Systems Thinking in Communities:

Understanding the Causes of Inactivity, Poor Diet/Nutrition, and Childhood Obesity in Louisville, Kentucky

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Acknowledgments

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mayor's Healthy Hometown

Introduction

Louisville's Healthy Kids, Healthy Communities (HKHC) is one of 49 community partnerships participating in the national *Healthy Kids, Healthy Communities* program of the Robert Wood Johnson Foundation (www.healthykidshealthycommunities.org). The purpose of this *Louisville's HKHC* project was to introduce systems thinking at the community level by identifying the essential parts of the Louisville, Kentucky 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, government agencies, community-based organizations, academic institutions, youth organizations) to better understand the systems (i.e., dynamics and structures) in the community (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 community partnerships' efforts to increase healthy eating and active living in order to reduce childhood obesity.

Louisville, Kentucky: Background and Local Participation

Louisville's Healthy Kids, Healthy Communities partnership worked in 12 neighborhoods in northwest Louisville and east downtown Louisville (see Figure 2). These communities were all identified by the city as distressed communities with significant environmental and social barriers to active living and healthy eating. In 2008, there were approximately 86,518 residents in the 12 neighborhoods, with 11 neighborhoods having predominantly African American populations.

Louisville's obesity prevention work began in 2003 with the ACTIVE Louisville partnership, supported by a grant from the Robert Wood Johnson Foundation as part of the Active Living by Design initiative and became institutionalized in 2004 with the establishment of the Mayor's Healthy Hometown Movement.

The partnership was led by the HKHC Project Director (PD) and Project Coordinator (PC), who were representatives of the lead agency, the Louisville Metro Department of Public Health and Wellness, Community Health Education and Promotion Division. Instrumental support was also provided by the Center for Health Equity, another division of Metro Public Health and Wellness. Although the health department changed directors midway through the HKHC grant, the partnership maintained the same leadership staff for all four years, and both department leaders were supportive of the HKHC efforts.

The PD and PC strived to ensure that HKHC project work was connected between healthy eating and active living strategies and they often convened meetings with committee chairs. In addition to those roles, Louisville's Healthy Kids, Healthy Communities benefited from the expertise of an on-staff Dietitian and a CPPW school committee staff member who assisted with funding the schools for nutrition and physical activity policy implementation.

The Louisville Metro Department of Public Health and Wellness became involved with a statewide coalition called the Partnership for a Fit Kentucky. This coalition had four working committees: built environment, worksite wellness, schools, and families and communities. These four committees became the four core committees of the Louisville Healthy Kids, Healthy Communities partnership.

Louisville's HKHC's Priorities and Strategies

The partnership and capacity building strategies of Louisville's HKHC included:

- **Food Policy Council (FPC):** began as a development committee under an executive order signed by the former Mayor. The committee and new Mayor made recommendations for membership; there were 26 people initially appointed to the FPC. The FPC was directed to work on four goals, including Locally Integrated Food Economy (LIFE) zoning (i.e., canning or local processing and retail in Portland neighborhoods); increasing revenue for farmers (i.e., bolster the farm to table movement); and assessing the demand for local food among food buyers, sellers and preparers (not consumers).
- **Louisville Youth Advocates (LYA):** a group of 50 youth activists from the 12 HKHC-designated neighborhoods, canvassed Louisville and documented its findings with Photovoice and digital storytelling methods. Results were presented back to policymakers, such as city council members.

The healthy eating and active living strategies of Louisville's HKHC included:

- **Healthy in a Hurry Corner Stores:** The goal of this healthy eating initiative was to increase access to fruits and vegetables in underserved communities. Louisville started working on its corner store strategy in December of 2007 under the umbrella of the Food Security Taskforce, with partners from the YMCA, Louisville Metro Department of Public Health and Wellness, and Center for Health Equity. Healthy in a Hurry (HiaH) Corner Store initiative launched in early 2009 with two initial stores.
- **Parks and Play Spaces (Trails):** Efforts focused on connecting the Louisville Loop with Mayor's Miles in order to increase residents' awareness of and access to physical activity opportunities in their neighborhoods. The Louisville Loop was a trail system, encircling the city and linking existing parks, new parks, and neighborhoods to civic attractions, transportation alternatives, and recreation opportunities. Mayor's Miles was a distance-marking system for walking paths, with wayfinding signage every tenth of a mile.

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

Systems Thinking in Communities: Louisville, Kentucky

"Systems thinking" represents a range of methods, tools, and approaches for observing the behaviors of a system (e.g., family, community, 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 Louisville, Kentucky 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.

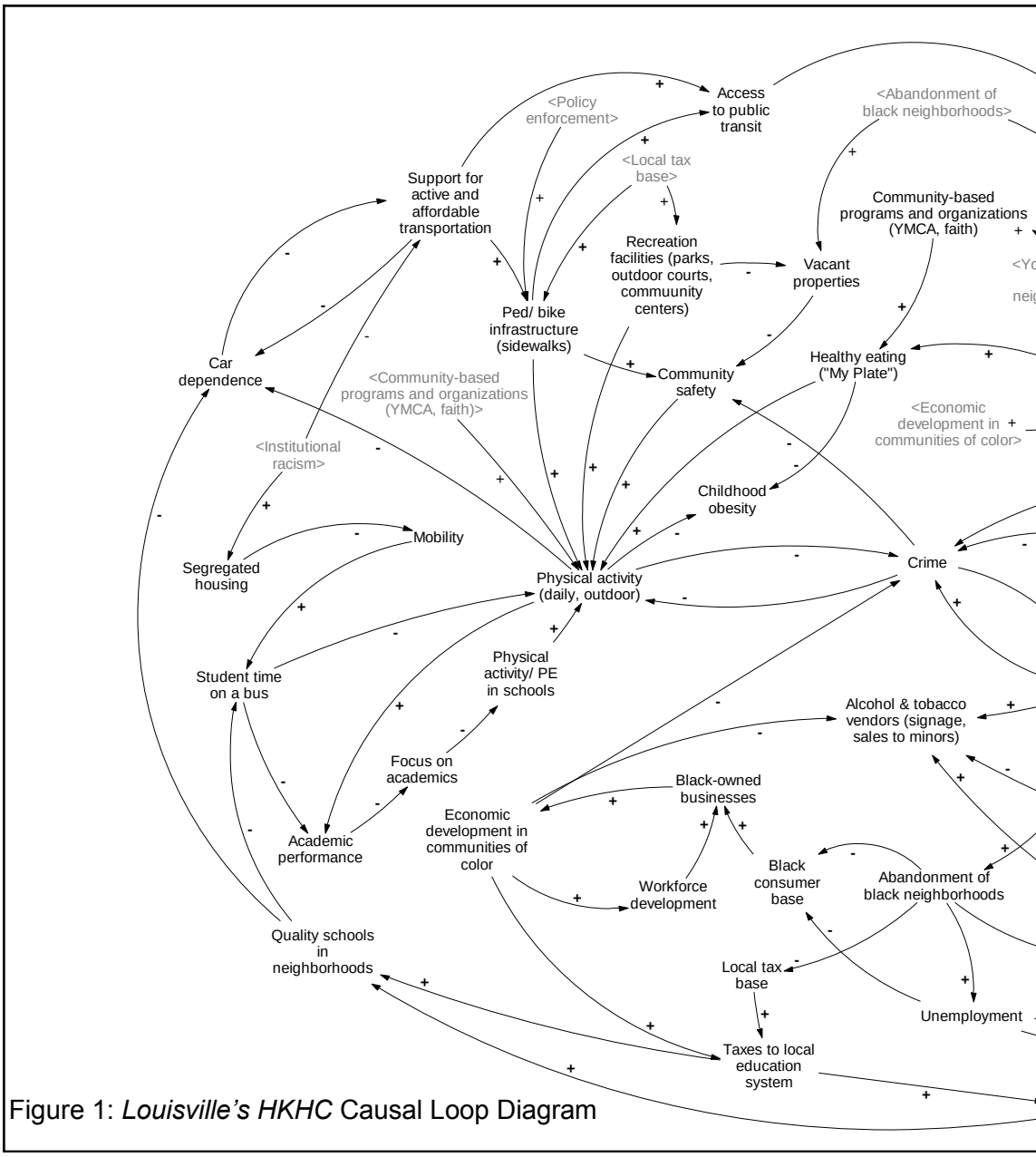
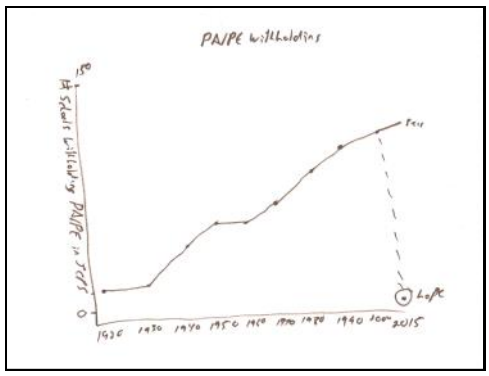


