A METHOD FOR EVALUATING RURAL COMMUNITY HEALTH COALITION FUNCTION AND STRUCTURE RELATED TO LONG-TERM HEALTH OUTCOMES

by

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A Dissertation

Submitted to the Faculty of Purdue University

In Partial Fulfillment of the Requirements for the degree of

Doctor of Philosophy

Department of Nutrition Science

West Lafayette, Indiana

August 2019

THE PURDUE UNIVERSITY GRADUATE SCHOOL
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To Ejike. You helped me to remember what is important.

ACKNOWLEDGMENTS

Dr. Savaiano, thank you for trusting me to be creative, innovative, and productive. I count myself extremely fortunate to have had a mentor like you. You are the best boss I will ever have.

Dr. Miller, thank you for continually readjusting my focus so that I could both interpret the finer details of my work and give real-world context to my findings.

Dr. Eicher-Miller, Dr. Bailey, and Dr. Beaulieu, thank you for serving on my committee and for providing feedback and opportunities for growth over the years.

Donna Vandergraff, thank you for making my work possible. Your contagious passion for community engagement inspired others to support me and be excited about research.

Dr. Lynch, thank you for being so kind to me when I didn't know what I was doing. Your experience and wisdom helped me feel safe during the uncomfortable process of growing.

Kevin Amstutz, thank you for all the technical support you gave me. I learned so much from you. You opened the door to data science for me and made me believe I could be an expert.

Tracy Eaton, thank you for keeping the lab in one piece. You helped me protect my study participants by ensuring study protocols met Institutional Review Board requirements.

Lily Darbishire, thank you for your help this last year. I wish we could have spent more time working together, but you are in good hands with your research team.

Blake Connolly, Melissa Maulding, Angie Abbott, and all current and past Nutrition Education Program and Health and Human Sciences Extension team members, thank you for allowing me to work with you and for being valuable research and evaluation partners.

Finally, thank you to the Extension Educators and Community Wellness Coordinators who participated in my studies. Thank you for recruiting your members to take surveys and for being engaged and interested during the research process.

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ABBREVIATIONS

_BMI5CAT.A.avg: BRFSS (2015-16), Calculated variable for the average adult BMI, mean

_HCVU651: BRFSS (2015-16), Calculated variable for respondents aged 18-64 who have any form of health care coverage, percent responding they do not have healthcare coverage

_RFBING5: BRFSS (2015-16), Calculated variable for binge drinkers (males having five or more drinks on one occasion, females having four or more drinks on one occasion), percent responding yes, that they did drink in the last 30 days and that they had 5 (men), 4 (women), or more drinks on one or more occasions

_RFBMI5.A: BRFSS (2015-16), Calculated variable for adults who have a body mass index greater than 25.00 (overweight or obese), percent of adults who are overweight or obese

_RFHLTH: BRFSS (2015-16), Would you say that in general your health is: excellent, very good, good, fair, poor, percent responding fair and poor

_RFMAM2Y: BRFSS (2015-16), Calculated variable for women respondents aged 40+ who have had a mammogram in the past two years, percent responding no (5 year estimate)

_RFPSA21: BRFSS (2015-16), Calculated variable for male respondents aged 40+ who have had a Prostate-Specific Antigen test in the past 2 years, percent responding no (5 year estimate)

_TOTINDA: BRFSS (2015-16), During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?, percent of people responding that they had no physical activity at all in the last 30 days, i.e., 0 days of physical activity in the last 30 days

ACHIEVE: Action Communities for Health, Innovation, and Environmental Change

ARS: Agricultural Research Service

BRFSS: Behavioral Risk Factor Surveillance System

Btw.: betweenness

CBPR: Community Based Participatory Research

CCAT: Community Coalition Action Theory

CDC: Centers for Disease Control and Prevention

CE: Community Engagement

CEnP: Community Engagement Professional

CEnR: Community Engaged Research

cent.: centralization

CHC(s): Community Health Coalition(s); Community Health Coalition Member(s)

CHECKUP1: BRFSS (2015-16), About how long has it been since you last visited a doctor for a routine checkup?, percent responding that it has been longer than two years or that they are not sure

CHIP: Community Health Improvement Partnership

CHIRP: Community Health Improvement and Research Partnership

ChronicAvg: BRFSS (2015-16), The average number of chronic diseases people have, out of nine possible options- myocardial infarction, angina/coronary heart disease, stroke, asthma, cancer, COPD/emphysema/chronic bronchitis, arthritis/rheumatoid arthritis/gout/lupus/fibromyalgia, kidney disease, diabetes, mean

ChronicSum3: BRFSS (2015-16), The percentage of people having three or more chronic diseases (from the above list of nine) at once, percent responding three or more

CoHealth: county-level health statistics

CSAS: Coalition Self-Assessment Survey

CSH: Coordinated School Health

CWC: Community Wellness Coordinator(s)

CWC-CHC(s): Community Health Coalition(s) partnering with Community Wellness Coordinators

DSCF: Dwass-Steel-Critchlow-Fligner

ECHO: Extension for Community Healthcare Outcomes

ECIGNOW: BRFSS (2015-16), Do you now use e-cigarettes or other electronic “vaping” products every day, some days, or not at all?, percent responding every day or some days

Egv.: eigenvector

ERS: Economic Research Service

Ext: Extension Educator(s)

Ext-CHC(s): Community Health Coalition(s) partnering with Extension Educators

FLUSHOT6: BRFSS (2015-16), During the past 12 months, have you had either a flu shot or a flu vaccine that was sprayed in your nose?, percent responding no

FNS: Food and Nutrition Service

FoodInsec: FeedingAmerica (2015), County food insecurity rate, percent

foodservice directors (FSDs)

FrailtySum1: BRFSS (2015-16), Percent of people having at least one indicator of frailty-difficulty walking or climbing stairs, difficulty dressing or bathing, difficulty running errands because of a physical/mental/emotional condition, percent having one or more

GTO: Getting to Outcomes

HHFKA: Healthy, Hunger-Free Kids Act of 2010

HLTHPLN1: BRFSS (2015-16), Do you have any kind of health care coverage, including health insurance, prepaid plans such as HMOs, or government plans such as Medicare, or Indian Health Service?, percent responding no, they do not have health care coverage

K-12: kindergarten through 12th grade

K: kindergarten

k: number of clusters

K-3: kindergarten through 3rd grade

K-5: kindergarten through 5th grade

KLM: W.K. Kellogg Foundation Logic Model

LBW: STATS (2016), Low birthweight infants, percent of live births

leader1: Leadership has a clear vision for the coalition.

leader2: Leadership has the necessary knowledge and skills.

leader3: Leadership is respected.

leader4: Leadership gets things done.

leader5: Leadership intentionally seeks others' views.

leader6: Leadership utilizes the skills and talents of many, not just a few.

leader7: Leadership is ethical.

leader8: Leadership is skillful at resolving conflict.

LF: one of the variables resulting from a cluster analysis on the Coalition Self-Assessment Survey, describing Community Health Coalition members' positive perceptions of their leadership and internal functioning

MATCH: Multi-level Approach to Community Health

MEDCOST: BRFSS (2015-16), Was there a time in the past 12 months when you needed to see a doctor but could not because of cost?, percent responding yes, this is true

MENTHLTH5: BRFSS (2015-16), Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?, percent reporting 5 or more days of poor mental health in the last 30 days

mg: milligrams

min.: minimum

N, n: number

N/A; NA: not applicable

NEP: Nutrition Education Program

NIDDK: National Institute of Diabetes and Digestive and Kidney Diseases

NIFA: National Institute of Food and Agriculture

NIH: National Institutes of Health

NS: not significant

NSLP: National School Lunch Program

opdeath: STATS (2016), Deaths from drug poisoning- involving opioid pain relievers, rate (crude rate per 100,000 population)

opEd: STATS (2016), Non-fatal emergency department visits due to opioid overdoses, rate (crude rate per 100,000 population)

opHosp: STATS (2016), Non-fatal hospitalizations due to opioid overdoses, rate (crude rate per 100,000 population)

opTrt: STATS (2016), Substance abuse treatment- other opiates and synthetics, rate (crude rate per 100,000 population)

OVS: Offer versus Serve

oz eq.: ounce equivalent

P; p: p-value, indicating the level statistical significance

PATCH: Planned Approach to Community Health

PERSDOC2: BRFSS (2015-16), Do you have one person you think of as your personal doctor or health care provider?, percent responding no, they do not have a personal doctor or health care provider

PHYSHLTH5: BRFSS (2015-16), Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?, percent reporting 5 or more days of poor physical health in the last 30 days

PICOS: Population, Intervention/indicator, Comparison, Outcomes, Setting

PNEUVAC3: BRFSS (2015-16), A pneumonia shot or pneumococcal vaccine is usually given only once or twice in a person´s lifetime and is different from the flu shot. Have you ever had a pneumonia shot?, percent responding no or don't know/now sure

POORHLTH5: BRFSS (2015-16), During the past 30 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation?, percent reporting 5 or more days in the last 30 days

pregsmok: STATS (2016), Mothers smoking during pregnancy, percent of live births

prenatal: STATS (2016), Mothers receiving prenatal care beginning in the first trimester, percent of live births

preterms: STATS (2016), Preterm infants, less than 37 weeks, percent of live births

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PROB: one of the variables resulting from a cluster analysis on the Coalition Self-Assessment Survey, describing Community Health Coalition members' problems for participation

PROSPER: Promoting School-community-university Partnerships to Enhance Resilience

PSE: policy, system, and environment

REACH: Racial and Ethnic Approaches to Community Health

RE-AIM: Reach- Adoption, Implementation, Maintenance

recruit1: The coalition is actively recruiting new members.

recruit2: New members receive adequate orientation to be effective members of the coalition.

recruit3: The current method for communication between coalition staff/leadership and its membership is effective.

recruit4: Resources are being identified to support the systemic, programmatic changes implemented through the work of the coalition.

REDCap: Research Electronic Data Capture

repprob1: Coalition activities do not reach my primary constituency.

repprob2: Being involved in policy advocacy is a problem.

repprob3: My skills and time are not well used.

repprob4: My opinion is not valued.

repprob5: The coalition is not taking any meaningful action.

repprob6: I am often the only voice representing my point of view.

repprob7: The financial burden of traveling to coalition meetings is too high.

repprob8: The financial burden of participation (barring travel) is too high.

repprob9: The coalition is competing with my organization.

SD: standard deviation

SEM: Social Ecological Model

SMOKDAY2: BRFSS (2015-16), Do you now smoke cigarettes every day, some days, or not at all?, percent responding every day or some days

SNA: Social Network Analysis

SNAP-Ed: Supplemental Nutrition Assistance Program-Education

SSBFRUT2: BRFSS (2015-16), During the past 30 days, how often did you drink sugar-sweetened fruit drinks (such as Kool-aid and lemonade), sweet tea, and sports or energy drinks (such as Gatorade and Red Bull)? Do not include 100 percent fruit juice, diet drinks, or artificially sweetened drinks, percent of people responding that they drank noncarbonated sugar-sweetened beverages every day in the last 30 days

SSBSUGR2: BRFSS (2015-16), During the past 30 days, how often did you drink regular soda or pop that contains sugar? Do not include diet soda or diet pop, percent of people responding that they drank sugar-sweetened soda every day in the last 30 days

STATS: Indiana STATS Explorer data

sustain1: The coalition is making progress in implementing activities that have potential to improve health in the county.

sustain2: The coalition is improving health outcomes for people in the county served by this coalition.

sustain3: My skills and abilities are effectively used by the coalition.

sustain4: I feel respected and recognized for my efforts

SWP: School Wellness Policy

SY: School Year

US; U.S.: United States

USDA: United States Department of Agriculture

USDHHS: Health Resources and Services Administration of the United States Department of Health and Human Services

USENOW3: BRFSS (2015-16), Do you currently use chewing tobacco, snuff, or snus every day, some days, or not at all?, percent responding every day or some days

VLBW: STATS (2016), Very low birthweight infants, percent of live births

ABSTRACT

Author: Ken-Opurum, Jennifer, L. PhD
Institution: Purdue University
Degree Received: August 2019
Title: A Method for Evaluating Rural Community Health Coalition Function and Structure Related to Long-Term Health Outcomes
Committee Chair: Dennis Savaiano

Rural Americans have higher rates of preventable chronic disease, poorer health behaviors and outcomes, and limited access to healthcare services, as compared to their urban/suburban counterparts. Interventions targeting individual behavior change and policy aimed at creating healthy environments have been only marginally successful at improving rural health. Thus, federal governing bodies and national public health organizations recognize community engagement as a viable strategy to mitigate health disparities. One such strategy is the development of community health coalitions (CHCs). Although CHCs have had isolated instances of success, evaluating CHC effectiveness is methodologically challenging. Traditional CHC assessments are subjective, with no standard for validation. Thus, this dissertation describes the development and implementation of a novel mixed-methods, multi-level evaluation framework, comparing CHC partnership networks using social network analysis, CHC perceived effectiveness using the Coalition Self-Assessment Survey, local policy, system, and environment change interventions through a qualitative assessment of program reports, and county-level health statistics. In Indiana there is a robust network of CHCs partnering with Purdue Extension Educators (Ext) and Nutrition Education Program Community Wellness Coordinators (CWC). Ext receive broad training, address general health topics, and serve CHCs in an advisory capacity, taking on leadership roles as needed. In contrast, CWC receive focused leadership and

research training, address nutrition-related health topics, and adopt a central leadership position in their partnerships. In year 1 partnership network interconnectedness positively correlated to perceived effectiveness for Ext-CHCs; however, for CWC-CHCs, network interconnectedness negatively correlated to perceived effectiveness. Additionally, CWC-CHCs reported more highly rated leadership and functioning, fewer problems for participation in their CHC, and had greater eigenvector centralization (indicating the presence of a network broker, i.e., a position of power), as compared to Ext-CHCs. At follow-up, increased collaboration centralization positively correlated to increased perceived effectiveness for Ext-CHCs, while increased communication centralization positively correlated to increased perceived effectiveness for CWC-CHCs. For both Ext-CHCs and CWC-CHCs, increased interconnectedness for good-high trust and formal ties positively correlated to increased perceived effectiveness. Findings are interpreted in the context of salient county-level health statistics and qualitative reports of CHC outcomes. This dissertation begins with **(1)** a systematic literature review on the impact of federal policy change on student dietary behaviors, then **(2)** present findings from a statewide survey examining differences in perceptions between school foodservice directors and CHC members regarding challenges related to implementing federal policy change and opportunities for school-based community engagement, then **(3)** explore rural CHC effectiveness across the public health logic model in a second systematic literature review, then **(4)** describe the development and pilot of a statewide CHC evaluation system, then present my findings from **(5)** year 1 and **(6)** follow-up, and finally **(7)** discuss conclusions and future directions.

CHAPTER 1. EFFECT OF SCHOOL WELLNESS POLICIES AND THE HEALTHY, HUNGER-FREE KIDS ACT ON FOOD-CONSUMPTION BEHAVIORS OF STUDENTS, 2006–2016: A SYSTEMATIC REVIEW

This chapter is adapted from Mansfield J, Savaiano D. Effect of School Wellness Policies and the Healthy, Hunger-Free Kids Act on Food-Consumption Behaviors of Students, 2006-2016: A Systematic Review. *Nutrition Reviews*. 2017;75(7):533-552.

Abstract

Context: Federal regulation mandates that the US National School Lunch Program nutrition standards align with the Dietary Guidelines for Americans. As students consume a substantial proportion of their nutrition during school lunch, increasing access to healthy foods is proposed to improve student dietary outcomes.

Objective: The purpose of this review is to assess whether policy changes impacted food-consumption behaviors of students during periods when (1) school wellness policies were implemented (2006–2007); (2) the Healthy, Hunger-Free Kids Act was passed (2010–2012); and (3) the Healthy, Hunger-Free Kids Act was implemented (2012–present).

Data Sources: PubMed, Web of Science, and Science Direct were searched for primary research studies.

Data Extraction: Policy evaluations and interventions implemented from 2006 to 2016 were included. A total of 31 studies evaluating plate waste, dietary intake, food selection, and/or purchasing patterns were identified and reviewed.

Results: Fourteen of 19 intervention and longitudinal observation studies reported improved food-consumption behaviors (increased selection, intake, and sales of healthy foods, and decreased plate waste). Only 2 of 12 one-time observation studies reported food-consumption behaviors meeting target nutrition standards.

Conclusions: The majority of studies indicated that increasing access to healthy foods during school lunch improved students' dietary intakes. Challenges related to study design, adaptation period, quality of foods, and policy implementation likely affect a school lunch program's ability to impact students' food-consumption behaviors. Ongoing evaluation of these programs is warranted.

Introduction

Rationale

Obesity in the United States has increased more than 200% in children and more than 400% in adolescents over the past 3 decades, according to data from the Centers for Disease Control and Prevention (Centers for Disease Control and Prevention, 2015). Currently, more than one-third of children are overweight or obese (Centers for Disease Control and Prevention, 2015). Children who are overweight have an increased risk for adult obesity and chronic disease (Centers for Disease Control and Prevention, 2015). Schools are an ideal setting in which to impact the food environment and may help to reduce childhood obesity; this is because schools not only provide a substantial portion of child nutrition, they can also implement policies and create environments that support healthy lifestyles and changes in behavioral outcomes (Centers for Disease Control and Prevention, 2015). The National School Lunch Program (NSLP), administered by the Food and Nutrition Service of the US Department of Agriculture (USDA FNS, 2015), served 31 million students during the school year (SY) 2012–2013, 21.5 million of whom received free or reduced-price lunches (Food Research and Action Center, 2015). The NSLP is a primary federal effort to address food insecurity and obesity (USDA FNS, 2015).

The US Department of Agriculture's School Nutrition Dietary Assessment is the mechanism by which the NSLP is assessed to determine its effectiveness in supporting child

nutrition (NCCOR Catalogue of Surveillance Systems, 2014). The School Nutrition Dietary Assessment is an ongoing national data and monitoring collection study conducted every 5 years since 1991. It evaluates the nutritional quality of NSLP meals offered to, served to, and consumed by students attending participating schools (NCCOR Catalogue of Surveillance Systems, 2014). School Nutrition Dietary Assessment data are used to inform policymakers, researchers, school foodservice programs, community members, and key stakeholders about compliance with federal school meal program regulations (NCCOR Catalogue of Surveillance Systems, 2014). The 24-hour dietary recall conducted as part of the third School Nutrition Dietary Assessment revealed that NSLP participants consumed more fruits and vegetables at school, but fewer at home, compared with nonparticipants (Ishdorj et al., 2013). Furthermore, several studies (Bergman et al., 2014; Caruso et al., 2015; Hubbard et al., 2014; Johnston et al., 2012) suggest that NSLP lunches may provide students with more nutrient-dense foods than lunches brought from home.

National School Lunch Program Policies

The NSLP nutrition standards have changed substantially in the last decade. The Child Nutrition and Women, Infants and Children Reauthorization Act of 2004 mandated that all schools participating in federally reimbursable meal programs develop a school wellness policy for implementation during SY 2006–2007 (USDA, 2015b). The Healthy, Hunger-Free Kids Act of 2010 (HHFKA) included more specific guidelines for evaluation, reporting, and development of wellness policies, community engagement, and federal standards for "nutrition guidelines to promote student health and reduce childhood obesity for all foods available in each school district" (USDA, 2015c). Table 1 describes the changes in NSLP meal patterns under the 2006–2007 school wellness policies (previous requirements) and the HHFKA (current requirements)

(USDA FNS, 2012). The HHFKA was implemented during SY 2012–2013; however, actual changes in school food policy and practices began as early as the implementation of the 2006–2007 wellness policies. This systematic review presents the research literature evaluating the impact of school wellness policies and the HHFKA on food-consumption-related behaviors and nutrient intake in US school-aged students between 2006 and 2016.

Methods

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Guidelines for Transparent Reporting of Systematic Reviews and Meta-Analyses (Moher et al., 2009; PRISMA, 2015) were followed. Primary research studies were retrieved from the PubMed, Web of Science, and ScienceDirect databases, using the term “national school lunch program” for studies published in the last 10 years. The search strategy in PubMed was as follows: “national school lunch program"[All Fields] AND (“2006/03/02”[PDat]: “2016/02/27”[PDat]). ScienceDirect, unlike PubMed and Web of Science, required specification that the search term be contained in the title, abstract, or keywords. A secondary search was conducted specifically for evaluations of current policy, using the search term “healthy, hunger free-kids act.” The PubMed search strategy was: healthy[All Fields] AND hunger-free[All Fields] AND kids[All Fields] AND act[All Fields].

Inclusion and exclusion criteria

Selected studies were from English-language peer- reviewed journals. Only studies evaluating student food-consumption-related behaviors and nutrient intake within US federally reimbursable meal programs were included. Randomized controlled trials, cohort studies, case–control studies, pre- and postintervention studies, cross-sectional studies, and other quasi-

experimental studies conducted during or after implementation of the 2006–2007 school wellness policies were included. Case reports, case series, editorials, conference abstracts, and position papers were excluded. Studies conducted before fall 2006 were excluded. When the year of study implementation was not included in the article, the first author was contacted. Objectives for study selection, using PICOS (Population, Intervention/indicator, Comparison, Outcomes, Setting) criteria, are: P, US school-aged children (5-18 years of age) participating in the NSLP; I, US NSLP interventions and policy changes; C, purchasing patterns, food selection, dietary intake, and plate waste; O, student food-consumption behaviors; S, US NSLP. The study selection process is shown in Figure 1.

Risk of bias

The Cochrane Collaboration's tool for assessing risk of bias in randomized controlled trials (The Cochrane Collaboration) was used where appropriate, given the majority of studies in this systematic review were observational studies. Study design, selective reporting, and other potential threats to validity were assessed using the following 6 questions modified from the validity topics suggested by the Cochrane Collaboration (The Cochrane Collaboration): (1) Were control and intervention groups evenly allocated? (2) Was there selection bias resulting from the use of a convenience sample? (3) Were outcome measures derived from the hypothesis, or were the analyzed data part of another study design? (4) Are changes in food-consumption-related behavior attributable to age of the population and/or an inadequate adaptation period? (5) Was there suggestive or selective reporting of results? (6) Was there potential bias caused by the funding source? Question 4, which asked about food behavior changes, age, and adaptation, was included because Dovey et al. (Dovey et al., 2008) suggested that young age, food neophobia, and exposure period and/or repeated exposure (among other social and cultural factors)

contribute to a child's willingness to eat unfamiliar foods. Thus, younger children with less exposure to certain foods may respond more negatively than their older peers who have had more exposure to the same foods.

The risk-of-bias rating procedure was adapted from the Academy of Nutrition and Dietetics' Evidence Analysis Manual (Academy of Nutrition and Dietetics, 2012). Each risk-of-bias category was assigned a weight of 1 (rather than a +, -, or neutral score, as suggested in the Evidence Analysis Manual (Academy of Nutrition and Dietetics, 2012)), and a sum score was calculated. One point toward the risk-of-bias score was assigned to the following responses to the modified Cochrane questions: (1) no, control, and intervention groups were not evenly allocated; (2) yes, there was bias resulting from use of a convenience sample; (3) data was from another study design; (4) yes, food-consumption-related behaviors were attributable to the study population age and/or an inadequate adaptation period; (5) yes, there was selective reporting of results; and (6) yes, there was potential bias caused by the funding source. A response of "possibly" was assigned one-half of a point toward the risk-of-bias score. "Unknown" responses were not factored into the risk of bias. Risk-of-bias scores of 0 to 1, 2–3, and 4–6 were defined as low risk, medium risk, and high risk, respectively. Studies with low or medium risk of bias are included in this review.

Potential causes of risk of bias across studies includes funding by the US Department of Agriculture (which has a bias toward reporting program success), lack of randomized controlled trials, reporting student fruit and vegetable selection patterns when current policy mandates selection of either 1 fruit or 1 vegetable per meal, and geographic/demographic differences between schools (Table 2 (Amin et al., 2015; Amin et al., 2014; Byker et al., 2014; Cohen et al., 2013; Cohen et al., 2014; Cohen et al., 2012; Connors et al., 2015; Cullen et al., 2015a; Cullen et

al., 2015b; Cullen et al., 2011; Dave et al., 2015; Echon, 2014; Eckart et al., 2010; Fiori et al., 2011; Goggans et al., 2011; Gosliner, 2014; Haas et al., 2014; Hakim et al., 2013; Hanks et al., 2013; Hanks et al., 2014; Johnson et al., 2016; Johnson et al., 2015; Just et al., 2014; Miller et al., 2015; Mobley et al., 2012; Robinson-O'Brien et al., 2010; Schwartz et al., 2015; Smith et al., 2014; Snelling et al., 2007; Williamson et al., 2013; Yon et al., 2014)).

Results

Analysis strategy

The research studies were categorized as one-time observation studies (having no comparison group), longitudinal observation studies (before/after and pre-/postintervention study designs, without a control group), or intervention studies (having a control group) (Table 3 (Amin et al., 2015; Amin et al., 2014; Byker et al., 2014; Cohen et al., 2013; Cohen et al., 2014; Cohen et al., 2012; Connors et al., 2015; Cullen et al., 2015a; Cullen et al., 2015b; Cullen et al., 2011; Dave et al., 2015; Echon, 2014; Eckart et al., 2010; Fiori et al., 2011; Goggans et al., 2011; Gosliner, 2014; Haas et al., 2014; Hakim et al., 2013; Hanks et al., 2013; Hanks et al., 2014; Johnson et al., 2016; Johnson et al., 2015; Just et al., 2014; Miller et al., 2015; Mobley et al., 2012; Robinson-O'Brien et al., 2010; Schwartz et al., 2015; Smith et al., 2014; Snelling et al., 2007; Williamson et al., 2013; Yon et al., 2014)). Intervention and longitudinal observation studies were designated as demonstrating improved food-consumption-related behaviors if more than 50% of measured outcomes improved, as demonstrating worsening food-consumption-related behaviors if more than 50% of measured outcomes worsened, or as neutral if equal numbers of measured outcomes were positive and negative or did not change. One-time observation studies compared student food-consumption-related behaviors with the previous NSLP nutrition standards under school wellness policy, with the 2009 Institute of Medicine

recommendations (which led to HHFKA nutrition standards, including an increase of fruit to 1 serving and an increase of vegetables to 2 servings, with 50% whole-grain foods), or with HHFKA standards.

The studies in the Results section are presented chronologically by policy period: (1) school wellness policy (fall 2006 to December 2009); (2) pre-HHFKA implementation (2010–2012); and (3) HHFKA evaluation (2012–present). Within each policy period, onetime observation studies are described first, followed by intervention and longitudinal observation studies grouped by direction (improvement, neutral, worsening) of food-consumption-related behaviors.

Summary of evidence

Of the 7 intervention studies, 5 (Cohen et al., 2013; Cohen et al., 2012; Cullen et al., 2015b; Mobley et al., 2012; Williamson et al., 2013) demonstrated improved food-consumption-related behaviors, while 2 (Dave et al., 2015; Goggans et al., 2011) showed neutral findings (Table 4 (Cohen et al., 2013; Cohen et al., 2012; Cullen et al., 2015b; Dave et al., 2015; Goggans et al., 2011; Mobley et al., 2012; Williamson et al., 2013)). Of the 12 longitudinal observation studies, 9 (Cohen et al., 2014; Cullen et al., 2015a; Eckart et al., 2010; Hakim et al., 2013; Hanks et al., 2013; Johnson et al., 2016; Just et al., 2014; Miller et al., 2015; Schwartz et al., 2015) demonstrated improved food-consumption-related behaviors, 1 (Yon et al., 2014) showed neutral findings, and 2 (Amin et al., 2015; Hanks et al., 2014) demonstrated worsening food-consumption-related behaviors (Table 5 (Amin et al., 2015; Cohen et al., 2014; Cullen et al., 2015a; Eckart et al., 2010; Hakim et al., 2013; Hanks et al., 2013; Hanks et al., 2014; Johnson et al., 2016; Just et al., 2014; Miller et al., 2015; Schwartz et al., 2015; Yon et al., 2014)). In total, 14 of 19 intervention and longitudinal observation studies (Cohen et al., 2013; Cohen et al.,

2014; Cohen et al., 2012; Cullen et al., 2015a; Cullen et al., 2015b; Eckart et al., 2010; Hakim et al., 2013; Hanks et al., 2013; Johnson et al., 2016; Just et al., 2014; Miller et al., 2015; Mobley et al., 2012; Schwartz et al., 2015; Snelling et al., 2007; Williamson et al., 2013) reported improvements in food-consumption-related behaviors, 3 (Dave et al., 2015; Goggans et al., 2011; Yon et al., 2014) reported neutral findings, and 2 (Amin et al., 2015; Hanks et al., 2014) reported worsening food-consumption-related behaviors. Of the 12 one-time observation studies, only 2 (Haas et al., 2014; Snelling et al., 2007) reported that the majority of target nutrition standards had been met, while 10 (Amin et al., 2014; Byker et al., 2014; Connors et al., 2015; Cullen et al., 2011; Echon, 2014; Fiori et al., 2011; Gosliner, 2014; Johnson et al., 2015; Robinson-O'Brien et al., 2010; Smith et al., 2014) did not (Table 6 (Amin et al., 2014; Byker et al., 2014; Connors et al., 2015; Cullen et al., 2011; Echon, 2014; Fiori et al., 2011; Gosliner, 2014; Haas et al., 2014; Johnson et al., 2015; Robinson-O'Brien et al., 2010; Smith et al., 2014; Snelling et al., 2007)).

2006-2007 School Wellness Policy Period (Fall 2006 to December 2009)

One-time observation studies

Twenty-four hour dietary recalls were administered to 103 4th- through 6th-grade children from low-income households in St Paul, Minnesota, during fall 2006 (Robinson-O'Brien et al., 2010). Eighty percent of children consumed fewer than 5 servings of fruits and vegetables per day. However, children consumed over half of their total fruit and vegetable intake at school (Robinson-O'Brien et al., 2010).

Food selection patterns and reported preferences among 9th-grade students in California, along with production records, were collected during February and March of 2009 (Fiori et al., 2011). Two-thirds of 151 students did not select whole fruits or vegetables during the 9 days of data collection (Fiori et al., 2011). Ten percent of students reported that pizza was their preferred

entree; however, nearly 30% of daily sales were pizza, and 46% of all students selected pizza at least once during the observation period. The authors suggested that this may have been due to the wide availability of pizza as an entree (as compared with chicken strips and yogurt parfaits) (Fiori et al., 2011).

Self-reported dietary intakes of 5653 Texas middle school students during spring 2008 were compared with the 2009 Institute of Medicine recommendations for school lunches (Cullen et al., 2011). National School Lunch Program participants (5414 students) reported consuming one half of a serving of fruit, three-fourths of a serving of vegetable, 8 oz of milk, and one-third of a serving of whole grains during lunch (Cullen et al., 2011). Furthermore, 40% of NSLP participants reported selecting a fruit, and two thirds reported selecting a vegetable (with 4% selecting dark green or orange vegetables) (Cullen et al., 2011). Participants in the NSLP reported consuming two-thirds of their fruit and vegetable selection (Cullen et al., 2011). Students not participating in the NSLP (n = 239) reported no consumption of fruit, vegetable, or milk and reported a consumption of one fourth of a serving of whole grains during lunch on the observation day (Cullen et al., 2011).

Food availability and purchasing patterns of 5429 students in 3 public high schools in Arlington, Virginia were tracked for 4 weeks during the semester that the 2006–2007 school wellness policies were implemented (Snelling et al., 2007). The nutrient composition of foods was coded as green (high nutrient density, low energy density), yellow (moderate nutrient and energy density), or red (low nutrient density, high energy density), in accordance with the Stoplight Diet approach (Epstein et al., 1988). National School Lunch Program offerings consisted of 32.8% green, 44% yellow, and 23.2% red items, with students purchasing 27.9% green, 45.2% yellow, and 26.9% red NSLP offerings (Snelling et al., 2007). Competitive food

offerings (foods offered outside the reimbursable school meals programs) were coded as green (22.5% of items), yellow (16.9% of items), or red (60.6% of items), with students purchasing 11.5% green, 5.5% yellow, and 83% red competitive food offerings (Snelling et al., 2007). Thus, students purchased NSLP items of specified nutrient or energy densities in proportion to the availability of the items, but they purchased proportionately more unhealthy (red) competitive foods (Snelling et al., 2007).

Improved food-consumption behaviors

The HEALTHY intervention was a 3-year (2006–2009) type 2 diabetes primary prevention trial that included 4603 students from 42 middle schools (21 control, 21 intervention) at 7 sites across the United States (Houston, Texas, Portland, Oregon, Philadelphia, Pennsylvania, Irvine, California, Chapel Hill, North Carolina, Pittsburg, Pennsylvania, and San Antonio, Texas) (Mobley et al., 2012). A registered dietitian trained staff in the reformulation of menu items, and students were offered taste tests and educational opportunities. Intervention schools limited portion sizes of desserts and snack foods (<200 kcal/serving) at both NSLP and a la carte venues, while serving significantly more fiber and eliminating milk with more than 1% fat (Mobley et al., 2012). Purchasing patterns and participation rates among students at intervention schools (not significantly different from patterns and rates at control schools) indicated acceptability of healthier foods (Mobley et al., 2012). The Wise Mind study (670 elementary students in 4 Louisiana schools, conducted over 2 years) and the LA Health study (2097 4th through 6th grade students in rural Louisiana public schools, conducted over 28 months) modified the school food environment in compliance with the Dietary Guidelines for Americans by reducing the total fat and energy composition of meals (Williamson et al., 2013). In both studies, there was a strong relationship between food selection and food consumption,

with minimal plate waste reported (Williamson et al., 2013). Additionally, selection and intake as measured according to the Healthy Eating Index improved, indicating improved nutrition outcomes (Williamson et al., 2013).

Food purchasing patterns among elementary and middle school students (enrollment of 2853) were measured over a 4-week intervention in Florida schools offering vegan menu items once per week during SY 2007–2008 (Eckart et al., 2010). On days when vegan entrees were offered, 76% of total purchases in elementary schools and 56% of total purchases in middle schools were these vegan options. These items had lower calories, fat, saturated fat, and protein and higher fiber than nonvegan items offered to students and were reportedly easy for school foodservice staff to prepare (Eckart et al., 2010).

The Chefs Move to Schools initiative, launched as part of the HHFKA, recruited local chefs to create menu items reflecting the Dietary Guidelines for Americans while working with parents, teachers, nutritionists, and school administrators to provide engaging nutrition education to students (letsmove.gov, 2015). A 2-year Chefs Move to School pilot study (2007–2009) in 2 Boston middle schools (1609 students) demonstrated a 51% increase in selection of whole grains and a 0.36-serving increase in selection of vegetables daily per student when compared with daily selections per student in 2 control schools (1440 students) (Cohen et al., 2012). Students in the intervention schools consumed 40.2% of vegetables selected vs only 10.8% in control schools, thus wasting fewer vegetables and having higher intakes of vitamin A, vitamin C, and fiber (Cohen et al., 2013). Interestingly, there was substantial food waste in both control and intervention schools (Cohen et al., 2013). Students in all schools consumed only half of the calories from the foods they selected. Regardless of menu changes, approximately 26.1% of total

foods were thrown away (Cohen et al., 2013). Furthermore, 19% of entrees, 47% of fruit, 25% of milk, and 73% of vegetables were discarded on a typical school day (Cohen et al., 2013).

Neutral findings

Offer versus serve (OVS) is designed to reduce plate waste by offering students 5 items but requiring them to take only 3 (USDA FNS, School Year 2013-2014). Weighed plate-waste data from NSLP participants at a Mississippi elementary school having OVS (383 tray observations) and another elementary school having a serve-only option (266 tray observations) were collected for 5 consecutive days in October 2009 (Goggans et al., 2011). Both schools offered the same menu on data collection days. A consistently higher percentage of fruit and vegetable consumption was observed at the OVS school (e.g., 81% vs 57% of applesauce, 67% vs 48% of carrots, and 58% vs 27% of mixed vegetables consumed), while higher consumption of French fries (67% vs 72% consumed) was observed at the serve-only school (Goggans et al., 2011). Plate waste was significantly lower ($P < 0.05$) at the OVS school; however, total fruit and vegetable consumption was not significantly different between schools (Goggans et al., 2011).

HHFKA Pre-implementation Period (2010–2012)

One-time observation studies

Variety, availability, and quality of NSLP fruit and vegetable offerings were assessed by direct observation of 5439 students in 31 California schools for 1 day during 2010 (Gosliner, 2014). Researchers also recorded the duration of the lunch period, other food offerings (such as snack and dessert foods), and interactions with school foodservice staff (Gosliner, 2014). Students were surveyed regarding consumption patterns and attitudes about having fruits and vegetables available for sale at school (Gosliner, 2014). Only 15% of students reported eating

vegetables at school, and only 26% reported eating fruit at school (Gosliner, 2014). All 31 schools offered at least 1 fruit, 35% of schools had a salad bar, and 30 schools offered at least 1 vegetable (Gosliner, 2014). A lunch period of 34 minutes or longer was significantly positively associated with increased fruit and vegetable consumption (P = 0.024) (Gosliner, 2014). Visually appealing fruit was associated with a 1.44 odds ratio of increased fruit consumption, while a salad bar was associated with a 1.48 odds ratio of increased vegetable consumption (Gosliner, 2014). Vegetable consumption was 56% higher among students in schools serving snack foods with meals than among students in schools not serving snack foods with meals (Gosliner, 2014). Additionally, interactions with school foodservice staff increased vegetable, but not fruit, consumption (Gosliner, 2014).

Assessment of plate waste from 317 Colorado high school students participating in the NSLP indicated that 29% of selected vegetables were discarded, and vegetables were selected least often (by only 20% of students), whereas only 12% of selected entrees, 26% of total fruit, 27% of canned fruit, 22% of fresh fruit, and 16% of milk were wasted (Haas et al., 2014). A perception survey administered to 127 students indicated that students slightly disagreed with or were neutral toward a statement that NSLP lunches were healthy, had variety, tasted good, and were satisfying (Haas et al., 2014). Additionally, students reported throwing away one-fourth of their food because it did not taste good (Haas et al., 2014). Students reported that the nutritional content of foods was not important, and boys were more likely (P = 0.05) than girls to report that their lunches did not make them feel full (Haas et al., 2014).

Selection and plate-waste data of 1890 students in 2 elementary schools in Atlanta, Georgia, were collected for 5 consecutive days during fall 2010 (Johnson et al., 2015). Entree offerings similar to those in fast-food restaurants (such as corn dogs, hamburgers, and pizza)

were selected (61.2% and 38.8% in each of the 2 schools) and consumed (43.9% and 56.1% of students ate half of the entree, while 66.8% and 33.2% ate most or all of the entree in each of the 2 schools) in the greatest amounts. However, fruits and vegetables were selected in the smallest amounts (between 0.2 and 0.36 serving per student), with 44% to 51% of students consuming little or none of their fruits and vegetables (Johnson et al., 2015).

Digital photography plate-waste data from 1418 NSLP trays from a convenience sample of 2 urban Texas middle schools were collected for 5 or 6 noncontiguous days during 2010–2011 (Connors et al., 2015). Meat- and cheese-based entrees were the most selected (by 74.3% of students) and least wasted (only 4.8% of students wasted half or more of the entree) among all NSLP offerings (Connors et al., 2015). Dark green, red, and orange vegetables and legumes were selected least (by 10.6% of students), with over half wasted 28.6% of the time for dark green, red, and orange vegetables and 71.4% of the time for legumes (Connors et al., 2015). Half or more of starchy vegetables, beans, apples, and rice were wasted more than 50% of the time (Connors et al., 2015). One-third of trays had no fruit, and canned fruit was preferentially selected (by 63.9% of students) over fresh fruit (Connors et al., 2015).

A fall 2010 analysis of food choice, plate waste, and nutrient intake of 535 elementary and 364 middle school students in northern Colorado eating school lunch indicated that 45% of elementary students and 34% of middle school students selected a vegetable (Smith et al., 2014). Elementary students wasted one-third of vegetable, fruit, and grain items. Middle-school students wasted half of their fresh fruit and one-third of their selected vegetables. Students in 4th and 5th grades wasted one-third to one-half less than students in 1st and 2nd grades. Girls wasted more than boys, and half of the students were not meeting the school lunch recommendations for

vitamin A, vitamin C, or iron (Smith et al., 2014). However, students did not exceed recommended intakes for percentage of energy from total and saturated fats (Smith et al., 2014).

Fruit and vegetable selection was studied at an elementary school in the Northeast with a self-service salad bar (284 tray observations) and was compared with selection in a control school without a self-service salad bar (271 tray observations) (Amin et al., 2014). Students with access to self-serve salad bars did not increase their fruit and vegetable selection but instead selected, on average, 81 g more processed fruits and vegetables than whole fruits and vegetables (Amin et al., 2014). Whole fruit and vegetable selections from students at the school without the salad bar were most often steamed vegetables (15% of students), fruit cup (12% of students), and vegetables served with dip (8% of students), though selection of processed fruits and vegetables remained high (Amin et al., 2014).

Improved food-consumption-related behaviors

A modified OVS program, Active Choice, was evaluated between December 2011 and January 2012 at elementary and middle schools of low socioeconomic status in Wichita, Kansas (2064 tray observations) (Hakim et al., 2013). Active Choice allowed students to select up to 2 vegetables of their choice, rather than only 1, as allowed prior to the intervention (Hakim et al., 2013). Fifteen percent more fruits and vegetables were consumed during the Active Choice intervention, without an increase in food waste (Hakim et al., 2013).

Allowing students additional vegetables vs limiting choice to 1 (control) was evaluated in 6 control (614 students) and 6 intervention (535 students) schools in Houston, Texas, during fall 2011 (Cullen et al., 2015b). All schools followed the same menu, while intervention schools also posted menus outside of the lunchroom. Students at the intervention schools selected and

consumed significantly more ($0.001 < P < 0.05$) vegetables, fruit, legumes, and protein foods than those at the control schools (Cullen et al., 2015b).

A “smarter lunchroom makeover” in 2 New York high schools (3762 tray observations over 12 days) employing changes to make healthy foods appear more “convenient, attractive, and normative” was evaluated during spring 2011 (Hanks et al., 2013). Altering the food environment led to an increase in selection of fruits and vegetables by 13.4% and 23%, respectively, as well as increased consumption of fruits and vegetables by 18% and 25%, respectively. There was no impact on selection or consumption of starchy vegetables (Hanks et al., 2013).

The effect of increasing fruit and vegetable portion size from 5 to 8 oz was evaluated in 1 elementary school (643–758 students) in Richfield, Minnesota, during 2 intervention days in spring 2011 (Miller et al., 2015). Students selecting the larger portion size of oranges, applesauce, and carrots consumed more (55% on control days vs 73% on intervention days) but also wasted 18% more applesauce and twice as many oranges (Miller et al., 2015). Increased waste of oranges was attributed to increased selection on intervention days (about 50%) compared with control days (35%), and waste per student on both control and intervention days was 67%.36 Increasing the portion size was only effective at increasing consumption for the few students who routinely selected fruits and vegetables (Miller et al., 2015).

The acceptability of lower-calorie reformulated flavored milk among elementary school students in 117 schools from 31 districts across the country was evaluated indirectly by number of milk shipments and NSLP participation rates during SY 2008–2009 and SY 2009–2010 (Yon et al., 2014). Participation in NSLP dropped 2.7% when reformulated milk was initially offered but recovered after 4 to 6 months (Yon et al., 2014).

Chefs Move to Schools programs in upstate New York (spring 2012) reformulated pizza and burger entrees to include whole grains, low-fat cheese, and more vegetables, including fresh fruit and vegetable sides, and provided educational events and taste tests for students (Just et al., 2014). Selection of reformulated items increased compared with selection of previous entrees (91.3% vs 97%), with no change in consumption or plate waste. Furthermore, there was a decrease in selection of fruit and an increase in selection of vegetables, with a 16.5% increase in vegetable consumption (Just et al., 2014).

Neutral findings

Point-of-service data (NSLP meals purchased and fruit and vegetable servings selected were recorded electronically at the register) were collected at 6 intervention and 2 control elementary schools in Houston, Texas, between January and May 2012 (Dave et al., 2015). At intervention schools, students' selection of fruits and vegetables was promoted via verbal and visual cues from cafeteria staff, schoolwide announcements about lunch offerings, and letters sent to parents (Dave et al., 2015). No significant difference in fruit and vegetable selection between control and intervention schools was observed (Dave et al., 2015).

Worsening food-consumption-related behaviors

During SY 2011–2012, 11 Oregon elementary schools participated in a study to investigate the outcome of banning flavored milk from school cafeterias (Hanks et al., 2014). Eliminating flavored milk resulted in a 9.9% decline in milk sales, with a 29.4% increase in waste of unflavored milk purchases as well as a 6.8% decrease in NSLP participation rates (Hanks et al., 2014). In contrast to the study describing acceptance of reformulated milk by students across the country, students in Oregon did not adapt to changes, as demonstrated by

depressed sales, increased waste, and no rebound of participation rates after a full school year (Hanks et al., 2014).

Evaluations of HHFKA

One-time observation studies

During SY 2010–2011 and SY 2011–2012, 600 000 lunch menus and related food-production records from 61 elementary schools in 39 districts from 5 states (Arkansas, Iowa, New York, Texas, Washington) were compared with HHFKA standards (Echon, 2014). Fifty-seven percent of meals did not meet minimum requirements for servings of fruits, 84% of meals did not meet minimum requirements for servings of vegetables, 61% of meals did not meet minimum requirements for whole grains, 45% of meals did not meet minimum requirements for meat, 19% of meals did not meet minimum requirements for milk, and only 47% of meals were in the correct range for calories (Echon, 2014).

Plate-waste data of prekindergarten and kindergarten students (304 meal observations) were collected for 5 consecutive school days at 1 elementary school in the Southwest in March 2013 (Byker et al., 2014). Students wasted 51.4% of vegetables, 51% of entrees, 33% of fruit, and 45.5% of milk (Byker et al., 2014).

Improved food-consumption-related behaviors

In fall 2012, 1030 elementary and middle school children who were served HHKFA standard meals in 4 urban low-income schools in Massachusetts increased entree consumption by 15.6% and increased vegetable consumption by 16.2%, with no change in entree or vegetable selection (Cohen et al., 2014). Students also selected 23% more fruits, with no change in fruit consumption. Fruit and vegetable waste did not increase after policy implementation; however,

students selected 24.7% less milk and wasted 10.1% more milk after policy changes (Cohen et al., 2014).

Consumption and plate-waste data were collected annually from 12 low-income middle school districts in New Haven, Connecticut, before (502 observations in 2012) and after (465 and 373 observations in 2013 and 2014, respectively) HHFKA implementation (Schwartz et al., 2015). After HHFKA implementation, there was a significant increase in selection of fruits (from 54% to 66%), without an increase in plate waste. Additionally, selection of fruits increased by 9% with each additional type of fruit offered (Schwartz et al., 2015). A decrease in selection of vegetables (from 68% to 52%), along with a 20% increase in vegetable consumption, and an increase in consumption (from 71% to 84%) of entree items were observed (Schwartz et al., 2015).

Lunch selection and consumption data were collected in 8 southeast Texas elementary schools before (472 observations in spring 2011) and after (573 observations in spring 2013) HHFKA implementation (Cullen et al., 2015a). After HHFKA implementation, students increased their selection of calories from 100% fruit juice (16.4%), fruit (17.8%), and vegetables (11.7%), while selecting fewer calories from starchy vegetables (-8.2%) (Cullen et al., 2015a). Students who selected these items consumed 0.03 cups more 100% fruit juice, 0.06 cups more fruit, 0.08 cups more dark green vegetables, and 0.09 cups more red/orange vegetables. Calories from select whole grains, milk, and protein foods increased by 67.3%, 3%, and 3%, respectively (Cullen et al., 2015a). Only plate waste of legumes increased (Cullen et al., 2015).

Nutritional quality of foods offered to and selected by students (1 741 630 school meals in Washington state) at 3 middle and 3 high schools were collected daily from January 2011 to January 2014 (Johnson et al., 2016). A mean adequacy ratio was assessed for calcium, vitamin C,

vitamin A, iron, fiber, and protein content of meals selected by students. After HHFKA implementation, students selected foods that were more nutrient dense (from 58.7 to 75.6 of the mean adequacy ratio) and less energy dense (from 1.65 to 1.44 energy density) (Johnson et al., 2016). Additionally, HHFKA implementation did not alter NSLP participation rates (Johnson et al., 2016).

Worsening food-consumption-related behaviors

Selection, consumption, and waste of fruit and vegetables were measured in 2 cohorts (spring 2012 and spring 2013) of 3rd through 5th graders in 2 elementary schools in the Northeast (1442 tray observations) before and after HHFKA implementation (Amin et al., 2015). Selection of fruit and vegetables increased by 0.2 cups, waste increased by 0.14 cups, and consumption decreased by 0.06 cups per student (Amin et al., 2015).

Overall Summary of Results

Worsening food-consumption-related behaviors during the pre-HHFKA implementation period included decreased milk purchasing and selection, with increased waste of milk, as well as increased waste of fruits and vegetables. Worsening food-consumption-related behaviors during the HHFKA period included decreased selection of vegetables and milk, along with decreased consumption and increased waste of fruits, vegetables, and milk. The majority of one-time observation studies demonstrated that schools were not meeting or exceeding target nutrition standards. According to these studies, it appears that schools were more successful at improving students' selection and consumption of entree items and milk rather than students' selection and consumption of fruits and vegetables; however, fruits were more likely to be selected and consumed than vegetables.

Discussion

The HHFKA policy changes were implemented merely 3 to 4 years ago, in SY 2012–2013, with amendments added during subsequent years. As a result, there is only a modest body of research on the impact of HHFKA on food-consumption-related behaviors of students. Hence, this review is a summary of the early findings from current school lunch policy. It is likely that a number of articles are in the submission and/or publication process. Surprisingly, there were no intervention studies conducted during the HHFKA implementation period, and only 1 longitudinal observation study was conducted during the school wellness policy period. Furthermore, only 1 of the one-time observation studies was conducted during the HHFKA implementation period, and only 1 study compared food-consumption-related behaviors of students with the 2009 Institute of Medicine recommendations.

Pre-HHFKA nutrient intake studies comparing the nutritional quality of school lunches with that of lunches brought from home have consistently concluded that participation in school lunch improved student nutritional outcomes (Bergman et al., 2014; Caruso et al., 2015; Hubbard et al., 2014; Ishdorj et al., 2013; Johnston et al., 2012). This systematic review confirms and expands the evidence that school lunch has a positive effect on nutrient intake, with HHFKA likely increasing the nutrient content of school lunches over that of lunches brought from home.

Not only are school lunches more nutritious, they are also likely more cost effective. Pre-HHFKA lunches brought from home cost $0.17 more ($1.93 vs $1.76) than NSLP lunches, according to 1 cost-analysis study (Caruso et al., 2015). Furthermore, lunches brought from home at lower income schools cost more ($1.94) than lunches brought from home at middle-income schools ($1.63).8 Cost analysis is particularly important to the discussion of community eligibility, with current provisions allowing free lunches to all students when at least 40% of

students in a district qualify for free or reduced-price lunches (USDA, 2015a). Thus, low-income students and their families are likely to benefit the most from school lunch, both nutritionally and financially.

Participation in school meal programs has been shown to mediate the double burden of malnutrition (obesity and nutrient deficiency caused by an energy dense, nutrient-poor diet) in low-income communities. The NSLP improved household income and food security in households with prekindergarten-aged children (Arteaga et al., 2014), decreased risk of overweight for food-insecure girls (Jones et al., 2003), and decreased food insufficiency of low-income students during the school year (Huang et al., 2015). The US School Breakfast Program alleviated marginal food insecurity in low-income households with elementary school children (Bartfeld et al., 2011) and decreased breakfast skipping among food-insecure Vermont middle schoolers (Khan et al., 2011). The HHFKA has achieved a maintenance of total participation rates and increased participation by low-income groups, likely furthering improvements in food security.

Waste remains a substantial problem, yet there are no guidelines on an acceptable amount of waste, and studies often report a change in waste rather than an absolute value. The development and evaluation of creative approaches to minimizing waste remains an area for future research.

The success of 14 of 19 interventions and longitudinal observation studies demonstrates that focused efforts to meet legislative guidelines can improve food-consumption-related behaviors of students. However, the overwhelming failure of 10 of 12 one-time observation studies to meet school nutrition target standards likely highlights district-specific challenges of and resistance against implementation of the HHFKA policy changes.

