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Impact of a multi-level, multi-component intervention to improve elementary school physical education on student cardiorespiratory fitness: an application of the parametric g-formula

### Permalink

<https://escholarship.org/uc/item/5hf386jj>

### Journal

Res Sq, 5(05-17)

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### Publication Date

2024-05-07

### DOI

10.21203/rs.3.rs-4331769/v1

Peer reviewed

RESEARCH

Open Access



# Impact of New York City's 4-year multi-component natural experiment to improve elementary school physical education on student cardiorespiratory fitness

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## Abstract

**Background** School physical education is an important population-level health intervention for improving youth fitness. This study estimated the impact of New York City's PE Works program - which included providing PE teachers, training for classroom teachers, and administrative/ teacher support for PE - on student cardiorespiratory fitness as measured by the FitnessGram's 15-meter PACER test for aerobic capacity.

**Methods** This longitudinal study (2014/15-2018/19) includes 581 elementary schools ( $n=315,999$  4th /5th -grade students; 84% non-white; 74% who qualify for free or reduced-price meals, a proxy for socioeconomic status). We apply the parametric g-formula to address schools' time-varying exposure to intervention components and time-varying confounding.

**Results** After four years of staggered PE Works implementation, 49.7% of students/school (95% CI: 42.6%, 54.2%) met age/sex-specific Healthy Fitness Zone (HFZ) aerobic capacity standards set by the FitnessGram. Had PE Works *not* been implemented, we estimate 45.7% (95% CI: 36.9%, 52.1%) would have met aerobic capacity HFZ standards. Had PE Works been fully implemented in *all* schools from the program's inception, we estimate 57.4% (95% CI: 49.1%, 63.3%) would have met aerobic capacity HFZ standards. Adding a PE teacher, alone, had the largest impact (6.4% (95% CI: 1.0, 12.0) increase).

**Conclusion** PE Works positively impacted student cardiorespiratory fitness. Mandating and funding multicomponent PE programs is an important public health intervention to increase children's cardiorespiratory fitness.

**Keywords** Cardiorespiratory fitness, Adolescent health, Physical education, Parametric g-formula

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## Background

The US Department of Health and Human Services recommends youth participate in at least 60 min of moderate-to-vigorous physical activity (MVPA) daily, specifically highlighting the importance of school-based physical activity opportunities to achieve this goal [1]. However, as of 2022, less than 25% of children aged 6–17 met the MVPA/day guideline [2]. Further, only 42% of US youth have adequate cardiorespiratory fitness, the lowest prevalence since estimates have been available [2, 3], which is expected to result in an estimated \$1.7 trillion in lost productivity throughout their lifetimes [4–6]. Adequate cardiorespiratory fitness in youth, the ability of the body's circulatory and respiratory systems to supply oxygen to muscles for energy during physical activity [7], is an important indicator of present-day physical and mental health and academic performance [7, 8]. It is also a predictor of later-life health, reducing the risk for cardiovascular disease, type 2 diabetes, metabolic syndrome, breast and colon cancer, and dementia and Alzheimer's disease [9–14]. Troublingly, racial/ethnic and income-related disparities in both physical activity and cardiorespiratory fitness will increase inequities in cardiometabolic outcomes [5, 15].

School physical education (PE) is an important population-level health intervention for increasing physical activity and improving youth fitness and has the potential to reduce health disparities [16, 17]. Almost all US states require elementary schools provide PE; however, few states offer sufficient resources (e.g., PE teachers) and support (e.g., funding for training/equipment) to ensure the implementation of that legislation. Even fewer states have accountability/surveillance systems in place that ensure schools meet PE law mandates [18]. Subsequently, compliance with state PE laws is extremely low [19–21]. Additionally, unequal provision of PE contributes to race/ethnic- and income-related health disparities in both physical activity and cardiorespiratory fitness [22, 23].

Elementary schools are less likely than middle and high schools to comply with PE state standards [21], making elementary schools a key target for interventions that increase compliance with existing PE laws. Qualitative evidence from educators suggests that interventions to increase PE-law adherence are more successful when they include an implementation process engaging multiple levels of influence (district, principals, and teachers) and provide tangible supports for PE, such as guidance for principals, credentialed PE teachers, and PE-related trainings [24–26]. However, evidence about approaches for improving PE that incorporate simultaneous interventions delivered at the district-, school-, and teacher levels is lacking.

