

Association between multi-component initiatives and physical activity-related behaviors: interim findings from the Healthy Schools Healthy Communities Initiative

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Abstract

Background: Little is known about the intensity of multi-component initiatives (MCI) inclusive of any combination of programs, practices, policies, and environmental changes (P3E) on youth behaviors.

Methods: The Healthy Schools Healthy Communities (HSHC) initiative worked to increase access to PA opportunities as part of 33 MCIs targeting school districts and respective communities. The purpose of this study was to assess whether MCIs with higher scoring PA-related strategies were associated with improved PA and sedentary behaviors among youth. PA-related interventions were assigned point values based on three characteristics: 1) purpose of initiative); 2) duration; and 3) reach. An overall composite score of all activities was calculated for each school district. Multivariate longitudinal regressions were applied, controlling for measurement period, Cohort, and district enrollment.

Results: P3E scores ranged from 0.3 to 3.0 with 20% considered “higher-scoring” (score > 2.1) and 47% considered “lower-scoring” (< 1.2). Average composite district P3E scores more than tripled over the evaluation period, rising from 14.8 in the first grant year to 32.1 in year 2, 41.1 in year 3, and 48.1 in year 4. For each additional point increase in average composite district P3E intensity score, the number of days per week that students reported being physically active for at least 60 minutes increased by 0.010 ($p < 0.01$). For each additional point increase in district P3E intensity score, the number of hours per weekday that students reported engaging in screen time activities decreased by 0.006 hours ($p < 0.5$).

Conclusions: MCIs are difficult to evaluate given the variations within which they are implemented. Findings from this study suggest the value of a systematic scoring approach in assessing MCIs. In addition to tracking intensity over time, scoring can provide justification for, or against, an individual activity and ways to increase the likelihood of the MCI impacting population-health outcomes.

Background

Childhood obesity remains a public health priority across the United States (U.S.) (1). The risk for overweight and obesity can be greatly decreased when youth engage in 60 minutes of moderate-to-vigorous physical activity (MVPA) per day (2). Leading agencies such as the US Department of Health and Human Services (HHS) (2, 3) and Institute of Medicine Efforts (IOM) (4) recommend obesity prevention efforts promote MVPA (2) and limit sedentary time (5). Traditional public health efforts primarily targeted the individual, and emphasized education and behavioral skills training, which have not resulted in sustained behavior change (4, 6, 7). Today, more successful public health approaches are multi-component initiatives (MCIs) closely aligned with the Social-Ecological Model (SEM), which considers the complex interactions between individual, interpersonal (e.g., family), organizational (e.g., schools), and community (e.g., streets) levels (8). In addition to educating or enhancing individual-level skills through programs/events, MCIs also ensure places support healthy behavior through practice, policy, and environmental changes (4, 6, 7).

Children spend almost half of each calendar year in school, and average seven hours per day on school grounds (9). To ensure children meet the recommended 60 minutes of MVPA per day, and are able to maintain a healthy weight, it is important that places like schools and the surrounding community support children and their families. Organizations such as The Alliance for a Healthier Generation (Alliance) and the Centers for Disease Control and Prevention (CDC) have identified numerous school-based evidence-informed strategies including implementing Comprehensive School Physical Activity Program (CSPAP) (10, 11). A CSPAP is a MCI approach by which school districts coordinate opportunities across the five components: 1) quality physical education (PE); 2) PA during the school day (PADS); 3) PA before and after school (B/A PA); 4) staff involvement (SI); and 5) family and community involvement (FCE) (11).

Because of their more comprehensive nature, MCIs typically have a greater reach and show promise of being effective, equitable, and sustainable (8, 12–20). Yet, they are extremely challenging to evaluate given the way they are implemented—

by various individuals, at different times, with different components, across varying geographies—and as such, strategy exposure varies (20, 21).

Further complicating the evaluations of MCIs is that population-level health behaviors (e.g., increased youth physical activity) and outcomes (e.g., reduced childhood obesity) take time; detecting changes in the short-term is difficult. While these challenges have likely impacted our understanding on the effectiveness of a complete CSPAP (22), there are a number of successful MCIs (12–15, 17–19, 23). For example, Shape Up Somerville, a comprehensive intervention that included activities developed to influence every part of an elementary school child's day, was found to decrease BMI z-score in children at high risk for obesity (24). The Fleurbaix–Laventie Ville Sante´ (FLVS) study (15) found that over a long period of time, MCIs with various strategies (e.g., new sporting facilities were built, educators were employed to promote physical activity in primary schools, and family activities were organized) had a synergistic effect on overweight prevalence. These types of rigorous evaluations, however, may not always be feasible when assessing the long-term effectiveness of MCIs.

In recent years, efforts to assess the impact of MCIs have expanded (17, 25–29). Largely building on the RE-AIM (reach, effectiveness, adoption, implementation, and maintenance) framework (30), many evaluations have assessed a combination of attributes among all strategies within an initiative (17, 25–29). Cheadle et. al. (31), developed and assessed reach, efficacy and strength of single strategies implemented as part of the Kaiser Permanente (KP) Community Health Initiative (CHI). Strategies with higher reach and strength were correlated with improved health behaviors (31).

Similarly, the Healthy Communities Study (HCS) assessed the relationship between child obesity and characteristics of 130 MCIs across the U.S. Each strategy within the MCIs was assessed, and overall MCI “intensity” scores were calculated. Building on RE-AIM, HCS researchers identified three attributes as important predictors of population health—the purpose (or behavioral intervention), duration, and reach (17, 26). In summary, the purpose of a strategy is how it impacts behavior, whether it be to increase the skills of an individual or to change broader conditions in communities (32). When a strategy improves access, reduces barriers, or changes broader conditions, there is a greater likelihood that behavior change will be sustainable (compared to simply enhancing the knowledge or skills of an individual) (4, 6, 7). Evidence also suggests that when more people are exposed, and for longer periods of time, the greater the likelihood that the strategy will lead to desired outcomes (26, 27, 31).

