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A Scoping Review of Whole-of-Community Interventions on Six Modifiable Cancer Prevention Risk Factors in Youth: A Systems Typology

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Abstract

Whole-of-community interventions delivered across entire geospatial areas show promise for improving population health for youth cancer prevention. The aims of this scoping review were to synthesize the whole-of-community intervention literature on six modifiable risk factors in youth for cancer prevention (alcohol use, diet, obesity, physical activity, sun exposure, tobacco use) and to develop and apply a typology describing the inclusion of fundamental control system functional characteristics. A systematic search was conducted in PubMed, Cumulative Index to Nursing and Allied Health Literature, Embase, PsycINFO, and Scopus for studies published to the end of 2019. Eligible studies included a geospatially defined whole-of-community intervention; youth 0–18 years; and at least one of the six cancer risk factor outcomes. An iterative process was undertaken to create a typology describing the functions for whole-of-community interventions guided by systems theory, and the typology was used to code the included interventions. A total of 41 interventions were included. Most interventions (43.9%) assessed multiple cancer risk factors. Few interventions provided fundamental functions necessary for community system coordination: sensor, controller, effector. Although communities are a patchwork quilt of microsystems where individuals interact in geographically bounded places nested within larger whole systems of influence, a control systems approach has not been used to frame the literature. Whole-of-community interventions can be characterized by the fundamental system functions necessary for coordinating population health improvement. Future whole-of-community intervention efforts should draw on fundamental knowledge of how systems operate and test whether adoption of the key functions is necessary for whole-of-community population health improvement.

Keywords

Population health, Systems, Youth, Cancer prevention, Whole-of-community interventions, Scoping review

1. Introduction

Understanding the health outcomes that result from daily life needs to begin with the evidence that individuals cluster together in geographic space and interact in a defined social entity called community (Warren, 1963). A community can be characterized as a complex whole system made up of a patchwork quilt of geographically located microsystems, where a group of individuals interact in physical places where they live, learn, work, and play. When a community is examined as a set of place-based microsystems nested within larger whole social systems of influence, the outcomes of a community are not simply an aggregation of individuals behaving as independent, isolated parts. Rather, an interdependency exists such that community outcomes are highly dependent on the interactions among the individuals within microsystem environments, and individual outcomes are dependent on exposure to the group microsystems available in structured daily community life (Warren, 1963; Bates and Bacon, 1972; Dzewaltowski, 2017). Our broad goal for this review is to describe whole-of-community interventions, defined as multi-strategy interventions delivered across entire geospatial areas (Wolfenden et al., 2014), to improve the health of an interdependent group of people. We aim to do this by drawing from fundamental control systems theory to develop and apply a typology that describes the inclusion of control system functional characteristics.

Community health promotion targeting the prevention of chronic diseases, globally known as noncommunicable diseases, is a significant public health priority given the vast consequences they have on communities and population health (GBD 2017 Disease and Injury Incidence and Prevalence Collaborators, 2018). These efforts include a focus on the promotion of health behaviors such as healthy diet and physical activity (PA) to aid in the prevention of such diseases, and researchers recognize the need for these efforts to be delivered within community systems and the microsystem environments of daily life (Mazzucca et al., 2021). Cancer is one such chronic disease that is a major cause of death worldwide (American Cancer Society, 2018) and in the United States (U.S.) (Murphy et al., 2018; Kochanek et al., 2017; Miniño, 2013) and is largely associated with modifiable risk factors (Islami et al., 2018). Addressing risk factors experienced early in life presents a significant opportunity for cancer prevention (Masseti et al., 2016). The present review focuses on whole-of-community interventions targeting cancer prevention and the promotion of preventive behaviors around tobacco use, obesity, alcohol use, ultraviolet radiation, diet, and PA among youth ages zero to 18 years. These factors were selected because they are high-frequency behaviors that occur in various places in a community or are influenced by high-frequency behaviors (e.g., obesity is influenced by diet and PA), are each associated with cancer, and are prevalent among U.S. youth (Gentzke et al., 2020; Hales et al., 2018; Jones et al., 2020; Kann et al., 2018; Banfield et al., 2016; Troiano et al., 2008). Additionally, risk factors established in youth can track throughout the lifespan and have a lasting impact on health and cancer risk in adulthood (Santelli et al., 2013; Craigie et al., 2011; Kelder et al., 1994). Thus, focusing on cancer prevention in youth allows for this review to examine whole-of-community interventions aimed at addressing the health of interdependent groups of people around a significant public health problem.

Youth cancer prevention can be framed as a community problem defined geographically, rather than an individual-level behavior change problem, because the conditions in which people live (e.g., social, economic) influence health, and these determinants operate at the community-level (National Academies of Sciences, Engineering, and Medicine, 2017). Further, a National Academy of Medicine Roundtable proposed that population health outcomes be framed using geopolitical boundaries to define the population group because funding decisions and lead intervention agencies are inherently geopolitical in nature (National Academies of Sciences, Engineering, and Medicine, 2015). Whole-of-community interventions delivered across entire geospatial areas show promise for addressing population health outcomes (Wolfenden et al., 2014). A previous systematic review of whole-of-community interventions targeting weight status found a reduction in body mass index z-scores among youth in intervention communities, suggesting that these interventions may be effective in impacting population weight gain (Wolfenden et al., 2014).