Risk of bias of individual studies (Table 2) may impact the interpretation of results. For example, data analyzed by Amin et al (Amin et al., 2015) were collected for use in a larger study to validate a digital imaging tool for assessment of dietary intake. As such, on each data collection day, selection and waste were not matched on a per-tray basis; rather, an aggregate mean for all selection and all waste was calculated (Amin et al., 2015). Though the authors accounted for trays without any fruits or vegetables, they did not account for trays in which students selected additional fruits and vegetables (Amin et al., 2015). Furthermore, Byker et al (Byker et al., 2014) collected data from prekindergarten and kindergarten students, an age group that wastes more food than their older peers (Byker et al., 2014). Additionally, waste may have been artificially elevated because data were collected months after HHFKA implementation, which did not allow for an adaptation period (Byker et al., 2014). Finally, studies reporting significant improvements in nutrient intake (e.g., (Cullen et al., 2015a)) may not have biological relevance. It is doubtful that an increase in fruit and vegetable serving size by less than one-fourth of a cup can have any impact on obesity or health outcomes, even though statistical significance was achieved (Cullen et al., 2015a).

Several studies either not meeting eligibility criteria or not captured using the search terms of this systematic review also support targeting the school lunch environment to alter food-consumption-related behaviors of students. Wansink et al (Wansink et al., 2012) reported that naming cafeteria menu items increased selection and consumption of healthy foods, substituting energy-dense concession stand items with healthful alternatives did not negatively impact student satisfaction (Laroche et al., 2015), increasing bowl size resulted in students requesting more food but also consuming and wasting more food (Wansink et al., 2014), and pre-slicing increased selection and consumption of fruit among elementary school students (Wansink et al.,

2013). Furthermore, Olsen et al (Olsen et al., 2012) demonstrated that cutting vegetables into star shapes increased preference and consumption among 9- to 12-year-old children. Students liked vegetables cut in slices and sticks only slightly less than they liked vegetables cut in shapes (Olsen et al., 2012). Finally, Privitera and Creary (Privitera et al., 2013) reported that setting a bowl of fruit on the kitchen counter increased college students' consumption of fruit while decreasing their consumption of energy-dense snack alternatives. Thus, creative approaches that could be applied to NSLP have additional potential to improve food-consumption-related behaviors.

Finally, the reviewed studies suggested that providing students with more fruits and vegetables and requiring them to take 1 fruit or vegetable increased their selection of these items. This is consistent with the findings of Wansink and Hanks (Wansink et al., 2013), who reported that improving access to healthy foods and/or altering the food environment results in positive dietary changes in adults.

Limitation of Individual Studies

Small sample sizes, convenience sampling, short intervention periods, variations in income eligibility or demographic makeup of the study populations, lack of randomized controlled trials, and differences in the food culture and location of intervention sites are typical limitations of studies evaluating federal nutrition programs. Most significantly, HHFKA policy changes are likely too recent to affect the stated target to reduce childhood obesity. Thus, there is potential bias in the findings from early studies. This is problematic for improving school lunch policy, as research publications inherently lag behind policy reauthorization and amendments.

Conclusion

Schools have been largely successful at implementing school lunch interventions and policy changes. More fruits and vegetables, whole grains, fat-free and low-fat milk, and lower-fat entrees are available to students than in previous decades. Participation in the NSLP has decreased modestly since implementation of current policy, related closely to improving economic conditions. Furthermore, HHFKA standards increased the number of students eligible for free or reduced-price meals. Interventions have generally demonstrated increased selection and consumption of items meeting federally mandated nutrition standards. Nationally, it is likely that plate waste has remained stable, suggesting that students are equally as likely to accept foods offered under HHFKA as they are to accept previous menu options. Though students initially resist nutrition changes, they appear to adapt well over time (Turner et al., 2014). Future policy should consider the potential beneficial outcomes of community partnerships to improve the nutritional quality of NSLP meals, as parents have a significant influence on whether their student participates in the NSLP (Ohri-Vachaspati, 2014). Policymakers should also consider revising HHFKA to include nutrition education in the curriculum for grades K–12 in an attempt to establish and reinforce healthy eating habits. Engagement, preparation, and marketing techniques show promise for changing the food-consumption-related behaviors and related health outcomes of students.

The findings of this review have several implications. First, the identification of district-specific barriers related to food culture, communication, and local policies and the development of approaches to overcome these barriers would be useful. Second, as nutrition standards change, food manufacturers and suppliers have the opportunity to meet the needs of their customers. Anecdotal reports of low-quality whole-grain products, reduced-fat items, and sugar substitutes

provide an opportunity for the food industry to develop new products and new markets. Third, only a moderate amount of literature supports environmental modifications to make the healthy food choice the easy choice. Research is needed to determine whether applying food environment principles across different food cultures can improve food-consumption-related behaviors. Finally, since a key endpoint of HHKFA is body mass index and a reduction in childhood obesity, long-term studies must be carried out in multiple environments to determine best practices and key variables influencing body mass index and obesity prevention.

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Table 1: National School Lunch Meal Pattern under School Wellness Policy (until 2012) and Current HHFKA Policy

National School Lunch Program Meal Standards				
Food Group	School Wellness Policy	HHFKA Requirements		
Fruits and Vegetables	½ - ¾ cup of fruit and vegetable combined per day	¾ - 1 cup vegetables plus ½ - 1 cup of fruit per day Students are allowed to select ½ cup fruit or vegetable under OVS.		
Vegetables	No specification as to type of vegetable subgroup	Weekly requirements for: dark green, red/orange, beans/peas (legumes), starchy, other		
Meat/ Meat Alternative	1.5 – 2 oz eq. (daily minimum)	Daily minimum and weekly ranges: Grades K-5: 1 oz eq. min. daily (8-10 oz weekly) Grades 6-8: 1 oz eq. min. daily (9-10 oz weekly) Grades 9-12: 2 oz eq. min. daily (10-12 oz weekly)		
Grains	8 servings per week (minimum of 1 serving per day)	Daily minimum and weekly ranges: Grades K-5: 1 oz eq. min. daily (8-9 oz weekly) Grades 6-8: 1 oz eq. min. daily (8-10 oz weekly) Grades 9-12: 2 oz eq. min. daily (10-12 oz weekly)		
Whole Grains	Encouraged	At least half of the grains must be whole grain-rich		
Milk	1 cup Variety of fat contents allowed; flavor not restricted	1 cup Must be fat-free (unflavored/ flavored) or 1% low fat (unflavored)		
Calories	Minimums only Traditional menu planning: 633 (grades K-3) 785 (grades 4-12) 825 (optional grades 7-12) Enhanced menu planning: 664 (grades K-6) 825 (grades 7-12) 633 (optional grades K-3) Nutrient based menu planning: 664 (grades K-6) 825 (grades 7-12) 633 (optional grades K-3)	Minimums and maximums Only food-based menu planning allowed 550-650 (grades K-5) 600-700 (grades 6-8) 750-850 (grades 9-12)		
Sodium	Reduce, no set targets	Target 1: SY 2014-15 ≤1230mg (K-5) ≤1360mg (6-8) ≤1420mg (9-12)	Target 1: SY 2017-18 ≤935mg (K-5) ≤1035mg (6-8) ≤1080mg (9-12)	Target 1: SY 2022-23 ≤640mg (K-5) ≤710mg (6-8) ≤740mg (9-12)
Saturated Fat	<10% of total calories	<10% of total calories		
Trans Fat	No limit	Zero grams per serving (nutrition label)		

Modified from the USDA Comparison of Previous and Current Regulatory Requirements under Final Rule “Nutrition Standards in the National School Lunch and School Breakfast Programs,” January 26, 2012. OVS (Offer Versus Serve) requires students to take three of five meal components, one of which must be either a fruit or vegetable.

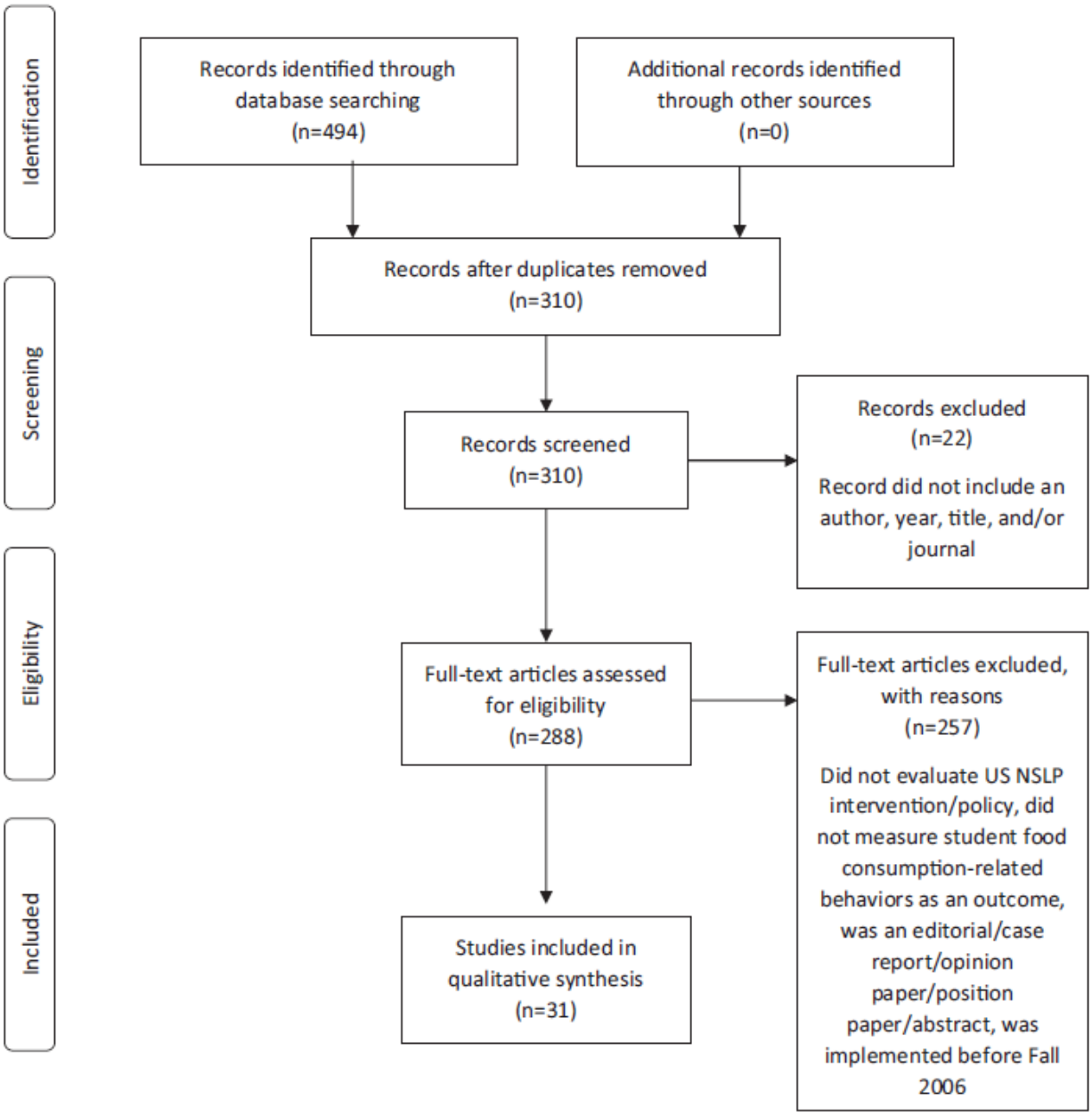

Figure 1: Flow diagram of the literature search process.

Table 2: Risk of Bias of Individual Studies

Reference	Were control and intervention groups evenly allocated?	Was there selection bias by use of a convenience sample?	Were outcome measures derived from the hypothesis, or were analyzed data part of another study design?	Are food consumption-related behaviors changes attributable to age of the population and/or inadequate adaptation period?	Was there suggestive or selective reporting of results?	Potential bias due to funding source?	Risk of bias rating (low, medium, or high risk)
Amin et al. (2014)	N/A (observational data from two elementary schools)	No	This study was part of a larger digital dietary intake assessment tool validation study; outcome measures reflect the larger study design, not the outcome measures indicated in the current study	No	Yes; statistical significance and analysis was reported using not yet validated dietary assessment tools	Unknown: funding source not stated	Medium
Amin et al. (2015)	N/A (observational data collected before and after policy changes)	No	This study was part of a larger digital dietary intake assessment tool validation study; outcome measures reflect the larger study design, not the outcome measures indicated in the current study	No	Yes; statistical significance was reported using a not yet validated dietary assessment tool	Possibly: USDA; Vermont Agricultural Experiment Station; University of Vermont Bickford Scholar Research Fund	Medium
Byker et al. (2014)	N/A (observational data from pre-K and kindergarten students at one elementary school)	No	Outcome measures were derived from the hypothesis	Yes; pre-kindergarten and kindergarten students reportedly waste more food than their older peers and there was not an adequate adaptation period.	Yes; statistical significance not indicated	Unknown: funding source not stated	Medium

Table 2 continued

Cohen et al. (2012)	Yes (two control and two intervention schools, matched for race, ethnicity, and percent of students free/reduced price lunches)	No	Outcome measures were derived from the hypothesis	No	No	No: Project Bread, Boston, MA	Low
Cohen et al. (2013)	Yes (two control and two intervention schools, matched for race, ethnicity, and percent of students free/reduced price lunches)	No	This study uses data from a Boston Chef Initiative pilot study [23]	No	No	No: Nutritional Epidemiology of Cancer Education and Career Development Program	Low
Cohen et al. (2014)	N/A (observational data collected before and after policy changes)	No	Outcome measures were derived from the hypothesis	Yes, data was collected the semester of policy implementation	No	Unknown: funding source not stated	Low
Connors et al. (2015)	N/A (plate waste study of students at two urban middle schools)	Yes	Outcome measures were derived from the hypothesis	No	Yes; statistical significance not indicated	Possibly: USDA ERS; FNS Research Programs; Research Planning Grants to Support Application of Behavioral Economics in USDA Child Nutrition Programs; University of North Texas Undergraduate Research Initiative	Medium

Table 2 continued

Cullen et al. (2011)	N/A (lunch food records from four SE Texas middle schools)	No	Outcome measures were derived from the hypothesis	No	No	Possibly: USDA/ARS	Low
Cullen et al. (2015)	Yes (twelve schools matched and randomly assigned to control or intervention)	No	Outcome measures were derived from the hypothesis	No	No	No: NIH	Low
Cullen et al. (2015)	N/A (observational data from 8 elementary schools before and after policy changes)	No	Outcome measures were derived from the hypothesis	No	No	Possibly: National Institutes of Health; USDA/ARS	Low
Dave et al. (2015)	No; six intervention and two control schools	No	Outcome measures were derived from the hypothesis	No	No	Possibly: USDA ERS	Medium
Echon et al. (2014)	N/A (food production records of 61 elementary schools)	No	Outcome measures were derived from the hypothesis	No	Yes; statistical significance not indicated	Possibly: USDA	Medium
Eckart et al. (2010)	N/A (schools served as own control)	Yes	Outcome measures were derived from the hypothesis	Possibly; the intervention lasted for only four weeks, and only one day each week	Yes; statistical significance was not indicated	Unknown: funding source not stated	Medium

Table 2 continued

Fiori et al. (2011)	N/A (surveys and observational data)	Yes	Outcome measures were derived from the hypothesis	No	Yes; surveys assessed entrée preferences, but only pizza is discussed in depth, and chicken strips and yogurt parfait are discussed superficially	No: Network for a Healthy California and by California State University, Chico	Medium
Goggans et al. (2011)	Yes (intervention school implemented OVS, control school did not)	No	Outcome measures were derived from the hypothesis	No	No	Unknown: funding source not stated	Low
Gosliner et al. (2014)	N/A (cross-sectional study of students from 31 schools in California)	No	Outcome measures were derived from the hypothesis	No	No	Possibly: The California Endowment and Kaiser Permanente	Low
Haas et al. (2014)	N/A (observational and survey data from two high schools)	No	Outcome measures were derived from the hypothesis	No	No	No: Coalition for Activity and Nutrition to Defeat Obesity	Low
Hakim et al. (2013)	N/A (observational data from one school; pre- and post-intervention design; students served as their own controls)	No	Outcome measures were derived from the hypothesis	Possibly. there was only one month between pre- and post-intervention observations	No	Unknown: funding source not stated	Low

Table 2 continued

Hanks et al. (2013)	N/A (before and after study design in two high schools)	No	Outcome measures were derived from the hypothesis	Yes; the intervention only lasted one month, not allowing for an adequate adaptation period or accounting for changes over time	Yes; the study design stated that food waste was measured, but no results for this outcome are presented	Possibly: USDA	Medium
Hanks et al. (2014)	N/A (observational data from a before/after study design)	No	Outcome measures were derived from the hypothesis	No	No	Possibly: USDA ERS; FNS and USDA NIFA/Hatch	Low
Johnson et al. (2015)	N/A (observational study of a Title 1 and non-Title 1 school)	No	Outcome measures were derived from the hypothesis	No	No	Unknown: funding source not stated	Low
Johnson et al. (2016)	N/A (observational data from 3 middle and 3 high schools before and after policy changes)	No	Outcome measures were derived from the hypothesis	No	No	No: US Department of Health and Human Services; Robert Wood Johnson Foundation	Low
Just et al. (2014)	N/A (before and after study design in one high school)	No	Outcome measures were derived from the hypothesis	Yes; the intervention lasted only one day	No	No: Cornell BEN Center, USDA Economic Research service	Low
Miller et al. (2015)	N/A (before and after study design in one elementary school)	No	Outcome measures were derived from the hypothesis	No	No	Possibly: ERS of the USDA, Minnesota Agricultural Experiment Station	Low

Table 2 continued

Mobley et al. (2012)	Yes (21 control and 21 intervention schools)	No	Outcome measures were derived from the hypothesis	No	No	No: NIDDK/NIH; STOPP-T2D collaborative group	Low
Robinson-O'Brien et al. (2010)	N/A (24hDR of 103 4-6th grade students)	Yes	Data used in this study were part of an evaluation of the Ready. Set. ACTION! (RSA) program [66]	No	No	No: National Institute of Diabetes and Digestive and Kidney Diseases; National Institutes of Health; CDC	Medium
Schwartz et al. (2015)	N/A (observational data from 12 middle schools before and after policy changes)	No	Outcome measures were derived from the hypothesis	No	No	No: National Institute of Child and Human Development; Robert Wood Johnson Foundation	Low
Smith et al. (2014)	N/A (plate waste data from 185 randomly selected students at each of three elementary and two secondary schools)	No	Outcome measures were derived from the hypothesis	No	No	No: The Coalition for Activity and Nutrition to Defeat Obesity (CanDo) of Fort Collins, Colorado	Low
Snelling et al. (2007)	N/A (sales data from three high schools)	No	Outcome measures were derived from the hypothesis	No	Yes; statistical significance not indicated	Unknown: funding source not stated	Low

Table 2 continued

Williamson et al. (2013)	Yes (Wise Mind: 2 control, 2 intervention schools; LA Health: 17 schools randomly assigned to 1 of 3 prevention arms)	No	Data used in this study were from the Wise Mind[67] and LA Health[68] studies	No	No	Possibly: NIH; USDA; NIDDK	Medium
Yon et al. (2014)	N/A (observational data of 17 schools changing milk offerings)	No	Outcome measures were derived from the hypothesis	No	No	Possibly: USDA Vermont Agricultural Experiment Station; Dairy Research Institute	Low

Risk of bias of individual studies was assessed using criteria modified from the Cochrane Collaboration's Tool for Assessing Risk of Bias in Randomized Control Trials.

Table 3: Intervention, Longitudinal Observation, and One-time Observation Studies Measuring School Lunch Food Consumption-Related Behavior Outcomes in U.S. School-Age Children

Outcome Measure			Food/Nutrient								
		Policy Period	Entrée	Fruit	Vegetable	Milk	Grains	Desserts, Sides, & Snacks	Energy (kcal)	Macro-nutrients	Vitamins & Minerals
	Purchasing Patterns	SWP	1 2	1	1	1	1	1			
		Pre-HHFKA		3	3	4 5 3	3		3	3	
		HHFKA									
	Selection	SWP	6 7 8	6 9 7 8	6 9 7 8	7 8	7 8	7 8	9 7 10	9 7 10	9
		Pre-HHFKA	11 12 13 14 15	11 12 13 14 16 17 18 19 15 20	11 12 13 14 16 17 18 19 15 20	11 13 14 17 15 5	13 17	12 15	17	17	
		HHFKA	21 22 23	21 22 23 24 25	21 22 23 24 25	21 22 23 24	24		24 26	24 26	26
	Consumption/ Intake	SWP	8 27	28 9 8 27 29	28 9 8 27 29	9 8 27	9 8	8	10 27	10 27	27
		Pre-HHFKA	12 15	30 12 31 17 18 19 15	30 12 31 17 18 19 15	17 15	17	12 15	14 17	14 17	14
		HHFKA	22 23	22 23 24 25	22 23 24 25	22 23 24	24		24	24	
	Waste	SWP	27	27 29	27 29	27					
		Pre-HHFKA	11 13 14	11 13 14 31 19	11 13 14 31 19	11 13 14 5	13 14				
		HHFKA	21	21 25	21 25	21					

Studies measuring purchasing patterns, selection, consumption/intake, and waste of entrées, fruits, vegetables, milk, whole grain and grain products, desserts/sides/snacks, energy (kcal), macronutrients, and vitamins and minerals during the School Wellness Policy

period (SWP) (Fall 2006-December 2009), the pre-HHFKA implementation period (2010-2012), and HHFKA evaluation studies. Intervention studies are highlighted in grey, longitudinal observation studies are highlighted in blue, and one-time observation studies are highlighted in purple.

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2. Eckart J, Strong KA, Moppert DK, Barnard ND. Students' willingness to purchase vegan menu items in the national school lunch program. Florida Public Health Review. 2010;7:64-69.

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25. Amin S, Yon B, Taylor J, Johnson R. Impact of the National School Lunch Program on Fruit and Vegetable Selection in Northeastern Elementary Schoolchildren, 2012-2013. Public Health Reports. 2015;130(September-October 2015):453-457.

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Table 4: Intervention Studies Demonstrating Improvement or No Change in School Lunch Food Consumption-Related Behaviors

			Food/Nutrient								
		Policy Period	Entrée	Fruit	Vegetable	Milk	Grains	Desserts, Sides, & Snacks	Energy (kcal)	Macro-nutrients	Vitamins & Minerals
Outcome Measure	Selection	SWP	1 2	1 2	1 2	1 2	1 2	1 2	1 3	1 3	
		Pre-HHFKA		4 5	4 5	4	4		4	4	
		HHFKA									
	Consumption/ Intake	SWP	2 6	2 6 7	2 6 7	2 6	2	2	3 6	3 6	6
		Pre-HHFKA		4	4	4	4		4	4	
		HHFKA									
	Waste	SWP	6	6 7	6 7	6					
		Pre-HHFKA									
		HHFKA									

Studies measuring selection, consumption/intake, and waste of entrées, fruits, vegetables, milk, whole grain and grain products, desserts/sides/snacks, energy (kcal), macronutrients, and vitamins and minerals during the School Wellness Policy period (SWP) (Fall 2006-December 2009), the pre-HHFKA implementation period (2010-2012), and HHFKA evaluation studies. Improvement (bringing foods/nutrients closer to school lunch nutrition standards or decreasing waste) is highlighted in green, and no change is highlighted in yellow. No studies reported a worsening of measured outcome. Purchasing patterns, whole grain, desserts/sides/snacks, energy, macronutrient, and vitamin/mineral waste, and selection of vitamins/minerals were not measured in any intervention studies.

1. Mobley CC, Stadler DD, Staten MA, et al. Effect of nutrition changes on foods selected by students in a middle school-based diabetes prevention intervention program: the HEALTHY experience. Journal of School Health. 2012;82:82-90.

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4. Cullen KW, Chen TA, Dave JM, Jensen H. Differential Improvements in Student Fruit and Vegetable Selection and Consumption in Response to the New National School Lunch Program Regulations: A Pilot Study. Journal of the Academy of Nutrition and Dietetics. 2015.

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6. Cohen JF, Richardson S, Austin SB, Economos CD, Rimm EB. School lunch waste among middle school students: nutrients consumed and costs. American Journal of Preventive Medicine. 2013;44(2):114-121.

7. Goggans MH, Lambert L, Chang YH. Offer versus serve or serve only: does service method affect elementary children's fruit and vegetable consumption? Journal of Child Nutrition and Management. 2011;35(2).

Table 5: Longitudinal Observation Studies Demonstrating Improvement, Worsening, or No Change in School Lunch Food Consumption-Related Behaviors

			Food/Nutrient								
		Policy Period	Entrée	Fruit	Vegetable	Milk	Grains	Desserts, Sides, & Snacks	Energy (kcal)	Macro-nutrients	Vitamins & Minerals
Outcome Measure	Purchasing Patterns	SWP	1								
		Pre-HHFKA				2 3					
		HHFKA									
	Selection	SWP									
		Pre-HHFKA	4	5 6 4	5 6 4	4 3		4			
		HHFKA	7 8	7 8 9 10	7 8 9 10	7 8 9	9		9 11	9 11	11
	Consumption/ Intake	SWP									
		Pre-HHFKA	4	12 5 6 4	12 5 6 4	4		4			
		HHFKA	7 8	7 8 9 10	7 8 9 10	7 8 9	9		9	9	
	Waste	SWP									
		Pre-HHFKA		12 6	12 6	3					
		HHFKA		10	10						

Studies measuring purchasing patterns, selection, consumption/intake, and waste of entrées, fruits, vegetables, milk, whole grain and grain products, desserts/sides/snacks, energy (kcal), macronutrients, and vitamins and minerals during the School Wellness Policy period (SWP) (Fall 2006-December 2009), the pre-HHFKA implementation period (2010-2012), and HHFKA evaluation studies. Improvement (bringing foods/nutrients closer to school lunch nutrition standards or decreasing waste) is highlighted in green, a worsening of the outcome is highlighted in red and no change is highlighted in yellow for longitudinal observation study designs. Fruit, vegetable, grain, desserts/sides/snacks, energy, macronutrient, and vitamin/mineral purchasing patterns, vitamin/mineral intake,

and entrée, grain, desserts/sides/snacks, energy, macronutrient, and vitamin/mineral waste were not measured for any longitudinal observation studies.

1. Eckart J, Strong KA, Moppert DK, Barnard ND. Students' willingness to purchase vegan menu items in the national school lunch program. Florida Public Health Review. 2010;7:64-69.

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7. Cohen JF, Richardson S, Parker E, Catalano PJ, Rimm EB. Impact of the new U.S. Department of Agriculture school meal standards on food selection, consumption and waste. American Journal of Preventive Medicine. 2014;46:388-394.

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12. Hakim SM, Meissen G. Increasing Consumption of Fruits and Vegetables in the School Cafeteria: The Influence of Active Choice. Journal of Health Care for the Poor and Underserved. 2013;24(2):145-157.

Table 6: One-time Observation Studies Meeting/Exceeding or Not Meeting Student Food Consumption-Related Standards of the Previous NSLP Nutrition Standards, the 2009 IOM Recommendations, or HHFKA

			Food/Nutrient								
		Policy Period	Entrée	Fruit	Vegetable	Milk	Grains	Desserts, Sides, & Snacks	Energy (kcal)	Macro-nutrients	Vitamins & Minerals
Outcome Measure	Purchasing Patterns	SWP	(1)	(1)	(1)	(1)	(1)	(1)			
		Pre-HHFKA		[2]	[2]	[2]	[2]		[2]	[2]	
		HHFKA									
	Selection	SWP	(3)	(3) 4	(3) 4				4	4	4
		Pre-HHFKA	(5) (6) (7) [8]	(5) (6) (7) [8] [9]	(5) (6) (7) [8] [9]	(5) (7) [8]	(7)	(6)			
		HHFKA	[10]	[10]	[10]	[10]					
	Consumption/ Intake	SWP		(11) 4	(11) 4	4	4				
		Pre-HHFKA	(6)	(12) (6)	(12) (6)			(6)	[8]	[8]	[8]
		HHFKA									
	Waste	SWP									
		Pre-HHFKA	(5) (7) [8]	(5) (7) [8]	(5) (7) [8]	(5) (7) [8]	(7) [8]				
		HHFKA	[10]	[10]	[10]	[10]					

One-time observation studies comparing student food consumption-related behaviors to the previous NSLP nutrition standards are shown in **parentheses**, studies comparing student food consumption-related behaviors to the 2009 IOM Recommendations (which led to HHFKA nutrition standards, including an increase of fruit to one serving and vegetables to two servings, with 50 % wholegrain food) are **underlined**, and studies comparing student food consumption-related behaviors to HHFKA are shown in **brackets**. Three studies[30,31,40] were conducted while the previous NSLP standards were in place, but compared student food consumption-related behaviors to HHFKA standards. Outcome measures meeting or exceeding target standards are shown in green. Outcome measures not meeting target standards are shown in red. No studies measured waste of desserts/sides/snacks, energy, macronutrients, or

vitamins/minerals. Outcomes were measured during the School Wellness Policy period (SWP) (Fall 2006-December 2009), the pre-HHFKA implementation period (2010-2012), and HHFKA evaluation studies.

1. Snelling AM, Korba C, Burkey A. The national school lunch and competitive food offerings and purchasing Behaviors of high school students. Journal of School Health. 2007;77(10):701-705.

2. Echon RM. Quantitative Evaluation of HHFKA Nutrition Standards for School Lunch Servings and Patterns of Consumption. School Nutrition Association. 2014;38(1).

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7. Connors P, Bednar C. Middle school cafeteria food choice and waste prior to implementation of Healthy, Hunger-Free Kids Act changes in the National School Lunch Program. Journal of Child Nutrition and Management. 2015;39(2).

8. Smith SL, Cunningham-Sabo L. Food choice, plate waste and nutrient intake of elementary- and middle-school students participating in the US National School Lunch Program. Public Health Nutrition. 2014;17(6):1255-1263.

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10. Byker CJ, Farris AR, Marcenelle M, Davis GC, Serrano EL. Food Waste in a School Nutrition Program After Implementation of New Lunch Program Guidelines. Journal of Nutrition Education and Behavior. 2014;46(5):406-411.

11. Robinson-O'Brien R, Burgess-Champoux T, Haines J, Hannan PJ, Neumark-Sztainer D. Associations between school meals offered through the National School Lunch Program and the School Breakfast Program and fruit and vegetable intake among ethnically diverse, low-income children. Journal of School Health. 2010;80(10):487-492.

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CHAPTER 2. COLLABORATION CHALLENGES AND OPPORTUNITIES: A SURVEY OF SCHOOL FOODSERVICE DIRECTORS AND COMMUNITY HEALTH COALITION MEMBERS

This chapter is adapted from Mansfield J, Savaiano D. Collaboration Challenges and Opportunities: A Survey of School Foodservice Directors and Community Health Coalition Members. *Journal of School Health*. 2018;88(7):481-492.

Abstract

Background: The Healthy, Huger-Free Kids Act (HHFKA) presents challenges for foodservice directors (FSDs) in sourcing and preparing foods that meet nutrition standards. Concurrently, community health coalition members (CHCs) are engaging schools through community and school nutrition initiatives. We hypothesized significant differences in perceptions between FSDs and CHCs related to implementation of HHFKA such that FSDs would perceive greater foodservice challenges, while CHCs would be more supportive of community nutrition initiatives.

Methods: A perceptions survey was administered by email to 528 FSDs and 334 CHCs during summer 2016. Experience, education level, urban/rural differences, school demographics, and involvement between FSDs and CHCs were compared.

Results: Overall, 132 FSDs and 80 CHCs responded (29.5% FSDs, 24.7% CHCs). Overall perception of HHFKA foodservice challenge ranged between neutral (e.g., neither challenging nor unchallenging) to somewhat challenging, and did not differ between groups. CHCs were significantly more supportive of community nutrition initiatives, while FSDs responded neutrally.

Conclusions: FSDs awareness of CHCs desire for collaboration may increase FSDs support for broader school nutrition initiatives such as school gardens, farm to school, and student/community engagement. There is great potential for integrating student and community health programs through partnerships.

Keywords: Healthy, Hunger-Free Kids Act; community health coalitions; school foodservice; school lunch policy; community nutrition initiatives

Introduction

The National School Lunch Program (NSLP) policy requirements have been significantly updated twice in the last 2 decades. The 2004 NSLP policy, the Child Nutrition and Women, Infants and Children Reauthorization Act, mandated that all schools participating in federally reimbursable meal programs develop a local School Wellness Policy (SWP) for implementation during the 2006 to 2007 school year (USDA, 2015a). The current NSLP policy, the Healthy, Hunger-Free Kids Act of 2010 (HHFKA), "added new provisions … related to implementation, evaluation, and publicly reporting on progress of local school wellness polices" (USDA, 2015b). Nutrition changes under HHFKA included increasing fruit and vegetable serving size, serving a variety of vegetables throughout the week, requiring students to select at least either one fruit or vegetable, setting age specific calorie, whole grain, and meat/meat alternative ranges, including only 1% unflavored milk or skim unflavored/flavored milk, setting targets for sodium reduction, and eliminating trans-fat (USDA FNS, 2012). Policy changes were issued in 2010 for implementation during the 2012-2013 school year.

According to a 2009 national survey of 112 school administrators, effective implementation of SWP was reportedly related to notifying staff of policy requirements, developing a wellness task force and ‘‘administrative procedures’’ for policy implementation, and training members on implementation procedures (Budd et al., 2012). However, wellness policy promotion and evaluation activities were enforced by only 63% and 54% of respondents, respectively (Budd et al., 2012). Likewise, Harriger et al. (2014) reported inconsistencies in the SWP evaluation literature, whereby methodology varied across studies, only portions of the policy were evaluated, and interpretation and implementation of SWP evolved over time (Harriger et al., 2014). Additionally, two studies (Cox et al., 2016; Meendering et al., 2016) suggested that smaller school districts actually had better written and more comprehensive SWP, while Hager et al. (2016) suggested that implementation of SWP was more effective when there was greater perceived support for the policies (Hager et al., 2016). However, Larson et al. (2017) reported that support for SWP and related interventions were limited in suburban, urban, and especially rural schools (Larson et al., 2017). Written SWP were present at only 55% of rural schools, compared to 64% and 85% at suburban and urban schools, respectively (Larson et al., 2017). Due to programmatic challenges of implementing and evaluating SWP in unique environments across the nation, HHFKA attempted to consolidate and fortify school wellness and nutrition approaches (USDA, 2015b).

A key component of SWP is the organization of an advisory committee to develop and implement policies. This advisory committee is required to permit parents, students, representatives of school food authorities, the school board, school administers, and the public to participate (USDA, 2016). A critical stakeholder in implementation of school nutrition standards under SWP and HHFKA are school foodservice directors (FSDs). Thiagarajah et al. (2015)

surveyed Indiana FSDs during fall 2013 regarding challenges of implementing HHFKA (Thiagarajah et al., 2015). FSDs reported that challenges included low student acceptance of menu changes, food waste (especially vegetables), and increased raw food costs. However, FSDs also reported that the majority of HHFKA changes were positive, and that vendors supplied appropriate foods (Thiagarajah et al., 2015). Similarly, Asada et al. (2017) reported that the nine FSDs who successfully implemented the HealthierUS School Challenge: Smarter Lunchrooms expressed overall positive perceptions of menu changes, despite initial difficulty reformulating menu items to meet lower sodium targets, obtaining and preparing whole grain products, and managing increased plate waste (Asada et al., 2017). Possibly due to the HealthierUS School Challenge, student acceptability and consumption of fruits and vegetables increased over time (Asada et al., 2017). In contrast, Cornish et al. (2016) surveyed and interviewed FSDs in rural areas, reporting that HHFKA changes presented major challenges for reformulation of menu items, student acceptability, plate waste, and increased costs—potentially due to these schools' isolation and limited financial and technical support (Cornish et al., 2016). In addition to following federally mandated nutrition standards, FSDs are responsible for administrative tasks (e.g., direct certification and community eligibility) and coordination of additional nutrition-related programs (e.g., the summer food program and the Fresh Fruit and Vegetable Program) (111th Congress, 2010).

Whereas FSDs experience daily challenges related to NSLP policy implementation and acceptability, community health coalition members (CHCs) are intimately involved in school and community health promotion. Coalitions address community-specific needs in order to promote and maintain community wellness (Purdue Extension, 2012). Though our literature search did not yield studies describing the role of CHCs in implementation of school nutrition

programming, there is evidence that partnerships with state and local organizations and governments may result in: (1) beneficial outcomes for improving student academic, mental, and physical health (Blank, 2015), (2) combining and streamlining of resources for student education and health (Kolbe et al., 2015), (3) increasing selection of fruits and vegetables during school lunch (Thompson et al., 2017), and (4) adoption of active transportation best practices to increase physical activity of students (Macridis et al., 2015). Additionally, school collaboration with the Land Grant University Extension system has promising implications for nutrition education of students and parents (Gold et al., 2017; Song et al., 2016). Our initial interviews with CHCs indicated that coalitions view school wellness as an opportunity to promote nutrition education, school gardens, local foods, and effective/safe utilization of foods wasted during school meals. Though FSDs and CHCs both address school wellness and nutrition, their perceived feasibility of school and community nutrition programs, as well as their priorities for accomplishing public health goals (i.e., meeting federal policy requirements and/or expanding local community health promotion efforts) may vary.

News and social media outlets have consistently reported anecdotal evidence of HHFKA implementation challenges. However, since August 1, 2017, only 9 primary research articles (Amin et al., 2015; Yoder et al., 2015; Byker et al., 2014; Chapman et al., 2017; Cohen et al., 2014; Cullen et al., 2015; Johnson et al., 2016; Niaki et al., 2017; Schwartz et al., 2015) evaluating HHFKA dietary outcomes have been published. Perhaps because of the limited scientific evidence, policy proposals for HHFKA continue to be a topic of debate (114th Congress 2nd Session, 2016). Thus, perceptions of key stakeholders may more accurately predict changes to federal policy than dietary intake research outcomes (OECD, 2012).

To explore NSLP stakeholder (FSDs and CHCs) perceptions, we conducted a literature search in PubMed, Web of Science, and Science Direct, using the terms ‘‘school foodservice’’ AND ‘‘community health coalition’’ AND ‘‘perceptions.’’ To our knowledge, this study is the first to evaluate and compare FSDs and CHCs perceptions. Our purpose was to identify the differences in Indiana FSDs and CHCs perceived challenges of and opportunities for implementing school-based community nutrition programs under HHFKA. We hypothesized that Indiana FSDs would perceive more foodservice challenge while CHCs would be more supportive of community nutrition initiatives. Our secondary hypotheses were: (1) CHCs with experience in school nutrition would respond more like FSDs than CHCs without experience, (2) FSDs with a bachelor’s degree or higher would respond similarly to CHCs with a bachelor’s degree or higher, (3) CHCs who were somewhat or very familiar with HHFKA would respond more like FSDs, (4) FSDs and CHCs that agreed schools should follow federal nutrition standards to receive funding would respond similarly, as would CHCs and FSDs who did not agree, and (5) FSDs and CHCs who believed HHFKA was realistic for schools to implement would respond similarly.

Methods

Participants

Indiana FSDs and CHCs were recruited through email using email addresses obtained from the Indiana Department of Education (FSDs) and contact lists from coalition leaders identified by Purdue Extension and the Indiana Healthy Weight Initiative (CHCs). In total, 528 FSDs and 334 CHCs email addresses were obtained, with 90 email addresses (80 FSDs and 10 CHCs) rejected by the email server, leaving a remaining 772 (448 FSDs, 324 CHCs) individuals.

Overall, 212 (132 FSDs and 80 CHCs) of these 772 individuals completed the survey, a total final response rate of 27.5% (29.5% FSDs and 24.7% CHCs).

Instrumentation

We developed a content valid and reliable survey during spring 2016. This survey questioned perceptions of foodservice challenges and opportunities for adopting school-based community nutrition initiatives. Content validity was established by an expert panel of 11 key informants (5 FSDs and 6 CHCs) critically evaluating the survey both in person and via email. Key informants contributed survey topic ideas, refined question wording and intent, and provided feedback on survey format and feasibility. Key informants were provided with and completed an evaluation form with each revision of the survey. This evaluation was adapted from Johnson and Chambers (Johnson et al., 2000) and Johnson (Johnson, 1998). Reliability of Likert scale questions was established using Cronbach's alpha test for internal consistency. Three previous FSDs perception surveys also used Cronbach's alpha to test for internal consistency (Grisamore et al., 2014; Leblanc, 2000; Longley et al., 2009). The average of the alpha scores from these studies was 0.84; thus, we used 0.84 as a reference alpha for determining sample size requirements. However, we were unable to include CHCs perception survey reliability scores when determining the reference alpha value because this has not yet been measured in previous studies. The internal consistency of categorical questions could not be tested, as response options are not continuous. Though Likert scale questions are technically not continuous, previous nutrition-related surveys (Bjelland et al., 2014; De Bourdeaudhuij et al., 2005; Grisamore et al., 2014; Leblanc, 2000; Longley et al., 2009) have used Cronbach's Alpha to test for reliability of Likert scale questions.

The first round of surveys was administered to 100 participants via email using REDCap (Harris et al., 2009) during spring 2016. We collected responses of 47 participants to fulfill the sample size necessary for establishing internal consistency using Cronbach's alpha, when the type I error is 0.05, the power is 0.8, the minimum alpha value is 0.7, the reference alpha value is 0.84, and at least 9 questions are being tested for internal consistency. We assessed internal consistency for all Likert scale questions (20 questions), internal consistency of Likert scale questions pertaining to perception of support for community nutrition initiatives (9 questions), and internal consistency of Likert scale questions pertaining to perception of foodservice challenge (9 questions). However, based on expert panel feedback, we developed no/yes options for 2 questions related to Smart Snack legislation. To test for reliability, the no/yes response options for these questions were scaled to 2 and 4, respectively. Completed responses were assessed for reliability using Cronbach's alpha procedure in SAS 9.4 (SAS Institute Inc., Cary, NC). Completed surveys from the reliability testing were included in the final survey analysis. Whole survey reliability was 0.68, the reliability of perception of foodservice challenge questions was 0.44, and the reliability of support for community nutrition initiatives questions was 0.83. We did not attempt to improve reliability of foodservice challenge questions, as we consider our collaboration with the expert panel of key informants to have established strong content validity. Furthermore, low reliability of foodservice challenge questions indicates the variability of challenges facing each school district, as evidenced by the wide range of responses to survey questions about food safety and employee turnover.

The final 33-item survey used in the analysis consisted of 7 demographic questions, 1 consent question, and 25 perception questions (20 5-point Likert scale questions and 5 categorical questions).

Procedure

The final survey was administered online via email using REDCap. ‘‘REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing: (1) an intuitive interface for validated data entry; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for importing data from external sources”(Harris et al., 2009). Responses were collected from the beginning of June through mid-July of 2016. One email reminder was sent per week (for 3 weeks) until the participant either completed the survey or asked to be removed the study. Participants whose contact information included a phone number were called if they had not yet responded by the third reminder.

Data Analysis

Data were analyzed using SAS 9.4 (SAS Institute Inc., Cary, NC). The primary independent variable of interest was whether the respondent was a FSD or a CHC. Other independent variables included years of experience with school nutrition, level of education, and familiarity with school lunch policy, etc. (Table 7). Responses to the remaining survey questions were the dependent variables. We analyzed the responses to Likert scale questions 1. assuming the variables were categorical, and 2. assuming the variables were continuous. We used descriptive statistics for condition 1, and non-parametric alternatives for condition 2, including Wilcoxon Signed Rank, Kruskal-Wallis, and Dwass-Steel-Critchlow-Fligner (DSCF) tests, as the data followed a non-Gaussian distribution. For condition 2, we considered a difference in perception to be ‘‘substantial’’ when the mean response between FSDs and CHCs was both statistically significant and separated by a mean difference of 0.9 or greater. Kennedy et al. found

that the ‘‘real’’ scale value of 1, 2, 3, 4, and 5 equaled 1, 2.2, 3.1, 4.1, and 5, respectively, when participants in a marketing study reported perception (Kennedy et al., 1996). Thus, the smallest real Likert scale difference between response values was 0.9. Dawkes (2008) cited Kennedy et al.'s study as an advancement in interpreting actual differences on Likert scale questions (Dawkes, 2008). Furthermore, Dawkes (2008) found that a mean difference of 0.3 for sample sizes of 185 was consistently statistically significant (Dawkes, 2008). We achieved statistical significance with a mean difference of 0.4, though our sample sizes were 132 and 80 for FSDs and CHCs, respectively. Additionally, we performed a 2-sample median test to determine whether the mean and median responses to individual Likert scale questions were significantly different between FSDs and CHCs. We also explored the variation between median and mode responses (Table 8).

We attempted to use chi-square tests to identify possible associations between demographic variables; however, many cell counts were less than 5. Thus, associations were explored by performing DSCF test. We explored possible associations between expertise (i.e., FSDs vs CHCs) and education, experience, and familiarity with HHFKA. We also explored whether FSDs and CHCs perceptions were associated with (1) agreeing that schools should meet federal nutrition standards to receive funding and (2) believing HHFKA was realistic to implement. Urban/rural differences and having a child were not explored because these did not significantly impact responses to Likert scale questions, according to Wilcoxon's signed rank test (data available upon request). Finally, we used descriptive statistics to calculate the frequency of responses between FSDs and CHCs to categorical questions regarding definitions of a healthy meal, percent of students receiving free/reduced-price lunches, foodservice

employee training time, employee turnover, and responsibility for nutrition education (Table 9), as well as the free response question regarding barriers to partnerships (Table 10).

Urban/rural classification

We explored associations between urban/rural classification (independent variable) and responses to survey perception questions (dependent variable). To accomplish this, we categorized self-reported zip code data as either urban or rural according to definitions by the Centers for Medicare & Medicaid Services- Rural Health Clinics Program and the Federal Office of Rural Health Policy Grant Programs (Rural Health Information Hub). When both Centers for Medicare & Medicaid Services- Rural Health Clinics Program and the Federal Office of Rural Health Policy Grant Programs defined the zip code area as ‘‘rural,’’ then we coded the response as rural. When both the Centers for Medicare & Medicaid Services- Rural Health Clinics Program and the Federal Office of Rural Health Policy Grant Programs defined the zip code area as ‘‘not rural,’’ then we coded the response as urban. When there was disagreement between the Centers for Medicare & Medicaid Services- Rural Health Clinics Program and the Federal Office of Rural Health Policy Grant Programs, we coded the zip code area as rural if more than 50% of the population lived in a rural area according to the 2010 US Census.

Analysis of estimated percent of students receiving free/reduced-price lunches

We explored whether FSDs or CHCs would more accurately estimate the percent of students in their district receiving free/reduced-price lunches (independent variable). Actual district level percent free/reduced-price lunch data from 2015 were retrieved from the Kids Count Data Center (Kids Count Data Center) and matched with zip code data according to the schools’ physical addresses. Survey responses were excluded from this analysis when more than

one school district was in the same zip code or if the survey respondent reported a zip code that did not match one of the zip codes reported on any of the school district websites. Of 212 total responses, 135 (90 FSDs and 45 CHCs) were included in the analysis (Table 9).

Results

Demographic Differences Between FSDs and CHCs

CHCs and FSDs were approximately evenly divided between urban and rural settings. Over three-fourths of FSDs and CHCs did not have a child attending school in the district where they worked/volunteered. Surprisingly, over half of the CHCs (57.5%) had no experience with school nutrition. Additionally, 93.8% of CHCs had a bachelor's degree or higher, while only 40.1% of FSDs had a bachelor's degree or higher. 97.7% of FSDs were somewhat or very familiar with HHFKA, while about half (51.3%) of CHCs were somewhat or very familiar with HHFKA. Both FSDs and CHCs overwhelmingly agreed that schools should meet federal nutrition standards in order to receive funding; however, only 37.9% of FSDs and 40% of CHCs believed that HHFKA was realistic for schools to implement (Table 7).

Primary hypothesis: FSDs versus CHCs perception of foodservice challenge and support for community nutrition initiatives.

The substantially different perceptions between FSDs and CHCs were primarily among questions regarding community nutrition initiatives, where CHCs consistently expressed more support for school gardens, partnering with local chefs, offering students a salad bar, conducting nutrition-related community engagement, and participating in the Farm to School Program. Surprisingly, there was not a substantial difference between FSDs and CHCs for questions related to foodservice challenges. FSDs and CHCs considered funding, food safety, employee compensation, and food waste to be important (Table 8).

Mean and median responses to Likert scale questions between FSDs and CHCs were not statistically different for all Likert scale questions except 2; regarding offering students organic foods and the feasibility of donating wasted foods (Table 8). However, there was considerable discrepancy between median and mode responses to Likert scale questions. The difference between the frequency of response for the mode and median was greater than 10% for questions regarding: interest in partnerships (CHCs), student acceptance of lunch items (CHCs), organic foods (FSDs), donating wasted foods (FSDs), the ease with which schools can obtain HHFKA foods (CHCs), funding (FSDs), food safety (FSDs), and how well parents understand policy requirements (FSDs).

Secondary hypothesis: differences in perception related to education, experience, and familiarity with HHFKA.

Contrary to our secondary hypothesis regarding level of experience, CHCs with no school nutrition experience responded more similarly to FSDs than did CHCs with any experience in school nutrition. Furthermore, CHCs responded similarly to all Likert scale questions regardless of their familiarity with HHFKA. Finally, FSDs and CHCs responses did not differ related to beliefs about meeting federal standards and implementation (data available upon request).

Education was the only demographic factor associated with CHCs and FSDs responses to Likert scale questions. FSDs with a bachelor's degree or higher responded more similarly to CHCs with a bachelor's degree or higher than FSDs with a high school diploma or some college. However, support for school gardens, salad bars, and partnering with local chefs was still substantially different between FSDs with a bachelor's degree or higher and CHCs with a

bachelor's degree or higher. Surprisingly, FSDs with more education were less supportive of partnering with local chefs than FSDs with less education (data available upon request).

FSDs and CHCs frequency of responses to categorical and free response questions.

FSDs and CHCs responses regarding the origin of their personal definition of a healthy meal were overall similar, with FSDs reporting a preference for federal recommendations. Furthermore, FSDs more often correctly estimated the percentage of students receiving free or reduced priced lunch in their district than did CHCs. Surprisingly, CHCs estimated that it took longer to train a foodservice employee and that employee turnover was worse than FSDs estimated. The overwhelming majority of FSDs (71.21%) and CHCs (87.5%) believed that nutrition education of students should be a collaborative effort between teachers, school foodservice, parent volunteers, and community health coalitions (Table 9). Finally, time was the most frequently reported barrier to partnerships between FSDs and CHCs, followed by funding and a lack of interest/commitment from partners (Table 10).

Discussion

Previous school nutrition perception studies indicated that there was not a high level of confidence and/or commitment from FSDs in the development of SWP (Conklin et al., 2009), FSDs were less aware of existing school competitive food policies than principals (McDonnell et al., 2006), nutrition education programs were needed but underfunded (Lambert et al., 2006), and implementation of HHFKA presented major challenges regarding food waste and reformulation of menu items (Asada et al., 2017; Cornish et al., 2016; Thiagarajah et al., 2015). Our findings regarding the challenges of successful policy implementation are consistent with the literature. Additionally, we hypothesized that CHCs would be less aware than FSDs of foodservice

challenges. However, CHCs and FSDs responded similarly to food service challenge questions. As expected, CHCs were more supportive than FSDs of community nutrition initiatives.

Previous studies suggest that occupation (Galobardes et al., 2001) and education (Hendrie et al., 2008; Macario et al., 1998; Parmenter et al., 2000) influence nutrition knowledge and behaviors. When we explored occupation and education, occupation (i.e. FSDs) was more closely associated with perception than was familiarity with and beliefs about school lunch policy. Furthermore, FSDs who attained a higher level of education perceived school foodservice challenges and opportunities similarly to CHCs. Surprisingly, the most educated FSDs were the least supportive of partnering with local chefs. More educated FSDs may feel competent about implementing alternative nutrition strategies, perhaps believing that local chefs would be unable to reformulate acceptable healthy menu items.