These types of studies have made an impactful contribution to the field by establishing a systematic way for measuring MCIs. Specifically, the HCS advanced the methodology for evaluating, more synergistically, the strategies within a MCI. That said, further exploration of this methodology is warranted to better understand the intensity necessary to achieve improvements in behaviors like physical activity and sedentary time, which are key to addressing childhood obesity.

Purpose and Objectives

The primary purpose of this specific investigation was to assess whether higher intensity PA-related strategies (those aiming to increase PA and/or reduce sedentary time) implemented as part of 33 multi-community MCIs were associated with improved physical activity-related behaviors among youth. Using the methodology proposed by HCS, this investigation capitalized on data collected during the first four years of a multi-year, MCI implemented throughout Missouri.

Intervention Approach

The Healthy Schools and Healthy Communities (HSHC) was implemented across 33 Missouri school district and their respective communities. It was established by the Missouri Foundation for Health (MFH) to address childhood obesity

targeting thousands of youth in grades K–8. Funding was intended to build on existing school and community assets to stimulate implementation of new and/or advanced efforts for increasing access to healthy food and PA in vulnerable communities throughout the foundation’s catchment area (see <https://mffh.org/the-foundation/where-we-work/>). As per the logic model, technical assistance and increased linkages within and across grantees, resources, and funding were intended to lead to short-term outcomes (e.g., establishment of strong, durable partnerships; regular collaboration and communication), intermediate outcomes (e.g., increased capacity to implement P3Es, improved perceptions and behaviors regarding PA), and ultimately, long-term outcomes (e.g., increased percentage of youth at a healthy weight). HSHC began with a cohort of 13 school districts in 12 communities in fall 2013 (Cohort 1), and expanded over the following two years. In 2014, HSHC added 11 new school districts and one new community (Cohort 2); in 2015, an additional 9 school districts were added (Cohort 3).

School and community coordinators conducted wellness assessments and created action plans to achieve the long-term goal of reducing childhood obesity. School action plans were guided by the Alliance for a Healthier Generation’s Healthy Schools Program Framework of Best Practices (Alliance Framework) (10) and addressed school food, physical education/activity, health education, school policy, and family engagement. Community action plans were informed by the YMCA’s Community Healthy Living Index (CHLI) (33) and addressed barriers to healthy eating and active living for children in targeted communities. Action plans were prepared by HSHC grantees every 12-to–18 months and approved by MFH. Across schools and communities, both the action plans and stakeholders implementing the activities varied greatly, however they all included any combination of CSPAP activities. Informed by the Alliance Framework and CHLI, the MCIs aimed to: 1) increase knowledge and awareness, enhance skills, support behavior change, and motivate the community, and 2) modify broader conditions to increase access to healthy food and opportunities for PA. Common strategies were walk-to-school days, health and wellness fairs, joint-use-agreements, and installation of playground equipment or walking trails. Table 1 provides examples and an overview of these activities, as recorded by school and community coordinators in real-time, by year.

Table 1. Activity Types Implemented Over the First Four Years, Missouri HSHC^a 2013–2017

Type	Purpose	Examples ^a	Measure	Activities and Population Reach ^c				
				Year 1	Year 2	Year 3	Year 4	Total
P3E ^b				Year 1 2013–2014	Year 2 2014–2015	Year 3 2015–2016	Year 4 2016–2017	
Programs & events (P)	Activities to provide information, enhance skills, & support behavior, practice, policy, and environmental change	<ul style="list-style-type: none"> · Walking/running clubs · Walk-to-school days · Health and wellness fairs 	programs/events (n)	145	388	560	610	1,703
			people reached ^c (n)	36,910	118,337	118,748	138,217	412,212
Practice, policy, and environmental change (PPE)	Changes or improvements in operations, documents, or infrastructure to increase access, improve places, and ensure sustainability	<ul style="list-style-type: none"> · Teachers implement classroom physical activity breaks · Trails used to provide hands-on learning · Joint-use agreements signed · School wellness policies & city/town plans revised · Trails/tracks/sidewalks built · Playground equipment installed 	strategies (n) people reached ^c (n)	18 1,567	123 58,585	209 310,565	121 431,113	471 801,830

^aAcross each multi-component initiative any combination of these activity types were implemented at varying times throughout the four years.

^bPrograms/events and practice, policy, and environmental changes (P3E) presented here only include those with a focus on physical activity and/or physical activity and healthy eating.

^cReach was defined as the number of individuals who either participated (e.g., program) or could have been exposed based on where the intervention was implemented (e.g., school wellness policy).

Methods

John Snow, Inc. (JSI), a research and consulting firm specializing in the implementation and evaluation of community-wide initiatives, was contracted by the Missouri Foundation for Health (MFH) to conduct a mixed-methods evaluation during the first half of the HSHC initiative (2013–2017). This study was reviewed by John Snow Inc. IRB (OHRP IRB00009069) and deemed exempt. The evaluation was guided by the work of HSHC logic model and assessed the activities set forth in each district and respective community’s action plans. Various methods were used to capture both quantitative and qualitative data including: 1) Health-e-link, an online data platform which allowed grantees to document their activities (e.g., number of P3Es and people reached) in real-time; 2) interviews with grantees; and 3) student surveys administered at school to all students in 5th–8th grades at baseline (in the fall) and once a year thereafter (in the spring) to assess PA behaviors and perceptions.

Regardless of how intentional or coordinated, each P3E activity was included in the evaluation if it was a reported by the coordinators. For this investigation, however, activities were only included in the analysis if they targeted physical activity

and/or sedentary behavior across the participating schools and communities (Table 1). Activities that only addressed healthy eating and those that were not reported by local champions between September 1, 2013 and July 31, 2017, were not included in these analyses (see Figure 1 for an evaluation overview).