Whole-of-community interventions create the potential for addressing community-level determinants of health and creating widespread reach (Wolfenden et al., 2014; National Academies of Sciences, Engineering, and Medicine, 2017). However, to our knowledge the literature on whole-of-community interventions on six modifiable risk factors in youth for cancer prevention has not been identified and synthesized. In order to capture the diversity of strategies that may be used to improve population health outcomes in a complex community system, interventions need to be described by the key functions they have, rather than the specific form they take (Hawe et al., 2004). Coding intervention functions allows us to synthesize the variety of intervention components that may be delivered across communities. Although typologies for describing health interventions exist, such as those characterizing the theoretical foundation of interventions (Michie and Prestwich, 2010) and behavior change techniques (Abraham and Michie, 2008; Michie et al., 2011), they are not adequate for examining the application of fundamental control systems theory functions necessary for community system coordination. This highlights the need to develop a typology for examining communities as social systems and how the functions of fundamental control systems theory can be applied for whole-of-community interventions. Developing a typology allows for the grouping of functions and may aid in

understanding the combinations of functions used and similarities and differences across whole-of-community interventions.

The learning healthcare system (LHS) provides an example of the application of control systems theory functions for coordinating a dynamic social system. An LHS is focused on continuous improvement in healthcare through utilization of knowledge gained in the care process, patient engagement, and care best practices (Institute of Medicine, 2013). This approach is driven by defining the population in population health improvement as a patient population, obtaining health data on the population, and using this data as part of cycles of study and feedback for continuous learning and improvement to advance patient care (Platt et al., 2020; National Academy of Medicine, 2017; Friedman et al., 2017). The use of data as a feedback mechanism is based on fundamental control systems theory and has been shown to maximize quality improvement efforts in a dynamic system, as it can inform whether improvements are occurring under changing conditions in the system over time (Langley et al., 1996; Perla et al., 2013).

Fundamental control systems theory defines the functions necessary for an LHS. There are three broad functions to a control system: sensor, controller, and effector (Liu and Barabási, 2016; Carver and Scheier, 2002; Wiener, 1948). The sensor monitors and collects information on the system that can be used to guide decision-making. The controller adopts a standard of reference or quality and makes decisions in order to move the system toward that standard based on the information obtained by the sensor. The effector implements the decisions made by the controller. The sensor, controller, and effector functions operate collectively to provide an architecture for a feedback loop to move the system closer to the standard of reference. This architecture and feedback loop provide the basis for developing a systems typology of whole-of-community interventions, illustrated in Fig. 1.

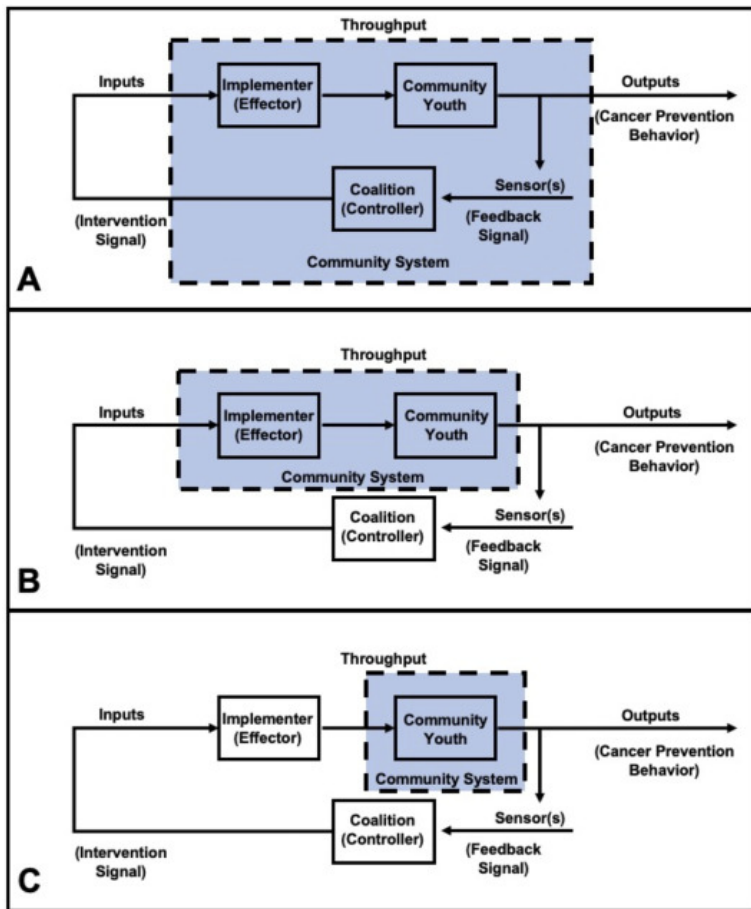


Fig. 1. Whole-of-Community Intervention Control System Logic Model.

1-A. Community System Throughput with Controller Location within Community. 1-B. Community System Throughput with Controller Location Outside of Community. 1-C. Community System Throughput with Controller and Implementer Location Outside of Community.