Figure 1: *Louisville's HKHC* Causal Loop Diagram

Group Model Building

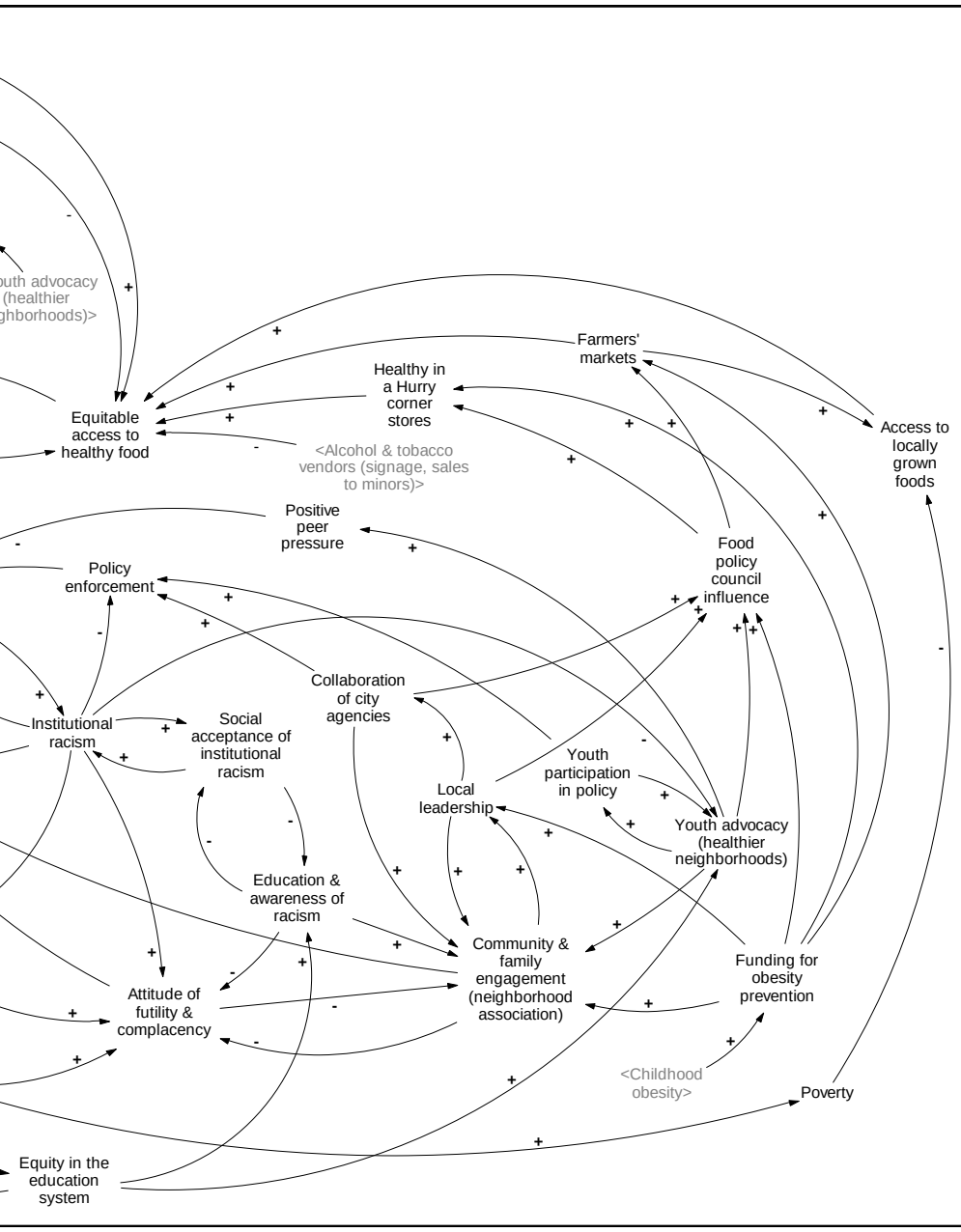
Members of the *Louisville's HKHC* partnership participated in a group model building session in September, 2011 and generated this system. also referred to as a causal loop diagram (Figure 1). Participants in the group model building session included residents and representatives from government agencies, civic organizations, youth-based organizations, academic institutions, and advocates. 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.



Behavior Over Time Graphs

To identify the range of things that affect or are affected by policy, system, and environmental changes in Louisville 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 withholding physical activity or physical education, the number of schools has increased fairly dramatically since 1920and the participant hopes that this increasing trend will immediately drop off into the future. Each graph is a tool to increase the use of common, specific language to describe *what* is changing in the community 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: local leadership → collaboration of city agencies → community and family engagement → local leadership.

What is important to notice is that there are other feedback loops interacting simultaneously to influence or to be influenced by local leadership. Some variables may increase local leadership 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 *Louisville's HKHC* 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 Louisville, Kentucky and to stimulate greater conversation related to Louisville'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 Louisville, Kentucky. 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 community 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.

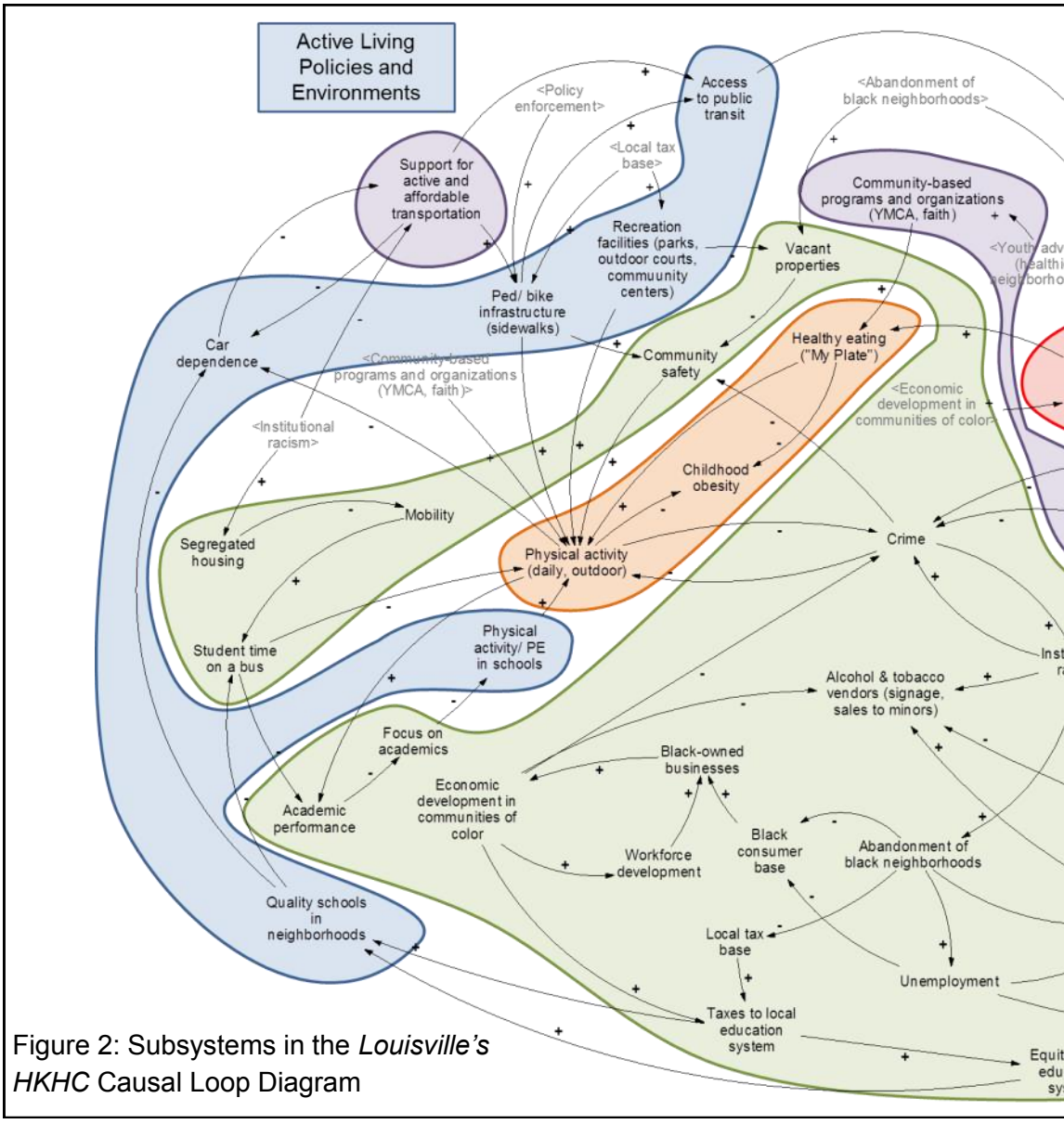


Figure 2: Subsystems in the *Louisville's HKHC* Causal Loop Diagram

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 nine graphs related to policy or environmental strategies (e.g., Healthy in a Hurry corner stores) or contexts (e.g., equitable access to healthy food) that affected or were affected by the work of *Louisville's HKHC*. The variables represent participants' conversations from the behavior over time graph and causal loop diagram exercises.

Active Living Policies and Environments (Blue)

