Cost Effectiveness of an Elementary School Active Physical Education Policy

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Introduction: Many American children do not meet recommendations for moderate to vigorous physical activity (MVPA). Although school-based physical education (PE) provides children with opportunities for MVPA, less than half of PE minutes are typically active. The purpose of this study is to estimate the cost effectiveness of a state "active PE" policy implemented nationally requiring that at least 50% of elementary school PE time is spent in MVPA.

Methods: A cohort model was used to simulate the impact of an active PE policy on physical activity, BMI, and healthcare costs over 10 years for a simulated cohort of the 2015 U.S. population aged 6–11 years. Data were analyzed in 2014.

Results: An elementary school active PE policy would increase MVPA per 30-minute PE class by 1.87 minutes (95% uncertainty interval [UI]=1.23, 2.51) and cost \$70.7 million (95% UI=\$51.1, \$95.9 million) in the first year to implement nationally. Physical activity gains would cost \$0.34 per MET-hour/day (95% UI=\$0.15, \$2.15), and BMI could be reduced after 2 years at a cost of \$401 per BMI unit (95% UI=\$148, \$3,100). From 2015 to 2025, the policy would cost \$235 million (95% UI=\$170 million, \$319 million) and reduce healthcare costs by \$60.5 million (95% UI=\$7.93 million, \$153 million).

Conclusions: Implementing an active PE policy at the elementary school level could have a small impact on physical activity levels in the population and potentially lead to reductions in BMI and obesity-related healthcare expenditures over 10 years.
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Introduction

Physical activity has positive impacts on children's health,[1] academic achievement, and cognition.[2,3] Physically active youth may be more likely to maintain a physically active lifestyle into adulthood,[4–6] and children with better motor skills are more likely to be physically active during childhood[7–9] and later in life.[10] Empirical evidence has not shown a consistent impact of physical activity on BMI,[11–18] but recent experimental and epidemiologic evidence demonstrates that changes in physical activity can lead to changes in BMI.[19,20]

National guidelines from the USDHHS suggest that children and adolescents should spend at least 60 minutes per day in physical activity.[21] However, the most recent available national data indicate that only 42% of children aged 6–11 years obtain at least 60 minutes per day of moderate to vigorous physical activity (MVPA).[22] Recognizing the crucial role of schools in helping children meet physical activity guidelines, the IOM recommends that elementary schools provide an average of 30 minutes per day (150 minutes per week) of high-quality curricular physical education (PE), during which students spend at least half of class time engaged in MVPA.[23]

However, only 4% of elementary schools currently provide 150 minutes per week of PE.[24,25] Although 99%

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of elementary schools require some PE,[26] students attend PE class for 97 minutes per week on average, typically in 2–3 class periods of 30–45 minutes each.[27] During an average PE class, students spend less than half of class time engaged in MVPA.[28–31] PE activity levels are lower when more lesson time is spent in management and knowledge activities such as organizing students and reviewing rules and techniques,[28,32,33] and when PE classes are led by generalist classroom teachers instead of trained PE specialists (i.e., teachers certified or licensed to teach PE).[28,30,34]

Several controlled experiments provide evidence that PE can be modified to increase activity levels. A recent meta-analysis[35] found that active PE interventions increased lesson time spent in MVPA by an absolute difference of 10.37%, and among studies in which teachers learned instruction-based strategies to encourage MVPA, the difference was 6.27%. Two notable evidence-based PE programs—the Sports, Play, and Active Recreation for Kids (SPARK) trial[30] and the Child and Adolescent Trial for Cardiovascular Health (CATCH)[29]—provide a model for implementation of such teaching strategies. Both programs provided schools with curricula and portable equipment designed to engage students in more MVPA during PE class and trained PE teachers on how to implement the curriculum.[29,30] In follow-up and dissemination studies, SPARK and CATCH investigators demonstrated that PE improvements were sustainable and translatable.[36–40] The programs have been widely disseminated to date, and the curricula, equipment, and training are commercially available.[41,42]

In recent years, school districts and states have pursued “active PE” policies, or policies aimed at increasing MVPA levels during PE class. Between the 2006–2007 and 2010–2011 school years, the proportion of school districts addressing activity levels during PE in their local school wellness policies significantly increased from 28% to 51% at the elementary school level.[43] Between 2001 and 2007, state legislatures introduced 43 bills related to activity levels during PE, and 11 bills were enacted.[44] As of 2014, Texas, Oklahoma, Arizona, and the District of Columbia had policies specifying that 50% of PE time for elementary school students be devoted to MVPA.[45,46] However, active PE policies frequently lack specific language addressing implementation or monitoring,[45,47] making them difficult to enforce.