In 2015, less than 5% of New York City elementary schools were compliant with state law mandating at

least 120 min of PE per week taught by a certified PE teacher [27]. To address this, the Department of Education (NYCDOE), the nation's largest school district and among the most racially/ethnically diverse [28], implemented PE Works, a multi-component intervention to improve PE [27]. PE Works sought to remove historical systems-level barriers to PE implementation (e.g. limited funding, priority, and expectations for PE) by employing several evidence-based interventions [29] simultaneously at both district and school levels. PE Works included: (1) a district-led PE audit and feedback system [20] combined with coaching at the school and teacher levels to help schools with PE implementation and ensure PE teachers had appropriate training/support; (2) the provision of state-certified PE teachers in elementary schools; and (3) increased classroom teacher training to supplement PE [30]. PE Works was implemented from school years 2015/16 through 2018/19, with intervention components rolled out in a time-varying fashion across the city's elementary schools. PE Works has the potential to serve as a national model for elementary PE, but the effect of this approach on objectively measured student cardiorespiratory fitness has yet to be evaluated.

This study aims to determine the impact of PE Works, a multi-component approach for improving elementary PE, on student cardiorespiratory fitness at the school level. We use data from 2014/15 to 2018/19 from 581 highly diverse NYCDOE elementary schools that participated in PE Works. We apply the parametric g-formula to address both schools' time-varying intervention component exposure and time-varying confounding.

## Methods

### Data sources and population

This non-randomized longitudinal study is a natural experiment spanning school years 2014/15 (baseline) and 2015/16–2018/19 (PE Works intervention Years 1–4). We draw data from: (1) NYCDOE Office of School Wellness Program's (OSWP) PE Works implementation dataset; (2) the NYC FitnessGram dataset maintained by the NYC Office of School Health, a joint office of the NYCDOE and Department of Health and Mental Hygiene; [31] and (3) publicly available school-level demographic and staffing data managed by NYCDOE [32]. School inclusion criteria included: (1) elementary school serving students in grades K-5 ( $n=663$ ); (2) in a traditional education district (excludes 3 schools that were not required to administer the FitnessGram); and (3) having at least 3 study years of student cardiorespiratory FitnessGram data (excludes 79 more schools). A total of 581 schools were eligible for inclusion. Study procedures were approved by UC Berkeley's Committee for the Protection of Human Subjects (#202009–13643) and NYCDOE's Institutional Review Board (#3788).

### PE works intervention

PE Works was implemented from 2015/16 to 2018/19 by OSWP, which used an internal system to track implementations annually. The first component was PE audit and feedback [20] combined with coaching. The PE Works audit consisted of 9 yes/no PE indicators, including those related to (1) PE teachers and instruction; (2) family-community ties; and (3) supportive environments. OSWP employees completed an audit through visual assessment and discussion with school administrators and the PE teacher, if available. OSWP personnel then created a feedback report detailing indicators needing improvement, with suggestions on how to improve. Feedback was shared with the school principal via tracked email requiring the principal's electronic signature for receipt. During follow-up meetings, emails, and/or phone calls, OSWP personnel provided direct PE-related coaching to principals, PE teachers, and classroom teachers and tracked the number of such interactions they had with each school. If a school made improvements, the number of indicators changed was recorded.

The second primary component was providing a state-certified PE teacher in elementary schools. Before PE Works began, only 10% of elementary PE classes were taught by a full-time certified PE teacher [33]. Publicly available data indicated when a new PE teacher was funded in each school (<https://infohub.nyced.org>). Most schools that received a PE teacher through PE Works (83%) did not have a PE teacher prior to the program. PE teachers typically taught in all grades present at the school.

The third primary component was classroom teacher training in Move-to-Improve [30], NYCDOE's classroom-based physical activity program designed to supplement PE minutes, with in-classroom fitness activities supporting State PE Learning Standards and aligned with core curriculum content areas [34]. Move-to-Improve activities include, for example, calisthenics, plyometrics, and choreographed dancing [35]. Classroom teachers were trained annually in Move-to-Improve through PE teacher-led workshops. A school is considered a

Move-to-Improve All-Star school each year if at least 85% of teachers in the school are trained in Move-to-Improve.

