PLOS COMPLEX SYSTEMS

RESEARCH ARTICLE

Determinants and facilitators of community coalition diffusion of prevention efforts

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Citation: Moore TR, Pachucki MC, Economos CD (2024) Determinants and facilitators of community coalition diffusion of prevention efforts. PLOS Complex Syst 1(1): e0000004. https://doi.org/10.1371/journal.pcsy.0000004

Editor: Hocine Cherifi, Université de Bourgogne: Universite de Bourgogne, FRANCE

Received: February 7, 2024

Accepted: June 25, 2024

Published: September 3, 2024

Peer Review History: PLOS recognizes the benefits of transparency in the peer review process; therefore, we enable the publication of all of the content of peer review and author responses alongside final, published articles. The editorial history of this article is available here: https://doi.org/10.1371/journal.pcsy.0000004

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Data Availability Statement: The deidentified data and data instruments that support the findings of this study are publicly available from the Center for Open Science: https://osf.io/b7e9r/.

Abstract

This study examines how individual characteristics and network features of coalition participation in an intervention predict coalition members' diffusion of Knowledge and Engagement in childhood obesity prevention. The study involved six communities in the U.S. measured across two to five time points from 2018 to 2021. Each community participated in the Stakeholder-driven Community Diffusion theory-informed intervention, a three-phase intervention that employs group model building and technical assistance with convened stakeholders to build Knowledge, Engagement, and utilize research evidence in community-led, childhood obesity prevention actions. Findings indicate that key individual-level characteristics (e.g., years of experience, gender, eigenvector centrality) and network-level features (e.g., hierarchy, clustering) are associated with higher increases in intervention outcomes of Knowledge and Engagement in childhood obesity prevention. We attend to issues of perceived influence and power in community coalitions, finding that younger, less experienced women who are not well connected to other well-connected coalition members experience smaller increases in intervention outcomes. Our discussion focuses on how individual- and network-level characteristics are associated with coalition support for evidence-based practice adoption and implementation.

Author summary

In this study, we examined the dynamics of coalition functioning in childhood obesity prevention across six diverse communities in the United States. By analyzing individual and network-level characteristics over seven years, we found that coalition members who increased their knowledge and engagement in childhood obesity prevention tended to have more years of experience in their field and are more centrally located within their social network. When attending to issues of perceived influence and power in community coalitions, we found that younger, less experienced women who are not well connected to other well-connected coalition members experience smaller increases in intervention outcomes. Our findings suggest that fostering participatory leadership and enhancing

Funding: TM, MP, and CE received funding from the JPB Foundation (PR0580) https://www.jpbfoundation.org. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests: The authors have declared that no competing interests exist.

network connectivity could help facilitate the adoption of evidence-based practices in community health initiatives. Moreover, our research highlights the importance of considering both individual attributes and social relationships in coalition dynamics, shedding light on potential avenues for improving public health interventions. These insights offer valuable implications for policymakers, practitioners, and researchers aiming to enhance the effectiveness of community-based prevention efforts.

Determinants and Facilitators of Community Coalition Diffusion of Prevention Efforts

Community prevention, which encompasses the implementation of policies, programs, and services aimed at promoting health and well-being, preventing disease, and addressing social issues within a specific community or population, has become increasingly well-documented in the last two decades [1,2]. Community coalitions often play a key role in the adoption of these prevention efforts, which we refer to as evidenced-based practices (EBPs) [3]. This is because they can bring together stakeholders from different sectors, such as government, business, and non-profit organizations, to work together to address a common problem. Coalitions can also help to build and sustain stakeholder (i.e., a person with an interest or concern in improving community conditions) buy-in for EBPs, and they can help to ensure that programs are delivered effectively. Research shows that increasing the effectiveness of coalition functioning can improve the implementation of EBPs [4].

In chronic disease prevention, researchers have identified several key aspects of coalition functioning that seem to be important for successful implementation, such as cooperative goal setting and planning; shared power, resources, and decision making; higher levels of funding; leadership strength; and strong internal and external relationships, to name a few [3,5–7]. Researchers also speculate that coalition characteristics such as lack of time [8], autonomy [8], and capacity [9], are barriers to the adoption of EBPs, but data on these characteristics are not often collected as part research on coalition functioning [9].

Less explored in coalition functioning is the composition and interpersonal relationships within the coalition network. The composition of the coalition network refers to the types of organizations and individuals that are represented in the coalition. Perhaps as, or more important, are the patterns of relationships between coalition members. Understanding the composition of the coalition network and relationships between its members can be useful for studying factors that could facilitate the adoption of EBPs [10,11]. For instance, research indicates that the composition (e.g., the density of connections) of a coalition network influences its effectiveness in collaboration [10,12,13]. Strong relationships within a coalition enhance the likelihood of successful goal achievement [14]. Moreover, an expanding body of research explores the role of social networks in implementing EBPs [11]. Some researchers are increasingly focusing on linking network measures, describing composition, to coalition functioning and capacity to adopt EBPs, particularly in areas like violence prevention and childhood obesity prevention [10,12].

This study aims to contribute to the expanding evidence base that highlights the link between coalition network characteristics and their role in preventing chronic diseases. Specifically, our focus is on coalition-committee members engaged in a childhood obesity prevention intervention, utilizing group model building and customized technical assistance to implement prevention research evidence. While other studies have examined broad factors (*e.g.*, member participation [15]) linked to coalition effectiveness, this study examines multiple

factors within coalition networks, particularly at the individual and group level. A better understanding of how coalition network characteristics might be linked to coalition functioning is of importance to policy-makers (*i.e.*, those who deliberate principles that guide decisions), state and local decision-makers (*e.g.*, state and local public health departments), mid-level managers (*e.g.*, health program managers), and intermediaries (*e.g.*, advocacy groups, consultants), who are often involved in community prevention coalitions and want to improve their ability to adopt EBPs.

Aspects of coalition functioning

Over the past two decades, the study of coalition functioning has advanced significantly, shedding light on key factors influencing the adoption and implementation of evidence-based practices EBPs within coalitions [6,16,17]. A systematic review by Zakocs and Edwards (2006) pinpointed vital coalition-building factors associated with improved indicators of coalition effectiveness. These factors encompass diverse dimensions, including the establishment of formal governance procedures, nurturing strong leadership, active member participation, cultivating diverse memberships, fostering interagency collaborations, and promoting group cohesion. Complementary studies have reinforced and extended these findings. McNall et al. (2009) emphasized cooperative goal setting, shared decision-making power, resources, group cohesion, and partnership management as indicators of enhanced coalition functioning [18]. Shapiro et al. (2015) highlighted the relevance of members' expertise, skill acquisition, attitudes, organizational linkages, and influence on organizations, showcasing their impact on the adoption of science-based prevention approaches [3]. Meanwhile, Brown et al. (2010) spotlighted the significance of funding, leadership quality, board efficacy, and both internal and external relationships to support high-quality EBP implementation [6].

Further investigations into coalition functionality have illuminated additional aspects that contribute to their success. The level of member participation is directly linked to subsequent coalition capacity and positive outcomes, spanning expertise, planning, funding, and perceived system impact [19,20]. Moreover, coalition process competencies play a pivotal role in sustaining success over time. Participatory leadership styles correlate with higher member engagement, evidence-based practice utilization, and sustainability [6,15,21]. Effective communication among coalition members boosts their confidence in achieving public health impact [22]. Strong group cohesion fosters better performance, while efficient coalition processes correlate with increased support for evidence-based program implementation [6].