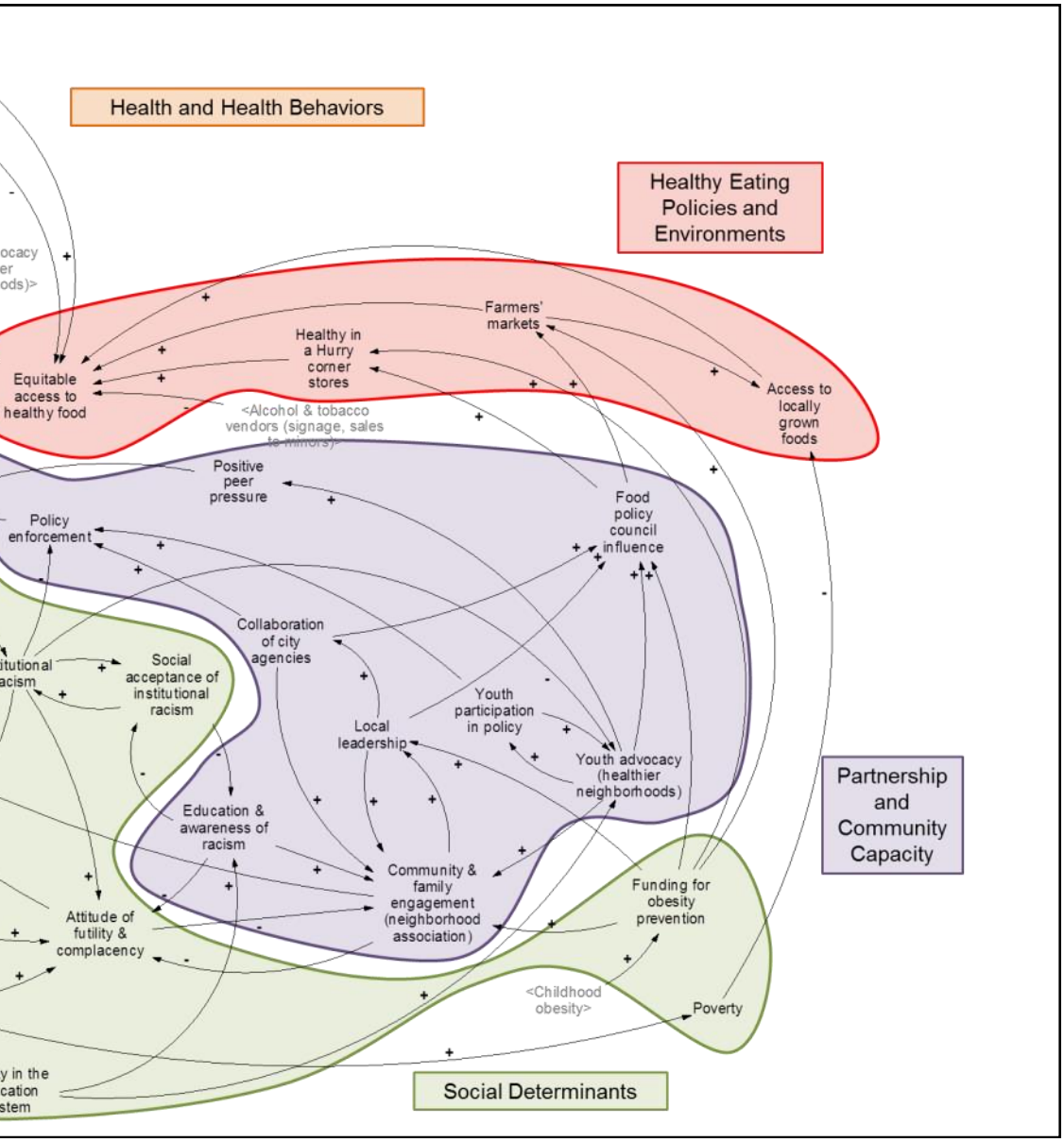
The active living policy and environmental subsystem includes design, planning, construction, and enforcement or maintenance related to access to opportunities for active transportation and recreation. For this topic, the group model building participants developed seven graphs related to policy or environmental strategies (e.g., physical education in schools) or contexts (e.g., quality schools in neighborhoods) 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 (not represented).

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, *Louisville's HKHC* worked to create a food policy council to advocate for their healthy eating strategies. This subsystem also includes community factors outside the partnership that may influence or be influenced by their efforts, such as community-based programs and organizations.



Social Determinants

Finally, the social determinants subsystem denotes societal conditions (e.g., institutional racism) and psychosocial influences (e.g., attitude of futility or complacency) in the community that impact health beyond the healthy eating and active living subsystems. In order to achieve health equity, populations and subgroups within the community 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 *Louisville's HKHC* partners or by other representatives in Louisville, Kentucky. Using this CLD as a starting place, community 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 *Louisville's HKHC* . 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.

Corner Stores Feedback Loop

To simplify the discussion about feedback loops, several loops drawn from the Louisville's HKHC CLD (see Figures 1 and 2) are shown in Figure 3. While the CLD provides a theory of change for the childhood obesity prevention movement in Louisville, Kentucky each feedback loop tells a story about a more specific change process.

Causal Story for Feedback Loop

Story A: In this case , the story is about the corner stores (purple highlighted loop in Figure 3). Louisville, Kentucky partners developed several *Healthy in a Hurry* corner stores to increase access to fresh produce in areas with poor access to these products. Participants described how these corner stores improve equitable access to healthy food in order to increase residents' ability to meet nutrition recommendations. With better nutrition, residents also have more energy to engage in outdoor physical activity. In turn, a larger constituency of residents outdoors increases "eyes on the street" and reduces crime. Lower crime rates in these neighborhoods with higher proportions of African American residents also reduces institutional racism, the abandonment of black neighborhoods, and rates of unemployment. A greater proportion of employed residents increase the black consumer base to support black -owned businesses, stimulating economic development in these communities. As a result, the community has a larger tax base to invest tax revenue into the local education system and increase the quality of the education system that, consequently, can recruit more youth advocates to voice their interests in healthy neighborhoods to food policy councils or other decision-makers that generates greater support for the corner stores.

Story B: While the preceding story reflected a positive scenario for Louisville, Kentucky, the same feedback loop also tells the opposite story. Fewer corner stores creating equitable access to healthy food reduces healthy eating and outdoor physical activity, thus establishing fewer barriers to crime and racism. These communities likely experience greater population displacement and higher rates of unemployment, leaving a relatively small consumer base to support local businesses, economic development, or revenue to support a quality education for youth. These young people likely have less of a voice to advocate for health improvements, such as *Healthy in a Hurry* stores.

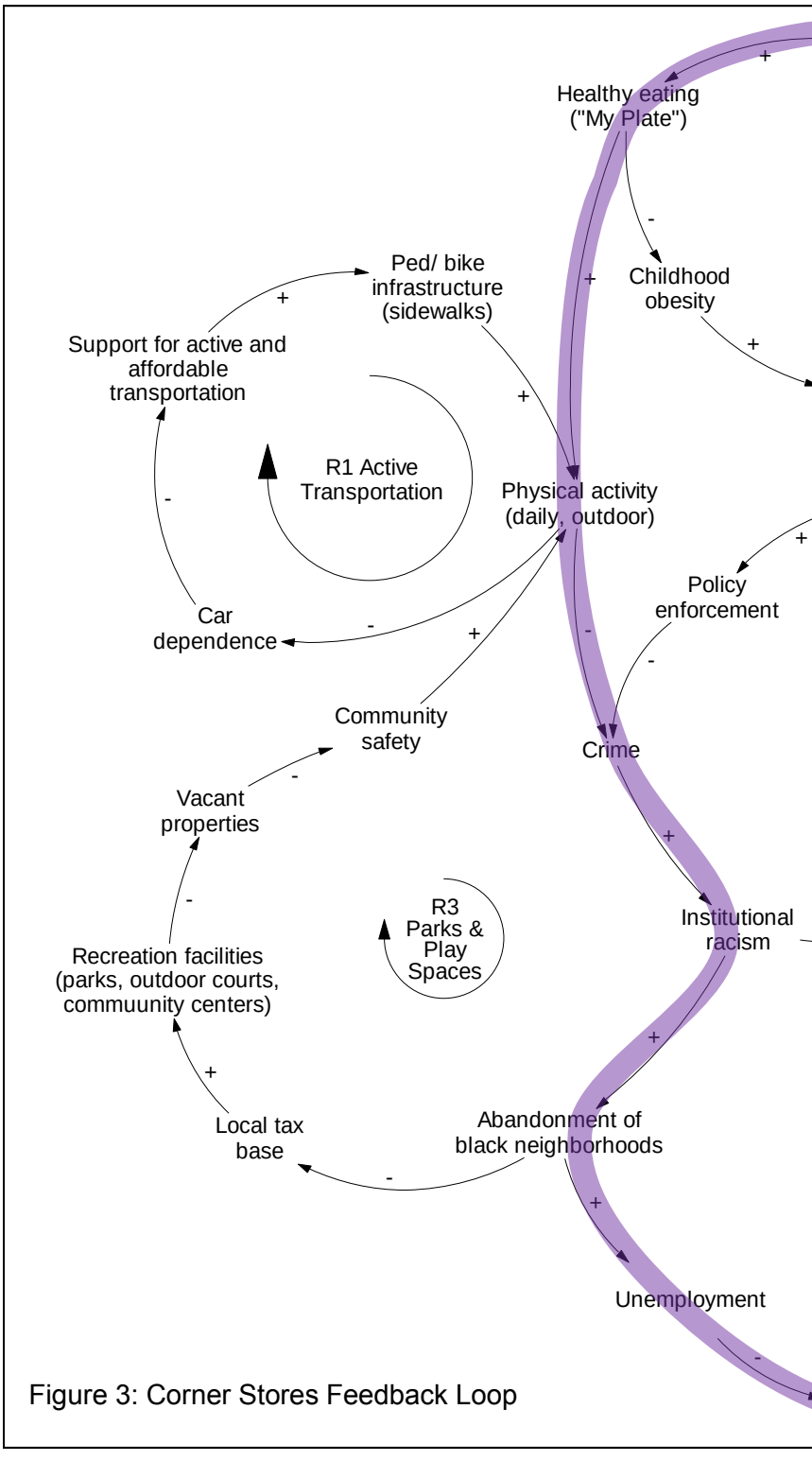
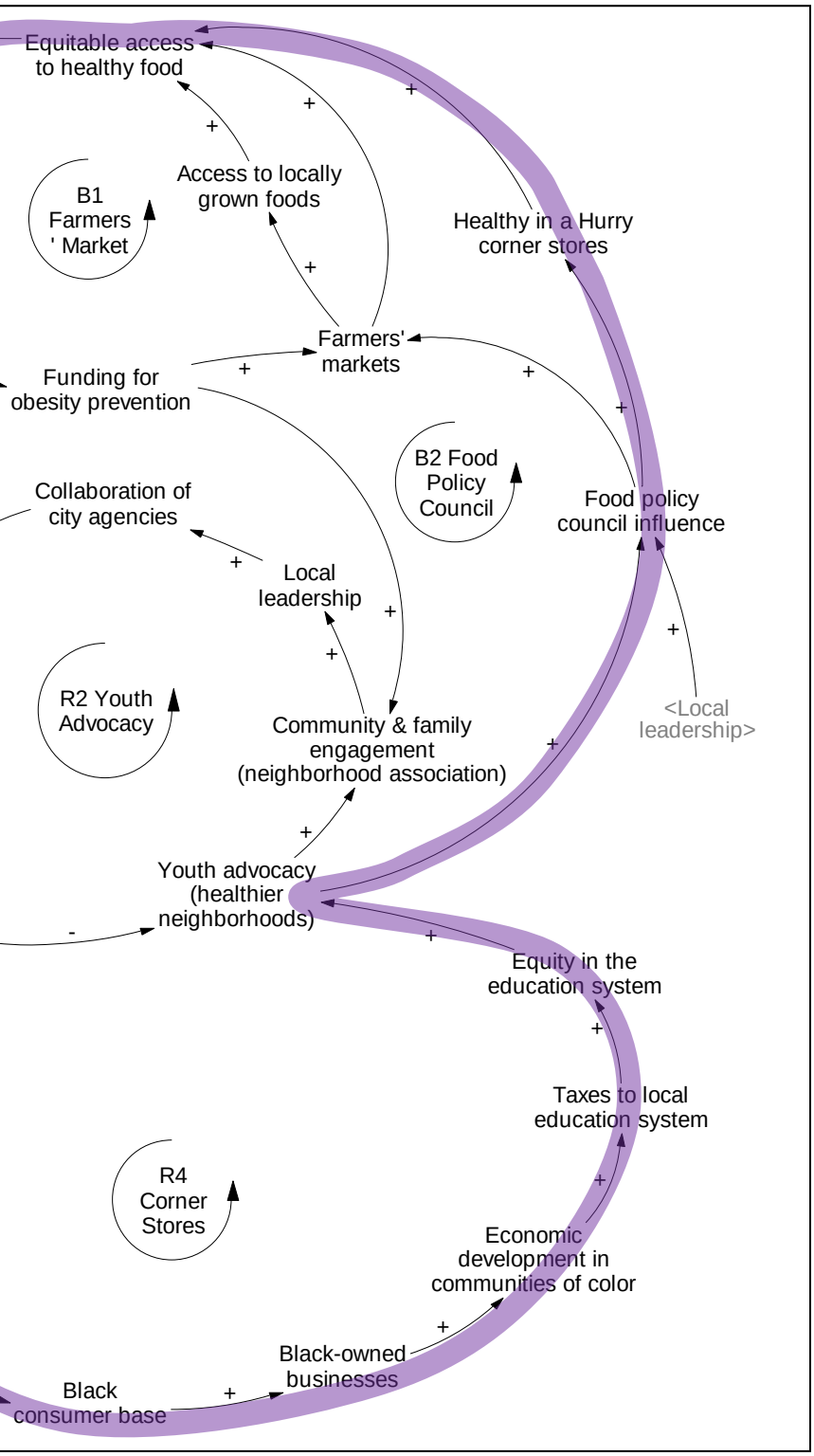