Due primarily to NYCDOE's size, implementation of the PE Works intervention components were staggered across elementary schools (Table 1). In Year 1 (2015/16), the program was implementation piloted in a cohort of 50 schools, which were purposely selected based on prior low compliance with state PE law and school characteristics associated with lower-quality PE provision (high proportion of students of color and students who qualify for free or reduced-price meals). The program was then rolled out to the city's remaining elementary schools across program Years 2 through 4, based on OSWP capacity, to cohorts 2 and 3. By Year 4 (2018/19), 99% of sample schools had received their Audit, 77% their Feedback and coaching, 82% their PE Works-provided PE teacher, and 77% had Move-to-Improve All-Star status.

### Data

#### PE works data

OSWP provided data on the timing of the implementation of all PE Works components. Due to different implementation dates, the audit, feedback, and coaching component was split into two analytic variables. The school year a school received its PE audit, the audit variable changed from 0 (no) to 1 (yes) and remained 1 until the end of the study. Similarly, the school year a school received its PE feedback report, the feedback and coaching variable changed from 0 to 1, and once a school received a PE teacher, the PE teacher variable changed from 0 to 1. Move-to-Improve All-Star status could change each study year.

OSWP-provided data also included: PE Works cohort (1, 2, or 3); the number of PE teachers at the school at baseline; the number of conditions met after the audit (0–9); the number of audit conditions changed after OSWP coaching (0–9); and the number of OSWP coaching interactions with each school.

#### Student cardiorespiratory fitness

The NYC FitnessGram is administered annually by formally trained physical education and classroom teachers

**Table 1** Number of elementary schools implementing PE works' primary intervention components,<sup>a</sup> 2014-15 through 2018-19 (total *n* = 581 schools)

|                                  | PE works |           |           |           |           |
|----------------------------------|----------|-----------|-----------|-----------|-----------|
|                                  | 2014-15  | 2015-16   | 2016-17   | 2017-18   | 2018-19   |
| Physical Education (PE) audit    | N/A      | 163 (28%) | 576 (99%) | 577 (99%) | 577 (99%) |
| PE feedback and coaching         | N/A      | 0 (0%)    | 204 (35%) | 411 (71%) | 411 (71%) |
| PE Works credentialed PE teacher | N/A      | 40 (7%)   | 78 (13%)  | 170 (60%) | 477 (82%) |
| Move-to-Improve All-Star status  | 71 (12%) | 105 (18%) | 103 (18%) | 211 (36%) | 445 (77%) |

<sup>a</sup> PE Works intervention components included: (1) a physical education (PE) needs assessment/audit; (2) feedback from the needs assessment in the form of an action plan, combined with coaching to help schools with PE implementation teacher training; (3) the provision of state-certified PE teachers in elementary schools; (3) 85% of classroom teachers trained in leading PE through the Move-to-Improve program. Note, unlike the other components, some schools received Move-to-Improve training before PE Works

[31] throughout the school year using district-provided equipment. NYCDOE schools are required to have at least 85% of eligible students complete the FitnessGram annually. Starting in the 4th grade, student aerobic capacity (the maximum rate of oxygen uptake and use during exercise) is assessed by the 15-meter Progressive Aerobic Cardiovascular Endurance Run (PACER test). The Cooper Institute (the developer of the FitnessGram) [36], uses Healthy Fitness Zones (HFZ) - criterion-referenced standards that represent minimum levels of fitness for age and sex that offer protection against the diseases that result from sedentary living. Meeting the aerobic capacity HFZ standard (i.e. running at/above the standardized number of laps for age and sex) is considered an indication of present and future cardiorespiratory health [31, 36]. For each study year (2014/15 (baseline) and 2015/16–2018/19 (PE Works intervention years 1–4)) the total number of 4th /5th -grade students tested (overall and by demographic subgroups of interest) were obtained from the NYC FitnessGram dataset. The primary outcome was the annual school-level proportion of 4th /5th -grade students who met aerobic capacity HFZ standards.

### School and student demographics

Publicly available school-level data were downloaded from NYCDOE's data website (<https://infohub.nyced.org>) for each study year, including total school enrollment, student enrollment by race/ethnicity (Asian, Non-Hispanic Black, Latino/a, and White), and proportion of students eligible for free or reduced-price meals (FRPM, a proxy for socioeconomic status).