INSERT FIGURE 1 HERE

Independent variables

Individually, four evaluation team members assigned point values for every activity based on the three attributes used in the HCS: 1) purpose (i.e., providing information, enhancing skills or services, modifying access, changing consequences, or changing broader conditions); 2) duration (i.e., occurring just once, several times, or ongoing); and 3) reach or penetration of the activity (i.e., the proportion of the total city/town population that either participated or could have been exposed based on where the intervention was implemented). Each attribute was scored on a scale of 0.1 (minimum), 0.55 (medium), or 1.0 (maximum) and summed to calculate an intensity score for every activity (Σ purpose value + duration value + reach value). Scores ranged from 0.3 (weakest and potentially of less influence on longer-term outcomes) to 3.0 (strongest and potentially more sustainable and of greater influence). To ensure inter-rater reliability, an agreement across the study team of at least 80% was accomplished. Scoring examples are provided in Table 2.

Table 2. Protocol for Assigning Intensity Score, Missouri HSHC 2013-2017

Dimension	Rubric for Scoring Intensity (0.1=low;1.0=high)	Related Examples
Purpose	<p>High (1.0): Modifying policies, systems, and access</p> <p>Med (0.55): Enhancing services and support</p> <p>Low (0.1): Providing information; enhancing skills</p>	<p>High: A long-term transportation plan was passed and included a sales tax to generate revenue to support pedestrian and transportation infrastructure</p> <p>Med: Physical activity opportunities were offered as a reward in place of food but was not a mandated policy</p> <p>Low: Fun fit night for families to engage in activities together</p>
Duration	<p>High (1.0): Ongoing, throughout the year</p> <p>Med (0.55): More than once per year</p> <p>Low (0.1): One-time event</p>	<p>High: Joint-use agreement in place to enable school grounds to be used for physical activity after school hours</p> <p>Med: Walking challenge occurring twice throughout the year</p> <p>Low: 5k Run</p>
Reach ^a	<p>High (1.0): 21% or more of the population</p> <p>Medium (0.55): 6-20% of the population</p> <p>Low (0.1): 0-5% of the population</p>	<p>High: Livable Streets policy</p> <p>Medium: Revised wellness policy impacted schools districtwide</p> <p>Low: A rock wall was installed at a middle school</p>

^aTargeted population was calculated using U.S. Census data for each targeted city/town

To account for sustainability, strategies classified as ongoing (i.e., assigned a duration score of 1.0) were included in the initial year of implementation and each subsequent year. For example, if a new park was installed in 2014, it would be accessible not only in 2014, but also in 2015, 2016, and 2017. An overall composite score comprised of all reported activities was then calculated for each school district and its respective community (henceforth referred to as “average composite district P3E intensity score”). Individual community-level P3E intensity scores were included in each school district’s average composite P3E intensity score in cases where multiple school districts were located in the same community, or served by the same community-based organization funded to implement HSHC activities. Thus, a single activity adds to the overall intensity score of each school district.

District Cohort: HSHC began with a cohort of 13 school districts in 12 communities in fall 2013 (Cohort 1) and was expanded by MFH over the next two years. In 2014, HSHC grew to include 12 new school districts and one new community (Cohort 2); in 2015, an additional 9 school districts were added (Cohort 3).

Time since enrolling in HSHC (Grant year): Grant year was defined as the number of years in which school districts were enrolled in HSHC. Because school districts enrolled in HSHC between the of fall of 2013 and 2015, the baseline of zero grant years (and subsequent years) corresponds to different calendar years depending on each school district's cohort. The first grant year for Cohort 1 was 2013, Cohort 2 was 2014, and Cohort 3 was 2015.

Student enrollment size: The total number of students enrolled in the targeted grades for HSHC (K–8) was determined annually by the Missouri Department of Elementary and Secondary Education's website (<https://mcids.dese.mo.gov/quickfacts/Missouri> School Directory). School districts were classified into a continuous format ranging from 1 to 63 for every 100 students (enrollment sizes of 1–100 students were assigned a value of 1, sizes of 101–200 students a value of 2, etc.).

Dependent Variables

PA. A self-reported survey was administered by classroom teachers to all 5th–8th grade students enrolled in the school districts. The survey was conducted in the spring of year 1 enrollment into HSHC (which was different for each cohort) and each subsequent school year. Standard questions on physical activity behaviors and perceptions were incorporated into the survey. Prior to administering the survey, the reading level of each survey question was verified (which averaged a 6th grade reading level) and piloted with a number of 5th and 6th graders. Students were asked, "During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day? Add up all of the time you spent in any kind of physical activity that increased your heart rate and made you breathe hard for some of the time." PA time was defined as the number of days students reported engaging in PA for at least 60 minutes.

Sedentary time. Using the same self-reported survey as defined above, students were asked about their sedentary behavior on an average school and weekend day. The questions were informed by the literature documenting recommended assessments of sedentary behaviors (34). Questions read the same with the exception of the day (school day and weekend day). "On an average "X" day, how many hours do you watch TV, play video games or computer games, or use a computer for something that is not school work? Count the time spent on things such as Xbox, PlayStation, an iPod, and iPad or other tablet, a smartphone, YouTube, Facebook or other social networking tools like Twitter or Pinterest, and the internet". Sedentary time was defined as the number of hours per school and weekend day spent engaging with such technology.

Outcomes were operationalized as the average district number of days reported being physically active for a total of at least 60 minutes per day during the past 7 days, and average district number of hours of sedentary time per school and weekend day.

Analysis

Data were aggregated at the school-district level for each school year, beginning September 1, 2013 through July 31, 2017. This includes both school and community activities. Descriptive statistics were generated to describe the average composite district P3E intensity scores and each of the three outcomes over time and by cohort. ANOVAs were run to detect significant differences between cohorts and outcome measures at baseline. Pearson's correlation was conducted to evaluate the crude association between average composite district P3E intensity scores and the three outcomes. To account for the correlation of repeated measurements within school districts, number of days per week physically active,

and both number of hours engaged in sedentary time outcomes were analyzed using linear mixed-effects models for repeated measures (repeated observations nested within districts). Models included a random effect for district. All models controlled for district cohort (1, 2, or 3), student enrollment size, and time since enrolling into HSHC. Controlling for these factors is important given the variations among schools and communities and the time within which they entered into HSHC. A variance components covariance structure was used; p-values and confidence limits for the differences in grant time (fixed effects) least squares means were adjusted for multiple comparisons using the Bonferroni correction. Analyses were conducted in SAS 9.4 (SAS Institute, Inc. Cary, NC).

