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Visualizing Complex Adaptive Systems: A Case Study of the Missouri Maternal, Infant, and Early Childhood Home Visiting Program

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Abstract

Background: The Maternal, Infant, and Early Childhood Home Visiting (MIECHV) program was created by the 2010 Patient Protection and Affordable Care Act. MIECHV provides comprehensive services to at-risk families through evidence-based home visiting programs.

Purpose: The following question is addressed: Does the Missouri MIECHV system meet the definition of a complex adaptive system (CAS)?

Methods: A systematic review was conducted of documents related to MIECHV programs (federal, state, and local levels), and to affiliated programs with a home visiting and early childhood (aged birth to 5 years) scope. The organizations' fit was identified for the scope of early childhood home visiting programs, and then its relationship extracted to MIECHV and its affiliates.

Results: MIECHV meets the definition of a CAS, being dynamic, massively entangled, scale independent, transformative, and emergent. Over 250 organizations were identified; 19 federal and 79 state organizations; 24 nonprofits at the federal level, 31 at the state; over 150 community-level agencies; and 13 home visiting models implemented in Missouri.

Implications: A considerable amount of organizational complexity exists within the MIECHV system and among its affiliates with a home visiting and early childhood scope. The complexity of the system challenges its potential for effective and efficient implementation, coordination, sustainability, and evaluation, and increases the potential for redundancy, overlap, and fragmentation. Evaluating a CAS requires acknowledgement of its complexity, beyond traditional approaches to evaluation. Creating visualization tools of federal, state, and local stakeholders and their relationships is a practical approach for aligning, organizing, and communicating the work flow.

Keywords

operations research, systems theory, home visit, early childhood programs, maternal, infant, affordable care act, MIECHV

INTRODUCTION

The 2010 Patient Protection and Affordable Care Act (ACA) has generated attention for programs that drive a systems-engineering approach to health-related services.[1,2] The Maternal, Infant, and Early Childhood Home Visiting (MIECHV) program was created by Section 2951 of the ACA. MIECHV is intended to provide comprehensive services to pregnant women and at-risk parents of children aged birth to 5 years through evidence-based home visiting programs. Funding for the MIECHV programs is administered through the Health Resources and Services Administration (HRSA) in partnership with the Administration for Children and Families (ACF), and includes an evaluation component. With participating states receiving funds to address their at-risk communities, evaluating the effectiveness of these programs becomes challenging. Applying a systems perspective is appropriate for many reasons, including acknowledging the history of home visiting programs, as home visiting programs having been in existence for decades.

Systems-thinking considers how components within a larger structure operate and interact over the life cycle of the system; and how to optimize the design, implementation, and evaluation of that system. A *system* can be defined as "a group of interacting, interrelated, and interdependent components that form a complex and unified whole."[3] The term *complex adaptive systems* (CAS) acknowledges that programs and activities are not conducted in vacuums, but are part of larger networks, with histories and evolving dynamics.[4]

The Health Resources and Services Administration and ACF operate from the idea that state MIECHV programs and home visiting should be regarded as a component rooted within a comprehensive, well-functioning early childhood system that fosters long-term maternal, infant, and early childhood outcomes and strong parent–child relationships.[5] This system includes a variety of programs that assist at-risk families with a wide range of needs.[5] HRSA and ACF collaborate with other federal and state agencies in implementing MIECHV as a system of "high-quality, well-coordinated home visiting programs"[5] in order to optimize impact. The strategy has been: "to encourage, support, and promote the [construction and] continuation of these collaborative activities, as close collaboration at all levels will be essential to effective, comprehensive home visiting and early childhood systems."[5]

Traditional evaluation approaches are limited in their ability to address the complexity of federal initiatives. Coffman[3] defines five areas to best understand systems initiatives: context, components, connections, infrastructure, and scale. We know of no work that has examined the MIECHV program from a systems approach (including local, state, and federal levels). The following question is addressed: Does the Missouri MIECHV system as it currently operates, meet the definition of a CAS, when defined using Coffman's framework?

METHODS

To define the Missouri MIECHV system, Coffman's five areas of focus were defined: (1) context, (2) components, (3) connections, (4) infrastructure and (5) scale.[3] Primary *context* is a mission directly related to improving the early childhood (pregnancy to birth to age 5) outcomes in Missouri, or one of MIECHV's benchmarks. Secondary *context* is a parent organization of

a *primary context* organization. Primary *components* are the primary organizations with a formal (funding) relationship to Missouri MIECHV and the Missouri Early Childhood Comprehensive System (ECCS). Secondary *components* include organizations within the context of early childhood outcomes in Missouri without a formal MIECHV relationship. *Connections* is defined comprehensively, first as a direct formal (e.g., funding) relationship; second as an indirect or collaborative relationship (e.g., serving together on committees); and third as having a shared *context*. *Infrastructure* is the visualization of these connections, not necessarily the operationalization of these relationships. *Scale* is defined as either local, state, or federal.