### Statistical analysis

Though not randomized, the staggered implementation of PE Works components forms a natural experiment that provides an opportunity for a careful analysis to estimate its impact, under certain standard assumptions. The parametric g-formula (a generalization of epidemiologic standardization to longitudinal data) estimates outcomes under hypothetical interventions [37, 38], making it a logical choice for estimating the impact of PE Works. In this case, the interventions considered were: (a) no PE Works (i.e., all components set to 0 in all 4 intervention years for all schools), (b) immediate implementation of all PE Works components (i.e., all components set to 1 in all years for all schools), (c) immediate implementation of PE audit, feedback and coaching, but no other PE Works components; (d) immediate implementation of hiring a dedicated PE teacher but no other PE Works components, (e) immediate implementation of Move-to-Improve training but no other PE Works components. Since PE Works components were implemented at the school level, this is a school-level analysis, with the

annual proportion of 4th /5th grade students meeting aerobic capacity HFZ standards as the outcome. A methodological strength of the parametric g-formula is its ability to control time-varying confounding even when confounders are affected by prior treatment. This analysis adjusted for the following time-varying covariates: total school enrollment; proportion of students who qualified for FRPM; the proportion of non-White students; the total number of students FitnessGram tested; the number of PE teachers at the school; the number of days of PE per week, PE Works cohort (1, 2, or 3), the number of conditions met after the audit, the number of audit conditions changed after OSWP coaching, and the number of OSWP coaching interactions with each school. An outline of how the parametric g-formula was applied and further analytic details are in the Supplement.

Separate analyses were run to test for effect modification by student sex, race/ethnicity, and FRPM status and to estimate the impact of PE Works in these subpopulations of students. Confidence intervals were generated nonparametrically using 500 bootstrap samples. Descriptive statistics were calculated in Stata (MP/16.1); the g-formula analyses were carried out in RStudio (2023.12.1) using the gfoRmula package (<https://github.com/CausalInference/gfoRmula>).

### Results

The final analytic sample included 581 schools, with a total of 315,999 students contributing 558,598 student-year observations over the 5-year study period. At baseline (2014/15), the average enrollment was 647 students/school, with an average 48.8% female, 14.4% Asian, 26.7% Non-Hispanic Black, 40.9% Hispanic/Latinx, and 16.0% White students per school (Table 2). On average, 73.7% of students qualified for FRPM.

At baseline, on average, 196 students (95.2% of those eligible) underwent fitness testing per school. At the school level, an average of 40.1% of students were meeting aerobic capacity HFZ standards. The school-level average for meeting aerobic capacity HFZ standards was higher for males (44.9%) than females (35.4%); for Asian (43.1%) and White (40.7%) than for Non-Hispanic Black (38.4%) and Hispanic/Latino (38.4%) students; and for students who did not qualify for FRPM (42.0%) compared with those who did (38.4%).

Table 3 presents the predicted school-level proportion of students meeting aerobic capacity HFZ standards under the observed PE Works components implementation across all 4 years (2015/16–2018/19) compared to: (1) what would have happened had PE Works *not* been implemented, and (2) under a hypothetical PE Works intervention in which *all schools* received *all 4* primary PE Works components (PE needs assessment/audit, feedback, PE teacher provision, and increased classroom



**Table 2** New York City department of education elementary school sample baseline demographic characteristics, 2014-15 school year ( $n = 581$  schools;  $n = 108,898$  4th /5th -grade students tested via FitnessGram)

|   | Mean $\pm$ SD   |
|---|-----------------|
| School-level characteristics  |                 |
| Enrollment, All Students  | 647 $\pm$ 318   |
| % female students   | 48.8 $\pm$ 2.4  |
| % Asian students  | 14.4 $\pm$ 20.1 |
| % Non-Hispanic Black students   | 26.7 $\pm$ 28.1 |
| % Hispanic/Latino students  | 40.9 $\pm$ 26.7 |
| % White students  | 16.0 $\pm$ 22.6 |
| % Other/multiple race/ethnicity students  | 2.0 $\pm$ 2.6   |
| % of students who qualify for free or reduced-price meals   | 73.7 $\pm$ 23.3 |
| Student-level characteristics   |                 |
| Number of 4th /5th grade students tested via FitnessGram, per school  | 196 $\pm$ 109   |
| Proportion of 4th /5th grade students tested for FitnessGram, per school  | 95.2 $\pm$ 12.4 |
| School-level proportion of 4th /5th grade students who met Healthy Fitness Zone <sup>A</sup> standards for aerobic capacity, All students | 40.1 $\pm$ 24.8 |
| Female  | 35.4 $\pm$ 25.1 |
| Male  | 44.9 $\pm$ 25.3 |
| Asian   | 43.1 $\pm$ 33.3 |
| Non-Hispanic Black  | 38.4 $\pm$ 27.3 |
| Hispanic/Latino   | 38.4 $\pm$ 25.0 |
| White   | 40.7 $\pm$ 31.9 |
| Students who qualify for free or reduced-price meals  | 38.4 $\pm$ 24.4 |
| Students who do not qualify for free or reduced-price meals   | 42.0 $\pm$ 28.0 |