To date, little evidence exists describing the cost effectiveness of physical activity interventions on improving physical activity levels, BMI, and health outcomes.[48–52] Cost-effectiveness analysis can provide valuable information to decision makers for setting priorities and allocating resources.[53,54] This paper describes a simulation modeling analysis estimating the cost effectiveness of an active PE policy on physical activity and BMI, using the best available evidence.

Methods

Intervention

The modeled intervention was an “active PE” policy, specified as the implementation of a state policy directing state boards of education (i.e., boards with regulatory or policy authority in educational settings) to include in the state’s elementary school PE curriculum a requirement that 50% of PE time be devoted to MVPA. The intervention was based on policies passed by state legislatures in Texas (SB 891, 2009) and Oklahoma (SB 1876, 2010). Implementation of the active PE policy was assumed to take place during existing PE classes (i.e., no PE minutes would be added), and would include providing schools with PE curricula, portable equipment, and teacher training, similar to the SPARK and CATCH PE programs. The intervention also included a monitoring component, which was considered necessary to achieve implementation, whereby principals would be trained to evaluate activity levels during PE classes as part of regular teacher evaluations.

Current Practice

The comparator for this intervention was current practice. Texas, Oklahoma, Arizona, and the District of Columbia were considered as having elementary school active PE policies as of 2014.[45,46] Other states that had policies requiring a non-specific amount of MVPA during PE, an amount of MVPA $<50\%$ of PE time, or MVPA during the school day but not specifically during PE were eligible to receive the modeled intervention. In the absence of an active PE policy intervention, elementary school students were estimated to engage in MVPA for 40%[35] of 97 weekly PE minutes,[27] on average. The average proportion of PE classes taught by PE specialists (compared with classroom teachers) was estimated at 86% based on a national survey.[24]

Modeling Framework

A detailed description of the Childhood Obesity Intervention Cost Effectiveness Study (CHOICES) modeling framework is provided elsewhere.[55] A team from the Harvard School of Public Health, Columbia Mailman School of Public Health, Deakin University, and the University of Queensland in Australia adapted and modified the Australian Assessing Cost Effectiveness (ACE)[53] in Obesity[52] and ACE-Prevention[49,56] methodologies to create the CHOICES model. The simulation model was developed as a Microsoft Excel–based Markov cohort model based on ACE,[56] but modified and replicated in a compiled programming language (Java) for CHOICES. The model was populated to represent the 2015 U.S. population and followed for 10 years without replacement (i.e., closed cohort) to evaluate the shift in BMI and related healthcare cost reductions due to the intervention operating in “steady state” (i.e., at its most likely effectiveness potential) over a meaningful 10-year policy window. The impact of the intervention was estimated using the best available evidence from randomized trials and epidemiologic and economic studies. The CHOICES evidence review protocol, derived from Cochrane guidelines and the Grades of Recommendation, Assessment, Development and Evaluation (GRADE) approach,[57,58] prioritized evidence obtained from RCTs, controlled natural or quasi experiments, and longitudinal studies of change in exposure and change in outcome.[55] The modified model estimated an added healthcare cost of $282 (2014 U.S. dollars) per year for obese compared to non-obese children and youth aged 6–19 years.[59] Because there is little evidence[60] for maintenance of childhood intervention effects over the 20–35 years required to impact obesity-related disease and healthcare costs, the CHOICES model estimated outcomes in a 10-year window only. Appendix Figure 1 displays the logic pathway linking the active PE policy to change in obesity-related healthcare costs.

Implementation and Equity Considerations

The framework also incorporated broader aspects of priority setting and included a qualitative assessment of key issues relevant to stakeholders.[53] As described elsewhere,[55] an expert stakeholder panel of physical activity and PE researchers and government public health practitioners was convened to help frame the intervention, identify relevant resources for simulation modeling, and provide input regarding broader key issues relevant to implementation. Implementation considerations included level of evidence, equity, acceptability, feasibility, sustainability, side effects, and social and policy norms.

Policy/Program Reach

The active PE policy intervention was scaled to the national level. Using nationally representative data,[61–63] the target population was estimated to be 18.5 million children aged 6–11 years attending more than 47,000 public elementary schools in the 47 states eligible to newly adopt the active PE policy, representing 75% of the total 2015 U.S. population aged 6–11 years. Students enrolled in private or home schooling and those residing in states that had already enacted an active PE policy were not included.

Estimates of the total number of people reached by the intervention (intent-to-treat [ITT] population) and receiving a health benefit from the intervention (benefiting population) were calculated, assuming all 47 states without an existing active PE policy would adopt the policy and all PE teachers in those states would receive training to implement the policy. The ITT population was defined as children in the target population who attended an elementary school offering any PE and regularly participated in any PE, and the benefiting population was confined to those children taught by PE teachers who actually implemented the policy. Based on studies of the ongoing maintenance[38] and institutionalization[39] of the CATCH PE program, the implementation rate among trained PE teachers was estimated at 72%.

