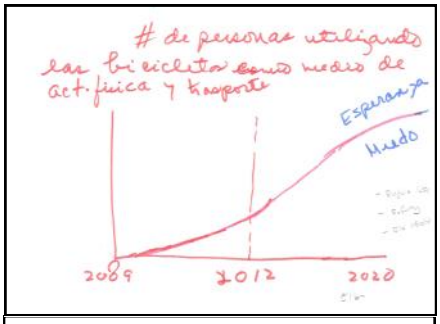
The feedback loop highlighted in blue in Figure 4 reflects the same concepts and notation for active transportation in Caguas, Puerto Rico.

In contrast to the previous loop, this one represents a balancing loop (one "-" sign). In addition, it includes causal relationships representing more immediate effects (e.g., increases in active transportation contribute to increases in overall levels of physical activity), and, potentially, delayed effects (e.g., decreases in rates of obesity lead to decreases in rates of different chronic diseases). Delayed effects are noted using two hash marks through the middle of the arrow line (not represented in Figure 4).



Miles of CicloRuta
(policy and environment)

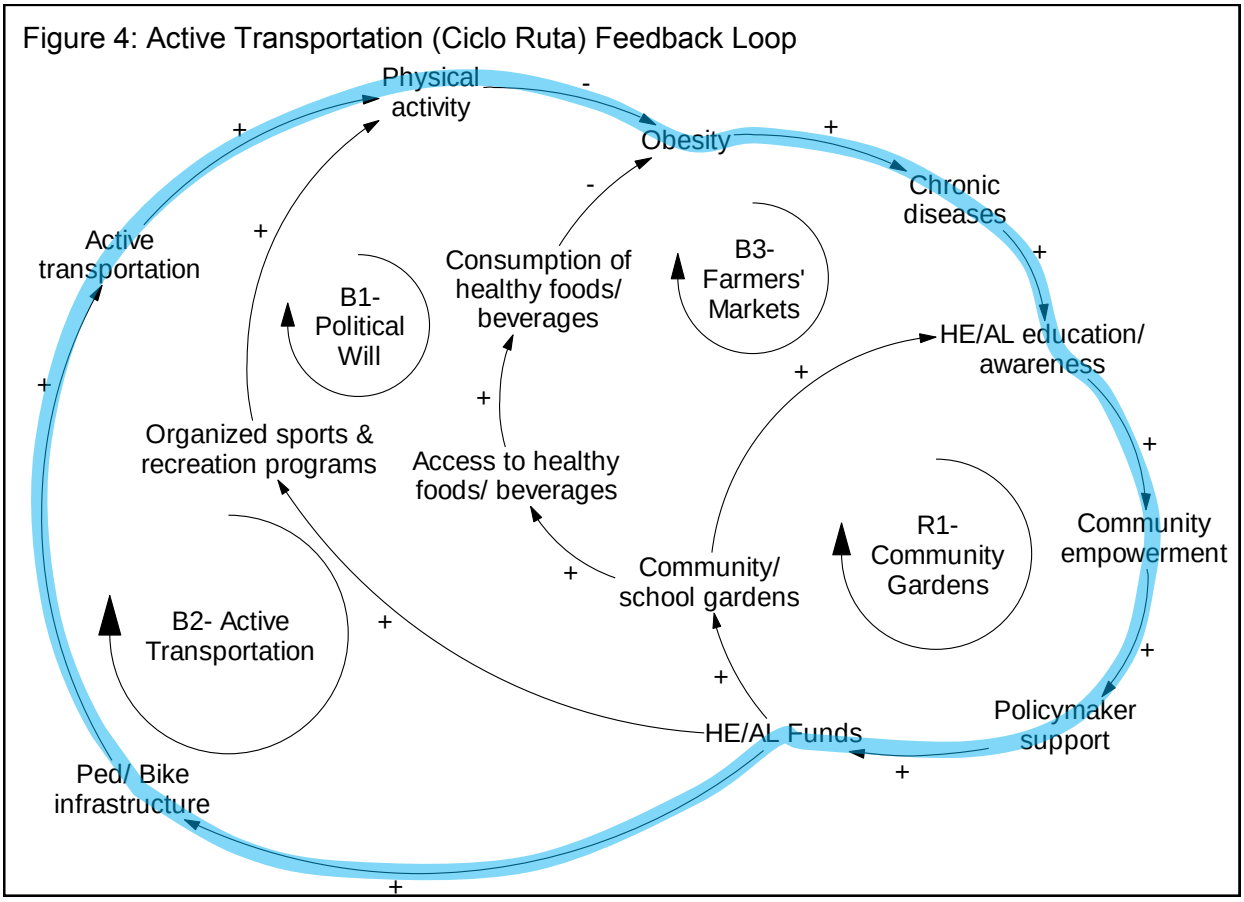
As in the previous loop, education and awareness, community empowerment, policy-maker support, and funding are all key ingredients for development and maintenance of the pedestrian and bicycle infrastructure necessary to support active transportation. At the same time, this figure illustrates why it is not advantageous to separate the feedback loop from the causal loop diagram (see Figures 1-2). For instance, while active transportation may have an influence on physical activity, the availability of organized sports and recreation programs also affects physical activity. In this case, examining this loop without the context of the other variables and loops may lead to inappropriate conclusions.