Interestingly, both FSDs and CHCs overwhelmingly agreed that nutrition education of students should be a collaborative effort, but indicated that time, funding, and lack of interest/commitment were barriers to partnerships. Po’e et al. (2010) (Po'e et al., 2010) and Bolton et al. (2016) (Bolton et al., 2016) also described similar challenges in sustaining community obesity prevention partnerships. Indiana FSDs and CHCs may benefit from utilizing (and/or continuing to utilize) the land grant university Extension system because Extension is already an institutionalized and active component of many communities and coalitions. For example, Extension educators in North Dakota (Gold et al., 2017) and Maryland (Song et al., 2016) spearheaded successful nutrition education interventions in schools. There are many opportunities for long-term partnerships and consolidation of resources and skills.

Limitations

Whereas ours was the first study to address FSDs and CHCs perceptions of school lunch policy and programs, one limitation is that the survey was administered during the summer, a time when many FSDs are out of the office and/or FSDs and CHCs may be on vacation. Thus, timing of the survey may have contributed to a low total response rate. Because of the response rate, we cannot be certain that our respondents were demographically representative of all FSDs and CHCs in Indiana. The vast majority of responding CHCs had at least a bachelor's degree and may be biased due to under-representation of less educated CHCs. Additional sample bias may be due to the variability in experience that FSDs have working with coalitions and district-level differences in FSDs workloads. A second limitation is that FSDs contact information were retrieved from cross referencing a list of publicly available email addresses from the Indiana Department of Education (Indiana Department of Education) and the Indiana State Department of Health's 2014 school food safety inspection sites (Indiana State Department of Health). Between the two lists, 213 FSDs names on the Indiana Department of Education list did not match FSDs names on the Indiana State Department of Health list. Additionally, the Indiana Department of Education (Indiana Department of Education) list of public contact information for the NSLP was accessed in April of 2016, and has since been updated. Thus, there was not a comprehensive list of FSDs and the lists we accessed included out of date information. Third, there is no publicly available list of CHCs. Some respondents were unaware that they were a member of a coalition and did not remember providing contact information. Finally, our survey did not include a question about the Fresh Fruit and Vegetable Program. Inclusion of this topic would have been timely and important, as legislation regarding removing "fresh" from the Fresh

Fruit and Vegetable Program (Rokita, April 20, 2016) was under debate during the time of this survey (Wootan, May 18, 2016).

Conclusions

Our study was the first to explore the differences in perceptions between FSDs and CHCs regarding school foodservice challenges and opportunities. Perception of foodservice challenge did not substantially differ between FSDs and CHCs; however, CHCs were substantially more supportive of community nutrition initiatives. While experience and familiarity with school nutrition policy did not impact responses, it appears that FSDs with a higher level of education were more supportive of community nutrition initiatives than FSDs with less education.

Implications for School Health

We demonstrated that CHCs have a modest level of understanding of the challenges faced by FSDs, though CHCs understanding may be limited by lack of experience with school nutrition. Furthermore, CHCs are eager to expand school nutrition programs. Communicating HHFKA challenges to CHCs may encourage partnerships and shared goals, facilitating implementation of school-based access and nutrition education programs. Providing CHCs with more experience with school nutrition and increasing their familiarity with HHFKA could establish a more realistic set of expectations for partnerships.

In addition, our demographic data demonstrates that more experience was inversely associated with education among FSDs, reflecting the changing field of school nutrition. Incentivizing educational attainment for FSDs is a possible strategy for enhancing partnerships. Partnerships between FSDs and CHCs may unify and expand efforts for community health,

while potentially mobilizing a broad spectrum of local organizations and utilizing federal resources for nutrition program development and success.

1. Get involved in your community health coalition: Indiana FSDs can contact their Purdue Extension Educator to learn about local coalition activities.
2. Offer to provide CHCs with information about school nutrition: hold an ‘‘open house’’ or allow CHCs to shadow a FSD for a day so that CHCs can better understand the day to day challenges of implementing HHFKA.
3. Reduce nutrition programming efforts by working together: CHCs may already be involved in community gardens and/or local food projects. FSDs can work with CHCs to expand related school-based initiatives.
4. Identify and combine skills and resources: CHCs may have the skills and experience necessary to write successful grants, and may be able to collaborate with FSDs to write Farm to School (Department of Agriculture Food and Nutrition Service), Team Nutrition (Department of Agriculture Food and Nutrition Service), and other program grants to the United States Department of Agriculture.

Human Subjects Approval Statement

This study protocol (number 1602017127) was granted exempt status by the Purdue University Institutional Review Board.

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Table 7: Number and Percent of Foodservice Director (FSD) (N=132) and Community Health Coalition Member (CHC) (N=80) Responses to Demographic Questions

Demographic question	Answers		1. N(%)	2. N(%)	3. N(%)	4. N(%)	5. N(%)
Is the school district where you work/ volunteer located in an urban or rural area? *	1. urban 2. rural	FSD(N=132)	74(**56.1**)	58(43.9)	-	-	-
		CHC(N=80)	42(**52.5**)	38(47.5)	-	-	-
Do you have a child attending school in the district where you work/ volunteer?	1. yes 2. no 3. I have a child attending school in a different district	FSD(N=132)	24(18.2)	101(**76.5**)	7(5.3)	-	-
		CHC(N=80)	14(17.5)	62(**77.5**)	4(5.0)	-	-
How many years of experience do you have in school nutrition?	1. none 2. 0-5 years 3. 5-10 years 4. 10-20 years 5. >20 years	FSD(N=132)	0(0)	20(15.2)	28(21.2)	43(**32.6**)	41(31.1)
		CHC(N=80)	46(**57.5**)	17(21.3)	4(5.0)	10(12.5)	3(3.8)
What is your highest level of education?	1. some high school 2. high school diploma 3. some college 4. bachelor's degree 5. master's degree or higher	FSD(N=132)	0(0)	35(26.5)	44(**33.3**)	35(26.5)	18(13.6)
		CHC(N=80)	0(0)	1(1.3)	4(5.0)	29(36.3)	46(**57.5**)

Table 7 continued

How familiar are you with the Healthy, Hunger-Free Kids Act?	1. not familiar at all 2. somewhat unfamiliar 3. neutral 4. somewhat familiar 5. very familiar	FSD(N=132)	1(0.8)	2(1.5)	0(0)	33(25.0)	96(**72.7**)
		CHC(N=80)	20(25.0)	12(15.0)	7(8.8)	39(**48.8**)	2(2.5)
Do you agree that schools should meet federal nutrition standards in order to receive government funding?	1. yes 2. no	FSD(N=132)	104(**78.8**)	28(21.2)	-	-	-
		CHC(N=80)	71(**88.8**)	9(11.3)	-	-	-
Do you think the Healthy, Hunger-Free Kids Act is realistic for schools to implement?	1. yes 2. no 3. I don't know	FSD(N=132)	50(37.9)	74(**56.1**)	8(6.1)	-	-
		CHC(N=80)	32(40.0)	9(11.3)	39(**48.8**)	-	-

Table 8: Foodservice Director and Community Health Coalition Member Mean, Median, and Mode Responses to Survey Likert Scale Questions

Question	**Answers**	**FSDs mean ± SD**	**CHCs mean ± SD**	**Mean diff.**	**p-value: Wilcoxon test**	**FSDs median (variance)**	**CHCs median (variance)**	**p-value: two-sample median test**	**FSDs mode (%)**	**CHCs mode (%)**
How important do you think it is to conduct nutrition related **community engagement** in the district where you work/volunteer?	1. not at all important 2. somewhat unimportant 3. neutral 4. somewhat important 5. very important	3.55 ± 1.06	4.64 ± 0.56	**1.09**	<.0001	4.0 (1.12)	5.0 (0.31)	<.0001	4.0 (47.0%)	5.0 (67.9%)
How important do you think it is to have a lunch **salad bar** for students in the district where you work/volunteer?	1. not at all important 2. somewhat unimportant 3. neutral 4. somewhat important 5. very important	3.59 ± 1.34	4.62 ± 0.56	**1.03**	<.0001	4.0 (1.80)	5.0 (0.32)	<.0001	5.0 (32.6%)	5.0 (65.4%)
How important do you think it is to partner with **local chefs** to create school lunch recipes in the district where you work/volunteer?	1. not at all important 2. somewhat unimportant 3. neutral 4. somewhat important 5. very important	2.90 ± 1.29	3.92 ± 0.91	**1.02**	<.0001	3.0 (1.66)	4.0 (0.83)	<.0001	3.0 (31.8%)	4.0 (39.7%)

Table 8 continued

How important do you think it is to have a **school garden** in the district where you work/volunteer?	1. not at all important 2. somewhat unimportant 3. neutral 4. somewhat important 5. very important	3.08 ± 1.12	4.08 ± 0.99	**1.00**	<.0001	3.0 (1.26)	4.0 (0.98)	<.0001	3.0 (42.4%)	4.0 (41.0%)
How important do you think it is for school foodservice to participate in the **Farm to School** program?	1. not at all important 2. somewhat unimportant 3. neutral 4. somewhat important 5. very important	3.41 ± 1.04	4.33 ± 0.77	**0.92**	<.0001	4.0 (1.08)	4.0 (0.59)	<.0001	4.0 (37.9%)	5.0 (46.2%)
How much of a problem do you perceive cafeteria **staff employee turnover** to be as it relates to implementing nutrition standards?	1. very problematic 2. somewhat problematic 3. neutral 4. somewhat unproblematic 5. not at all problematic	3.42 ± 1.29	2.71 ± 0.98	**0.71**	<.0001	4.0 (1.66)	3.0 (0.97)	<.0001	5.0 (27.3%)	2.0 (42.5%)
How **interested are you in partnering** with a school foodservice director or community health coalition to accomplish school nutrition goals?	1. not at all interested 2. somewhat uninterested 3. neutral 4. somewhat interested 5. very interested	3.39 ± 1.15	4.01 ± 1.2	**0.62**	<.0001	4.0 (1.32)	4.0 (1.44)	.0001	4.0 (37.1%)	5.0 (47.4%)

Table 8 continued

How well do you think **students understand** the requirement to take at least one fruit or vegetable with their meal?	1. not at all 2. somewhat unwell 3. neutral 4. somewhat well 5. very well	3.72 ± 1.32	3.10 ± 1.12	**0.62**	<.0001	4.0 (1.75)	3.0 (1.26)	<.0001	5.0 (35.6%)	4.0 (37.2%)
Do you think Smart Snack regulations should apply to **fundraising food**?	2. no 4. yes	2.65 ± 0.94	3.13 ± 1.0	**0.48**	0.0009	2.0 (0.89)	4.0 (1.0)	.0007	2.0 (67.4%)	4.0 (56.3%)
How **acceptable** do you think students find school lunches?	1. not at all acceptable 2. somewhat unacceptable 3. neutral 4. somewhat acceptable 5. very acceptable	3.51 ± 1.11	3.04 ± 1.0	**0.47**	.0009	4.0 (1.23)	3.0 (1.0)	.0005	4.0 (53.0%)	4.0 (43.8%)
How important do you think it is to offer students **organic foods** in the district where you work/volunteer?	1. not at all important 2. somewhat unimportant 3. neutral 4. somewhat important 5. very important	2.38 ± 1.18	2.85 ± 1.29	**0.47**	.0115	2.0 (1.38)	3.0 (1.66)	NS	1.0 (32.6%)	3.0 (25.6%)

Table 8 continued

Do you think **Smart Snack** rules should apply to foods NOT sold to students, such as party/reward foods?	2. no 4. yes	2.78 ± 0.98	3.18 ± 0.99	**0.40**	.0069	2.0 (0.96)	4.0 (0.98)	.0063	2.0 (60.6%)	4.0 (58.8%)
How feasible do you think it is for schools to **donate wasted food**?	1. not at all feasible 2. somewhat unfeasible 3. neutral 4. somewhat feasible 5. very feasible	2.98 ± 1.39	3.36 ± 1.30	**0.38**	.0451	3.0 (1.93)	4.0 (1.68)	NS	4.0 (31.8%)	4.0 (36.3%)
How **easily do you think schools can obtain** the foods they need to meet HHFKA standards?	1. not at all easily 2. somewhat uneasily 3. neutral 4. somewhat easily 5. very easily	3.37 ± 1.09	3.0 ± 1.10	**0.37**	.0155	4.0 (1.19)	3.0 (1.22)	.0080	4.0 (46.2%)	2.0 (33.8%)
How important do you think it is that schools include **ingredient labels** on all food/beverage items sold to students (for food allergy/ dietary restriction purposes)?	1. not at all important 2. somewhat unimportant 3. neutral 4. somewhat important 5. very important	3.86 ± 1.22	4.19 ± 0.92	**0.33**	NS	4.0 (1.48)	4.0 (0.84)	NS	5.0 (37.1%)	5.0 (45.0%)

Table 8 continued

How appropriate do you think is the amount of **funding** school foodservice receives to implement school lunch nutrition standards?	1. not at all appropriate 2. somewhat inappropriate 3. neutral 4. somewhat appropriate 5. very appropriate	2.98 ± 1.13	2.69 ± 1.11	**0.29**	NS	3.0 (1.27)	3.0 (1.23)	NS	4.0 (38.6%)	2.0 and 3.0 (28.8%)
How concerned are you with school lunch **food safety** practices?	1. very concerned 2. somewhat concerned 3. neutral 4. somewhat unconcerned 5. not at all concerned	2.93 ± 1.71	2.64 ± 1.22	**0.29**	NS	3.0 (2.95)	2.5 (1.50)	NS	1.0 (35.6%)	2.0 (31.3%)
How well do you think **parents understand** school lunch policy?	1. not at all 2. somewhat well 3. neutral 4. somewhat unwell 5. very well	2.16 ± 1.18	1.88 ± 0.87	**0.28**	NS	2.0 (1.39)	2.0 (0.75)	NS	1.0 (40.9%)	2.0 (42.3%)
How much of a problem do you perceive school lunch **food waste** to be?	1. very problematic 2. somewhat problematic 3. neutral 4. somewhat unproblematic 5. not at all problematic	2.07 ± 1.02	1.85 ± 0.84	**0.22**	NS	2.0 (1.03)	2.0 (0.71)	NS	2.0 (49.2%)	2.0 (50.0%)

Table 8 continued

How appropriate do you think are the **pay and benefits** cafeteria staff receive for the work they do?	1. not at all appropriate 2. somewhat appropriate 3. neutral 4. somewhat inappropriate 5. very appropriate	2.59 ± 1.31	2.41 ± 0.91	**0.18**	NS	2.0 (1.72)	2.0 (0.83)	NS	2.0 (36.4%)	2.0 (42.5%)

FSDs: foodservice directors (N=132); CHCs: community health coalition members (N=80)

Table 9: Foodservice Director and Community Health Coalition Member Frequency of Responses to Categorical Questions

Question	**Responses**	**% FSDs selecting this response**	**% CHCs selecting this response**
Which groups/ organizations most influence your personal definition of a "**healthy meal**?"	1. personal experience	25.76	25.00
	2. federal recommendation	16.67	3.75
	3. educational experience	33.33	37.50
	4. professional nutrition organizations	20.45	30.00
	5. other	3.79	3.75
Please estimate the percentage of enrolled students that qualify for **free/ reduced-price** school lunches in the district where you work or volunteer.	1. less than 25%	15.91	2.50
	2. 25%- 50%	41.67	51.25
	3. 50%- 75%	28.03	36.25
	4. more than 75%	14.39	10.00
These respondents **estimated correctly** according to district and zip code data*	1. estimated correctly	66.67	53.33
	2. estimated incorrectly	33.33	46.67
Please estimate how many **hours you think it takes to train** a school foodservice worker.	1. less than 40 hours	28.79	25.00
	2. 40-80 hours	43.94	31.25
	3. 80-160 hours	15.91	36.25
	4. 160-240 hours	6.82	3.75
	5. more than 240 hours	4.55	3.75
Please estimate what you think the **employee turnover** of school foodservice workers is in the district where you work or volunteer.	1. 0%-25%	68.18	38.75
	2. 25%-50%	23.48	46.25
	3. 50%-100%	8.33	13.75
	4. 100%-150%	0	1.25
	5. more than 150%	0	0
In your opinion, who should be responsible for **nutrition education** of students?	1. teachers	15.91	0
	2. school foodservice	6.82	1.25
	3. parent volunteers	1.52	0
	4. community health coalitions	2.27	7.50
	5. all of the above	71.21	87.50
	6. none of the above	2.27	3.75

*% free/reduced-price lunch data were retrieved from the Kids Count Data Center(Kids Count Data Center) and matched with zip code data according to the schools' physical address. In some cases, multiple schools fell within the same zip code. These responses were excluded from the analysis. In some cases respondents reported working/volunteering in a zip code that could not be matched with a school from the Kids that Count Data Center. These responses were also excluded from the analysis. Of 212 total responses, only 135 (90 FSDs and 45 CHCs) were included in the analysis for the above mentioned reasons.

Table 10: Foodservice Director and Community Health Coalition Member Responses to the Open-Ended Question "What are the barriers that prevent this type of partnership?"

Barriers related to	**Count**	**% (out of 121 people who responded)**
Time	65	53.72
Cost/ funding	15	12.40
Lack of interest/ commitment from partners	12	9.92
There are no barriers	11	9.09
Not having or knowing whether there is a coalition in the area; not knowing where to begin or who to contact	10	8.26
Implementation/ severity of federal regulations	8	6.61
Location / setting (rural, correctional facility, etc.)	7	5.79
FSDs doesn't want the community to interfere	6	4.96
Communication	5	4.13
Foodservice staff	5	4.13
Educational background (coalitions, parents), not knowing the school lunch requirements	3	2.48
Lack of support from the district	2	1.65
Retiring/ retired	2	1.65
Fear	1	0.83
Kids have too many choices	1	0.83

CHAPTER 3. ASSESSING COALITION PATHWAYS USING THE PUBLIC HEALTH LOGIC MODEL: A SYSTEMATIC LITERATURE REVIEW AND MARKET BASKET ANALYSIS OF RURAL COMMUNITY HEALTH COALITIONS

Abstract

Context: Rural communities face unique challenges including fewer healthcare providers and restricted access to nutritious foods, which likely lead to poor health outcomes. Employing community health coalitions (CHCs) is one strategy for implementing sustainable policy, system, and environment changes for long-term health improvements. However, CHC success is variable and there is no standard for evaluation. Thus, we retrospectively assessed rural CHCs using the W.K. Kellogg Foundation Logic Model (KLM).

Evidence Acquisition: PubMed, Web of Science, Science Direct, CINAHL, and PsycINFO were searched: (coalition) AND (rural) AND (health) AND (effectiveness OR impact OR outcome OR logic model). We included full-text, peer-reviewed articles written in English that met the PICOS criteria (Population: rural communities; Intervention: the presence of a CHC; Comparator: the CHC over time; Outcomes: CHC pathways reported across the public health logic model; Study Design: no exclusions).

Evidence Synthesis: CHC pathways were categorized according to KLM: inputs/resources, activities (internal and external), outputs, short-, medium-, and long-term outcomes, and impact. The 10 most frequently reported pathway items were partner diversity, organizational structures, implementing pilot studies/programs/interventions, funding, community engagement/outreach, university partners, holding regular meeting, having working groups/subcommittees, operating under/partnering with a regional research initiative, and conducting a community health/needs

assessment. A market basket analysis revealed that 50% of CHCs reported 4 or 5 of the following 6 pathway items: funding, partner diversity, university partners, organizational structures, community engagement/outreach, and implementing pilot studies/programs/interventions.

Conclusions: Many CHCs reported inputs and capacity building efforts, while few impacted health. However, recommending common early phase logic model pathways may facilitate downstream success.

Context

Chronic health conditions including obesity, hypertension, hyperlipidemia, and depression occur at a greater rate in rural compared to urban areas (Meit et al., 2014). Furthermore, residents of rural counties are more likely to smoke, drink, and be physically inactive (Meit et al., 2014). Disparities in rural health are rooted in socioeconomic, geographic, racial, and political systems (Olson et al., 2018), and rural communities face unique challenges including geographic isolation, fewer healthcare providers, and restricted access to nutritious foods, all of which likely lead to poor health outcomes (Rural Health Information Hub, 2019b).

One strategy for addressing local health needs is the development of community health coalitions (CHCs). The Rural Health Information Hub defines a coalition as “a collaboration between diverse organizations or constituencies that agree to work on a specified action-oriented opportunity” (Rural Health Information Hub, 2019b). While many coalitions and community health centers may exist in metropolitan areas, one CHC typically serves as the central (and often only) resource for improving the provision of health resources to a rural community (Rural

Health Information Hub, 2019c). Therefore, rural CHCs are instrumental for improving healthcare access and increasing health-related services.

The importance of organizational infrastructure to improve public health is expressed in the Healthy People 2020 goal "to ensure that local health agencies have the necessary infrastructure to effectively provide essential public health services" (Office of Disease Prevention and Health Promotion, 2019). Additionally, the Health Resources and Services Administration of the United States Department of Health and Human Services (USDHHS) supports the use of evidence-based public health interventions aimed at preventing chronic disease (Rural Health Information Hub, 2019d). While short-term public health interventions may be designed and implemented by academic researchers, CHCs rely on community involvement and ownership for the sustainability of programming for long-term impact (Butterfoss, 2007; Hicks et al., 2012; Kegler et al., 2011; Minkler, 2012; Roussos et al., 2000). Furthermore, the USDHHS calls for research on the effective delivery of community-based interventions through local public health programs (Office of Disease Prevention and Health Promotion, 2019). Therefore, public health researchers are charged with understanding how to optimize CHC partnerships and infrastructure to maximize the effectiveness of program delivery (Rural Health Information Hub, 2019a).

In order to better understand program implementation and evaluation, the Centers for Disease Control and Prevention (CDC) supports the use of logic models (Centers for Disease Control and Prevention, 2019). Logic models create a shared understanding across a broad range of stakeholders, facilitate planning, describe the processes and methods of a program, provide the framework for consistent reporting, and establish a common language for assessment. The

potential for CHCs to employ logic models for program design and evaluation is great. One of the most widely known and commonly cited logic models is the W.K. Kellogg Foundation Logic Model (KLM), which acts as a linear map from planned work to intended results (W.K. Kellogg Foundation, 2006). Additionally, Anderson et al. (2011) and Kneale et al. (2015) suggest that logic models provide a robust evaluative framework for conducting systematic literature reviews (Anderson et al., 2011; Kneale et al., 2015). To date, CHC literature has focused mainly on inner-city/non-rural communities. While there have been reported successes of CHCs across geographic locations, health topics, and member organization characteristics, it is impossible to isolate coalition effects on changes in policies, systems, environments, and health outcomes (Roussos et al., 2000). The purpose of this review is to compare the pathways of rural CHCs through inputs to impact using the KLM as a retrospective assessment framework, in order to identify best practices to improve rural health.

Evidence Acquisition

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Guidelines for Transparent Reporting of Systematic Reviews and Meta-Analyses (Moher et al., 2009) were followed.

Search Strategy

On March 24, 2018, PubMed, Web of Science, Science Direct, CINAHL, and PsycINFO were searched for the following terms pasted directly into the search bar: (coalition) AND (rural) AND (health) AND (effectiveness OR impact OR outcome OR logic model). The filter “all fields” was applied to four of the five databases; the filter “title, abstract, or key words” was applied to Science Direct.

Article Selection

Titles and abstracts were screened by authors Ken-Opurum and Savaiano between March 25, 2018 and May 14, 2018 for inclusion according to the PICOS criteria (Figure 2). Full article screening and data abstraction were conducted by authors Ken-Opurum and Darbishire between May 15, 2018 and October 27, 2018. Included articles met the PICOS criteria and were full-text, peer-reviewed, and written in English. When there was disagreement between authors regarding article inclusion, the articles in question were rescreened until consensus was obtained.

Data Abstraction

Data were abstracted in duplicate by authors Ken-Opurum and Darbishire. To prevent order bias, articles were arranged alphabetically by first author's last name; author Ken-Opurum abstracted data from articles in alphabetical order, author Darbishire abstracted data from every fifth article in reverse order. Authors Ken-Opurum and Darbishire abstracted articles meeting inclusion criteria for the following information: article reference, health focus, study design, theoretical framework/guiding principles, outcomes assessment, and analysis; as well as reported pathways across the phases of the KLM, i.e., inputs/resources, activities (internal and external), outputs, short-, medium-, and long-term outcomes, and impact.

PICOS Defined

We considered a population to be a *rural community* if 1. The article met the search strategy, 2. The authors explicitly use the term "rural" or name a community that is identified as rural, and 3. Differences in actions and results between rural and urban communities can be identified in cases where coalitions in both settings are discussed. A *community health coalition, i.e., CHC,* is a group of local (community- or county-level) organizations working together to

address local health needs. This excludes CHCs operating at the international, national, regional, or state level, partnerships addressing topics unrelated to health, and CHCs whose membership is from a single sector. The *presence of a CHC* refers to an active CHC operating at the community- or county-level. An *account of the CHC over time* indicates that the history, development, and state of the CHC is described in terms of actions/steps/pathways occurring across the logic model, which follows an inherent sequence.

CHC actions/steps/pathways reported across the public health logic model (henceforth pathway items) are adapted from definitions outlined in the KLM Development Guide (W.K. Kellogg Foundation, 2006). *Resources/inputs* "include the human, financial, organizational, and community resources a program has available to direct toward doing the work." *Activities* are the "processes, tools, events, technology, and actions that are an intentional part of the program implementation"—we differentiate between *internal* capacity building activities and the delivery of *external* services and programming. *Outputs* are the "direct products of program activities" relating exclusively to the CHC. *Short-term outcomes* indicate a change in knowledge, skills, attitudes, and beliefs of the target population. *Medium-term outcomes* indicate a behavior change in the target population. *Long-term outcomes* indicate a change in health status in the target population. *Impact* refers to structural community changes at the policy, system, or environment level.

Risk of Bias Assessment

Risk of bias of individual studies was assessed using the Critical Appraisal Skills Programme checklist for qualitative research (Singh, 2013). We considered all studies included

in this review as qualitative studies because the unit of analysis is the CHC. No articles were excluded based on their risk of bias.

Primary Analysis

The primary analysis is the frequency (count) of pathway items among reviewed articles, where the minimum is a pathway item occurring in only one article and the maximum is a pathway item occurring in all reviewed articles (n=30 (Andrews et al., 2014; Barnidge et al., 2015; Bencivenga et al., 2008; Brownson et al., 2004; Brownson et al., 1996; Carvalho et al., 2013; Chalmers et al., 2003; Chinman et al., 2014; Davis et al., 2014; Fouad et al., 2004; Friedell et al., 2001; Greenberg et al., 2015; Hill et al., 2008; Horne et al., 2013; Jaros et al., 2001; Jenkins et al., 2004; M. C. Kegler et al., 2008; Kluhsman et al., 2006; Lengerich et al., 2007; Luque et al., 2011; Mahon et al., 2007; Martinez-Donate et al., 2015; McFall et al., 2005; Mueller-Luckey et al., 2017; Page-Reeves et al., 2014; Plescia et al., 2004; Redmond et al., 2009; Schetzina et al., 2011; Smith et al., 2011; Ward et al., 2006)). Examples of pathway items include: “conduct a community health/needs assessment”, “study findings shared with the coalition”, “change in health status”.

CHC pathway items were identified and tabulated across reviewed articles by concept, guided by definitions and principles outlined in the KLM Development Guide. Authors Ken-Opurum and Darbishire worked first independently and then collaboratively to categorize concepts presented across articles until consensus was met.

Secondary Analysis

According to Aguinis et al. (2013), market basket analysis “is a data-mining technique that originated in the field of marketing to identify relationships between groups of products,

items, or categories" (Aguinis et al., 2013). We conducted a market basket analysis to determine sets of activities CHCs commonly reported across the logic model. This provides more robust and relevant results than a simple frequency analysis, as CHCs do not perform single pathway items, but rather perform pathway itemsets. Pathway itemsets refer to a set of pathway items occurring together; e.g., "community buy-in" is a pathway item, whereas "funding, hold regular meetings, community focus groups, cancer screenings" is a pathway itemset consisting of 4 pathway items.

Other public health researchers also have applied market basket analysis; e.g., to identify student dietary and physical activity patterns, weight status and management strategies, and perceptions about school meal and vending machine offerings (Liew, 2018), to explore the regularity of physical activity patterns in relation to daily sleeping patterns and access/proximity to exercise equipment (Sharma et al., 2015), to determine common co-occurring causes of fatigue and subsequent coping mechanisms among manufacturing employees (Lu et al., 2017), and to mine the National Health and Nutrition Examination Survey for comorbidities of diabetes and high blood pressure (Lee et al., 2013). Market basket analysis has also been applied in operations/management research for optimizing work flow and outputs; e.g., for improving customer relationship management (Ngai et al., 2009), to make context-specific recommendations for resolving partnership disputes (Chou et al., 2016), and for bridging "micro-macro and science-practice divides" in management research, including human resource management, organizational behavior, entrepreneurship, and strategic management (Aguinis et al., 2013). Thus, as theories around work flow and optimization in operations/management research are conceptually similar to the public health logic model, we posit that market basket

analysis is an appropriate method for understanding the progression of rural CHCs through inputs to impact.

To prepare our data for market basket analysis, we entered the results from the primary analysis into a binary matrix, where 0 indicated that a pathway item did not occur, and 1 indicated that the pathway item did occur in the referenced article. Pathway items that occurred in less than two articles were dropped. Lift, confidence, and support are commonly reported measures in market basket analysis. We only report on support due to small sample size (n=30). Support is defined as the proportion of articles in which a pathway itemset occurred; e.g., if a pathway itemset occurred in 3 of 30 articles, support is 0.1. We consider pathway itemsets with high support to be of greater significance. The specifications for the market basket analysis were: apriori algorithm, minimum support=0.06; minimum itemset length=2; target=frequent itemsets; return only itemsets where all pathway items are present.

Evidence Synthesis

Search

Our search strategy yielded 106 unique references. 64 references were excluded after initial screening because they either did not meet the PICOS criteria, were not available in full-text, or were not primary research. 12 additional articles were excluded after secondary screening because they did not meet our definition of a CHC, covered a geographic area larger than the community- or county-level, were methods papers, or did not delineate the pathways of the CHC across the logic model (Figure 3). Thus, 30 articles (Andrews et al., 2014; Barnidge et al., 2015; Bencivenga et al., 2008; Brownson et al., 2004; Brownson et al., 1996; Carvalho et al., 2013; Chalmers et al., 2003; Chinman et al., 2014; Davis et al., 2014; Fouad et al., 2004; Friedell et al.,

2001; Greenberg et al., 2015; Hill et al., 2008; Horne et al., 2013; Jaros et al., 2001; Jenkins et al., 2004; Kegler et al., 2008; Kluhsman et al., 2006; Lengerich et al., 2007; Luque et al., 2011; Mahon et al., 2007; Martinez-Donate et al., 2015; McFall et al., 2005; Mueller-Luckey et al., 2017; Page-Reeves et al., 2014; Plescia et al., 2004; Redmond et al., 2009; Schetzina et al., 2011; Smith et al., 2011; Ward et al., 2006) were included in this systematic review.

Data Abstraction

The following information was abstracted from each reviewed article: CHC focus, study design, theoretical framework/guiding principles, outcomes assessment, and analysis (Table 11). CHC foci included: cancer (Bencivenga et al., 2008; Fouad et al., 2004; Friedell et al., 2001; Jaros et al., 2001; Kluhsman et al., 2006; Lengerich et al., 2007; Luque et al., 2011; Mueller-Luckey et al., 2017; Ward et al., 2006), childhood obesity prevention (Davis et al., 2014; Page-Reeves et al., 2014; Schetzina et al., 2011), adult obesity prevention (Barnidge et al., 2015), physical activity/active living (Brownson et al., 2004; Smith et al., 2011), nutrition/healthy eating (Carvalho et al., 2013; Martinez-Donate et al., 2015), diabetes prevention and control (Hill et al., 2008; Jenkins et al., 2004), chronic disease prevention (Horne et al., 2013; Plescia et al., 2004), cardiovascular disease (Brownson et al., 1996; Chalmers et al., 2003), community health improvement (Kegler et al., 2008; McFall et al., 2005), tobacco control (Mahon et al., 2007), maternal/child health (Andrews et al., 2014), early childhood health (Chinman et al., 2014), youth substance misuse reduction (Greenberg et al., 2015), and reducing adolescent problem behaviors/promoting family health (Redmond et al., 2009). Study designs fell into three broad categories: 1. case studies (n=15) (Andrews et al., 2014; Barnidge et al., 2015; Brownson et al., 1996; Chalmers et al., 2003; Fouad et al., 2004; Hill et al., 2008; Horne et al., 2013; Jenkins et al., 2004; Kegler et al., 2008; Kluhsman et al., 2006; Luque et al., 2011; Mahon et al., 2007;

McFall et al., 2005; Mueller-Luckey et al., 2017; Plescia et al., 2004), 2. non-controlled community interventions (n=10) (Bencivenga et al., 2008; Carvalho et al., 2013; Chinman et al., 2014; Davis et al., 2014; Friedell et al., 2001; Jaros et al., 2001; Lengerich et al., 2007; Page-Reeves et al., 2014; Schetzina et al., 2011; Smith et al., 2011), and 3. community controlled trials (n=5) (Brownson et al., 2004; Greenberg et al., 2015; Martinez-Donate et al., 2015; Redmond et al., 2009; Ward et al., 2006). 26 articles (Andrews et al., 2014; Barnidge et al., 2015; Brownson et al., 2004; Brownson et al., 1996; Chinman et al., 2014; Davis et al., 2014; Fouad et al., 2004; Friedell et al., 2001; Greenberg et al., 2015; Hill et al., 2008; Horne et al., 2013; Jenkins et al., 2004; Kegler et al., 2008; Kluhsman et al., 2006; Lengerich et al., 2007; Luque et al., 2011; Mahon et al., 2007; Martinez-Donate et al., 2015; McFall et al., 2005; Mueller-Luckey et al., 2017; Page-Reeves et al., 2014; Plescia et al., 2004; Redmond et al., 2009; Schetzina et al., 2011; Smith et al., 2011; Ward et al., 2006) applied a theoretical framework/guiding principles; the most common being Community Based Participatory Research (Andrews et al., 2014; Barnidge et al., 2015; Davis et al., 2014; Lengerich et al., 2007; Luque et al., 2011; Mueller-Luckey et al., 2017; Schetzina et al., 2011; Ward et al., 2006), followed by other participatory research designs (Davis et al., 2014; Hill et al., 2008; Jenkins et al., 2004; Mahon et al., 2007; Martinez-Donate et al., 2015). Outcomes assessment targeted either coalition members (Andrews et al., 2014; Barnidge et al., 2015; Carvalho et al., 2013; Chalmers et al., 2003; Chinman et al., 2014; Davis et al., 2014; Friedell et al., 2001; Greenberg et al., 2015; Hill et al., 2008; Horne et al., 2013; Kegler et al., 2008; Kluhsman et al., 2006; Lengerich et al., 2007; Luque et al., 2011; Mahon et al., 2007; McFall et al., 2005; Mueller-Luckey et al., 2017; Plescia et al., 2004) or community members (Bencivenga et al., 2008; Brownson et al., 2004; Brownson et al., 1996; Fouad et al., 2004; Jaros et al., 2001; Jenkins et al., 2004; Lengerich et al., 2007; Mahon et al., 2007;

Martinez-Donate et al., 2015; McFall et al., 2005; Page-Reeves et al., 2014; Redmond et al., 2009; Schetzina et al., 2011; Smith et al., 2011; Ward et al., 2006). Outcomes were assessed via qualitative (Barnidge et al., 2015; Carvalho et al., 2013; Chalmers et al., 2003; Chinman et al., 2014; Davis et al., 2014; Fouad et al., 2004; Friedell et al., 2001; Hill et al., 2008; Horne et al., 2013; Jaros et al., 2001; Lengerich et al., 2007; Mahon et al., 2007; McFall et al., 2005; Page-Reeves et al., 2014; Plescia et al., 2004) and quantitative (Andrews et al., 2014; Bencivenga et al., 2008; Brownson et al., 2004; Brownson et al., 1996; Chalmers et al., 2003; Davis et al., 2014; Greenberg et al., 2015; Jaros et al., 2001; Jenkins et al., 2004; Kegler et al., 2008; Kluhsman et al., 2006; Lengerich et al., 2007; Luque et al., 2011; Martinez-Donate et al., 2015; Mueller-Luckey et al., 2017; Redmond et al., 2009; Schetzina et al., 2011; Smith et al., 2011; Ward et al., 2006) analyses.

Risk of Bias

Overall risk of bias was low (Table 12). Although we did not exclude any article based on risk of bias, CHCs receiving high levels of funding and technical support are likely to progress further along the public health logic model than CHCs receiving no/limited funding or operating independently. We did not report the level of funding granted to CHCs because this information was reported inconsistently. Additionally, quantity and quality of technical support was not specified within studies. Finally, because our analysis retrospectively applies the KLM to rural CHCs, it is almost certain that some (perhaps many) pathway items were not reported despite having occurred in practice.

Primary Analysis: Frequency of Pathway

Table 13 describes the reported CHC pathways across the KLM. The 10 most frequently reported pathway items were (Figure 4, Panel A):

- partner diversity (Andrews et al., 2014; Barnidge et al., 2015; Bencivenga et al., 2008; Brownson et al., 2004; Brownson et al., 1996; Carvalho et al., 2013; Chalmers et al., 2003; Chinman et al., 2014; Davis et al., 2014; Fouad et al., 2004; Friedell et al., 2001; Greenberg et al., 2015; Hill et al., 2008; Horne et al., 2013; Jaros et al., 2001; Jenkins et al., 2004; Kegler et al., 2008; Kluhsman et al., 2006; Lengerich et al., 2007; Luque et al., 2011; Mahon et al., 2007; Martinez-Donate et al., 2015; McFall et al., 2005; Mueller-Luckey et al., 2017; Page-Reeves et al., 2014; Plescia et al., 2004; Redmond et al., 2009; Schetzina et al., 2011; Smith et al., 2011; Ward et al., 2006) (n=30)
- organizational structures (Andrews et al., 2014; Barnidge et al., 2015; Bencivenga et al., 2008; Brownson et al., 2004; Brownson et al., 1996; Carvalho et al., 2013; Chalmers et al., 2003; Chinman et al., 2014; Davis et al., 2014; Fouad et al., 2004; Friedell et al., 2001; Greenberg et al., 2015; Hill et al., 2008; Horne et al., 2013; Jaros et al., 2001; Jenkins et al., 2004; Kegler et al., 2008; Kluhsman et al., 2006; Lengerich et al., 2007; Luque et al., 2011; Mahon et al., 2007; McFall et al., 2005; Mueller-Luckey et al., 2017; Page-Reeves et al., 2014; Plescia et al., 2004; Redmond et al., 2009; Schetzina et al., 2011; Smith et al., 2011; Ward et al., 2006) (n=29)
- implementing pilot studies/programs/interventions/etc. (Andrews et al., 2014; Barnidge et al., 2015; Bencivenga et al., 2008; Brownson et al., 2004; Brownson et al., 1996; Carvalho et al., 2013; Chalmers et al., 2003; Chinman et al., 2014; Davis et al., 2014; Friedell et al., 2001; Greenberg et al., 2015; Hill et al., 2008; Horne et al., 2013; Jaros et al., 2001;

Jenkins et al., 2004; Kegler et al., 2008; Kluhsman et al., 2006; Luque et al., 2011; Mahon et al., 2007; Martinez-Donate et al., 2015; McFall et al., 2005; Page-Reeves et al., 2014; Plescia et al., 2004; Redmond et al., 2009; Schetzina et al., 2011; Smith et al., 2011; Ward et al., 2006) (n=27)

- funding (Andrews et al., 2014; Barnidge et al., 2015; Bencivenga et al., 2008; Brownson et al., 2004; Brownson et al., 1996; Carvalho et al., 2013; Chalmers et al., 2003; Chinman et al., 2014; Davis et al., 2014; Fouad et al., 2004; Friedell et al., 2001; Greenberg et al., 2015; Hill et al., 2008; Horne et al., 2013; Jaros et al., 2001; Jenkins et al., 2004; Kegler et al., 2008; Luque et al., 2011; Mahon et al., 2007; Martinez-Donate et al., 2015; McFall et al., 2005; Page-Reeves et al., 2014; Plescia et al., 2004; Smith et al., 2011; Ward et al., 2006) (n=25)
- community engagement/outreach (Andrews et al., 2014; Barnidge et al., 2015; Bencivenga et al., 2008; Brownson et al., 2004; Brownson et al., 1996; Carvalho et al., 2013; Chalmers et al., 2003; Davis et al., 2014; Fouad et al., 2004; Friedell et al., 2001; Greenberg et al., 2015; Hill et al., 2008; Horne et al., 2013; Jaros et al., 2001; Jenkins et al., 2004; Kegler et al., 2008; Kluhsman et al., 2006; Lengerich et al., 2007; Luque et al., 2011; Mahon et al., 2007; Mueller-Luckey et al., 2017; Page-Reeves et al., 2014; Redmond et al., 2009; Smith et al., 2011) (n=24)
- university partners (Andrews et al., 2014; Barnidge et al., 2015; Brownson et al., 2004; Carvalho et al., 2013; Chalmers et al., 2003; Davis et al., 2014; Fouad et al., 2004; Friedell et al., 2001; Greenberg et al., 2015; Hill et al., 2008; Jenkins et al., 2004; Kluhsman et al., 2006; Lengerich et al., 2007; Luque et al., 2011; Martinez-Donate et al., 2015; Mueller-

Luckey et al., 2017; Redmond et al., 2009; Schetzina et al., 2011; Ward et al., 2006) (n=19)

- holding regular meetings (Andrews et al., 2014; Barnidge et al., 2015; Brownson et al., 2004; Chalmers et al., 2003; Chinman et al., 2014; Fouad et al., 2004; Greenberg et al., 2015; Hill et al., 2008; Horne et al., 2013; Jaros et al., 2001; Lengerich et al., 2007; Luque et al., 2011; Mahon et al., 2007; McFall et al., 2005; Mueller-Luckey et al., 2017; Redmond et al., 2009; Ward et al., 2006) (n=17)
- having working groups/subcommittees/etc. (Andrews et al., 2014; Barnidge et al., 2015; Brownson et al., 1996; Carvalho et al., 2013; Chinman et al., 2014; Friedell et al., 2001; Greenberg et al., 2015; Hill et al., 2008; Horne et al., 2013; Jaros et al., 2001; Lengerich et al., 2007; Mahon et al., 2007; McFall et al., 2005; Mueller-Luckey et al., 2017; Redmond et al., 2009; Ward et al., 2006) (n=16)
- operating under/partnering with a regional research initiative (Barnidge et al., 2015; Bencivenga et al., 2008; Brownson et al., 2004; Brownson et al., 1996; Chalmers et al., 2003; Friedell et al., 2001; Jaros et al., 2001; Jenkins et al., 2004; Kegler et al., 2008; Kluhsman et al., 2006; Lengerich et al., 2007; Luque et al., 2011; Mueller-Luckey et al., 2017; Plescia et al., 2004; Ward et al., 2006) (n=15)
- conducting a community health/needs assessment (Andrews et al., 2014; Brownson et al., 1996; Carvalho et al., 2013; Chinman et al., 2014; Fouad et al., 2004; Hill et al., 2008; Horne et al., 2013; Jenkins et al., 2004; Kegler et al., 2008; Lengerich et al., 2007; Luque et al., 2011; Martinez-Donate et al., 2015; McFall et al., 2005; Page-Reeves et al., 2014; Plescia et al., 2004) (n=15)

The most frequently occurring pathway items under each logic model phase were (Figure 4, Panel A):

- Inputs/resources: partner diversity (Andrews et al., 2014; Barnidge et al., 2015; Bencivenga et al., 2008; Brownson et al., 2004; Brownson et al., 1996; Carvalho et al., 2013; Chalmers et al., 2003; Chinman et al., 2014; Davis et al., 2014; Fouad et al., 2004; Friedell et al., 2001; Greenberg et al., 2015; Hill et al., 2008; Horne et al., 2013; Jaros et al., 2001; Jenkins et al., 2004; Kegler et al., 2008; Kluhsman et al., 2006; Lengerich et al., 2007; Luque et al., 2011; Mahon et al., 2007; Martinez-Donate et al., 2015; McFall et al., 2005; Mueller-Luckey et al., 2017; Page-Reeves et al., 2014; Plescia et al., 2004; Redmond et al., 2009; Schetzina et al., 2011; Smith et al., 2011; Ward et al., 2006) (n=30)
- Internal activities: holding regular meetings (Andrews et al., 2014; Barnidge et al., 2015; Brownson et al., 2004; Chalmers et al., 2003; Chinman et al., 2014; Fouad et al., 2004; Greenberg et al., 2015; Hill et al., 2008; Horne et al., 2013; Jaros et al., 2001; Lengerich et al., 2007; Luque et al., 2011; Mahon et al., 2007; McFall et al., 2005; Mueller-Luckey et al., 2017; Redmond et al., 2009; Ward et al., 2006) (n=17)
- External activities: implementing pilot studies/programs/interventions/etc. (Andrews et al., 2014; Barnidge et al., 2015; Bencivenga et al., 2008; Brownson et al., 2004; Brownson et al., 1996; Carvalho et al., 2013; Chalmers et al., 2003; Chinman et al., 2014; Davis et al., 2014; Friedell et al., 2001; Greenberg et al., 2015; Hill et al., 2008; Horne et al., 2013; Jaros et al., 2001; Jenkins et al., 2004; Kegler et al., 2008; Kluhsman et al., 2006; Luque et al., 2011; Mahon et al., 2007; Martinez-Donate et al., 2015; McFall et al., 2005; Page-Reeves et al., 2014; Plescia et al., 2004; Redmond et al., 2009; Schetzina et al., 2011; Smith et al., 2011; Ward et al., 2006) (n=27)

- Coalition outputs: production/revision of coalition research materials (Carvalho et al., 2013; Fouad et al., 2004; Mueller-Luckey et al., 2017; Schetzina et al., 2011; Ward et al., 2006) (n=5)
- Short-term outcomes: program reach (Bencivenga et al., 2008; Brownson et al., 2004; Brownson et al., 1996; Friedell et al., 2001; Jaros et al., 2001; Jenkins et al., 2004; Kluhsman et al., 2006; Redmond et al., 2009; Smith et al., 2011) (n=9)
- Medium-term outcomes: health screenings (Bencivenga et al., 2008; Brownson et al., 1996; Friedell et al., 2001; Hill et al., 2008; Jaros et al., 2001; Jenkins et al., 2004; Kluhsman et al., 2006; Luque et al., 2011) (n=8)
- Long-term outcomes: change in health status (Bencivenga et al., 2008; Jenkins et al., 2004; Page-Reeves et al., 2014) (n=3)
- Impact: changes to health systems (Bencivenga et al., 2008; Friedell et al., 2001; Hill et al., 2008; Jaros et al., 2001; Jenkins et al., 2004; Kluhsman et al., 2006; Luque et al., 2011; Plescia et al., 2004; Smith et al., 2011) and environments (Barnidge et al., 2015; Brownson et al., 2004; Davis et al., 2014; Hill et al., 2008; Horne et al., 2013; Martinez-Donate et al., 2015; Page-Reeves et al., 2014; Schetzina et al., 2011; Smith et al., 2011) (n=9 for both)

Secondary Analysis: Market Basket Analysis

The market basket analysis returned 14,374,685 unique itemsets of lengths 2 to 23 (data available upon request). Itemsets of shorter length had the highest support, i.e., occurred more frequently across reviewed articles: support = 0.966667 for itemsets of length 2, e.g., "*partner diversity, organizational structures"* versus support = 0.066667 for an itemset of length 23.

However, there were more combinations of itemsets between lengths 9 to 12, where the itemset length for the 1st quartile was 9, the median was 11, the mean was 10.64, and the 3rd quartile was 12. This distribution gives us insight into the number of pathway items that two or more coalitions reported as itemsets.

- The highest support for itemset length 9 was 0.2: e.g., *regional research initiative, partner diversity, organizational structures, implement pilot study/programs/interventions/etc., healthcare/health systems interventions, deliver community education, community engagement/outreach, system change, health screenings*
- The highest support for itemset length 10 was 0.167: e.g. *regional research initiative, organizational structures, implement pilot study/programs/interventions/etc., healthcare/health systems interventions, deliver community education, community engagement/outreach, program reach, screening programs established, system change, health screenings*
- The highest support for itemset length 11 was 0.167: e.g., *regional research initiative, partner diversity, organizational structures, implement pilot study/programs/interventions/etc., healthcare/health systems interventions, deliver community education, community engagement/outreach, program reach, screening programs established, system change, health screenings*
- The highest support for itemset length 12 was 0.133: e.g., *regional research initiative, partner diversity, organizational structures, implement pilot study/programs/interventions/etc., healthcare/health systems interventions, deliver*

community education, community engagement/outreach, program reach, cancer screenings, screening programs established, system change, health screenings

The high number of itemsets between lengths 9 to 12 and the relatively low support level at each of these itemset lengths indicate that CHCs pursued differing activities and pathways to impact local health. Thus, an overly simplified "one size fits all" approach may minimize the necessity of and opportunities for program adaptation. Although we identified over 100 pathway items across reviewed articles (Table 13), there was limited overlap between CHC pathways itemsets, with reporting skewed towards inputs/resources and internal activities. Likewise, CHC pathways appear to diverge after the "planned work" stage depending on the health topic; and CHCs focusing on health topics with well-defined, easily measured immediate outcomes may have fewer difficulties with reporting. Thus, it may be possible to provide recommendations for best practices to CHCs in the early phases of the logic model, but recommending activities for achieving improvements in community health remains a major challenge.

Comparison of Primary and Secondary Analyses

To compare the findings from our primary and secondary analyses, we reran the market basket analysis with only the most frequently occurring pathway items from the primary analysis. The specifications for the market basket analysis were: apriori algorithm, minimum support=0.06; minimum itemset length=2; target=frequent itemsets; return only itemsets where all items are present. This analysis resulted in 4,811 unique itemsets, where the itemset length for the 1st quartile was 4, the median was 5, the mean was 5.3, and the 3rd quartile was 6.0 (data availabe upon request). The longest itemset legth was 10; there were 5 variants of itemsets at this length, all with a support of 0.067:

- *funding, regional research initiative, partner diversity, organizational structures, implement pilot studies/programs/interventions/etc., community engagement/outreach, program reach, change in health systems, change in health status, health screenings*
- *funding, regional research initiative, partner diversity, organizational structures, working groups/subcommittees/etc., implement pilot studies/programs/interventions/etc., community engagement/outreach, program reach, change in health systems, health screenings*
- *funding, regional research initiative, partner diversity, university partners, organizational structures, implement pilot studies/programs/interventions/etc., community engagement/outreach, program reach, change in health systems, health screenings*
- *funding, regional research initiative, partner diversity, university partners, organizational structures, conduct a community needs assessment, implement pilot studies/programs/interventions/etc., community engagement/outreach, change in health systems, health screenings*
- *funding, partner diversity, university partners, organizational structures, conduct a community needs assessment, hold regular meetings, implement pilot studies/programs/interventions/etc., community engagement/outreach, change in health systems, health screenings.*

Thus, with the data set derived from the 30 reviewed articles (Table 13), we were not able to empirically confirm that the most frequent pathway items from the primary analysis occurred as an itemset.

To explore the robustness of reporting for "planned work" pathway items, we searched for the maximum itemset length at a support of ≥0.5 (i.e., whereby itemsets occurred in at least 15/30 reviewed articles). The result was an itemset length of 5, with support of 0.533:

- *funding, partner diversity, organizational structures, implement pilot study/programs/interventions/etc., community engagement/outreach.*

There were also 7 itemsets at length 4 and support ≥0.5:

- *funding, partner diversity, organizational structures, implement pilot studies/programs/interventions/etc.*
- *partner diversity, organizational structures, implement pilot study/programs/interventions/etc., community engagement/outreach*
- *funding, partner diversity, organizational structures, community engagement/outreach*
- *funding, organizational structures, implement pilot study/programs/interventions/etc., community engagement/outreach*
- *funding, partner diversity, implement pilot study/programs/interventions/etc., community engagement/outreach*
- *partner diversity, university partners, organizational structures, community engagement/outreach*
- *partner diversity, university partners, organizational structures, implement pilot studies/programs/interventions/etc.*

By combining the itemsets with lengths 4 and 5 and support ≥0.5, we can infer that the typical rural CHC is progressing through the public health logic model as such: ***funding, partner***

diversity, university partners, organizational structures, community engagement/outreach, implement pilot studies/programs/interventions (Figure 4, Panel B). There appears to be a core set of 6 pathway items that is common among CHCs. 4 of the 6 core pathway items are inputs/resources (funding, partner diversity, university partners, and organizational structures), while the other 2 are external activities (community engagement/outreach and implementing pilot studies/programs/interventions/etc.).