Results

PA-related P3E strategies by CSPAP

There were 2,174 PA-related strategies implemented over the four years (Figure 2). Almost one-third (31%) of the strategies were FCE; 19% of the activities were BAPA with the majority of them occurring primarily afterschool (n = 218); and 16% were PADS. Fifteen percent (15%) of the activities were either environmental or policy changes which occurred in the school and/or community.

INSERT FIGURE 2 HERE

PA-related P3E Score by Attribute

Across all activities, purpose, duration, and reach were score. Out of the 2,174 PA-related P3Es implemented from 2013–2017, over half (56.2%) were low-scoring in purpose (0.1), 31.6% were medium scoring (0.55), and 12.2% were high-scoring (1.0). This trend was similar for duration where 49.2% of all P3Es were low-scoring in duration, 39.1% were medium-scoring, and 11.7% were high-scoring. Finally, among the reach attribute score components, 51.7% were low-scoring, and almost one-quarter (24.4% and 24.0%) were both medium and high-scoring, respectively.

PA-related Average Composite Districts P3E Intensity Score

All 2,174 PA-related P3Es were implemented and scored across the 33 school districts and respective communities. Overall, P3E activity scores ranged from 0.3 to 3.0, with 20% considered “higher-scoring” (a score of 2.1 or higher) and almost half (47%) considered “lower-scoring” (score of 1.2 or below). Activities defined as ongoing were treated as “active” in each subsequent year after its reported adoption/installment, unless otherwise reported as over. Therefore, the P3E activity score of any activity with a duration score of 1.0 was carried forward each grant year and contributed to the average composite district score. Across all years and districts, the average activity score was 1.33 per activity.

Average composite district P3E intensity scores rose from 14.8 in the first grant year to 32.1 in year 2, 41.1 in year 3, and 48.1 in year 4 (Table 3). The total mean PA-related composite district P3E score for all Cohort 1 districts increased with every subsequent year engaged in HSHC except in the last year, rising from a mean of 15.4 in the first year to 48.1 in the fourth year. At the time of analysis, Cohort 2 was involved in HSHC for three years with an average composite district intensity P3E score of 15.3 in the first year and 31.2 in the third year. Cohort 3 was involved for two years and had a lower average composite district intensity P3E score both years compared to Cohorts 1 and 2 (average of 13.4 and 27.0, respectively). Cohort 1 P3E scores were higher every grant year (2014–2017) compared to Cohorts 2 and 3, and Cohort 2 scores were higher than Cohort 3’s scores, where comparisons were possible.

Table 3: Characteristics of Districts, Missouri HSHC 2013-2017

Year in HSHC (actual Year)	N	Number of days/week physically active for 60+ minutes (SD)	Number of screen time hours per weekday (SD)	Number of screen time hours per weekend day (SD)	Total Number of Activities	Average Composite District Intensity Score (SD)	Average P3E Intensity Score per Activity
Baseline^a		4.4 (0.5)	2.4 (0.4)	3.1 (0.3)	0.0	0.0	0.0
Cohort 1 (2013)	13	4.2 (0.4)	2.5 (0.3)	3.2 (0.2)	0.0	0.0	0.0
Cohort 2 (2014)	12	4.7 (0.5)	2.3 (0.4)	3.1 (0.3)	0.0	0.0	0.0
Cohort 3 (2015)	10	4.2 (0.5)	2.4 (0.5)	3.0 (0.4)	0.0	0.0	0.0
Year 1		4.8 (0.5)	2.4 (0.4)	3.0 (0.3)	417	14.8 (8.7)	
Cohort 1 (2014)	13	4.7 (0.4)	2.5 (0.3)	3.1 (0.2)	163	15.4 (10.3)	1.24
Cohort 2 (2015)	12	5.1 (0.6)	2.4 (0.3)	3.0 (0.3)	144	15.3 (8.3)	1.27
Cohort 3 (2016)	10	4.7 (0.6)	2.4 (0.5)	2.9 (0.3)	110	13.4 (7.2)	1.04
Year 2		4.7 (0.6)	2.5 (0.3)	3.0 (0.3)	836	32.1 (15.5)	
Cohort 1 (2015)	13	4.7 (0.3)	2.5 (0.3)	3.1 (0.3)	377	37.0 (19.8)	1.28
Cohort 2 (2016)	12	5.0 (0.9)	2.6 (0.4)	3.0 (0.3)	248	30.6 (12.4)	1.48
Cohort 3 (2017)	10	4.3 (0.5)	2.5 (0.4)	3.0 (0.3)	211	27.0 (11.1)	1.12
Year 3		4.9 (0.5)	2.5 (0.4)	3.0 (0.3)	730	41.1 (19.1)	
Cohort 1 (2016)	13	4.8 (0.3)	2.6 (0.4)	3.1 (0.4)	478	50.2 (16.8)	1.37
Cohort 2 (2017)	12	5.1 (0.7)	2.4 (0.4)	3.0 (0.4)	252	31.2 (16.9)	1.48
Year 4		4.8 (0.6)	2.6 (0.4)	3.1 (0.3)	454	48.1 (20.0)	
Cohort 1 (2017)	13	4.8 (0.6)	2.6 (0.4)	3.1 (0.3)	454	48.1 (20.0)	1.38

^aIt is likely that activities were implemented prior to the launch of HSHC, however, they were not documented and therefore assumed as 0.

