Public Health Nutrition

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Research Paper

Cite this article: Linares A, Hewawitharana SC, Plank K, Rider CD, Woodward-Lopez G, and Brown MW (2025). Student and school characteristics modify the impact of SNAP-Ed on student dietary and physical activity outcomes. *Public Health Nutrition* **28**: e143, 1–14. doi: 10.1017/S136898002510092X

Received: 30 August 2024
Revised: 20 February 2025
Accepted: 16 April 2025

Keywords:
SNAP-Ed; Dietary behaviours; Physical activity; School-based interventions; Health equity

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Student and school characteristics modify the impact of SNAP-Ed on student dietary and physical activity outcomes

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Abstract

Objective: To examine the impacts of school-based CalFresh Healthy Living (CFHL-California's SNAP-Ed) interventions post-COVID-19-related school closures and whether student and school characteristics modified intervention impacts on student diet and physical activity (PA). *Design:* Quasi-experimental, two-group, pre-post, self-report. *Setting:* CFHL-eligible public schools ($n_{intervention} = 51$; $n_{comparison} = 18$). *Participants:* 4th/5th grade students ($n_{intervention} = 2115$; $n_{comparison} = 1102$). *Results:* CFHL interventions were associated with an increase in consumption frequency of fruit (0·19 times/d ($P = 0·015$)) and vegetables (0·35 times/d ($P = 0·006$)). Differences in baseline diet and PA behaviours were observed by student race and gender and by whether the proportion of free and reduced-price meal (FRPM)-eligible students was above the state average. Notably, students in schools with FRPM above the state average reported more frequent consumption of sugar-sweetened beverages (Mean (SE): 3·18 (0·10) *v.* 2·58 (0·11); $P = 0·001$) and fewer days/week with 60+ min of moderate-to-vigorous PA (MVPA) (Mean (SE): 2·8 (0·10) *v.* 3·21 (0·12); $P = 0·020$) than those at schools with FRPM at/below the state average. Student gender, school urbanicity and school FRPM modified the relationship between the interventions and certain dietary and/or PA outcomes. Interventions were associated with greater increases in vegetable consumption in more urban schools (β (95 % CI) = 0·67 (0·15, 1·20)), and greater increases in fruit consumption (β (95 % CI) = 0·37 (0·07, 0·66)) and in MVPA in higher FRPM schools (β (95 % CI) = 0·86 (0·33, 1·39)). *Conclusions:* Findings reaffirmed effectiveness of school-based CFHL interventions. We identified existing student and school-level disparities and then observed that interventions were associated with greater increases in MVPA in the highest FRPM schools. Findings can inform an equity-centred approach to delivery of school-based interventions that facilitate equal opportunity for all children to achieve lifelong health.

Poor diet and physical activity (PA) behaviours early in life can persist and subsequently lead to chronic diseases like type 2 diabetes, CVD and specific types of cancer and other negative health outcomes like overweight and obesity[1]. Most children in the USA fail to meet recommendations for healthy eating and PA, consuming too few fruits and vegetables (FV) and too many sugar-sweetened beverages (SSB), and engaging in too little PA[2,3]. Youth aged 9–13 years consume about a cup each of fruit and vegetables daily, while recommendations indicate that 1·5–3·5 cups of vegetables and 1·5–2 cups of fruit are needed for good health[2]. SSB account for 15–25 % of children's total added sugar intake, and by adolescence, this increases to 32 % or higher[2]. In addition, while it is recommended that children engage in moderate-to-vigorous PA (MVPA) for at least 60 min daily[3], only 23 % of children do[4]. Furthermore, children of colour, particularly Hispanic and Black children, and those from lower socio-economic status (SES), are at an even greater risk for suboptimal nutrition and activity[5,6].

While the link between individual-level characteristics and dietary and PA behaviours has been well established[5,6], the relationship between school-level attributes and these behaviours is mixed. As it relates to diet, higher school-level SES is positively associated with greater FV and lower SSB intakes[7,8]. As it relates to PA, students from higher SES schools are more likely to achieve cardiorespiratory fitness targets, and overall, face fewer barriers to activity[9]. Findings related to rural–urban disparities in student diet and PA have proven less consistent. A 2015 meta-analysis by McCormack and Meendering showed mixed results regarding both diet and PA outcomes, likely due to differences in data collection methodology and inconsistent school urbanicity definitions across studies[10].