Importantly, the goal of many CHCs is to improve local health, which includes but does not end at community engagement and program delivery. Although researcher-lead community interventions may result in measurable outcomes, local and federal support for CHCs relies on the assumption that CHCs have a greater capacity to elicit long-term sustainable community health improvements than researcher-led interventions. However, the methodology for measuring and reporting distal outcomes of CHC activities has not been well developed.

Conclusions

In summary, we retrospectively applied the KLM to assess rural CHC activities, then tabulated the results and conducted a market basket analysis to mine for commonly occurring logic model pathways. We found that:

- The progression of rural CHCs through the public health logic model is variable.
- Some CHCs reported activities from inputs to impact, while others reported solely on the "planned work" phases of the logic model.
- CHCs pursued diverse activities related to capacity building and internal functioning.

These observations are consistent with the extant literature that focuses mainly on capacity building and internal functioning. For example, Zakocs and Edwards (2006) found that the most commonly reported measures of coalition effectiveness related to internal functioning and coalition building factors, while few described external community change (Zakocs et al., 2006). Additionally, Shapiro et al. (2013) developed a model for coalition functioning (including goal-directedness, efficiency, opportunities for participation, and cohesion), highlighting the importance of not only coalition capacity, but also reporting, tracking, and evaluation (Shapiro et al., 2013). Metzger et al. (2005) also describe the crucial role of "empowering leadership" and decision making processes on member participation (Metzger et al., 2005), which precedes coalition activities, outcomes, and impact. Finally, Butterfoss et al. (2003) (Butterfoss et al., 2003) and Butterfoss (2004) (Butterfoss, 2004) demonstrated the value of coalition training and technical assistance for capacity building and sustainability of partnerships and activities.

However, we found that internal activities seldom occurred in itemsets with high support, suggesting that CHCs employ a diverse variety of internal functioning and capacity building practices. Similarly, in a review of quality care improvement strategies in nursing home facilities, Miller et al. (1995) found that many strategies were employed to address a wide range of problems. Thus, recommendations for best practice were outlined in a general process, whose success is likely determined by the engagement and commitment of actors involved rather than the process itself (Miller et al., 1995). This is consistent with our findings that CHCs reporting the 6 core pathways items may have increased capacity for long-term success. We also found that:

- Some CHCs are making changes to local health policies, systems, and environments.

- Few rural CHCs have demonstrated improvements to local health.
- Many CHCs are engaging their communities and delivering programming that provides opportunities for immediate health behavior change.

We expected to find that Cooperative Extension System (Extension) partners would appear as one of most frequent pathway items and/or would have been appeared among the high-support (≥0.5) pathways itemsets because addressing rural health and health disparities through CHCs is a viable engagement strategy for Extension. Andress and Fitch (2016) described Extension's unique ability to promote health equity and address the social determinants of health by delivering culturally appropriate programming to communities (Andress et al., 2016). Goard and Dresbach (2003) described the success of Ohio State University Extension in initiating collaboration among diverse community partners to conduct a community health assessment (Goard et al., 2003). Extension in South Carolina (Parisi et al., 2018) and Kentucky (Scutchfield et al., 2007) act as the coordinating body for building local collaborations around statewide public health initiatives. Thus, the robust statewide networks of Extension professionals who receive training in evidence-based programming can be an important resource to CHCs seeking to implement interventions that affect rural policies, systems, and environments.

Limitations

Major limitations of CHC research consistent with our study include:

- Inconsistent reporting
- A lack of a common logic model for program design, delivery, and assessment.
- Publication bias; i.e., CHCs having university partners and/or state/federal/university funding are more likely to publish

Additionally, requests for proposals often require detailed methods in which logic models can be instrumental in conveying CHC processes and goals. Likewise, CHCs have different objectives for publishing, whether to describe the development of a newly established coalition or to celebrate the impact of a long-standing collaboration. As a result, there is variability in which logic model phases are described.

One methodological limitation is that we merged pathway items that were conceptually similar into broad categories. For example, the broad category of "organizational structures" included several specific subcategories; however, both the broad and specific subcategories were included in the analyses. Although this potentially diluted more nuanced findings, best practices often make non-specific recommendations that can be adapted to suit a CHC's needs. Merging some pathways items reduces the complexity and improves the translation of our findings.

Finally, we only reviewed articles in which CHCs served rural communities. Thus, our findings may not be translatable to non-rural settings. However, a distinction between rural and non-rural health needs may be warranted, as rural health is increasingly becoming recognized as an issue of health equity. As such, interest and support for rural CHCs continues to grow, especially with changing political climates, agricultural technological innovations, dynamic changes in the food systems, public demand for locally grown organic foods, and distrust of conventional agriculture.

Implications for Public Health

The continued development, support, and mobilization of CHCs is one viable strategy for closing the gap of rural health disparities. Thus, consistent documentation of CHC progression

through the public health logic model is crucial for building the evidence around making recommendations for best practices.

Arguably, CHCs are the most cognizant of their community's health needs and local capacity to address those needs. Thus, it is imperative that researchers allow CHCs to retain their autonomy. Researchers can celebrate CHC success by sharing their story through publication (whether scientific/academic or local). In this way, researchers can also impress upon CHCs the importance of telling their story in a way that can be shared across time and place. CHC work is an emerging science. As we build the methodology around this public health movement, consistent reporting and evaluation are essential.

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Population	Rural communities
Intervention	Presence of a community health coalition
Comparator	An account of the community health coalition over time
Outcomes	Community health coalition actions/steps/pathways reported across the public health logic model; i.e., pathway items
Study Design	All study designs meeting the PICO criteria were included

Figure 2: PICOS criteria for article inclusion

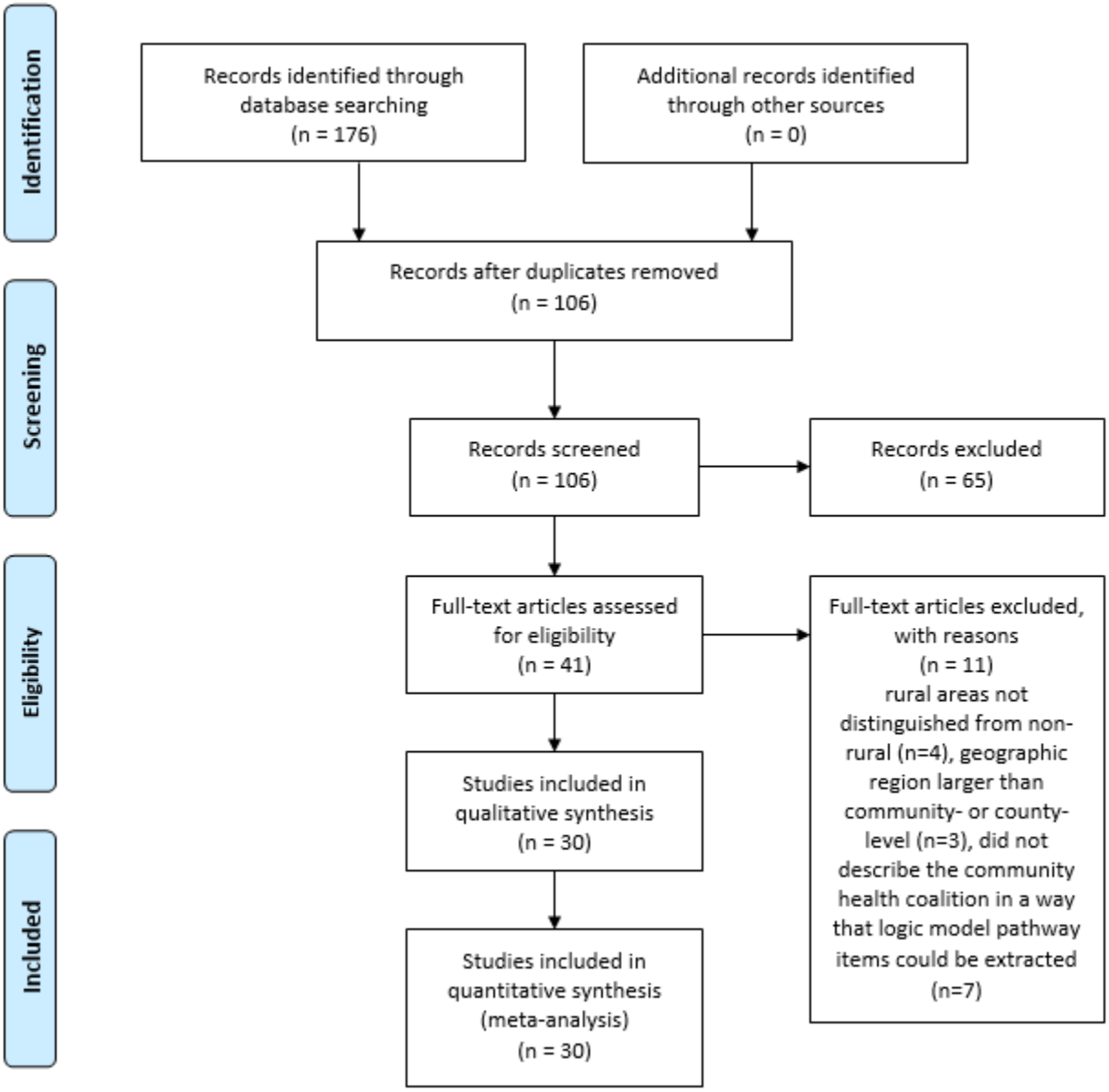

Figure 3: PRISMA Flow Chart
Study selection of articles meeting inclusion criteria.

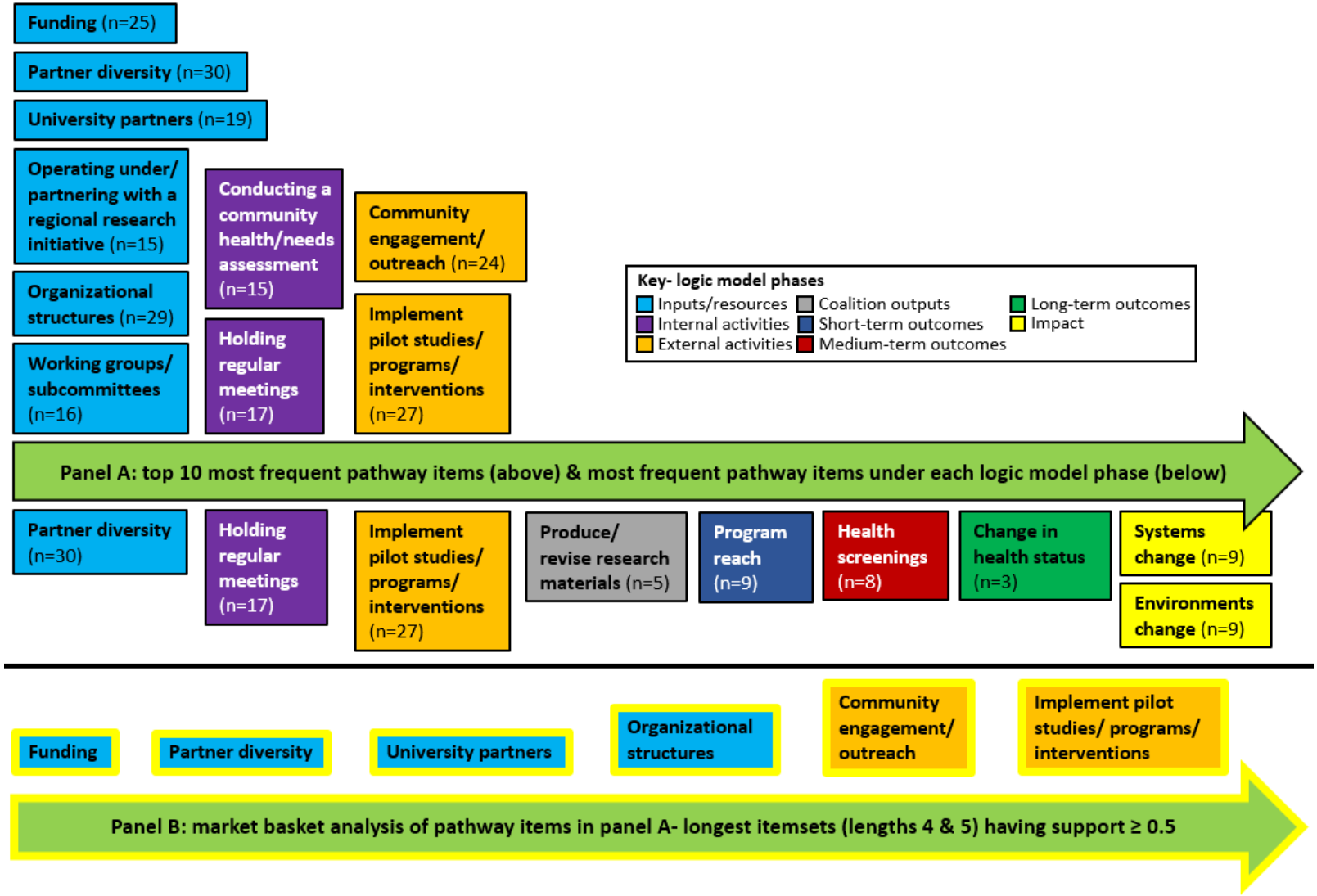

Figure 4: Community health coalitions progressing through the public health logic model

Panel A: count. Panel B: market basket analysis: apriori algorithm, minimum support=0.06; minimum itemset length=2; target=frequent itemsets; return only itemsets where all items are present. Support is the proportion of articles in which an itemset occurred. There was 1 itemset at length 5 and support 0.533 and 7 itemsets at length 4 and support 0.5.

Table 11: Article details

Article reference	Coalition focus/ health priority	Study design	Theoretical framework/ guiding principle (yes/ no)? Which one(s)?	Were coalition outcomes assessed (yes/ no)? Using what tool/ method?	How were coalition outcomes analyzed?
(Andrews et al., 2014)	Maternal/ child health	Multistage participatory evaluation design	Yes. CHIP; CBPR; social ecological framework	Yes. Online tracking/ data monitoring system; Coalition Self-Assessment Survey to coalition members	Count
(Barnidge et al., 2015)	Obesity prevention	Case study	Yes. CBPR; evidence-based public health	Yes. Group interviews to coalition members	Qualitative
(Bencivenga et al., 2008)	Cancer control (breast)	Non-controlled community-based intervention	No.	Yes. Number of no-cost mammograms provided	Count
(Brownson et al., 1996)	Cardiovascular disease	Case study	Yes. PATCH; Social Learning Theory; Stage Theory of Innovation	Yes. Risk factor survey to community members; media content analysis	Count; frequency; regression analysis-interrupted time series; linear regression analysis; student's t-test; analysis of variance
(Brownson et al., 2004)	Physical activity	Quasi-experimental design; 6 intervention, 6 comparison communities	Yes. Ecological frameworks; computer-based tailoring; self-efficacy; social support; perceived benefits and barriers; motivation health-related behaviors; resource availability; walking preference; positive reinforcement; motivation and support	Yes. Risk factor survey to community members	Analysis of variance
(Carvalho et al., 2013)	Nutrition	Non-controlled community-based intervention	No.	Yes. Project report forms; leader interviews; coalition focus groups	Qualitative
(Chalmers et al., 2003)	Cardiovascular disease	Process evaluation	No.	Yes. Monitoring system of coalition activities; interviews with event log recorders	Qualitative; descriptive statistics

Table 11 continued

(Chinman et al., 2014)	Early childhood health	Community intervention	Yes. GTO Framework; ECHO distance-learning approach	Yes. GTO Activity Monitoring Tool; GTO Capacity Interview; Plan Quality Index	Qualitative
(Davis et al., 2014)	Childhood obesity prevention	Non-controlled intervention	Yes. CE; CEnR; CHIP; CHIRP; CBPR	Yes. Surveys to participants regarding CHIRP process; pilot study evaluations	Qualitative; descriptive statistics
(Fouad et al., 2004)	Cancer control (breast and cervical-reduce racial disparities)	Case study	Yes. REACH 2010; logic model; MATCH	Yes. Community focus groups	Qualitative
(Friedell et al., 2001)	Cancer control (breast, cervical)	Non-randomized community trial: community interventions; control and intervention counties	Yes. Community activation	Yes. Tracking system of coalition activities	Qualitative
(Greenberg et al., 2015)	Substance misuse reduction	Community-level randomized trial	Yes. PROSPER	Yes. Surveys to team members and leaders	Descriptive statistics; bivariate correlations
(Hill et al., 2008)	Diabetes prevention and control	Case study	Yes. Community based participatory action; Border Health Strategic Initiative model	Yes. Culture of Health interviews with coalition members and community leaders; coalition Critical Reflections; Wilder Collaboration Factors Inventory	Qualitative
(Horne et al., 2013)	Chronic disease prevention	Case study	Yes. ACHIEVE	Yes. Surveys to coalition members	Qualitative
(Jaros et al., 2001)	Cancer control (breast, cervical)	Community-based intervention	No.	Yes. Community survey	Qualitative; count

Table 11 continued

(Jenkins et al., 2004)	Diabetes (health disparities)	Case report	Yes. REACH 2010; logic model; community-driven participatory action research	Yes. Medical record audits	Descriptive statistics; chi-squared test; paired t-tests
(Kegler et al., 2008)	Community health improvement	Multiple case study; cross-sectional analysis	Yes. Healthy cities and communities; social ecology	Yes. Survey to coalition members	Descriptive statistics
(Kluhsman et al., 2006)	Cancer control (colorectal, breast, other)	Cross-sectional	Yes. CCAT	Yes. Coalition data collection system	General estimating equations; Pearson chi-squared test
(Lengerich et al., 2007)	Cancer control (colorectal)	Non-controlled intervention	Yes. CBPR; PRECEDE-PROCEED model	Yes. City of Hope Quality of Life Survey to community members; Livestrong Survey for Post-Treatment Cancer Survivors to community members; qualitative review of coalition community plans	Qualitative; two-sided McNemar's test
(Luque et al., 2011)	Cancer control (cancer health disparities)	Case study	Yes. Program logic model; CBPR; CCAT	Yes. Social network analysis; perception surveys to coalition members	Social network analysis; bootstrap paired sample t-test; Quadratic Assignment Procedure; Kruskal-Wallis test; Wilcoxon Signed Rank test
(Mahon et al., 2007)	Tobacco control	Case study	Yes. Participatory approach	Yes. Key informant interviews with coalition coordinators; community surveys	Qualitative

Table 11 continued

(Martinez-Donate et al., 2015)	Healthy eating	Randomized community trial; 1 intervention, 1 control community	Yes. RE-AIM; SEM; participatory research approach; social marketing	Yes. Surveys to community members (customers) and intervention participants (store/ restaurant owners); Nutritional Environment Measures Surveys	Descriptive statistics; paired t-tests; multiple linear regression analysis; logistic regression analysis
(McFall et al., 2005)	Community health improvement	Comparative case study	Yes. Coalition development framework	Yes. Interviews to community members; interviews to project staff; community survey	Qualitative
(Mueller-Luckey et al., 2017)	Cancer control (lung)	Case study	Yes. CBPR	Yes. Sustainability Assessment of Materials tool to coalition members	Descriptive statistics
(Page-Reeves et al., 2014)	Childhood obesity prevention	Non-controlled community trial	Yes. Collective impact; culturally situated community interventions; "past-present-future"	Yes. Community interviews	Qualitative (latent structural content analysis)
(Plescia et al., 2004)	Chronic disease prevention	Case study	Yes. Community health planning theory	Yes. Stakeholder and steering committee interviews	Qualitative
(Redmond et al., 2009)	Youth and family health; adolescent problem behaviors	Randomized community trial; 14 intervention, 14 control communities	Yes. PROSPER; family risk and protective factor models; social influence model of prevention; health belief model; social learning theory; self-efficacy theory of behavior change; problem behavior theory	Yes. Surveys to students	Multivariate analysis of covariance
(Schetzina et al., 2011)	Childhood obesity prevention	Pilot study; non-controlled community intervention	Yes. CDC CSH model; CBPR	Yes. Surveys to students; surveys to teachers; student pedometer data; cafeteria menu/ nutrition environment data	Descriptive statistics; chi-squared test; independent t-tests

Table 11 continued

(Smith et al., 2011)	Active living	Non-controlled community intervention	Yes. 5Ps (preparation, promotion, programs, policy, and physical projects)	Yes. Surveys to program participants (pre- and post-test); key informant interviews	Descriptive statistics
(Ward et al., 2006)	Cancer control (colorectal)	CBPR pilot study; 2-group pilot intervention; pre-study post-study design with random selection of community organizations; 9 intervention, 9 matched control communities	Yes. Diffusion of innovations; CBPR	Yes. Surveys to participating organizations	Descriptive statistics; chi-squared test

ACHIEVE: Action Communities for Health, Innovation, and Environmental Change; CBPR: Community Based Participatory Research; CCAT: Community Coalition Action Theory; CE: Community Engagement; CEnR: Community Engaged Research; CDC: Centers for Disease Control and Prevention; CHIP: Community Health Improvement Partnership; CHIRP: Community Health Improvement and Research Partnership; CSH: Coordinated School Health; ECHO: Extension for Community Healthcare Outcomes; GTO: Getting to Outcomes; MATCH: Multi-level Approach to Community Health; PATCH: Planned Approach to Community Health; PRECEDE-PROCEED: *no acronym*; PROSPER: Promoting School-community-university Partnerships to Enhance Resilience; REACH: Racial and Ethnic Approaches to Community Health; RE-AIM: Reach- Adoption, Implementation, Maintenance; SEM: Social Ecological Model

Table 12: Risk of bias across reviewed articles

Article reference	1. Was there a clear statement of the aims of the research?	2. Is a qualitative methodology appropriate?	3. Was the research design appropriate to address the aims of the research?	4. Was the recruitment strategy appropriate to the aims of the research?	5. Was the data collected in a way that addressed the research issue?	6. Has the relationship between researcher and participants been adequately considered?	7. Have ethical issues been taken into consideration?	8. Was the data analysis sufficiently rigorous?	9. Is there a clear statement of findings?	10. How valuable is the research?
(Andrews et al., 2014)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Barnidge et al., 2015)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Bencivenga et al., 2008)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Brownson et al., 1996)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes
(Brownson et al., 2004)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Carvalho et al., 2013)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Chalmers et al., 2003)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Chinman et al., 2014)	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
(Davis et al., 2014)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Fouad et al., 2004)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Friedell et al., 2001)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
(Greenberg et al., 2015)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes

Table 12 continued

(Hill et al., 2008)	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
(Horne et al., 2013)	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
(Jaros et al., 2001)	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
(Jenkins et al., 2004)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Kegler et al., 2008)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
(Kluhsman et al., 2006)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Lengerich et al., 2007)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Luque et al., 2011)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Mahon et al., 2007)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Martinez-Donate et al., 2015)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(McFall et al., 2005)	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
(Mueller-Luckey et al., 2017)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes
(Page-Reeves et al., 2014)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Plescia et al., 2004)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Redmond et al., 2009)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 12 continued

(Schetzina et al., 2011)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Smith et al., 2011)	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
(Ward et al., 2006)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Risk of bias determined by the Critical Appraisal Skills Programme checklist for qualitative research (https://casp-uk.net/wp-content/uploads/2018/01/CASP-Qualitative-Checklist-2018.pdf).

Table 13: Rural community health coalition pathways through the W.K. Kellogg Foundation Logic Model

Inputs/ resources	**Internal activities (i.e., capacity building/ internal functioning)**	**External activities (i.e., delivery of programs and interventions)**	**Coalition outputs (relating to coalition)**	**Short-term outcomes; change in knowledge (relating to target population)**	**Medium-term outcomes; change in behavior (relating to target population)**	**Long-term outcomes; change in health (relating to target population)**	**Impacts; i.e., PSE change**
• Funding[1-25] ○ University[12,13,19] ○ CTSA[9] ○ DOH[1,4,7,15,21] ○ CDC[2,5,10,13,15,16,21] ○ Prevention Research Center[6,7] ○ USDA[13] ○ NIH[16] ○ NCI[11,15,24,25] ○ AHRQ[20] ○ HRSA[13,22] ○ Other federal grants[8,14] ○ State[14,15] ○ Local/ fundraising[7,12,23,25] ○ American Cancer Society[3] ○ Other private foundation[17,18,23] • Regional research initiative[2-5,7,11,15-17,22,24-28]	• Set priorities/ goals/ objectives/ mission statement[1,2,10,12,14,16,17,20,21,24] • Conduct a community health/ needs assessment[1,4,6,8,10,13,14,16,17,19-22,25,27] • Use of secondary data for coalition program design/ assessment[4,5,9,11,14-16,20,23,24,27,28] • Develop a community health improvement/ action plan[1,2,8,10,13,14,16,17,20,22,27] • Hold regular meetings (i.e., reported as a count/ frequency)[1,2,5,7,8,10,12-15,18,20,24,25,27-29] • Member recruitment/	• Implement pilot studies/ programs/ interventions/ services/ evidence-based interventions & programs[1-9,11-26,29,30], e.g.: ○ Physical activity[2,4,5,7,13,16,23,30] ○ Nutrition[2,4-6,9,13,16,19,21,23,30] ○ Healthcare/ health systems[1,3,8,11,13,15,16,20,22,23,25,26] ○ Worksite wellness[14,23] • Deliver community education[1,3,4,10,11,13-16,18,23,25,26] • Community engagement/	• Study findings shared with the coalition[1,7,25,28] • Coalitions tracking/ monitoring/ evaluation system developed/ employed[1,7,11,26] • Coalition research materials produced/ revised[6,10,24,28,30] ○ Coalition revised study materials[30] ○ Protocol adaptation[6,24]	• Community buy-in[2,12,13,21,23] • Study findings shared with community[2,7,9,13] • Program reach[3-5,11,15,16,23,26,29] • Knowledge of the coalition increased[4] • Knowledge of health topic increased[4,13,15,16,19,21,29] • Change in attitude/ skills regarding health topic[21,23,24,29,30]	• Screenings[3,4,11,13,15,16,25,26] ○ Cancer[3,11,15,25,26] ○ Blood pressure[4] ○ Diabetes[13,16] • Improved blood pressure self-management[23] • Improved diabetes self-management[23] • Improved nutrient intake[9,21,23,30] • Increased physical activity[5,23,30]	• Change in health status[3,16,21] ○ Breast cancer cases treated[3] ○ Decrease in diabetes-related health disparities for African Americans[16] ○ Decreased childhood overweight[21]	• Policies[1,5,9,13] ○ New policies implemented (not specified)[1] ○ Smoke free air policies[5] ○ Shared use agreements for physical activities[5] ○ School wellness committees formed[13] ○ Change in school lunch/ food policy[9,13] • Systems[3,11,13,15,16,22,23,25,26] ○ Screening programs established[3,11,15,16,26]

Table 13 continued

○ Appalachian Community Cancer Network[3,24,26,27] ○ Appalachian Leadership Initiative on Cancer[11] ○ Tampa Bay Community Cancer Network[25] ○ Bootheal Heart Health Project[4,5] ○ Ozark Heart Health Project[7] ○ Other [2,15-17,22,28] • Partner diversity*[1-30] ○ DOH[1,2,7,10,11,13-16,18,20,22,25,28] ○ University[1,2,5-7,9-13,16,19,24-30] ○ Cooperative Extension System[3,10-12,18,20,27,29] • Organizational structures**[1-18,20-30] ○ Coalition/ project coordinator(s)[1,6,7,9-12,15,17,18,21,22,30] ○ Coalition/ project staff[2,3,11,16,22,23,26,29]	partnership building[1,2,7,10-15,20,21,23,25] • Receive research training[1-3,6,7,9-11,13,24-27] • Receive technical assistance/ training[6,8,11,12,14-16,18,20,28,29] • Receive leader training[11,14] • Report/ track coalition activities[1,7,11,26] • Grant writing[1,9-11,13,14,22,25,29] Sustainability planning[2,7,12,17]	outreach[1-7,9-18,21,23,25-29] • Policy advocacy[1,13,18] • Media campaign[2-7,11,13-15,18,19,24] • Community focus groups[5,10,16] • Community surveys[4,5,13,15,16,18-21,23,24,27] • Health fairs[7,11,16] • Cancer screening referrals made to community members[3,11]	○ Develop community focus group protocols[10] ○ Coalition mini reports developed[28] • Coalition partnership/ leadership transformation[2,9,16,17] ○ Change in partnership model[2,9] ○ Develop Health Information Network[16] ○ New leadership roles developed[17]		• Reduced/ delayed adolescent substance misuse[12,29]		○ Increased health insurance coverage[25] ○ Improved diabetes care system[13,16] ○ Improved systems of care[22,23] • Environments[2,5,9,13,14,19,21,23,30] ○ Community gardens[2,14,21] ○ Improved school physical activity environment[2] ○ Walking/ biking trails developed[5,9,14,23] ○ Improved school nutrition environment[13,30] • Improved community nutrition environment[19,21]

Table 13 continued

○ Coalition leader(s)[7-9,11,12,14,15,17,18,28,29] ○ Coalition co-leader(s)[12,29] ○ Coalition chair(s)[5,10,14,15,17,24] ○ Coalition co-chair(s)[10,14,15] ○ Steering committee[10,20,22,25,28] ○ Advisory board/ group[6,15,25] • Working groups/ subcommittees/ sub-coalitions/ committees/ task force/ community action team/ facilitation team[1,2,4,6,8,11-15,18,20,24,27-29]							

AHQR: Agency for Healthcare Research and Quality; CDC: Centers for Disease Control and Prevention; CTSA: Clinical and Translational Science Awards Program; DOH: Department of health; HRSA: Health Resources and Services Administration; NCI: National Cancer Institute; NIH: National Institutes of Health; USDA: United States Department of Agriculture.

*Partners: by definition, community health coalitions are comprised of diverse membership; however, we opted to highlight three partners who have the potential to have a strong presence/influence in all rural counties across the U.S.: local and state departments of health, universities, and the Cooperative Extension System.

**Organizational structures: as described by the coalition itself; e.g., “leaders” or “leadership” may be described by the authors in the overall discussion or evaluation, but the coalition may refer to their lead members as “coordinators” or “chairs”.

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CHAPTER 4. A MIXED-METHODS EVALUATION USING EFFECTIVENESS PERCEPTION SURVEYS, SOCIAL NETWORK ANALYSIS, AND COUNTY-LEVEL HEALTH STATISTICS: A PILOT STUDY OF EIGHT RURAL INDIANA COMMUNITY HEALTH COALITIONS

This chapter is adapted from Ken-Opurum J, Lynch K, Vandergraff D, Miller D, Savaiano D. A Mixed-methods Evaluation Using Effectiveness Perception Surveys, Social Network Analysis, and County-level Health Statistics: A Pilot Study of Eight Rural Indiana Community Health Coalitions. Under review at *Evaluation and Program Planning*.

Abstract

Community health coalitions (CHCs) are a promising approach for addressing disparities in rural health statistics. However, their effectiveness has been variable, and evaluation methods have been insufficient and inconsistent. Thus, we propose a mixed-methods evaluation framework and discuss pilot study findings. CHCs in our pilot study partnered with Purdue Extension. Extension links communities and land grant universities, providing programming and support for community-engaged research. We conducted social network analysis and effectiveness perception surveys in CHCs in 8 rural Indiana counties during summer 2017 and accessed county-level health statistics from 2015-16. We compared calculated variables (i.e., effectiveness survey k-means clusters, network measures, health status/outcomes) using Pearson's correlations. CHC members' positive perceptions of their leadership and functioning correlated with interconnectedness in their partnership networks, while more centralized partnership networks correlated with CHC members reporting problems in their coalitions. CHCs with highly rated leadership and functioning developed in counties with poor infant/maternal health and opioid outcomes. Likewise, CHCs reporting fewer problems for participation developed in counties with poor infant/maternal health, poor opioid outcomes, and more people without

healthcare coverage. This pilot study provides a framework for iterative CHC evaluation. As the evidence grows, we will make recommendations for best practices that optimize CHC partnerships to improve local health in rural areas.

Keywords: Behavioral Risk Factor Surveillance System; Capacity Building; Community Health; Health Promotion; Implementation Evaluation; Multilevel Assessment; Outcome and Process Assessment; Program Evaluation; Rural Health

Introduction

Health behaviors and outcomes are worse in rural than in urban/suburban communities. "Geographic isolation, lower socio-economic status, higher rates of health risk behaviors, and limited job opportunities" are hypothesized to cause poor rural health (Rural Health Information Hub, 2014). The resulting health disparities are potentially mutable. For example, disparities in cancer (Zahnd et al., 2017) and chronic disease (Matthews et al., 2017) have been modified through prevention and lifestyle interventions. Engagement, networking, and collaboration strategies may overcome access, resource, and infrastructural limitations and improve the efficacy of public health initiatives (Pennel et al., 2008). Community health coalitions (CHCs) are one strategy for mobilizing local organizations and individuals to improve rural health.

Indiana is largely rural and has some of the worst health outcomes in the United States. Indiana ranks 38th out of 50 states for overall health, 40th for health behaviors (e.g., physical inactivity, smoking, and drug deaths), is in the bottom ten states for health outcomes (e.g., obesity, cancer deaths, and infant mortality) and clinical care (e.g., limited access to/availability of dentists, mental health providers, and preventable hospitalizations), and ranks 49th for public

health funding (https://www.americashealthrankings.org/explore/annual/measure/Overall/state/IN).

Rural Indiana communities have been developing CHCs in partnership with local public and private organizations, academic institutions, public health associations, and via cross-sector collaborations. One resource for Indiana CHCs is the robust statewide network of Purdue University Extension Educators and the Nutrition Education Program (NEP, funded by the United States Department of Agriculture; https://extension.purdue.edu/Pages/default.aspx). NEP implements the Supplemental Nutrition Assistance Program-Education (SNAP-Ed) and Expanded Food and Nutrition Education Program (http://www.purdue.edu/hhs/extension/programs/detail.aspx?programId=5&category=food) in Indiana.

Despite efforts of CHCs to supplement public health efforts (Butterfoss, 2007; Roussos et al., 2000; US Department of Health and Human Services et al., 2012), a major barrier to improving community health is sustaining effective partnerships and activities (Roussos et al., 2000). Rigorous research examining pathways to successfully developing and sustaining effective CHC efforts is lacking. Zakocs and Edwards (2006) reported that outcome measures rarely encompass internal coalition functioning and external community changes (Zakocs et al., 2006). Roussos and Fawcett (2000) cite “weak outcomes, contradictory results, or null effects” due to lack of strong methodological designs as major limitations to generalizing findings from studies evaluating collaborative partnerships across community settings (Roussos et al., 2000). Provan and Milward (2001) suggest that partnership network outcomes need to be evaluated at the network-, organization/participant-, and community-level through a systematic,

comprehensive, cross-sectional/longitudinal evaluation framework (Provan et al., 2001). Accordingly, the W.K. Kellogg Foundation (https://www.bttop.org/sites/default/files/public/W.K.%20Kellogg%20LogicModel.pdf) and the Centers for Disease Control and Prevention (https://www.cdc.gov/prc/pdf/prc-logic-model.pdf) link inputs, activities, outputs, outcomes, and impact as a guiding framework for evaluating and accomplishing program goals. Unfortunately, coalition evaluation across the logic model from inputs through health impacts seldom occurs. However, there have been multiple examples of mixed-methods, multi-level community engagement evaluation efforts, such as The Need to Know Project (Manitoba, Canada) (Bowen et al., 2006), the Tampa Bay Community Cancer Networks (Florida, USA) (Simmons et al., 2015), Healthy Kids, Healthy Communities (49 communities in the United States and Puerto Rico) (Brownson et al., 2015), and Partnering Healthy@Work (Tasmania, Australia) (Jose et al., 2017). Researchers involved in these partnerships engaged community members in a transparent and iterative mixed-methods evaluation, working with community partners to design, develop, implement, and disseminated findings from assessments relevant to community-identified needs. In all cases, both qualitative and quantitative evaluations were conducted, focusing primarily on partnership outcomes, program development, and capacity building. We (the authors) have applied similar methods to our evaluation framework, but also incorporate longitudinal tracking of county-level health statistics related to the health topics of interest to CHCs in our pilot study.

Through partnership with Extension Educators, author Vandergraff provided content-expertise as the Purdue University Extension Specialist in Nutrition Science to identify and recruit county-level CHC members to participate in a mixed-methods, multi-level evaluation pilot study. The evaluation period spans the summer of 2017. We define a CHC as a

partnership/collaboration among local (i.e., county- or community-level) organizations addressing disparities in community health statistics. Thus, the term CHC(s) in this report excludes regional, state, and national coalitions, and coalitions with partners from only one discipline such as healthcare or faith-based organizations.

Purpose and Objectives

The Purdue Extension System provides a "link between Land Grant Research and Indiana citizens" (https://extension.purdue.edu/Pages/article.aspx?intItemID=1922#.UxX07fRdXfM). Community outreach and programming are organized and coordinated primarily by Extension Educators in each of Indiana's 92 counties. Many, though not all, Extension Educators engage communities by developing or partnering with local CHCs. According to the Extension Educators partnering with the CHCs described in this manuscript, current health priorities include obesity prevention, wellness, mental health, systems of care, child well-being/maternal health, tobacco control, and substance abuse reduction. As per reporting objectives for the Cooperative Extension System, Purdue Extension CHC effectiveness has been tracked using traditional survey methods; however, county-level differences in health priorities, resources, and human/social capital limits the interpretation and generalizability of findings. Specifically, Extension Educators submit annual Impact Reports, but respondents are de-identified so the results are available only in aggregate. Additionally, multi-level assessments of CHC efforts by Purdue Extension have not been conducted to date. Thus, we undertook an in-depth exploration of CHC partnership dynamics in relationship to salient county-level health statistics.

The objectives of our evaluation were: 1. To determine the optimal CHC internal network structure that correlates to increased CHC perceived effectiveness, 2. To relate CHC internal

network structure and perceived effectiveness to the delivery of programs and policy, system, and environment (PSE) change interventions, 3. To relate CHC internal network structure, perceived effectiveness, and programming/PSE change interventions to health status and changes in county-wide health over time. We plan to collect data from CHCs across Indiana for cross-sectional and longitudinal comparisons.

Community-level differences in health statistics, availability of resources, and organizational representation on CHCs can confound efforts to develop and replicate successful interventions across locations. Thus, CHCs may adapt programming and implement site-specific procedures and activities. However, it is possible to identify general processes to achieving successful health-related outcomes across a diverse group of locales (Miller et al., 1995). Therefore, in this research effort, we aim to identify the underlying developmental approaches and intermediate markers of CHC success. This manuscript describes the development and application of a mixed-methods, multi-level statewide CHC effectiveness evaluation system and presents findings from a pilot study.

Study Population

Purdue Extension CHCs develop across Indiana to address disparities in local health statistics. Through CHCs, the community takes ownership of their public health needs and works together to improve community health. Though technical assistance from Purdue is provided, CHCs retain autonomy and ultimately decide on programming and allocation of available resources.

Inclusion Criteria

We recruited Extension Educators from 8 rural counties in 4 geographic regions of the state: West/Central, Northeast, Southwest, and Southeast. These geographic designations have been utilized by the Indiana Clinical and Translational Science Institute Community Health Partnerships to target community engagement and coalition building strategies. CHCs were chosen within region based on their experience to that point; specifically, they were in between novice/inexperienced CHCs and those that had been in operation for some time and already achieved significant success. Novice/inexperienced CHCs were excluded because they would have been unlikely to answer the survey questions due to their limited time working together, and CHCs having achieved significant success would likely have already achieved network saturation and would have a highly skewed positive perception of their effectiveness. Thus, in order to maintain variability in the survey responses and avoid highly skewed data, we opted to recruit CHCs operating at the middle level. One CHC was recruited from one of the regions, 2 CHCs were recruited from two regions, and 3 CHCs were recruited from the final region.

Counties were not matched on demographic characteristics. Thus, uncontrolled factors affecting CHC work existed, including: external alternative public health initiatives/community interventions, CHC capacity and working relationships, CHC size and comembership, county-level infrastructure, and receptivity of CHC and community members to technological innovations. Extension Educators provided a contact list of their CHC members. Thus, we did not account for CHCs members' external ties to other health promotion partners in the community or the potential skills, resources, and organizational support that each CHC member could bring to the partnership; rather, we entrusted Extension Educators to determine who the most important actors were.

CHC members were contacted by email or phone to schedule a face-to-face or phone interview for a social network analysis survey or to receive a link to the survey via email; a second survey regarding internal functioning and perceived effectiveness was sent as a link in an email as a follow-up. Informed consent was provided during the interviews or on the first page of the survey link, and signatures were obtained from all study participants. No individual was excluded by age, gender/sex, race/ethnicity, occupation/education, health status, or any other demographic factor.

Development of the Evaluation Framework

Ongoing evaluation allows for iterative recommendations for best practice to improve CHC impact. According to the W.K. Kellogg Foundation, "the program logic model is defined as a picture of how [an] organization does its work—the theory and assumptions underlying the program. A program logic model links outcomes (both short- and long-term) with program activities/processes and the theoretical assumptions/principles of the program" (https://www.bttop.org/sites/default/files/public/W.K.%20Kellogg%20LogicModel.pdf). The Centers for Disease Control and Prevention's Logic Model for the Prevention Research Centers Program places inputs, activities, outputs, and outcomes under evaluation and community engagement for refining and improving program activities to elicit long-term impact (https://www.cdc.gov/prc/pdf/prc-logic-model.pdf). Likewise, the evaluation model described in this manuscript assumes that iterative data collection and feedback will guide CHCs toward improving and sustaining community health (Figure 5). In order to operationalize and assess CHC effectiveness along our logic model, we conducted surveys regarding partnership network connections and perceived effectiveness, then compared our primary data with county-level health statistics. The geometry of partnership network connections was determined using social

network analysis (SNA), a statistical technique to objectively analyze, quantify, and visually represent the orientation of actors in a network and network structural characteristics (Figure 6). SNA allows us to explore how underlying CHC relationships impact members' perceived effectiveness and provides insight into partnership sustainability and potential for successful programming. This programming, in turn, should focus on salient disparities in health statistics and result in improvements to county-level health. Developing and maintaining connections are instrumental in Extension Educators' ability to lead or mentor CHCs. Although organization, communication, and activities are at the discretion of CHCs, our mixed-methods, multi-level evaluation framework will contribute to tailored feedback and recommendations for best practices.

Evaluation Methods

In this pilot study, we assessed partnership networks and perceived effectiveness and characterized community health, then compared interrelations between assessment components. 1. Partnership networks were evaluated using SNA, with survey questions adapted from Provan et al. (2005) (Provan et al., 2005) and Cullerton et al. (2015) (Cullerton et al., 2016) (survey instrument available upon request). 2. Coalition perceived effectiveness was evaluated using a modified version of the Coalition Self-Assessment Survey (CSAS) developed by Kenney and Sofaer (2000) (Kenney et al., 2000) (survey instrument available upon request). 3. Short-/long-term community health was characterized via publicly-available health statistics (i.e., Indiana Stats Explorer (https://gis.in.gov/apps/isdh/meta/stats_layers.htm), Behavioral Risk Factor Surveillance System (BRFSS) (https://www.cdc.gov/brfss/annual_data/annual_data.htm), and Feeding America Food Insecurity (http://map.feedingamerica.org/county/2015/overall/indiana)). Indiana Stats Explorer and Feeding America Food Insecurity data are publicly available at the

county-level; BRFSS data are publicly available at the state level and were made available to us at the county-level via contract with the Indiana State Department of Health. The county-level health statistics (CoHealth) included in our evaluation framework (Table 17, footnote) were selected based on their ability to characterize the status of the CHC priorities identified by the Extension Educators. As future reports of county-level health statistics are released, we plan to track and compare changes in health status to CHC operational metrics (Figure 7).

These three assessment components capture different levels of CHC effectiveness, as defined by Provan and Milward (2001) (Provan et al., 2001). SNA measures partnership connections at the network-level. CSAS measures members' perceived effectiveness at the organization/participant-level. CoHealth include measures of community-level public health. We did not measure program activities or PSE change interventions due to the large variability across CHCs and the lack of accepted standardized methods for PSE assessments. Additional qualitative assessment is being pursued to fill this gap.

SNA and CSAS were administered during summer 2017 (primary data), while CoHealth were acquired during summer 2017 and reflect 2015-16 (secondary data). We accessed county-level BRFSS data through contract with the Indiana State Department of Health; all other CoHealth are from publicly available datasets.

This study was approved by the Purdue University Institutional Review Board, protocol number 1506016147. For anonymity, the CHCs are identified as CHC1, CHC2, CHC3, etc. according to size (CHC1 is the smallest, CHC8 is the largest).

Statistical Analysis

Our data analysis was conducted in four parts: 1. Calculating network variables from the SNA survey, 2. Conducting a k-means cluster analysis on CSAS responses, 3. Computing descriptive statistics on CoHealth, and 4. Comparing calculated variables from SNA, CSAS, and CoHealth analyses using Pearson's Correlation. The unit of analysis for cross-county comparisons is the CHC; N=8.

First, we calculated network variables from the SNA survey (Figure 6, Table 14). Due to the dependent nature of social ties between respondents, a low response rate to SNA surveys has historically presented major analytic challenges. Stork and Richards (1992) suggest that in the case of actor non-response, missing data can be imputed by reconstruction if the graph is non-directional, ties are logically symmetrical, and respondents and non-respondents are not systematically different (Stork et al., 1992). During reconstruction, within the dyad A (responding) and B (non-responding), A's response about B is assumed to be what B would respond about A. However, the issue of missing data in a dyad of two non-responders persists. Burt (1987) found that missing data corresponded to weak ties (Burt, 1987). However, Huisman (2009) suggests that weak ties (0 in binary networks) should be imputed in sparse networks (density < 0.5), whereas strong ties (1 in binary networks) should be imputed in dense networks (density > 0.5) (Huisman, 2009). Thus, we reconstructed missing data for dyads with a single non-respondent and imputed values for doubly non-responsive dyads according to the density of the reconstructed network. To examine the robustness of our primary approach, we conducted sensitivity analyses by 1. Replacing no missing data and 2. Replacing all missing data with 0. The overall results and interpretation of findings did not differ significantly (data available upon request).

Second, we performed k-means clustering on CSAS responses (Figure 8). According to the cluster plots, distance matrix, and optimal number of clusters as determined by the average silhouette width, we selected two clusters: 1. containing ten items, describing CHC members' problems for participating in their coalition- **PROB**, 2. containing fifteen items, describing CHC members' positive perceptions of their leadership and internal functioning- **LF**. Although the gap statistic plot indicates that five is the optimal number of clusters, this is inconsistent with the distance matrix and there is overlap between clusters 1 and 4 in the k=5 cluster plot. The optimal number of clusters is difficult to discern based on the total within sum of squares, however, all cluster plots except k=2 have some degree of overlap between clusters. Thus, we settled on two clusters. For subsequent analyses we calculated the cluster means for each county (Table 15).

Third, CoHealth were selected according to CHC-identified priorities. Items from the BRFSS span two years (2015-16) due to the Centers for Disease Control and Prevention's data security requirement to only report on sample sizes > 50. We were not able to compare items related to children's health, because sample sizes on these items were below 50 for most counties, even when data from five years (2012-16) were combined. Data from the Indiana Stats Explorer are from 2016, and the county food insecurity rates from Feeding America are from 2015. In all cases, the latest available data was used.

Finally, we compared calculated variables from SNA, CSAS, and CoHealth using Pearson's Correlations (Table 16, Table 17). Despite our small sample size (N=8 CHCs), only 13/87 calculated variables had a non-Gaussian distribution, thus we performed Pearson's rather than Spearman Correlations. Descriptive statistics for BRFSS data were computed using SAS

software, Version 9.3 (SAS Institute Inc., Cary, NC, USA). All other analyses were performed in R 3.5.0 (R Core Team, 2018).

Author Ken-Opurum collaborated with Purdue University's Extension Specialist and the Purdue Nutrition Education Program's Research and Evaluation Specialist to develop the survey instruments. Authors Lynch and Ken-Opurum collected the primary data; Ken-Opurum conducted all analyses.

Results

Response rates

CHC size (n) and survey completion rates for SNA and CSAS for each of the 8 counties are shown in Tables 5 and 6. The CSAS response rate for CHC4 was 11/10. We believe this was because a CHC member forwarded the anonymous survey link to a colleague not on our distribution list. CHC size ranged from 7-42 members, SNA response rate ranged from 50%-91%, and CSAS response rate ranged from 32%-89%. The CSAS has been used extensively across coalition evaluation work (e.g., (Andrews et al., 2014; Hasnain-Wynia et al., 2003; Peters et al., 2016; Peterson et al., 2006)), and the response rates we obtained are consistent with work by Hasnain-Wynia et al. (2003) (28%-83% across partnerships) (Hasnain-Wynia et al., 2003). The SNA response rate was also satisfactory, as Costenbader and Valente (2003) demonstrated that several network centrality measures remain stable at a sampling rate of at least 50% (Costenbader et al., 2003).

Characteristics of study participants

Organizational representation across CHC membership included law enforcement, public schools, community gardens, philanthropies, youth development and 4-H, utility companies,

gyms, hospitals, the local public health department, parks and recreation, libraries, legal offices, and others. The primary role of CHC members responding to the CSAS (n=75) was coalition officer or chair (11/75, 14.7%), coalition staff (1/75, 1.3%), chair/co-chair of a committee or task force (2/75, 2.7%), member of executive or steering committee (5/75, 6.7%), committee member (13/75, 17.3%), member having no other responsibility (37/75, 49.3%), and other role (6/75, 8.0%). Member responses to involvement in the CHC over the past year were very (20/75, 26.7%), moderately (16/75, 21.3%%), a little (33/75, 44.0%), and not at all (6/75, 8.0%%). 55/75 (73.3%) CHC members participated in some coalition building activity, 20/75 (26.7%) respondents did not. Of those reporting activities, 26 participated in only 1 activity, 8 participated in 2, 10 participated in 3, 6 participated in 4, and 5 participated in 5. Across activities, 15 people acquired funding or other resources for the coalition, 21 attempted to get outside support for coalition positions on key issues, 20 recruited new members, 20 served as a spokesperson, and 45 worked on implementing activities or events sponsored by the coalition.

Main findings of evaluations:

SNA to CSAS correlations (Table 16, Figure 9)

LF correlated positively to the following calculated SNA variables: cooperation mean degree, coordination mean degree, collaboration mean degree, collaboration closeness centralization, formal ties mean degree, formal ties degree centralization, and frequent mass communication closeness centralization. Thus, overall it appears that partnership networks with higher mean degree (i.e., having more connections on average across the network) and central communication were related to CHC members' perceptions of effective leadership and functioning.

LF correlated negatively to the following calculated SNA variables: cooperation betweenness centralization, coordination betweenness centralization, formal ties density, and good-high trust betweenness centralization. Thus, overall it appears that CHC members rated their leadership and functioning as lower in partnership and trust networks with higher centralization.

PROB correlated positively with the following calculated SNA variables: cooperation betweenness centralization, coordination betweenness centralization, formal ties density, formal ties transitivity, good-high trust transitivity, and frequent direct contact betweenness centralization. Thus, overall it appears that high centralization in the partnership networks was related to CHC members reporting problems for participation in the coalition, as was transitivity in the formal ties and trust networks.

PROB correlated negatively to the following calculated SNA variables: formal ties degree centralization and formal ties eigenvector centralization. Thus, centralization in the formal ties network was related to CHC members reporting fewer problems for participation in the coalition.

The strongest positive correlation between calculated SNA variables and LF was to coordination mean degree (r=0.675); the strongest negative correlation between calculated SNA variables and LF was to coordination betweenness centralization (r=-0.591); the strongest positive correlation between calculated SNA variables and PROB was to formal ties density (r=0.668); the strongest negative correlation between calculated SNA variables and PROB was to formal ties eigenvector centralization (r=-0.500).