A typology based on control systems theory provides an improved frame for examining population health improvement efforts. Koczwara and colleagues suggest that implementation science (i.e., “work to promote the systematic uptake of evidence-based interventions”) and improvement science (i.e., “systems-level work to improve the quality, safety, and value of health care”) primarily operate independently, but integrating these fields can create synergy to improve cancer care (Koczwara et al., 2018). Fundamental control systems theory underlies these fields (Chassin and O’Kane, 2010). Thus, drawing on the control systems functions underlying both implementation and improvement science can allow us to better align the fields for cancer prevention. Further, researchers suggest that the LHS concept needs to extend beyond healthcare to communities to impact population health (Sheikh, 2020; Mullins et al., 2018). To our knowledge this is the first attempt to extend the LHS concept to whole-of-community systems and to apply fundamental control system functions to characterize whole-of-community interventions as LHS for cancer prevention in youth.

Extension of the LHS concept to whole-of-community cancer prevention raises several challenges in the application of fundamental control system principles. In the LHS, a population is often defined as patients under care and the functions may be fulfilled by the electronic health records collecting patient data, hospital administrators defining quality patient care and making decisions to improve care, and hospital staff implementing decisions made by administration. For whole-of-community cancer prevention, a feedback control system requires coordinating all people living interdependently within a geographically defined area. This

expanded system boundary requires the LHS architecture to go beyond the healthcare system and address dynamic community systems made up of interacting agents within place-based microsystems and coordination and continuous improvement of this broader community context (Sheikh, 2020; Mullins et al., 2018).

In sum, communities are complex whole social systems made up of interacting agents within place-based microsystems, and the coordination of the whole community system and the microsystems nested within can be defined by fundamental control systems theory functions. Fundamental control system architectures have been shown to provide the capacity to coordinate system improvement by driving it from an initial state to a desired final state in finite time through feedback (Kalman, 1963). Application to whole-of-community interventions allows us to define the functions necessary for improving health outcomes in a community system.

This paper aims to:

1. Identify the existing literature on geospatially defined whole-of-community interventions on six health promotion and cancer prevention behaviors in youth (alcohol use, diet, obesity, PA, sun exposure, and tobacco use); and
2. Develop and apply a typology that describes the inclusion of fundamental control system functional characteristics within the identified interventions.

2. Methods

2.1. Aim 1: identification of whole-of-community interventions

2.1.1. Database search

We conducted a systematic scoping review with a defined Population, Intervention, Comparison, and Outcome (PICO) (Methley et al., 2014; Schardt et al., 2007; O'Connor et al., 2008). With the assistance of a medical librarian, electronic database searches were conducted in MEDLINE via PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Embase, PsycINFO, and Scopus for studies published through the end of December 2019. The results were limited to English only. The search strategy was established in MEDLINE using a combination of database-specific controlled vocabulary and keywords. The following keywords or close analogs were used: (1) *community*; and (2) *physical activity, nutrition, obesity, alcohol use, tobacco use, or sun exposure*; and (3) *youth*. Following MEDLINE, the other database searches were conducted. The last database search was conducted on January 15, 2020. For a complete list of the literature search strategies, see Appendix A.

2.1.2. Study selection

The citations returned from the search were imported into a reference manager, and duplicates were removed. Three reviewers (AE, JE, research assistant) screened titles and abstracts to determine relevance. All relevant articles were retained for full-text screening. A minimum of two independent reviewers (AE, CM, JE, research assistant) screened each full-text article using the inclusion/exclusion criteria defined below. All disagreements were discussed until consensus was reached. If needed, an additional investigator (DD) was consulted. Additional companion papers (e.g., trial protocols) referenced in eligible articles were hand-searched for relevant information.

2.1.3. Eligibility criteria

To be eligible for this review, the study population needed to include persons aged zero to 18 years. Interventions included any whole-of-community approach where community was defined by a geospatial area in which the target population lives, learns, and plays; and the intervention targeted two or more settings or microsystems within the whole-of-community system geospatial area (e.g., school, community organizations). Whole-of-community interventions were operationalized as those targeting more than one setting in the

community because they addressed multiple parts, necessary for coordinating whole-of-community improvement. An intervention and comparison community condition were required, where the comparison could not be in the same geospatial area. A study design that included a counterfactual was required (e.g., quasi-experimental study, randomized clinical trial). We included six separate cancer prevention behavior outcomes: (1) alcohol use, (2) diet, (3) obesity, (4) PA, (5) sun exposure, or (6) tobacco use. Studies needed to be in English language and published in a peer-reviewed journal.

Criteria for exclusion were: interventions that did not meet the whole-of-community definition (i.e., studies that did not have clear geospatial definitions, targeted only one setting in the geospatial area, and/or included intervention and comparison or control settings within the same geospatial area); studies with alcohol use, diet, obesity, PA, sun exposure, and/or tobacco use as correlates, not outcomes; literature reviews or commentary; physiological studies; pilot or protocol studies, unless complementary to a study that met inclusion criteria; studies that targeted subjects with a medical condition such as cardiovascular disease or diabetes; studies restricted to specific child population subgroups (e.g., preterm infants, children with disabilities); and studies published only in abstract form.