Contextual factors also significantly influence coalition functionality. Positive community sentiment enhances local collective action capacity, whereas histories of distrust can erode partnerships [23,24]. Community awareness and support for public health matters play a role in coalition capacity-building [24]. Additionally, the presence of community champions has been found to catalyze coalitions, providing critical support and resources [4,19,25,26]. Finally, Brown and colleagues found that community support for prevention and community champions predicted several measures of coalition process competence [27].

Coalition functioning and network composition

A growing body of evidence suggests that studying coalitions as social networks with specific network features can help provide context and depth to coalition functioning [10–12]. **Table 1** defines the most common network characteristics and their salience to understanding coalition functioning.

Researchers are beginning to unpack the nuance of these factors by studying coalition functioning at intervention baseline [11,12], over time [10,11,13,28], and with respect to

Table 1. Summary of Common Network Characteristics and Potential Relevance to Coalition Functioning.

	Definition	Application to Coalition Functioning
Node-Level Characteristics		
Degree Centrality	Counts the number of connections an individual has	Generally, individuals with high degree are the local connectors, but are not necessarily the best connected to the wider community beyond the coalition
Closeness Centrality	Measures the distance each individual is from all other individuals in the network	Generally, individuals with high closeness can spread information to the rest of the coalition most easily and usually have high visibility into what is happening across the network
Betweenness Centrality	Measures how many times an element lies on the shortest path between two other elements	Individuals with high betweenness centrality have more control over the flow of information and act as key bridges within the coalition. They can also be potentially bottlenecks of information flow or gatekeepers of information
Eigenvector Centrality	Measures how well connected an individual is to other well connected individuals	Individuals with high eigenvector centrality are generally the leaders of the coalition, though they may not always have the strongest influence among the coalition
Network-Level Characteristics		
Size	Measures the number of neighbors an individual has plus the individual themself	The size of a coalition is generally tracked over time to linked to member participation, and member and coalition capacity
Reach	Measures the portion of the network within two steps of an individual	Individuals with high reach can spread information through the network through close friend-of-a-friend contacts
Assortativity	The preference for an individual to attach to others that are similar in some way	A coalition with high assortativity will have individuals who associate with another based on a shared characteristic such as sector affiliation
Density	Represents the proportion of possible relationships among individuals in the network that are actually present	Coalitions generally have higher density during initial formation that tends to decrease over time as individuals leave or disengage from the movement
Motifs	Small, local clusters within a network that occur more often than would be expected in random networks with comparable characteristics	Coalitions, just as any social network, may contain network motifs that describe relational patterns in coalition formation and sustainment. These motifs, such as dyads, triads, and tetrads, described below, influence the ebb and flow of social hierarchy throughout the life course of the coalition
Motif: Dyads	Captures the reciprocity, or the lack of reciprocity, between two individuals	Mutual connections between coalition members influence coalition growth as well as hierarchy
Motif: Triads	A common foundation of social networks that describes the likelihood of reciprocity between three individuals who are directly and/or indirectly connected	Generally, researchers study triads to look for transitivity, the measure of the tendency of individuals to cluster together. In coalitions, transitivity may point to why specific individuals are grouped together or leave the coalition over time
Motif: Tetrads	A four-individual network motif that forms social structures such as clusters and bridges	The presence of tetrads in coalitions may point to why information or influence flows (or does not flow) in a certain direction

https://doi.org/10.1371/journal.pcsy.0000004.t001

community context [27]. Moore and colleagues (2021) found that coalition-committees (i.e., group of stakeholders within a convened coalition) and their coalitions were patterned in their structure at baseline in a childhood obesity prevention intervention [12]. For example, coalition-committees displayed sector heterogeneity and assortativity, and coalitions across six

different communities in the U.S. demonstrated similar levels of network density, degree centralization, and degree assortativity. In a cross-sectional study over time, Korn and colleagues (2021) found that coalition density, centralization, and hierarchy decreased, potentially increasing access to resources and information and support for more equal participation and control over intervention efforts [13]. These studies represent a clear focus on the role social relationships within specific community contexts have in coalition functioning that may support EBP implementation. By closely examining the interplay between different organizations, sectors, and stakeholders within these networks, we can unravel the complex web of relationships that contribute to coalition effectiveness and, in turn, enhance our ability to design strategies for sustainable community health improvements.

The current study

In the current study, we examined network characteristics and social network dynamics at the individual- and network-level that could influence changes in Knowledge, Engagement, and Organizational Readiness. Knowledge is conceptualized as coalition members' understanding of community-wide efforts to prevent childhood obesity. Engagement is conceptualized as a latent construct representing coalition members' enthusiasm and agency for preventing childhood obesity in their community. Knowledge and Engagement scores can be conceptualized both as precursors and facilitators of EBP adoption, a crucial step in the EBP implementation process. Organizational Readiness refers to the preparedness of community organizations to implement change and improve their capabilities effectively [29]. This concept is critical for successful capacity building efforts, as it involves organizational members' willingness, commitment, and perceived ability to undertake initiatives aimed at enhancing their function within the community [29]. Fig 1 conceptually illustrates the Stakeholder-driven Community Diffusion (SDCD) theory [30] that informs the childhood obesity prevention intervention in this study.

The SDCD theory-informed intervention is our hypothesized necessary upstream component of improving diffusion of Knowledge and Engagement, improving Organizational Readiness, and includes four core elements: (1) Convening a group of stakeholders; (2) group model building (GMB); (3) customized technical assistance to support the use of research evidence in decision-making; and (4) providing seeding funding to support evidence-based actions in communities [30,31]. The SDCD theory-informed intervention steps have been documented in full detail elsewhere [30,31].

The figure illustrates where Knowledge and Engagement fall within the community engagement process, and how we hypothesize these two constructs and the prioritization of EBP reciprocally influence each other. That is, Knowledge in and Engagement with childhood obesity prevention is hypothesized to be influenced by organizational readiness and a part of identifying the problem, the gap between current knowhow and barriers to local action, identifying and prioritizing EBPs, and adopting those EBPs to implement more broadly. In our theory, this process exists within group and community capacity building activities and actions to promote the diffusion of EBPs into the broader community, with the goal of creating mid-stream changes in organizational policies, systems, and environments and down-stream changes in child health outcomes. In this study we focus on the network factors and individual characteristics that may be influencing the diffusion of Knowledge and Engagement to understand how to improve the adoption of EBPs as well as extrapolate the results of coalition functioning to the broader prevention literature. Knowledge and Engagement are viewed as essential elements of the implementation process. For example, Engagement has been operationalized as a facilitator of customizing Knowledge to a particular situation. That is, without Engagement in