^bMean number of days engaging in 60 or more physical activity and number of hours engaged in screen time per weekday and weekend day were not significantly different across cohorts at baseline (ANOVA; physical activity, p=0.1004; screen time weekday, p=0.4743; screen time weekend day, p=0.2711)

Although there were differences in the number of strategies implemented across each cohort, the average intensity varied (Figure 3). The number of Cohort 1 activities more than doubled in the second year compared to the first (n = 377 vs. 163) whereas the average intensity score per activity increased slightly (1.28 from 1.24). Cohort 2 activities did not quite double in year 2 compared to year 1 (n = 248 vs. 144), but the average intensity score per activity was higher in the second year compared to the first (1.48 from 1.27). Cohort 3 activities almost doubled in year 2 compared to year 1 (n = 211 vs. 110), but the activities had the lowest average intensity score in both year 1 (1.04) and year 2 (1.12) compared to the other cohorts' year 1 and 2 scores. In the third year, Cohort 1 implemented 478 activities compared to Cohort 2's 252, with a lower average intensity score per activity (1.37 vs. 1.48, respectively). Cohort 1 was the only one involved all four years of the study, with 454 activities implemented in year 4, averaging an intensity of 1.38 per activity.

INSERT FIGURE 3 HERE

The total mean number of days per week students reported being physically active for at least 60 minutes increased from 4.4 at baseline to 4.8 at year 4 (Table 3). While Cohort 1 showed a 0.6 day increase from baseline to year 4, Cohorts 2 and 3 showed a 0.1 day increase from baseline to years 3 and 2, respectively. The mean number of sedentary hours per weekday and weekend day remained relatively stable across all study years for all cohorts. Though there was no obvious conclusion that P3Es had a positive or negative impact on PA-related activities, these results were cumulated over all districts within each cohort, therefore individual district P3E intensity and scale could have been overshadowed in the mean. Further analyses addressed this issue by modeling PA-related outcomes and individual district mean composite P3E scores.

Student Outcomes

As indicated in Table 3, there were no significant differences at baseline across cohorts in mean number of days per week students reported being physically active for at least 60 minutes per day, or number of sedentary hours reported per school or weekend day. At baseline, the average number of days students reported engaging in PA 60 minutes or more per day over the past 7 days was 4.4. Cohorts 1 and 3 reported fewer days compared to Cohort 2 (4.2 days vs. 4.7, respectively). The number increased for each cohort after their first year in HSHC (average 4.8 days compared to 4.4 days at baseline) and remained higher than baseline each year thereafter. The number of hours engaged in sedentary time on the average weekday increased slightly from baseline, with reported cohort averages ranging from 2.3 to 2.6 across all cohorts and survey years. Students reported engaging in more hours of sedentary time on a weekend day, compared to a weekday, with averages ranging from 2.9 to 3.1.

Relationship between P3E scores and outcomes

Multivariate longitudinal regressions were applied to better understand the association between average composite district intensity scores and the identified student outcomes, controlling for measurement period, cohort, and district enrollment size (Table 4). There was a statistically significant positive correlation between number of days per week students reported being physically active for at least 60 minutes per day and average composite district P3E intensity score. For each additional point increase in average composite district intensity score, the number of days per week students reported being physically active for at least 60 minutes increased by 0.010 ($p = 0.004$). In other words, holding cohort, student enrollment size, and grant time constant, an increase of 50 points in average composite district score was associated with an average increase of 0.5 days per week of being physically active for at least 60 minutes. There was also a statistically significant negative correlation between the number of hours per weekday students reported being engaged in sedentary time and P3E intensity score. For each additional point increase in average composite district intensity score, the number of hours per weekday that students reported engaged in sedentary time activities decreased by 0.006 hours ($p = 0.016$). In other words, holding cohort, student enrollment size, and grant time constant, an increase of 55 points in average composite district score was associated with an average decrease of 20 minutes of sedentary time per weekday. Even though average number of weekday hours spent engaged in sedentary activities increased slightly over time, higher P3E intensity scores were still significantly related to lower sedentary time. There was also a negative correlation between weekend sedentary hours per day and P3E intensity score, but it was not significant ($p = 0.098$).

Table 4: Summary of multiple longitudinal regression analysis, Missouri HSHC 2013-2017**Model 1: Number of days per week physically active 60 + minutes**

	β	SE	99% CI	p-value ^a
Constant	4.437	0.11	4.295 to 4.670	<0.0001
Average Composite District Intensity Score	0.010	0.00	0.003 to 0.017	0.004
Baseline (<i>ref</i>)	.	.	.	.
1 year	0.257	0.13	-0.009 to 0.522	0.058
2 years	-0.040	0.16	-0.367 to 0.286	ns
3 years	0.039	0.20	-0.355 to 0.432	ns
4 years	0.035	0.23	-0.421 to 0.491	ns
Cohort 1 (<i>ref</i>)	.	.	.	.
Cohort 2	0.342	0.11	0.125 to 0.559	0.003
Cohort 3	0.050	0.13	-0.214 to 0.314	ns
Enrollment size	-0.015	0.00	-0.025 to -0.006	0.002

Model 2: Number of screen time hours per weekday

	β	SE	99% CI	p-value ^a
Constant	2.420	0.08	2.256 to 2.583	<0.0001
Average Composite District Intensity Score	-0.006	0.00	-0.011 to -0.001	0.016
Baseline (<i>ref</i>)	.	.	.	.
1 year	0.123	0.09	-0.065 to 0.310	ns
2 years	0.308	0.12	0.078 to 0.539	0.009
3 years	0.339	0.14	0.061 to 0.618	0.018
4 years	0.394	0.16	0.071 to 0.716	0.017
Cohort 1 (<i>ref</i>)	.	.	.	.
Cohort 2	-0.108	0.07	-0.261 to 0.044	ns
Cohort 3	-0.135	0.09	-0.321 to 0.051	ns
Enrollment size	0.006	0.00	-0.001 to 0.012	0.080