2.1.4. Descriptive data extraction

A minimum of two independent reviewers (AE, JE, research assistant) extracted descriptive data, and all disagreements were discussed until consensus was reached. Descriptive data included study design, intervention duration, theories and frameworks informing the intervention, geospatial definition of intervention and control communities, target population, and cancer risk behavior(s) targeted for intervention and assessed.

2.2. Aim 2: systems typology

The sensor, controller, and effector functions of a control system guided the development of a systems typology for whole-of-community interventions. Through an iterative process, we identified how the functions are included in the whole-of-community interventions in order to operationalize codes for each function. The process consisted of the following stages:

1. Articles that met all inclusion criteria, further described in the Results, were re-read to identify variability and commonalities in approaches that fulfilled each function. We looked for commonalities and differences in the collection and feedback of information on the population health problem and intervention to inform action, who made decisions regarding the intervention (e.g., whether the control function resided with the research team or community), and who implemented decisions related to the intervention.
2. Studies were sorted into functionally similar groups based on the three functions.
3. Codes for each function were operationalized based on the commonalities identified.
4. Codes were refined through study review and discussions among the lead author and senior investigator.
5. Codes were refined through discussions among the authors.

The stages were conducted iteratively until the new typology captured all evident codes for each function in the included interventions and no new codes emerged. The included articles were then re-read, and each intervention was coded using the developed typology.

3. Results

3.1. Aim 1: identification of whole-of-community interventions

The flow diagram of the article selection process is illustrated in Fig. 2. A total of 105 articles corresponding to 41 unique intervention projects were included in this review.

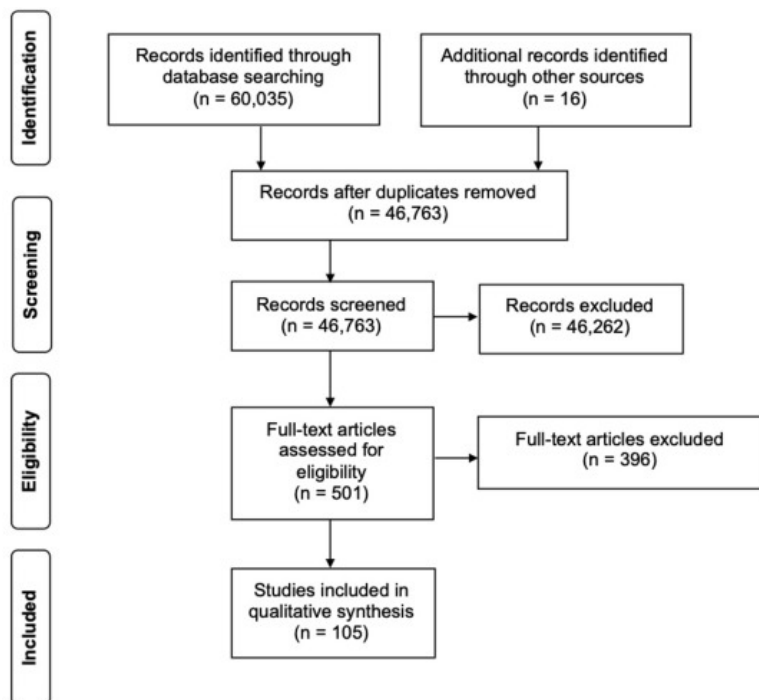


Fig. 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

3.1.1. Cancer risk factor outcomes

The number and percentage of interventions reporting each of the cancer risk factors are presented in Table 1. Nearly half of the interventions ($n = 18$, 43.9%) assessed multiple outcomes. Of those 18, 10 interventions assessed diet, PA, and obesity. The remaining interventions assessed PA and obesity ($n = 1$); diet and PA ($n = 1$); alcohol and tobacco use ($n = 4$); diet, PA, and tobacco use ($n = 1$); and diet, PA, obesity, and tobacco use ($n = 1$). Study characteristics and the cancer risk factor outcomes are further described in Appendix B.

Table 1. Number and percentage of intervention projects assessing each cancer risk factor outcome.

Risk factor	Total % (n)	Project
Alcohol use	22 (9)	Alcohol Moderation among Adolescents in the Achterhoek (Jansen et al., 2016); Local Alcohol Policy Project (Holmila et al., 2010; Holmila and Warpenius, 2007); Prevention of Underage Drinking on California Indian Reservations (Moore et al., 2018; Gilder et al., 2017; Lee et al., 2011; Moore et al., 2012); Prevention Trial in the Cherokee Nation (Komro et al., 2017; Komro et al., 2015; Livingston et al., 2018; Wagenaar et al., 2018); Project Northland Chicago (Komro et al., 2004; Komro et al., 2008); Reducing Youth Access to Alcohol: Oregon (Flewelling et al., 2013); Social Marketing and Community Mobilisation in Australia (Rowland et al., 2018; Rowland et al., 2013); Strategic Prevention Framework (Anderson-Carpenter et al., 2016); Wegschauen ist keine Losung (Looking Away is not a Solution) (Kraus et al., 2013)
Dietary	9.8 (4)	5 a Day-Power Play! (Foerster et al., 1998); Creating Healthy, Active and Nurturing Growing Up Environments (Cohen et al., 2014); Community Nutrition Education Cooperative (Hosig et al., 1998; Dollahite et al., 1998);