<sup>A</sup> The FitnessGram uses Healthy Fitness Zones to evaluate students' fitness performance. These zones are criterion-referenced standards and represent minimum levels of fitness for age and sex that offer protection against the diseases that result from sedentary living. Aerobic capacity reflects the maximum rate of oxygen uptake and use during exercise

teacher training in Move-to-Improve) for *all* 4 years. Under observed PE Works conditions, by the final year (2018/19), 49.7% of students (95% CI: 42.6%, 54.2%) met aerobic capacity HFZ standards. Had PE Works *not* been implemented, we estimate 45.7% (95% CI: 36.9%, 52.1%) would have met aerobic capacity HFZ standards (difference of -4.0%-points (95% CI: 0.3%, 8.1%) from observed PE Works implementation). Had PE Works been fully implemented in *all* schools from the beginning of Year 1, we estimate 57.4% (95% CI: 49.1%, 63.3%) of students would have met aerobic capacity HFZ standards (difference of 11.7% percentage-points (95% CI: 3.8, 19.2) from *no* PE Works implementation).

There was no formal evidence of effect modification (male vs. female,  $p=0.917$ ); race/ethnicity (Asian vs. Non-Hispanic Black,  $p=0.932$ ; Asian vs. Hispanic/Latino,  $p=0.595$ ; Asian vs. White,  $p=0.994$ ; Non-Hispanic Black vs. Hispanic/Latino,  $p=0.656$ ; Non-Hispanic

Black vs. White,  $p=0.926$ ; Hispanic/Latino vs. White,  $p=0.590$ ); and FRPM status (qualifies vs. does not qualify,  $p=0.682$ ; Supplement). However, we present stratified models (Table 3), as differences in outcomes by student demographic characteristics are of consistent interest to NYCDOE and researchers.

Figure 1 shows the observed and predicted proportions of all students meeting aerobic capacity HFZ standards for each school year. Figures stratified by student sex, race/ethnicity, and FRPM status can be found in the Supplementary Materials.

We additionally examined the estimated effect of each PE Works component individually. Compared to PE Works not being implemented, adding a PE teacher, alone, resulted in an estimated 6.4%-point (95% CI: 1.0, 12.0) increase in the school-level proportion of students meeting aerobic capacity HFZ standards after 4 years. Move-to-Improve All-Star status, alone, resulted in an estimated 5.3%-point (95% CI: 0.3%, 10.6%) increase. Neither the PE audit, alone, or the Feedback/Action Plan, alone, nor the Audit and Feedback combined, resulted in a statistically significant estimated increase in the proportion of students meeting aerobic capacity HFZ standards.

## Discussion

This is the first known study to capitalize on a large, natural experiment to examine the impact of a multi-component PE intervention on elementary students' cardiorespiratory fitness. NYCDOE's PE Works program, intentionally designed to address low PE provision and improve student health, had a positive impact on cardiorespiratory fitness across student groups after four years of varying implementation across 581 schools. This study adds to the evidence base demonstrating PE's contributions to improvements in students' aerobic capacity [39].