Assessment of Benefit

Expected effectiveness of the active PE policy on per capita MVPA was modeled using results from a recent meta-analysis[35] of active PE trials. Intervention-related increase in MVPA during PE class was estimated as 6.24% of class time (i.e., the average effect observed when teaching strategies were used to increase MVPA levels).[35] MVPA minutes were also converted to MET-hours gained, assuming an average MET level of 4.5. Total daily increase in physical activity on PE days was assumed to be equal to the physical activity increase during PE class, based on evidence suggesting that children do not compensate for increased school day physical activity during other times of the same day.[64–68]

Two studies identified from >600 reviewed according to the CHOICES evidence review protocol[55] were used to estimate the change in BMI expected from a change in MVPA. One study[19] provided evidence of change in BMI resulting from a change in objectively measured MVPA in an RCT of a school-based physical activity intervention with no co-interventions. Another study[20] provided evidence of the change in BMI resulting from change in MVPA using a 6-year longitudinal observational design. Based on results from the two studies, each 1-minute increase in regular daily MVPA was estimated to result in an average per capita BMI reduction of 0.023. This estimate is similar to the expected BMI change of 0.018 calculated according to the model of childhood energy balance developed by Hall and colleagues.[69] The Appendix provides more details regarding the review of the relationship between physical activity and BMI.

Costs of Intervention

The 1-year and 10-year costs of implementing the policy in the closed cohort were estimated in 2014 U.S. dollars using a modified societal perspective,[54,70] because the health and economic burden of obesity is borne and should be addressed at the societal level.[71] Start-up costs were not included according to established protocols,[72,73] but were conceptualized as providing an introductory full training to all PE teachers and a set of PE curricula and equipment to every school (estimates of start-up costs given in Appendix). Resources required to sustain regular implementation of the active PE policy were identified as (1) training PE teachers on strategies and curricula to implement active PE; (2) training school principals on how to assess whether PE teachers are using active PE strategies in their lessons; (3) replacement of equipment and curricular materials needed to maintain active PE; and (4) state PE coordinator time for oversight, implementation, and monitoring of the active PE policy. Two levels of training for PE teachers were modeled—an intensive training for teachers newly hired in a school district, and a refresher training for teachers returning to the same school district. Additional training time during existing training opportunities was included for directing principals on how to observe and assess, as part of regular evaluations of teachers, whether PE teachers incorporated active PE strategies into their lessons. Teachers' time costs for training were assumed to be covered by annual professional development allowances in current practice; thus, only training facilitator time costs were included for PE teacher training. Nearly all (96%) states and school districts provide funding for or offer some physical activity–related professional development for PE teachers, with 67% of states and 55% of districts offering opportunities on the topic of methods to increase MVPA levels during PE class.[74] Appendix Table 1 shows line-item costs included in the cost calculation.

Cost-Effectiveness Analysis

The incremental cost effectiveness of the active PE intervention compared to current practice was expressed as the cost (in 2014

U.S. dollars) per MET-hour increase per day after 1 year and cost per BMI unit change after 2 years. The full BMI effect was assumed to occur after 2 years of intervention to account for the time course of weight change.[69] The 10-year cost of implementing the intervention, reduced healthcare costs, and net costs (10-year intervention costs plus reduced healthcare costs) were estimated. Intervention implementation was simulated for individuals in the 2015 cohort for as long as they remained in the target age range during the 10-year time frame. Therefore, the average intervention duration across the cohort was 3.5 years. The model assumed that BMI effects achieved after implementing the policy were maintained for 10 years. Because no changes in obesity-related morbidity and mortality were expected in children, changes in disability-adjusted life years were not estimated.

Sensitivity Analyses

Probabilistic sensitivity analyses were conducted by simultaneously sampling values from within specified distributions using Monte Carlo simulations in @RISK, version 6.1.2, to estimate physical activity and BMI changes over 10,000 iterations and in Java to estimate 10-year outcomes over 1,000,000 iterations. Data were analyzed in 2014. Table 1 shows uncertainty intervals (UIs) modeled around mean values for key model variables.

Uncertainty about the specification of the modeled intervention was assessed by comparing the primary scenario to a secondary scenario in which more PE time was added as a result of the intervention. In the SPARK trial,[30] a positive side effect (hereafter, the "SPARK effect") was that trained classroom teachers and PE specialists provided an additional 27 and 42 minutes of PE per week, respectively. In the secondary scenario, the increase in MVPA minutes gained from adding new PE minutes with 46% of time spent in MVPA[35] (i.e., at the intervention level) was added to the increase expected from the primary scenario. Additional PE minutes provided by classroom teachers were assumed to replace time spent in other academic subjects at no cost. Costs associated with additional PE minutes provided by PE specialists included costs of training the additional number of PE specialists needed to cover those instruction minutes while maintaining the same teacher–student ratio. Costs of hiring the additional PE specialists (i.e., annual wages) were not included.