Visualization utensils were used (lines, colors, shapes, and proximity) to display the *infrastructure* (see the attached Additional File for Figure 1). Rectangles and circles indicate *components* within the early childhood *context.* Circles indicate nongovernmental organizations (NGOs); rectangles indicate federal, state, and local organizations. The *connections* depicting funding relationships are indicated by red lines; partnerships with black, dotted lines. Shared *context* is assessed by grouping programs with similar missions and with complementary missions. Programs that carry out missions under specific categories (mental health, health care access, coordinating bodies, resources and referral, childcare, child abuse/neglect prevention, home visiting) were noted with colors, to indicate possible duplication or nature of a coordination that could prove useful among these programs.

FIGURE 1. Missouri's 2015 Maternal, Infant, and Early Childhood Home Visiting Program (MIECHV) Complex Adaptive System as a Visualization Tool to Identify Stakeholders and Resources (in the attached Additional File to allow for expansion)

To identify the content, a systematic review was conducted of publicly available documents, websites, and artifacts. Snowballing of primary and secondary *connections* was used to identify additional *connections*. Draw.io website was used to create the visual graphic.

The definition of a CAS[4] was then applied against the visual representation of the MIECHV system designed with Coffman's framework,[3] to validate its fit. Because publicly available documents were reviewed, University of Missouri Health Sciences Institutional Review Board approval was not required.

RESULTS

The Maternal, Infant, and Early Childhood Home Visiting program meets the definition of a CAS, being dynamic, massively entangled, scale independent, transformative, and emergent[4] when defined with Coffman's framework[3] (see the attached Additional File for Figure 1). Over 250 stakeholders were identified; a total of 19 federal and 79 state organizations; 24 nonprofits at the federal level, 31 at the state, and over 150 community-level agencies. Thirteen different identified home visiting models were implemented in Missouri (four of which are part of the MIECHV program). The majority of the relationships indicate *ownership* of an organization (i.e., divisions under sections under departments).

Considerable organizational complexity (massive entanglement) exists within the MIECHV program at the local, state, and federal levels, among its community-based resources, and the

affiliated programs with an early childhood context. That the MIECHV early childhood affiliates have operated in varying timeframes (are emergent), they contribute to the system components being dynamic and transformative.[4] MIECHV's systems approach to early childhood has elements of CAS that do not follow a smooth, predictable pattern,[4] given that elements are indefinite and change constantly.[4] Despite an extensive review of documents, this visualization is likely incomplete. This is one system (among U.S. states) illustrated within the larger federal MIECHV system, with scale independence of local, state, and federal levels with self-similar levels of organization requiring micro- and macro-patterns and structures for evaluation.[4]

IMPLICATIONS

Creating a system visualization is a first step in aligning stakeholders at multiple levels of *scale* toward systems-thinking. Identifying the *connections* in this *context* become feedback loops as a mechanism to create linkages[3] and begin to provide a framework to evaluate the effectiveness of the CAS.[4] Because CASs are dynamic, emergent, and transformative, visualizations (*infrastructure*) should be captured at various time points to learn from the change and the noise.[4] By identifying "the dynamic patterns in the environment, the group can begin to build coping mechanisms for the future" and "look for those 'differences that make a difference.'"[4]

The complexity of the Missouri MIECHV system challenges its potential for effective and efficient implementation, coordination, sustainability, and evaluation of MIECHV programs, and increases the potential for redundancy, overlap, and fragmentation with the absence of an organizing principle. Evaluating a CAS requires acknowledgement of its complexity, beyond traditional approaches to evaluation that assume more discrete intervals, such as the beginning and ending of an intervention.[4]

As next steps, we need to address the quality of relationships and partnerships; the extent of collaboration and coordination; redundancies; gaps; strengths; and inefficiencies. Creating an interactive map and searchable database of national, state, and local organizations, their missions, their target populations, their beginning and ending dates, and other early childhood-focused characteristics could help disseminate this information to ensure that a comprehensive system is available to as many people as possible,[3] and to minimize redundancy when planning initiatives if the system needs are recognized.[3]

SUMMARY BOX

What is already known about this topic? Systems approaches to implementation of public and private service delivery require a more comprehensive and coordinated approach than what is traditional. CASs are difficult to design, implement, and evaluate.

What is added by this report? Building a comprehensive visualization of the CAS informs a more useful understanding of a CAS. Identifying, visualizing, and outlining each component provides a tool for organizational alignment, and a foundation for effective design, development, and implementation of evaluation. Combining CAS theory with Coffman's evaluation framework aids this practice.

What are the implications for public health practice, policy, and research? Coordinating agencies implementing programs within local, state, and federal systems; and the organizations within that system; might benefit from defining and visualizing the system. For Missouri MIECHV, aligning on the infrastructure facilitates the process of coordinating the early childhood system in order to advance the State's early childhood outcomes.

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