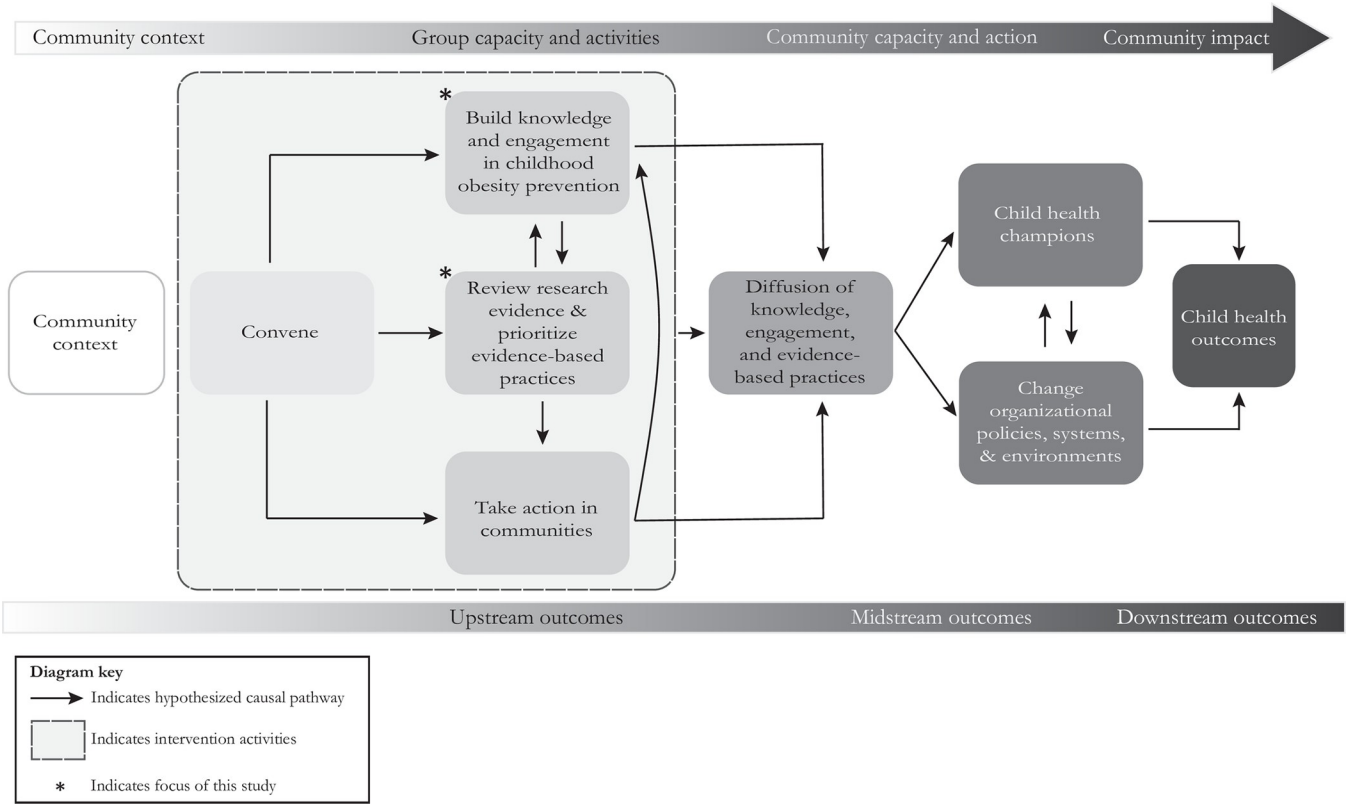


Fig 1. The Stakeholder-driven Community Diffusion Framework. The grey-shaded box, which includes "convene", "build organizational readiness", "build knowledge and engagement in childhood obesity prevention", and "review research evidence and prioritize evidence-based practices", also includes the four core intervention activities of convening stakeholders, group model building, technical assistance, and seed funding. "Community context" influences all aspects of the framework.

https://doi.org/10.1371/journal.pcsy.0000004.g001

prevention efforts or those supporting those efforts, Knowledge inquiry and synthesis can become disconnected from the selection, tailoring, and implementation of interventions [32].

For this study, we developed three research questions grounded in SDCD theory with associated hypotheses, research to support our hypotheses, indicators and measures, data collection information, and analyses (Table 2).

Methods

This study uses demographic and social network data collected from six different coalitions (from six different communities) over five years (from 2018 to 2022) as part of the Catalyzing Communities project, which currently deploys the SDCD-informed intervention in nine different communities across the U.S. The six coalitions were chosen based on completed data collection at the time of this study. Table 3 describes each included community in a nested fashion, from coalition-committee network (consisting of coalition-committee members who participate in our intervention and their nominated alters with whom they discuss childhood obesity prevention) to the broader community in which the coalition is situated geographically. Two of these coalition-committees are newly formed, convened for the study and comprised of stakeholders from an array of sectors (e.g., community-based organizations, community members, hospitals, schools, philanthropy) serving children and their families. The other three coalition-committees were convened from existing coalitions.

Table 2. Summary of Study Research Questions and Associated Methods and Analyses.

Research Question	Hypotheses	Indicators, Measures	Data Collection, Sample, Sample Size	Analyses
What individual-level characteristics are associated with CCs changes in Knowledge? In Engagement? In Organizational Readiness?	We hypothesize that individuals who identify as female, Caucasian, having more years of experience, and in the nonprofit sector are associated with higher increases in Knowledge, Engagement, and Organizational Readiness. We also hypothesize that higher increases in these key outcomes are associated with positive changes in individual-level network characteristics such as in degree centrality	Demographic characteristics, Knowledge, Engagement, Organizational Readiness, and Network Metrics (e.g., degree centrality, betweenness centrality, closeness centrality, etc.). Measured using the Stakeholder-driven Community Diffusion Survey	Minimum two time points, maximum 5 time points; coalition-committee members; n = 87 maximum	Cross-tabulation of demographic data, network data, and key outcomes conducted on whole sample as well as quartiles; cross-sectional position analysis
What network-level characteristics are associated with changes in Knowledge? In Engagement? In Organizational Readiness?	We hypothesize that decreases in CC density, increases in hierarchy (i.e., triads, tetrads) between CC members, and assortativity (preferential attachment) based on sector affiliation will be associated with increases in Knowledge, Engagement, and Organizational Readiness	Demographic characteristics, Knowledge, Engagement, Organizational Readiness, and Network Metrics (e.g., degree centrality, betweenness centrality, closeness centrality, etc.). Measured using the Stakeholder-driven Community Diffusion Survey	Minimum two time points, maximum 5 time points; coalition-committee members and their first-degree alters; n = 87 maximum	Cross-tabulation of network data, and key outcomes conducted on whole sample as well as quartiles; cross-sectional position analysis; triad and tetrad census; speaker-listener propagation algorithm
Are there patterns in how scores on Engagement subdomain "Influence and Power" relate to coalition-committee network characteristics?	We hypothesize that those who score in the bottom half of Influence and Power will not see increases in their individual- or network-level characteristics, such as degree centrality and betweenness centrality	Demographic characteristics, Knowledge, Engagement, Organizational Readiness, and Network Metrics (e.g., degree centrality, betweenness centrality, closeness centrality, etc.). Measured using the Stakeholder-driven Community Diffusion Survey	Minimum two time points, maximum 5 time points; coalition-committee members and their first-degree alters; n = 87 maximum	Cross-tabulation of network data, and key outcomes conducted on whole sample as well as quartiles; cross-sectional position analysis; triad and tetrad census; speaker-listener propagation algorithm

Note. "CC" is Catalyzing Communities.

https://doi.org/10.1371/journal.pcsy.0000004.t002

Reported previously, the study team identified changemakers (i.e., community leaders) through past partnerships and prior research collaborations [12]. Two to three changemakers per community were selected based on their capacity to participate in the SDCD-informed intervention and their individual alignment with their community characteristics (race, ethnicity, median household income, population, and land area), and perceived readiness to participate. Changemakers identified between 11 and 19 stakeholders across communities to participate in the intervention, described elsewhere [30]. These stakeholders formed the coalition-committee that participated in the intervention. Selection of stakeholders was guided by existing relationships between changemakers and their social network as well as sector diversity, as the changemakers and the study team wanted representation from an array of sectors, including healthcare, early care settings, local government, nonprofits, to name a few.