		Project FIT (Alaimo et al., 2015; Eisenmann et al., 2011; Paek et al., 2014; Paek et al., 2015)
Obesity	4.9 (2)	Niños Sanos, Familia Sana (Sadeghi et al., 2017; de la Torre et al., 2013); the Tioga County Fit for Life Project (Gombosi et al., 2007)
Physical activity	2.4 (1)	Active Winners (Pate et al., 2003)
Sun exposure/protection	4.9 (2)	SunSafe (Grant-Petersson et al., 1999; Dietrich, 2000; Dietrich et al., 1998; Dietrich et al., 2000); SunSafe in Middle School (Olson et al., 2007)
Tobacco use	12.2 (5)	Cancer Action in Rural Towns Project (Hancock et al., 2001; Hancock et al., 1996); Project ACTIVITY (Arora et al., 2010a; Harrell et al., 2016; Arora et al., 2013; Arora et al., 2010b); Project SixTeen (Biglan et al., 2000); the New Hampshire Study (Stevens et al., 1993); Tobacco Policy Options for Prevention (Blaine et al., 1997; Forster et al., 1998)
Multiple outcomes	43.9 (18)	Be Active Eat Well (Bell et al., 2008; Sanigorski et al., 2008; Swinburn et al., 2014); Community Health Promotion Grants Program (Cheadle et al., 1995; Wagner et al., 1991); Communities that Care (Hawkins et al., 2002; Hawkins et al., 2009; Hawkins et al., 2014; Hawkins et al., 2012; Oesterle et al., 2014; Rhew et al., 2018; Oesterle et al., 2018); Communities that Care: Australia (Toumbourou et al., 2019); Healthy Youth Healthy Communities (Kremer et al., 2011; Waqa et al., 2013); IDEFICS Intervention (Pigeot et al., 2015; De Bourdeaudhuij et al., 2015a; De Henauw et al., 2015; De Bourdeaudhuij et al., 2015b); Isfahan Healthy Heart Program (Sarraf-Zadegan et al., 2003; Sarrafzadegan et al., 2014; Kelishadi et al., 2012; Sarrafzadegan et al., 2006); Massachusetts Childhood Obesity Research Demonstration Project (Davison et al., 2015; Blaine et al., 2017; Taveras et al., 2015; Franckle et al., 2017); Ma'alahi Youth Project (Fotu et al., 2011a; Fotu et al., 2011b); Mebane on the Move (Benjamin Neelon et al., 2015; Martinie et al., 2012); Minnesota Heart Health Program – Class of 1989 (Perry et al., 1992; Perry et al., 1989; Kelder et al., 1993; Kelder et al., 1995); Prevention of Overweight among Pre-School and School Children Project (De Coen et al., 2012); Project Northland (Komro et al., 1999; Komro et al., 1994; Perry et al., 1993; Perry et al., 2002; Perry et al., 1996); Romp and Chomp (Bell et al., 2008; de Silva-Sanigorski et al., 2010; de Silva-Sanigorski et al., 2011; McGlashan et al., 2018; Korn et al., 2018); Shape up Somerville (McGlashan et al., 2018; Korn et al., 2018; Chomitz et al., 2012; Burke et al., 2009; Coffield et al., 2019; Economos et al., 2013; Economos et al., 2007; Economos et al., 2009; Goldberg et al., 2009; Folta et al., 2013); THAO-Child Health Program (Gómez et al., 2018; Gomez et al., 2014); the Kahnawake Schools Diabetes Prevention Project (Macaulay et al., 1997; Paradis et al., 2005); Well London (Frostick et al., 2017; Wall et al., 2009; Phillips et al., 2014)

3.2. Aim 2: systems typology

The developed systems typology is presented in Table 2 and illustrated in Fig. 1. Based on reviewing the interventions for how the sensor function was specified in the whole-of-community interventions, three mutually exclusive codes were operationalized: 1) no data feedback, 2) implementation feedback, and 3) continuous feedback for community change. A subset of projects illustrated no data feedback, in which there was no specification of feedback of information to the community to inform decision-making throughout the intervention. A subset of projects illustrated implementation feedback, in which data was fed back to the

community to improve implementation of the established intervention (e.g., to improve fidelity or accountability to implementation). The remaining interventions illustrated continuous feedback for community change, evidenced by specification of an iterative cycle of assessment and improvement using collected information to make decisions related to intervention implementation and health outcomes in the community.

Table 2. Systems typology of whole-of-community interventions.