Number of people using
bicycle infrastructure

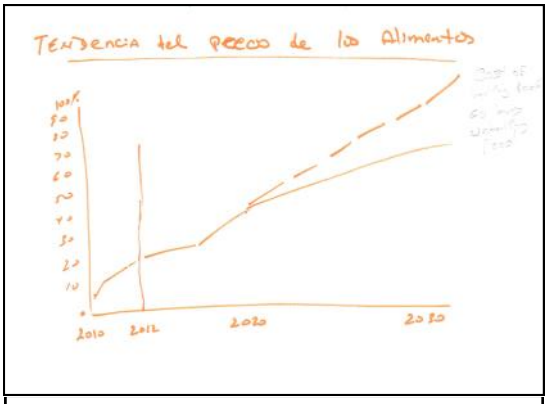
In the behavior over time graphs exercise, participants described recent increases in the miles of CicloRuta and people using bicycle infrastructure with the hope that both will continue to increase into the future (see illustrations. These changes are anticipated to increase physical activity and reduce obesity and related chronic diseases and conditions.

Figure 4: Active Transportation (Ciclo Ruta) Feedback Loop



Farmers' Market Feedback Loop

Highlighted in red in Figure 5, the farmers' market feedback loop represents one of the *Caguas Healthy Kids, Healthy Communities* strategies to increase healthy eating in Caguas, Puerto Rico. Similar to the previous loop (see Figure 4), this is a balancing loop (one "-" sign). In addition, it includes causal relationships representing more immediate effects (e.g., greater policy-maker support leads to more funding for healthy eating initiatives), and, potentially, delayed effects (e.g., community empowerment generating policy-maker support).

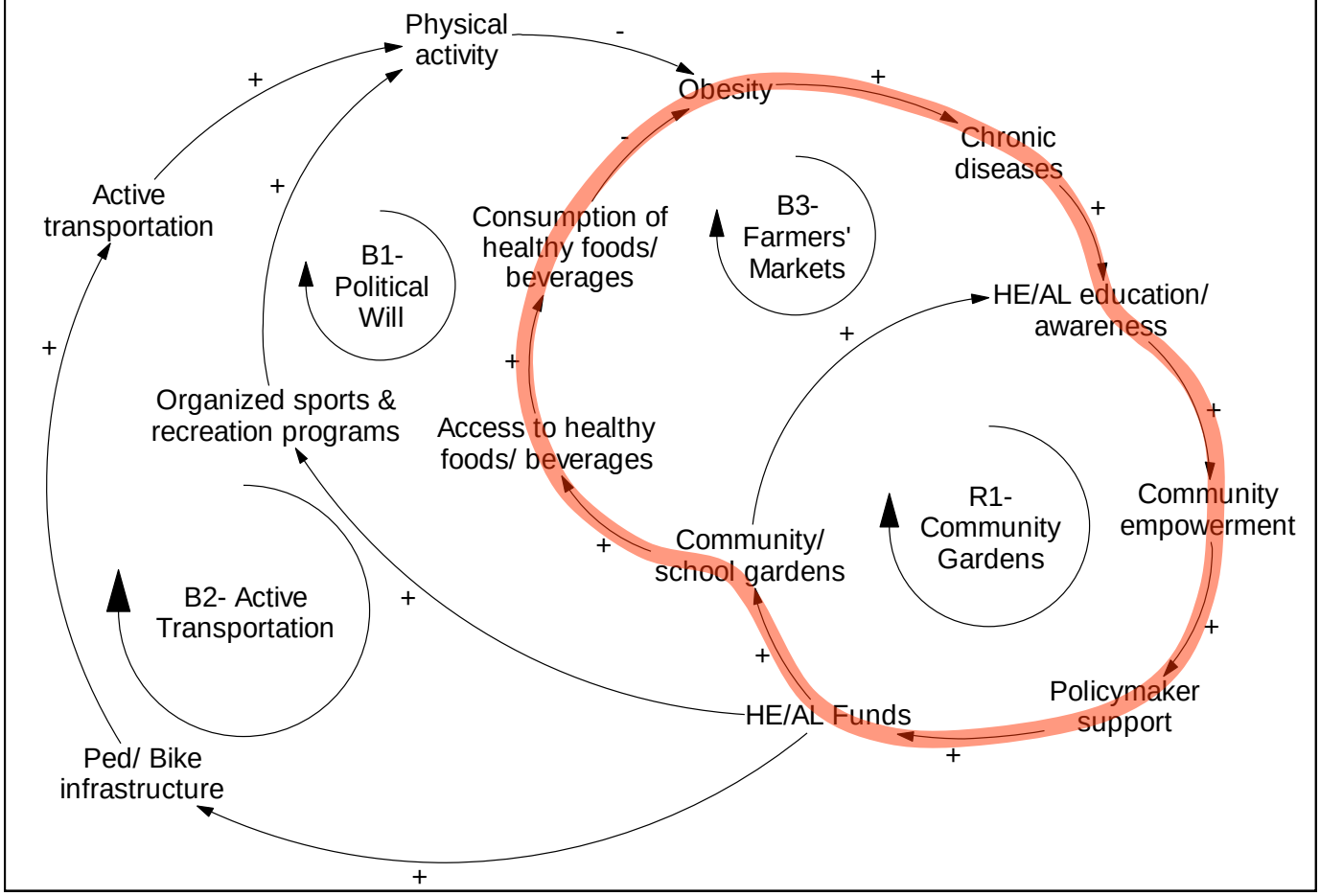


Food price trends
Cost of healthy food

In the behavior over time graphs exercise, participants described an increase in the cost of healthy foods with the fear that this trend will continue to increase (see illustration). However, participants also described how the farmers' market in the SANOS parking lot — along with the community and school gardens — helps to reduce the costs of fresh fruits and vegetables. Increasing the affordability of fresh produce helps to increase the accessibility of these products, particularly for those who have limited resources to purchase foods and beverages.