In summary, partnership mean degree was positively correlated to LF, while partnership centralization was negatively correlated to LF; partnership centralization, as well as formal ties density, and trust and formal ties transitivity, were positively correlated to PROB, while formal ties centralization was negatively correlated to PROB. Thus, partnership mean degree may promote CHC effectiveness, while partnership centralization may be a barrier to CHC effectiveness; however, having a formal partner in the center of the network may promote CHC stability, although cliques of trust and formal ties (i.e., high transitivity), may disrupt network cohesiveness.

CSAS to CoHealth correlations (Table 17)

LF correlated positively to the following CoHealth: opioid deaths, opioid treatments, mothers smoking during pregnancy, preterm births, and people reporting poor or fair health. LF correlated negatively to the following CoHealth: people drinking sugar sweetened soda every day and people not having a personal doctor or healthcare provider. PROB correlated positively to the following CoHealth: people drinking sugar sweetened soda every day, people drinking sugar sweetened fruit drinks every day, and people having on average more chronic diseases at once. PROB correlated negatively to the following CoHealth: opioid deaths, opioid treatments, mothers smoking during pregnancy, people (of all ages and those 18-64) not having healthcare coverage.

In summary, CHCs with highly rated leadership and functioning developed in counties with especially poor health statistics for infant/maternal health and opioid outcomes. Likewise, CHCs reporting few problems for participation developed in counties with poor health statistics for infant/maternal health, poor opioid outcomes, and more people without healthcare coverage.

On the other hand, CHCs with low-rated leadership and functioning and those reporting more problems for participation developed in counties with poor dietary behaviors related to intake of sugar sweetened beverages, more chronic disease, and less personalized care.

SNA to CoHealth correlations (Table 17)

The interpretation of correlations between SNA and CoHealth was derived through pattern identification. Groupings of related correlates were visibly detectable when the direction of the correlation (positive or negative) was highlighted in green or red, respectively.

CHCs with high density across connection types (cooperation, coordination, collaboration, formal ties, good-high trust, frequent direct contact, frequent mass communication) had worse CoHealth statistics for substance use prevention, more people not exercising in the past month, fewer mothers receiving prenatal care beginning in the first trimester, but a lower county food insecurity rate, fewer infants born at a very low birth weight, and fewer people reporting 5 or more days of poor overall or physical health in the last 30 days. Compared to network density, the direction (positive or negative) of correlations to CoHealth was nearly opposite for network mean degree. Notably, networks with higher mean degree were in counties with poorer health behaviors related to tobacco control, poorer obesity prevention indicators, poorer infant/maternal health statistics, and more people with 5 or more days of poor mental or overall health in the past month. The pattern of correlations between centralization measures is less clear; however, it appears that hospitalizations due to opioid overdose are consistently low when degree, betweenness, and closeness centralization are high. Additionally, degree, betweenness, closeness, and eigenvector centralization negatively correlated to people not exercising in the last 30 days. Degree and betweenness centralization in the communication

networks were related to better systems of care. However, high degree centralization also coincided with more people reporting 5 or more days of poor overall health in the last month and poor infant/maternal health. Interestingly, network transitivity took on a similar pattern of correlations to CoHealth as network density.

Discussion

Given our findings, perhaps CHCs perceive they are more effective when responding to crises than when addressing chronic disease and prevention. On the same note, CHCs responding to crises likely form cross-coalition partnerships whereby coalition members equally bear the weight and responsibility for delivering programs and activities. Meanwhile, when CHCs lack a sense of urgency, a centralized leader may act as the unifying agent to the coalition, while less engaged members may rest on the periphery. Furthermore, an interconnected CHC responding to a crisis may be less stable than a centralized CHC addressing long-term health topics.

There are many opportunities for working collaboratively across disciplines to maximize the potential for both rapid response and institutionalized CHCs. A CHC with a centralized/formal lead agency that serves as a connecting body and support center to external working groups could potentially have the greatest impact on local health. The centralized/formal lead agency could ensure CHC sustainability by coordinating efforts to minimize duplicate public health initiatives and wasted resources by multiple groups addressing similar issues. The CHCs described in this pilot study were partnered with Purdue Extension Educators. As a result, the infrastructure for programmatic sustainability was present; however, the extent to which Extension Educators were able to engage and mobilize their CHC members varied. One recommendation would be to enhance leader training and establish learning

communities among CHCs across the state. As such, community stakeholders would have access to a statewide network of CHCs in which members could share success stories and be involved in an iterative discussion about what works. This would lay the groundwork for building the qualitative evidence around recommendations for best practices.

Meanwhile, the collection of objective quantitative effectiveness evaluations on a continuing basis could inform recommendations for best practices through iterative feedback. In this pilot study we attempted to refine and improve CHC evaluations by comparing traditional survey methods with social network analysis and county-level health statistics. These three layers of assessment provide a deeper understanding about the structural mechanisms influencing CHC functioning, as well as underlying environmental factors that may influence where CHCs develop and on which health priorities they focus.

Other authors have statistically compared network parameters to effectiveness measures, e.g., Valente et al. (2008) (Valente et al., 2008) and Valente et al. (2007) (Valente et al., 2007). A qualitative comparison between network measures and outcomes has been explored by a number of researchers as well, including: Provan and Milward (1995) (Provan et al., 1995), Provan and Sebastian (1998) (Provan et al., 1998), Lucidarme et al. (2016) (Lucidarme et al., 2016), Varda and Retrum (2012) (Varda et al., 2012), and Lemieux-Charles et al. (2005) (Lemieux-Charles et al., 2005). However, there is a dearth of quantitative analyses between calculated SNA variables and outcomes. Due to the small sample size of this pilot study (N=8) and inclusion of county-level health statistics in our evaluation model, we utilized Pearson's Correlations. As we collect additional cross-sectional and longitudinal data, we will build a predictive model using linear

regression analysis. We will also incorporate the number and quality of coalition-initiated PSE change interventions.

Some of our findings were unexpected. For example, Bavelas found that individuals had lower morale when they were not well connected in a communication network (Bavelas, 1950); likewise, we found that CHC members reported more problems for participation when the direct contact network had high betweenness centralization. However, we also found that CHC members rated their leadership and functioning higher when the mass communication network had high closeness centralization. Additionally, in agreement with Granovetter (1973) (Granovetter, 1973), we found that there was strength in weak ties: coordination mean degree more strongly correlated to highly rated leadership and functioning than did collaboration mean degree. However, we also found that cooperation mean degree was not as strongly correlated to leadership and functioning as was coordination mean degree.

Additionally, the literature on rural CHCs highlights the tenuous relationship between communities and researchers; whereby coalitions serve as a bridge for building trust and bidirectional communication and feedback for involvement in community engaged research (Baquet et al., 2013). In this pilot study, Extension Educators served as the linking agents between communities and the university. Rural community-university partnerships have also demonstrated great success in addressing methamphetamine use (Calvert et al., 2014); which is parallel to the opioid abuse reduction priority of some of the CHCs in this pilot study. Meanwhile, a community-based participatory research study implemented PSE change to overcome racial/social injustices in a rural community (Devia et al., 2017). PSE change interventions is also one strategy that CHCs in Indiana implement to reduce health disparities.

Finally, our work shares several similarities and differences with existing mixed-methods partnership evaluation efforts. Like others (Bowen et al., 2006; Brownson et al., 2015; Jose et al., 2017; Simmons et al., 2015), we are engaging our community partners in an iterative feedback evaluation loop, disseminating our findings to them, making recommendations for best practices, and monitoring programmatic change. Similar to The Need to Know Project (Manitoba, Canada) (Bowen et al., 2006), the Tampa Bay Community Cancer Networks (Florida, USA) (Simmons et al., 2015), Healthy Kids, Healthy Communities (49 communities in the United States and Puerto Rico) (Brownson et al., 2015), and Partnering Healthy@Work (Tasmania, Australia) (Jose et al., 2017), we have administered partnership surveys and, like the Tampa Bay Community Cancer Networks (Florida, USA) (Simmons et al., 2015) we also performed SNA, all of which we plan to track over time. While we rely on anecdotal evidence from Extension Educators to interpret our findings, the researchers of the above community-engaged partnerships conducted systematic, semi-structured key-informant interviews, which strengthened the rigor of their report. Although we are pursuing qualitative assessments of program outcomes and PSE change, the aforementioned researchers had great success analyzing program documents, making direct observations, and conducting environmental scans to fill this gap. In contrast, although community health improvement is a major end goal of many community partnerships, our evaluation framework is one of the few to 1. Identify publicly available health statistics that align with CHC priorities and 2. Track health statistics over time against CHC activities and partnership networks.

Limitations

Though this pilot study provides a framework for future evaluations of CHC effectiveness across the logic model, several limitations exist. First, we were not able to assess

CHC activities, including but not limited to PSE change interventions. Second, there is a lag time in the release of publicly available county health data reports. Third, we obtained a lower response rate on the CSAS compared to the SNA. This arguably weakened the cluster analysis. Fourth, CHC members are more likely than the general public to be attuned to health disparities and usually represent organizations with special health interests. The CHCs surveyed in this pilot study are connected to the Extension System, while other CHCs may be initiated and led by other universities, the private sector, or various public health organizations. Additionally, this pilot study was conducted in only 8 rural Indiana counties; thus, findings may not be generalizable to all rural counties, to CHCs in urban environments, or to states with different health priorities and higher public health spending. Finally, we searched for patterns across a large number of correlations, which is problematic in itself, but was exasperated by our small sample size.

Lessons Learned

Our work provides a framework for mixed-methods/multi-level assessment that can be conducted cross-sectionally and longitudinally, spanning the public health logic model from inputs through impacts. Notably, depending on the nature of the coalition and/or partnership, different tools can be used. For example, SNA survey questions can be tailored to suit the connection type (e.g., focusing on client referrals or funding received), and other coalition assessment tools (e.g., the Coalition Effectiveness Inventory (Butterfoss, 1994, revised 1998)) might be more appropriate than the CSAS. Additionally, while standardized methods for PSE-focused evaluations are lacking, program- and location-specific observations can be made. Finally, disparities in local health statistics should be reflected in coalition priorities, and

assessment methods should be adapted to those priorities using a variety of different data sources.

Conclusions

In conclusion, CHCs are mobilizing to address local health disparities. CHCs may be initiated by community members, pursued via partnerships with universities, or organized under federally mandated programs. As such, the development, growth, and sustainability of CHCs provide numerous opportunities for evaluation and assessment, in order to build the evidence around recommendations for best practices. However, coalition outcomes are variable, and most reports are anecdotal or subjective rather than analytic. Furthermore, assessment tends to be narrow in scope, with much of the published literature and available tools focusing on self-reported capacity and capacity building activities. Though poor sustainability of partnerships and activities is a major barrier to coalition success, some coalitions do successfully improve local health. Thus, ongoing evaluation is necessary to understand the underlying mechanisms and functional characteristics of effective coalitions. Researchers must engage communities to explore, apply, and refine comprehensive, iterative, mixed-methods, multi-level evaluation that will serve as the basis for feedback and programmatic improvements.

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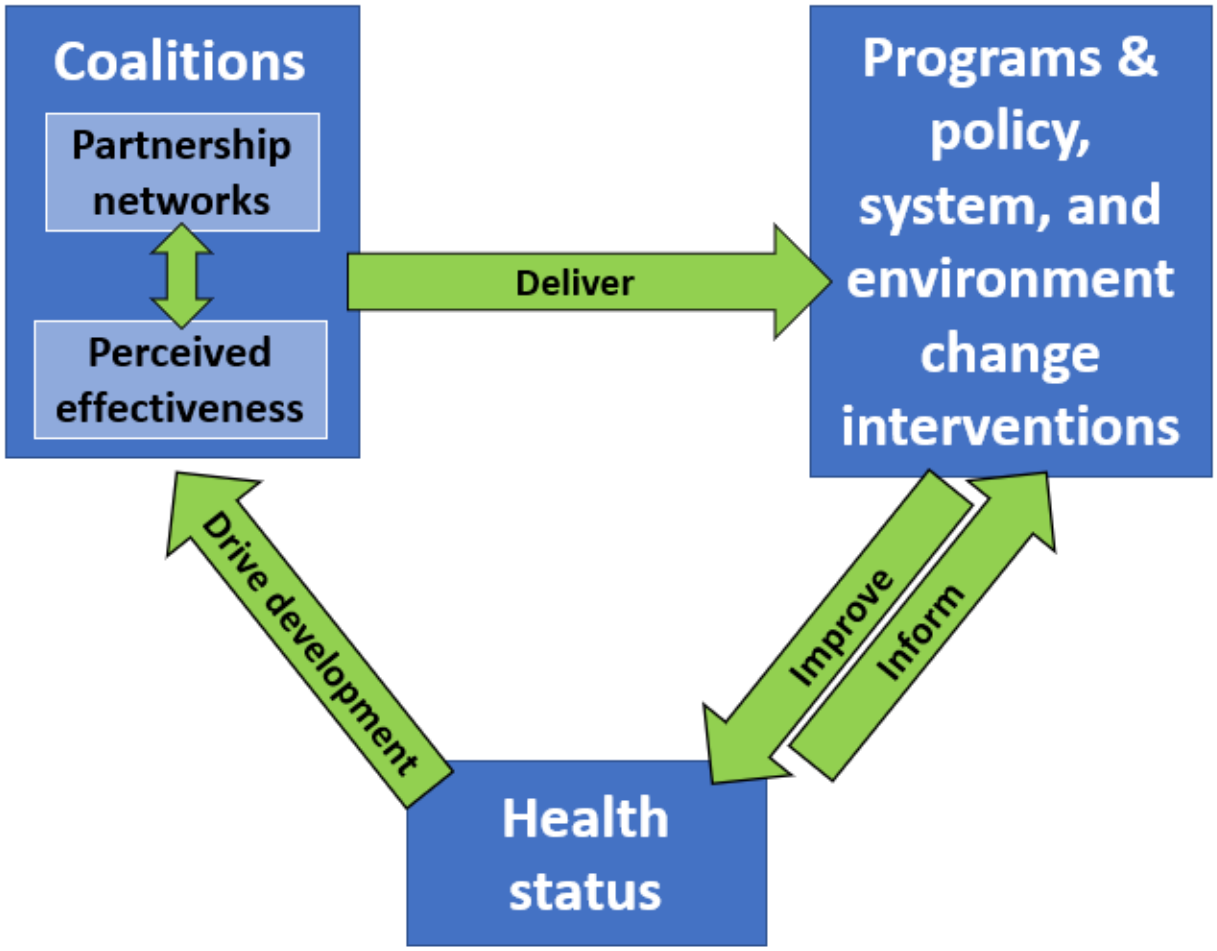


Figure 5: Coalition Evaluation Study Components

Partnership networks were evaluated using social network analysis, with survey questions adapted from Provan et al. (2005) and Cullerton et al. (2015). Coalition perceived effectiveness was evaluated using a modified version of the Coalition Self-Assessment Survey (Kenney and Sofaer, 2000). Programs & policy, system, & environment change initiatives were not included in this set of analyses but will be in subsequent evaluations. Short-/long-term community health status was evaluated via publicly available county-level health statistics (i.e., Indiana Stats Explorer, Behavioral Risk Factor Surveillance System, Feeding America Food Insecurity in Indiana) and county identifiers obtained through contract with the Indiana State Department of Health.

Social network analysis definitions and survey questions

Social network analysis definitions

- **Actors:** individuals in a network; represented by a dot
- **Tie:** the connection between actors in a network; represented by a line connecting two dots
- **Path:** the number of actors an actor must go through to reach another actor; measured by the number of ties between actors
- **Degree:** the number of ties an actor holds
- **Mean degree:*** i.e., Freemen degree; the average number of (incoming and outgoing) ties actors hold across the network
- **Density:*** the proportion of observed ties to possible ties
- **Degree centralization:*** i.e., Freeman degree centralization; the extent to which some actor holds more (incoming and outgoing) ties than other actors across a network
- **Betweenness centralization:*** the extent to which some actor serves as a bridge along the path between other actors across the network; a measure of control over the flow of some tie characteristic
- **Closeness centralization:*** the extent to which some actor has a relatively high proximity to other actors in the network; at the actor level, the average length of the shortest path
- **Eigenvector centralization:*** the extent to which some actor holds ties to other actors holding many ties; a measure of influence or power
- **Transitivity:*** the potential for two actors to be connected through a common connection; i.e., if $actor_x$ sends a tie to $actor_y$ and $actor_y$ sends a tie to $actor_z$ then $actor_x$ is likely to form a tie with $actor_z$

Social network survey questions

- **Describe the level of connection you have with each of the members in your coalition [check one]**
  - No connection (We do not work with each other)
  - Cooperative (We know each other and share information)
  - Coordinative (We work side-by-side on a few projects)
  - Collaborative (We rely on each other to achieve common goals)
- **Describe the type of connection you have with each of the members in your coalition [check one for each of your connections in the coalition]**
  - Formal: Connection is between the overall organization (not tied to certain people)
  - Informal: Connection would be lost if certain people left their organization
- **Rate the connection quality between you and each of the members in your coalition [check one for each of your connections in the coalition]**- Can you trust this organization to keep its word, do a good job, respond to your organization and client needs, and accomplish coalition related activities?
  - Little trust
  - Some trust
  - Good trust
  - High trust
- **How often are you in direct contact with each member of your coalition?** (i.e., an email, phone call, etc. addressed specifically to you or a working group that you actively engage in) **[check one]**
  - Never
  - More frequently than once per month
  - Less frequently than once per month
- **How often do you exchange mass communication with each member of your coalition?** (e.g., a listserv email, group Facebook message, newsletter, texting group) **[check one]**
  - Never
  - More frequently than once per month
  - Less frequently than once per month

Figure 6: Social Network Analysis Definitions and Survey Questions

*Calculated network variables; used in the primary cross-methods analyses. From the social network survey to each of the 8 coalitions, we analyzed 7 connection types: cooperation, coordination, collaboration (i.e., three levels of partnership), formal ties, good-high trust (i.e., two measures of connection quality), direct contact, mass communication (i.e., communication

networks); for each of these 7 connection types we calculated the following network variables: mean degree, density, degree centralization, betweenness centralization, closeness centralization, eigenvector centralization, and transitivity; for a total of 49 measures for each of the 8 coalitions.

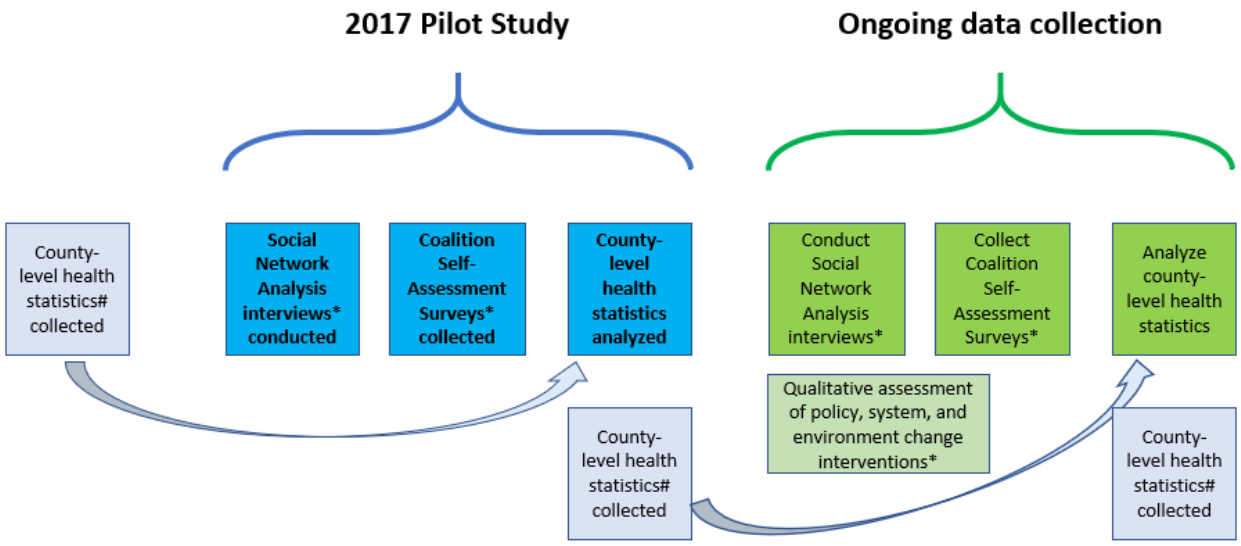
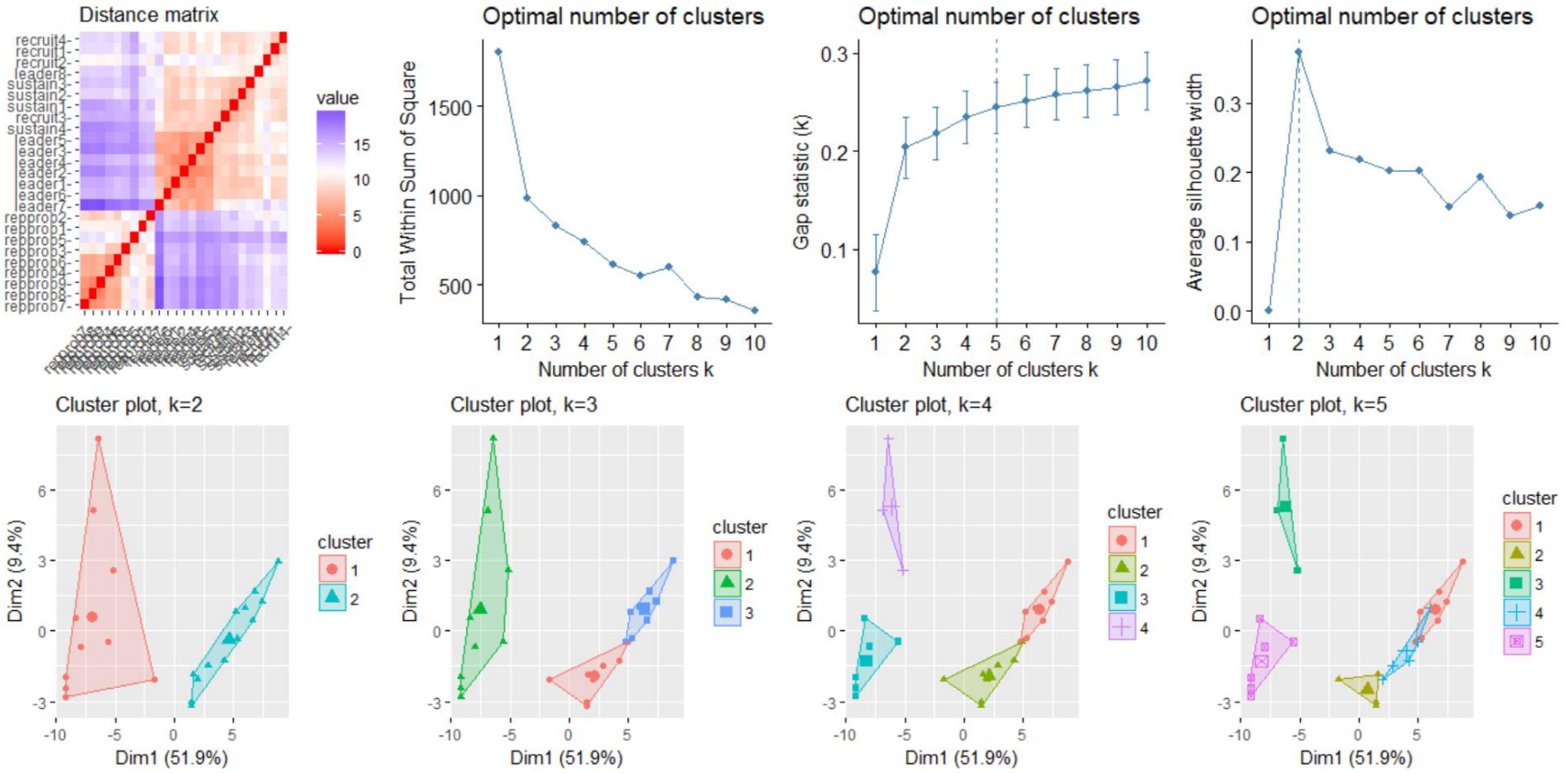


Figure 7: Timeline of data collection

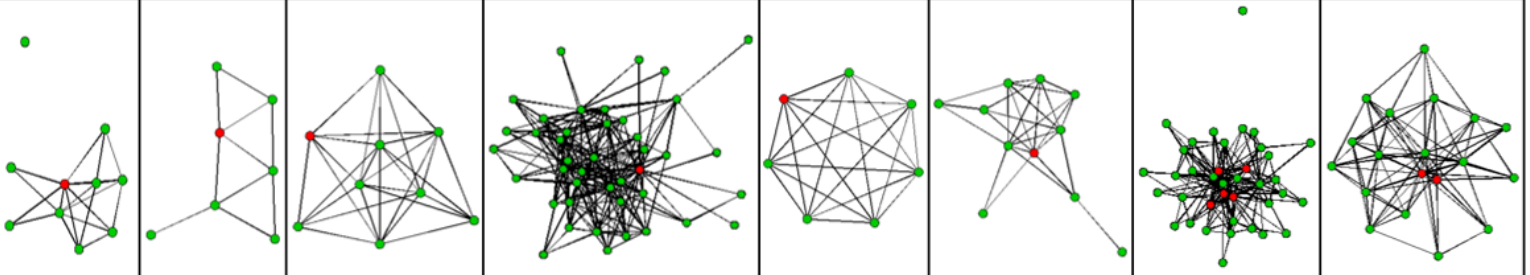
*primary data; #secondary data. During the 2017 pilot study, social network interviews were conducted, the Coalition Self-Assessment Surveys were collected, and county-level health statistics were analyzed for each of the 8 coalitions. In ongoing iterations of this evaluation framework, we will continue collecting and analyzing the aforementioned data sources, as well as purse qualitative assessment of policy, system, and environment change interventions.



Cluster vectors	
1	repprob1, repprob2, repprob3, repprob4, repprob5, repprob6, repprob7, repprob8, repprob9, recruit2
2	recruit1, recruit3, recruit4, sustain1, sustain2, sustain3, sustain4, leader1, leader2, leader3, leader4, leader5, leader6, leader7, leader8
Within cluster sum of squares by cluster	
1	433.3347
2	547.6419
Between sum of squares/total sum of squares	45.5%

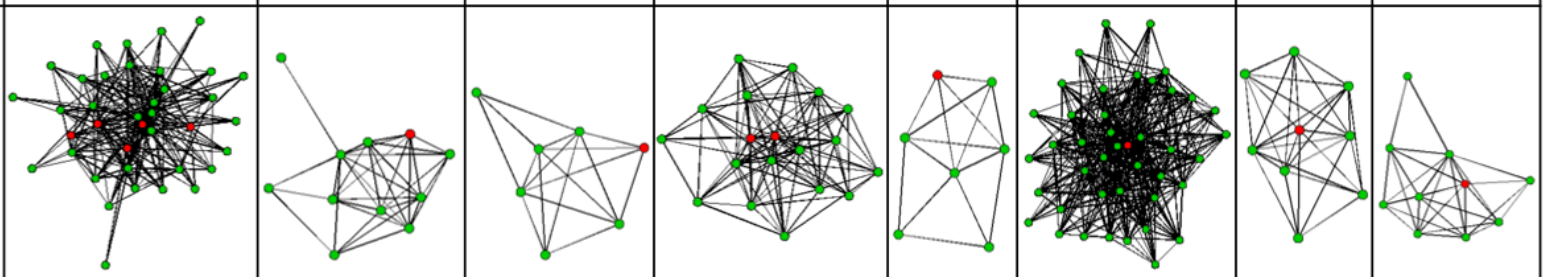
Figure 8: K-means clustering of Coalition Self-Assessment Survey responses

n=75 respondents. k, number of clusters; repprob1, Coalition activities do not reach my primary constituency; repprob2, Being involved in policy advocacy is a problem; repprob3, My skills and time are not well used; repprob4, My opinion is not valued; repprob5, The coalition is not taking any meaningful action; repprob6, I am often the only voice representing my point of view; repprob7, The financial burden of traveling to coalition meetings is too high; repprob8, The financial burden of participation (barring travel) is too high, repprob9, The coalition is competing with my organization; recruit1, The coalition is actively recruiting new members; recruit2, New members receive adequate orientation to be effective members of the coalition; recruit3, The current method for communication between coalition staff/leadership and its membership is effective; recruit4, Resources are being identified to support the systemic, programmatic changes implemented through the work of the coalition; sustain1, The coalition is making progress in implementing activities that have potential to improve health in the county; sustain2, The coalition is improving health outcomes for people in the county served by this coalition; sustain3, My skills and abilities are effectively used by the coalition; sustain4, I feel respected and recognized for my efforts; leader1, Leadership has a clear vision for the coalition; leader2, Leadership has the necessary knowledge and skills; leader3, Leadership is respected; leader4, Leadership gets things done; leader5, Leadership intentionally seeks others' views; leader6, Leadership utilizes the skills and talents of many, not just a few; leader7, Leadership is ethical; leader8, Leadership is skillful at resolving conflict.

	CHC4	CHC1	CHC3	CHC8	CHC2	CHC5	CHC7	CHC6
Coordination network								
LF[1]	48.5	54.06	63.34	64.23	65.86	69	75.96	79.98
Mean degree[2]	6.000	4.857	11.11	18.000	11.143	8.000	15.211	14.211
Btw. cent.[3]	0.329	0.294	0.169	0.207	0.013	0.153	0.188	0.164

Highly rated leadership and functioning with higher mean degree in the coordination network, r=0.675*

Low-rated leadership and functioning with higher betweenness centralization in the coordination network, r=-0.591*

	CHC7	CHC5	CHC2	CHC6	CHC1	CHC8	CHC3	CHC4
Formal ties network								
PROB[1]	17.58	19.54	23.48	24.36	26.43	28.05	28.85	32.2
Density[3]	0.312	0.500	0.571	0.558	0.595	0.411	0.667	0.633
Egv. cent.[3]	0.171	0.221	0.228	0.136	0.217	0.165	0.146	0.130

More problems for participation with greater density in the formal ties network, r=0.668*

Fewer problems for participation with higher eigenvector centralization in the formal ties network, r=-0.500*

Figure 9: Strongest correlations between Coalition Self-Assessment Survey cluster means and calculated social network analysis variables across eight community health coalitions

CHC, community health coalition; Btw., betweenness; Egv., eigenvector; cent., centralization; Footnotes: [1]out of 100; [2]out of 2(n-1), where n is the number of members in each CHC; [3]out of 1.0.

Table 14: Social Network Analysis Results by CHC

Connection type	Calculated network variable	County (n=network size, response rate)							
		CHC1 (n=7, 5/7)	**CHC2** (n=7, 6/7)	**CHC3** (n=9, 8/9)	**CHC4** (n=10, 8/10)	**CHC5** (n=11, 10/11)	**CHC6** (n=19, 17/19)	**CHC7** (n=38, 19/38)	**CHC8** (n=42, 23/42)
Cooperation	**Density**	0.929	1.000	0.958	0.667	0.800	0.667	0.679	0.641
	Mean degree	11.143	12.000	15.333	12.000	16.000	24.000	50.263	52.571
	Degree centralization	0.100	0	0.054	0.417	0.244	0.373	0.339	0.364
	Betweenness centralization	0.007	0	0.002	0.180	0.029	0.051	0.026	0.024
	Closeness centralization	0.083	0	0.047	0.277	0.177	0.259	0.240	0.260
	Eigenvector centralization	0.028	0	0.015	0.115	0.063	0.093	0.059	0.067
	Transitivity	0.917	1.000	0.955	0.763	0.824	0.732	0.781	0.741
Coordination	**Density**	0.405	0.929	0.694	0.333	0.400	0.395	0.206	0.220
	Mean degree	4.857	11.143	11.111	6.000	8.000	14.211	15.211	18.000
	Degree centralization	0.367	0.100	0.393	0.556	0.367	0.490	0.439	0.410
	Betweenness centralization	0.294	0.013	0.169	0.329	0.153	0.164	0.188	0.207

Table 14 continued

	Closeness centralization	0.700	0.076	0.275	0	0.605	0.419	0	0.259
	Eigenvector centralization	0.195	0.029	0.124	0.349	0.178	0.239	0.275	0.187
	Transitivity	0.485	0.934	0.753	0.449	0.580	0.526	0.385	0.422
Collaboration	**Density**	0.262	0.857	0.472	0.200	0.218	0.178	0.139	0.135
	Mean degree	3.143	10.286	7.556	3.600	4.364	6.421	10.263	11.095
	Degree centralization	0.333	0.200	0.438	0.444	0.283	0.266	0.410	0.306
	Betweenness centralization	0.131	0.046	0.221	0.401	0.091	0.292	0.257	0.123
	Closeness centralization	0	0.148	0.477	0	0	0.528	0	0
	Eigenvector centralization	0.339	0.061	0.244	0.356	0.284	0.219	0.361	0.245
	Transitivity	0.643	0.876	0.636	0.297	0.644	0.328	0.297	0.359
Formal ties	**Density**	0.595	0.571	0.667	0.633	0.500	0.558	0.312	0.411
	Mean degree	7.143	6.857	10.667	11.400	10.000	20.105	23.105	33.714
	Degree centralization	0.333	0.250	0.348	0.319	0.306	0.462	0.598	0.426
	Betweenness centralization	0.094	0.044	0.185	0.109	0.293	0.103	0.142	0.060

Table 14 continued

	Closeness centralization	0.449	0.535	0.293	0.311	0.425	0.329	0.346	0.375
	Eigenvector centralization	0.217	0.228	0.146	0.130	0.221	0.136	0.171	0.165
	Transitivity	0.629	0.781	0.724	0.754	0.658	0.671	0.472	0.506
Good-high trust	**Density**	0.643	0.976	0.903	0.622	0.655	0.617	0.356	0.589
	Mean degree	7.714	11.714	14.444	11.200	13.091	22.211	26.368	48.286
	Degree centralization	0.383	0.033	0.125	0.403	0.178	0.397	0.608	0.406
	Betweenness centralization	0.231	0.002	0.011	0.179	0.040	0.072	0.127	0.036
	Closeness centralization	0.322	0.028	0.101	0.308	0.295	0.287	0.388	0.288
	Eigenvector centralization	0.169	0.009	0.036	0.146	0.147	0.111	0.180	0.080
	Transitivity	0.674	0.975	0.904	0.735	0.689	0.704	0.484	0.717
Frequent direct contact	**Density**	0.238	1.000	0.278	0.389	0.436	0.222	0.145	0.194
	Mean degree	2.857	12.000	4.444	7.000	8.727	8.000	10.737	15.905
	Degree centralization	0.250	0	0.366	0.625	0.322	0.776	0.389	0.693
	Betweenness centralization	0.133	0	0.171	0.569	0.175	0.677	0.193	0.408

Table 14 continued

	Closeness centralization	0	0	0	0.477	0.444	0.498	0	0.441
	Eigenvector centralization	0.387	0	0.395	0.291	0.271	0.387	0.234	0.253
	Transitivity	0.400	1	0.659	0.500	0.590	0.317	0.364	0.427
Frequent mass communication	**Density**	0.333	0.714	0.403	0.344	0.300	0.193	0.227	0.323
	Mean degree	4.000	8.571	6.444	6.200	6.000	6.947	16.789	26.524
	Degree centralization	0.583	0.400	0.446	0.681	0.367	0.809	0.631	0.531
	Betweenness centralization	0.328	0.160	0.381	0.467	0.334	0.743	0.174	0.126
	Closeness centralization	0	0.256	0.269	0.523	0.680	0.529	0.503	0.447
	Eigenvector centralization	0.322	0.123	0.206	0.312	0.361	0.451	0.255	0.164
	Transitivity	0.519	0.736	0.494	0.386	0.612	0.246	0.335	0.494

CHCx, community health coalition in each of the 8 counties, ordered by the size of coalition membership; i.e., CHC1 had the fewest members, CHC8 had the most. Possible values for density, degree centralization, betweenness centralization, closeness centralization, eigenvector centralization, and transitivity are between 0.0 and 1.0. Possible values for mean degree are 2(n-1), where n is the number of members in each coalition.

Table 15: Mean and Median Responses to Coalition Self-Assessment Survey Questions and Cluster Scores by CHC

CSAS question (response on a scale of 0-100). $\bar{x}$, $\tilde{x}$	**County (n=network size, response rate)**							
	CHC1 (n=7, 4/7)	**CHC2** (n=7, 6/7)	**CHC3** (n=9, 8/9)	**CHC4** (n=10, 11*/10)	**CHC5** (n=11, 8/11)	**CHC6** (n=19, 11/19)	**CHC7** (n=38, 12/38)	**CHC8** (n=42, 15/42)
Coalition activities do not reach my primary constituency.	21.3, 24.5	40.3, 50	40.8, 45	39.6, 47	18.9, 5	24.4, 20	25.3, 16	23.1, 20
Being involved in policy advocacy is a problem.	27.3, 7	52.3, 51	45.4, 50	35.1, 38	20.9, 20	31.8, 26.5	8.5, 3.5	33.2, 37.5
My skills and time are not well used.	26.8, 29	6, 6	35.4, 33	35.4, 29	25.8, 0	39.3, 25	25.3, 11	24.6, 13.5
My opinion is not valued.	21, 16	6.5, 6.5	11.3, 5	18.6, 15	6.4, 0	9.8, 10	23.8, 4	25.5, 9
The coalition is not taking any meaningful action.	49.3, 41	11.3, 9	42.3, 46.5	45.7, 52	43.6, 41	24.5, 10	15.8, 6	53.7, 45
I am often the only voice representing my point of view.	20.3, 19	27, 27	9.3, 8	7.5, 8.5	13.8, 0	26.5, 15	8.2, 2	22.7, 10
The financial burden of traveling to coalition meetings is too high.	1.3, 0	1, 1	0.7, 0	19.6, 8	0.2, 0	9.8, 2	2.3, 2	8.5, 4.5
The financial burden of participation (barring travel) is too high.	24.5, 24.5	1, 1	10.3, 0.5	5.8, 5.5	0.3, 0	3, 4	2, 1	6.2, 3

Table 15 continued

The coalition is competing with my organization.	25, 25	0, 0	0.5, 0.5	23.7, 5.5	13, 1	3.3, 5	1.5, 1	2.8, 2
The coalition is actively recruiting new members.	52.5, 52.5	37.7, 37	40.2, 25	42, 41	61.3, 61.5	70.8, 69.5	70.4, 75	52.9, 61
New members receive adequate orientation to be effective members of the coalition.	49.7, 47	20, 5	50, 50	55.9, 61.5	42.7, 36.5	42.5, 37	45.4, 35	43.2, 42.5
The current method for communication between coalition staff/leadership and its membership is effective.	45.5, 45.5	41.8, 36.5	51.1, 52	55.8, 53	62.7, 36.5	77.2, 80	62.9, 73.5	65.5, 67
Resources are being identified to support the systemic, programmatic changes implemented through the work of the coalition.	44, 21	52.8, 58	41.6, 40	60.5, 61	55.4, 51	77.8, 81	62.8, 65	44.9, 47.5
The coalition is making progress in implementing activities that have potential to improve health in the county.	47.8, 48.5	62.8, 63	50, 50	47.9, 51	65.5, 64.5	86.9, 90	78.1, 81	56.4, 59

Table 15 continued

The coalition is improving health outcomes for people in the county served by this coalition.	35, 31	51.3, 54	48.4, 51	47, 54.5	53.5, 64.5	66.2, 68	75.7, 81	56.3, 60
My skills and abilities are effectively used by the coalition.	45.3, 42.5	45.8, 45	67, 70	40.4, 40	61.5, 50	65.8, 62	59.6, 52	46.7, 50
I feel respected and recognized for my efforts.	53, 50	81.5, 87.5	76.9, 80	55.4, 52	80.4, 83.5	82.7, 81	71.4, 84	66.8, 71
Leadership has a clear vision for the coalition.	56.8, 64	75, 75	60.1, 68	37.2, 19	69.5, 67.5	81.3, 79	78.2, 80.5	52.8, 68
Leadership has the necessary knowledge and skills.	69, 66	83.3, 86	70.3, 73	56.2, 51	76.3, 77	85.7, 90	84.6, 85	73.8, 71
Leadership is respected.	66.7, 64	91.7, 100	71.4, 70.5	49.8, 51	79, 78.5	82.8, 90	85.9, 91	84.8, 84
Leadership gets things done.	57.7, 59	62.3, 68	63.9, 68	50.2, 52	72.8, 70.5	81.9, 80	81.6, 85	60.4, 61.5
Leadership intentionally seeks others' views.	53, 58.5	77, 88	72.8, 76.5	45.8, 40	78.8, 80.5	86.4, 88	81, 94.5	73.5, 85
Leadership utilizes the skills and talents of many, not just a few.	42, 40	79.3, 86	61.1, 59.5	47.5, 46	63.5, 55	82, 78.5	75.7, 81	63.1, 59.5
Leadership is ethical.	85.3, 85	84, 76	92.3, 100	54.8, 56	87.1, 94.5	91.9, 96	92.3, 100	90.3, 97.5
Leadership is skillful at resolving conflict.	64.3, 65	76.7, 86	68.4, 61	28, 20	49.5, 49.5	79.5, 82	75.2, 83	77, 80

Table 15 continued

CSAS Cluster means								
LF (out of 100)	54.06	65.86	63.34	48.5	69	79.98	75.96	64.23
PROB (out of 100)	26.43	23.48	28.85	32.2	19.54	24.36	17.58	28.05

CSAS, Coalition Self-Assessment Survey. CHCx, community health coalition in each of the 8 counties, ordered by the size of coalition membership; i.e., CHC1 had the fewest members, CHC8 had the most. $\bar{x}$, sample mean. $\tilde{x}$, sample median. LF, coalition members' positive perceptions of their leadership and functioning. PROB, coalition members reporting problems for participating in their coalition. *the response rate for CHC4 exceeded membership size; this is likely because the survey was sent as an anonymous survey link and may have been distributed to members' colleagues who were not on our distribution list.

Table 16: Social Network Analysis and Coalition Self-Assessment Survey Correlation Results

Connection type	Calculated SNA variable	CSAS Cluster	
		LF	PROB
Cooperation	**Density**	.	.
	Mean degree	0.458	.
	Degree centralization	.	.
	Betweenness centralization	-0.449	0.488
	Closeness centralization	.	.
	Eigenvector centralization	.	.
	Transitivity	.	.
Coordination	**Density**	.	.
	Mean degree	0.675	.
	Degree centralization	.	.
	Betweenness centralization	-0.591	0.497
	Closeness centralization	.	.
	Eigenvector centralization	.	.
	Transitivity	.	.
Collaboration	**Density**	.	.
	Mean degree	0.486	.
	Degree centralization	.	.
	Betweenness centralization	.	.
	Closeness centralization	0.430	.
	Eigenvector centralization	.	.
	Transitivity	.	.
Formal ties	**Density**	-0.533	0.668
	Mean degree	0.401	.
	Degree centralization	0.589	-0.411
	Betweenness centralization	.	.
	Closeness centralization	.	.
	Eigenvector centralization	.	-0.500

Table 16 continued

	Transitivity	.	0.429
Good-high trust	**Density**	.	.
	Mean degree	.	.
	Degree centralization	.	.
	Betweenness centralization	-0.488	.
	Closeness centralization	.	.
	Eigenvector centralization	.	.
	Transitivity	.	0.448
Frequent direct contact	**Density**	.	.
	Mean degree	.	.
	Degree centralization	.	.
	Betweenness centralization	.	0.403
	Closeness centralization	.	.
	Eigenvector centralization	.	.
	Transitivity	.	.
Frequent mass communication	**Density**	.	.
	Mean degree	.	.
	Degree centralization	.	.
	Betweenness centralization	.	.
	Closeness centralization	0.423	.
	Eigenvector centralization	.	.
	Transitivity	.	.

SNA, Social Network Analysis. CSAS, Coalition Self-Assessment Survey. LF, coalition members' positive perceptions of their leadership and functioning. PROB, coalition members reporting problems for participating in their coalition. Pearson's correlation coefficients between calculated SNA variables and CSAS cluster means. An arbitrary cutoff value of ±0.4 was selected to identify correlation values that may be important (i.e., "significant"). Any correlation values falling between +0.4 and -0.4 are denoted by a period (.). For visual clarity, positive correlation values are highlighted in green and negative correlation values are highlighted in red.

Table 17: Calculated Social Network Analysis Variables and Coalition Self-Assessment Survey Cluster Means versus County-level Health Statistics Correlation Results

Coalition priorities:	Substance use prevention					Tobacco control			Obesity prevention						Infant/maternal health					Systems of care								*	(← *Mental health) Wellness					
County-level health statistics	opdeath	opEd	opHosp	opTrt	_RFBING5	SMOKDAY2	USENOW3	ECIGNOW	_BMI5CAT.A.avg	_RFBMI5.A	SSBSUGR2	SSBFRUT2	_TOTINDA	FoodInsec	LBW	VLBW	pregsmok	prenatal	preterms	MEDCOST	HLTHPLN1	_HCVU651	PERSDOC2	CHECKUP1	FLUSHOT6	PNEUVAC3	_RFMAM2Y	_RFPSA21	MENTHLTH5	_RFHLTH	PHYSHLTH5	POORHLTH5	ChronicAvg	ChronicSum3	FrailtySum1
CSAS Cluster																																			
LF	.421	.	.	.431	.	.	.	.	.	.	-.503	.	.	.	.	.	.641	.	.713	.	.	.	-.454	.	.	.	.	.	.	.423	.	.	.	.	.
PROB	-.622	.	.	-.645	.	.	.	.	.	.	.448	.443	.	.	.	.	-.798	.	.	.	-.624	-.604	.	.	.	.	.	.	.	-.472	.	.	.544	.	.
Density																																			
Coop-eration	.	.	.887	.	.	.	.	.	.	.	.	.	.619	-.448	.	-.732	.	-.629	-.463	.	.	.	.524	.736	.	.	.	.	-.443	.	.	-.561	.	.	.
Coord-ination	.	.	.604	-.630	.563	.	.	.	.	.	.	.	.559	-.502	.	-.578	.	-.530	.	.	.	.	.	.	.	.	.511	.	.	-.401	.	-.439	-.546	.	.	.
Collab-oration	.	.	.559	-.530	.584	.	.	.	.414	.	.	.	.636	-.458	.	-.602	.	-.553	.	.	.	.	.	.435	.	.517	.	.	.	.	-.454	-.486	.	.	.
Formal Ties	-.745	.	.422	-.876	.	-.499	-.409	.	.	.	.	.	.	-.654	.	.	-.924	.	.	.	-.700	-.726	.	.	.	.	.	.	-.597	-.580	.	-.522	.	.	-.532
Good-high Trust	-.659	.	.591	-.774	.622	.	.	.	.	.	.	.	.515	-.521	.	-.424	-.526	-.401	.	.	.	.	.	.	.	.	.	.	.	-.405	.	-.585	.	.	.
Direct Contact	.	.	.465	-.565	.760	.	.	.	.	.	.	-.417	.	-.573	.	-.604	.	.	.	.	.	.	.	.	.	.	.499	.	.	.	.	-.553	-.600	-.419	.	.
Mass Comm	.	.	.513	-.530	.691	.	.	.	.557	.	.	.	.636	-.452	.	-.550	.	-.444	.	.	.	.	.	.429	.462	.448	.	.	.	.	.	-.400	-.464	.	.	.
Mean degree																																			
Coop-eration	.609	.	-.649	.767	-.457	.627	.692	.	.	.	.	.496	.	.781	.479	.646	.719	.	.	.	.425	.473	.	.	.	.	.	.	.703	.568	.	.716	.	.	.505
Coord-ination	.	.	-.598	.436	.	.623	.665	.	.409	.	.	.466	.	.611	.671	.597	.606	.	.720	.	.	.	-.431	.	.	.	.	.	.527	.441	.	.518	.	.	.

Table 17 continued

Collab-oration	.	.	.	.	.	.	.650	-.605	.735	.524	.	.	.622	.503	.682	.	.645	-.474	.482	.	.	.	.	.	.	.	.	.	.542	.413	.	.415	.	.	.
Formal Ties	.	.	-.761	.531	-.422	.486	.767	.	.	.	.	.633	.	.651	.621	.766	.499	.	.533	.	.	.	.	.	.	-.468	.	.	.642	.	.	.622	.	.	.
Good-high Trust	.	.	-.634	.456	.	.591	.874	.	.404	.	.	.715	.	.611	.761	.717	.471	.	.520	.	.	.	.	.	.	-.495	.	.	.703	.	.	.524	.	.	.
Direct Contact	.	.	-.445	.	.	.690	.741	-.622	.502	.	.	.	.	.	.687	.	.659	.	.577	.	.443	.444	.	.	.	.	.	.	.686	.	.	.	.	.	.
Mass Comm	.	.	-.555	.534	.	.766	.904	.	.600	.543	.	.656	.	.644	.739	.608	.584	.	.	.	.444	.485	.	.	.	.	.	.	.802	.	.	.568	.	.	.459
Degree centralization																																					
Coop-eration	.	.	-.856	.	.	.	.	.	.	.	.	.	-.700	.	.	.691	.	.689	.405	.	.	.	-.524	-.780	.	.	.	.	.	.	.	.512	.	.	.
Coord-ination	.	.	-.661	.	.	.	.	.	.	.	.	.	-.647	.	.	.658	.	.557	.	.	.	.	.	-.641	.	.	.	.	.	.	.558	.548	.	.	.
Collab-oration	.	.647	.	.	.	.	.	.	.	.486	.466	.	.	.524	.	.465	.	.	.	.600	.	.	.	.	.	.	.617	.846	.	.482	.901	.714	.594	.	.492
Formal Ties	.794	.	-.678	.806	-.718	.	.	.	.	.	.	.	.	.715	.	.525	.634	.	.	.	.	.	.	.	.	.	.	.	.	.602	.	.764	.	.	.
Good-high Trust	.626	.	-.677	.670	-.689	.	.	.	.	.	.	.	-.466	.454	.	.413	.413	.443	.	.	.	.	.	.	.	.	.	.	.	.	.	.636	.	.	.
Direct Contact	.	.	-.810	.	.	.	.	.	.	.	.	.495	-.600	.	.	.777	.	.660	.500	.	-.413	.	-.466	-.707	-.480	.	.	.	.	.	.	.432	.	.411	.
Mass Comm	.	.	-.687	.	-.549	.	.	.	.	.	-.484	.	-.674	.	.	.	.	.672	.	.	-.534	-.491	-.483	-.438	.	.	-.499	.	.	.	.	.	.	.712	-.440
Betweenness centralization																																					
Coop-eration	.	.	-.532	.	.	.	.	.	.	.	.	.	-.623	.	.	.	.	.653	.	.	-.452	-.449	-.471	-.728	.	.	.	.	.	.	.	.	.	.	.
Coord-ination	.	.	.	.	.	.	.	.432	.	.	.	.	-.502	.	.	.	.	.557	-.492	.	.	.	.	.	.	.	.	.	.	.505	.	.	.	.	.
Collab-oration	.	.	-.687	.	.	.	.	.	.	.	.	.	-.518	.	.	.466	.	.427	.	.	-.665	-.635	-.626	-.682	.	.	.	.403	.	.	.446	.536	.	.	.
Formal Ties	.	.481	.	.	.	.	.	.	-.564	.	.	.	.	.	-.551	.	.	.	.	.	.	.	.	.	-.716	.	.510	.	.	.510	.457	.	.	-.816	.451
Good-high Trust	.	.	.	.	-.430	-.461	.	.468	.	.	.	.	-.503	.	-.509	.	.	.502	-.680	.	.	.	.	.	.446	.	.	.	.	.	.	.	.	.	.