Model 3: Number of screen time hours per weekend day

	β	SE	99% CI	p-value ^a
Constant	3.131	0.07	2.993 to 3.269	<0.0001
Average Composite District Intensity Score	-0.003	0.00	-0.007 to 0.001	0.098
Baseline (<i>ref</i>)	.	.	.	.
1 year	-0.060	0.08	-0.218 to 0.098	ns
2 years	0.033	0.10	-0.161 to 0.227	ns
3 years	0.049	0.12	-0.186 to 0.283	ns
4 years	0.113	0.14	-0.159 to 0.385	ns
Cohort 1 (<i>ref</i>)	.	.	.	.
Cohort 2	-0.079	0.06	-0.208 to 0.050	ns
Cohort 3	0.173	0.08	-0.330 to -0.017	0.031
Enrollment size	0.007	0.00	0.001 to 0.012	0.022

^ap-values for the differences in grant time (fixed effects) least squares means were adjusted for multiple comparisons using the Bonferroni correction. All analyses conducted in SAS 9.4 (SAS Institute, Inc. Cary, NC).

Discussion

MCI designed to achieve sustainable place-based improvements can create positive, long-term health effects. Communities nationwide are implementing MCIs, but approaches vary, including intensity-levels, funding, target populations, and implementation techniques.

Unlike a controlled setting where all possible confounders can be eliminated, MCIs are unpredictable in timing and scope, and different populations are exposed (or not) to a potentially causal factor or factors (e.g., a new trail, a policy to ensure children have recess). Although evaluating these complex initiatives is necessary to ensure approaches are effective and resources are best utilized, they are difficult for these very reasons. This study supports the use of a systematic method to

assess the intensity of activities within a MCI as a more realistic and cost-effective evaluation approach. Scoring evidence-informed attributes of all activities within a MCI can help to redirect resources (e.g., to increase the intensity of an activity or activities), and demonstrate progress towards reaching long-term goals which can take years to be realized. Similar to Pate et al. (35) who discovered a higher intensity scoring index in the HCS was positively associated with non-Hispanic white children's MVPA, we found increased PA and decreased sedentary time among children living in a community with a higher overall MCI intensity score.

Building on the RE-AIM Framework²⁸ and previous research,^{25,26,29} higher intensity activities can lead to improved health outcomes. This study expanded upon the HCS by suggesting the number of points required by a MCI to increase the average number of days reported being physically active for 60 minutes and reduce the number of minutes of sedentary time. We found an increased average composite district intensity score was associated with improved PA and sedentary behaviors, where an increase of 50 points was associated with an average 0.5 day increase in number of weekdays physically active and an increase of 55 points was associated with an average decrease of 20 minutes of sedentary time per weekday. These findings are meaningful given that different interventions may contribute between 0.3 to 3.0 points to its district's overall composite score. Therefore, the effort to reach 50 to 55 points and see these results can also vary. The average contribution of each intervention across all districts and years was 1.33. Using this information, communities would have to implement 38 average-scoring interventions to decrease screen time by 20 minutes per weekday and/or implement 42 average-scoring interventions to increase 60 minutes of daily physical activity by 0.5 days per week. Findings demonstrate how improvements in PA and sedentary behaviors require community-wide initiatives to be implemented over time. Higher composite district intensity scores (> 50 points) can be accomplished by implementing 1) strategies that modify access or change broader conditions which reach more people over longer periods of time, 2) a greater number of strategies that increase knowledge or enhance skills but reach fewer people for shorter periods of time, or 3) a combination of both. Given that resources are often limited, efforts to modify access or change broader conditions should be prioritized to see the greatest impact.

Understanding the mechanisms of effects can help stakeholders and their funders assess whether a package of interventions is performing in the way it is intended along the full range of its implementation, rather than simply an evaluation of its ultimate impact. During the first four years of HSHC, there were 2,174 P3E activities implemented by 33 school districts and community partners to increase PA opportunities and/or decrease sedentary time. However, despite the number of activities increasing substantially over time—almost doubled across all cohorts—just about half (47.1%) were considered lower-scoring strategies meaning that they intended to increase knowledge or improve skills, were shorter in duration, and/or reached less than 5% of the population. Intermediate findings such as this can help stakeholders and funders to more efficiently use available resources; efforts could have been shifted from implementing numerous lower intensity activities to fewer higher intensity activities that modify access and change broader conditions. Across all cohorts, the number and intensity of PA P3Es increased the first two years of participation in HSHC. However, our findings suggest that Cohort 1 implemented more, but lower intensity, activities than Cohort 2, for example. During the second year, Cohort 1 implemented 377 activities, more than two times the number in year 1 (n = 163), but the average intensity score per activity remained about the same over the two years (1.28 up from 1.24 in year 1). Cohort 2 activities did not quite double in year 2 compared to year 1 (248 vs. 144), but the average intensity score per activity was higher in the second year compared to the first (1.48 up from 1.27 in year 1). Adjustments made to action plans to reduce the number of lower intensity activities may free up resources to implement fewer, more intense efforts that are more likely to lead to improved outcomes. Additional evaluations should consider the use of intensity scoring for both assessing, and redirecting action plans, and understanding the impact of a MCI on youth physical activity and sedentary behavior.

This study has limitations. First, data were analyzed at the school district level and limited in terms of the overall small sample of districts and number of districts per year. Different types of interventions have varying levels of impact, and thus using a composite district-level score of all P3Es cannot differentiate between intervention types or combinations.