At the same time, partners have been working to increase agricultural entrepreneurship among youth in Caguas as another strategy to improve the availability of locally grown produce, thus the loop in Figure 5 is more meaningful in the larger system represented in Figures 1-2. In the face of the increasing cost of healthier options, these types of strategies are necessary to lead to better health behaviors and outcomes.

Figure 5: Farmers' Market Feedback Loop



Opportunities for Systems Thinking in Caguas, Puerto Rico

This storybook provided an introduction to some basic concepts and methods for systems thinking at the community level, including: causal loop diagrams, variables, causal relationships and polarities, reinforcing feedback loops, and balancing feedback loops, among others. For the *Caguas Healthy Kids, Healthy Communities* partners, this storybook also summarized the healthy eating, active living, partnership and community capacity, social determinants, and health and health behaviors subsystems in Caguas' causal loop diagram as well as three specific feedback loops corresponding to the partnership's primary strategies.

This causal loop diagram reflects a series of conversations among partners and residents from 2011 to 2013. Some discussions probed more deeply into different variables through the behavior over time graphs exercise, or causal relationships through the causal loop diagram exercise.

This represented a first attempt to collectively examine the range of things that affect or are affected by policy, system, and environmental changes in Caguas, Puerto Rico to promote healthy eating and active living as well as preventing childhood overweight and obesity.

Yet, there are several limitations to this storybook, including:

- the participants represent a sample of the *Caguas Healthy Kids, Healthy Communities* partners (organizations and residents) as opposed to a representative snapshot of government agencies, Caguas, Puerto Rico organizations, businesses, and Caguas, Puerto Rico residents;
- the behavior over time graphs and the causal loop diagram represent perceptions of the participants in these exercises (similar to a survey or an interview representing perceptions of the respondents);