Table 17 continued

Direct Contact	.	.	-.767	.	.	.	.	.	.	.	.	.	-.740	.	.	.579	.	.790	.494	.	-.588	-.570	-.575	-.775	.	.	.	.	.	.	.	.	.	.477	.
Mass Comm	.	.	.	-.419	.	-.790	-.531	.440	-.744	-.686	-.511	.	-.701	.	.	.	-.484	.531	.	-.593	-.779	-.790	-.406	-.507	-.422	.	-.408	.	-.619	.	.	.	.	.	-.619
Closeness centralization																																			
Coop-eration	.	.	-.846	.	.	.	.	.	.	.	.	.	-.693	.	.	.701	.	.678	.	.	.	.	-.489	-.753	.	.	.	.	.	.	.	.521	.	.	.
Coord-ination	-.442	.	.573	.	.	-.646	.	.845	-.639	-.533	-.519	.	.	.	.	.	.	.	.	-.694	.	.	.669	.	.	-.689	.	-.550	-.436	.	.	-.586	.	.	.
Collab-oration	.	-.461	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.498	.	-.735	-.743	-.404	.	.	.	.	.	-.445	.	.	.	.663	.	.
Formal Ties	.	.	.656	.	.	.	.	.	.	.	.	-.457	.	-.560	.	-.784	.	.	.	.	.532	.496	.486	.615	.463	.	.	-.451	.	-.452	-.684	-.711	-.676	.	.
Good-high Trust	.449	.	-.452	.631	-.609	.	.	.	-.408	.	.	.	-.660	.	.	.	.	.549	.	.	.	.	.	.	.	.	.	.	.	.	.	.405	.	.	.
Direct Contact	.	.	-.505	.	.	.	.	.	-.449	-.407	.	.	-.725	.	.	.516	.	.765	.535	-.483	.	.	.	-.780	-.643	.	.	-.524	.	.	.	.	.	.	.
Mass Comm	.	.	-.556	.	.	.	.	-.501	.	.	.	.	-.455	.403	.	.603	.	.	.667	.	.	.	-.645	-.862	-.700	.	.	.	.463	.474	.	.	.	-.476	.
Eigenvector Centralization																																			
Coop-eration	.	.	-.743	.	.	.	.	.	-.418	.	.	.	-.832	.	.	.567	.	.799	.	.	.	.	-.520	-.843	.	.	.	.	.	.	.	.	.	.	.
Coord-ination	.	.	-.664	.	.	.	.	.	.	.	.	.	-.719	.	.	.466	.	.633	.	.	.	.	.	-.609	.	.	.	.	.	.	.478	.519	.	.	.
Collab-oration	.401	.586	.	.509	-.442	.	.	.	.	.	.	.	-.440	.	-.486	.	.	.	-.441	.	.	.	.	.	.	.	.	.442	.	.	.698	.509	.	.	.
Formal Ties	.	.	.793	.	.	.	.	.	.	.	.	-.413	.	.	.	-.740	.	.	.	.	.710	.673	.655	.688	.	.	.	.	.	.	-.434	-.621	-.567	-.467	.
Good-high Trust	.448	.460	.	.554	-.518	-.410	.	.	-.519	.	.	.	-.652	.	-.619	.	.	.455	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Direct Contact	.	.	.	.	-.573	-.536	.	.699	-.538	.	.	.	-.412	.	.	.	-.504	.	.	.	-.405	.	.	.	-.413	.	.	.	.	.	.	.	.535	.	.
Mass Comm	.	.	.	.	-.403	-.866	-.600	.521	-.949	-.831	-.693	.	-.886	.	-.607	.	.	.617	.	-.741	.	.	.	-.423	-.443	.	-.431	.	-.501	.	.	.	.	.	-.428
Transitivity																																			
Coop-eration	.	.	.826	.	.	.	.	.	.	.	.	.	.700	.	.	-.702	.	-.685	-.462	.	.	.	.466	.728	.410	.	.	.	.	.	.	-.471	.	.	.

Table 17 continued

Coord-ination	.	.	.589	-.588	.599	.	.	.	.	.	.	.	.579	-.430	.	-.507	.	-.567	.	.	.	.	.	.	.	.484	.	.	.	.	-.430	-.532	.	.	.
Collab-oration	.	.	.909	-.403	.430	.	.	.	.	.	.	.	.556	-.507	.	-.740	.	-.546	.	.	.	.	.522	.663	.	.	.	.	.	.	-.426	-.709	.	.	.
Formal Ties	-.642	.	.403	-.915	.690	.	-.464	.	.	.	.	.	.	-.705	.	-.445	-.673	.	.	.	-.594	-.646	.	.	.	.594	.	.	-.532	-.513	.	-.593	.	.	-.480
Good-high Trust	-.679	-.425	.433	-.814	.671	.	.	.	.	.	.	.	.495	-.485	.	.	-.523	.	.	.	.	-.421	.	.	.	.	.	.	.	-.415	.	-.505	.	.	.
Direct Contact	.	.	.543	-.514	.798	.	.	-.440	.414	.	.403	.	.620	.	.	-.467	.	-.550	.	.	.	.	.	.	.	.551	.	.	.	.	.	-.444	.	.	.
Mass Comm	.	.	.763	.	.604	.	.	.	.	.	.	.	.579	.	.	-.543	.	-.462	.	.	.464	.418	.542	.550	.	.	.	.	.	.	.	-.578	.	-.481	.

CSAS, Coalition Self-Assessment Survey. Comm, communication. Pearson's correlation coefficients between calculated social network analysis variables (density, mean degree, degree centralization, betweenness centralization, closeness centralization, eigenvector centralization, and transitivity; across the following connection types: cooperation, coordination, collaboration, formal ties, good-high trust, frequent direct contact, frequent mass communication) and CSAS clusters (LF, coalition members' positive perceptions of their leadership and functioning. PROB, coalition members reporting problems for participating in their coalition). An arbitrary cutoff value of ±0.4 was selected to identify correlation values that may be important (i.e., "significant"). Any correlation values falling between +0.4 and -0.4 are denoted by a period (.). For visual clarity, positive correlation values are highlighted in green and negative correlation values are highlighted in red.

County-level health statistics retrieved from: STATS, Indiana Stats Explorer (https://gis.in.gov/apps/isdh/meta/stats_layers.htm). BRFSS, Behavioral Risk Factor Surveillance System (https://www.cdc.gov/brfss/annual_data/annual_data.htm). FeedingAmerica, Feeding American Food Insecurity in Indiana (http://map.feedingamerica.org/county/2015/overall/indiana).

opdeath, STATS (2016), Deaths from drug poisoning- involving opioid pain relievers; *rate (crude rate per 100,000 population)*. **opEd**, STATS (2016), Non-fatal emergency department visits due to opioid overdoses; *rate (crude rate per 100,000 population)*. **opHosp**, STATS (2016), Non-fatal hospitalizations due to opioid overdoses; *rate (crude rate per 100,000 population)*. **opTrt**, STATS (2016), Substance abuse treatment- other opiates and synthetics; *rate (crude rate per 100,000 population)*. **_RFBING5**, BRFSS (2015-16), Calculated variable for binge drinkers (males having five or more drinks on one occasion, females having four or more drinks on one occasion); *percent responding yes, that they did drink in the last 30 days and that they had 5 (men), 4 (women), or more drinks on one or more occasions*. **SMOKDAY2**, BRFSS (2015-16), Do you now smoke cigarettes every day, some days, or not at all?; *percent responding every day or some days*. **USENOW3**, BRFSS (2015-16), Do you currently use chewing tobacco, snuff, or

snus every day, some days, or not at all?; *percent responding every day or some days*. **ECIGNOW**, BRFSS (2015-16), Do you now use e-cigarettes or other electronic "vaping" products every day, some days, or not at all?; *percent responding every day or some days*. **_BMI5CAT.A.avg**, BRFSS (2015-16), Calculated variable for the average adult BMI; *mean*. **_RFBMI5.A**, BRFSS (2015-16), Calculated variable for adults who have a body mass index greater than 25.00 (overweight or obese); *percent of adults who are overweight or obese*. **SSBSUGR2**, BRFSS (2015-16), During the past 30 days, how often did you drink regular soda or pop that contains sugar? Do not include diet soda or diet pop; *percent of people responding that they drank sugar-sweetened soda every day in the last 30 days*. **SSBFRUT2**, BRFSS (2015-16), During the past 30 days, how often did you drink sugar-sweetened fruit drinks (such as Kool-aid and lemonade), sweet tea, and sports or energy drinks (such as Gatorade and Red Bull)? Do not include 100 percent fruit juice, diet drinks, or artificially sweetened drinks; *percent of people responding that they drank noncarbonated sugar-sweetened beverages every day in the last 30 days*. **_TOTINDA**, BRFSS (2015-16), During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?; *percent of people responding that they had no physical activity at all in the last 30 days, i.e., 0 days of physical activity in the last 30 days*. **FoodInsec**, FeedingAmerica (2015), County food insecurity rate; *percent*. **LBW**, STATS (2016), Low birthweight infants; *percent of live births*. **VLBW**, STATS (2016), Very low birthweight infants; *percent of live births*. **pregsmok**, STATS (2016), Mothers smoking during pregnancy; *percent of live births*. **prenatal**, STATS (2016), Mothers receiving prenatal care beginning in the first trimester; *percent of live births*. **preterms**, STATS (2016), Preterm infants, less than 37 weeks; *percent of live births*. **MEDCOST**, BRFSS (2015-16), Was there a time in the past 12 months when you needed to see a doctor but could not because of cost?; *percent responding yes, this is true*. **HLTHPLN1**, BRFSS (2015-16), Do you have any kind of health care coverage, including health insurance, prepaid plans such as HMOs, or government plans such as Medicare, or Indian Health Service?; *percent responding no, they do not have health care coverage*. **_HCVU651**, BRFSS (2015-16), Calculated variable for respondents aged 18-64 who have any form of health care coverage; *percent responding they do not have healthcare coverage*. **PERSDOC2**, BRFSS (2015-16), Do you have one person you think of as your personal doctor or health care provider?; *percent responding no, they do not have a personal doctor or health care provider*. **CHECKUP1**, BRFSS (2015-16), About how long has it been since you last visited a doctor for a routine checkup?; *percent responding that it has been longer than two years or that they are not sure*. **FLUSHOT6**, BRFSS (2015-16), During the past 12 months, have you had either a flu shot or a flu vaccine that was sprayed in your nose?; *percent responding no*. **PNEUVAC3**, BRFSS (2015-16), A pneumonia shot or pneumococcal vaccine is usually given only once or twice in a person´s lifetime and is different from the flu shot. Have you ever had a pneumonia shot?; *percent responding no or don't know/now sure*. **_RFMAM2Y**, BRFSS (2015-16), Calculated variable for women respondents aged 40+ who have had a mammogram in the past two years*; percent responding no (5 year estimate)*. **_RFPSA21**, BRFSS (2015-16), Calculated variable for male respondents aged 40+ who have had a Prostate-Specific Antigen test in the past 2 years; *percent responding no (5 year estimate)*. **MENTHLTH5**, BRFSS (2015-16), Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?; *percent reporting 5 or more days of poor mental health in the last 30 days*. **_RFHLTH**, BRFSS (2015-16), Would you say that in general your health is: excellent, very good, good, fair, poor; *percent responding fair and*

poor. **PHYSHLTH5**, BRFSS (2015-16), Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?; *percent reporting 5 or more days of poor physical health in the last 30 days*. **POORHLTH5**, BRFSS (2015-16), During the past 30 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation?; *percent reporting 5 or more days in the last 30 days*. **ChronicAvg**, BRFSS (2015-16), The average number of chronic diseases people have, out of nine possible options: myocardial infarction, angina/coronary heart disease, stroke, asthma, cancer, COPD/emphysema/chronic bronchitis, arthritis/rheumatoid arthritis/gout/lupus/fibromyalgia, kidney disease, diabetes; *mean*. **ChronicSum3**, BRFSS (2015-16), The percentage of people having three or more chronic diseases (from the above list of nine) at once; *percent responding three or more*. **FrailtySum1**, BRFSS (2015-16), Percent of people having at least one indicator of frailty: difficulty walking or climbing stairs, difficulty dressing or bathing, difficulty running errands because of a physical/mental/emotional condition; *percent having one or more*.

CHAPTER 5. FOCUSED LEADERSHIP IMPROVES PARTNERSHIP OUTCOMES FOR COMMUNITY HEALTH COALITIONS ADDRESSING CHRONIC DISEASE PREVENTION

Abstract

Context: Rural Americans have higher rates of chronic disease, comorbidities, and poor health outcomes, compared to urban/suburban Americans. Community health coalitions (CHCs) are one strategy for improving local health through community-led, sustainable changes to policies, systems, and environments. In Indiana, there is a robust statewide network of CHCs partnering with Purdue University through Cooperative Extension System Educators (Ext) and Nutrition Education Program Community Wellness Coordinators (CWC). Ext and CWC both receive training in community engagement; however, CWC receive more focused research and leadership training, whereas Ext receive broad training.

Objective: To compare CHC partnership network structures and member reported perceived effectiveness between focused (CWC) versus broad (Ext) training models.

Design: CHCs partnering with Ext and CWC were recruited to participate in a statewide evaluation study; participants completed two surveys administered online or in person.

Setting: 24 rural counties in Indiana in which there is an active CHC partnering with either Ext or CWC.

Participants: members of 24 CHCs (8 partnering with Ext, 16 partnering with CWC).

Intervention: an observational cross-sectional study design in which Ext and CWC receive differing levels of training according to job responsibilities, program requirements, and federal mandate.

Main Outcome Measures: partnership network measures calculated from a social network analysis questionnaire; CHC perceived effectiveness determined from a cluster analysis of responses to the Coalition Self-Assessment Survey; Pearson's correlation between social network analysis and Coalition Self-Assessment Survey variables.

Results: Ext-CHC perceived effectiveness positively correlated to partnership network interconnectedness, while CWC-CHC perceived effectiveness negatively correlated to network interconnectedness. CWC-CHCs also rated their leadership and functioning higher, reported fewer problems for participating in their CHC, and were more centralized, compared to Ext-CHCs.

Conclusions: Different training models related to differences in CHC partnership networks and outcomes. Greater interconnectedness or centralization may be preferable for a CHC, depending on its stage of development, health focus, and roles of its membership.

Introduction

Rural Americans have a higher risk of mortality from chronic illness compared to urban Americans (Centers for Disease Control and Prevention, 2017). Increased rates of smoking, obesity, and high blood pressure, opioid abuse, geographic isolation, and limited access to care put rural Americans at a greater risk for poor health (Centers for Disease Control and Prevention, 2017). Indiana has a large rural population (21.9% in 2017) (Rural Health Information Hub,

2019), and ranks 13th out of 50 states for deaths from heart disease, 9th for deaths from cancer, and 9th for deaths from chronic lower respiratory disease (Centers for Disease Control and Prevention, 2018b). Indiana also has an infant mortality rate and drug overdose death rate that are greater than the national average (7.5 versus 5.9 and 24.0 versus 19.8, respectively) (Centers for Disease Control and Prevention, 2018b).

Community health coalitions (CHCs) have been promoted and supported by the Purdue University Cooperative Extension System, and other community development organizations, to address poor local health in rural Indiana. Purdue Extension Educators (Ext) work and live in each of Indiana's 92 counties and are instrumental in community outreach and engagement efforts. In counties with CHCs, Ext often serve as either the CHC leader or in an advisory capacity, providing university support and evidence-based programming to community members (Purdue Extension Health and Human Sciences). However, continued systematic program improvements have been limited due to the methodological challenges of capturing and quantifying CHC activities in the context of dynamic local partnerships. Furthermore, historic inconsistent data collection and reporting have limited the generalizability of findings.

Thus, in a pilot study, we partnered with Purdue Extension to develop and implement a mixed-methods coalition effectiveness evaluation framework (Figure 10). During the Summer of 2017, we administered the Coalition Self-Assessment Survey (Kenney et al., 2000) and a Social Network Analysis (SNA) survey (questions adapted from (Provan et al., 2005) and (Cullerton et al., 2016)) to 8 CHCs led by/partnering with their local Ext.

We found that CHCs with greater interconnectedness in their partnership networks (mean degree) rated their leadership and functioning higher. We also found that having a higher density

of formal ties, whereby existing connections were at the organization rather than the personal level, was related to members reporting more problems for participation in their CHC. Together, these findings suggest that CHCs may perceive they are more effective when members are interconnected and have positive working relationships that are not overly professional. We also found that CHCs addressing crises (e.g., the opioid epidemic) perceived their leadership and functioning as more effective than did CHCs addressing chronic disease prevention (e.g., obesity). We suspect that the low centralization of CHCs responding to crises possibly indicates the formation of transient cross-sector collaborations resulting from a sense of urgency. Making progress toward resolving rapid response issues may have allowed these CHCs to witness immediate results to their work. However, CHCs addressing chronic disease perhaps lacked a sense of urgency and adopted a network structure where a single coordinating body maintained connections between seasonal/yearly programming cycles. It will likely take several years for these CHCs to witness the impact of their work (Chapter 4). Thus, there appears to be a relationship between partnership network structures, member reported perceived effectiveness, and salient county-level health statistics.

Importantly, under the Cooperative Extension System, Ext are granted autonomy over what health topics they pursue through their CHCs. Ext receive broad training covering food, family, money, and health, serve on CHCs having variable funding streams, and may operate under grants or initiatives following specific program goals and reporting requirements (Purdue Extension Health and Human Sciences). The Purdue Nutrition Education Program Community Wellness Coordinators (CWC) live and work in communities with Supplemental Nutrition Assistance Program-eligible populations. In accordance with federal mandate (funding through the United States Department of Agriculture Supplemental Nutrition Assistance Program-

Education Division and the Expanded Food and Nutrition Education Program), the Nutrition Education Program focuses its engagement and CHC building efforts on nutrition, physical activity, food security, food safety, and food resource management. Purdue Nutrition Education Program created the position of the CWC to serve as a local health promotion leader in order to fulfill program requirements (Purdue Extension Health and Human Sciences). Purdue Nutrition Education Program provides CWC with an intensive 25 week training program on nutrition-related policy, system, and environment change interventions (Purdue Extension Health and Human Sciences).

There are several examples exploring the effect of differing leadership models on coalition functioning and impact. Willems et al. (2017) suggested that a balanced leadership style of centralized and dispersed power and influence may yield preferable outcomes for organizational functioning (Willems et al., 2017). They argued that an overly centralized coalition is likely to disband if the leader leaves, whereas coalitions having overly dispersed power may take an inappropriate amount of time to come to a consensus in situations where decisions must be made rapidly (Willems et al., 2017). Likewise, Butterfoss et al. (1993) posited that coalition functioning is improved by "strong central leadership" who are also "attentive to and supportive of individual member concerns," thus promoting coalition cohesiveness (Butterfoss et al., 1993). Finally, Metzger et al. (2005) found that coalition member participation and positive perceptions increased when leadership was empowering and supportive of collaborative decision making (Metzger et al., 2005). Altogether, coalition effectiveness may markedly improve when the leader shares power and responsibility.

Ext have broad leadership responsibilities, while CWC adopt focused leadership roles. Thus, while Ext and CWC both aim to improve health at the local level, their organizational structures, funding streams, program objectives, and training impact their capacity to deliver effective programming. The purpose of this study is to compare coalition member partnership networks and leadership outcomes between CHCs having broad versus focused leadership styles in order to better understand the advantages and weaknesses of each leadership approach in determining successful CHC outcomes; namely CHCs partnering with Ext (Ext-CHCs), compared to those partnering with CWC (CWC-CHCs).

Methods

Survey, study design, and methods are described in Chapter 4. In brief, the survey consisted of two parts: 1. SNA, which asks CHC members to describe their relationships with each of the other members and 2. CSAS, which asks members to rate their perceptions of internal functioning, leadership, and problems for participating in the CHC. For the present study we compared survey results from the original 8 Ext-CHCs collected during the Summer of 2017 to surveys collected from a convenience sample of 16 CWC-CHCs during the Spring of 2018. During the Spring of 2018, CWC were working in 34 counties across Indiana. All CWC were contacted by email to participate in the study, with email reminders sent up to three times once per week after initial contact.

From the SNA survey, we calculated density, mean degree, centralization (degree, betweenness, closeness, and eigenvector), and transitivity for the following connection types: cooperation, coordination, collaboration, formal ties, good-high trust, frequent direct contact, and frequent mass communication (Appendices 1 and 2). We also conducted a k-means cluster

analysis on the CSAS survey, which resulted in two clusters; LF: describing CHC members' positive perceptions of their leadership and internal functioning, and PROB: describing CHC members' problems for participating in the CHC (Appendix 3). We then compared SNA measures and CSAS k-means cluster scores using Pearson's Correlations (Table 18).

In order to explore the position of Ext and CWC within their networks, we calculated their (node-specific) degree and centrality (betweenness, closeness, and eigenvector) (Appendix 4). We refer to Ext and CWC collectively as Community Engagement Professionals (CEnP). We compared CEnP-node SNA measures to CSAS k-means cluster scores using Pearson's Correlations (Table 19).

Finally, we explored mean differences in CSAS and SNA measures between Ext-CHCs and CWC-CHCs using a two-sample t-test or Wilcoxon Rank Sum test when the distributions were non-Gaussian.

The Ext-CHC study was approved by Purdue University's Institutional Review Board, protocol number 1506016147. The CWC-CHC study was granted exempt status by Purdue University's Institutional Review Board, exemption number 1712020009.

Results

Characteristics of study participants

Study participant characteristics for the Ext-CHCs are described in Chapter 4.

Of the CWC-CHC members completing the SNA portion of the survey, 253 also completed the CSAS. The primary role of CWC-CHC members responding to the CSAS was coalition officer or chair (24/253, 9.5%), coalition staff (6/253, 2.4%), chair/co-chair of a

committee or task force (21/253, 8.3%), member of executive or steering committee (41/253, 16.2%), committee member (59/253, 23.3%), member having no other responsibility (81/253, 32.0%), and other role (21/253, 8.3%). Member responses to involvement in the CHC over the past year were very (73/253, 28.9%), moderately (90/253, 35.6%), a little (78/253, 30.8%), and not at all (12/253, 4.7%). 186/253 (73.5%) CHC members participated in some coalition building activity, 67/253 (26.5%) respondents did not. Of those reporting activities, 80 participated in only 1 activity, 40 participated in 2, 25 participated in 3, 21 participated in 4, and 20 participated in 5. Across activities, 53 people acquired funding or other resources for the coalition, 80 attempted to get outside support for coalition positions on key issues, 67 recruited new members, 71 served as a spokesperson, and 146 worked on implementing activities or events sponsored by the coalition.

Main findings of evaluations

For CWC-CHCs, LF correlated positively to the following SNA measures: collaboration density, collaboration transitivity, and frequent direct contact density. LF correlated negatively to cooperation mean degree, coordination mean degree, coordination degree centralization, formal ties mean degree, good-high trust mean degree, and good-high trust closeness centralization. PROB correlated positively to coordination mean degree and good-high trust closeness centralization; and PROB correlated negatively to collaboration transitivity and frequent direct contact density (Table 18). Thus, high mean degree (i.e., having more connections on average) across network types appears to decrease CWC-CHC members' ratings of their leadership and internal functioning.

Although Ext-CHCs and CWC-CHCs appear to be have differing partnership outcomes related to measures of organizational structures at the network-level, we were also interested in the roles that individual CEnP played in their CHC networks (i.e., CEnP-node specific network measures). Interestingly, most correlations in this analysis related to the frequent direct contact network; such that LF was lower when the CEnP was more central in the direct contact network and PROB was higher when the CEnP was more central and held more ties in the direct contact network (Tables 19 and 20).

To compare overall differences between Ext-CHCs and CWC-CHCs, we explored mean differences between each calculated CSAS and SNA measures. Of the 79 independent t-tests performed (2 CSAS clusters + 49 SNA measures + 28 CEnP-node SNA measures), only 3 were statistically significantly different at $p < 0.05$:

- LF (out of 100): CWC (mean = 74.556, median = 75.245) > Ext (mean = 60.594, median = 64.600); p-value = 0.03243
- PROB (out of 100): CWC (mean =12.029, median = 9.747) < Ext (mean = 29.584, median = 25.395); p-value < 0.001
- Collaboration eigenvector centralization (out of 1.0): CWC (mean = 0.361, median = 0.349) > Ext (mean = 0.264, median = 0.265); p-value = 0.03022

Thus, CWC-CHCs reported their leadership and functioning as higher, their problems for participation as lower, and had greater eigenvector centralization in their collaboration network. A network with high eigenvector centralization is characterized by there being an individual serving as a connection between groups who are well-connected internally, but otherwise not well-connected to the other group(s). This central person is assumed to be in a position of power.

Interestingly, the CEnP-node eigenvector centrality was not statistically significantly different between CWC and Ext.

Discussion

Overall differences in network structures, leadership styles, and outcomes between Ext-CHCs and CWC-CHCs could potentially be attributed to differences in training. Training modules CWC participate in include: Systems Change for Health, Conduct CHANGE Tool (Centers for Disease Control and Prevention, 2018a) Assessments, and REDCap (Harris et al., 2009) Training. In contrast, training for Ext is designed to be sufficiently broad to allow them to identify and deliver programming to suit the community's needs. As such, Ext have a less well-defined role, while CWC are tasked with very specific activities and outcomes. The benefits of research training for coalitions has been described elsewhere. For example, under a 1995 Center for Pediatric Research grant, the Immunization Coalition Training Institute convened nearly 300 participants to learn about and apply coalition building, evaluation, advocacy, needs assessment, community planning, action planning, and funding/resource development. Four months after the training institute, participants reported developing or improving existing coalitions, increased coalition effectiveness, and obtaining funding (Butterfoss et al., 2003). Butterfoss (2004) also described the long-term effects of The Coalition Technical Assistance and Training Framework, which improved coalition functioning and outcomes three years post-training for the coalition involved in the Virginia Healthy Start Initiative, which aims to reduce infant mortality and decrease low-weight births (Butterfoss, 2004). Thus, comprehensive, focused training can result in immediate and lasting improvements to coalition activities and sustainability.

For CWC-CHCs, high mean degree correlating to decreased ratings of leadership and internal functioning could be related to a sense of gridlock from members holding too many connections and potentially not bringing in new members. This finding differs from our previous evaluation of Ext-CHCs, in which we found higher mean degree correlated to increased ratings of leadership and internal functioning. Differences between Ext-CHCs and CWC-CHCs may also be related to the experience-level of the CHCs. CWC were hired only as recently as 2016, while some Ext may have been working in their communities for several decades. Thus, CWC-CHCs may still be in the early stages of coalition development while Ext-CHCs may be in the latter developmental stage of institutionalizing.

Additionally, because Ext have broad leadership responsibilities, often serving as the leader by default, rather than by design, there are many opportunities for leadership roles to pass between CHC members (anecdotally, when Ext-CHCs lack a sense of direction, it can be challenging for them to plan and deliver programming). Furthermore, centralized Ext-CHCs reported greater problems for participation, perhaps indicating resistance to a truly central leader. On the other hand, CWC-CHCs may function more effectively in working groups where their leaders delegate roles and responsibilities.

It also appears that CHC members feel they are less effective when the CEnP is central in the communication networks. As such, perhaps it would beneficial to disperse communication using sub-groups or action committees having sub-leaders that manage communications for specific projects. Furthermore, CHCs reporting the fewest problems for participating in their CHC may be communicating with each other directly rather than going through the CEnP; or

alternatively, CHC members may be initiating direct contact rather than waiting for directions from the CEnP.

Additionally, while CWC and Ext appear to hold the same position of power in their networks (as indicated by no measures being statistically significantly different between groups), CWC-CHCs also have other CHC members holding positions of power as well, as indicated by higher whole network eigenvector centralization. Taken together, these findings suggest that leadership power plays a lesser role in overall CHC perceived effectiveness than does elevating the power and status of CHC members.

Finally, in the present study, Ext and CWC are paid professionals holding leadership and/or advisory positions in their CHCs as part of their job requirements; however, member participation in the CHC is voluntary. Thus, it is important to distinguish the unique role of coalition leadership as it relates to developing, convening, and sustaining partnerships of unpaid volunteer members. For example, in a study across 8 different organizations, Adams et al. (1998) reported that workers of volunteer organizations had higher motivation and were more satisfied with the decision-making process than were paid employees at traditional for-profit organizations (Adams et al., 1988). Volunteers felt a greater sense of individual worth and value in their work (Adams et al., 1988). However, Liao-Troth (2001) reported that volunteers and paid workers doing the same work at the same organization had similar attitudes (Liao-Troth, 2001). Thus, the organization/organizational culture may play a critical role in influencing worker perceptions, rather than employment status or the nature of the work. Catano et al. (2001) found that leaders of volunteer organizations adopted a transformational leadership style, in which the

leader imparted a sense of inspiration to members, working together to identify needs and creating a vision for change (Catano et al., 2001).

In the present study, although CWC-CHCs rated their leadership and functioning significantly higher than did Ext-CHCs, the difference was only 10%, at a median of 75 (CWC-CHCs) compared to 65 (Ext-CHCs) out of 100. It is difficult to determine the effect of a 10% difference in ratings of leadership and functioning on CHC activities, and whether a 10 point difference between a rating of 65 and 75 is comparable to a difference between 85 and 95. Additionally, despite statistical improvements associated with focused coalition training, CHC member perceptions may be attributed to personal motivation to serve their communities, with or without having received training. However, comprehensive focused research training could potentially facilitate tangible community wide change, which may subsequently increase CHC members' motivation to continue volunteering. Additional longitudinal evaluation studies are needed to test this hypothesis.

Limitations

Our findings suggest differences in leadership styles and outcomes between Ext-CHCs and CWC-CHCs, which may be attributed to differences in employment priorities and training. However, several limitations exist. First, our sample sizes are small (n=8 Ext-CHCs and n=16 CWC-CHCs), which weakened our statistical analysis. Second, the CHCs that agreed to participate in this study have a longer history than some of the partnerships developing in other counties having Ext and CWC. In fact, some Ext are not involved in coalitions, and some CWC engage action groups instead. Thus, our findings may not be generalizable to the Cooperative Extension System or the Nutrition Education Program as a whole. Third, there is departmental

and staff overlap between the Cooperative Extension System and the Nutrition Education Program, resulting in a highly supportive climate for coalition building, which may not be present in other states. Fourth, the role of the CWC is unique to Purdue University's Nutrition Education Program, and the training they receive was developed internally, so translation to other settings is limited. Finally, although policy, system, and environment changes are an intermediate outcome expected to result in health improvements, the qualitative assessments we are currently conducting are difficult to incorporate into the statistical analytic framework presented in this paper. However, we are working to fill this gap. Additionally, there are numerous examples of confounding factors for which there is not available data and for which we did not survey study participants about; such as: CHC members' personal motivation for volunteerism, familial and/or social ties to other CHC members, employment history and length of employment at current position, co-membership on CHCs of similar or different health topics, the presence of additional public health activities within communities, target population demographics, and community receptivity to CHC activities.

Summary and Conclusions

In summary, first we found that Ext-CHCs had greater perceived effectiveness with higher mean degree in their partnership networks, while CWC-CHCs had lower perceived effectiveness with higher mean degree across their networks. Next, we found that more problems for participation arose across CHCs when the CEnP held a central position in the direct contact network. Finally, we found that CWC-CHCs were more centralized and reported better partnership outcomes than did Ext-CHCs.

In conclusion, Ext and CWC play a crucial role in bridging the gap between research and communities. Historically, the Cooperative Extension System has been the driving force behind applying best practices around agriculture, economic development, and health in rural areas. However, the nature of Extension work is changing to favor CHC development, whereby community members are engaged, but also participate in delivering evidence-based practices. With this change comes the necessity of ensuring that Ext are well equipped to serve as CHC leaders and are able to cement themselves in the iterative feedback process of community engaged research. Likewise, CWC are instrumental in raising awareness around and providing solutions for food insecurity and nutrition-related chronic disease. The training CWC receive serves as a model for focused leadership, research, and evaluation. As both programs continue engaging communities in developing and sustaining CHCs, we will be able to further delineate the impacts of their efforts on local health. Importantly, partnership networks and member perceived effectiveness likely impact CHC sustainability. Thus, continued, systematic assessment of CHCs across the logic model will be instrumental in building recommendations for best practice.

Implications for Policy & Practice

- Federal funding requires the Nutrition Education Program to submit annual program reports on community engagement efforts related to direct education, social marketing, and policy, system, and environment change interventions. As such, CWC become research partners through the implementation and evaluation of their work. On the other hand, Ext are funded to be research ambassadors, translating research to the local level.

- However, as more Ext become involved in CHCs, **additional funding is needed for research training**.
- Additionally, CWC are tasked with specific leadership responsibilities and clear end goals, while Ext have more autonomy to decide how to address community engagement. However, Ext often take on CHC leadership roles by default without having received comprehensive training.
- Finally, while Ext succeeded in promoting network interconnectedness and a shared sense of inclusion, CWC organized CHCs with working groups, delegating tasks and dispersing power and influence. A network of working groups arguably increases program capacity and boosts morale for members engaged in specific projects. Sustainability of CHCs will likely depend on ongoing support from Extension and other community development organizations.

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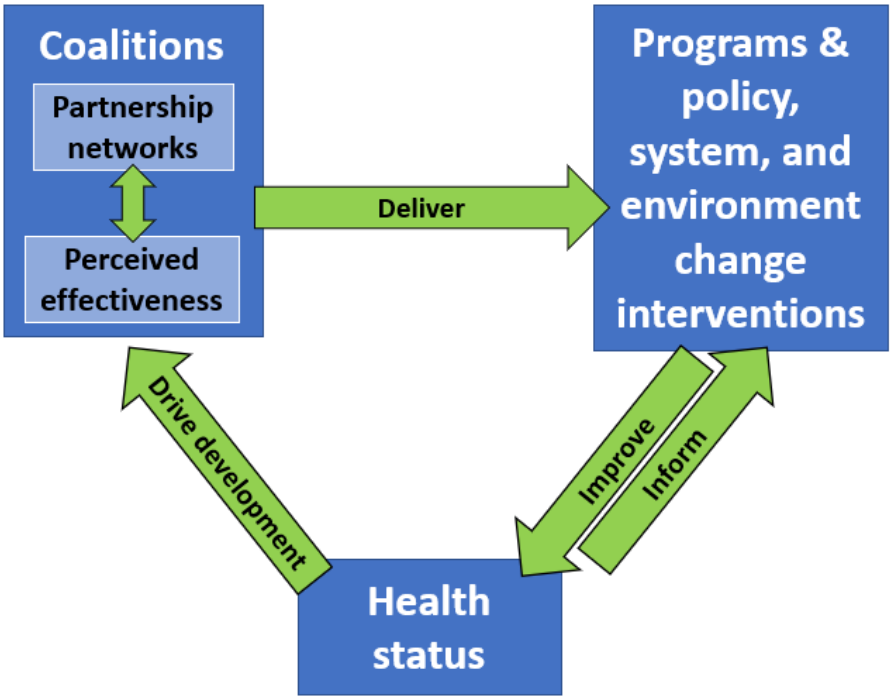


Figure 10: Coalition Evaluation Study Components

Partnership networks were evaluated using social network analysis, with survey questions adapted from Provan et al. (2005) and Cullerton et al. (2015). Coalition perceived effectiveness was evaluated using a modified version of the Coalition Self-Assessment Survey (Kenney and Sofaer, 2000). Programs & policy, system, and environment change initiatives and health status were not included in the present study.

Table 18: Social Network Analysis and Coalition Self-Assessment Survey Correlation Results

Connection type	Calculated SNA variable	CSAS Cluster	
		LF	PROB
Cooperation	**Density**	.	.
	Mean degree	-0.486	.
	Degree centralization	.	.
	Betweenness centralization	.	.
	Closeness centralization	.	.
	Eigenvector centralization	.	.
	Transitivity	.	.
Coordination	**Density**	.	.
	Mean degree	-0.421	0.447
	Degree centralization	-0.434	.
	Betweenness centralization	.	.
	Closeness centralization	.	.
	Eigenvector centralization	.	.
	Transitivity	.	.
Collaboration	**Density**	0.424	.
	Mean degree	.	.
	Degree centralization	.	.
	Betweenness centralization	.	.
	Closeness centralization	.	.
	Eigenvector centralization	.	.
	Transitivity	0.409	-0.422
Formal ties	**Density**	.	.
	Mean degree	-0.478	.
	Degree centralization	.	.
	Betweenness centralization	.	.
	Closeness centralization	.	.
	Eigenvector centralization	.	.
	Transitivity	.	.
Good-high trust	**Density**	.	.
	Mean degree	-0.444	.
	Degree centralization	.	.
	Betweenness centralization	.	.
	Closeness centralization	-0.529	0.485
	Eigenvector centralization	.	.
	Transitivity	.	.
Frequent direct contact	**Density**	0.468	-0.466
	Mean degree	.	.
	Degree centralization	.	.
	Betweenness centralization	.	.
	Closeness centralization	.	.
	Eigenvector centralization	.	.
	Transitivity	.	.
Frequent mass communication	**Density**	.	.
	Mean degree	.	.
	Degree centralization	.	.

Table 18 continued

	Betweenness centralization	.	.
	Closeness centralization	.	.
	Eigenvector centralization	.	.
	Transitivity	.	.

SNA, Social Network Analysis. CSAS, Coalition Self-Assessment Survey. LF, coalition members' positive perceptions of their leadership and functioning. PROB, coalition members reporting problems for participating in their coalition. Pearson's correlation coefficients between calculated SNA variables and CSAS cluster means. An arbitrary cutoff value of ±0.4 was selected to identify correlation values that may be important (i.e., "significant"). Any correlation values falling between +0.4 and -0.4 are denoted by a period (.). For visual clarity, positive correlation values are highlighted in green and negative correlation values are highlighted in red.

Table 19: Community Engagement Professional-Node Social Network Analysis and Coalition Self-Assessment Survey Correlation Results

Connection type	Calculated SNA variable	CSAS Cluster	
		LF	PROB
Cooperation	**Degree**	.	.
	Betweenness centrality	.	.
	Closeness centrality	.	.
	Eigenvector centrality	.	.
Coordination	**Degree**	.	.
	Betweenness centrality	.	.
	Closeness centrality	.	.
	Eigenvector centrality	.	.
Collaboration	**Degree**	.	.
	Betweenness centrality	.	.
	Closeness centrality	.	.
	Eigenvector centrality	.	.
Formal ties	**Degree**	-0.400	.
	Betweenness centrality	.	.
	Closeness centrality	.	.
	Eigenvector centrality	.	.
Good-high trust	**Degree**	.	.
	Betweenness centrality	.	.
	Closeness centrality	.	.
	Eigenvector centrality	.	.
Frequent direct contact	**Degree**	.	0.414
	Betweenness centrality	-0.478	0.461
	Closeness centrality	.	.
	Eigenvector centrality	.	.
Frequent mass communication	**Degree**	.	.
	Betweenness centrality	.	.
	Closeness centrality	.	.
	Eigenvector centrality	.	.

SNA, Social Network Analysis. CSAS, Coalition Self-Assessment Survey. LF, coalition members' positive perceptions of their leadership and functioning. PROB, coalition members reporting problems for participating in their coalition. Community Engagement Professional-Node refers to the SNA variables calculated specifically for either the Extension Educators or the Community Wellness Coordinator in their respective coalition networks (as opposed to whole network measures). Pearson's correlation coefficients between calculated SNA variables and CSAS cluster means. An arbitrary cutoff value of ±0.4 was selected to identify correlation values that may be important (i.e., "significant"). Any correlation values falling between +0.4 and -0.4 are denoted by a period (.). For visual clarity, positive correlation values are highlighted in green and negative correlation values are highlighted in red.

Table 20: Community Engagement Professional direct contact degree and betweenness centrality, organized from fewest to most member-reported problems for participation in the coalition

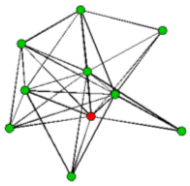
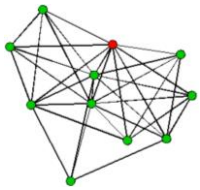
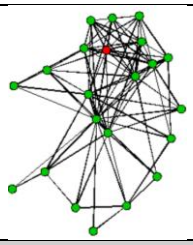
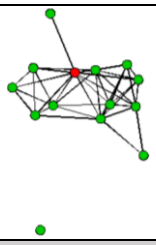
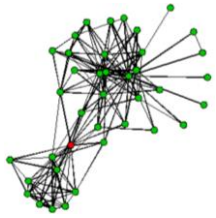
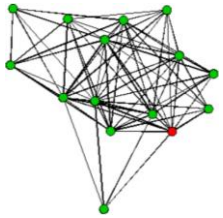
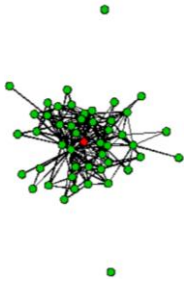
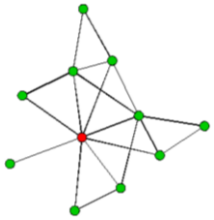
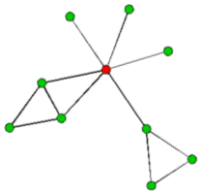
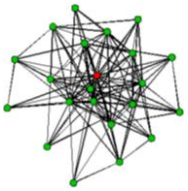
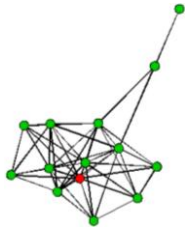
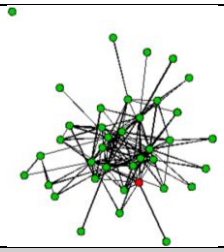
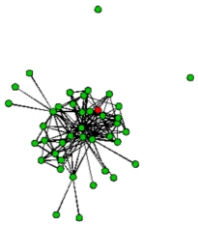
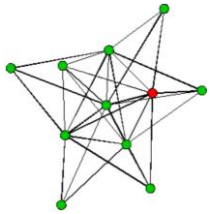
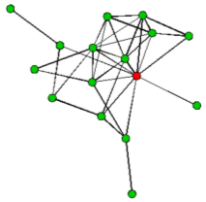
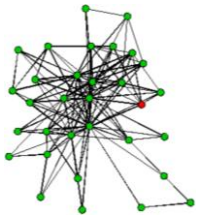
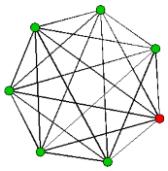
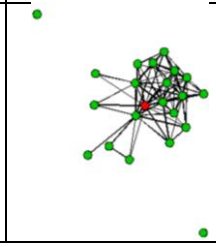
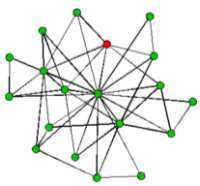
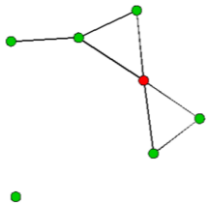
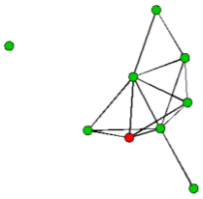
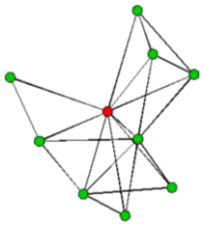
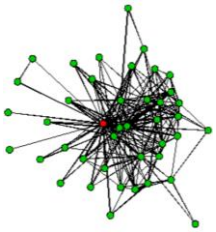
CHC	**CWC-CHC 10**	**CWC-CHC 12**	**CWC-CHC 19**	**CWC-CHC 14**	**CWC-CHC 22**
PROB	3.344444	4.343434	5.580247	7.080808	8.654321
degree	14	16	22	20	30
btw	7.417	22.383	9.491	43.55	418.625
Direct contact					
CHC	**CWC-CHC 16**	**CWC-CHC 24**	**CWC-CHC 11**	**CWC-CHC 9**	**CWC-CHC 20**
PROB	8.91453	9.537778	9.955556	11.76389	13.68333
degree	20	50	10	11	33
btw	8.475	438.016	48.5	52	98.287
Direct contact					
CHC	**CWC-CHC 15**	**Ext-CHC 7**	**CWC-CHC 23**	**Ext-CHC 5**	**CWC-CHC 17**
PROB	17.05983	17.58	17.84795	19.54	19.76852
degree	17	23	22	13	17
btw	11.219	111.217	30.253	17.917	80.157
Direct contact					
CHC	**CWC-CHC 21**	**Ext-CHC 2**	**CWC-CHC 18**	**Ext-CHC 6**	**Ext-CHC 1**
PROB	22.05797	23.48	23.60417	24.36	26.43
degree	16	12	27	9	5
btw	13.36	0	82.283	15.5	6
Direct contact					

Table 20 continued

CHC	Ext-CHC 3	Ext-CHC 4	Ext-CHC 8		
PROB	28.85	32.2	64.23		
degree	6	16	70		
btw	6	43.667	689.74		
Direct contact					

CHC, Community Health Coalition. CWC, Community Wellness Coordinator. Ext, Extension Educator. PROB, the Coalition Self-Assessment Survey cluster describing member reported problems for participating in their CHC, on a scale of 0-100. degree, the number of incoming and outgoing connections the Community Engagement Professional holds in the network. btw, betweenness centrality, the number of times the Community Engagement Professional lies on the shortest path between two nodes. Direct contact, occurring at least once per month.

CHAPTER 6. INCREASED COALITION EFFECTIVENESS CORRELATES TO INCREASED INTERCONNECTEDNESS FOR MEASURES OF PARTNERSHIP QUALITY AND INCREASED CENTRALIZATION FOR ACTION-ORIENTED CONNECTIONS

Introduction

Coalitions have been employed across health topic and geographic location to close the gap on health disparities where traditional public health approaches have had challenges eliciting community-level improvements (Roussos et al., 2000). The local wisdom, resources, skills, and vested interest that coalitions bring to their communities allow for population specific program adaptations that can result in sustainable policy, system, and environment change (Butterfoss et al., 1993). However, community-level change often takes years to achieve, and evaluating coalitions, notwithstanding longitudinally tracking coalition progress, has presented major methodological issues (Granner et al., 2004).

Due to the challenges and amount of time required to track long-term outcomes, coalitions often report short- or intermediate-term outcomes, including internal functioning, capacity building, and the delivery of programs. For example, Bright et al. (2017) conducted a cross-sectional survey to compare working relationships before and after the formation of an academic-community coalition (Bright et al., 2017). They quantified the growth of partnership connections using social network analysis, reporting that collaboration increased as the coalition matured (Bright et al., 2017). Brown et al. (2010) found that community-level factors, such as a high poverty rate and the presence of an institutionalized coalition, negatively impacted the community's receptivity to implementing evidence-based programs (Brown et al., 2010). However, coalition factors, including effective leadership, strategic planning, strong working

relationships, and funding, mediated community resistance to change (Brown et al., 2010). Furthermore, Collie-Akers et al. (2007) tracked coalition activities on community change over a three-year period, reporting that ¾ of activities aimed to reduce the risk for cardiovascular disease and diabetes, over ½ targeted minority populations, and ½ were sustained over the evaluation period (Collie-Akers et al., 2007). The authors attributed some community health changes to strategic support of internal coalition functioning and external partnership development (Collie-Akers et al., 2007). Finally, there have been reports of coalition activities associated with improved community health outcomes. For example, Paine-Andrews et al. (2002) reported decreased rates of teen pregnancy in communities that implemented a "greater amount, intensity, duration, and exposure" of local initiatives compared to those implementing fewer/less intense interventions (Paine-Andrews et al., 2002). However, it may be more challenging to track coalition-related changes in chronic disease (Roussos et al., 2000).

Importantly, a coalition's capacity to sustain partnerships and activities to impact community health may be related to receiving training and technical assistance. For example, Keene Woods et al. (2014) reported that coalition training and technical assistance increased coalition capacity and the delivery of sustainable community-level programming and practice/policy change one-year post intervention (Keene Woods et al., 2014). The authors attributed coalition outcomes to improved internal functioning and operations (Keene Woods et al., 2014). Watson-Thompson et al. (2008) also reported that technical support and strategic planning improved coalition outcomes and affected community change over a three-year period (Watson-Thompson et al., 2008). Coalition functioning, technical assistance, and adherence to a strategic model in the early stages of development were also related to sustainability three years later (Feinberg et al., 2008; Gomez et al., 2005).

In Indiana, there is a robust network of community health coalitions (CHCs) partnering with the Purdue University Cooperative Extension System and the Nutrition Education Program. Purdue Extension serves as a link between research institutions and communities by providing direct education and community engagement related to the topics of food, family, money, and health (Purdue Extension Health and Human Sciences). The Nutrition Education Program "works to improve the nutrition and health of audiences with limited resources" by providing direct education and implementing policy, system, and environment change interventions with a focus on nutrition, physical activity, food security, food safety and food resource management (Purdue Extension Health and Human Sciences). At the county-level, Purdue Extension Educators (Ext) and Nutrition Education Program Community Wellness Coordinators (CWC) are actively involved in developing, supporting, leading, and/or advising local CHCs.

Although Ext and CWC are not always the CHC leader, they do provide invaluable guidance and resources as Community Engagement Professionals (CEnP) connected to Purdue University. Ext work and live in each of Indiana's 92 counties, and some of them may work with a particular county for decades. On the other hand, CWC work in roughly 1/2 of Indiana's counties at any given time, but often take on additional counties or move to work in new communities after a couple years. In this way, CWC are a resource to initiate partnerships and support existing CHCs, while ultimately equipping and entrusting the community to sustain the CHC. Thus, while Ext address broad health topics, receive general training, and engage communities at multiple levels, including through CHC work and developing long-term community partnerships, CWC address specifically nutrition, receive focused leadership training, and engage communities through CHCs with the goal of implementing policy, system, and environment changes in multiple counties over time.

In a previous study we developed and piloted a mixed-methods, multi-level framework for evaluating CHC effectiveness (Chapter 4; Figure 5). The components of this evaluation framework include:

1. self-reported perceptions of CHC effectiveness, measured using the Coalition Self-Assessment Survey (CSAS) (Kenney et al., 2000)
2. partnership network structures, measured using social network analysis (SNA) questions adapted from (Provan et al., 2005) and (Cullerton et al., 2016)
3. the delivery of programs and policy, system, and environment change interventions, qualitatively assessed through program reports
4. county-level health statistics calculated from multiple data sources, e.g., the Behavioral Risk Factor Surveillance System (for which we have access to county-level identifiers through contract with the Indiana State Department of Health) and Indiana STATS Explorer (publicly available at the county-level)

We then applied the first two components of this evaluation to CHCs partnering with the two groups of CEnP previously described (Chapter 5). We found that partnership network interconnectedness correlated to greater perceived CHC effectiveness for Ext-CHCs, while network interconnectedness correlated to lower perceived CHC effectiveness for CWC-CHCs. We also found that on average, CWC-CHCs rated their leadership and functioning higher, reported fewer problems for participation in the CHC, and had more centralized collaboration networks, as compared to Ext-CHCs (Chapter 5).

The purpose of this study is to track changes in CHC perceived effectiveness and partnership network structures over time. We hypothesized that CWC-CHCs would become

more centralized and would rate their leadership and functioning higher after the CWC received one year of focused leadership training. We also hypothesized that Ext-CHCs would remain stable over time because the Ext would not receive the same leadership training as the CWC.

Methods

Ext-CHCs who participated in the study during the Summer of 2017 (Chapter 4) were recruited to participate in a follow-up study during the Summer of 2018. CWC-CHCs who participated in the study during the Spring of 2018 (Chapter 5) were recruited to participate in a follow-up study during the Spring of 2019.

All 8 Ext-CHCs participating in the initial study participated in the follow-up study. CHC size ranged from 6 to 48 members with response rates ranging from 31.3% to 100%. Ext-CHC overall response rate was 54.2%.

Fourteen of the 16 CWC-CHCs participating in the initial study participated in the follow-up study. CHC size ranged from 11 to 49 members with response rates ranging from 35.4% to 100%. CWC-CHC overall response rate was 55.2%.