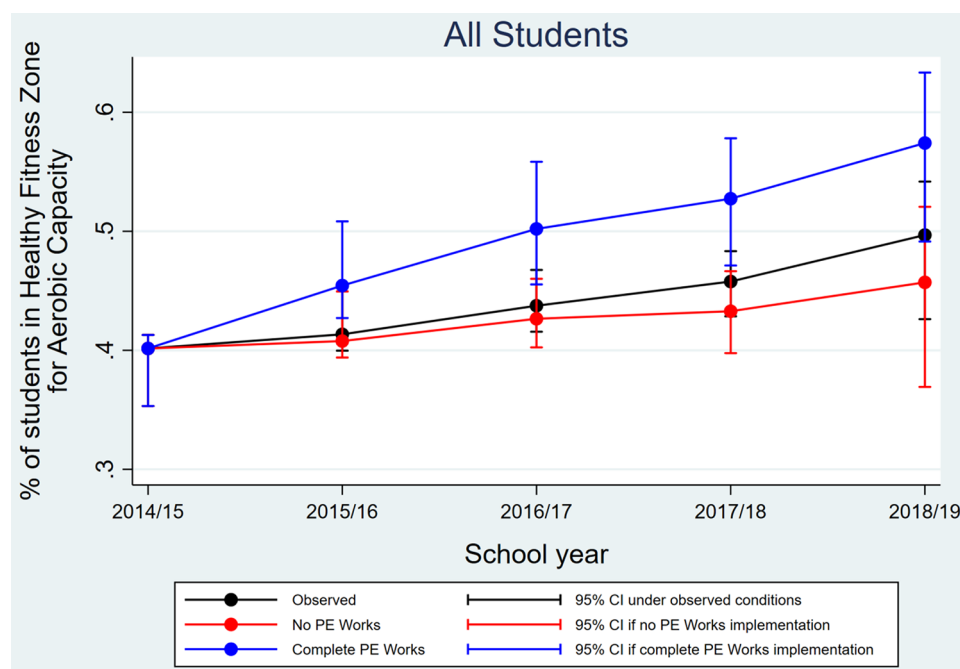
A major strength of this study is the application of the parametric g-formula, which allowed for a comparison of what would have occurred *without* PE Works to what would have occurred had PE Works been implemented in *all* schools from the *beginning* of the program and determined the impact of a non-randomized natural experiment. Had all schools received PE Works from Day 1, we estimate a 12% increase in the proportion of students meeting aerobic capacity HFZ standards after four years, compared to had PE Works not been implemented. This translates to improved cardiorespiratory fitness for nearly 85,000 students annually, representing large public health impact. While implementation in all schools from day 1 was not realistic in NYCDOE, smaller districts could more feasibly provide PE teachers and an evidence-based curriculum (like Move-to-Improve [30]) across all schools, with potentially comparable impact, using lessons learned from NYCDOE [40]. Testing this method

**Table 3** Predicted school-level proportion of students meeting aerobic capacity healthy Fitness Zone standards<sup>A</sup> in 2018/19 (final year of PE Works) under: (A) the observed PE works implementation across all 4 intervention years (2015/16–2018/19), compared to what would have happened had (B) PE works not been implemented and (C) all schools received all PE works components<sup>B</sup> for all 4 intervention years ( $n = 581$  elementary schools)

|  | A. Mean under observed PE Works components (95% CI) | B. Estimated mean under no PE Works components (95% CI) | C. Estimated mean under all/complete PE Works components (95% CI) | Mean difference observed vs. no PE Works components (A vs. B) (95% CI) | Mean difference no vs. all/complete PE Works components (B vs. C) (95% CI) |
|--|---|---|---|--|--|
| All students                                 | 49.7 (42.617, 54.176)                               | 45.7 (36.923, 52.056)                                   | 57.4 (49.143, 63.336)   | 4.0 (0.307, 8.081)   | 11.7 (3.812, 19.179)   |
| Female                                       | 50.0 (43.236, 54.640)                               | 46.7 (37.888, 52.883)                                   | 57.6 (50.094, 62.859)   | 3.4 (-0.468, 7.742)  | 10.9 (3.646, 19.199)   |
| Male   | 52.2 (45.223, 56.934)                               | 47.8 (38.731, 54.800)                                   | 59.7 (52.063, 65.445)   | 4.4 (0.508, 8.584)   | 11.9 (4.019, 19.623)   |
| Non-Hispanic Black                           | 49.6 (43.031, 55.745)                               | 48.7 (39.158, 57.158)                                   | 54.2 (46.709, 61.725)   | 0.9 (-3.710, 6.177)  | 5.5 (-2.633, 14.014)   |
| Asian  | 40.3 (30.006, 51.407)                               | 37.1 (23.937, 50.302)                                   | 44.2 (34.242, 56.122)   | 3.2 (-3.010, 10.224)   | 7.1 (-3.087, 18.833)   |
| Hispanic/Latino                              | 46.7 (40.496, 52.284)                               | 42.8 (34.296, 50.014)                                   | 54.1 (46.966, 61.011)   | 3.9 (0.063, 8.227)   | 11.3 (3.904, 18.999)   |
| White  | 50.9 (43.931, 56.998)                               | 49.4 (39.524, 57.606)                                   | 56.0 (48.381, 63.336)   | 1.5 (-3.311, 6.848)  | 6.7 (-1.387, 15.401)   |
| Eligible for free or reduced-price meals     | 47.5 (41.563, 53.375)                               | 43.6 (35.935, 51.251)                                   | 54.9 (47.821, 62.344)   | 3.9 (0.030, 8.104)   | 11.3 (3.791, 19.806)   |
| Not eligible for free or reduced-price meals | 50.0 (41.825, 57.783)                               | 51.6 (41.157, 61.478)                                   | 55.2 (45.776, 64.902)   | -1.6 (-6.797, 4.422)   | 3.5 (-5.945, 14.474)   |