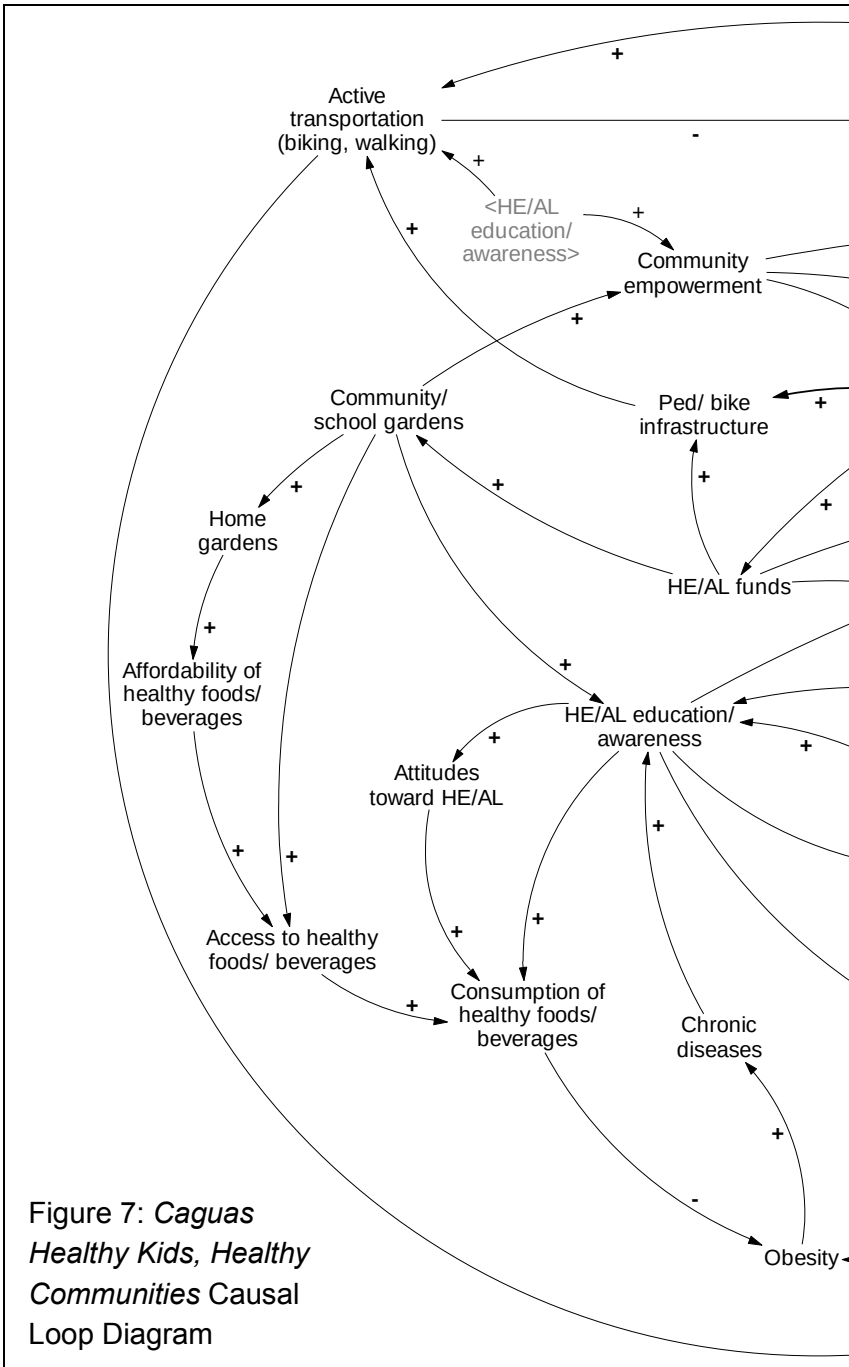


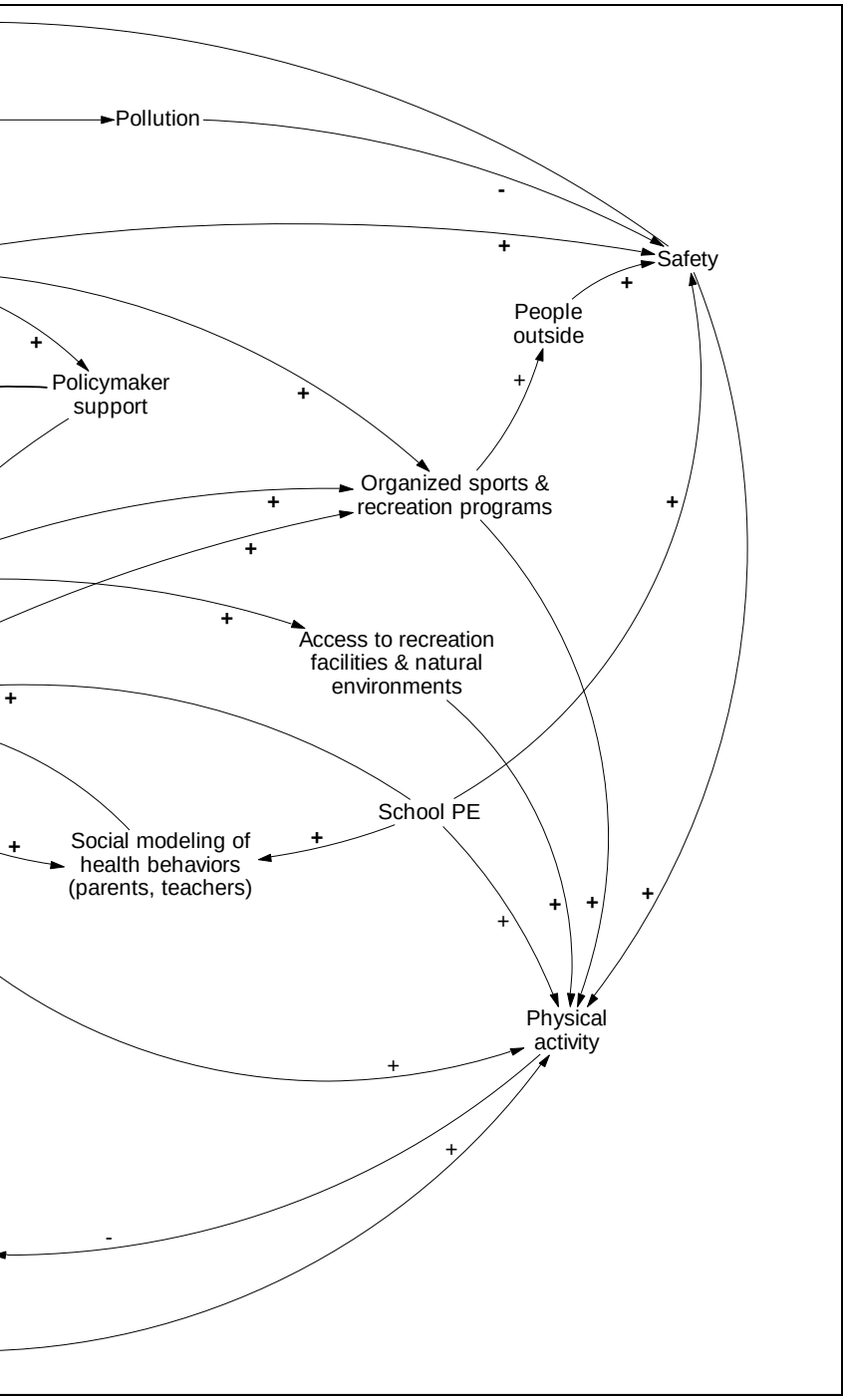
Figure 7: *Caguas Healthy Kids, Healthy Communities* Causal Loop Diagram

- the exercises and associated dialogue took place in brief one- to two-hour sessions, compromising the group's capacity to spend too much time on any one variable, relationship, or feedback loop; and
- the responses represent a moment in time so the underlying structure of the diagram and the types of feedback represented may reflect "hot button" issues of the time.