Element	Definition
Sensor	
Data and feedback	
1. No data feedback	No specification of data feedback to the community
2. Implementation feedback	Iterative data feedback to the community throughout the intervention to improve implementation
3. Continuous feedback for community change	Data feedback to the community throughout the intervention for cyclic community and intervention assessment and improvement
Controller	
Coalition	
1. No coalition	No specification of a group of local stakeholders working together to support the intervention
2. Presence of a coalition	Specification of a local group of stakeholders working together to support the intervention
Intervention	
1. Evidence-based program without community choice or adaptation	Implementation of a standardized evidence-based intervention program without specification of community involvement in choice, adaptation, or design of the intervention
2. Evidence-based program with community choice	Community chooses evidence-based intervention program or activities for implementation from options provided by the research team
3. Evidence-based program with adaptation	Community adapts evidence-based intervention program or activities from the research team for local implementation
4. Evidence-based program with community choice and adaptation	Community chooses evidence-based intervention program or activities from options provided by the research team and adapts for local implementation
5. Co-design	Shared design of the intervention between research team and community
6. Local design	Community locally designs the intervention, and research team involvement is limited to evaluation
Effector	
Community implementer	
1. No community implementer	Community members are not involved in implementing the intervention
2. Community implementer	Community members are involved in implementing the intervention

The included interventions illustrated the controller function under two categories: a coalition and the intervention. Coalition codes were operationalized as: 1) the absence of a coalition or 2) the presence of a coalition. The presence of a coalition illustrates a local controller or coordinating group in the community supporting the intervention. Conversely, absence of a coalition suggests that there is no local coordinating group fulfilling the controller function, and the function is fulfilled elsewhere (e.g., by the research team or a funding

agency). Various terms illustrated the presence of a coalition, including task force, advisory board, and action team.

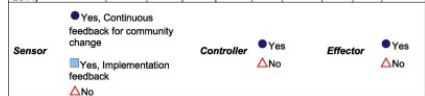
A feedback control system function provides a process for finding effective and optimal intervention solutions for population health improvement. The controller process was defined as an intervention code, which operationalized varying levels of community involvement in intervention design. This resulted in six mutually exclusive codes: 1) evidence-based program (EBP) without community choice or adaptation, 2) EBP with community choice, 3) EBP with adaptation, 4) EBP with community choice and adaptation, 5) co-design, and 6) local design. The code for EBP without choice or adaptation resulted from studies illustrating intervention programs that were selected and/or designed by the research team and static, with no specification of community choice or adaptation. The community choice code resulted from projects stating community selection of intervention programs or activities from options provided by the research team. In another subset of projects, communities adapted or tailored interventions to fit their local contexts, leading to the code for EBP with adaptation. Further, a subset of projects demonstrated both community choice and adaptation. Community involvement in intervention design resulted in the co-design code, illustrated by explicit statement of community involvement in intervention planning and design, collaborative or joint decision-making, and/or use of a community-based participatory research (CBPR) approach. The final intervention code resulted from a subset of interventions designed by the community, with research team involvement limited to evaluation. Community involvement in choosing, adapting, or designing the intervention suggests that the controller is located within the community system rather than outside of the system and the community is involved in decision-making.

Finally, we reviewed the included projects for where the effector function was located. The resulting codes were: 1) no community implementer or 2) community implementer. The community implementer code was evidenced by specification of community involvement in implementation of the intervention, illustrating that the community is involved in fulfilling the effector function. No community involvement in implementation suggests that the effector function is fulfilled outside of the community system (e.g., by the research team).

Table 3 shows the coding results of the included whole-of-community interventions by the control system functions using the developed typology. Note, this table reflects observation of reporting of elements by the study authors in coded papers rather than what might have happened in actual community implementation. See Appendix C for the coding table with specification of how each function was reported in the interventions. Overall, a majority of included projects ($n = 34$) lacked evidence of data feedback to the community. Implementation feedback was illustrated in two projects, and continuous feedback for community change was illustrated in five projects.

Table 3. Results of the application of the systems typology.