While individual and school-level inequities existed prior to the COVID-19 pandemic, associated school closures may have widened disparities by creating barriers to accessing healthy school meals and opportunities for PA that disproportionately affected children already at risk.

School closures affected students in lower-income schools more, as they remained in distance learning longer[11]. Despite creative efforts to distribute school meals, 45 % fewer lunches were distributed nationally as part of the National School Lunch Program (NSLP) from March to November 2020 as compared to the previous year[12]. Furthermore, one study suggested that NSLP participants unable to obtain school meals during closures may have had reduced intake of key nutrients like Ca and vitamin D and increased daily energetic intake, as lunches brought from home have, on average, 128 more calories than school-provided lunch[13]. School closures also hindered access to PA opportunities like PE and recess. Having a safe built environment was key for outdoor community and neighbourhood PA during school closures; however, low-SES and Hispanic children reported significantly less safety walking or playing in their neighbourhoods than their middle- and high-SES, non-Hispanic peers[14]. Overall, the magnitude of the reduction of MVPA during COVID closures was significantly higher among children living in low-SES households than that of children living in middle- and high-SES households[14].

Supplemental Nutrition Assistance Program-Education (SNAP-Ed) implements nutrition education and obesity prevention programmes for eligible individuals that promote dietary and PA behaviours consistent with the Dietary Guidelines for Americans[15]. Based on the disproportionate representation of BIPOC groups among SNAP-Ed-eligible individuals, the programme is well positioned to address inequities and, as such, has recently adopted additional measures to promote health equity[16]. SNAP-Ed has been shown to improve dietary and PA behaviours of participants across the lifespan and settings[17], with efforts in schools proving especially effective, even during COVID-19-related school closures[18,19]. In California, SNAP-Ed is referred to as CalFresh Healthy Living (CFHL). The California Department of Public Health (CDPH) is one state implementer of CFHL (hereby referred to as *CDPH-CFHL*), conducting programming through a network of sixty-one local health departments (LHD). Schools are a priority setting for CDPH-CFHL, and as such, LHD partner directly with schools within their jurisdiction by implementing school-based interventions to those interested in receiving them. In many cases, intervention is implemented by LHD staff, but often, classroom teachers or other site-level staff are trained to support intervention as well. School-based CDPH-CFHL programming includes a combination of nutrition and PA education and policy, systems, and environmental change (PSE) approaches in schools that predominantly serve students from low-income families. This study aims to build upon previous findings highlighting the overall impact of school-based CDPH-CFHL interventions during COVID-19-related school closures in the 2020–2021 school year[19] by examining intervention impacts in the following year, after school closures concluded. It also seeks to advance equity by examining baseline differences in dietary and PA outcomes by student and school characteristics, and the effect modification by these characteristics on intervention impacts. Though health equity has always been woven into CDPH-CFHL's mission, explicitly examining existing disparities, understanding relationships between student/school characteristics and intervention impacts, and addressing the root cause of disparities is an increasing programmatic priority.

Method

Sampling and data collection

This study used a quasi-experimental, two-group, pre-post design to examine the impact of CDPH-CFHL school-based interventions on students' dietary and PA behaviours. Schools and school-based afterschool programmes (hereafter referred to collectively as *schools*) in California serving fourth and fifth grades that were CFHL-eligible were eligible to participate. CFHL eligibility is typically determined by assessing the proportion of students who meet criteria to receive free and reduced-price meals (FRPM), with schools where at least 50 % of students are FRPM-eligible qualifying for CFHL programming. Alternatively, schools can qualify via the Community Eligibility Provision, which eliminates the need to collect household applications in favour of relying on household participation in other means-tested programmes. CFHL eligibility was determined using FRPM data from 2017 to 2018, the latest data available when school recruitment began.

Random assignment of schools is not characteristic of CFHL intervention, as the programme is driven by local needs and relationships. As such, intervention schools were invited to participate by LHD if they planned to partner on delivery of CDPH-CFHL intervention during the 2021–2022 school year, the intervention included direct education and PSE approaches with fourth and fifth grades, and they were agreeable to conducting the required elements for evaluation. There were no additional geographic criteria for intervention school selection; schools across California were included. Schools that were CFHL-eligible, had not received any CDPH-CFHL intervention in at least three years and were in the same LHD jurisdiction as corresponding intervention schools were invited to participate in the study as comparison schools. A convenience sample of fifty-one intervention schools and eighteen comparison schools consented to participate. Comparison schools were compensated with a $1000 stipend for their participation.