Much work is yet to be done to ensure that this causal loop diagram is accurate and comprehensive, for example:

- having conversations to discuss existing feedback loops to ensure that the appropriate variables and relationships are represented accurately;

- reviewing the behavior over time graphs (see also Appendix E) to confirm that the trends reflect common perceptions among residents and compare these trends to actual data;



- revisiting variables removed because they were not part of feedback loops, including employment, local economy, fast food restaurants, consumption of unhealthy foods/ beverages, screen time, access to space for gardens at home, crime (drug organizations), healthy foods/ beverages in school, food distribution & exportation, families spending time together, CidoRuta event, media campaigns, cross sector collaboration; and

- starting new conversations about other variables (behavior over time graphs exercise) or relationships (causal loop diagram exercise) to add to this diagram.

In addition, different subgroups in Caguas may use this causal loop diagram to delve in deeper into some of the subsectors (e.g., healthy eating, active living) or feedback loops, creating new, more focused causal loop diagrams with more specific variables and causal relationships.

Use of more advanced systems science methods and analytic approaches to create computer simulation models is another way to take this early work to the next level. The references section includes citations for resources on these methods and analytic approaches, and it is necessary to engage professional systems scientists in these activities.

Please refer to the Appendices for more information, including:

- Appendix A: Behavior over time graphs generated during site visit
- Appendix B: Photograph of the original version of the *Caguas Healthy Kids, Healthy Communities* Causal Loop Diagram
- Appendix C: Original translation of the causal loop diagram into Vensim PLE
- Appendix D: Transcript translation of the causal loop diagram into Vensim PLE
- Appendix E: Behavior over time graphs not represented in the storybook

References for Systems Thinking in Communities:

Group model building handbook:
Hovmand, P., Brennan L., & Kemner, A. (2013). Healthy Kids, Healthy Communities Group Model Building Facilitation Handbook. Retrieved from http://www.transtria.com/hkhc.

Vensim PLE software for causal loop diagram creation and modification:
Ventana Systems. (2010). Vensim Personal Learning Edition (Version 5.11A) [Software]. Available from http://vensim.com/vensim-personal-learning-edition/

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Andersen, D. F. and G. P. Richardson (1997). "Scripts for group model building." System Dynamics Review 13(2): 107-129.

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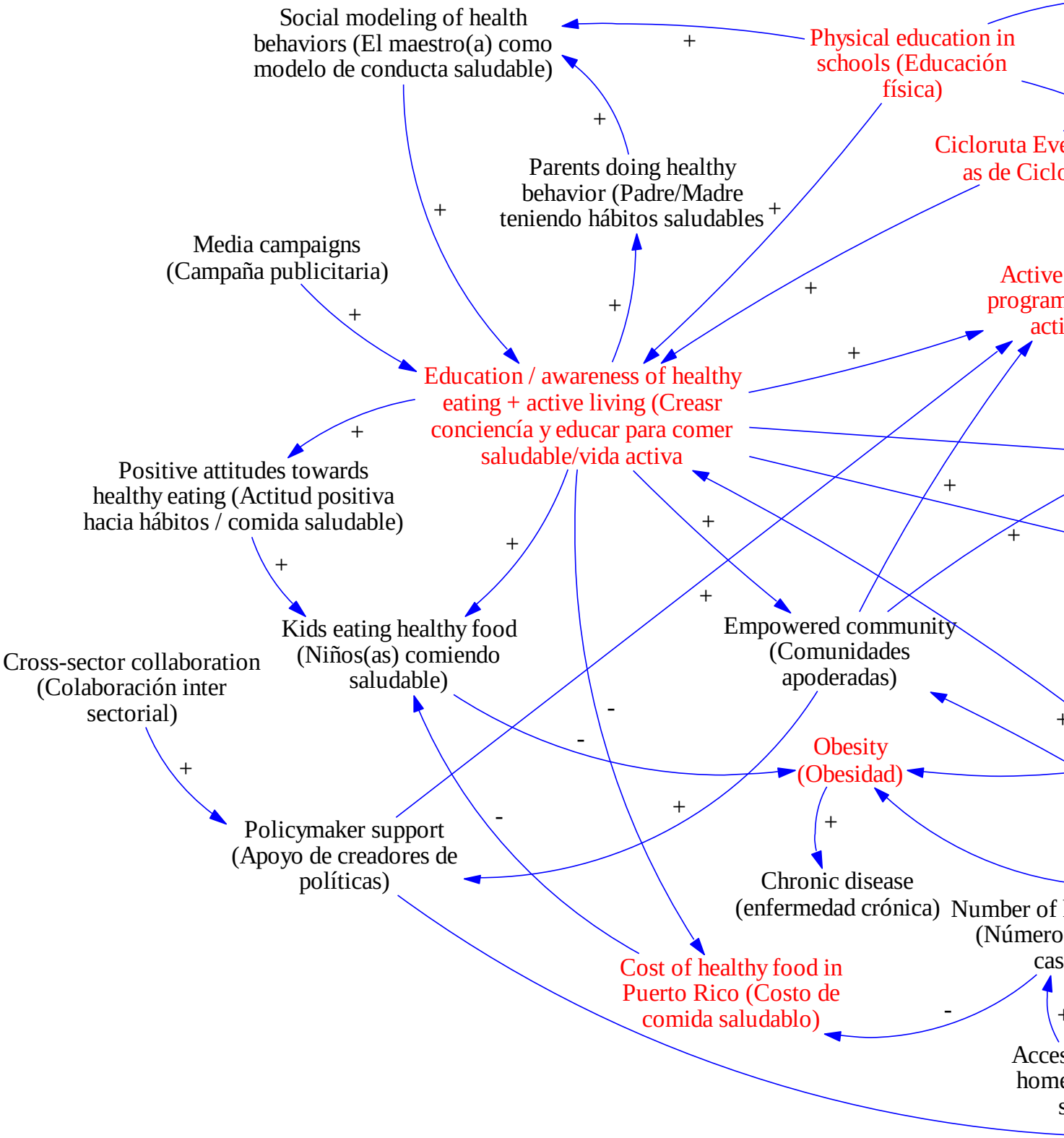
Appendix A: Behavior Over Time Graphs Generated during Site Visit