Additional sensitivity analyses were conducted. To provide a benchmark for expected impact of the intervention under perfect compliance, a univariate sensitivity analysis was conducted assuming 100% implementation among trained teachers. Sensitivity to the parameter estimating the change in BMI from a change in MVPA was examined by alternatively using the model developed by Hall et al.[69] The impact of the active PE policy was also calculated assuming all children reached attended PE class for 150 minutes per week. The costs of providing a full training to the additional PE specialists needed to provide PE at the current teacher–student ratio were added to all other intervention costs. Annual wages of newly hired PE specialists were considered start-up costs and were excluded (estimates of start-up costs shown in Appendix).

Results

If an active PE policy were enacted in the 47 states currently lacking the policy, an estimated 46,700 elementary schools providing PE would be impacted. On average, a total of 169,000 teachers would be trained on strategies to promote active PE. The intervention would reach 17.6 (95% UI=17.4, 17.7) million students aged 6–11 years (i.e., ITT population), representing 95% of the 18.5 million children in the target population and 71% of the 24.6 million children in the total U.S. population aged 6–11 years.

National implementation of an elementary school active PE policy would cost \$70.7 million (95% UI=\$51.1 million, 95.9 million) in the first year (Table 2), or \$4.03 per person reached. The intervention would increase mean MVPA per benefiting child by 1.87 minutes (95% UI=1.23, 2.51) during a 30-minute PE class, representing a 16% increase over existing MVPA levels during PE. The intervention would increase mean per capita MVPA levels by 157 minutes per year (95% UI=25, 335) and cost \$0.34 per MET-hour gained (95% UI=\$0.15, 2.15). After 2 years, this physical activity increase could reduce mean per capita BMI in the population reached by 0.020 BMI units (95% UI=0.003, 0.050), costing \$401 per BMI unit reduced (95% UI=\$148, \$3,100). The distribution of cost-effectiveness results is presented in Figure 1. Over the period from 2015 to 2025, the intervention would cost \$1,720 per BMI unit reduced (95% UI=\$272, \$5,710). The BMI reductions achieved after the intervention would avert an estimated \$60.5 million in healthcare costs (95% UI=\$7.93 million, \$153 million), resulting in net costs of \$175 million (95% UI=\$62.9 million, \$277 million).

Table 3 shows results of the sensitivity analyses. If active PE were implemented by 100% of trained teachers, the resulting increase in children benefiting would reduce the cost per BMI unit reduced to \$287 (95% UI=\$108, \$2,170), and healthcare cost savings over 10 years would rise to \$84.4 million. If additional minutes of PE at 50% MVPA were provided by trained PE specialists (the SPARK effect, secondary scenario), mean per capita MVPA would increase by 629 minutes per year (95% UI=389, 925) among the population reached at an estimated annual intervention cost of \$78.5 million (95% UI=\$57.5 million, \$105 million). The intervention with the SPARK effect would cost \$111 per BMI unit reduced (95% UI=\$54.1, \$310) and reduce healthcare costs after 10 years by \$241 million (95% UI=\$89.7 million, \$457 million). If all children attended PE for 150 minutes per week, implementing the active PE intervention would cost \$305 per BMI unit reduced (95% UI=\$143, \$856).

Discussion

National implementation of a state active PE policy would increase school-based MVPA by 16% (approximately 1 minute per day) among 17.6 million children aged 6–11