At each participating school, a sample of approximately sixty fourth- and/or fifth-grade students from at least three classrooms were invited to participate in a pre-post survey. When required by the school district, passive parental consent was obtained by distributing an opt-out form two weeks prior to survey administration. Students were also given the opportunity to opt out of the survey on the day of administration. Surveys were administered online by trained LHD nutrition educators and/or classroom teachers. Students were excluded from analyses if they were missing a pre-test survey, a post-test survey or demographic information or if the change in their demographic information was implausible between the pre- and post-test surveys (e.g. reporting a younger age at post compared to pre). Pre- and post-surveys were matched using unique ID numbers assigned to each student and maintained by the survey administrator.

Pre-surveys were administered from September 2021 to March 2022, always prior to the start of annual CDPH-CFHL interventions at a given school. Post-survey data were collected within the last three and a half months of the school year (March–June 2022), after interventions were complete. Though intended to capture data on a consistent, full school-year timeline, due to the challenges securing time in schools, the total evaluation period ranged from two months to six months, with most beginning intervention before the December holiday break, and concluding in April through June. To ensure that all students reported school-day dietary and PA behaviours, students were surveyed on a weekday when school was in session the day prior.

Student dietary and physical activity behaviours

Students' self-reported dietary and PA behaviours were assessed using the Eating and Activity Tool for Students (EATS),

https://doi.org/10.1017/S136898002510092X Published online by Cambridge University Press

administered in a student's choice of English or Spanish. Dietary behaviours assessed included consumption frequencies of fruits, vegetables and beverages in the past day, assessed via sixteen questions adapted from the validated School Physical Activity and Nutrition (SPAN) survey[20,21]. Five questions asked about frequency of consumption of vegetables (starchy vegetables (corn, potatoes, peas), orange vegetables, salad and green vegetables, other vegetables, beans), two about fruit (fruit, 100 % fruit juice), one about French fries and chips, one about diet soda, six about SSB (fruit drinks, sports drinks, regular soda, energy drinks, sweetened coffee and tea, flavoured milk) and one about water[20,21]. With the exception of the fruit question, response options ranged from '*No, I didn't eat/drink ___ yesterday*' to '*Yes, I ate/drank ____ 3 or more times yesterday*'. Response options for fruit ranged from '*No, I didn't eat fruit yesterday*' to '*Yes, I ate fruit 5 or more times yesterday*'. Responses to individual fruit, vegetable and SSB questions were summed to derive total fruit, total vegetable and total SSB intakes, respectively.

Three PA behaviours from EATS are reported here: (1) the number of days students were active for at least 60 min daily, to measure attainment of the MVPA recommendation[3] (2) the number of days per week students had a structured PE class and (3) the relative proportion of time they were active in PE class. The question assessing the number of days per week students were active for at least 60 min was used in its original, validated form[20,21], and the PE-related questions were developed by the authors to assess specific CDPH-CFHL programmatic priorities. For further information regarding survey questions and response categories, refer to EATS (supplementary material).

Student-level and school-level demographics

The survey collected student demographic data, including race/ethnicity, gender, age and grade as well as type of school attendance (in-person, distance learning, combination) in the past day and week. School-level demographic data, including racial/ethnic distribution, student enrolment, proportion of students qualifying for FRPM and grade range served were retrieved from the California Department of Education[22–24]. The proportion of students qualifying for FRPM was categorised into a binary variable based on whether schools had a proportion of students eligible for FRPM greater than 0·788, the average proportion of students eligible for FRPM among CFHL-eligible schools in California (referred to hereafter as 'above state average FRPM' if so or as 'at/below state average FRPM' if not). Urbanicity of schools was determined using 2019 National Center for Education Statistics (NCES) Public School Locale data[25].