During the follow-up study we administered a SNA survey and the CSAS through REDCap (Harris et al., 2009). We have described study instruments and procedures elsewhere (Chapter 4). In brief:

- SNA survey questions were adapted from Provan et al. (2005) (Provan et al., 2005) Cullerton et al. (2016) (Cullerton et al., 2016)

a. We surveyed respondents on the following network types: cooperation, coordination, collaboration, formal ties, good-high trust, direct contact, mass communication
b. On these seven network types we calculated the following measures: density, mean degree, degree centralization, betweenness centralization, closeness centralization, eigenvector centralization, and transitivity; as well as CEnP-node degree, betweenness centrality, closeness centrality, eigenvector centrality (Appendix 1)
c. Before calculating network measures, we imputed missing data for non-respondents first by reconstruction then by imputing remaining missing data according to the density of the reconstructed graph, where missing data on graphs with a density of < 0.5 were imputed to 0 and missing data on graphs with a density of > 0.5 were imputed 1; calculated network measures are shown in Appendix 5 (methodology described in Chapter 4)

- The CSAS questions were adapted from Kenney and Soafaer (2000) (Kenney et al., 2000)
    a. We administered a modified version of the CSAS and analyzed all analogue scale response questions, which we set to a scale of 0-100
    b. We did not impute missing data for non-respondents, and removed all incomplete responses
    c. We performed a cluster analysis using the k-means clustering algorithm, then calculated cluster means across CHCs. We determined the number of clusters using output from the distance matrix (which appeared to display two groups),

total within sum of squares plot (in which slope of the line decreased at 2 clusters), average silhouette width (which clearly defined 2 clusters as the optimal number), and cluster plots (in which the plot for 2 clusters was the only one in which the clusters did not overlap); this resulted in 2 clusters: LF- high ratings of leadership and internal functioning; and PROB- problems for participating in the CHC (Appendix 6)

To explore differences in partnership networks and CHC perceived effectiveness over time, we first conducted a paired t-test (or a Wilcoxon Rank Sum test when the data were non-Gaussian) between all calculated variables at time 1 and follow-up. We also conducted a Pearson's Correlation on the change scores across calculated variables; i.e., we calculated the difference between time 1 and follow-up for each of the calculated variables and performed the analysis on the resulting numbers (Table 21). Change scores are shown in Appendix 7. This methodology has been discussed and statistically validated by Gardner and Neufeld (1987) (Gardner et al., 1987); an example related to the present study is described by Valente et al. (2007), who regressed a change in coalition outcomes against a change in network density pre- and post-intervention (Valente et al., 2007). We analyzed Ext-CHCs and CWC-CHCs separately in order to explore whether CHCs partnering with these programs change differently over time.

This study was granted exemption status by the Purdue University Institutional Review Board, protocol number 1712020009.

Results

Characteristics of study participants

Of the Ext-CHC members completing the SNA portion of the survey, 92 also completed the CSAS. The primary role of Ext-CHC members responding to the CSAS was coalition officer or chair (13/92, 14.1%), coalition staff (2/92, 2.2%), chair/co-chair of a committee or task force (1/92, 1.1%), member of executive or steering committee (10/92, 10.9%), committee member (9/92, 9.8%), member having no other responsibility (53/92, 57.6%), and other role (4/92, 4.3%). Member responses to involvement in the CHC over the past year were very (25/92, 27.2%), moderately (31/92, 33.7%), a little (31/92, 33.7%), and not at all (5/92, 5.4%). 60/92 (65.2%) CHC members participated in some coalition building activity, 32/92 (34.8%) respondents did not. Of those reporting activities, 27 participated in only 1 activity, 16 participated in 2, 5 participated in 3, 6 participated in 4, and 6 participated in 5. Across activities, 14 people acquired funding or other resources for the coalition, 22 attempted to get outside support for coalition positions on key issues, 24 recruited new members, 25 served as a spokesperson, and 43 worked on implementing activities or events sponsored by the coalition.

Of the CWC-CHC members completing the SNA portion of the survey, 204 also completed the CSAS. The primary role of CWC-CHC members responding to the CSAS was coalition officer or chair (21/204, 10.3%), coalition staff (6/204, 2.9%), chair/co-chair of a committee or task force (19/204, 9.3%), member of executive or steering committee (41/204, 20.1%), committee member (42/204, 20.6%), member having no other responsibility (65/204, 31.9%), and other role (10/204, 4.9%). Member responses to involvement in the CHC over the past year were very (80/204, 39.2%), moderately (53/204, 26.0%), a little (57/204, 27.9%), and not at all (14/204, 6.9%). 157/204 (77.0%) CHC members participated in some coalition building activity, 47/204 (23.0%) respondents did not. Of those reporting activities, 54 participated in

only 1 activity, 41 participated in 2, 21 participated in 3, 22 participated in 4, and 19 participated in 5. Across activities, 58 people acquired funding or other resources for the coalition, 89 attempted to get outside support for coalition positions on key issues, 55 recruited new members, 62 served as a spokesperson, and 118 worked on implementing activities or events sponsored by the coalition.

Main findings of evaluations

Paired t-test results

For Ext-CHCs, the only statistically significantly different calculated variable between time 1 and follow-up was PROB ($p = 0.02813$). At follow-up, Ext-CHCs reported fewer problems for participating in their coalitions (mean: 29.6 in 2017, 16.9 in 2018; median: 25.4 in 2017, 16.0 in 2018).

For CWC-CHCs, the only statistically significantly different calculated variable between time 1 and follow-up was mass communication transitivity ($p = 0.04833$). At follow-up, CWC-CHC mass communication networks became less transitive (mean: 0.584 in 2018, 0.446 in 2019; median: 0.569 in 2018, 0.427 in 2019).

Pearson's Correlation on change scores results (Table 21)

For Ext-CHCs, an increase in perceived effectiveness from year 1 to follow-up, i.e., increased LF and decreased PROB, related to increased collaboration density and centralization (degree, betweenness, and closeness). Additionally, increased LF related to greater density, mean degree, and transitivity of mass communication, as well as a greater proportion of good-high trust and formal connections developed over time (as indicated by increased density in these networks).

For CWC-CHCs, increased perceived effectiveness from year 1 to follow-up, i.e., increased LF and decreased PROB, related to increased centralization (degree, closeness, eigenvector) across communication networks (mass communication and cooperation (the level of partnership where information is shared)), as well as the CWC taking a more central role in communication networks (direct contact, mass communication, cooperation). However, increased PROB related to increased centralization in the good-high trust networks.

Discussion

In this study we compared year 1 and follow-up findings from a statewide CHC evaluation, calculating social network analysis measures from self-reported partnership connections and identifying two topics related to perceived effectiveness (LF and PROB) based on a cluster analysis of the CSAS. We hypothesized that CHCs would rate their leadership and functioning higher and become more centralized over time when the CEnP received focused training. We found that CHCs where the CEnP did not receive training (Ext-CHCs) reported significantly fewer problems for participating in their CHC between year 1 and follow-up. We also found that CHCs where the CEnP did receive training (CWC-CHCs) increased their mass communication network transitivity over time.

We found several interesting correlations. First, increased interconnectedness for trust and formal ties correlated to increased perceived effectiveness for CHCs partnering with both Ext and CWC. Meanwhile, increased centralization for action-oriented connections, i.e., collaboration and communication, correlated to increased perceived effectiveness as well. However, that correlation did not necessarily hold true for the CEnP centrality in those networks; thus, other members may be taking on more central and active partnership roles.

Particularly, for Ext-CHCs increased collaboration centralization correlated to increased perceived effectiveness. This could be related to the nature of collaboration, such that network centralization may be more efficient for accomplishing tasks (Bavelas, 1950). On the other hand, interconnectedness could promote member buy in and a shared sense of belonging (Provan et al., 2005). Interestingly, decreased perceived effectiveness, i.e., decreased LF and increased PROB, related to the Ext taking a more central position across network types over time. This may suggest that while centralized networks could be more efficient for collaborations, it may be preferred to have CHC members with area expertise lead focused efforts instead of Ext, who have broad training and responsibilities.

Furthermore, for CWC-CHCs increased communication centralization correlated to increased perceived effectiveness. Over time, the CWC became more central to mass communication and sharing information (cooperation), but not direct contact. However, depending on the type of communication and the potential path of the message between partners (as indicated by different types of centralization and centrality measures), the CWC may or may not be the preferred individual to oversee this task.

Our findings related to the potential benefits of increasing interconnectedness for measures of partnership quality (i.e., good-high trust and formal ties) are similar to several reports describing the application and interpretation of the community capital framework. Flora et al. (2004) define seven community capitals that both describe the complexity of collaborating across all aspects of community life and the opportunities to maximize local assets through diverse partnerships: natural, cultural, human, social, political, financial, and built (Flora et al., 2004). Emery et al. (2006) recognized the potential challenges of pursuing community

improvements when community members may resist change (Emery et al., 2006a). They proposed a method for pairing the community capitals framework with an asset mapping process using Appreciative Inquiry in order to raise awareness around and support for local assets, as well as identify underlying factors contributing to resistance against change (Emery et al., 2006a). This process engaged community members to shift the conversation away from potential concerns and mistrust about working across sectors toward promoting partnerships for community betterment (Emery et al., 2006a). However, maximizing all seven community capitals at once can be an overwhelming task. Thus, Beaulieu (2014) argues that communities should start by having the conversation about which asset is most easily tapped immediately, then focus on building up that capital (Beaulieu, 2014). As one capital grows, there is a spiraling up effect where the community rallies support and commitment around growing the other capitals (Beaulieu, 2014). Emery et al. (2006b) also described this spiraling up effect, where social capital was determined to be the most important capital to invest in initially to reverse the decline of a rural community (Emery et al., 2006b). They cite both bonding ("close redundant ties that build community cohesion") and bridging ("loose ties that bridge among organizations and communities") social capital as having been equally important in the process, as well as human capital defined in this context as strong leadership (Emery et al., 2006b). Thus, the community capitals framework suggests the importance of building trust and interconnectedness among community members through strong leadership in order to maximize local assets. Likewise, we attempted to quantify changes in partnership network structures (e.g., interconnectedness in the trust networks) using social network analysis and to assess CHC leadership and functioning using responses from the CSAS.

While one goal of CHCs is to ensure community buy-in and partner cohesion, the ultimate goal of many CHCs is to impact community health. As such, the seemingly incongruent concepts of interconnectedness and centralization can be better understood through the lens of high performing teams. A high performing team is defined as a group of members who share a common goal-oriented purpose and are characterized by high levels of innovation and collaboration that allow them to remain highly productive. Hakanen and Soudunsaari (2012) posit that trust is one of the most important factors for building high performing teams (Hakanen et al., 2012). High levels of trust facilitate communication, which allow these teams to achieve success even without a perfectly crafted action plan (Hakanen et al., 2012). Although trust can take a long time to build and effective communication improves with trust, these factors increase a team's ability to react to unforeseen barriers and resolve conflict without hindering overall performance (Hakanen et al., 2012). Delizonna (2017) also suggests that teams need to be protected from situations, individuals, and environments that make them feel unsafe (Delizonna, 2017). High performing teams are highly competitive, which can lead to emotional and psychological burnout. Thus, team leaders can avoid member burnout by implementing measures to promote productivity, motivation, resiliency, and creativity (Delizonna, 2017). Once trust and safety are established, high performing teams are more likely to be successful if they also have the following factors in place: organizational impact, knowledge and skills, defined focus, needs of the individual, external entities, group culture, measures of performance, system factors, and human factors (Castka et al., 2001). Similarly, the role of individual members is crucial to team performance. Chong (2007) found that established teams comprised of some members assigned specific roles related to performance goals and other members responsible for coordinating activities adopt behaviors and characteristics associated with high performance outcomes

(Chong, 2007). However, rigid role assignment may be a hindrance for newly developed teams whose members have not yet established partnership and operating norms (Chong, 2007). In addition to dedicated members, the success of high performing teams can be maximized through transformational leadership. To et al. (2015) propose that transformational leadership has implications across multiple levels of persons and processes (To et al., 2015). They describe a model of leadership focused on the individual as well as the team, to promote creativity across team, interpersonal, and personal creativity (To et al., 2015). Thus, our findings related to CHC perceived effectiveness across varying network structures are consistent with the literature related to community capitals and high performing teams. In fact, CHC development, growth, and sustainability can be modeled after these two frameworks to: 1. promote community buy-in and maximize local assets and 2. ensure that long-term community-wide health improvements are achieved.

Limitations

This study has several limitations. First the response rates between year 1 and follow-up dropped, which may suggest that either the CEnP, the CHC members, or both, considered the cost of participating in the study to outweigh the benefits, the timing of the survey conflicted with other initiatives the CHC was engaged in, or automated email reminders may have been filtered to CHC members' spam or junk folders, among other reasons. However, it may be that surveying every year is not time efficient, and it may be more appropriate to collect data on a 2-year cycle instead. Second, while tracking county-level health statistics and assessing programs and policy, system, and environment change interventions remain an important component of our evaluation framework, this study reports only on the two components related to partnership networks and perceived effectiveness. Thus, we cannot elucidate whether our findings have any

practical relevance for improving the delivery of programs or impacting health. However, assessment is intended to be ongoing, so the relationship between the components of our evaluation framework is expected to be clarified over time. Third, to date, we have only studied rural communities in which the CHCs partner with CEnP connected to Purdue University, so our findings may not be generalizable across geographic locations or to CHCs working under different programs. Finally, a major limitation of our survey instruments is that they don't gauge the stage of development that the coalition is in. It may be that newly established CHCs have an entirely different optimal network structure as compared to mature CHCs, which may also be different from CHCs experiencing a flux in leadership, membership, or community changes occurring over time. Additionally, there are a number of confounding factors that were not controlled for because of the scarcity of available data, including the presence of ongoing community-wide initiatives, nutrition and physical activity environments, community perceptions of CHC effectiveness, and target population demographics and behaviors.

Conclusions

In conclusion, we attempted to determine how changes in network structures may relate to changes in CHC effectiveness over time. We demonstrated increases in interconnectedness for trust and formal ties and increased centralization across different network types correlating to increased perceived effectiveness for both Ext-CHCs and CWC-CHCs. Differences in program priorities, job responsibility, level of training, and community-level factors likely affect CHC outcomes. As we continue working with these CHCs and refining our evaluation tools, we will be able to better inform best practices. Qualitative assessments and focus groups with CHCs should help to clarify some of the uncertainties we've expressed in interpreting our findings. Importantly, although CHCs aim to optimize local partnerships to improve long-term health, we

are aware that there is likely not a single optimal network type, even for CHCs at similar stages of development. Thus, a one-size-fits-all paradigm is not the goal of this work, but rather a process for continual data collection and feedback.

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Table 21: Correlation between changes scores for Coalition Self-Assessment Survey clusters and Social Network Analysis measures

	CEnP	Ext		CWC	
	CSAS cluster	LF	PROB	LF	PROB
CHC-level SNA measures					
Density	Cooperation	0.760	-0.736	-0.573	0.444
	Coordination	.	.	.	.
	Collaboration	0.543	-0.441	.	.
	Formal ties	0.541	-0.488	.	.
	Good-high trust	0.472	.	.	.
	Direct contact	.	.	.	.
	Mass communication	0.744	-0.842	.	0.522
Mean degree	Cooperation	.	.	.	0.415
	Coordination	.	.	.	.
	Collaboration	.	.	.	.
	Formal ties	.	.	.	.
	Good-high trust	.	.	.	.
	Direct contact	.	.	.	.
	Mass communication	0.693	-0.776	.	.
Degree centralization	Cooperation	-0.723	0.679	0.546	.
	Coordination	.	.	.	.
	Collaboration	0.838	-0.705	.	.
	Formal ties	.	0.458	.	.
	Good-high trust	-0.442	0.427	.	0.510
	Direct contact	.	.	.	0.429
	Mass communication	-0.528	0.619	0.550	.
Betweenness centralization	Cooperation	-0.420	.	.	.
	Coordination	.	.	.	.
	Collaboration	0.507	-0.456	.	.
	Formal ties	-0.405	.	.	.
	Good-high trust	-0.468	.	.	.
	Direct contact	.	0.436	.	.
	Mass communication	.	.	.	.
Closeness centralization	Cooperation	-0.720	0.695	0.451	.
	Coordination	0.433	.	.	.
	Collaboration	0.833	-0.646	.	.
	Formal ties	-0.426	.	.	.
	Good-high trust	-0.515	0.436	-0.475	0.513
	Direct contact	.	.	-0.669	.
	Mass communication	-0.485	.	.	.
Eig env	Cooperation	-0.578	0.513	0.519	.
	Coordination	.	.	.	.

Table 21 continued

	Collaboration	.	.	.	.
	Formal ties	-0.514	0.440	.	.
	Good-high trust	.	.	.	0.568
	Direct contact	.	.	.	.
	Mass communication	.	0.458	0.443	.
Transitivity	**Cooperation**	0.668	-0.697	-0.638	.
	Coordination	.	.	.	.
	Collaboration	.	.	.	-0.515
	Formal ties	0.595	-0.586	.	.
	Good-high trust	.	.	.	.
	Direct contact	.	-0.445	.	-0.432
	Mass communication	0.509	-0.654	.	.
CEnP-node SNA measures					
Degree	**Cooperation**	.	.	-0.464	0.475
	Coordination	.	.	.	.
	Collaboration	.	.	.	0.777
	Formal ties	.	.	.	.
	Good-high trust	.	.	.	-0.514
	Direct contact	-0.557	0.582	.	-0.466
	Mass communication	.	.	.	.
Betweenness centrality	**Cooperation**	-0.757	0.840	.	-0.533
	Coordination	-0.760	0.805	.	.
	Collaboration	.	.	.	.
	Formal ties	-0.769	0.849	.	.
	Good-high trust	-0.819	0.878	.	.
	Direct contact	-0.787	0.803	.	.
	Mass communication	-0.741	0.770	-0.416	.
Closeness centrality	**Cooperation**	.	.	-0.718	.
	Coordination	.	.	.	.
	Collaboration	0.780	-0.713	.	.
	Formal ties	.	.	.	.
	Good-high trust	.	.	-0.617	.
	Direct contact	-0.493	.	-0.557	.
	Mass communication	.	.	.	-0.483

Table 21 continued

Eigenvector centrality	**Cooperation**	.	.	.	-0.444
	Coordination	.	.	.	0.473
	Collaboration	.	.	.	.
	Formal ties	.	.	.	.
	Good-high trust	.	.	.	.
	Direct contact	.	.	.	.
	Mass communication	.	.	.	.

SNA, Social Network Analysis. CEnP, Community Engagement Professional, referring to either the Extension Educator or Community Wellness Coordinator. CEnP-node, refers to the SNA variables calculated specifically for either the Extension Educators or the Community Wellness Coordinator in their respective coalition networks (as opposed to whole network measures). CSAS, Coalition Self-Assessment Survey. CWC, Community Wellness Coordinator. Ext, Extension Educator. LF, coalition members' positive perceptions of their leadership and functioning. PROB, coalition members reporting problems for participating in their coalition. Pearson's correlation coefficients between calculated SNA variables and CSAS cluster means. An arbitrary cutoff value of ±0.4 was selected to identify correlation values that may be important (i.e., "significant"). Any correlation values falling between +0.4 and -0.4 are denoted by a period (.). For visual clarity, positive correlation values are highlighted in green and negative correlation values are highlighted in red.

CHAPTER 7. CONCLUSIONS AND FUTURE DIRECTIONS

In conclusion, interventions targeting individuals and policy change aimed at reshaping nutrition environments have been only marginally successful at promoting and improving community health. There are several examples of public health models suggesting the complex and interdependent relationship between the behavior choices of individuals and their social and physical environments; e.g., the Social Ecological Model (https://www.cdc.gov/violenceprevention/publichealthissue/social-ecologicalmodel.html) and the Community Organization Model (https://www.ruralhealthinfo.org/toolkits/health-promotion/2/program-models/community-organization). Meanwhile, community engagement strategies have been gaining support from federal governing bodies and national public health organizations as a viable and sustainable solution to closing the gap on health disparities (Agency for Toxic Substances and Disease Registry, 2015; Balls-Berry et al., 2017; Centers for Disease Control and Prevention; Cooperative Extension, 2019; National Center for Chronic Disease Prevention and Health Promotion, 2018; Robert Wood Johnson Foundation, 2015). One community engagement strategy is through the development and mobilization of local community health coalitions (CHCs).

There are a number highly cited models for CHC development and evaluation; e.g., The Centers for Disease Control and Prevention's Sustainability Planning Guide for Healthy Communities (Centers for Disease Control and Prevention), Butterfoss and Kegler's Community Coalition Action Theory (Butterfoss et al., 2009), Community and Collaborative Empowerment Models developed by researchers at the University of Kansas (Fawcett et al., 1995), PROmoting School-community-university Partnerships to Enhance Resilience (PROSPER), coming from

Iowa State University (PROSPER Partnerships, 2019), and Communities that Care, coming from the University of Washington (Communities that Care, 2019), are examples relevant to this thesis research. What these models have in common is an emphasis on partnership building to impact long-term community health outcomes. However, impacting community health, and evaluating health improvements, are challenging. Although there is a robust literature describing recommendations for best practice related to CHC internal functioning, the translation of research across communities presents additional difficulties. In this dissertation, I have attempted to build a framework for integrating evaluation components across the public health logic model from inputs through impact. In particular, I presented a comparison of subjective reports of perceived effectiveness, which is the traditional assessment method for CHCs, and objectively quantified partnership network structures using social network analysis. I am not the first to compare partnership networks to other indicators of success, e.g., (Bright et al., 2017; Provan et al., 1995; Valente et al., 2007), and the Robert Wood Johnson Foundation makes a strong argument in support of the application of social network analysis for partnership evaluation (https://www.rwjf.org/en/library/research/2013/12/using-social-network-analysis-in-evaluation.html). However, through partnership with the Purdue University Cooperative Extension System and the Nutrition Education Program, I established a statewide system for long-term partnership evaluation, which may be adopted as a primary framework for reporting and feedback.

Notably, I found that interconnectedness of high-quality partnership connections, i.e., high mean degree and density of good-high trust and formal ties, consistently correlated to reports of highly rated leadership and functioning. The inverse was true as well: that centralized trust and formal ties, i.e., where CHC members have high-quality connections with only a select

group of individuals, was related to poorly perceived CHC effectiveness. Additionally, increased network centralization for action-oriented ties, i.e., collaboration and communication, appeared to be related to increased perceived effectiveness over time between CHCs partnering with both Extension Educators and Community Wellness Coordinators. However, there was also a negative correlation between CHC perceived effectiveness and increased centrality of the Extension Educators or Community Wellness Coordinators in these networks over time. Thus, it may be preferable for CHC members having area expertise to take on central leadership roles for certain projects, programming, or interventions. Additional research is needed to understand this relationship.

This work has several limitations. First, there is no available repository of CHC member demographics and characteristics, so it is difficult to compare study participants to the entire population of CHC members in Indiana, as well as other partnerships throughout the United States and other nations. Survey respondents may have a more positive perception of their CHC and may be more actively engaged in internal and community-wide activities, as compared to CHC members who did not respond. Second, we only attempted to recruit CHCs that had a connection to the Purdue University Cooperative Extension System. Thus, our findings are potentially not translatable to coalitions operating under different programs or partnering with other universities or institutions. Additionally, our first point of contact was with the Extension Educator or the Community Wellness Coordinator, who then gave us permission to contact their CHC members for recruitment in the studies. Thus, we were not able to survey willing CHC members partnering with an Extension Educator or Community Wellness Coordinator who did not agree to participate in our studies. Third, although we surveyed several hundred CHC members at each round of data collection, the unit of analysis was the CHC and/or county, so our

statistical analysis suffered from small sample sizes. Fourth, controlling for community-level confounding factors has been difficult in accessing sufficient data; i.e., data available for some counties may not be available for others, or simply not available at all. Finally, although I did not compare the delivery of programs and policy, system, and environment change interventions to the other study metrics, the CHCs participating in these studies partner with programs that have reporting requirements related to their activities. Thus, I am able to use these reports to qualitatively guide the interpretation of my findings. Meanwhile, although there is a lag time between the collection and release of county-level health statistics, I have developed a good working relationship with the Indiana State Department of Health in which I can apply for access to annual data. Thus, across the evaluation components in my logic model, I have established sustainable mechanisms for long-term assessment.

This work can be expanded and improved in several areas. First, I argued that differences between CHCs partnering with Extension Educators compared to Community Wellness Coordinators could potentially be attributed to differences in leadership styles and training, whereby Extension Educators address many health topics, receive broad training, and serve as a resource to, though not necessarily the leader of CHCs. In contrast, Community Wellness Coordinators address specifically nutrition-related health topics, receive focused leadership and research training, and adopt central leadership roles. Partnering with CHCs to implement rigorous study designs, including community-controlled trials, could help clarify the relationship between focused training and CHC outcomes. Second, the methodology for evaluating policy, system, and environment change interventions is underdeveloped; however, as this methodology develops over time, researchers will be able to retrospectively assess CHC activities from the reports collected during the study period, as well as refine assessment in the

coming years. Third, available county-level health statistics may not be robust enough to capture health outcomes for target populations (i.e., small sample size and irrelevant measured variables). Thus, depending on the nature of CHC activities and programming, relevant data may need to be collected; e.g., the number of diabetes screenings conducted during a health fair organized by a CHC. Finally, focus groups with CHC members and leaders will provide a better understanding of these findings and guide recommendations for best practice to facilitate CHC growth and sustainability. Learning from CHCs' experiences and insights will be instrumental in further designing appropriate research partnerships and evaluation systems.

My work makes an important contribution to the literature by 1. validating existing concepts of CHC research related to partner cohesion, member roles, community assets, strong central leadership, and dynamic growth and 2. integrating evaluation components into a cross-sectional and longitudinal data collection system that will potentially illuminate new discoveries and expand the understanding of CHC effectiveness over time. To shift the model of CHC evaluation toward long-term tracking for community health improvements, several technological and programmatic changes should be considered. The current data collection system is extremely labor intensive. Participant recruitment, data collection, analysis, and dissemination of findings were performed manually, which is neither cost nor time efficient. Partnering with computer scientists, data scientists, and statisticians could provide the infrastructure to establish data warehouses, pipelines, and information flows to facilitate this work. Additionally, the evaluation framework described in this dissertation was developed and implemented with Cooperative Extension and the Nutrition Education Program but has not been adopted by these programs for long-term assessment. Normalizing the use of this evaluation system and promoting it as a viable solution to meet reporting requirements would likely increase the sustainability and impact of the

evaluation efforts described herein. Importantly, as this evaluation system is refined and improved over time, researchers must continually engage CHCs in an iterative feedback evaluation to ensure that the findings are translatable to communities. This can be accomplished by further engaging Extension Educators and Community Wellness Coordinators in the research process, learning from their experience, and adjusting our research objectives to maximize its usefulness to increasing CHC effectiveness.

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APPENDIX

Appendix 1: Social network analysis definitions and survey questions

Social network analysis definitions

- **Actors (nodes):** individuals in a network; represented by a dot
- **Tie:** the connection between actors in a network; represented by a line connecting two dots
- **Path:** the number of actors an actor must go through to reach another actor; measured by the number of ties between actors
- **Degree:** the number of ties an actor holds (incoming and outgoing)
- **Mean degree:*** i.e., Freemen degree; the average number of (incoming and outgoing) ties actors hold across the network
- **Density:*** the proportion of observed ties to possible ties
- **Degree centralization:*** i.e., Freeman degree centralization; the extent to which some actor holds more (incoming and outgoing) ties than other actors across a network
- **Betweenness centrality:*** the number of times an actor lies on the shortest path between two nodes
- **Betweenness centralization:*** the extent to which some actor serves as a bridge along the path between other actors across the network; a measure of control over the flow of some tie characteristic
- **Closeness centrality:*** a measure of the inverse distance of a node; how close a node is to all other nodes
- **Closeness centralization:*** the extent to which some actor has a relatively high proximity to other actors in the network; at the actor level, the average length of the shortest path
- **Eigenvector centrality:*** an node's position in the network relative to its connections to other highly connected nodes
- **Eigenvector centralization:*** the extent to which some actor holds ties to other actors holding many ties; a measure of influence or power
- **Transitivity:*** the potential for two actors to be connected through a common connection; i.e., if $actor_x$ sends a tie to $actor_y$ and $actor_y$ sends a tie to $actor_z$ then $actor_x$ is likely to form a tie with $actor_z$

Appendix 1 continued

Social network survey questions

- **Describe the level of connection you have with each of the members in your coalition [check one]**
  - No connection (We do not work with each other)
  - Cooperative (We know each other and share information)
  - Coordinative (We work side-by-side on a few projects)
  - Collaborative (We rely on each other to achieve common goals)
- **Describe the type of connection you have with each of the members in your coalition [check one for each of your connections in the coalition]**
  - Formal: Connection is between the overall organization (not tied to certain people)
  - Informal: Connection would be lost if certain people left their organization
- **Rate the connection quality between you and each of the members in your coalition [check one for each of your connections in the coalition]**- Can you trust this organization to keep its word, do a good job, respond to your organization and client needs, and accomplish coalition related activities?
  - Little trust
  - Some trust
  - Good trust
  - High trust
- **How often are you in direct contact with each member of your coalition?** (i.e., an email, phone call, etc. addressed specifically to you or a working group that you actively engage in) **[check one]**
  - Never
  - More frequently than once per month
  - Less frequently than once per month
- **How often do you exchange mass communication with each member of your coalition?** (e.g., a listserv email, group Facebook message, newsletter, texting group) **[check one]**
  - Never
  - More frequently than once per month
  - Less frequently than once per month

*Calculated network variables; used in the primary cross-methods analyses. From the social network survey to each of the 24 coalitions, we analyzed 7 connection types: cooperation, coordination, collaboration (i.e., three levels of partnership), formal ties, good-high trust (i.e., two measures of connection quality), direct contact, mass communication (i.e., communication networks); for each of these 7 connection types we calculated the following whole network variables: mean degree, density, degree centralization, betweenness centralization, closeness centralization, eigenvector centralization, and transitivity; as well as the following variables specific to the Community Engagement Professional: degree, betweenness centrality, closeness centrality, and eigenvector centrality; for a total of 77 network measures for each coalition

Appendix 2: Social Network Analysis measures for coalitions partnering with Community Wellness Coordinators

Connection type	Calculated network variable	Coalition; responses/coalition size															
		CHC 9; 8/10	CHC 10; 10/10	CHC 11; 10/11	CHC 12; 11/11	CHC 13; 11/13	CHC 14; 11/14	CHC 15; 13/14	CHC 16; 13/15	CHC 17; 12/16	CHC 18; 14/22	CHC 19; 15/22	CHC 20; 20/22	CHC 21; 22/32	CHC 22; 26/39	CHC 23; 19/41	CHC 24; 24/48
Cooperation	Density	0.522	0.900	0.609	0.964	0.756	0.610	0.692	0.886	0.775	0.723	0.647	0.716	0.560	0.538	0.698	0.353
	Mean degree	9.400	16.200	12.182	19.273	18.154	15.857	18.000	24.800	23.250	30.364	27.182	30.091	34.750	40.923	55.854	33.167
	Degree centralization	0.597	0.125	0.478	0.044	0.288	0.365	0.314	0.132	0.257	0.305	0.336	0.312	0.434	0.473	0.291	0.487
	Betweenness centralization	0.205	0.036	0.149	0.012	0.077	0.138	0.089	0.029	0.061	0.062	0.098	0.067	0.094	0.098	0.048	0.176
	Closeness centralization	0.492	0.025	0.246	0.004	0.070	0.106	0.059	0.008	0.042	0.035	0.048	0.048	0.056	0.089	0.024	0.067
	Eigenvector centralization	0.366	0.084	0.289	0.031	0.185	0.313	0.251	0.101	0.187	0.214	0.258	0.202	0.318	0.317	0.218	0.398
	Transitivity	0.713	0.940	0.722	0.974	0.838	0.702	0.790	0.907	0.840	0.806	0.756	0.825	0.721	0.712	0.819	0.472
Coordination	Density	0.389	0.733	0.527	0.518	0.615	0.385	0.505	0.448	0.438	0.413	0.240	0.556	0.321	0.212	0.245	0.232
	Mean degree	7.000	13.200	10.545	10.364	14.769	10.000	13.143	12.533	13.125	17.364	10.091	23.364	19.875	16.103	19.610	21.792
	Degree centralization	0.556	0.333	0.578	0.406	0.405	0.224	0.308	0.431	0.452	0.436	0.417	0.331	0.604	0.498	0.662	0.546
	Betweenness centralization	0.292	0.101	0.212	0.198	0.137	0.170	0.135	0.208	0.208	0.150	0.254	0.123	0.191	0.298	0.249	0.282
	Closeness centralization	0.375	0.112	0.448	0.142	0.122	0.101	0.110	0.097	0.200	0.095	0.319	0.126	0.192	0.346	0.219	0.210
	Eigenvector centralization	0.625	0.205	0.343	0.459	0.324	0.254	0.199	0.464	0.337	0.000	0.271	0.295	0.396	0.310	0.460	0.460
	Transitivity	0.631	0.825	0.688	0.695	0.764	0.559	0.646	0.674	0.557	0.577	0.439	0.744	0.499	0.462	0.401	0.361
Collaboration	Density	0.244	0.411	0.291	0.373	0.237	0.176	0.242	0.319	0.183	0.190	0.110	0.262	0.183	0.094	0.154	0.146
	Mean degree	4.400	7.400	5.818	7.455	5.692	4.571	6.286	8.933	5.500	8.000	4.636	11.000	11.375	7.179	12.341	13.708
	Degree centralization	0.389	0.389	0.622	0.583	0.508	0.154	0.167	0.497	0.362	0.314	0.298	0.367	0.475	0.330	0.666	0.503
	Betweenness centralization	0.524	0.356	0.349	0.275	0.462	0.388	0.400	0.356	0.322	0.259	0.438	0.290	0.320	0.348	0.345	0.344

Appendix 2 continued

	Closeness centralization	0.218	0.194	0.419	0.311	0.293	0.159	0.142	0.272	0.209	0.192	0.415	0.118	0.211	0.338	0.399	0.344
	Eigenvector centralization	0.833	0.725	0.535	0.553	0.692	0.000	0.244	0.548	0.000	0.000	0.000	0.547	0.444	0.000	0.562	0.448
	Transitivity	0.371	0.860	0.448	0.556	0.371	0.460	0.443	0.474	0.353	0.435	0.265	0.415	0.347	0.464	0.313	0.280
Formal ties	**Density**	0.356	0.767	0.573	0.700	0.692	0.258	0.495	0.710	0.579	0.344	0.429	0.346	0.370	0.295	0.340	0.266
	Mean degree	6.400	13.800	11.455	14.000	16.615	6.714	12.857	19.867	17.375	14.455	18.000	14.545	22.938	22.410	27.220	24.958
	Degree centralization	0.389	0.292	0.400	0.244	0.265	0.372	0.276	0.253	0.405	0.276	0.262	0.431	0.534	0.480	0.549	0.544
	Betweenness centralization	0.348	0.082	0.165	0.124	0.100	0.259	0.221	0.096	0.134	0.183	0.178	0.267	0.189	0.195	0.176	0.243
	Closeness centralization	0.393	0.076	0.168	0.037	0.057	0.219	0.108	0.042	0.144	0.073	0.112	0.181	0.129	0.240	0.089	0.121
	Eigenvector centralization	0.566	0.185	0.367	0.293	0.273	0.000	0.401	0.235	0.318	0.000	0.310	0.506	0.437	0.482	0.409	0.441
	Transitivity	0.458	0.839	0.732	0.808	0.816	0.436	0.634	0.799	0.719	0.573	0.601	0.561	0.553	0.567	0.469	0.385
Good-high trust	**Density**	0.400	0.833	0.609	0.936	0.647	0.462	0.571	0.838	0.708	0.626	0.604	0.617	0.435	0.411	0.377	0.317
	Mean degree	7.200	15.000	12.182	18.727	15.538	12.000	14.857	23.467	21.250	26.273	25.364	25.909	27.000	31.231	30.195	29.792
	Degree centralization	0.611	0.208	0.478	0.078	0.318	0.269	0.321	0.187	0.257	0.255	0.383	0.421	0.378	0.579	0.549	0.513
	Betweenness centralization	0.247	0.057	0.149	0.022	0.119	0.152	0.146	0.045	0.085	0.097	0.115	0.104	0.160	0.149	0.158	0.196
	Closeness centralization	0.645	0.041	0.246	0.006	0.112	0.165	0.135	0.014	0.051	0.055	0.072	0.078	0.049	0.150	0.075	0.076
	Eigenvector centralization	0.358	0.138	0.289	0.057	0.259	0.158	0.345	0.143	0.233	0.282	0.285	0.268	0.388	0.387	0.392	0.427
	Transitivity	0.571	0.884	0.722	0.950	0.750	0.618	0.699	0.866	0.797	0.740	0.739	0.731	0.566	0.606	0.515	0.447
Frequent direct contact	**Density**	0.256	0.556	0.245	0.482	0.417	0.385	0.434	0.571	0.246	0.288	0.335	0.353	0.217	0.175	0.147	0.145
	Mean degree	4.600	10.000	4.909	9.636	10.000	10.000	11.286	16.000	7.375	12.091	14.091	14.818	13.438	13.333	11.756	13.625
	Degree centralization	0.444	0.417	0.311	0.389	0.443	0.449	0.301	0.371	0.367	0.390	0.548	0.476	0.457	0.522	0.450	0.481
	Betweenness centralization	0.273	0.186	0.371	0.287	0.220	0.232	0.175	0.138	0.208	0.206	0.226	0.264	0.225	0.296	0.278	0.242
	Closeness centralization	0.662	0.199	0.459	0.199	0.117	0.253	0.159	0.095	0.325	0.179	0.295	0.212	0.189	0.466	0.237	0.228

	Eigenvector centralization	0.500	0.342	0.345	0.428	0.502	0.000	0.253	0.315	0.177	0.000	0.444	0.474	0.333	0.355	0.000	0.000
	Transitivity	0.367	0.679	0.361	0.587	0.646	0.652	0.639	0.694	0.421	0.556	0.579	0.537	0.433	0.462	0.379	0.308
Frequent mass communication	**Density**	0.333	0.567	0.309	0.491	0.596	0.434	0.456	0.771	0.358	0.442	0.411	0.381	0.268	0.242	0.182	0.156
	Mean degree	6.000	10.200	6.182	9.818	14.308	11.286	11.857	21.600	10.750	18.545	17.273	16.000	16.625	18.410	14.585	14.625
	Degree centralization	0.556	0.403	0.356	0.378	0.330	0.526	0.545	0.223	0.390	0.588	0.464	0.629	0.419	0.646	0.676	0.593
	Betweenness centralization	0.257	0.163	0.297	0.317	0.135	0.230	0.219	0.063	0.197	0.163	0.187	0.225	0.228	0.251	0.308	0.356
	Closeness centralization	0.622	0.197	0.287	0.163	0.047	0.272	0.303	0.044	0.139	0.262	0.092	0.328	0.153	0.298	0.352	0.268
	Eigenvector centralization	0.382	0.402	0.301	0.473	0.367	0.409	0.394	0.178	0.320	0.400	0.460	0.390	0.393	0.483	0.537	0.569
	Transitivity	0.582	0.758	0.427	0.700	0.793	0.540	0.652	0.843	0.536	0.620	0.634	0.555	0.465	0.466	0.356	0.290

CHC, community health coalition.

Appendix 3: Mean and median responses and cluster mean scores to the Coalition Self-Assessment Survey for coalitions partnering with Community Wellness Coordinators

Survey question (response on a scale of 0-100). $\bar{x}$, $\tilde{x}$		**Coalition; responses/ coalition size**															
		CHC 9; 8/10	**CHC 10; 10/10**	**CHC 11; 10/11**	**CHC 12; 11/11**	**CHC 13; 11/13**	**CHC 14; 11/14**	**CHC 15; 13/14**	**CHC 16; 13/15**	**CHC 17; 12/16**	**CHC 18; 14/22**	**CHC 19; 15/22**	**CHC 20; 20/22**	**CHC 21; 22/32**	**CHC 22; 26/39**	**CHC 23; 19/41**	**CHC 24; 24/48**
1	Coalition activities do not reach my primary constituency.	14.1, 3.5	2.6, 0	17.8, 14.5	10.1, 2.0	15.3, 8.0	9.6, 3.0	16.6, 6.0	15.5, 2.0	37.0, 32.5	25.4, 25.0	12.4, 4.5	22.7, 11.5	36.6, 40.0	16.4, 5.0	25.2, 13.0	13.2, 5.0
2	Being involved in policy advocacy is a problem.	27.3, 22.5	8.2, 2.5	22.3, 13.0	13.4, 3.0	11.5, 5.0	16.1, 10.0	28.2, 25.0	18.7, 4.0	24.2, 21.5	25.9, 18.0	6.5, 0	26.9, 24.0	23.1, 17.0	15.6, 7.0	22.0, 9.0	15.4, 4.0
3	My skills and time are not well used.	18.0, 11.0	6.9, 0	17.6, 3.0	2.4, 0	7.2, 3.0	6.5, 1.0	15.9, 11.0	10.8, 4.0	35.5, 30.0	35.0, 29.5	10.1, 1.0	21.2, 15.5	35.0, 35.0	10.7, 4.0	23.4, 5.0	19.4, 4.0
4	My opinion is not valued.	5.1, 2.0	4.8, 0	6.3, 0	0.4, 0	13.9, 0	2.0, 0	10.8, 4.0	3.8, 1.0	8.5, 3.0	20.7, 18.5	1.4, 0	6.1, 1.0	21.0, 10.0	6.1, 2.0	16.5, 3.0	7.2, 0
5	The coalition is not taking any meaningful action.	15.1, 4.0	2.6, 0	14.4, 6.5	1.3, 0	8.3, 1.0	3.2, 0	37.6, 37.0	12.5, 2.0	39.3, 40.5	33.1, 28.0	3.1, 0	14.8, 2.5	38.2, 45.0	12.6, 3.0	30.5, 20.0	12.2, 2.0
6	I am often the only voice representing my point of view.	9.8, 4.0	3.3, 0	0.4, 0	0.6, 0	7.5, 1.0	4.9, 0	17.5, 9.0	11.6, 3.0	16.8, 9.0	26.9, 18.5	8.4, 1.0	9.7, 1.0	16.7, 5.0	6.7, 1.0	14.1, 4.0	9.6, 4.0
7	The financial burden of traveling to coalition meetings is too high.	8.0, 1.0	0.5, 0	2.4, 0	3.3, 0	8.7, 0	6.5, 0	14.5, 2.0	2.6, 0	0.4, 0	13.2, 0	3.1, 0	5.8, 0	9.0, 0	2.3, 0	10.1, 2.0	3.2, 0

Appendix 3 continued

8	The financial burden of participation (barring travel) is too high.	4.0, 1.0	0.7, 0	2.0, 0	1.3, 0	4.5, 1.0	2.5, 0	3.9, 0	2.2, 0	9.3, 0	16.4, 1.5	3.2, 0	10.6, 0	8.3, 0	2.3, 0	8.0, 2.0	3.0, 0
9	The coalition is competing with my organization.	4.5, 3.5	0.5, 0	6.4, 0	6.5, 0	6.6, 0	12.4, 0	8.5, 0	2.6, 0	7.0, 0	15.9, 4.5	2.2, 0	5.5, 0	10.6, 0	5.2, 0	11.0, 2.0	2.5, 0
10	The coalition is actively recruiting new members.	65.9, 60.5	43.3, 50.0	49.2, 49.5	51.1, 50.0	60.1, 53.0	73.1, 75.0	53.8, 51.0	63.2, 62.0	54.5, 56.0	54.4, 51.0	74.8, 78.5	55.8, 50.0	57.8, 50.0	55.8, 52.0	58.1, 50.0	66.2, 70.0
11	New members receive adequate orientation to be effective members of the coalition.	51.9, 52.0	57.9, 50.0	57.6, 55.5	62.4, 51.0	48.8, 50.0	73.5, 70.0	47.1, 48.0	54.5, 50.0	48.8, 50.0	43.1, 48.0	63.8, 50.0	56.5, 50.0	49.3, 50.0	49.2, 50.0	44.7, 50.0	52.8, 48.0
12	The current method for communication between coalition staff/leadership and its membership is effective.	69.8, 74.0	80.6, 90.0	73.8, 80.5	79.4, 75.0	73.5, 79.0	90.2, 100.0	64.2, 63.0	74.8, 80.0	62.8, 56.0	63.8, 67.0	74.9, 79.5	77.8, 90.0	55.2, 51.0	68.4, 78.0	59.1, 56.0	72.3, 74.0
13	Resources are being identified to support the systemic, programmatic changes implemented through the work of the coalition.	72.9, 73.5	89.0, 92.0	65.3, 63.0	70.8, 74.0	64.3, 54.0	86.8, 84.0	49.6, 50.0	61.2, 54.0	59.6, 61.0	55.1, 51.0	80.1, 90.0	67.3, 64.5	58.0, 52.0	62.1, 67.0	55.3, 56.0	69.8, 70.0
14	The coalition is making progress in implementing activities that have potential to improve health in the county.	74.8, 76.5	96.0, 100.0	76.5, 79.5	85.5, 90.0	78.6, 82.0	84.5, 92.0	61.2, 60.0	75.2, 75.0	60.7, 65.0	69.7, 72.5	87.3, 88.5	73.4, 74.5	61.5, 59.0	69.7, 76.0	72.1, 74.0	76.2, 77.0

Appendix 3 continued

15	The coalition is improving health outcomes for people in the county served by this coalition.	80.1, 80.5	92.1, 95.0	74.2, 70.0	79.5, 80.0	76.9, 75.0	76.7, 79.0	49.8, 50.0	69.4, 69.0	50.5, 50.0	64.6, 66.0	77.4, 84.0	74.0, 71.5	55.6, 51.0	69.1, 75.0	67.8, 66.0	69.0, 64.0
16	My skills and abilities are effectively used by the coalition.	80.0, 85.0	90.2, 88.0	67.0, 70.5	74.3, 75.0	71.5, 67.0	85.1, 87.0	63.9, 67.0	65.2, 61.0	58.8, 50.5	55.9, 51.5	72.9, 82.0	70.9, 73.0	53.3, 51.0	62.4, 60.0	69.3, 67.0	70.0, 70.0
17	I feel respected and recognized for my efforts.	85.6, 94.0	95.7, 100.0	71.6, 76.5	89.9, 100.0	76.4, 92.0	93.0, 100.0	75.5, 85.0	76.7, 72.0	74.3, 80.0	62.0, 59.5	85.1, 96.5	83.7, 90.0	66.0, 62.0	72.5, 79.0	79.3, 89.0	84.9, 93.0
18	Leadership has a clear vision for the coalition.	83.0, 85.0	95.5, 100.0	84.3, 90.0	90.7, 90.0	88.1, 95.0	86.5, 90.0	56.5, 52.0	75.4, 74.0	55.7, 66.0	72.3, 81.5	91.1, 100.0	83.0, 87.0	67.3, 67.0	70.1, 77.0	57.2, 65.0	83.1, 90.0
19	Leadership has the necessary knowledge and skills.	89.5, 97.5	95.9, 100.0	83.4, 90.5	93.0, 95.0	83.1, 90.0	88.6, 90.0	75.4, 75.0	77.2, 77.0	70.2, 77.5	80.8, 83.5	92.3, 100.0	86.8, 96.0	69.7, 69.0	71.5, 81.0	77.2, 80.0	83.6, 92.0
20	Leadership is respected.	91.0, 100.0	95.5, 98.0	83.3, 92.5	95.6, 100.0	85.5, 96.0	86.7, 100.0	76.7, 84.0	84.2, 87.0	63.6, 60.0	73.8, 81.0	93.8, 100.0	86.3, 91.0	71.5, 71.0	71.8, 91.0	77.9, 81.0	83.9, 90.0
21	Leadership gets things done.	87.5, 97.5	95.9, 100.0	80.4, 86.5	95.0, 95.0	87.7, 86.0	88.6, 100.0	67.5, 74.0	70.3, 75.0	60.6, 62.0	74.9, 81.5	87.8, 89.5	85.2, 90.0	63.3, 66.0	71.7, 81.0	70.4, 75.0	82.2, 84.0
22	Leadership intentionally seeks others' views.	89.5, 98.5	92.4, 95.5	83.0, 92.5	94.4, 94.0	74.6, 84.0	88.1, 100.0	79.1, 77.0	73.6, 77.0	74.3, 82.5	68.4, 68.0	86.4, 100.0	86.0, 95.0	70.0, 77.0	72.6, 84.0	75.3, 76.0	82.6, 91.0
23	Leadership utilizes the skills and talents of many, not just a few.	89.3, 97.5	95.1, 97.0	81.6, 90.0	93.5, 97.0	84.6, 90.0	89.7, 91.0	71.4, 77.0	76.1, 80.0	75.5, 80.0	74.1, 79.0	89.6, 99.5	85.4, 94.0	66.9, 71.0	71.5, 81.5	72.0, 65.0	79.5, 83.0
24	Leadership is ethical.	95.4, 98.0	100.0, 100.0	85.5, 95.0	98.9, 100.0	84.5, 98.0	94.0, 100.0	89.1, 95.0	88.9, 89.0	83.9, 95.0	84.1, 87.5	92.3, 100.0	88.9, 100.0	78.5, 88.0	80.2, 99.5	84.7, 93.0	92.9, 99.0

25	Leadership is skillful at resolving conflict.	81.3, 79.5	82.9, 90.0	80.1, 90.0	93.0, 96.0	72.9, 79.0	69.1, 53.0	77.9, 75.0	76.1, 77.0	60.9, 60.0	66.6, 69.0	88.4, 99.0	86.6, 94.0	67.3, 61.0	68.0, 75.5	64.3, 60.0	80.1, 87.0
	CSAS Cluster means																
	LF (out of 100)	80.45	87.38	74.80	84.18	75.69	84.65	66.16	72.63	63.41	66.46	83.63	77.76	63.20	67.89	67.80	76.82
	PROB (out of 100)	11.76	3.34	9.96	4.34	9.26	7.08	17.06	8.92	19.77	23.60	5.58	13.68	22.06	8.65	17.85	9.54

CHC, community health coalition. CSAS, Coalition Self-Assessment Survey. LF, highly rated leadership and functioning, cluster: questions 10-25. PROB, problems for participating in the coalition, cluster: questions 1-9.