Project	Sensor		Controller						Effector	
	Data and Feedback	Coalition	Intervention						Local Design	Community Implementer
			Evidence-Based Program (EBP)			Adaptation				
			EBP without Choice or Adaptation	Choice	Adaptation	Choice & Adaptation	Co-Design			
Ma'alalah Youth Project (Fotu et al., 2011a; Fotu et al., 2011b)	△	●	△	△	△	△	△	△	●	
Massachusetts Childhood Obesity Research Demonstration Project (Davison et al., 2015; Blaine et al., 2017; Iavaras et al., 2015; Franckle et al., 2017)	△	●	△	△	△	△	△	△	●	
Meats on the Move (Benjamin Neelon et al., 2015; Marinis et al., 2012)	△	●	△	△	△	△	△	△	●	
Minnesota Heart Health Program - Class of 1989 (Perry et al., 1992; Keider et al., 1993; Keider et al., 1995)	△	●	△	△	△	△	△	△	●	
Nikos Sanos, Familia Sana (Sadeghi et al., 2017; de la Torre et al., 2015)	△	●	△	△	△	△	△	△	●	
Prevention of Overweight among Pre-School and School Children Project (De Coen et al., 2012)	△	●	△	△	△	△	△	△	●	
Prevention of Underage Drinking on California Indian Reservations (Moore et al., 2018; Gilder et al., 2017; Lee et al., 2011; Moore et al., 2012)	△	●	△	△	△	△	△	△	●	
Prevention Trial in the Cherokee Nation (Komro et al., 2017; Komro et al., 2015; Livingston et al., 2018)	●	●	△	△	△	△	△	△	●	
Project ACTIVITY (Arora et al., 2010a; Harrell et al., 2016; Arora et al., 2013; Arora et al., 2010b)	△	●	△	△	△	△	△	△	●	
Project FIT (Alaimo et al., 2015; Eisenmann et al., 2011; Paek et al., 2014; Paek et al., 2015)	△	●	△	△	△	△	△	△	●	
Project Northland (Komro et al., 1999; Komro et al., 1994; Perry et al., 1993; Perry et al., 2002; Perry et al., 1996)	△	●	△	△	△	△	△	△	●	
Project Northland Chicago (Komro et al., 2004; Komro et al., 2008)	△	●	△	△	△	△	△	△	●	
Project SixTeen (Biglan et al., 2000)	△	●	△	△	△	△	△	△	●	
Reducing Youth Access to Alcohol: Oregon (Flewelling et al., 2013)	△	●	△	△	△	△	△	△	●	
Romp and Chomp (Bell et al., 2008; de Silva-Sanigorski et al., 2010; de Silva-Sanigorski et al., 2011; McGlashan et al., 2018; Korn et al., 2018)	●	●	△	△	△	△	△	△	●	
Shape up Somerville (McGlashan et al., 2018; Korn et al., 2018; Chomitz et al., 2012; Burke et al., 2009; Coffield et al., 2019)	△	●	△	△	△	△	△	△	●	
Economos et al., 2007; Economos et al., 2007; Economos et al., 2007	△	●	△	△	△	△	△	△	●	
2009; Goldberg et al., 2009; Folla et al., 2013)	△	●	△	△	△	△	△	△	●	
Social Marketing and Community Mobilisation in Australia (Rowland et al., 2018; Rowland et al., 2013)	△	●	△	△	△	△	△	△	●	
Strategic Prevention Framework (Anderson-Carpenter et al., 2016)	●	●	△	△	△	△	△	△	●	
SunSafe (Grant-Peterson et al., 1999; Dietrich, 2000; Dietrich et al., 1998; Dietrich et al., 2000)	△	●	△	△	△	△	△	△	●	
SunSafe in Middle School (Olson et al., 2007)	△	●	△	△	△	△	△	△	●	
Thao-Child Health Program (Gomez et al., 2018; Gomez et al., 2014)	△	●	△	△	△	△	△	△	●	
The Kahawake Schools Diabetes Prevention Project (Macaulay et al., 1997; Paradis et al., 2005)	△	●	△	△	△	△	△	△	●	
The New Hampshire Study (Stevens et al., 1993)	△	●	△	△	△	△	△	△	●	
The Iloga County Fit for Life Project (Gombosi et al., 2007)	△	●	△	△	△	△	△	△	●	
Tobacco Policy Options for Prevention (Blaine et al., 1997; Forster et al., 1998)	△	●	△	△	△	△	△	△	●	
Wagschausen ist keine Lösung (Looking Away is not a Solution) (Kraus et al., 2013)	△	●	△	△	△	△	△	△	●	
Well London (Frostick et al., 2017; Wall et al., 2008; Phillips et al., 2014)	△	●	△	△	△	△	△	△	●	



A majority of included projects ($n = 37$) illustrated a local controller by involving a group of stakeholders working together to support the intervention, while four projects lacked evidence of a coalition.

A total of seven projects demonstrated implementation of standardized evidence-based programs without community choice or adaptation. A total of five projects illustrated community choice of intervention programs or activities, six projects illustrated adaptation of the intervention for local implementation, and three projects illustrated a combination of community choice and adaptation. A total of 17 projects illustrated co-design of the intervention by the research team and communities in which the interventions were implemented. Finally, three projects lacked research team involvement in designing the intervention.

In all included projects, community members were involved in implementing intervention components.

4. Discussion

The broad goal of this review was to describe whole-of-community approaches to improve population health outcomes for youth cancer prevention and to develop and apply a control systems typology to frame the

literature. We developed a typology based on fundamental control systems theory that illustrates the functions necessary for coordinating social systems and used the typology to assess inclusion of the functions in whole-of-community interventions targeting cancer risk factors in youth. A majority of the included interventions illustrated a local controller in the form of a coalition and local decision-making through community choice, adaptation, or co-design of the intervention. In all included interventions, the communities functioned as an effector by implementing intervention components. Importantly, the sensor function is lacking in whole-of-community interventions.

A predominant approach in community health promotion efforts is the scaling of health interventions. In such approaches, effective interventions are implemented more widely to have a broader impact (Milat et al., 2013). As there is insufficient evidence that fidelity to evidence-based interventions in a “one-size-fits-all” approach is the solution to population health problems, there has been a push for studying the adaptation of such interventions to increase effectiveness within the context of the systems in which they are delivered (Chambers and Norton, 2016; Wiltsey Stirman et al., 2019). Another widespread approach is the participatory approach, such as CBPR (Wallerstein et al., 2017; Ortiz et al., 2020). It is suggested that community engagement allows for even greater understanding of local contexts and unique community assets and needs (National Academies of Sciences, Engineering, and Medicine, 2017). However, studying interventions within the context of a single community may put gaining generalizable knowledge at risk. Adaptation and community participation show an attempt to improve community health promotion efforts, but strong evidence on effective routes for improving population health in dynamic community social systems is lacking.