Second, student behaviors were self-reported and reading comprehension levels vary between 5th and 8th graders. Nonetheless, the survey questions were adapted from valid and reliable sources, each question averaged a 6th grade reading level, and the survey was piloted with 5th and 6th graders. At the time of implementation, it was concluded that the same survey should be used across all grades. Because HSHC coordinators and/or teachers implemented the survey to the students and the high number of classrooms and participating students (>25,000), it was deemed more important to reduce the potential for error in terms of the coordinators and/or teachers administering the wrong survey. Additionally, using the same survey version made it more methodologically sound to be able to make comparisons across grades over time. Third, the data used to calculate intensity was self-reported by various school and community stakeholders and may have been incomplete and/or subjective. Although the evaluators provided guidance and training on data collection tools and processes in various formats (e.g., webinars, protocols, one-on-one technical assistance) and worked closely with stakeholders to collect high-quality data, there were likely variances in data collection and reporting across individuals. Fourth, these were MCIs that included both physical activity and healthy eating activities. This investigation only looked at strategies that focused on physical activity-related behaviors (even if they also included healthy eating). It is possible that the healthy eating-only strategies may have confounded the results. Finally, HSHC began with a cohort of 13 school districts in 12 communities in fall 2013. The number of districts expanded to a total of 33 by 2017 but in most of the same communities. Children attending the schools later enrolled into HSHC may have been exposed to community-level interventions implemented prior to their school being on-boarded, and their behaviors and weight status may have been influenced and baseline data subsequently impacted. Moreover, the time in which any child could have been exposed to a P3E may have varied for similar reasons. It is difficult to avoid confounding factors in an evaluation such as this, where the evaluators have no control in enrollment and implementation, and where the funding is limited. Nevertheless, these limitations are not unique to MCI being implemented and evaluated in “real-time.”

Conclusion

MCIs are difficult to evaluate given the variations within which they are implemented. Findings from this study suggest the value of a systematic scoring approach in assessing MCIs. In addition to tracking intensity over time, scoring can provide justification for, or against, an individual activity and ways to increase the likelihood of the MCI impacting population-health outcomes.

List Of Abbreviations

B/A PA—PA before and after school

CDC—Centers for Disease Control and Prevention

CHI—Community Health Initiative

CHLI—Community Healthy Living Index

CSPAP—Comprehensive School Physical Activity Program

FCE—Family and community involvement

FLVS—Fleurbaix-Laventie Ville Santé study

HCS—Healthy Communities Study

HHS—US Department of Health and Human Services

HSHC—Healthy Schools and Healthy Communities

IOM—Institute of Medicine Efforts

JSI—John Snow, Inc.

KP—Kaiser Permanente

MCI- Multi-component initiative

MFH—Missouri Foundation for Health

MVPA—Moderate-to-vigorous physical activity

P3E—Programs, practices, policies, and environmental changes

PADS—PA during the school day

PE—Physical Education

RE-AIM—Reach, effectiveness, adoption, implementation, maintenance

SEM—Social-Ecological Model

SI—Staff involvement

U.S.—United States

Declarations

Ethics approval and consent to participate.

This study was approved by John Snow Inc. IRB (OHRP IRB00009069). Per the IRB the evaluation was deemed exempt and therefore parental consent was not required.

Consent for publication.

Not applicable.

Availability of data and materials.

The authors do not wish to make the dataset available for several reasons: 1) it is the intellectual property of the authors and 2) the data were collected at the school level. Some of the schools were in rural areas and it is important that the schools (and students) remain anonymous.

Competing interests.

The authors declare that they have no competing interests.

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Authors' contributions.

TVC provided lead direction on the MCI study and oversaw the P3E intensity scoring.

NS provided analytical analysis of the P3E intensity scoring.

LR assisted with the scoring of the P3Es and the overall development of the manuscript.

AR assisted with the scoring of the P3Es and the overall development of the manuscript.

CW assisted with the scoring of the P3Es and the overall development of the manuscript.

AH provided analytical analysis of the P3E intensity scoring.

All authors read and approved the final manuscript.