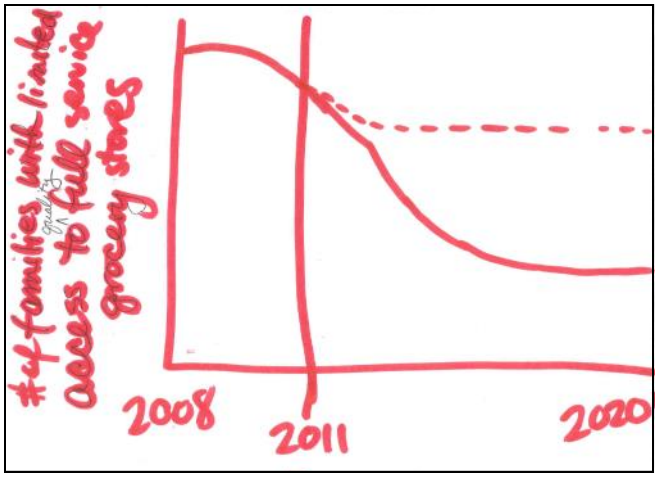
Figure 3: Corner Stores Feedback Loop

"If you look at the concentration of corner stores and liquor stores in communities of color, it reduces their ability to develop businesses that sell healthy food (e.g., grocery stores, farmers' markets), and the connection I was making was between alcohol and tobacco vendors, economy, and communities of color and the relationship to equitable access." (Participant)

Reinforcing Loop and Notation

These stories represent a reinforcing loop, and the notation in the feedback loop identifies it as a reinforcing loop (see "R4 — Corner Stores" and purple highlighted loop in Figure 3). The words represent variables of quantities that increase and decrease as illustrated in the causal stories. 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 the influence of corner stores on healthy eating. To understand other influences on these variables, 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.

System Insights for *Louisville's HKHC*

Since 2008, participants identified a slight decrease in the number of families with limited access to full-service grocery stores in Louisville, Kentucky, with the hope that this number continues to decrease (see behavior over time graph).

From the systems thinking exercises, several insights can inform the corner stores strategy. For instance, economic development investments in healthy corner stores can increase both community health and vitality.

In addition to these insights, systems thinking can also help to pose key questions for assessment and evaluation, including assessing the influence of youth advocacy and the food policy council on corner stores.

Opportunities for Systems Thinking in Louisville, Kentucky

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 *Louisville's HKHC* partners, this storybook also summarized the healthy eating, active living, partnership and community capacity, social determinants, and health and health behaviors subsystems in the Louisville causal loop diagram as well as an example feedback loop corresponding to the partnership's primary strategies.

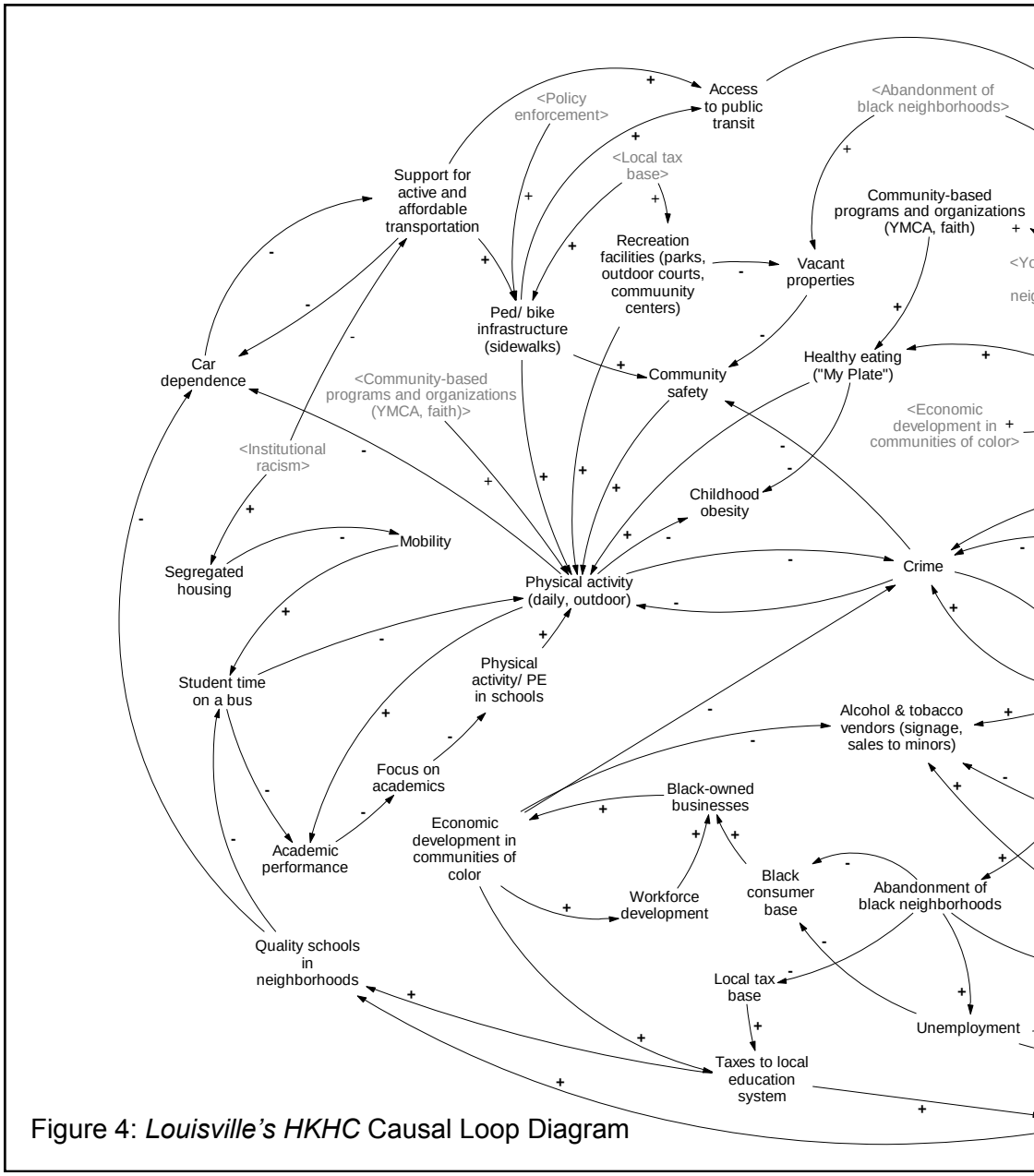


Figure 4: *Louisville's HKHC* Causal Loop Diagram

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.