<sup>A</sup> The FitnessGram uses Healthy Fitness Zones to evaluate students' fitness performance. These zones are criterion-referenced standards and represent minimum levels of fitness for age and sex that offer protection against the diseases that result from sedentary living. Aerobic capacity reflects the maximum rate of oxygen uptake and use during exercise

<sup>B</sup> PE Works intervention components included: (1) a physical education (PE) needs assessment/audit; (2) feedback from the needs assessment in the form of an action plan, combined with coaching to help schools with PE implementation teacher training; (3) the provision of state-certified PE teachers in elementary schools; 3) increased classroom teacher training in leading PE through the evidence-based Move-to-Improve program



**Fig. 1** Adjusted school-level proportion of students who met aerobic capacity Healthy Fitness Zone standards before (2014/15) and during PE Works (2015/16–2018/19) under observed and predicted PE Works conditions ( $n = 581$  schools)

in financially-able school districts would help further inform scalability and generalizability.

While PE Works did not reduce disparities in aerobic capacity HFZ achievement, it did not increase them (as other well-intentioned health policies have); [41] the program resulted in improved aerobic capacity for students

across groups. While formal tests for effect modification did not yield statistically significant results, stratified models signified a particularly strong impact for both sexes, Hispanic/Latino students, and students qualifying for FRPM. While formal evidence of a reduction in fitness disparities was hoped for, improving fitness for all

students is still far preferable to leaving certain students behind.

This work represents a real-world program, highlighting efforts driven and executed by the largest public school district in the US, rather than by researchers. The program's first year was funded by an unprecedented Mayoral initiative, which provided \$6 M to pilot PE Works in 185 elementary schools, with 50 schools adding a credentialed PE teacher [43]. Data from the pilot year offered valuable insight into the specific challenges schools faced in providing PE and informed Year 2–4 implementation, which occurred after the city invested significant additional funding (\$100 M) for citywide expansion [42].

This massive cash infusion is not easily replicated in other school districts; thus understanding the singular impact of each primary PE Works intervention component is important. Adding a PE teacher, alone, resulted in an estimated 6% increase in the proportion of students meeting aerobic capacity HFZ standards. Before PE Works began, OSWP estimated that fewer than one-third of elementary schools had a full-time credentialed PE teacher on staff; after PE Works, nearly all (95%) did. Classroom teachers, whose multi-subject credential usually involves only a few hours of PE-specific education, are less well-equipped to deliver PE than credentialed PE teachers, who have at least a year of PE-specific training.<sup>61,71</sup> Other studies support this finding, demonstrating that credentialed PE teachers are associated with greater amounts of PE,<sup>72</sup> more daily MVPA,<sup>73</sup> and better student cardiorespiratory fitness [12].

Increased classroom teacher training in an evidence-based program also led to improved student fitness. Had all schools had Move-to-Improve All Star Status from Day 1, we estimate a resulting 5% increase in the school-level proportion of students meeting fitness standards. This finding is substantiated by prior evidence, with widely disseminated evidence-based PE programs (e.g. CATCH [43] and SPARK [44]) demonstrating increases in student physical activity and fitness. Given the typically lower cost of programs that support elementary classroom teachers to lead PE, investing in programs like Move-to-Improve could be a sound alternative in the absence of PE teacher funding.

While audit, feedback, and coaching alone did not impact student cardiorespiratory fitness, qualitative evidence from NYCDOE demonstrated the critical importance of the support (including resources tailored to a school's individual needs based on trusting district-school relationships) that audit, feedback, and coaching provided as part of this program [40]. As this is a less expensive intervention than adding PE teachers or Move-to-Improve, it is important to test this approach. Work is currently underway to examine the impact of

audit, feedback, and coaching alone on student health in Oakland, California elementary, with forthcoming results expected to contribute additional evidence.