Table 1. Key Model Variables: Mean Values and 95% UIs

Parameter	Mean (95% UI)	Sources and modeling parameters
Policy/program reach		
Percent of children regularly participating in PE, among those whose schools offer PE	96 (95, 97)	Samples drawn from a uniform distribution (min=95, max=97) based on estimates reported by school administrators in New York[75] and California[76]
Percent of trained physical educators that implement the policy (% benefiting among ITT)	72 (58, 87)	Samples drawn from a beta distribution (min=54, mode=70, max=95) based on two studies of ongoing implementation of the CATCH active PE curriculum[38,39]
Assessment of benefit		
Weekly minutes of PE provided to elementary school students	97 (16, 185)	Samples drawn from a normal distribution (M=94.4, SD=45.6) based on estimates from one nationally representative survey of school administrators[27]
Percent of PE class spent in MVPA at baseline	40 (21, 56)	Samples drawn from a beta distribution (min=13.5%, mode=44.5%, max=48.6%) based on a meta-analysis of interventions designed to increase MVPA during PE using teaching strategies[35]
Increase in percent of PE class spent in MVPA due to active PE intervention	6.24% (4.10%, 8.38%)	Samples drawn from a normal distribution (M=6.27%, SE=1.08%) based on a meta-analysis of interventions designed to increase MVPA during PE using instruction strategies[35]
Change in BMI per 1-minute change in daily MVPA	0.023 (0.010, 0.039)	Samples drawn from a uniform distribution between parameters drawn from a normal distribution (M=0.02, SE=0.008) based on estimates from a group RCT[19] and a beta distribution (min=0.005, mode=0.02, max=0.06) based on mean estimates for the 10th, 50th, and 90th percentiles of BMI from a longitudinal observational study[20]
Costs of intervention		
Principal time costs (FTE, nationally) for attending training on evaluating active PE	10.8 (7.0, 14.6)	Samples drawn from a beta distribution for annual minutes of training time (min=10, mode=20, max=30) for one principal in all ITT schools; assumes 1 FTE=8 hours/day for 180 days/year
Training facilitator time costs (FTE, nationally) for training principals and physical educators	3.4 (1.5, 8.1)	Trainer time costs calculated as the sum of trainee time costs (principals + physical educators) divided by number of trainees per trainer, with samples drawn from a uniform distribution (min=30, max=40); assumes 1 trainer FTE=8 hours/day for 260 days/year
Pages (millions, nationally) of active PE training materials for physical educators	0.6 (0.2, 1.5)	Physical educators receive pages of active PE materials sampled from beta distributions (full training for new teachers: min=5, mode=10, max=15; brief training every other year for returning teachers: min=2, mode=5, max=10)
Sets (nationally) of active PE curricula and equipment	9900 (7200, 13400)	Samples drawn from a beta distribution for the frequency (years) with which each ITT school replaces one set of active PE curriculum and equipment (min=3, mode=5, max=7)
Unit cost ($) of active PE curriculum and equipment set	6900 (6200, 7500)	One set includes one package for a class of 36 students in grades K-2 and one package for grades 3–5; samples drawn from uniform distributions (K-2: min=1,900, max=3,100; 3–5: min=3,100, max=3,200) based on estimates from two commercial websites; 2010 cost inflated to 2014

$, U.S. dollars; FTE, full-time equivalent; ITT, intent-to-treat; MVPA, moderate to vigorous physical activity; PE, physical education, UI, uncertainty interval.

years and cost an estimated $401 per BMI unit reduction after 2 years. BMI reductions could be achieved through small but measureable increases in physical activity levels, at a cost of $0.34 per MET-hour gained. The active PE policy intervention falls within the range of $0.19–$0.40 (converted from 2007 to 2014 U.S. dollars) per MET-hour suggested as a benchmark of cost effectiveness for interventions targeting youth.[48] Although there is no established benchmark of cost effectiveness for BMI unit reductions, the active PE intervention is cheaper on average than estimates reported for clinical and surgical interventions for obese children and adolescents—estimated in the

Table 2. Mean Cost-Effectiveness Results With 95% Uncertainty Intervals

Total population reached (ITT) aged 6–11 years (millions)	**17.6 (17.4, 17.7)**
Total population benefiting (millions)	12.6 (10.2, 15.3)
First-year intervention cost ($ millions)	70.7 (51.1, 95.9)
Short-term outcomes[a]	
Average daily increase in minutes of MVPA per child in the population reached[b]	0.87 (0.14, 1.86)
Average daily increase in MET-hours per child in the population reached[b]	0.065 (0.010, 0.139)
Mean BMI unit reduction per child in the population reached[c]	0.020 (0.003, 0.050)
Total population MET-hours gained (millions)	206 (33.0, 440)
Total BMI units reduced (thousands)[c]	319 (41.7, 806)
Cost ($) per MET-hour gained	0.34 (0.15, 2.15)
Cost ($) per BMI unit reduced[c]	401 (148, 3100)
10-year outcomes[d]	
Cohort 10-year intervention costs ($ millions)	235 (170, 319)
Healthcare costs[e] ($ millions)	−60.5 (−153, −7.93)
Net costs[f] ($ millions)	175 (62.9, 277)

[a]All short-term outcomes were modeled using probabilistic uncertainty analysis over 10,000 iterations in @Risk.
[b]On school days.
[c]BMI reductions were assumed to occur after 2 years of intervention. Cost per BMI was based on the cost to implement the intervention for 2 years.
[d]All 10-year outcomes were modeled using probabilistic uncertainty analysis over 1,000,000 iterations in Java. Health effects and costs associated with 10-year outcomes over the period 2015–2025 are discounted at 3% annually. Intervention costs are borne by the 2015 closed cohort and do not represent the annual costs of implementing the policy.
[e]Healthcare costs over 10 years refers to the simulated difference in healthcare costs due to the intervention over the period 2015–2025 for a baseline cohort of the U.S. population in 2015, reported as present value in 2014 dollars discounted at 3% annually.
[f]Net costs are the sum of intervention costs and healthcare costs (i.e., savings in healthcare costs due to the intervention) over 10 years.
$, 2014 U.S. dollars; ITT, intent-to-treat; MVPA, moderate-to-vigorous physical activity.