Ethics statement

This study was approved by the Tufts University Social, Behavioral, and Educational IRB. Formal consent was obtained in writing from each participant.

Data collection: Sampling and participants

We employed a snowball sampling approach initiated from coalition-committee members with the goal to identify community-wide connections related to early childhood obesity

Table 3. Summary of Community and Coalition-Committee Characteristics.

Community	1	2	3	4	5	6
Coalition-Committee characteristics[3]						
Coalition-committee size (n)	19	15	13	11	13	16
Bachelor's degree and above (%)	94.7	93.3	84.6	90.9	84.6	93.8
Female (%)	78.9	66.6	84.6	90.9	76.9	87.5
Target age	0–18 y	0–18 y	0–8 y	0–18 y	0–5 y	0–5 y
Coalition Focus Area(s) [1]	Policy, practice, and environmental change; Health equity; WIC [2] participation; Nutrition security and food justice; Health equity	Increase utilization of community resources among underserved populations; increasing youth physical activity; mental health	Advocacy, communications, evaluation of early care programs	Improve school programs to increase access to healthy foods and physical activity opportunities; increase use of state tax credits for school funding; youth mental health	Improve health status of children 0–5 by increasing resource coordination across the community; advocacy for healthy environments;	Decrease early childhood obesity through community-based environ-mental intervention
Community characteristics (2019)[3]						
Population estimate	514,213	46,655	385,282	541,482	594,548	80,906
Land area (mi ^{2})	785.0	4.8	82.5	226.7	96.8	4.22
Median household income (USD)	$53,739	$48,704	$20,407	$24,102	$25,266	108,896
Foreign born (%)	7.9	50.4	5.9	15.3	5.0	24.2
State's adult obesity prevalence (%)	34.1	27.2	38.1	33.2	37.7	27.2
Community race and ethnicity (%)						
Hispanic or Latino (all races)	8.8	57.4	11.9	33.6	19.2	12.4
NH White	69.0	32.6	40.0	62.1	44.8	79.7
NH Black or African American	18.0	2.6	48.8	5.2	38.4	8.6
NH American Indian and Alaska Native	0.2	0.0	0.5	3.7	0.8	0.8
NH Asian	2.2	3.8	2.6	3.2	4.3	11.6
NH Native Hawaiian and Other Pacific Islander	0.1	0.1	0.1	0.2	0.0	0.1
NH some other race	0.1	0.2	0.1	0.1	0.2	3.8
NH two or more races	1.7	3.4	1.8	1.6	2.4	4.3

[1]Focus areas were determined through group model building activities. The focus areas were used in multiple correspondence analysis as part of coalition-committee dissimilarity measures. [2]Special Supplemental Nutrition Program for Women, Infants, and Children. [3]American Community Survey, 2019 [33].

https://doi.org/10.1371/journal.pcsy.0000004.t003

prevention. The network included coalition-committee members and nominees of coalition-committee members ("first-degree alters"), collectively named "stakeholders" when describing all network members. Coalition-committee members completed three web-based surveys described below, nominating up to 20 individuals for each survey (defined as "first degree alter community members"). The first survey was administered after the recruitment/relationship building phase. The second survey was administered after the intervention (approximately 6 months). The third survey was administered as a follow-up (approximately one year). First-degree alter surveys were administered to nominees of coalition-committee members at the same timepoints. Some communities received additional surveys based on ongoing participation in the intervention.

The Tufts University Social, Behavioral, and Educational Research Institutional Review Board approved all study procedures in each community. Coalition-committee members provided written informed consent electronically and received a $1,000 e-gift card stipend over the course of the study. First degree alters provided informed consent electronically and were offered a gift card per survey.

Measures

Demographics, Knowledge, Engagement, and social networks were assessed via the Stakeholder-driven Community Diffusion survey with demonstrated reliability [34,35]. Respondents were asked to identify their gender, age, and years of experience in preventing childhood obesity. Organizational readiness to address childhood obesity was also measured. For thorough descriptions of the Knowledge and Engagement constructs and associated items on the survey, please see Korn et. al (2018) and Korn et. al (2021).

Knowledge. Survey respondents were asked to score their understanding of childhood obesity prevention in their community (broadly termed "Knowledge"). Knowledge of the topic of childhood obesity prevention is assessed on a 5-point Likert scale from "strongly agree" to "strongly disagree" (internal scale consistency Cronbach's alpha = 0.86) across five domains: (1) knowledge of the problem (5 questions); (2) modifiable determinants of the problem (5 questions); (3) stakeholders' roles related to addressing the problem in their community (3 questions); (4) sustainable intervention approaches (7 questions); and, (5) knowledge of available resources (4 questions). Knowledge of community-wide efforts has been shown to be a key aspect of understanding the issue of interest, identifying the EBPs most likely to be effective, developing and implementing strategies for adopting and implementing these practices, and monitoring and evaluating the impact of these efforts [36]. For example, those with higher levels of knowledge are more likely to adopt and implement EBPs [37].

Engagement. Survey respondents were asked to score their level of enthusiasm for and commitment to childhood obesity prevention (broadly termed "Engagement"). Engagement is conceptualized as enthusiasm and agency for the topic of childhood obesity prevention (internal scale consistency Cronbach's alpha = 0.92). Engagement comprises five domains: (1) exchange dialogue and mutual learning (6 questions); (2) flexibility (4 questions); (3) influence and power (4 questions); (4) leadership and stewardship (10 questions); (5) trust (4 questions).

As a composite measure, Engagement has been shown to be a key aspect of coalition functioning related to attracting and retaining members, building trust and collaboration, promoting ownership and commitment, and fostering innovation and creativity. For example, in a study examining coalition engagement in youth violence prevention, issues of influence and power were key determinants of evidence-based practice adoption, and created different types of engagement [38]. In the current study, we examine the Engagement subdomain "Influence and Power" more closely due to consistent evidence across communities we work with

showing that coalition members' perception of their influence and power to create local change is rated lower than other measured domains [28]. This focus is also supported by Kumanyika's Equity-Oriented Obesity Prevention Framework that incorporates considerations related to social disadvantage and social determinants of health to assist in evaluating obesity prevention interventions [39].

Network Structure. Survey respondents were asked to provide the names of up to 20 people with whom they discussed issues related to childhood obesity prevention. These nominations are the foundation of the overall network structure. For surveys 2 and 3, coalition-committee members were prompted with a list of nominees from their prior survey responses and were instructed to renominate any current ties.