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Figures

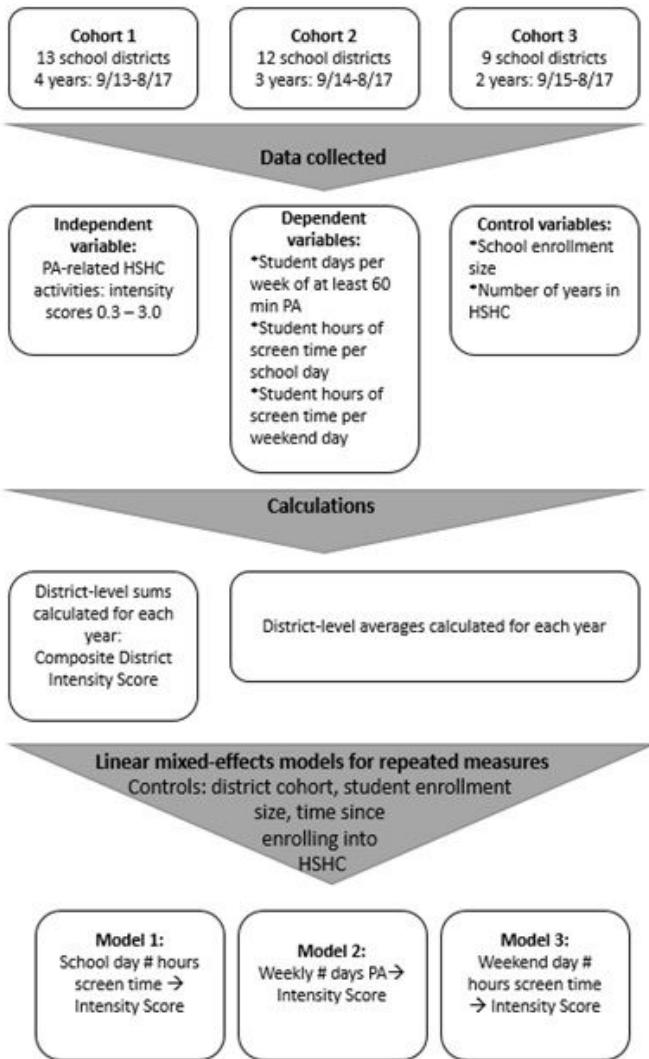


Figure 1

Evaluation Overview

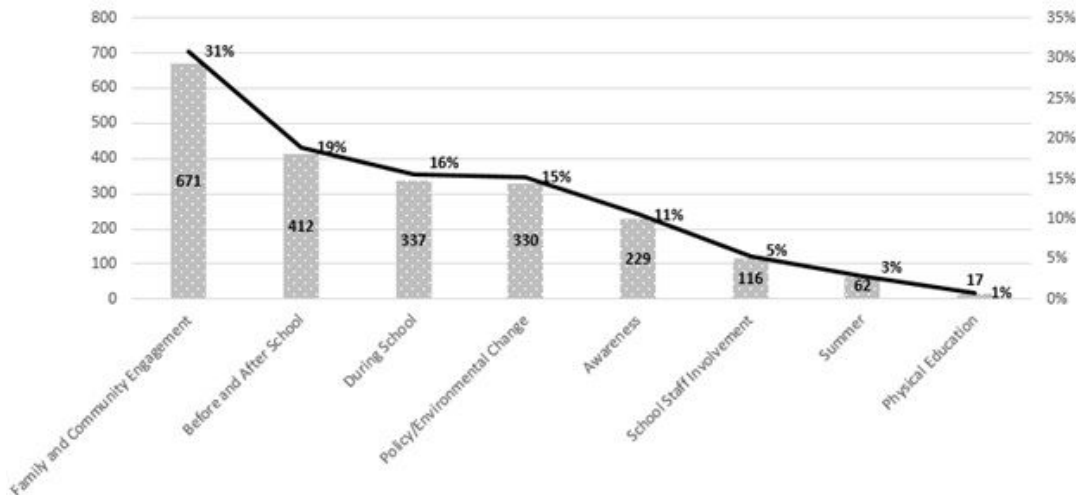


Figure 2

Total Number and Percentage of Activities by Comprehensive School Physical Activity Program (CSPAP) Interventions a The CSPAP framework organizes school physical activity interventions into five categories: 1) physical activity before and after school, 2) physical activity during school. 3) family and community engagement, 4) physical education, and 5) school staff involvement. For the purposes of this analysis, the categories of awareness, enu

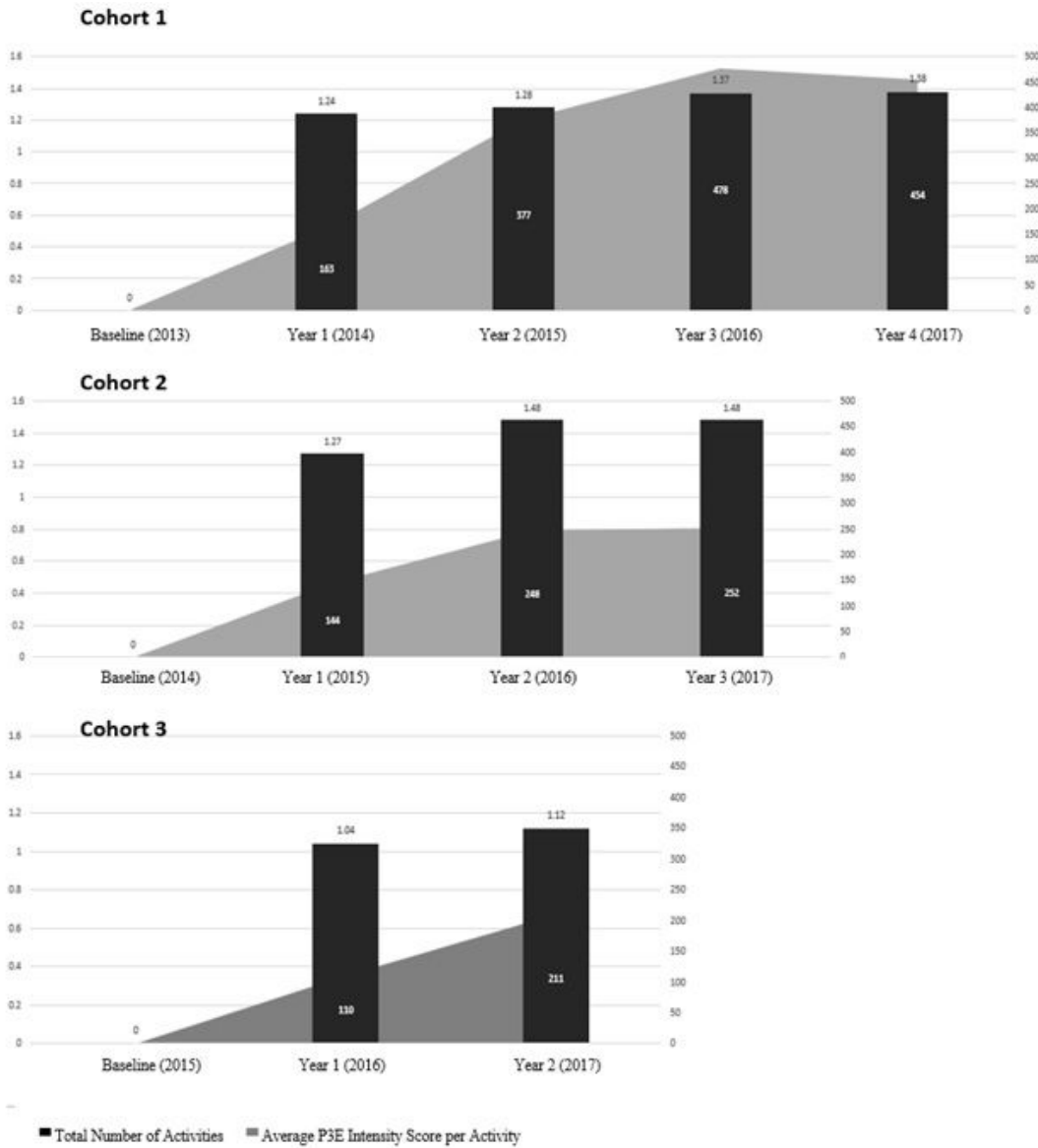


Figure 3

Total Number of Activities and Average Intensity Score per Activity