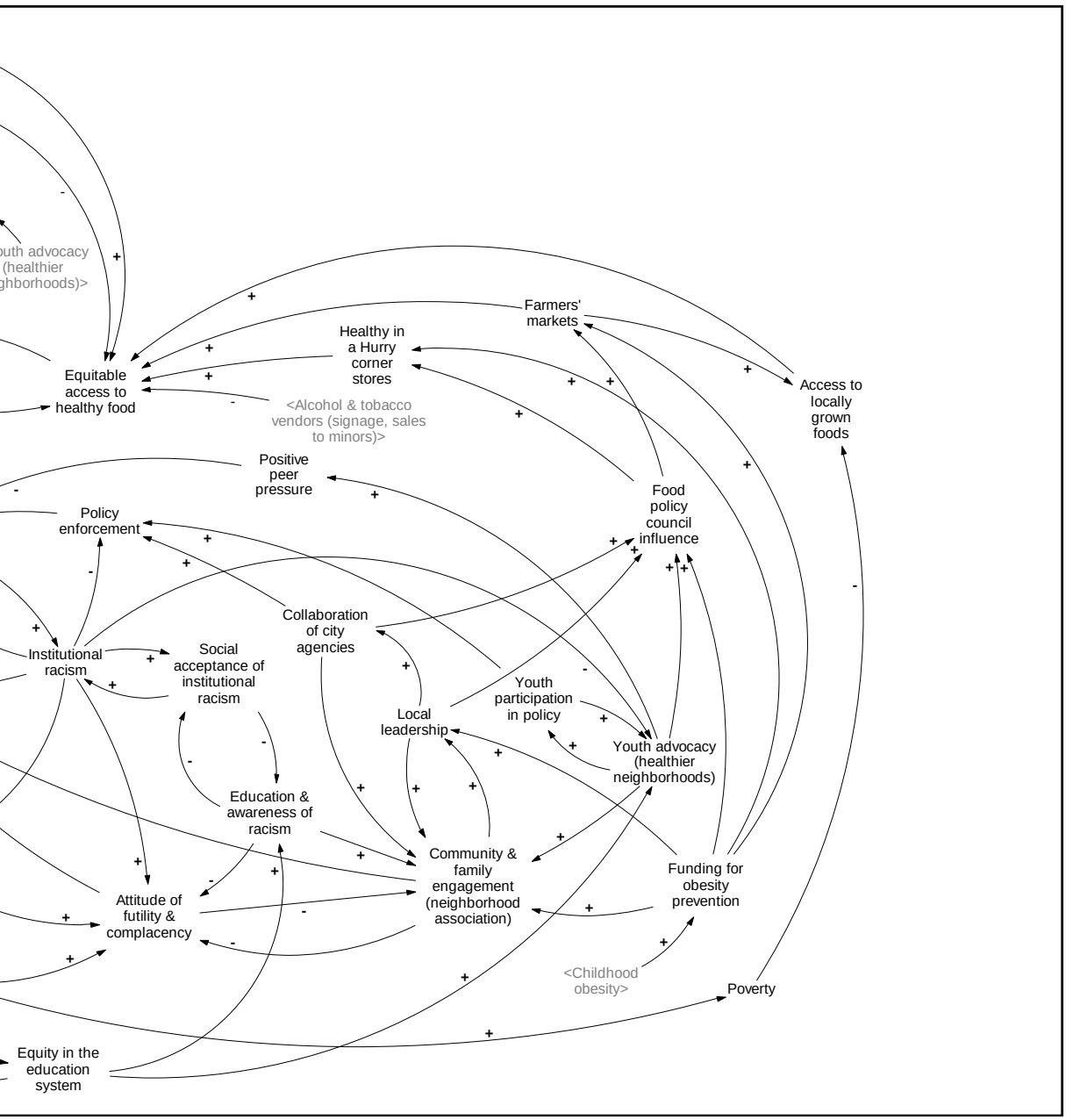
This represented a first attempt to collectively examine the range of things that affect or are affected by policy, system, and environmental changes in Louisville, Kentucky to promote healthy eating and active living as well as preventing childhood overweight and obesity.

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

- the participants represent a sample of the *Louisville's HKHC* partners (organizations and residents) as opposed to a representative snapshot of government agencies, community organizations, businesses, and community 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);
- 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 tobacco & drug use, food insecurity, government spending, federal transportation funding, suburban sprawl, gas prices, student disciplinary action, kids' health, community gardens, consumerism, access to quality, full-service grocery stores, lactation stations, breastfeeding, healthy snacks at childcare, fast food establishments, farm bill, participation in the global food market; 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 Louisville 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 *Louisville's HKHC* 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/

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

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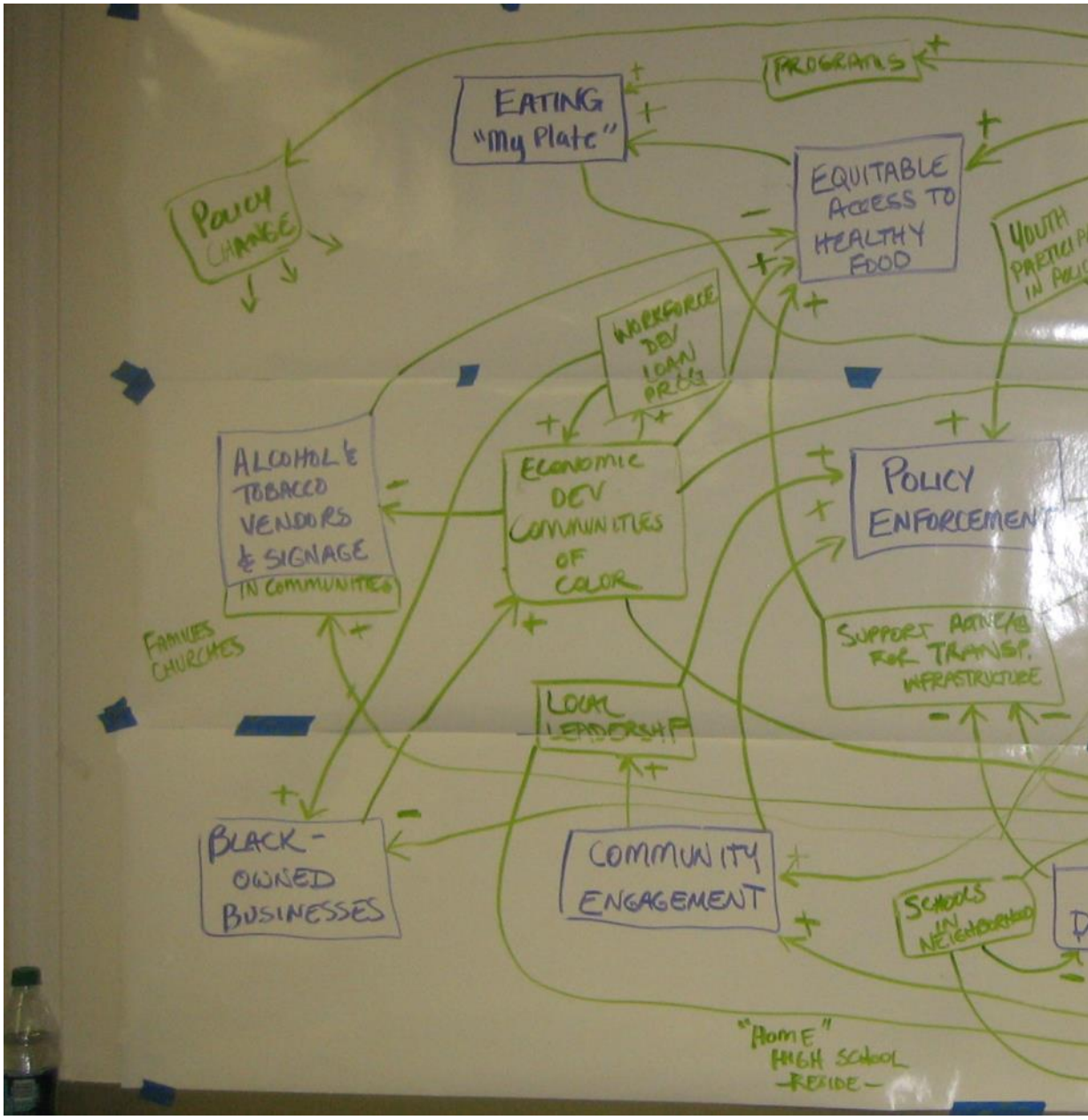
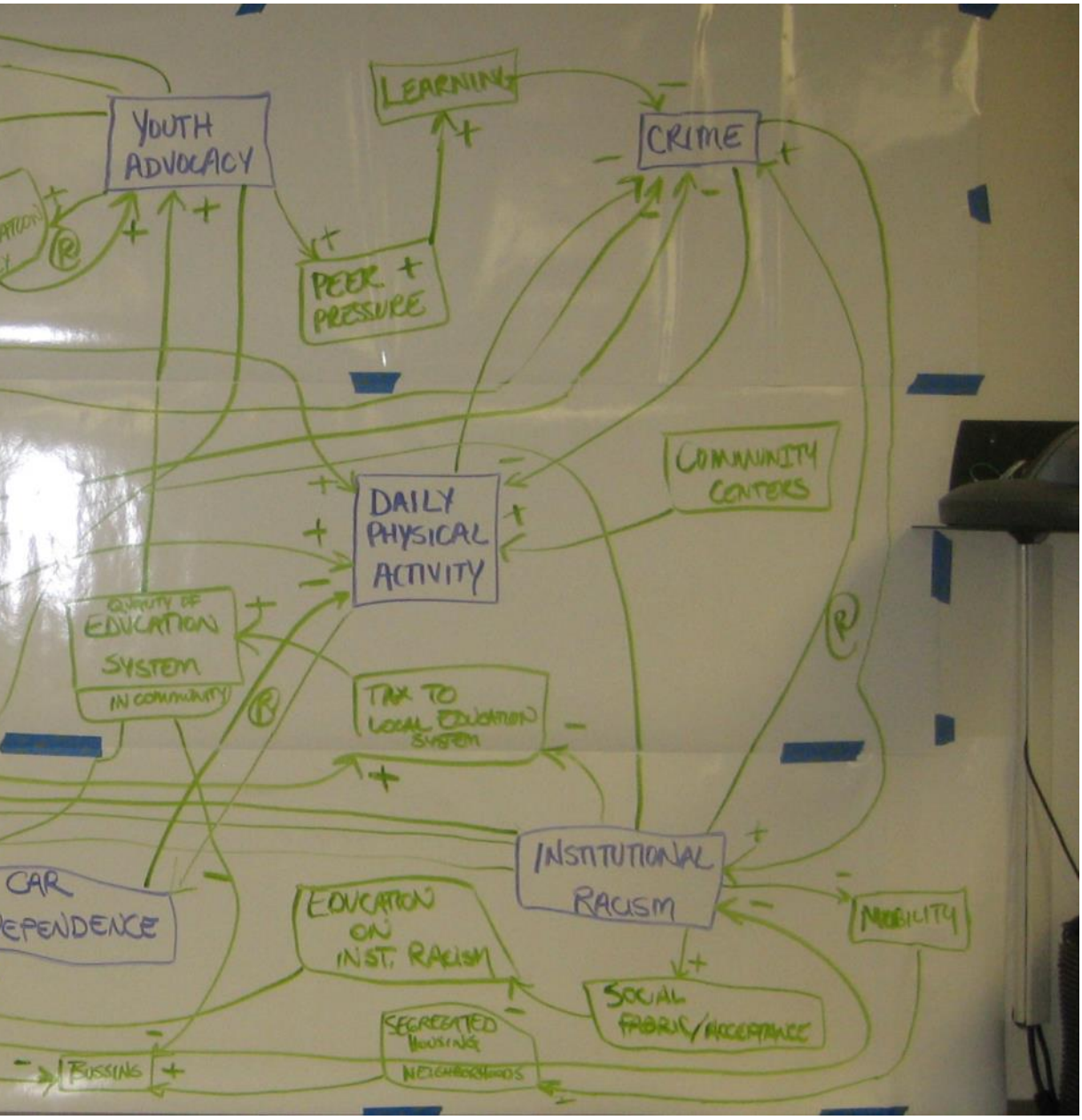
Appendix A: Behavior Over Time Graphs Generated during Site Visit