range of $1,000–$2,100 per BMI unit change.[55,77–79] Compared with these clinical interventions and other interventions concurrently modeled in the CHOICES project,[55] the active PE intervention has a small effect on BMI (i.e., a 0.1% reduction), corresponding to a weight reduction of approximately 30 grams (0.07 pounds) for an average 8-year-old girl. The effect is within range of per capita BMI reductions estimated in the Australian ACE-Obesity cost-effectiveness analyses of a walking school bus program (0.03)[80], an afterschool physical activity program (0.07)[81], and a community program promoting active transportation to school (0.01–0.07).[82] Greater impact of the active PE intervention could be achieved if 100% of trained teachers implemented the policy or if PE were provided for the recommended 150 minutes per week, but BMI effects may still be small. However, reversing the childhood obesity epidemic requires combining many interventions in different settings where children spend their time, and even small effects may help accomplish this goal.

Implementation and Equity Considerations

Areas for concern regarding implementation of the active PE policy include the potential for increasing inequity and acceptability issues among key stakeholders (Table 4). Because PE is less likely to be provided in communities with more low-income and racial/ethnic minority students,[76,83,84] the intervention may increase existing income-related and racial/ethnic disparities in obesity. As specified, the active PE policy intervention would be implemented within existing PE minutes, so students in schools currently providing little or no minutes of PE class would receive less or no benefit, potentially exacerbating existing chronic disease disparities. Also, the acceptability of devoting resources to any PE policy may be limited given increased emphasis among educators and education administrators on academic progress and performance on standardized tests, especially in light of budget constraints.[27,85,89] Even though PE is a key educational component of primary and secondary education, it often does not hold the same priority as other subjects.