The size and scope of PE Works makes it challenging to compare it to other interventions. Texas's \$37 million, 5-year, Texas Fitness Now program, a large (though less structured) investment, demonstrated no impact on student cardiorespiratory fitness [45]. However, it focused on middle schools, where PE is typically already block-scheduled and taught by credentialed PE teachers. In addition, middle schoolers may have already formed physical activity habits that are harder to change. Confirming the impact of a similar program on elementary students in other locations/states is important.

Several limitations deserve mention. First, this research relied upon secondary, NYCDOE-collected data; we lacked detailed quantitative data on coaching exposure/dose and direct systematic observations of PE classes (to validate how often PE occurred or to assess instructional content/class quality). Second, school-reported data on PE minutes lacked variability (over 75% of schools self-reported meeting the state PE minute law at baseline), precluding our ability to use law compliance as an outcome. Other research has demonstrated that schools overreport PE time when self-reporting compliance [20, 40]. Third, the PACER test, which was used to determine student cardiorespiratory fitness, is an effort-dependent test. It is plausible that PE Works may have impacted the psychological aspects of such testing. Thus, improvements seen in cardiorespiratory fitness could be a result of both real physiological changes, as well as improvements in test-taking motivation. Fourth, as in any observational study, attributing causality to the estimates depends on adequate control for confounding factors. We adjusted for and/or stratified by what we believe to be a sufficient set of covariates to eliminate most confounding, but the potential for unmeasured confounding remains. For example, over the study period, it's possible that additional community- and school-level policies/programs with similar physical activity-related objectives were implemented in parallel. However, we did not have data on such programs, nor on individual student fitness pursuits (like sports participation), which prevented us from adjusting for these factors. Finally, NYCDOE is a large and highly diverse urban school district; findings from this study may not generalize to other school districts with different school, student, and staff characteristics.

## Conclusions

PE Works had a robust, positive impact on student cardiorespiratory fitness, with adding PE teachers into schools having the greatest singular impact on improved student aerobic capacity. Synergistic and comprehensive



PE programming that includes the provision of PE teachers, PE training for classroom teachers, and administrative/teacher support for leading PE, can positively impact student cardiovascular health. Further, it is feasible to implement in a large, highly diverse, and heterogeneous school district. When multi-component approaches are not viable, adding and supporting PE teachers in elementary schools is a public health intervention worth investing in. Future evidence from other school districts will better illuminate the potential for less costly interventions, such as PE audits, feedback, and coaching to impact student health.

### Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12889-024-20673-9>.

Supplementary Material 1

### Acknowledgements

The authors would like to acknowledge the tremendous work of the NYCDOE Office of School Wellness Programs and NYCDOE elementary school administrators, teachers, and students for implementing the PE Works Program. Without their tireless vision and endless hard work, this study would not have been possible. In particular, we would like to thank Alice Goodman, Jeremy Walter, Erica Irvine, Despina Zaharakis, and Lindsey Harr for their support for this research.

### Author contributions

All authors have contributed to (1) the concept and design or analysis and interpretation of data, (2) the drafting or revision of the manuscript, and (3) the approval of the final version. HRT: conceived of and designed the study, analyzed and interpreted the data, and drafted the manuscript. KAM: Helped conceive of the study, assisted with data interpretation, and provided manuscript edits. CN and TM: Assisted with analysis and interpretation of the data and provided manuscript edits. SP: Assisted with study design, advised on data analysis and interpretation, and provided manuscript edits.

### Funding

This study was funded by the National Heart, Lung, and Blood Institute, 1K01HL51805.

### Data availability

The authors do not have permission to share data, but data could be made available through required IRB approval and data use agreement(s) with the New York City Department of Education.

### Declarations

#### Ethics approval and consent to participate

Informed consent for parents/guardians of participants under the age of 16 was not required as this was a secondary data analysis using de-identified school-level data. Study procedures, including a waiver for consent to participate, were approved by UC Berkeley's Committee for the Protection of Human Subjects (#202009 – 13643) and NYCDOE's Institutional Review Board (#3788).

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare no competing interests.

Received: 26 April 2024 / Accepted: 8 November 2024

Published online: 14 November 2024

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