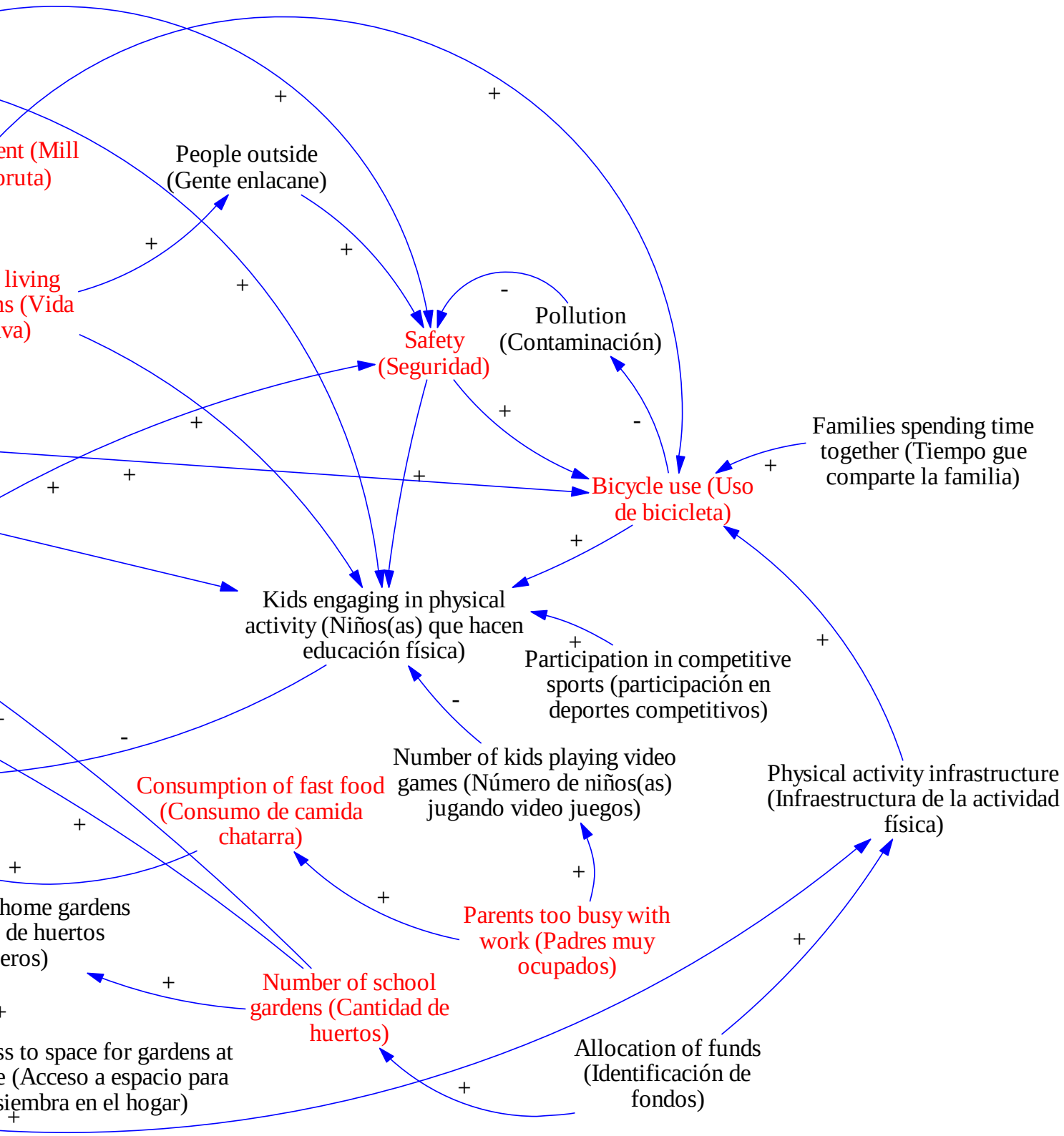
Caguas, Puerto Rico: *Caguas Healthy Kids, Healthy Communities*	
Categories	**Number of Graphs**
Active Living Behavior	4
Active Living Environments	1
Funding	0
Healthy Eating Behavior	3
Healthy Eating Environments	5
Marketing and Media Coverage	0
Obesity and Long Term Outcomes	2
Partnership & Community Capacity	0
Policies	0
Programs & Promotions (Education and Awareness)	1
Social Determinants of Health	1
Total Graphs	**17**