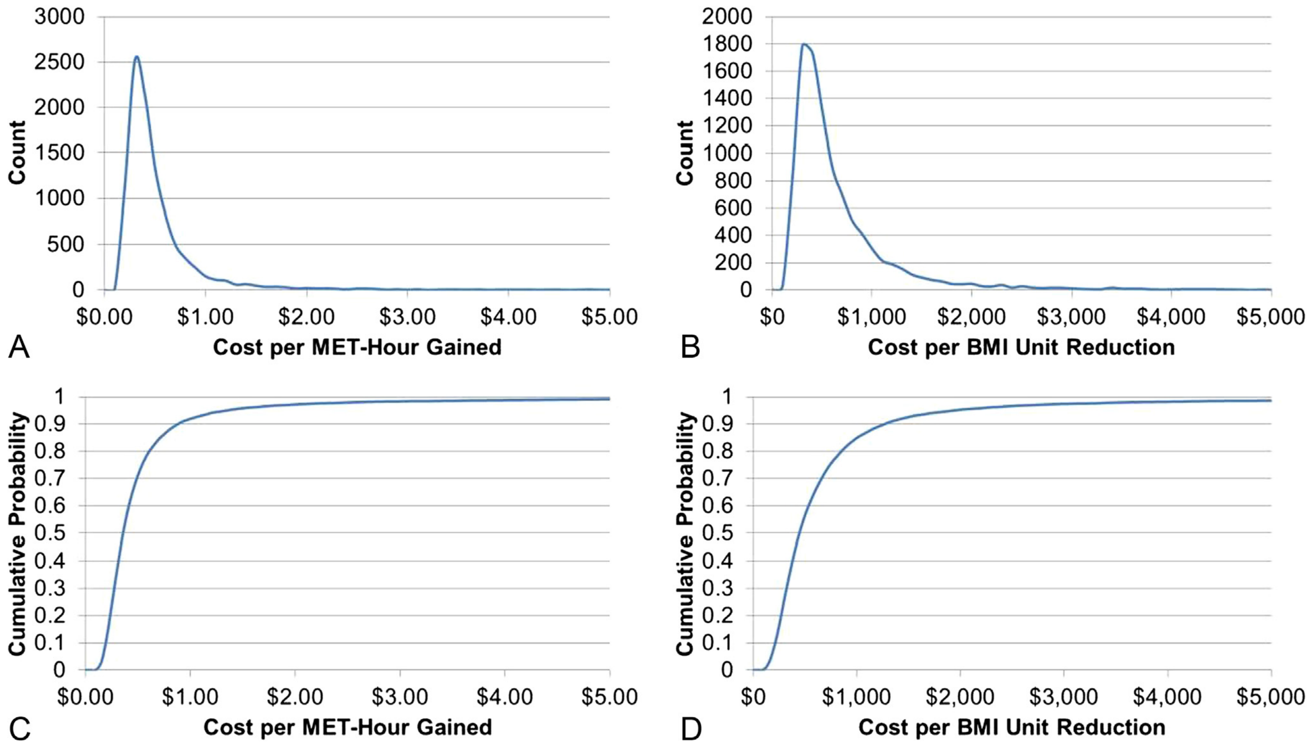

Figure 1. Distribution (A, B) and cost-effectiveness acceptability (C, D) curves of estimated cost per MET-hour gained and cost per BMI unit reduction for the primary Active PE scenario.
Note: Panels (A) and (B) depict the distribution of results for cost per MET-hour gained and cost per BMI unit reduction, respectively. Panels (C) and (D) depict the cumulative probability that cost-effectiveness results are below the cost per benefit cut points along the horizontal axis. Distributions were derived from simulation modeling of the active PE intervention primary scenario using probabilistic uncertainty analysis over 10,000 iterations via @Risk in Excel.
PE, physical education.

Strengths of the active PE policy intervention include its feasibility and acceptability relative to other PE interventions, such as offering more PE time or offering PE in schools currently not offering it, which would be very costly given already stretched school budgets and the pressure to succeed on academic measures. Implementation of active PE policies may be an incremental way of changing the social norms and culture around incorporating health-promoting physical activity into the school day. Trained teachers may also be effective in promoting movement during other parts of the school day.[23,88]

In addition to the BMI-mediated reductions in healthcare costs, increased physical activity may lead to other benefits not explicitly incorporated in this model. Physical activity has been shown to be independently associated with improvements in fitness and reductions in the risk of heart disease, diabetes mellitus, osteoporosis, and high blood pressure.[1] The long-term effects of physical activity include substantial mortality benefits,[90] which can be achieved from changes in MVPA as small as 15 minutes per day.[91] Considering that physical activity tracks from childhood to adulthood, increasing children's daily MVPA by just a few minutes may not be trivial, especially over the course of a lifetime. Of particular interest in the school setting is evidence that physical activity can improve cognitive function, mood, and academic performance.[2,3,23] It is a limitation of the current model that other physical activity–related health and cognitive outcomes and potential long-term increases in wages and productivity are not quantified, and these impacts should be considered in future studies of school-based physical activity interventions.

Limitations

There are several other limitations to the CHOICES modeling approach. The intervention-related BMI reduction occurring after 2 years was assumed to persist for 10 years (i.e., a child's BMI trajectory was shifted down in level), which may be optimistic. However, the BMI effect occurring after just 2 years of intervention may underestimate the true effect size, as children would be exposed to the intervention each year they attended public elementary school. Physical activity increases during childhood may have the potential to impact even longer-term positive outcomes, ideally through changes in lifelong physical activity habits. Simulation modeling

Table 3. Mean Sensitivity Analysis Results With 95% Uncertainty Intervals

	Secondary scenario (SPARK effect): increase MVPA + increase PE time provided	100% implementation among trained teachers	Change in BMI using Hall Model[69]	Students attend PE class 150 minutes per week
Total population reached (ITT) aged 6–11 years (millions)	17.6 (17.4, 17.7)	17.6 (17.4, 17.7)	17.6 (17.4, 17.7)	17.6 (17.4, 17.7)
Total population benefiting (millions)	12.6 (10.2, 15.3)	17.6 (17.4, 17.7)	12.6 (10.2, 15.3)	12.6 (10.2, 15.3)
First-year intervention cost ($ millions)	78.5 (57.5, 105)	70.7 (51.1, 95.9)	70.7 (51.1, 95.9)	70.7 (51.1, 95.9)
Short-term outcomes[a]				
Average daily increase in minutes of MVPA per child in the population reached[b]	3.49 (2.16, 5.14)	0.87 (0.14, 1.86)	0.87 (0.14, 1.86)	1.34 (0.84, 1.92)
Average daily increase in MET-hours per child in the population reached[b]	0.262 (0.162, 0.385)	0.065 (0.010, 0.139)	0.065 (0.010, 0.139)	0.100 (0.063, 0.144)
Mean BMI unit reduction per child in the population reached[c]	0.0879 (0.029, 0.151)	0.020 (0.003, 0.050)	0.015 (0.002, 0.033)	0.030 (0.012, 0.058)
Total population MET-hours gained (millions)	828 (513, 1220)	288 (47, 596)	206 (33, 440)	318 (200, 455)
Total BMI units reduced (thousands)[c]	1280 (473, 2430)	445 (59.5, 1,120)	246 (39.1, 524)	489 (186, 931)
Cost ($) per MET-hour gained	0.09 (0.06, 0.17)	0.25 (0.11, 1.52)	0.34 (0.15, 2.15)	0.26 (0.15, 0.47)
Cost ($) per BMI unit reduced[c]	111 (54.1, 310)	287 (108, 2170)	520 (223, 3270)	305 (143, 856)
10-year outcomes[d]				
Cohort 10-year intervention costs ($ millions)	261 (191, 350)	235 (170, 319)	235 (170, 319)	275 (186, 396)
Healthcare costs[e] ($ millions)	−241 (−457, −89.7)	−84.4 (−211, −11.3)	−43.6 (−92.9, −6.95)	−92.8 (−176, −35.4)
Net costs[f] ($ millions)	20.1 (−207, 198)	151 (9.28, 266)	192 (108, 282)	182 (60.3, 318)