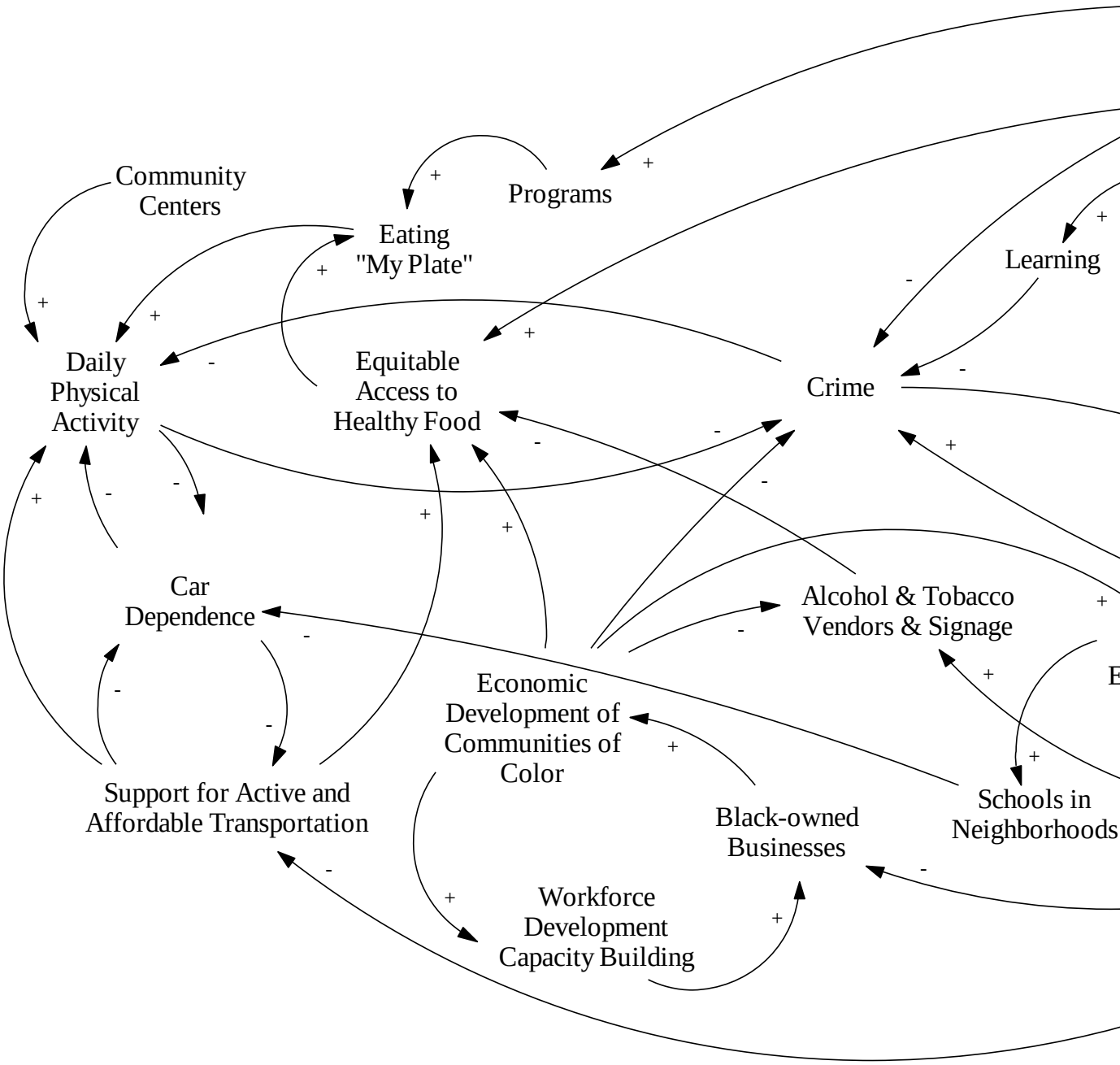
Louisville, Kentucky: *Louisville's Healthy Kids, Healthy Communities*	
Categories	**Number of Graphs**
Active Living Behavior	5
Active Living Environments	2
Funding	2
Healthy Eating Behavior	3
Healthy Eating Environments	6
Marketing and Media Coverage	0
Obesity and Long Term Outcomes	0
Partnership & Community Capacity	3
Policies	3
Programs & Promotions (Education and Awareness)	1
Social Determinants of Health	7
Total Graphs	**32**

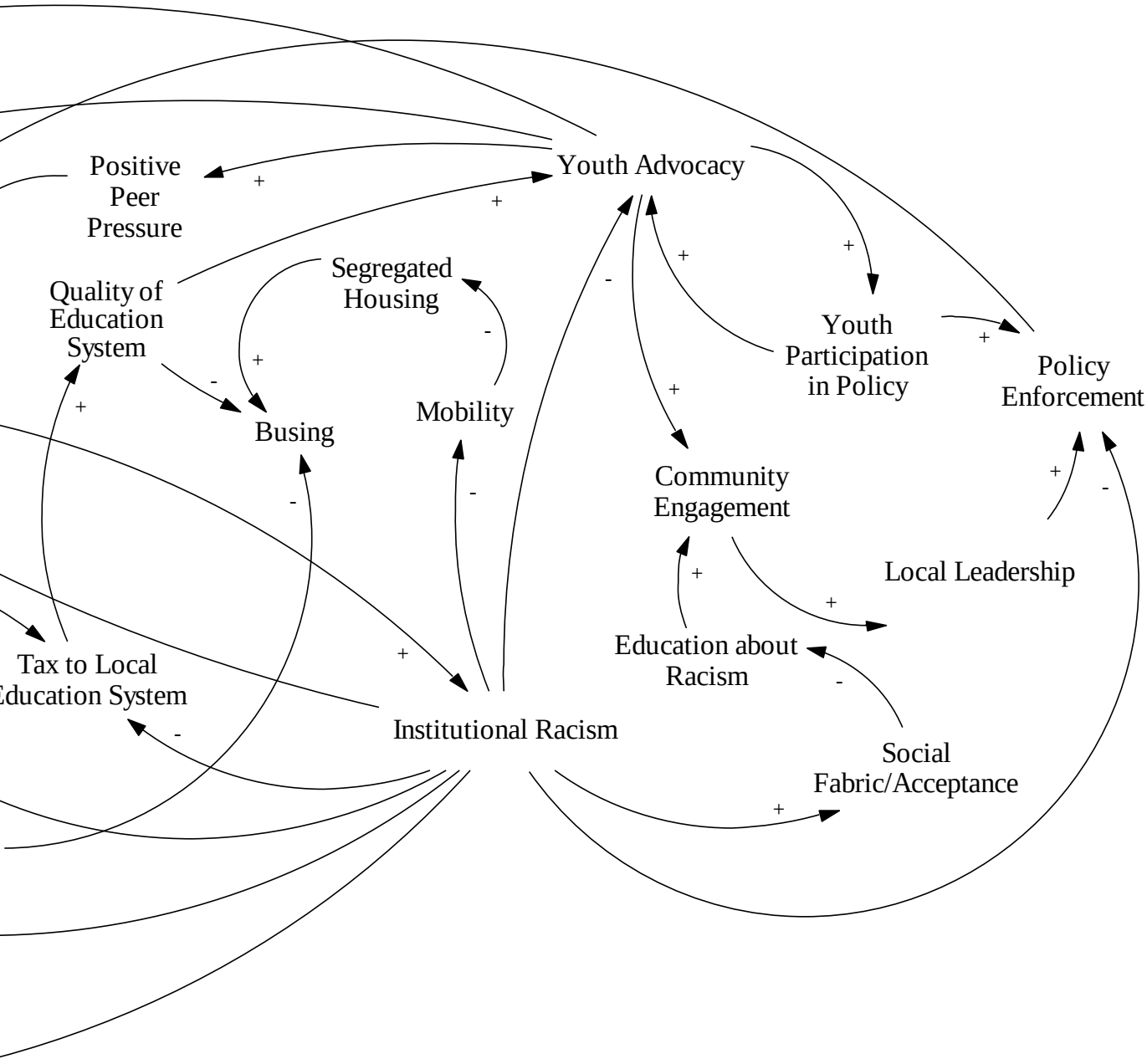
Appendix B: Photograph of the Original Version of *Louisville's Healthy Kids, Healthy Communities* Causal Loop Diagram