Despite the push for determining how to scale population health interventions and engage communities in intervention efforts, these approaches are examined irrespective of how control systems are structured and the functions by which a community system is coordinated. The lack of evidence on how to impact population health highlights the need to draw on consensus of evidence of the architecture necessary to deliver essential community system coordination functions for population health improvement. Research on community coordination for natural resource management by Elinor Ostrom, leading to the Nobel Prize in economics, shows one-size-fits-all approaches are not effective, and community self-management is one route to effective community change, but is not the only or necessarily always the best route for community improvement (Ostrom, 2010). Thus, there is a need to better understand the generalizable elements of community systems and the functions necessary to coordinate improvement. Kilbourne and colleagues illustrate a move in this direction in a recent review that highlighted common elements of successful implementation studies (Kilbourne et al., 2020). The elements, including quality improvement, a shared agenda with stakeholders, and empowering implementers, align with fundamental control system functions (Kilbourne et al., 2020). Drawing from control system evidence can accelerate progress in identifying the infrastructure and functions necessary to coordinate a system and improve population health.

The sensor, controller, and effector operating together is integral to a self-regulated system for improving community population health. The sensor collects information on what is occurring in the system, allowing the controller to make decisions and the effector to implement actions to move the system toward a desired state. The functions operate collectively in a feedback loop, rather than in isolation. This allows for data-informed continuous learning and improvement, as illustrated by the LHS in healthcare (Friedman et al., 2017; Sheikh, 2020). Despite the importance of this, a majority of included whole-of-community interventions lacked evidence of the sensor function. Continuous feedback is needed not only to improve implementation but inform whether the intervention being delivered is the best solution to move the community system to the desired state. The control system functions are critical for collecting information on what is occurring in the system and making and implementing decisions to find the best solution for improving population health based on local, dynamic conditions.

It is important to note that coding of the included interventions using the developed typology was limited to author-specification in the published studies. Information was obtained from multiple published studies, if available, but did not include contacting authors directly or other non-published information. Most interventions in this review specified a coalition and community involvement in choosing, adapting, or designing the interventions, demonstrating community involvement in decision-making. However, due to insufficient detail, we were unable to understand more specifics related to the coalitions in these interventions, such as how they coordinated the interventions, the level of engagement, and whether communities had autonomy in decision-making. This challenge in understanding what actually occurred in the interventions is consistent with previous reviews of the literature, which have highlighted the need for stronger reporting to understand community-engaged research (Ortiz et al., 2020) and the extent of research-practice partnerships (Ovretveit et al., 2014). Thus, there is a need for future research to provide sufficient detail for understanding approaches used in whole-of-community interventions.

4.1. Study limitations and strengths

There are limitations of this review. The search strategy was limited to English language, published studies only, creating potential for selection bias. Understanding of the interventions was limited to what was explicitly reported by the authors, and insufficient detail made it difficult to understand what actually occurred in the interventions. The typology includes codes that address only the presence or absence of components, such as a coalition, and there may be important additional information within these codes, such as the level of coalition engagement. Whole-of-community interventions were operationalized as those that addressed more than one setting in the community. However, two settings may not fully capture whether interventions were delivered across the whole-of-community. Due to the inclusion of a wide diversity of outcomes, intervention effectiveness by the developed typology was not examined. Future reviews should further examine effectiveness of various approaches.

This review has several strengths. The literature search and selection processes were well-constructed, as the search strategy was created by a medical librarian and supplemented by hand-searching. A rigorous, iterative process was undertaken by the authors to develop a novel typology for describing whole-of-community interventions and the necessary control system elements. Furthermore, this is the first review to synthesize the literature on whole-of-community interventions targeting geospatial areas on six modifiable risk factors in youth for cancer prevention. The developed typology is a preliminary attempt at framing population health improvement efforts in whole-of-community interventions based on critical control system functions. Future studies should further examine the typology and its application, including its reliability, validity, and application to studies beyond the 41 interventions included in this review.

5. Conclusion

Whole-of-community interventions have been recommended for impacting population health and improving cancer risk factors in youth. However, these interventions have been examined in absence of the critical control system elements necessary for improving outcomes of a community social system. This scoping review systematically synthesized whole-of-community interventions for cancer prevention in youth and developed and applied a typology for such interventions by drawing on fundamental control systems theory. Drawing on control system evidence allows for better alignment of implementation science and improvement science to optimize the synergy for cancer prevention (Koczwara et al., 2018). Further, a control system informs how to drive a system to a desired state, as illustrated by LHS using health data for continuous learning and improvement to advance healthcare (Platt et al., 2020; National Academy of Medicine, 2017; Friedman et al., 2017). This review extended the concept of the LHS beyond healthcare to whole-of-community interventions for population health improvement and cancer prevention in youth. The iterative study review process allowed us

to operationalize how the sensor, controller, and effector functions are specified in whole-of-community interventions. Without a typology it is difficult to study interventions, understand what has been done to impact community population health, and identify approaches contributing to intervention effectiveness. This review fills a gap in the literature by providing a preliminary, simplified control systems typology for framing whole-of-community intervention efforts based on the foundational knowledge of how systems operate and the key functions necessary for coordination. Future research should further examine whole-of-community intervention approaches by drawing on control systems, as this may aid in understanding how to impact community population health.

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Conflicts of interest

The authors declare there are no conflicts of interest.

Ethical compliance

The study is exempt from ethical compliance.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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