Appendix B: Photograph of the Original Version of the *Caguas Healthy Kids, Healthy Communities*

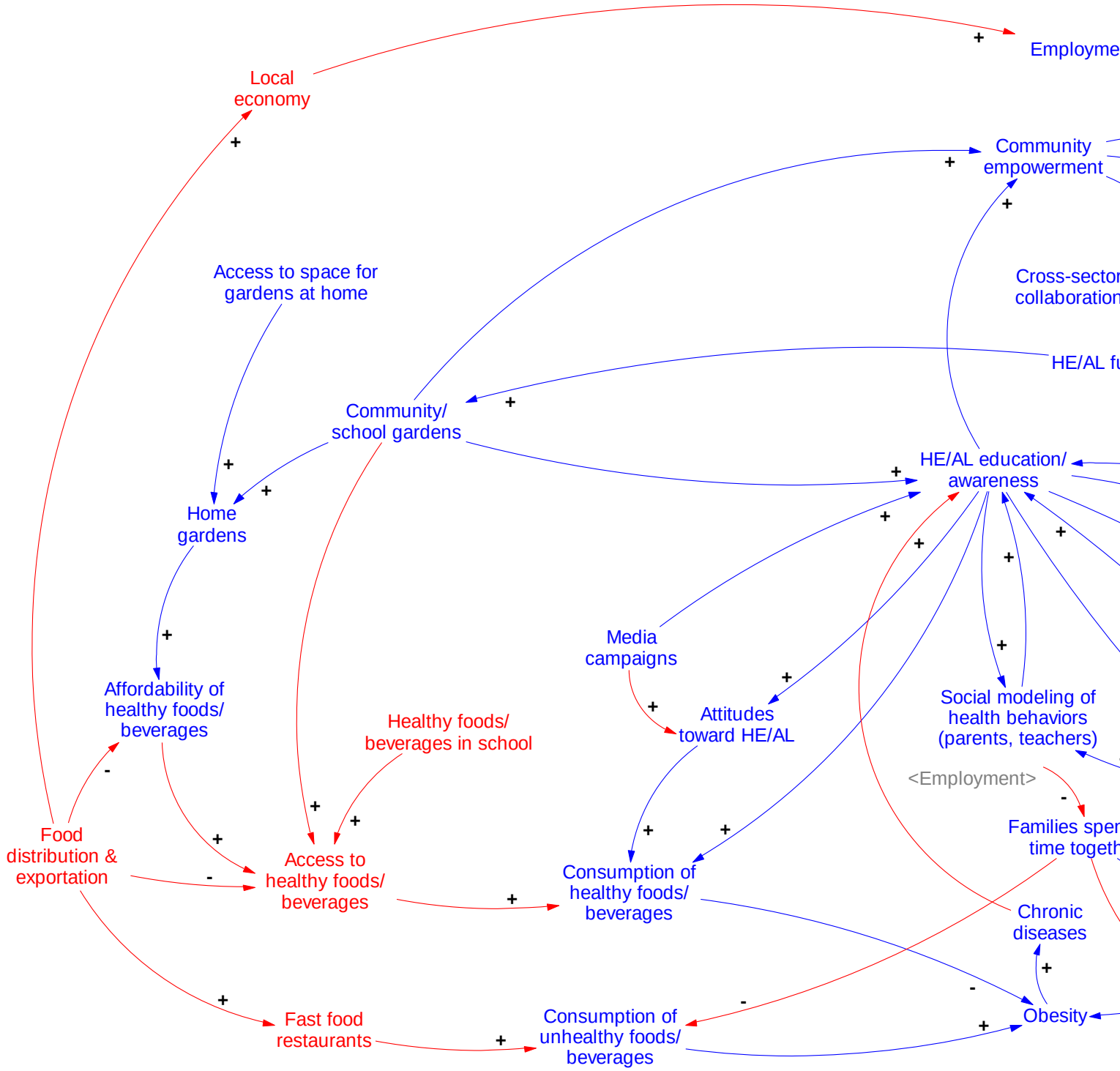

O SON AFECTADAS POR POLÍTICAS
ALES EN TU COMUNIDAD
ACTIVA, OBESIDAD INFANTIL)
GENTE EN LA CALLE
Safety
(Seguridad)
Pollution
Contaminación
NIÑO(AS) QUE HACEN EDUCACIÓN FÍSICA
Kids engaging in PA
MODELO DE
CONDUCTA SALUDABLE
PARTICIPAR EN DEPORTES COMPETITIVOS
Bicycle Use
(Uso de bicicleta)
TIEMPO QUE COMPARTE LA FAMILIA
Parents too busy to Work
(Padres muy ocupados)
Chronic Disease
ENFERMEDADES CRÓNICAS
# of Kids playing video games
DE NIÑOS(AS) JUGANDO VIDEO JUEGOS
of School Gardens
(cantidad de) huertos
Physical Activity Infrastructure
INFRAESTRUCTURA PARA ACTIVIDAD FÍSICA
Allocation of Funds
Identificación de FONDOS