Organizational Readiness. Survey respondents were asked to score their organization's role in childhood obesity prevention efforts on a scale of one to five, one being strongly disagree and five being strongly agree. Items include, "My organization considered childhood obesity in our community to be a problem"; "Leadership in my organization uses scientific evidence to make decisions"; "Staff at my organization have skills to prevent childhood obesity"; "My organization has resources to address childhood obesity"; and "My organization influences community awareness and/or policies related to preventing childhood obesity".

In a systematic review and content analysis of organizational readiness assessments, Miake-Lye and colleagues found that most (68%) survey items mapped onto constructs of the organization's "inner setting", that includes readiness for implementation, networks and communication, implementation climate, structural characteristics, and culture [40]. The remaining items were mapped onto characteristics of individuals, the organization's outer setting, process, and intervention characteristics. Our measure, consisting of five items, spans the inner setting of coalition-committee members' (described below) organizations as well as their individual characteristics, assessing readiness for implementation, leadership, structural characteristics (resources), beliefs, and skills. Given that many coalitions are comprised of individuals who represent multiple different organizations, organizational readiness could be an important aspect of coalition functioning that is linked to Knowledge and Engagement and that improves adoption of EBPs, as has been found in other studies [41].

Data preparation and analysis

Data were cleaned to simplify multiple names to unique names of stakeholders nominated multiple times to yield a set of unique names. Each network was treated as directed and retained all ties and stakeholders in analyses as our best approximation of each community's network structure related to childhood obesity prevention. In social networks, when ties are treated as directed, it means that the connection or relationship between people is not necessarily mutual or two-sided. Demographic data and Knowledge, Engagement, and organizational readiness scores were appended to stakeholder IDs. Each wave of data collection report includes respondents who have data for each wave, with sample sizes reported in each summative results table.

Due to the nested nature of coalition-committee members, the results were compiled to construct profiles for coalition-committee members, coalition-committees, and coalition-committee networks. These profiles were designed to explore potential patterns in and across individual and network-level characteristics that correlate with Knowledge, Engagement, and organizational readiness and that vary based on the level of nesting (i.e., coalition committee members vs. coalition committees vs. coalitions). The aim was to identify specific coalition-committee member characteristics, network positions, and relationships that exhibit a stronger association with positive outcomes in the intervention, as well as describe patterns that could be explored further in future research that directly measures EBP adoption.

To systematically analyze the characteristics and dynamics at multiple levels within our study—specifically at the coalition-committee member, the coalition-committee, and the overall coalition levels—we implemented a detailed, multi-step analytical process. Initially, we conducted descriptive statistics and exploratory data analysis across all levels to capture the distribution and variance in both individual and collective network attributes within different communities. Following this initial analysis, we applied a suite of analytical tools, including cross-sectional position analysis, a triad and tetrad census, and the speaker-listener propagation algorithm (SPLA). These methods were systematically applied at each level of analysis to examine the evolving composition and relational dynamics of coalition-committee members. Our objective was to illuminate how network structures and interactions shifted, particularly in response to variations in Knowledge, Engagement, and organizational readiness over time. Further, to uncover patterns associated with intervention success, we examined changes in network characteristics among coalition-committee members in the upper and lower quartile of Knowledge and Engagement score changes.

A cross-sectional position analysis is a method used to understand the roles, positions, and relationships of individuals within a network at a specific point in time [42]. It involves analyzing various network characteristics or features listed in Table 1 and key intervention outcomes to classify and contextualize coalition-committee member position within the committee and within their broader network [43]. We conducted a triad and tetrad census to examine and count specific patterns or configurations of relationships within the committee and the broader network [44,45]. Seen in Fig 2, triads refer to sets of three nodes and the relationships between them, while tetrads involve sets of four nodes and their interconnections. Our census involves systematically identifying and counting transitive, intransitive, and mixed triads and tetrads. Transitive triads represent a fully connected set of three nodes, where if Node A is related to Node B, and Node B is related to Node C, then Node A is also connected to Node C. These triads reflect cohesion and the potential for information or influence to flow easily through the network. Intransitive triads include relationships where two nodes are linked to a third node but are not connected to each other. They demonstrate a lack of direct connection or communication between specific nodes and can represent fragmentation or separation within the network. As the name suggests, mixed triads combine both transitive and intransitive relationships. Understanding these patterns can reveal information about local and global hierarchy, clustering, or the flow of information within coalitions. This is particularly salient for our third research question that proposes to examine the link between scores on the Engagement subdomain "Influence and Power" and coalition-committee relationships. Local hierarchy examines the immediate, direct relationships between nodes within small subsets of the network, such as triads and tetrads, offering insights into the distribution of power or influence in a more confined context. Global hierarchy, however, extends this examination to the entire coalition network, assessing how positions of power, influence, or connectivity are distributed across all nodes, potentially revealing an overarching structure of interactions.

Results

To build a comprehensive profile of emergent patterns that answer each research question, the following results are separated based on a sequence from individual-level (i.e., coalition-committee member, **Table 4**), to interpersonal-level (i.e., coalition-committee, **Table 5**, to network-level (i.e., coalition-committee network, **Table 6**. Below, we discuss the emergent patterns within each of these levels. In the discussion, we build a profile of associations to increasing Knowledge and Engagement scores that draw from each level of emergent patterns.

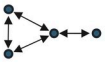
Triad or tetrad name	Description	Network node illustration	Hierarchy type
Triad	A group of three nodes and the relationships among them.		Local
Transitive Triad	A fully connected set of three nodes where if Node A is related to Node B, and Node B is related to Node C, then Node A is also connected to Node C. Represents cohesion.		Local
Intransitive Triad	Includes relationships where two nodes are linked to a third node but are not directly connected to each other. Demonstrates lack of direct connection or communication.		Local
Mixed Triad	Combines features of both transitive and intransitive triads, indicating a mixture of direct and indirect relationships among the three nodes.		Local
Tetrad	A group of four nodes and the relationships among them.		Local
Hierarchy Tetrad	A tetrad with a clear hierarchical structure, usually one node acts as a central point of control or influence over the others.		Local and global
Hierarchy and Clustering Tetrad	A tetrad that combines hierarchical relationships with clustering among some of the nodes, indicating both a hierarchical order and tight-knit subgroups.		Local and global
Bridging Tetrad	A tetrad where one of the nodes acts as a bridge connecting different parts of the network, facilitating the flow of information or resources between otherwise disconnected nodes.		Global

Fig 2. Triad and tetrad descriptions with corresponding hierarchy types. Finally, SPLA is a method used for community detection in social networks [46,47]. It simulates the communication process in a network, where nodes (individuals or entities in the network) take turns acting as speakers and listeners. Through multiple iterations, this process helps in identifying cohesive groups or communities within a network based on communication patterns. The algorithm can be used to detect subgroups or clusters within the coalition that frequently exchange information, share common goals, or closely collaborate on specific tasks. It can reveal communities of practice, expertise, or influence, highlighting how certain clusters of members interact more frequently, potentially indicating areas of strong collaboration or specialized knowledge within the coalition. Understanding these community structures can aid in optimizing communication channels, identifying key influencers, or fostering collaboration among specific groups, ultimately enhancing the effectiveness of the coalition's efforts in combating childhood obesity.

https://doi.org/10.1371/journal.pcsy.0000004.g002

Coalition-committee member patterns

Coalition-committee members in the upper quartile of Knowledge and Engagement score increases are compared by their demographics, network characteristics, and key intervention outcomes (Table 4). Across coalitions by wave of data collection, coalition-committee members in the upper quartile of Knowledge and Engagement see increases in their betweenness centrality, closeness centrality, closeness weighted (i.e., closeness centrality weighted by how influential the committee member was rated by others), degree centrality, indegree, and outdegree, while Eigenvector centrality remains unchanged. These members are also predominately white (54.54%). From wave 1 to wave 3, these coalition-committee members also increase their Knowledge, Engagement, and Engagement subdomain 3 (influence and power). On the other hand, coalition-committee members in the lower quartile see decreases in their betweenness centrality, closeness centrality, closeness weighted, degree centrality, indegree, and Eigenvector centrality. These members are predominately female (100%). From wave 1 to wave 3, lower quartile coalition-committee members decrease in their Knowledge, Engagement, and Engagement subdomain 3 (influence and power) scores. Comparatively, coalition-committee members in the upper quartile tend to be older, with more years of experience in childhood obesity prevention. Coalition committee-members in the lower quartile are younger, with fewer years of experience in childhood obesity prevention.