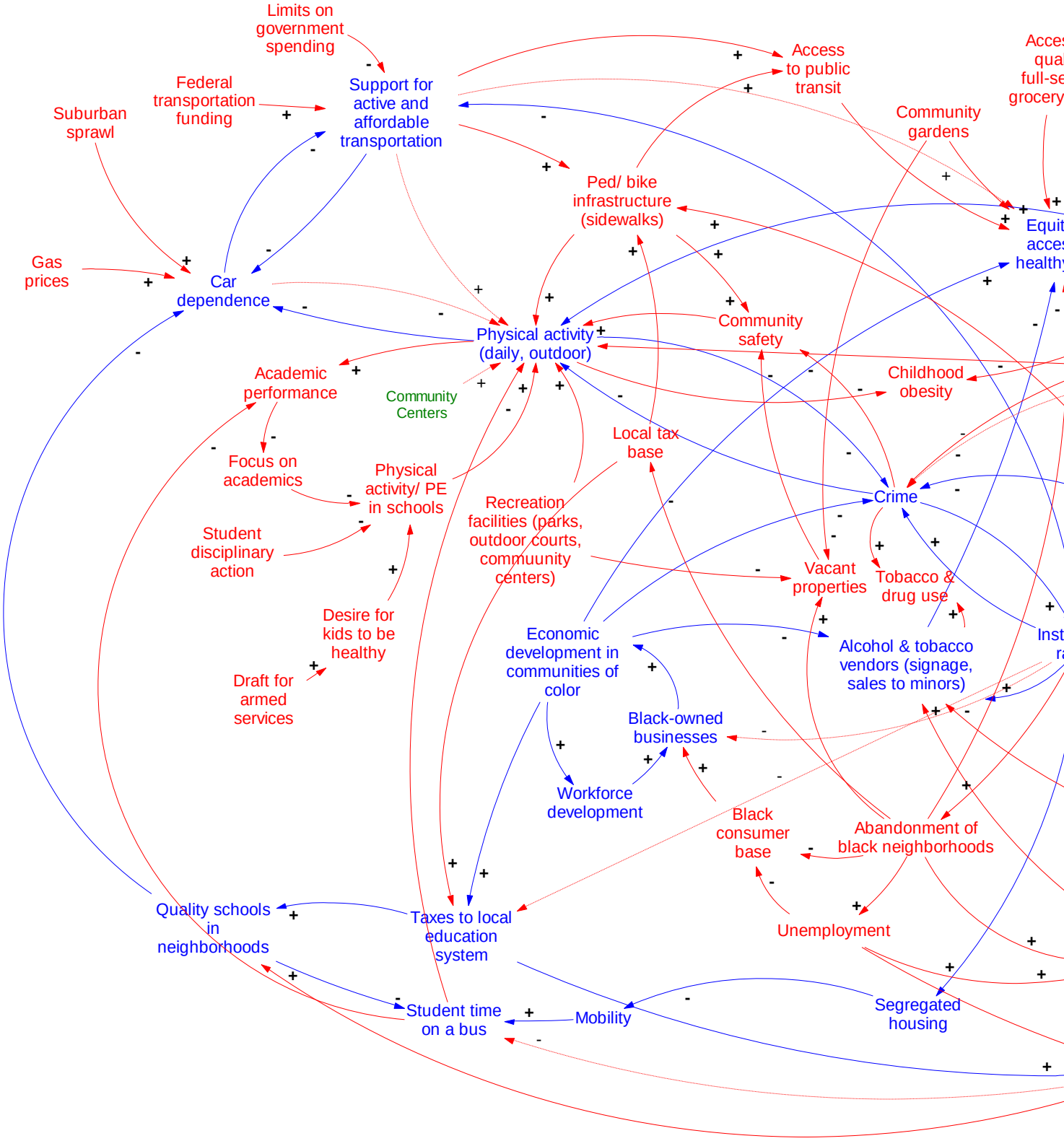

YOUTH ADVOCACY
LEARNING
CRIME
PEER + PRESSURE
COMMUNITY CENTERS
DAILY PHYSICAL ACTIVITY
QUALITY OF EDUCATION SYSTEM IN COMMUNITY
TAX TO LOCAL EDUCATION SYSTEM
INSTITUTIONAL RACISM
CAR DEPENDENCE
EDUCATION ON INST. RACISM
MOBILITY
SOCIAL FABRIC/ACCEPTANCE
SEGREGATED HOUSING NEIGHBORHOODS
BUSSING

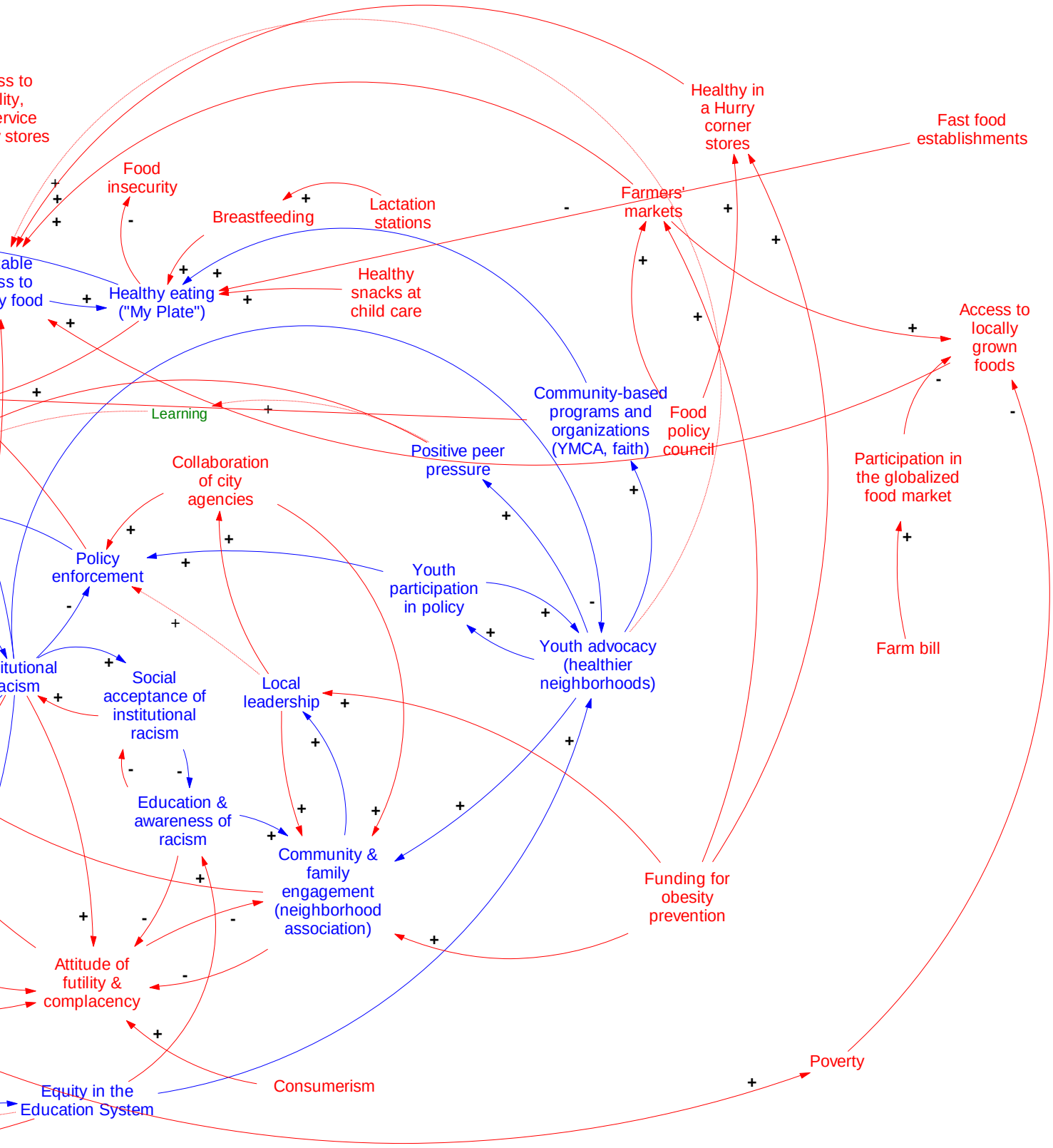
Appendix C: Original Translation of the Causal Loop Diagram into Vensim PLE



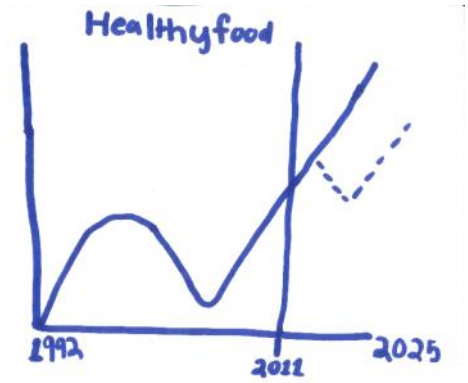

Positive Peer Pressure
Youth Advocacy
Quality of Education System
Segregated Housing
Youth Participation in Policy
Policy Enforcement
Busing
Mobility
Community Engagement
Local Leadership
Education about Racism
Tax to Local Education System
Institutional Racism
Social Fabric/Acceptance

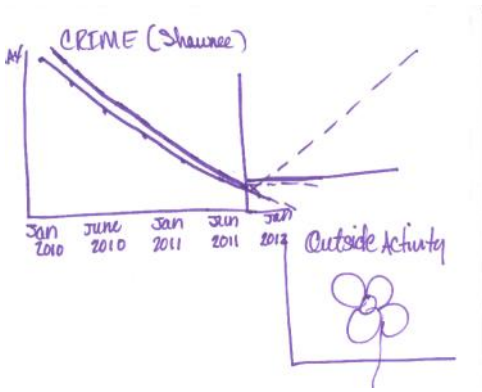
Appendix D: Transcript Translation of the Causal Loop Diagram into Vensim PLE