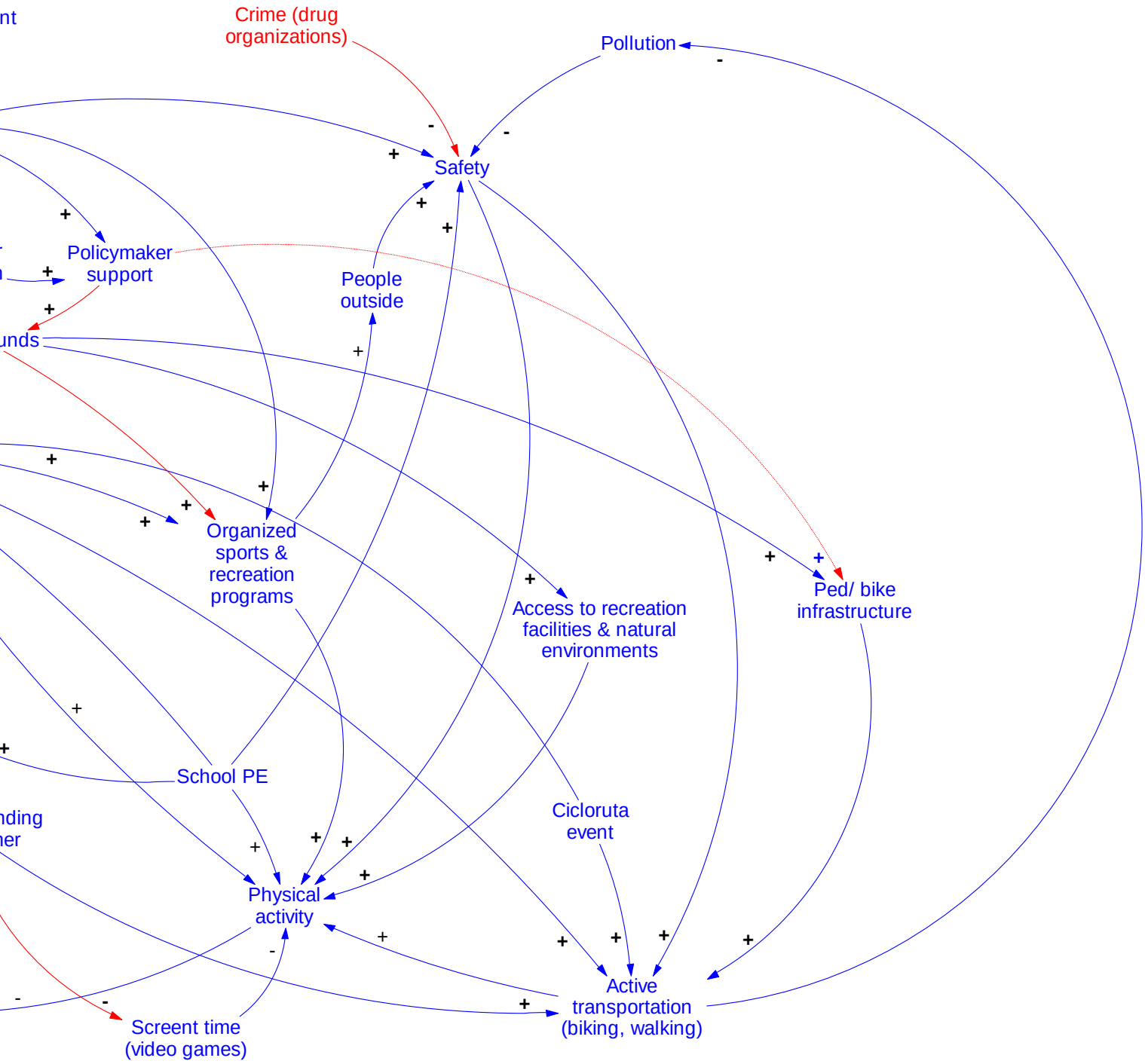
Appendix C: Original Translation of the Causal Loop Diagram into Vensim PLE




ent (Mill
oruta)
People outside
(Gente enlacane)
living
ns (Vida
va)
Safety
(Seguridad)
Pollution
(Contaminación)
Families spending time
together (Tiempo gue
comparte la familia)
Bicycle use (Uso
de bicicleta)
Kids engaging in physical
activity (Niños(as) que hacen
educación física)
Participation in competitive
sports (participación en
deportes competitivos)
Number of kids playing video
games (Número de niños(as)
jugando video juegos)
Consumption of fast food
(Consumo de camida
chatarra)
Physical activity infrastructure
(Infraestructura de la actividad
física)
home gardens
de huertos
eros)
Parents too busy with
work (Padres muy
ocupados)
Number of school
gardens (Cantidad de
huertos)
ss to space for gardens at
e (Acceso a espacio para
siembra en el hogar)
Allocation of funds
(Identificación de
fondos)

Appendix D: Transcript Translation of the Causal Loop Diagram into Vensim PLE




nt
Crime (drug organizations)
Pollution
Safety
Policymaker support
People outside
unds
Organized sports & recreation programs
Access to recreation facilities & natural environments
Ped/ bike infrastructure
School PE
nding
her
Cicloruta event
Physical activity
Active transportation (biking, walking)
Screent time (video games)

Appendix E: Behavior Over Time Graphs not Represented in the Storybook