[a]All short-term outcomes were modeled using probabilistic uncertainty analysis over 10,000 iterations in @Risk.
[b]On school days.
[c]BMI reductions were assumed to occur after 2 years of intervention. Cost per BMI was based on the cost to implement the intervention for 2 years.
[d]All 10-year outcomes were modeled using probabilistic uncertainty analysis over 1,000,000 iterations in Java. Health effects and costs associated with 10-year outcomes over the period 2015–2025 are discounted at 3% annually. Intervention costs are borne by the 2015 closed cohort, and do not represent the annual costs of implementing the policy.
[e]Healthcare costs over 10 years refers to the simulated difference in healthcare costs due to the intervention over the period 2015–2025 for a baseline cohort of the U.S. population in 2015, reported as present value in 2014 dollars discounted at 3% annually.
[f]Net costs are the sum of intervention costs and healthcare costs (i.e., savings in healthcare costs due to the intervention) over 10 years.
$, 2014 U.S. dollars; ITT, intent-to-treat; MVPA, moderate-to-vigorous physical activity; PE, physical education.

relies on many assumptions that limit conclusions; however, this study performed extensive probabilistic sensitivity analyses to relax assumptions around several model parameters. Although the model utilized the best available experimental and epidemiologic evidence, each study comes with its own limitations.

Conclusions

Implementing an active PE policy at the elementary school level could have a small impact on physical activity levels in the population and potentially lead to reductions in BMI and obesity-related healthcare expenditures over 10 years. There is strong evidence that

Table 4. Implementation and Equity Considerations

Level of evidence	Equity	Acceptability to stakeholders	Feasibility	Sustainability	Side effects	Social and policy norms
One meta-analysis of 8 RCTs observed statistically significant effects of modified PE implementation on change in MVPA during PE class[35] One RCT[19] and one longitudinal observational study[20] show impact of change in physical activity on change in BMI	Potential to increase disparities for children provided less frequent or no PE (e.g., low-income students and students of color)[76,83,84] Potential to decrease disparities, because obese children have lower levels of MVPA during PE at baseline[76]	Three states and the District of Columbia already have policies requiring 50% MVPA in PE[45,46] School administrators may hesitate to spend money and effort on improving PE in the face of academic pressures[27,85] Classroom teachers may not be interested in spending effort on PE training	Economic crises among schools, education agencies, and state and local governments may make it difficult to prioritize PE[27,85] Schools with limited infrastructure for PE may find it difficult to implement active PE[27,85] More feasible than adding PE time because of lower cost and less competition with academic time	Monitoring compliance to the policy may be difficult[45] Ongoing teacher training can improve sustainability[86] Low levels of school teacher and administrator attrition[87] can assist long-term implementation and minimize costs	Positive: Other benefits of physical activity, including cardiovascular health, mental health, classroom behavior, cognition, and academic achievement[1–3,35]	Successfully being able to implement more active PE within existing PE may lead the way for more PE time and other promotion of physical activity during the school day[23,88]
Decision Point: Sufficient evidence of effectiveness	Disparities likely to increase on average	Acceptable to policymakers, but competing interests for implementers	Concern for financial feasibility, but more feasible than adding PE time	Sustainable if system for ongoing training and monitoring in place	Positive side effects only expected	Potential to lead to other school-based health promotion strategies

MVPA, moderate to vigorous physical activity; PE, physical education.

school-based physical activity interventions, including those targeting PE, can successfully increase physical activity levels among children and adolescents.[11,92–96] This paper demonstrates the positive impact of an active PE policy, at a cost that appears reasonable compared to alternative approaches for increasing physical activity among children.

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Appendix

Supplementary data

Supplementary data associated with this article can be found at http://dx.doi.org/10.1016/j.amepre.2015.02.005.