Table 4. Cross-Committee Member Comparison by Demographics, Network Characteristics, and Key Intervention Outcomes.

		Round				
		1	2*	3**	4***	5***
Upper Quartile Inclusion (n = 19)						
Demographics						
Gender (% Female)	54					
Age	50.08					
Years of Experience	23.42					
Ego-Centric Metrics						
	Betweenness centrality	0.016	0.003	0.019	0.002	0.005
	Closeness centrality	0.052	0.074	0.115	0.070	0.123
	Closeness weighted	0.170	0.288	0.497	0.274	0.278
	Degree centrality	4.250	7.667	12.125	7.500	11.000
	Indegree	2.583	2.167	3.125	2.500	3.000
	Outdegree	3.417	5.750	8.875	5.000	8.000
	Eigenvector centrality	0.010	0.025	0.011	0.023	0.018
	Isolate (% Yes)	9.21	3.12	1.82	1.92	2.33
Key Outcomes						
	Organizational readiness	4.236	4.286	4.480		
	Engagement Average	3.527	3.956	3.957	4.660	4.820
	Engagement Subdomain 3 (influence and power)	3.247	3.483	3.466	5.000	5.000
	Knowledge Average	3.189	3.795	3.332	4.334	4.611
Lower Quartile Inclusion (n = 18)						
Demographics						
Gender (% Female)	100					
Age	44					
Years of Experience	11.9					
Ego-Centric Metrics						
	Betweenness centrality	0.038	0.005	0.001	0.000	0.001
	Closeness centrality	0.135	0.060	0.081	0.068	0.039
	Closeness weighted	0.664	0.294	0.276	0.292	0.273
	Degree centrality	8.077	8.538	6.778	4.500	2.000
	Indegree	4.308	3.077	0.889	2.500	0.000
	Outdegree	5.692	5.538	5.778	2.000	1.000
	Eigenvector centrality	0.010	0.008	0.007	0.011	0.000
	Isolate (% Yes)	5.94	4.23	7.71	6.31	5.98
Key Outcomes						
	Organizational readiness	3.747	3.702	3.755		
	Engagement Average	3.284	3.343	3.186	3.840	3.700
	Engagement Subdomain 3 (influence and power)	3.111	2.920	2.823	2.500	2.000
	Knowledge Average	3.224	3.332	2.999	3.694	3.583

*Represents results from 6 coalitions that had 2 rounds of data collection.

**Represents results from 4 coalitions that had 3 rounds of data collection.

***Represents results from one coalition who had 5 rounds of data collection.

https://doi.org/10.1371/journal.pcsy.0000004.t004

Coalition committee patterns

Next, coalition-committees are compared across communities by their key intervention outcomes and demographics (Table 5). Average Knowledge, Engagement, and Engagement subdomain 3 (influence and power) scores increase for communities 1, 2, 4, 5, and 6. Across

communities, community 2, 3, and 5 display lower average scores. These same communities display a higher percentage of individuals who affiliated with the philanthropy sector.

Coalition-committee network patterns

Coalition-committee networks are next compared by their network-level features across three waves of data collection (Table 6). Looking across committee networks, network density, total network connections, and reciprocity decreases; average degree increases from wave 1 to wave 2 and decreases in wave 3 (after the intervention); and the number of isolates either decreases or remains unchanged. The triad census showed mixed results, with intransitive triads increasing in coalition-committee networks 1, 2, 3, 4, transitive triads increasing in coalition 2 and 5, and mixed triads increasing in coalition-committee networks 3, 4, and 6, and decreasing in coalition-committee networks 2 and 5. The tetrad census revealed hierarchical tetrads increasing in all coalition-committees from wave 1 to wave 3, mixed hierarchical and clustering tetrads increasing or remaining unchanged for coalitions 1, 3, and 6, and bridging tetrads decreasing in coalition-committees 2, 3, and 5 by wave 3.

Finally, as seen in Fig 3, which visually combines results from our position analysis, SLPA community-detection algorithm, and triad census, community-coalition members who see Knowledge and Engagement score increases within the upper quartile also experience becoming more central to the coalition-committee network over time. Each cross section also shows how triads and tetrads form and dissolve over time, pointing to the changing presence of hierarchy as the coalition-committee evolves.

Discussion

Prevention research to date has largely studied the process-oriented factors of coalition functioning without examining how individual and relational network characteristics are associated with adoption of EBPs. Even when researchers do examine the influence of community context and social relationships [27], the more granular relationships between individual characteristics and dyadic and group relationship dynamics are neglected. Building on prior research that conceptualizes coalition-committee activities as an intervention within the coalition and within the broader community [10,48], as well as our own research that gave precedent to examining why some individuals and coalitions seem to be better positioned within coalitions to adopt and implement EBPs [12,13], our results begin to fill this gap in research, offering insight into the possible roles of individual- and network-level characteristics on coalition functioning in the context of EBP adoption in childhood obesity prevention.

Results indicate that there are consistent individual- and network-level features involved in facilitating and limiting increases in Knowledge and Engagement across committees and their broader coalition-committee networks. Coalition-committee members who are in the upper quartile of increasing their Knowledge and Engagement scores are less likely to be female and more likely to be older compared to their lower quartile peers. These members tend not to be isolated (i.e., not have any connections with others) within the committee and, over time, increase their profile of network characteristics (e.g., are more highly connected) compared to their lower quartile peers. These coalition-committee members tend to look like the ones represented in Fig 3, wherein over time members become more central to the committee. This suggests that coalition-committee members who increase in their ability to spread information to the rest of the coalition, who increase their visibility into what is happening in the coalition, and who increase their ability to act as bridges within the coalition, may also be positioned to facilitate the adoption and implementation of childhood obesity prevention. This finding supports current research on the importance of member engagement, participatory leadership

Table 5. Cross-Coalition-Committee Demographic and Key Outcome Comparison.