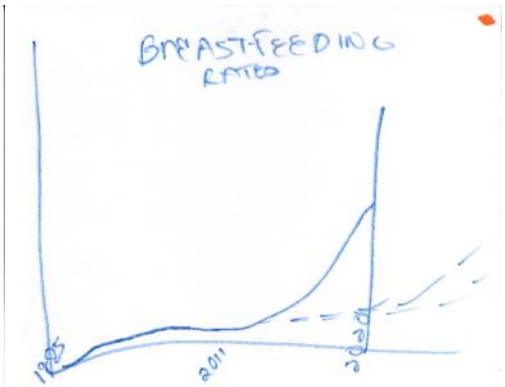


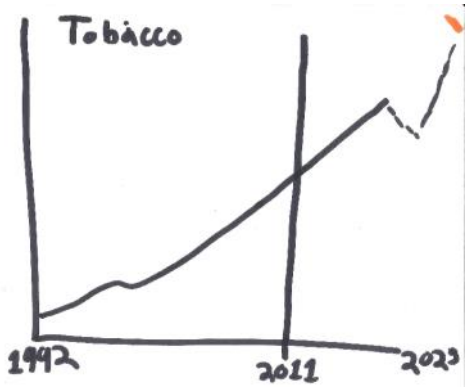

ss to
lity,
ervice
stores
Healthy in
a Hurry
corner
stores
Fast food
establishments
Food
insecurity
Breastfeeding
Lactation
stations
Farmers'
markets
able
ss to
y food
Healthy eating
("My Plate")
Healthy
snacks at
child care
Access to
locally
grown
foods
Learning
Community-based
programs and
organizations
(YMCA, faith)
Food
policy
council
Positive peer
pressure
Collaboration
of city
agencies
Participation in
the globalized
food market
Policy
enforcement
Youth
participation
in policy
Youth advocacy
(healthier
neighborhoods)
Farm bill
itutional
acism
Social
acceptance of
institutional
racism
Local
leadership
Education &
awareness of
racism
Community &
family
engagement
(neighborhood
association)
Funding for
obesity
prevention
Attitude of
futility &
complacency
Poverty
Consumerism
Equity in the
Education System

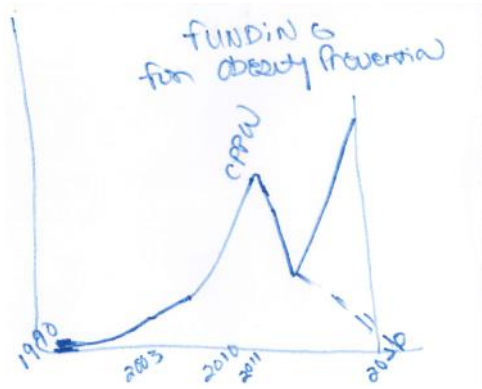
Appendix E: Behavior Over Time Graphs not Represented in the Storybook

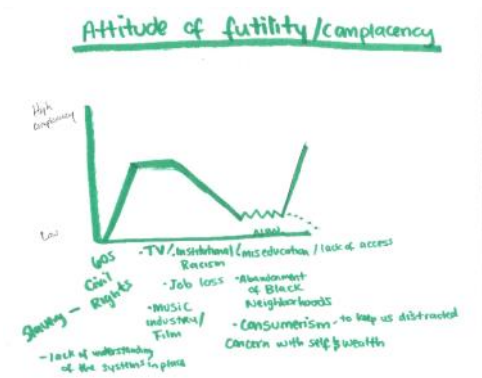


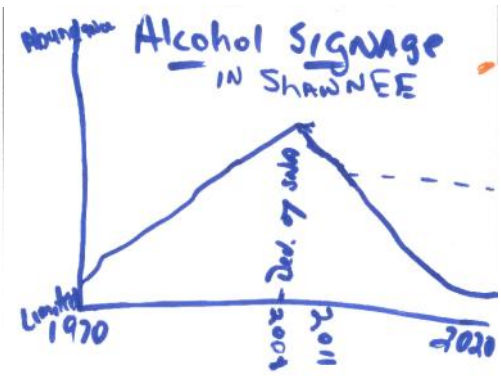


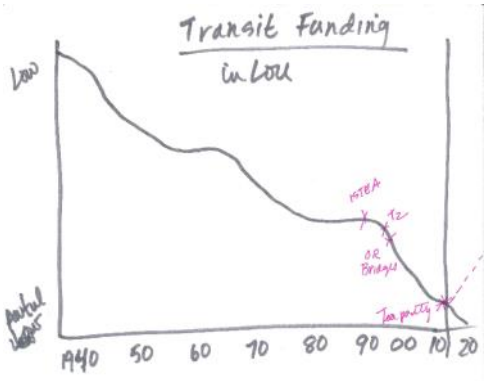


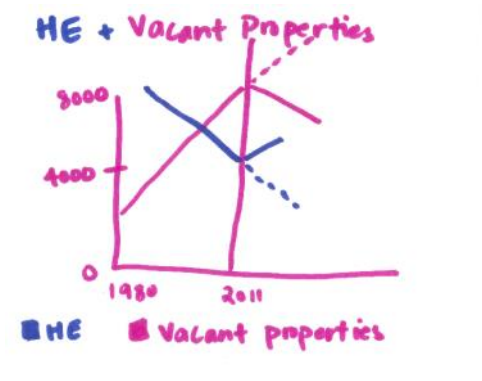


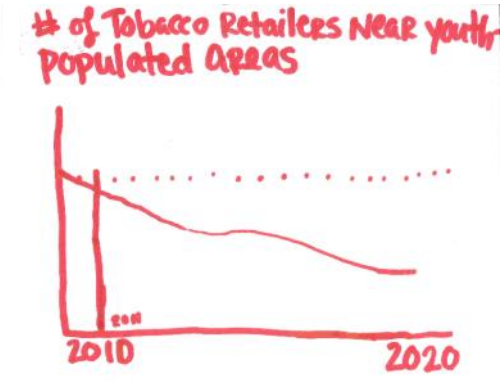


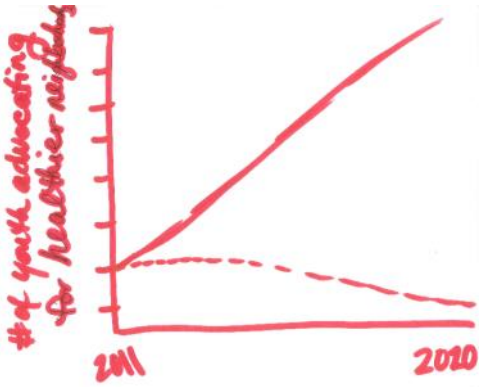


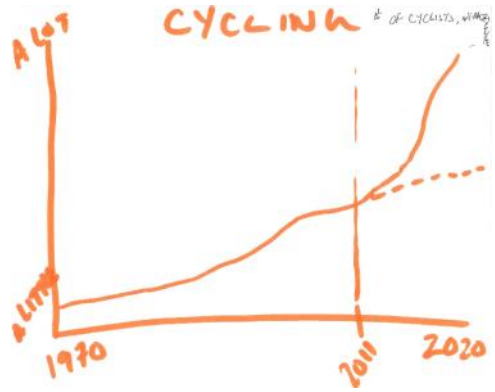


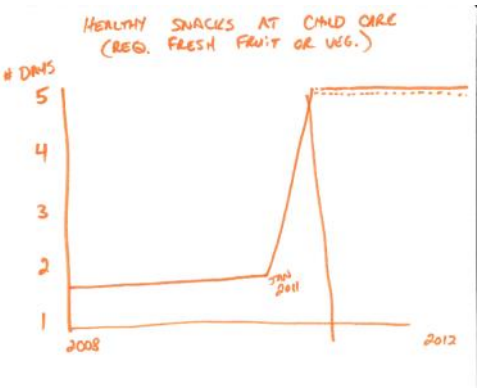


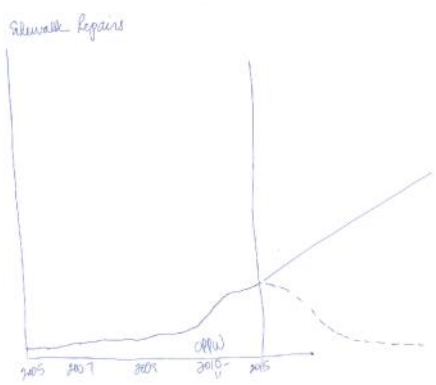


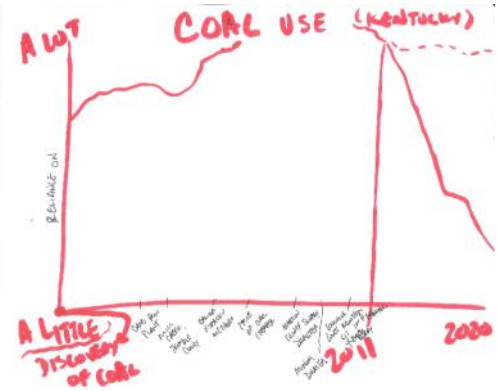


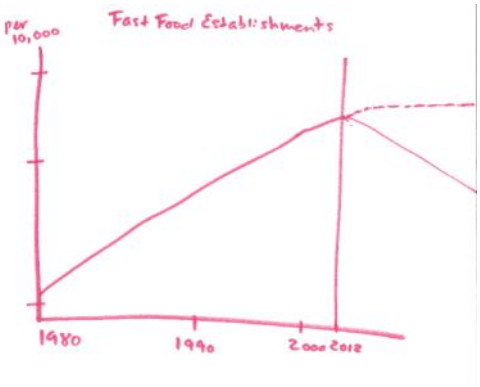

# of youth advocating for healthier neighborhoods
2011
2020


CYCLING
# of cyclists, walkers
A LOT
A LITTLE
1970
2011
2020


HEALTHY SNACKS AT CHILD CARE (REG. FRESH FRUIT OR VEG.)
DAYS
5
4
3
2
1
JAN 2011
2008
2012


Sidewalk Repairs
(MPH)
2005
2007
2009
2015-11
2015


COAL USE (KENTUCKY)
A LOT
BITUMINOUS
A LITTLE
DISCOVERY OF COAL
2011
2020


Fast Food Establishments
per 10,000
1980
1990
2000
2012