Appendix 4: Community Engagement Professional-Node Social Network Analysis Results

Connection type		Coalition																							
	Calculated network variable	CHC1		CHC2		CHC3		CHC4		CHC5		CHC6		CHC7		CHC8		CHC9		CHC10		CHC11		CHC12	
Cooperation	Degree	12.0		12.0		15.0		18.0		20.0		33.0		40.0		81.0		18.0		18.0		20.0		20.0	
	Betweenness centrality	0.600		0.0		0.286		14.683		4.360		16.076		4.673		53.069		36.167		2.533		24.067		0.667	
	Closeness centrality	1.0		1.0		1.0		1.0		1.0		0.900		0.673		1.0		1.0		1.0		1.0		1.0	
	Eigenvector centrality	0.401		0.378		0.346		0.403		0.353		0.280		0.119		0.214		0.474		0.342		0.411		0.310	
Coordination	Degree	7.0		12.0		10.0		14.0		14.0		21.0		22.0		50.0		15.0		17.0		20.0		17.0	
	Betweenness centrality	9.0		0.750		1.650		26.333		17.750		27.603		13.278		367.48		27.500		8.983		41.367		14.733	
	Closeness centrality	0.0		1.0		0.800		0.0		0.0		0.667		0.0		0.732		1.0		1.0		1.0		1.0	
	Eigenvector centrality	0.416		0.400		0.337		0.585		0.377		0.271		0.225		0.307		0.510		0.388		0.458		0.435	
Collaboration	Degree	4.0		12.0		7.0		10.0		9.0		6.0		12.0		16.0		9.0		11.0		16.0		17.0	
	Betweenness centrality	3.0		2.033		1.500		31.500		11.0		16.500		5.949		87.810		20.0		0		39.0		30.250	
	Closeness centrality	0		1.0		0.667		0		0		0		0		0		0.500		1.0		0.909		1.0	
	Eigenvector centrality	0.252		0.425		0.242		0.570		0.372		0.076		0.127		0.192		0.311		0.535		0.548		0.497	
Formal ties	Degree	7.0	4.0	4.0	15.0	16.0	11.0	26.0	67.0	12.0	17.0	18.0	17.0	11.0	19.0	23.0	28.0	12.0	24.0	14.0	30.0	54.0	24.0	42.0	
	Betweenness centrality	0.333	0	11.867	10.367	1.833	21.064	14.328	120.49	31.667	4.833	17.233	4.567	11.500	18.018	5.849	34.770	0	12.222	4.902	23.150	217.63	7.854	136.22	

Connection type		Coalition																							
	Calculated network variable	CHC13		CHC14		CHC15		CHC16		CHC17		CHC18		CHC19		CHC120		CHC21		CHC22		CHC23		CHC24	
Cooperation	Degree	25.0		24.0		25.0		28.0		30.0		42.0		32.0		42.0		48.0		75.0		47.0		58.0	
	Betweenness centrality	10.727		20.608		10.727		3.005		11.564		19.909		9.866		25.343		23.602		139.847		13.559		152.217	
	Closeness centrality	1.0		1.0		1.0		1.0		1.0		1.0		0.808		1.0		0.816		1.0		0.667		0.723	
	Eigenvector centrality	0.337		0.386		0.337		0.283		0.301		0.265		0.225		0.264		0.229		0.244		0.101		0.201	
Coordination	Degree	15.0		15.0		15.0		15.0		25.0		34.0		21.0		36.0		18.0		52.0		23.0		58.0	
	Betweenness centrality	5.411		21.395		5.411		5.526		48.430		41.424		36.701		60.232		4.938		510.59		17.381		335.15	
	Closeness centrality	0.619		0.619		0.619		0.737		0.938		0.0		0.618		0.875		0.585		0.792		0.500		0.723	
	Eigenvector centrality	0.253		0.286		0.253		0.327		0.427		0.324		0.358		0.270		0.169		0.427		0.078		0.273	
Collaboration	Degree	9.0		6.0		9.0		13.0		15.0		20.0		9.0		12.0		6.0		31.0		15.0		36.0	
	Betweenness centrality	32.500		3.500		32.500		11.450		49.417		56.383		37.333		28.814		0.500		506.98		10.144		216.50	
	Closeness centrality	0.448		0		0.448		0.700		0		0		0		0.583		0.470		0		0.449		0.573	
	Eigenvector centrality	0.163		0.125		0.163		0.316		0.481		0.397		0.227		0.229		0.099		0.429		0.085		0.272	
Formal ties	Degree	19.0		11.0		19.0		23.0		28.0		12.0		24.0		14.0		30.0		54.0		24.0		42.0	
	Betweenness centrality	18.018		11.500		18.018		5.849		34.770		0		12.222		4.902		23.150		217.63		7.854		136.22	

Appendix 4 continued

Frequent mass communication				Frequent direct contact				Good-high trust					
Eigenvector centrality	Closeness centrality	Betweenness centrality	Degree	Eigenvector centrality	Closeness centrality	Betweenness centrality	Degree	Eigenvector centrality	Closeness centrality	Betweenness centrality	Degree	Eigenvector centrality	Closeness centrality
0.583	0	10.0	9.0	0.290	0	6.0	5.0	0.126	0.545	0.333	5.0	0.371	0.750
0.469	1.0	5.833	12.0	0.378	1.0	0	12.0	0.385	1.0	0.200	12.0	0	0
0.168	0.500	0.667	5.0	0.271	0	6.0	6.0	0.363	1.0	1.176	15.0	0.453	1.0
0.553	1.0	35.333	16.0	0.533	1.0	43.667	16.0	0.423	1.0	15.08	17.0	0.397	0.900
0.230	0.370	11.167	10.0	0.292	0.667	17.917	13.0	0.312	0.769	5.900	16.0	0.239	0.556
0.126	0.514	17.0	6.0	0.186	0.545	15.500	9.0	0.263	0.818	17.28	30.0	0.274	0.783
0.378	1.0	176.437	60.0	0.283	0	111.21	23.0	0.193	0.661	28.52	37.0	0.122	0.569
0.198	0.695	226.994	52.0	0.367	0.932	689.74	70.0	0.223	1.0	74.33	80.0	0.297	0.953
0.508	0.818	47.0	14.0	0.533	0	52.0	11.0	0.519	0.900	48.0	16.0	0.358	0.692
0.348	0.750	3.283	13.0	0.429	0.900	7.417	14.0	0.358	1.0	4.150	18.0	0.376	1.0
0.421	0.714	30.333	12.0	0.264	0.526	48.500	10.0	0.411	1.0	24.06	20.0	0.392	0.909
0.276	0.714	18.667	16.0	0.366	0.769	22.383	16.0	0.226	0.769	0.500	17.0	0.338	0.833
0.456	1.0	47.318	23.0	0.454	0	43.550	20.0	0.277	0.650	10.25	16.0	0.318	0
0.435	1.0	51.950	24.0	0.277	0.619	11.219	17.0	0.267	0.684	3.862	18.0	0.240	0.684
0.268	0.875	5.076	24.0	0.296	0.778	8.475	20.0	0.297	1.0	4.718	28.0	0.278	0.824
0.204	0.536	35.617	15.0	0.385	0.600	80.157	17.0	0.299	0.938	14.44	27.0	0.361	1.0
0.348	1.0	115.727	41.0	0.314	0	82.283	27.0	0.216	0.750	8.227	30.0	0	0
0.297	0.808	17.134	28.0	0.322	0.700	9.491	22.0	0.187	0.700	6.688	27.0	0.223	0.636
0.394	1.0	145.021	40.0	0.406	0.955	98.287	33.0	0.297	1.0	39.21	42.0	0.012	0.368
0.227	0.620	53.755	24.0	0.190	0.554	13.360	16.0	0.204	0.674	21.24	32.0	0.220	0.660
0.367	0.950	437.965	65.0	0.183	0.623	418.62	30.0	0.289	1.0	227.0	73.0	0.282	0.760
0.098	0.465	11.486	19.0	0.197	0	30.253	22.0	0.137	0.635	28.67	41.0	0.084	0.556
0.298	0.644	222.257	42.0	0.355	0	438.01	50.0	0.207	0.712	191.4	56.0	0.180	0.644

CHC, community health coalition.

Appendix 5: Social network analysis measures for follow-up data

Network measures		Ext-CHC								CWC-CHC													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Whole network measures																							
Cooperation	**Density**	0.796	0.834	0.839	0.782	0.779	1.000	0.891	0.857	0.748	0.381	0.909	0.259	0.613	0.650	0.695	0.725	0.840	0.641	0.825	0.780	0.702	0.845
	Mean degree	43.000	61.684	30.211	15.636	73.250	10.000	17.818	10.286	37.385	25.176	18.182	24.857	25.727	45.500	22.235	24.667	53.758	15.385	29.684	37.440	65.958	16.909
	Degree centralization	0.219	0.161	0.180	0.267	0.230	0.000	0.133	0.200	0.273	0.657	0.111	0.686	0.348	0.355	0.346	0.243	0.154	0.424	0.196	0.239	0.311	0.189
	Betweenness centralization	0.019	0.005	0.009	0.046	0.009	0.000	0.009	0.052	0.033	0.195	0.009	0.165	0.086	0.031	0.065	0.041	0.006	0.102	0.015	0.027	0.023	0.048
	Closeness centralization	0.151	0.132	0.144	0.185	0.173	0.000	0.106	0.141	0.203	0.386	0.091	0.430	0.298	0.270	0.231	0.234	0.127	0.291	0.140	0.169	0.217	0.124
	Eigenvector centralization	0.042	0.027	0.040	0.062	0.032	0.000	0.032	0.063	0.051	0.171	0.030	0.201	0.087	0.065	0.081	0.065	0.027	0.122	0.043	0.047	0.043	0.049
	Transitivity	0.869	0.877	0.860	0.835	0.854	1.000	0.900	0.882	0.828	0.541	0.922	0.419	0.781	0.783	0.784	0.850	0.894	0.717	0.870	0.846	0.833	0.899
Coordination	**Density**	0.221	0.282	0.383	0.264	0.253	0.867	0.745	0.333	0.268	0.198	0.455	0.126	0.450	0.206	0.316	0.252	0.190	0.333	0.468	0.633	0.200	0.736

Appendix 5 continued

	Mean degree	11.929	20.895	13.789	5.273	23.750	8.667	14.909	4.000	13.385	13.059	9.091	12.082	18.909	14.389	10.118	8.556	12.182	8.000	16.842	30.400	18.833	14.727
	Degree centralization	0.360	0.458	0.503	0.411	0.724	0.200	0.311	0.467	0.512	0.450	0.422	0.542	0.474	0.735	0.492	0.379	0.629	0.739	0.315	0.308	0.601	0.261
	Betweenness centralization	0.179	0.146	0.163	0.245	0.249	0.070	0.066	0.369	0.172	0.214	0.160	0.273	0.059	0.344	0.230	0.163	0.464	0.587	0.064	0.044	0.346	0.054
	Closeness centralization	0.394	0.420	0.442	0.000	0.438	0.130	0.218	0.000	0.000	0.000	0.457	0.000	0.474	0.485	0.496	0.000	0.522	0.462	0.411	0.278	0.389	0.253
	Eigenvector centralization	0.218	0.225	0.207	0.264	0.198	0.065	0.078	0.265	0.207	0.225	0.258	0.311	0.146	0.332	0.302	0.271	0.369	0.329	0.181	0.085	0.241	0.091
	Transitivity	0.382	0.429	0.540	0.459	0.447	0.899	0.806	0.480	0.471	0.444	0.509	0.339	0.660	0.303	0.409	0.559	0.357	0.382	0.617	0.791	0.299	0.864
Collaboration	**Density**	0.103	0.156	0.222	0.145	0.167	0.533	0.136	0.071	0.126	0.103	0.236	0.069	0.229	0.130	0.162	0.121	0.083	0.154	0.219	0.387	0.120	0.400
	Mean degree	5.571	11.526	8.000	2.909	15.708	5.333	2.727	0.857	6.308	6.824	4.727	6.612	9.636	9.111	5.176	4.111	5.333	3.692	7.895	18.560	11.292	8.000
	Degree centralization	0.148	0.549	0.559	0.250	0.525	0.400	0.261	0.250	0.427	0.389	0.567	0.330	0.560	0.694	0.667	0.195	0.294	0.261	0.407	0.418	0.641	0.428

Appendix 5 continued

	Transitivity	0.405	0.262	0.324	0.630	0.354	0.613	0.273	0.000	0.259	0.294	0.379	0.366	0.404	0.227	0.215	0.315	0.313	0.429	0.344	0.583	0.201	0.692
	Eigenvector centralization	0.490	0.419	0.388	0.421	0.230	0.309	0.435	0.000	0.373	0.322	0.483	0.333	0.331	0.458	0.477	0.358	0.324	0.196	0.365	0.224	0.433	0.262
	Closeness centralization	0.000	0.541	0.503	0.000	0.000	0.457	0.000	0.000	0.000	0.000	0.671	0.000	0.644	0.561	0.670	0.000	0.000	0.000	0.572	0.428	0.459	0.536
	Betweenness centralization	0.143	0.284	0.366	0.024	0.192	0.380	0.193	0.033	0.217	0.326	0.561	0.220	0.238	0.595	0.522	0.120	0.207	0.038	0.171	0.143	0.541	0.182
Formal ties	**Density**	0.721	0.765	0.681	0.627	0.712	0.400	0.318	0.452	0.692	0.275	0.709	0.192	0.450	0.263	0.408	0.333	0.250	0.372	0.708	0.285	0.259	0.618
	Mean degree	38.929	56.632	24.526	12.545	66.958	4.000	6.364	5.429	34.615	18.118	14.182	18.449	18.909	18.444	13.059	11.333	16.000	8.923	25.474	13.680	24.375	12.364
	Degree centralization	0.241	0.219	0.263	0.456	0.256	0.450	0.528	0.417	0.290	0.545	0.233	0.701	0.474	0.613	0.529	0.353	0.566	0.348	0.327	0.483	0.651	0.344
	Betweenness centralization	0.021	0.012	0.027	0.200	0.015	0.120	0.364	0.232	0.036	0.212	0.111	0.244	0.084	0.278	0.172	0.150	0.215	0.097	0.044	0.253	0.167	0.101
	Closeness centralization	0.216	0.174	0.259	0.310	0.176	0.829	0.489	0.568	0.200	0.364	0.253	0.482	0.417	0.436	0.433	0.000	0.483	0.000	0.226	0.418	0.421	0.340

Appendix 5 continued

	Eigenvector centralization	0.060	0.040	0.098	0.133	0.041	0.346	0.370	0.283	0.063	0.208	0.113	0.282	0.157	0.235	0.230	0.212	0.288	0.210	0.079	0.243	0.229	0.129
	Transitivity	0.830	0.849	0.726	0.714	0.822	0.778	0.381	0.533	0.785	0.462	0.780	0.314	0.602	0.393	0.503	0.600	0.396	0.530	0.783	0.513	0.342	0.796
Good-high trust	**Density**	0.664	0.738	0.795	0.682	0.738	0.967	0.618	0.667	0.695	0.347	0.800	0.220	0.563	0.362	0.629	0.559	0.680	0.577	0.787	0.687	0.305	0.809
	Mean degree	35.857	54.632	28.632	13.636	69.375	9.667	12.364	8.000	34.769	22.882	16.000	21.102	23.636	25.333	20.118	19.000	43.515	13.846	28.316	32.960	28.625	16.182
	Degree centralization	0.342	0.248	0.167	0.389	0.273	0.050	0.161	0.467	0.330	0.694	0.244	0.661	0.402	0.661	0.385	0.331	0.324	0.402	0.239	0.341	0.615	0.233
	Betweenness centralization	0.076	0.017	0.012	0.106	0.013	0.005	0.082	0.389	0.052	0.254	0.037	0.261	0.088	0.149	0.110	0.052	0.042	0.186	0.023	0.057	0.118	0.056
	Closeness centralization	0.228	0.191	0.177	0.268	0.200	0.040	0.256	0.285	0.236	0.404	0.179	0.455	0.331	0.407	0.273	0.373	0.232	0.240	0.166	0.229	0.417	0.154
	Eigenvector centralization	0.074	0.044	0.053	0.102	0.039	0.014	0.092	0.175	0.063	0.192	0.068	0.237	0.107	0.173	0.105	0.123	0.057	0.122	0.054	0.074	0.197	0.060
	Transitivity	0.801	0.841	0.822	0.756	0.837	0.964	0.725	0.778	0.810	0.517	0.837	0.392	0.736	0.499	0.745	0.756	0.827	0.688	0.846	0.785	0.406	0.870

Mass communication		Direct contact						
Mean degree	Density	Transitivity	Eigenvector centralization	Closeness centralization	Betweenness centralization	Degree centralization	Mean degree	Density
18.429	0.341	0.365	0.477	0.656	0.343	0.503	7.786	0.144
45.474	0.615	0.411	0.269	0.482	0.280	0.634	17.526	0.237
12.421	0.345	0.418	0.276	0.000	0.270	0.534	9.789	0.272
6.727	0.336	0.200	0.427	0.000	0.164	0.233	2.182	0.109
26.542	0.282	0.516	0.183	0.000	0.202	0.556	18.875	0.201
8.667	0.867	0.833	0.071	0.177	0.060	0.250	8.333	0.833
7.455	0.373	0.419	0.343	0.458	0.254	0.444	6.727	0.336
4.000	0.333	0.250	0.566	0.000	0.089	0.200	2.286	0.190
12.846	0.257	0.425	0.247	0.000	0.233	0.495	10.154	0.203
12.765	0.193	0.450	0.275	0.000	0.230	0.455	9.706	0.147
3.091	0.155	0.363	0.387	0.668	0.376	0.583	5.455	0.273
9.633	0.100	0.382	0.233	0.000	0.204	0.368	9.102	0.095
18.182	0.433	0.616	0.184	0.451	0.114	0.421	16.909	0.403
9.722	0.139	0.361	0.326	0.000	0.279	0.443	8.722	0.125
4.706	0.147	0.430	0.293	0.000	0.303	0.421	6.118	0.191
16.333	0.480	0.651	0.208	0.464	0.123	0.375	13.667	0.402
22.121	0.346	0.469	0.173	0.404	0.105	0.626	23.394	0.366
5.231	0.218	0.386	0.287	0.000	0.409	0.439	5.077	0.212
24.842	0.690	0.623	0.121	0.190	0.116	0.288	16.737	0.465
14.160	0.295	0.470	0.289	0.461	0.227	0.466	14.400	0.300
7.375	0.078	0.336	0.284	0.000	0.091	0.271	7.625	0.081
10.182	0.509	0.610	0.153	0.500	0.232	0.428	8.000	0.400

Appendix 5 continued

	Degree centralization	0.550	0.336	0.515	0.567	0.738	0.200	0.461	0.817	0.762	0.744	0.361	0.829	0.519	0.821	0.258	0.386	0.613	0.383	0.284	0.540	0.484	0.356
	Betweenness centralization	0.258	0.077	0.186	0.385	0.163	0.100	0.198	0.733	0.414	0.298	0.161	0.679	0.131	0.674	0.137	0.074	0.161	0.314	0.062	0.252	0.313	0.134
	Closeness centralization	0.450	0.279	0.463	0.590	0.416	0.130	0.432	0.605	0.468	0.567	0.000	0.000	0.398	0.538	0.000	0.408	0.394	0.000	0.230	0.480	0.000	0.455
	Eigenvector centralization	0.198	0.062	0.258	0.335	0.177	0.069	0.286	0.369	0.263	0.286	0.410	0.397	0.175	0.410	0.304	0.161	0.177	0.531	0.087	0.263	0.387	0.200
	Transitivity	0.622	0.828	0.455	0.409	0.430	0.909	0.503	0.290	0.415	0.359	0.259	0.269	0.554	0.275	0.256	0.682	0.464	0.439	0.780	0.487	0.230	0.768
CEnP-node measures																							
Cooperation	**Degree**	30.000	73.000	36.000	20.000	89.000	10.000	19.000	12.000	37.000	66.000	20.000	25.000	6.000	34.000	32.000	31.000	63.000	24.000	36.000	48.000	94.000	20.000
	Betweenness centrality	2.257	11.743	5.487	5.967	24.326	0.000	1.548	2.200	10.337	220.043	1.629	6.036	0.000	5.535	19.458	6.579	10.846	16.793	7.438	19.553	62.182	5.471
	Closeness centrality	0.600	1.000	1.000	1.000	0.959	1.000	1.000	1.000	0.781	1.000	1.000	0.558	0.000	0.636	1.000	0.944	1.000	1.000	1.000	1.000	1.000	1.000
	Eigenvector centrality	0.082	0.186	0.265	0.350	0.166	0.408	0.329	0.424	0.180	0.320	0.327	0.113	0.000	0.096	0.307	0.279	0.196	0.382	0.265	0.238	0.179	0.336

Formal ties	Collaboration				Coordination			
Degree	Eigenvector centrality	Closeness centrality	Betweenness centrality	Degree	Eigenvector centrality	Closeness centrality	Betweenness centrality	Degree
24.000	0.000	0.000	17.000	4.000	0.050	0.000	36.928	11.000
72.000	0.267	0.649	133.840	31.000	0.288	0.771	131.734	51.000
21.000	0.284	0.474	12.533	12.000	0.331	0.750	18.114	23.000
13.000	0.330	0.000	0.000	5.000	0.491	0.000	28.500	12.000
72.000	0.297	0.000	187.785	46.000	0.276	0.783	130.684	61.000
3.000	0.236	0.500	4.500	6.000	0.453	1.000	1.833	10.000
6.000	0.000	0.000	0.000	0.000	0.297	0.833	1.500	14.000
5.000	0.000	0.000	1.000	3.000	0.563	0.000	12.500	8.000
29.000	0.256	0.000	12.867	10.000	0.252	0.000	7.910	19.000
52.000	0.440	0.000	363.404	31.000	0.360	0.000	247.944	41.000
16.000	0.238	0.556	19.000	6.000	0.369	0.714	7.017	13.000
20.000	0.027	0.000	0.000	4.000	0.150	0.000	6.227	13.000
5.000	0.000	0.000	0.000	2.000	0.000	0.000	0.000	5.000
18.000	0.033	0.365	2.192	8.000	0.157	0.556	10.013	16.000
19.000	0.158	0.457	25.333	9.000	0.304	0.696	54.275	21.000
18.000	0.206	0.000	11.000	7.000	0.369	0.000	40.750	19.000
15.000	0.295	0.000	16.291	9.000	0.127	0.444	4.599	12.000
15.000	0.244	0.000	6.333	9.000	0.555	1.000	80.033	23.000
29.000	0.380	0.643	33.061	15.000	0.281	0.750	11.978	22.000
16.000	0.213	0.750	92.087	31.000	0.263	1.000	31.912	44.000
32.000	0.288	0.588	177.455	28.000	0.229	0.603	47.499	32.000
16.000	0.428	0.714	9.000	10.000	0.361	1.000	6.160	19.000

Appendix 5 continued

Direct contact		Good-high trust						
Betweenness centrality	Degree	Eigenvector centrality	Closeness centrality	Betweenness centrality	Degree	Eigenvector centrality	Closeness centrality	Betweenness centrality
91.236	12.000	0.087	0.587	3.237	26.000	0.069	0.563	1.354
91.556	39.000	0.197	1.000	25.574	72.000	0.194	1.000	21.528
64.350	24.000	0.262	0.947	7.043	34.000	0.144	0.643	3.877
0.000	3.000	0.240	0.667	1.617	13.000	0.252	0.667	1.900
217.221	47.000	0.155	0.887	29.317	81.000	0.147	0.825	22.661
1.833	10.000	0.419	1.000	0.250	10.000	0.000	0.000	0.000
5.667	7.000	0.087	0.588	0.533	6.000	0.310	0.588	2.333
0.000	3.000	0.172	0.600	0.000	7.000	0.458	0.667	0.000
41.226	21.000	0.160	0.714	8.927	32.000	0.139	0.676	7.811
101.472	27.000	0.338	1.000	282.228	66.000	0.335	0.805	244.150
35.833	15.000	0.356	1.000	5.002	20.000	0.251	0.769	12.293
16.742	9.000	0.123	0.552	9.092	23.000	0.090	0.533	7.725
0.000	3.000	0.000	0.000	0.000	5.000	0.000	0.000	0.000
42.718	19.000	0.152	0.614	9.588	31.000	0.101	0.538	5.451
78.817	18.000	0.326	1.000	30.758	31.000	0.310	0.696	17.804
12.363	17.000	0.294	0.895	19.322	29.000	0.220	0.000	6.710
6.619	21.000	0.075	0.627	7.923	28.000	0.035	0.390	1.672
57.833	14.000	0.375	0.857	9.167	20.000	0.421	0.000	17.025
22.177	26.000	0.247	0.900	7.915	33.000	0.215	0.750	9.569
93.867	32.000	0.260	1.000	37.636	48.000	0.081	0.462	35.390
136.346	22.000	0.172	0.627	37.586	38.000	0.154	0.603	51.744
25.083	15.000	0.345	1.000	6.486	20.000	0.368	0.833	5.367

Appendix 5 continued

	Closeness centrality	0.563	0.685	0.000	0.000	0.000	1.000	0.526	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.607	0.582	0.000	0.783	0.727	0.000	0.000
	Eigenvector centrality	0.257	0.290	0.459	0.288	0.250	0.462	0.196	0.000	0.162	0.342	0.589	0.096	0.000	0.221	0.469	0.195	0.121	0.503	0.311	0.371	0.322	0.400
Mass communication	**Degree**	19.000	69.000	24.000	4.000	84.000	10.000	12.000	11.000	36.000	59.000	3.000	7.000	4.000	12.000	12.000	14.000	57.000	7.000	30.000	34.000	30.000	16.000
	Betweenness centrality	10.036	114.704	30.875	0.000	244.513	2.333	7.317	22.000	83.283	325.600	0.000	0.200	0.000	2.317	38.033	2.893	117.157	0.000	8.388	152.202	289.784	14.417
	Closeness centrality	0.600	1.000	0.750	0.000	0.959	1.000	0.714	1.000	0.781	1.000	0.000	0.000	0.000	0.389	0.000	0.567	0.941	0.000	0.857	0.750	0.000	0.909
	Eigenvector centrality	0.125	0.206	0.278	0.000	0.294	0.455	0.442	0.647	0.372	0.411	0.000	0.072	0.000	0.053	0.178	0.117	0.307	0.000	0.259	0.350	0.360	0.417

CHC, community health coalition. CEnP, Community Engagement Professional-node, referring to the relative network measures of CWC and Ext. CWC, Community Wellness Coordinator. Ext, Extension Educator.

Appendix 6: Mean responses and cluster scores to the Coalition Self-Assessment Survey

		Ext-CHC								CWC-CHC													
Survey question (response on a scale of 0-100). $\bar{x}$		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
1	Coalition activities do not reach my primary constituency.	17.3	21.0	31.3	44.5	16.1	8.2	48.5	22.0	17.0	18.5	18.7	26.4	14.8	25.1	27.9	11.0	12.4	16.6	15.9	23.0	28.5	6.2
2	Being involved in policy advocacy is a problem.	16.5	23.8	13.0	47.7	23.0	12.8	63.8	17.0	24.5	12.9	17.7	23.4	11.3	22.2	26.8	13.2	21.4	18.4	21.5	20.1	33.9	5.8
3	My skills and time are not well used.	13.2	25.8	18.7	21.0	20.3	8.0	35.8	24.5	9.7	15.7	25.7	28.1	9.4	18.6	37.9	19.2	8.4	10.3	16.1	21.8	33.2	7.3
4	My opinion is not valued.	5.1	13.9	11.9	13.7	14.7	5.2	18.8	11.5	3.0	6.9	4.4	20.6	5.6	12.8	21.2	5.5	7.9	4.2	14.3	12.5	17.4	3.2
5	The coalition is not taking any meaningful action.	11.5	33.3	23.7	37.0	11.5	16.8	73.7	45.0	10.0	13.9	26.3	18.3	4.9	28.4	40.1	23.1	20.1	8.6	20.5	20.4	24.3	5.4
6	I am often the only voice representing my point of view.	8.8	18.0	10.3	27.5	13.6	11.2	28.0	26.8	16.2	9.1	9.6	21.3	5.3	14.5	23.4	7.2	16.1	11.7	16.6	18.4	16.1	2.3
7	The financial burden of traveling to coalition meetings is too high.	3.6	11.6	4.5	0.2	2.3	1.7	10.3	0.0	0.3	8.4	4.7	8.2	8.6	3.4	5.5	1.5	12.9	1.1	4.1	5.6	6.5	0.8
8	The financial burden of participation (barring travel) is too high.	3.2	8.9	7.3	0.2	1.7	2.2	10.0	6.0	0.4	6.6	3.2	7.1	8.7	4.2	8.8	5.9	7.1	6.0	3.4	9.6	11.0	0.4
9	The coalition is competing with my organization.	4.7	3.6	7.7	8.2	3.1	5.5	21.0	8.0	5.8	7.6	9.2	8.8	5.0	10.1	11.7	3.9	6.9	2.1	3.9	8.4	8.8	0.9
10	The coalition is actively recruiting new members.	69.0	54.5	53.1	46.3	56.3	65.3	33.7	40.8	55.4	64.1	42.4	62.4	65.6	54.4	62.3	58.3	63.5	54.9	57.9	53.4	57.4	60.3
11	New members receive adequate orientation to be effective members of the coalition.	63.8	43.2	46.0	41.0	49.5	40.8	39.5	37.3	38.5	55.0	57.8	49.8	59.7	51.9	51.3	61.9	62.2	62.5	54.5	56.5	49.6	72.2

Appendix 6 continued

12	The current method for communication between coalition staff/leadership and its membership is effective.	78.3	53.1	57.9	67.3	70.6	63.7	43.7	51.0	65.2	72.1	71.2	66.3	71.1	67.9	64.3	62.6	71.2	76.0	74.6	74.1	52.7	88.2
13	Resources are being identified to support the systemic, programmatic changes implemented through the work of the coalition.	79.0	57.6	63.5	59.3	76.9	65.8	49.2	35.3	70.0	65.7	71.3	73.5	68.2	66.2	45.3	57.6	70.8	77.4	76.5	70.6	64.6	89.8
14	The coalition is making progress in implementing activities that have potential to improve health in the county.	83.7	64.5	73.9	65.7	84.8	81.8	48.5	36.8	78.4	72.7	74.7	81.6	77.0	79.6	55.0	70.3	80.3	84.4	80.0	70.8	71.4	93.8
15	The coalition is improving health outcomes for people in the county served by this coalition.	77.3	65.5	75.1	57.8	85.7	70.3	37.3	38.5	66.5	68.5	77.6	77.9	77.7	72.1	53.8	67.5	68.6	82.9	74.5	62.4	66.8	95.5
16	My skills and abilities are effectively used by the coalition.	67.8	58.9	63.6	59.8	74.1	64.7	48.3	38.5	69.2	68.8	66.6	61.9	73.9	66.2	46.6	61.6	75.9	88.7	72.1	68.2	64.0	92.9
17	I feel respected and recognized for my efforts.	79.2	71.9	73.4	72.5	82.5	89.5	66.3	44.3	83.7	75.2	83.2	74.3	77.9	79.5	69.2	81.7	77.4	93.6	85.1	72.6	75.5	94.8
18	Leadership has a clear vision for the coalition.	88.4	67.3	64.7	67.8	86.6	80.0	37.0	44.0	80.6	77.8	70.7	76.2	83.2	66.8	65.1	66.7	83.1	90.1	76.7	80.1	71.3	89.1
19	Leadership has the necessary knowledge and skills.	88.9	79.6	76.4	82.5	90.3	80.2	46.5	72.0	82.3	78.4	80.0	76.7	82.3	76.2	71.7	81.7	84.3	91.3	77.5	84.6	77.6	91.3
20	Leadership is respected.	90.6	80.9	71.7	86.8	89.5	91.3	71.7	71.8	79.4	85.1	83.9	74.5	84.4	82.8	70.8	79.2	85.9	91.8	86.5	85.9	76.5	91.7
21	Leadership gets things done.	88.8	75.9	67.9	87.0	83.3	84.5	52.7	58.8	81.5	79.9	77.7	78.5	83.5	71.3	68.9	68.1	86.9	90.4	71.4	88.2	68.8	92.5
22	Leadership intentionally seeks others' views.	86.6	74.9	72.9	88.5	81.3	84.7	54.8	65.3	82.5	77.6	78.9	75.0	78.1	72.1	81.6	71.5	83.6	84.9	83.2	86.3	70.4	91.5

23	Leadership utilizes the skills and talents of many, not just a few.	82.7	71.5	71.5	80.2	76.1	85.5	49.3	60.5	80.2	74.3	76.6	71.4	82.2	75.9	68.3	74.0	82.3	86.9	82.3	82.7	73.5	94.5
24	Leadership is ethical.	90.2	86.4	84.6	90.5	91.2	96.0	79.8	84.5	92.1	87.4	89.1	80.2	84.1	88.5	91.5	88.5	92.5	96.2	95.5	92.4	88.5	96.3
25	Leadership is skillful at resolving conflict.	83.0	72.2	70.3	63.2	82.8	84.5	61.3	60.0	72.5	76.1	86.7	67.1	76.9	68.7	59.6	72.5	75.2	87.2	79.9	80.7	69.3	90.4
Cluster Means																								
LF (out of 100)		81.1	67.4	67.9	69.8	78.8	76.8	51.2	52.4	73.6	73.7	74.3	71.7	76.6	71.3	63.1	70.2	77.7	83.7	76.8	75.6	68.6	89.0
PROB (out of 100)		9.3	17.8	14.3	22.2	11.8	7.9	34.4	17.9	9.7	11.1	13.3	18.0	8.2	15.5	22.6	10.1	12.6	8.8	12.9	15.5	20.0	3.6

CHC, community health coalition. CSAS, Coalition Self-Assessment Survey. CWC, Community Wellness Coordinator. Ext, Extension Educator. LF, highly rated leadership and functioning, cluster: questions 10-25. PROB, problems for participating in the coalition, cluster: questions 1-9. Analyses for Ext-CHCs and CWC-CHCs were kept separate. A sensitivity analysis of all CHCs produced the same cluster results.

Appendix 7: Difference between study measures at year 1 and follow-up

Study measures		Ext-CHC								CWC-CHC													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
CSAS cluster scores																							
	LF	1.088	39.319	19.415	0.771	2.887	10.932	-12.111	-1.623	7.450	5.779	-9.918	8.486	0.918	3.454	-0.343	-13.386	-6.925	3.247	4.142	-2.170	-8.200	1.672
	PROB	-15.059	-46.458	-17.927	2.664	-5.790	-15.536	5.594	-8.569	-7.403	2.420	8.928	-4.069	-1.090	-2.358	2.827	4.485	5.503	-2.986	4.026	1.851	10.430	0.230
Whole network measures																							
Cooperation	**Density**	0.130	0.192	0.173	-0.018	0.100	0.000	-0.067	-0.071	0.055	-0.157	-0.055	-0.302	-0.144	-0.048	-0.080	0.078	0.230	0.119	-0.061	0.064	0.349	-0.055
	Mean degree	19.000	9.113	18.211	-0.364	22.987	-2.000	2.485	-0.857	19.385	-15.747	-1.091	-9.893	7.573	-10.354	-1.015	-2.515	37.900	5.985	4.884	7.349	32.792	0.709
	Degree centralization	-0.153	-0.203	-0.237	0.022	-0.108	0.000	0.080	0.100	-0.041	0.185	0.067	0.251	0.060	0.064	0.089	-0.093	-0.212	-0.173	0.064	-0.073	-0.175	0.064
	Betweenness centralization	-0.032	-0.019	-0.171	0.017	-0.018	0.000	0.007	0.046	-0.026	0.105	0.005	0.109	0.016	0.007	0.023	-0.007	-0.100	-0.389	0.006	-0.021	-0.044	0.023
	Closeness centralization	-0.108	-0.128	-0.132	0.009	-0.067	0.000	0.060	0.058	-0.048	0.070	0.059	0.112	0.113	0.051	0.044	-0.023	-0.186	-0.075	0.039	-0.033	-0.181	0.040
	Eigenvector centralization	-0.051	-0.040	-0.076	0.000	-0.026	0.000	0.017	0.035	-0.038	0.073	0.018	0.107	0.011	0.017	0.020	-0.033	-0.111	-0.083	0.014	-0.021	-0.133	0.013

Appendix 7 continued

Collaboration	Coordination							
Density	Transitivity	Eigenvector centralization	Closeness centralization	Betweenness centralization	Degree centralization	Mean degree	Density	Transitivity
-0.075	-0.144	-0.021	-0.025	0.015	-0.130	-2.282	-0.174	0.137
0.020	0.007	0.038	0.162	-0.061	0.048	2.895	0.063	0.136
0.022	0.091	-0.142	0.442	-0.166	-0.052	7.789	0.050	0.096
-0.073	-0.121	0.086	-0.605	0.093	0.044	-2.727	-0.136	0.011
0.028	0.063	-0.076	0.438	0.061	0.285	8.539	0.047	0.073
-0.324	-0.035	0.036	0.054	0.058	0.100	-2.476	-0.062	0.000
-0.336	0.053	-0.046	-0.057	-0.103	-0.082	3.798	0.051	-0.054
-0.190	-0.005	0.070	-0.700	0.075	0.100	-0.857	-0.071	-0.035
-0.116	-0.174	0.073	-0.199	0.062	0.204	0.242	-0.238	0.039
0.009	-0.017	-0.073	-0.310	-0.132	-0.048	-3.044	-0.014	-0.170
-0.136	-0.186	0.060	-0.002	0.018	0.017	-1.273	-0.064	-0.052
-0.115	-0.160	0.120	-0.396	0.081	-0.062	-7.793	-0.195	-0.302
-0.008	-0.104	0.009	0.151	-0.063	0.069	4.140	-0.165	-0.057
-0.024	-0.098	0.083	0.024	0.125	0.073	-5.221	-0.040	-0.037
-0.022	-0.149	0.094	0.159	0.030	0.039	-3.007	-0.121	-0.056
0.011	0.120	0.017	-0.271	-0.156	-0.038	-1.535	0.011	0.094
-0.092	-0.202	0.199	0.268	0.363	0.405	2.182	-0.194	0.192
-0.091	-0.248	0.036	-0.163	0.212	0.183	1.000	-0.056	0.004
-0.100	-0.057	-0.027	-0.053	-0.033	-0.116	4.309	0.020	-0.036
0.125	0.047	-0.037	-0.017	-0.082	-0.023	7.036	0.077	0.021
-0.026	-0.062	-0.040	-0.071	0.136	0.055	-2.958	-0.031	0.361
-0.011	0.040	-0.010	0.048	-0.058	-0.072	1.527	0.003	-0.040

Formal ties	**Degree centralization**	-0.222	18.823	0.162	0.077	0.272	-0.528	-0.150	-0.118	-0.850
		-0.207	22.917	0.354	-0.098	0.174	0.541	0.161	0.243	0.431
		-0.056	13.126	0.048	0.026	0.033	0.503	-0.036	0.114	4.400
		0.150	2.545	0.127	-0.014	0.137	0.000	-0.067	-0.033	-1.455
		-0.342	43.853	0.400	0.057	-0.131	0.000	-0.065	0.115	5.445
		0.200	-2.857	-0.171	-0.263	0.247	0.309	0.334	0.200	-4.952
		0.180	-4.303	-0.348	-0.363	0.191	-0.477	-0.028	-0.176	-4.828
		0.083	-1.714	-0.143	-0.643	-0.339	0.000	-0.097	-0.083	-2.286
		0.014	21.758	0.198	-0.184	-0.028	-0.244	0.075	0.260	0.022
		0.066	-4.293	-0.020	-0.171	-0.026	0.000	-0.012	0.059	-0.356
		-0.011	0.182	0.009	-0.177	0.208	0.118	0.250	-0.017	-2.727
		0.167	-4.489	-0.178	0.019	0.013	-0.444	0.010	-0.145	-4.763
		0.209	2.294	-0.242	0.032	-0.131	-0.048	-0.055	0.052	3.944
		0.064	-8.775	-0.077	-0.086	0.113	-0.001	0.196	0.028	-3.230
		0.124	-4.316	-0.171	-0.138	0.155	0.670	0.312	0.305	-0.324
		0.091	-6.667	-0.095	0.050	-0.079	0.000	-0.295	-0.103	-0.525
		0.194	9.286	-0.008	-0.147	-0.065	0.000	0.048	0.140	0.762
		-0.040	2.523	0.016	0.057	-0.328	-0.833	-0.180	-0.128	-0.708
		0.074	5.607	-0.002	-0.130	0.009	0.024	-0.100	-0.090	-1.039
		0.052	-0.865	-0.061	0.168	-0.066	-0.119	0.025	0.051	7.560
		0.106	-0.583	-0.006	-0.079	0.090	0.011	0.197	0.138	-2.417
		0.053	-1.436	-0.148	-0.168	-0.095	-0.189	-0.012	0.039	0.600

	Betweenness centralization	-0.081	-0.048	-0.082	-0.094	-0.127	0.076	0.179	0.138	-0.072	-0.027	0.074	0.115	0.027	0.190	0.028	0.038	-0.004	-0.296	0.002	0.072	0.046	0.026
	Closeness centralization	-0.113	-0.201	-0.052	-0.115	-0.170	0.294	0.196	0.119	-0.201	-0.118	-0.039	0.045	0.144	0.027	0.115	-0.310	0.483	-0.566	-0.008	-0.088	-0.020	0.155
	Eigenvector centralization	-0.076	-0.126	-0.032	-0.088	-0.130	0.118	0.223	0.066	-0.158	0.013	-0.011	0.093	0.057	0.060	0.096	0.034	0.029	-0.138	-0.016	-0.024	-0.015	0.047
	Transitivity	0.158	0.344	-0.028	0.056	0.350	-0.003	-0.343	-0.095	0.151	-0.105	-0.028	-0.239	-0.214	-0.076	-0.216	-0.001	-0.041	0.071	-0.016	-0.048	-0.044	-0.043
Good-high trust	**Density**	0.047	0.149	0.173	0.027	0.382	-0.010	-0.285	0.024	0.124	-0.064	-0.136	-0.216	-0.085	-0.016	-0.080	-0.045	0.218	0.177	-0.052	0.070	-0.012	-0.024
	Mean degree	13.647	6.346	17.432	0.545	43.007	-2.048	-2.081	0.286	19.912	-8.348	-2.727	-5.898	8.098	-4.862	-1.132	-6.364	31.515	6.646	4.849	7.051	-1.167	1.182
	Degree centralization	-0.055	-0.158	-0.236	0.211	-0.335	0.017	0.036	0.083	0.009	0.115	0.167	0.283	0.084	0.111	0.128	-0.052	0.055	-0.210	0.052	-0.081	0.102	0.025
	Betweenness centralization	0.004	-0.019	-0.167	0.066	-0.114	0.003	0.071	0.158	-0.083	0.104	0.030	0.212	-0.024	0.074	0.059	-0.020	-0.123	-0.459	0.009	-0.021	0.042	0.015
	Closeness centralization	-0.059	-0.097	-0.131	-0.027	-0.188	0.012	0.156	-0.037	-0.109	0.017	0.122	0.068	0.072	0.015	0.039	0.088	0.074	-0.117	0.023	-0.039	-0.009	0.015

Appendix 7 continued

Direct contact	**Transitivity**	0.048	-0.016	-0.082	-0.390	0.152	-0.167	-0.239	-0.150	-0.214	-0.012	-0.224	-0.051	-0.030	-0.017	0.009	0.071	-0.183	0.018	-0.071	-0.067	0.028	-0.070
	Eigenvector centralization	0.090	0.017	-0.015	0.155	-0.051	0.071	-0.052	0.179	0.072	-0.021	0.100	0.008	-0.036	0.049	0.085	-0.018	-0.059	0.014	-0.017	0.025	0.041	-0.033
	Closeness centralization	0.159	0.041	-0.477	-0.444	0.000	0.177	0.458	0.000	-0.253	-0.355	0.240	-0.333	-0.050	0.000	-0.177	0.020	0.404	-0.500	-0.124	-0.014	0.000	0.158
	Betweenness centralization	-0.334	-0.128	-0.298	-0.011	0.009	0.060	0.084	-0.044	0.074	-0.236	0.177	0.015	-0.002	0.043	-0.022	-0.172	-0.149	-0.253	0.021	0.015	-0.137	0.033
	Degree centralization	-0.273	-0.058	-0.091	-0.089	0.168	0.250	0.078	-0.050	0.194	-0.067	0.194	-0.089	-0.022	-0.007	0.054	-0.173	0.177	-0.005	-0.083	-0.010	-0.211	0.011
	Mean degree	-0.214	1.622	2.789	-6.545	8.138	-3.667	2.283	-0.571	-1.132	-3.627	-4.182	-4.335	6.909	-3.034	-1.257	-0.424	13.394	0.477	0.737	-0.418	-6.000	-2.000
	Density	-0.078	0.043	-0.117	-0.327	0.056	-0.167	0.059	-0.048	-0.231	-0.028	-0.209	-0.122	-0.014	-0.022	-0.055	0.066	-0.019	-0.044	-0.107	-0.053	-0.064	-0.156
	Transitivity	0.096	0.124	0.087	0.067	0.353	-0.011	-0.179	0.103	0.111	-0.089	-0.113	-0.174	-0.014	-0.016	-0.052	0.017	0.210	0.117	-0.020	0.053	-0.040	-0.014
	Eigenvector centralization	-0.038	-0.036	-0.094	-0.045	-0.140	0.005	0.056	0.006	-0.083	0.042	0.046	0.077	-0.012	0.014	0.020	0.009	-0.095	-0.125	0.009	-0.030	0.001	0.003

Mass communication																					
	Density	0.148	0.291	0.001	0.036	0.055	0.152	-0.030	0.000	-0.199	-0.049	-0.336	-0.168	-0.163	-0.043	-0.211	0.069	-0.088	-0.115	-0.081	-0.086	-0.077	-0.058
	Mean degree	11.481	18.950	6.221	0.727	9.752	0.095	1.010	0.000	0.989	-5.646	-6.727	-6.992	3.874	-4.863	-6.044	-0.939	10.836	-0.769	3.242	-1.840	-7.250	-0.018
	Degree centralization	-0.259	-0.196	-0.166	0.200	0.107	-0.200	0.015	0.233	0.217	0.098	-0.017	0.410	0.190	0.145	-0.132	-0.078	0.088	-0.173	0.062	-0.089	-0.108	-0.047
	Betweenness centralization	-0.485	-0.049	-0.280	0.050	-0.011	-0.060	-0.182	0.406	0.111	0.000	-0.001	0.526	0.084	0.322	-0.002	-0.018	-0.111	-0.308	0.017	-0.076	0.045	-0.063
	Closeness centralization	-0.079	-0.168	-0.060	-0.090	-0.087	-0.126	0.163	0.605	0.074	0.084	-0.473	-0.393	0.031	0.001	-0.320	-0.052	-0.015	-0.382	0.052	0.090	-0.569	0.054
	Eigenvector centralization	-0.253	-0.102	-0.054	-0.026	-0.078	-0.054	0.080	0.047	0.044	0.035	0.094	0.169	0.040	0.102	0.107	-0.026	-0.053	0.274	0.024	0.038	0.031	0.038
	Transitivity	0.376	0.334	0.069	-0.203	0.095	0.173	0.009	-0.228	-0.237	-0.106	-0.441	-0.197	-0.238	-0.081	-0.280	0.049	-0.075	-0.143	-0.063	-0.068	-0.060	0.010
CEnP-node measures																							
Cooperation	**Degree**	-3.000	-8.000	18.000	0.000	49.000	-2.000	4.000	0.000	12.000	-9.000	0.000	-23.000	6.000	-13.000	2.000	-1.000	39.000	6.000	8.000	6.000	36.000	2.000
	Betweenness centrality	-13.819	-41.326	-9.196	1.607	19.653	0.000	1.262	1.600	-0.390	80.196	0.962	-17.566	0.000	-8.024	7.894	-3.287	-9.762	-19.374	4.433	-5.790	-90.035	2.938

Collaboration			Coordination					
Closeness centrality	**Betweenness centrality**	**Degree**	**Eigenvector centrality**	**Closeness centrality**	**Betweenness centrality**	**Degree**	**Eigenvector centrality**	**Closeness centrality**
0.000	0.500	-2.000	-0.220	-0.667	9.325	-10.000	-0.197	-0.300
0.649	46.031	15.000	-0.019	0.039	-235.75	1.000	-0.028	0.000
0.474	-18.967	2.000	-0.254	0.750	-8.220	9.000	-0.138	0.000
0.000	-11.000	-4.000	0.114	0.000	10.750	-2.000	-0.003	0.000
0.000	181.836	34.000	0.050	0.783	117.405	39.000	0.047	0.286
-0.500	2.467	-6.000	0.052	0.000	1.083	-2.000	0.030	0.000
-0.667	-1.500	-7.000	-0.039	0.033	-0.150	4.000	-0.017	0.000
0.000	-2.000	-1.000	0.147	0.000	3.500	1.000	0.023	0.000
-0.448	-19.633	1.000	-0.001	-0.619	2.499	4.000	-0.157	-0.219
0.000	-143.579	0.000	-0.067	-0.792	-262.64	-11.000	0.076	0.000
-0.444	-11.250	-11.000	-0.066	-0.286	-7.716	-4.000	0.017	0.000
-0.470	-0.500	-2.000	-0.019	-0.585	1.289	-5.000	-0.116	-0.258
0.000	0.000	2.000	0.000	0.000	0.000	5.000	0.000	0.000
-0.084	-7.952	-7.000	0.079	0.056	-7.368	-7.000	-0.005	-0.031
0.457	-24.084	-6.000	-0.123	-0.242	5.845	-4.000	0.006	0.000
0.000	-26.333	-2.000	0.011	-0.618	4.049	-2.000	0.054	0.136
0.000	12.791	3.000	-0.159	-0.175	-16.796	-3.000	-0.190	0.000
-0.500	-13.667	0.000	0.045	0.000	52.533	8.000	-0.092	0.000
-0.057	21.611	2.000	-0.046	0.013	6.452	7.000	-0.018	0.000
0.167	63.273	19.000	-0.007	0.125	-28.320	8.000	-0.026	0.000
0.015	-39.048	-8.000	-0.044	-0.120	-287.65	-26.000	-0.022	0.277
-0.286	9.000	-1.000	-0.027	0.000	-2.823	2.000	-0.006	0.000

Appendix 7 continued

Appendix 7 continued

		Formal ties																			
	Eigenvector centrality	-0.076	0.075	-0.286	-0.042	0.170	-0.189	-0.242	-0.252	0.093	0.011	-0.259	-0.072	0.000	-0.052	-0.323	-0.021	0.170	-0.067	0.064	-0.016	0.016	-0.107
	Degree	-5.000	5.000	5.000	2.000	46.000	-1.000	-9.000	-2.000	10.000	-2.000	-1.000	-10.000	5.000	-6.000	-9.000	-6.000	4.000	3.000	6.000	2.000	-10.000	-1.000
	Betweenness centrality	-19.711	-98.963	-6.490	0.067	8.333	0.000	-9.533	-0.333	-10.207	26.511	7.726	-15.425	0.000	-2.403	-16.966	-5.512	-9.828	-14.642	3.720	30.488	-84.478	0.534
	Closeness centrality	-0.220	0.047	-0.257	0.111	0.255	0.000	-0.412	-0.083	-0.008	0.045	-0.064	-0.127	0.000	-0.018	-0.304	-0.636	0.390	-0.692	-0.074	0.094	-0.041	-0.167
	Eigenvector centrality	-0.205	-0.103	-0.253	0.013	0.025	0.000	-0.143	0.087	-0.101	0.053	-0.087	-0.130	0.000	0.017	-0.051	-0.003	-0.283	0.063	-0.063	0.069	-0.026	-0.008
Good-high trust	**Degree**	-4.000	-8.000	17.000	-3.000	44.000	-2.000	-9.000	2.000	14.000	-7.000	3.000	-9.000	5.000	-10.000	4.000	2.000	12.000	4.000	5.000	6.000	-18.000	2.000
Good-high trust	**Betweenness centrality**	-14.051	-48.757	-8.040	-4.283	0.794	0.050	-0.643	-0.333	5.065	55.224	4.502	-12.149	0.000	-19.082	16.317	12.634	-2.327	-38.833	3.197	-1.581	-153.87	2.336
Good-high trust	**Closeness centrality**	-0.231	0.000	-0.053	-0.103	0.226	0.000	-0.412	0.055	0.030	0.000	0.231	-0.122	0.000	-0.021	0.062	0.195	-0.023	-0.043	-0.100	0.000	-0.085	0.000
Good-high trust	**Eigenvector centrality**	-0.176	-0.026	-0.161	-0.072	-0.038	0.034	-0.276	0.046	-0.107	0.049	0.130	-0.081	0.000	0.015	0.027	0.107	-0.202	-0.144	-0.050	-0.037	-0.035	-0.013

Direct contact	**Degree**	3.000	-31.000	8.000	-10.000	24.000	-2.000	1.000	-2.000	4.000	-3.000	-1.000	-7.000	3.000	-3.000	1.000	-5.000	1.000	3.000	6.000	-1.000	-28.000	1.000
	Betweenness centrality	75.736	-598.184	20.683	-17.917	106.004	1.833	-0.333	-6.000	30.007	-317.153	13.450	3.382	0.000	12.465	-1.340	2.872	-36.931	5.833	13.702	-4.420	-301.670	17.666
	Closeness centrality	0.017	-0.247	-1.000	-0.667	0.000	0.000	0.526	0.000	-0.619	-0.623	0.231	-0.554	0.000	0.000	-0.600	-0.093	0.582	0.000	0.005	-0.228	0.000	-0.900
	Eigenvector centrality	0.071	-0.077	-0.075	-0.004	-0.032	0.084	-0.075	-0.290	-0.115	0.159	0.223	-0.094	0.000	0.024	0.084	-0.127	-0.333	-0.030	0.015	-0.035	-0.033	-0.029
Mass communication	**Degree**	13.000	17.000	8.000	-6.000	24.000	-2.000	7.000	2.000	12.000	-6.000	-13.000	-17.000	4.000	-7.000	-3.000	-14.000	34.000	-7.000	6.000	-6.000	-12.000	3.000
	Betweenness centrality	-6.964	-112.291	-4.458	-11.167	68.077	-3.500	6.650	12.000	31.333	-112.365	-18.667	-53.555	0.000	-9.169	2.416	-14.241	69.839	-47.000	3.312	7.181	67.527	11.134
	Closeness centrality	0.086	0.305	-0.250	-0.370	-0.041	0.000	0.214	1.000	-0.219	0.050	-0.714	-0.620	0.000	-0.076	-0.536	-0.241	-0.059	-0.818	-0.018	-0.250	-0.644	0.159
	Eigenvector centrality	-0.001	0.008	-0.276	-0.230	-0.085	-0.015	0.274	0.064	-0.063	0.044	-0.276	-0.155	0.000	-0.045	-0.026	-0.180	-0.149	-0.508	-0.009	-0.044	0.062	0.069

CHC, community health coalition. CEnP, Community Engagement Professional-node, referring to the relative network measures of CWC and Ext. CSAS, Coalition Self-Assessment Survey. CWC, Community Wellness Coordinator. Ext, Extension Educator. LF, the CSAS cluster describing highly rated leadership and functioning. PROB, the CSAS cluster describing CHC members' problems for participating in their CHC.