		Coalition-Committees					
		1 (n = 15)	2 (n = 19)	3 (n = 13)	4 (n = 11)	5 (n = 13)	6 (n = 16)
Key Outcomes							
Knowledge (mean)							
	Round 1	3.74	3.62	3.41	3.82	3.78	3.72
	Round 2	4.10	4.09	4.00	4.20	4.13	3.97
	Round 3	4.36	4.15	4.01			3.97
	Round 4						4.13
	Round 5						4.11
	Average	4.07	3.95	3.80	4.00	3.98	3.97
Engagement (mean)							
	Round 1	3.97	3.80	3.65	3.99	3.97	4.06
	Round 2	4.21	4.08	4.00	4.04	4.15	4.08
	Round 3	4.35	4.10	4.10			4.21
	Round 4						4.21
	Round 5						4.08
	Average	4.18	3.99	3.92	4.01	4.06	4.13
Engagement Subdomain 3 (mean)							
	Round 1	4.08	3.78	3.62	4.25	3.75	4.02
	Round 2	4.43	4.11	3.94	3.97	3.91	4.08
	Round 3	4.39	4.16	4.00			4.37
	Round 4						4.31
	Round 5						4.13
	Average	4.30	4.02	3.85	4.11	3.83	4.18
Demographics							
Gender (%)							
	Female	66.67	78.95	91.67	95.24	83.33	93.33
	Male	33.33	21.05	8.33	4.76	16.67	6.67
	Other	0	0	0	0	0	0
Age (mean)		44	49	49	40	49	50
Years of experience (mean)		19	17	20	13	14.6	20
Sector (%)							
	Community-based Organization	100	15.79	15.38	27.27	50	6.25
	Early Education and Schools	0	10.53	46.15	18.18	8.33	43.75
	Healthcare	0	21.05	7.69	9.09	16.67	18.75
	Local Government	0	5.26	7.69	9.09	0	6.25
	Philanthropy	0	10.53	7.69	0	8.38	0
	Private Sector	0	0	7.69	0	8.33	0
	State Government	0	26.32	7.69	9.09	0	25
	Academic Partners	0	0	0	27.27	8.38	0

https://doi.org/10.1371/journal.pcsy.0000004.t005

style, and coordinator skill [6,27,49], but adds nuance to the dynamics of social relationships that may act as moderators of these functions enroute to EBP implementation. Conversely, coalition-committee members who appear in the lower quartile of Knowledge and Engagement increase their outdegree and decrease their indegree, which suggests that there is a tendency toward network hierarchy. This pattern implies a shift towards a more centralized or hierarchical network structure where certain members on the outskirts of the network are actively seeking connections externally while receiving fewer connections internally. This

Table 6. Cross-Coalition-Committee Network Comparison by Wave of Data Collection.

		Coalition-Committee Network					
		1	2	3	4	5	6
	Nodes (evernet)	n = 234	n = 379	n = 729	n = 671	n = 318	n = 558
	Committee members	n = 15	n = 19	n = 13	n = 11	n = 13	n = 16
Network Features							
Round 1							
	Density	0.01	0.01	0.01	0	0	0
	Connections	138	279	276	442	189	101
	Average degree	1.84	2.24	1.67	2.12	1.94	1.28
	Reciprocity	0.07	0	0	0.02	0.04	0.01
	Isolates (committee members only)	6	3	0	0	0	10
	Number of community clusters	20	61	140	90	169	69
	Largest Connected Component Size	32	52	33	112	5	39
	Triads (% intransitive)	0	7.89	0	15.15	0	0
	Triads (% transitive)	12.50	57.89	50.00	27.27	5.26	50.00
	Triads (% mixed)	37.50	5.26	8.33	15.15	57.89	0
	Tetrads (% hierarchy)	0	5.26	0	3.03	5.26	0
	Tetrads (% hierarchy and clustering)	0	5.26	8.33	18.18	10.53	0
	Tetrads (% bridging)	50.00	18.42	33.33	21.21	21.05	50.00
Round 2							
	Density	0.01	0.01	0	0	0.01	0
	Connections	118	242	254	507	199	225
	Average degree	2.19	2.4	1.38	2.37	2.16	1.76
	Reciprocity	0.04	0.02	0.01	0.03	0.03	0.02
	Isolates (committee members only)	2	1	1	0	0	1
	Number of community clusters	20	8	140	36	160	78
	Largest Connected Component Size	32	77	30	131	5	75
	Triads (% intransitive)	7.69	7.69	0	0	0	25.00
	Triads (% transitive)	23.08	53.85	0	21.62	11.11	25.00
	Triads (% mixed)	15.32	23.08	0	32.43	11.11	12.5
	Tetrads (% hierarchy)	0	7.69	0	16.22	33.33	0
	Tetrads (% hierarchy and clustering)	15.38	46.15	100	10.81	33.33	0
	Tetrads (% bridging)	38.46	7.69	0	18.92	11.11	37.5
Round 3							
	Density	0.01	0.01	0			0
	Connections	71	104	465			210
	Average degree	2	2.02	2.31			1.95
	Reciprocity	0.01	0.02	0.03			0.01
	Isolates (committee members only)	3	3	0			0
	Number of community clusters	6	8	59			68
	Largest Connected Component Size	32	34	49			55
	Triads (% intransitive)	18.75	22.22	2.70			11.11
	Triads (% transitive)	25.00	33.33	40.54			38.89
	Triads (% mixed)	18.75	5.56	18.92			11.11
	Tetrads (% hierarchy)	0.00	16.67	2.70			5.56
	Tetrads (% hierarchy and clustering)	18.75	11.11	16.22			11.11

(*Continued*)

Table 6. (Continued)

	Tetrads (% bridging)	18.75	11.11	18.92			22.22

Note. Community six had five rounds of data collection. To enable comparison to other coalitions, we normalized this community's rounds 1 and 2 as round 1, round 3 as round 2, and rounds 4 and 5 as round 3.

https://doi.org/10.1371/journal.pcsy.0000004.t006

behavior contributes to a trend where a few individuals or groups might exert more control over the information flow within the network, leading to a more hierarchical structure. This finding is supported by Bess (2015) and suggests that coalition-committee members in the upper quartile tend toward insularity and those in the lower quartile tend toward hierarchy outside of the coalition-committee [10].

Member engagement is cited as fundamental to functioning for coalitions, with planning, funding, and perceived system impact as positively associated with coalition outcomes. Our results indicate that coalition-committee members, or those who take on participatory leadership roles within their coalitions, who become more centralized and act as facilitators of information flow within coalitions, are poised for increasing their Knowledge and Engagement in childhood obesity prevention. By extension, this profile of characteristics could be associated with increases in EBS adoption, but more research is needed that directly measures EBS adoption and that links Knowledge and Engagement to a measure of EBS adoption.

Our results also indicate that those who decrease in some or all their network characteristics (e.g., become less connected) also see an increase in their Knowledge and Engagement scores, only to a lesser extent. In cases where Engagement subdomain 3 (influence and power) decreases, coalition-committee members tend to be female, younger, with less than 10 years of experience, and see decreases in their Eigenvector centrality when compared to their committee peers. These individuals seem to lose their connection to committee members who are

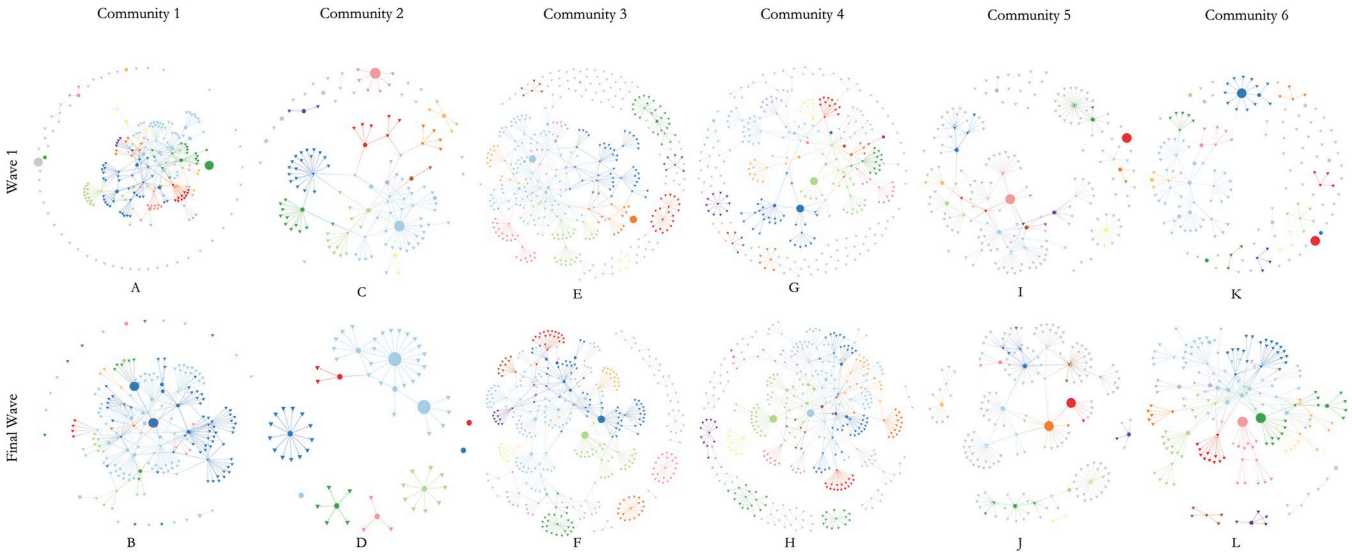


Fig 3. Cross-section of coalition-committee networks by wave of data collection. This figure, panels A-L, illustrates the cross-section (by wave of data collection) network position movement of two coalition-committee members in each community who demonstrated the highest increases in their Knowledge and Engagement scores; it combines our positional, triad, and community detection analysis with changes in two of our key outcomes. Circles are coalition-committee members, with the two largest circles indicating the coalition-committee members who saw the largest increase in their Knowledge and Engagement scores. Triangles are those with whom coalition-committee members discuss childhood obesity prevention, termed first-degree alters. The colors correspond to community clusters that were identified using the SPLA algorithm.

https://doi.org/10.1371/journal.pcsy.0000004.g003

well-connected within the coalition. This finding could be similarly associated with member engagement and participatory leadership styles [21], wherein younger, less experienced committee members feel less empowered to use EBPs in childhood obesity prevention over time as they take on competing priorities, thereby moving away from their initial levels of leadership. Without participatory leadership, catalyzing community coalitions can be more difficult, leading to a lack in support for program adaptation and sustainability [25]. Prevention interventions, like the one reported on in this study, could benefit from ensuring that coalition-committee members who seem to be moving to the periphery of the coalition are connected to engaged, centralized leaders in the network.

Coalition-committee members are nested within the committee, which is nested within the larger coalition network. This conceptualization has been used by the primary author and others [10,12], as it provides a salient way to describe the rippling effects small committee (inter) actions can have on the larger intervention system. While Bess (2015) uses this conceptualization to describe the influence of coalitions on larger intervention system capacity building, we use it to think about diffusion potential of EBP in childhood obesity prevention from the committee outward to their larger, local community [29,50]. The network motif for coalition-committees participating in our childhood obesity prevention intervention displayed a pattern of attenuating density, reciprocity, and overall connections, and an increase in transitive triads (with a decrease in intransitive triads), and an increase in both hierarchical and mixed hierarchical and cluster tetrads. The overall tendency toward local hierarchy for the coalition-committees was not seen at the broader coalition network level, nor was it seen in previous work [13]. Higher levels of centralization and hierarchy within a network is associated with increased coalition functioning for EBP implementation. Paired with decreasing density and global hierarchy in the broader coalition network, the increasing local hierarchy within the coalition-committee may suggest greater capacity for EBP adoption and implementation. This dynamic can be seen across the literature that suggests density and centralization are inversely correlated [10,11,24], and is hypothesized to contribute to optimal coalition structure for the diffusion of information.

Limitations and future research

This study explores how individual and network-level characteristics are associated with coalition functioning. Although we believe our sample generally represents the demographic heterogeneity of coalitions that work in childhood obesity prevention and in prevention more broadly, they cannot be firmly applied to other coalitions in other geographic contexts, especially contexts outside of the SDCD-informed intervention. As our earlier study suggests [12], coalitions are patterned in their composition but require interventions tailored to their unique community context. Results from this study should be used to inform theory related to coalition functioning and prevention coalitions. Results could also be used as inputs to more causal studies that seek to develop and implement network interventions [51]. Additionally, due to the nature of complex systems, it is possible that both events and other factors involved in coalition functioning contributed to the social relationship patterns generated in this study. Contributing to this point, data collection did not occur at the same time across communities, instead spanning several years; however, data collection did occur at the same time points within the intervention period.

Our findings point to several mechanisms that warrant exploration in future research. Firstly, our study emphasizes the influence of individual- and network-level characteristics on Knowledge and Engagement, shedding light on the roles of gender, age, and connectivity within committees. Future work could delve into more detailed examinations of how specific individual attributes and relationship dynamics contribute to the adoption and

implementation of EBPs. Moreover, the observed tendency toward network hierarchy in the lower quartile of Knowledge and Engagement suggests a need to investigate the impact of hierarchical network structures on information flow and decision-making processes. The identified shift towards local hierarchy within coalition-committees also hints at the potential for further exploration into the implications of network motifs on the diffusion potential of Knowledge and Engagement, especially considering the contrasting patterns at the broader coalition network level. Additionally, the study underscores the importance of considering the temporal aspects of data collection, urging future research to explore the temporal evolution of social relationships and coalition dynamics. Finally, future research should consider mixed-method research to capture participant meanings and coalition dynamics.

Conclusion

This study contributes to understanding how an array of individual and network-level characteristics are related to coalition-committee member increases in Knowledge and Engagement in childhood obesity prevention. Knowledge and Engagement offer support that individual and network-level characteristics may be associated to the adoption of EBP. The strengths of this study include the level of granularity in which coalitions were examined across six different communities in the U.S., multiple years of coalition functioning measurement through the lens of social network change and EBP adoption, and the conceptual and thematic associations between coalition-committee, committee, and coalition-committee networks derived from cross-sectional results. Coalition-committee members who increase their Knowledge and Engagement scores the most seem to follow demographic and relational patterns. Committees, and the coalitions in which committees are nested, also follow relational patterns, with committees increasing in local hierarchy and coalitions decreasing in global hierarchy overtime, for example. Prior research has shown that factors involved in coalition functioning for EBP implementation includes social relationships, leadership styles, member engagement, and resources [27]. This study lays the initial foundation for future research that extends this work to focus more explicitly on the individual- and network-level characteristics of coalitions in supporting EBP implementation.

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