Statistical analyses

Descriptive statistics were calculated for measured sociodemographic characteristics. *T* tests, chi-square tests and Fisher's exact tests, adjusted for clustering by schools, were used to assess differences in student sociodemographic characteristics between intervention and comparison groups. Wilcoxon–Mann–Whitney tests and Fisher's exact tests were used to assess differences in school characteristics between intervention and comparison groups. ANCOVA, adjusted for school total enrolment, student age, sex, and race/ethnicity, outcome at pre-test, and clustering by school, was used to examine the intervention impact on change scores of continuous outcomes (all dietary intake outcomes, days achieving 60 min or more of MVPA and days of PE class). Generalised estimating equations, adjusted for school total enrolment, student age, sex, and race/ethnicity, and clustering by school, were used to assess the impact of intervention on time spent active in PE class. Simple regression, logistic regression and chi-square tests, adjusted for clustering, were used to examine baseline differences in outcomes by student and school characteristics. Generalised linear models, adjusted for clustering by site along with school total enrolment and student age, race/ethnicity, sex, and pre-test outcomes, were used to determine if student and school characteristics modified the impact of interventions on behavioural outcomes. All analyses were performed in SAS v.9.4. (SAS Institute Inc.). *P*-values of $< 0·05$ were considered statistically significant.

Results

Study sample

A total of 5731 and 4761 students completed the pre-test and post-test surveys, respectively. Of the 4214 students with matched pre-test and post-test surveys, 997 were excluded due to missing or implausible demographics, yielding a final sample of 3217 students ($n_{\text{intervention}} = 2115$, $n_{\text{comparison}} = 1102$) from sixty-nine schools ($n_{\text{intervention}} = 51$, $n_{\text{comparison}} = 18$) (Table 1). Intervention and comparison schools had comparable average total enrolment (505 *v.* 510, $P = 0·9$) and had fairly equal percentages of schools with FRPM above the state average (49 % *v.* 61 %, $P = 0·4$). Most schools were located in urban areas. Sample student race/ethnicity, gender and age were not statistically significantly different between intervention and comparison groups. In both groups, around half of students identified as Latino/a, and more than a quarter as multiracial. There was a fairly equal gender distribution between males and females, and, on average, students were 9·6–9·7 years old.

Intervention

The CDPH-CFHL interventions at all fifty-one intervention schools included nutrition and/or PA education curricula. Eight curricula were used, with the Dairy Council's Let's Eat Healthy[26] (45 %, twenty-three schools) being the most common (Table 2). Over half of intervention schools (55 %, twenty-eight schools) implemented at least one PSE strategy, and of those, 39 % (eleven schools) implemented multiple strategies. Of schools implementing PSE strategies, the most frequently used were increasing non-PE PA in schools (50 %, fourteen schools), Smarter Lunchroom Movement strategy adoption (e.g. product placement strategies to encourage selection of healthy options) (32 %, nine schools) and improved food distribution (e.g. mobile produce markets) (25 %, seven schools).

Overall intervention impact

Intervention was associated with a statistically significant relative increase in consumption frequency of total fruit (by 0·19 times/d (95 % CI 0·04, 0·34)) and total vegetables (by 0·35 times/d (95 % CI 0·10, 0·59)) (Table 3). More specifically, students from intervention schools had statistically significant relative increases in consumption frequencies of 100 % fruit juice (increased by 0·10 times/d (95 % CI 0·02, 0·18)), starchy vegetables (increased by 0·10 times/d (95 % CI 0·03, 0·17)) and orange vegetables (increased by 0·07 times/d (95 % CI 0·00, 0·13)), compared to students from comparison schools.

https://doi.org/10.1017/S136898002510092X Published online by Cambridge University Press

Table 1. Sociodemographic characteristics of sampled students and sites, by intervention status, 2021–2022 school year

	Intervention (*n* 2115 students; 51 sites)			Comparison (*n* 1102 students; 18 sites)			
	n	%	SE	*n*	%	SE	*P*-value
Student characteristics*,†							
Race/ethnicity							
Asian	109	5·2 %	1·2	20	1·8 %	0·5	0·071
Black	85	4·0 %	0·8	49	4·5 %	1·4	
Latino	1143	54·0 %	3·8	548	49·7 %	3·5	
White	175	8·3 %	1·7	131	11·9 %	2·2	
Multiracial	579	27·4 %	2·0	347	31·5 %	2·9	
Another race/ethnicity	24	1·1 %	0·3	7	0·6 %	0·3	
Gender							
Male	1011	48·8 %	1·3	507	47·3 %	1·4	0·453
Female	1061	51·2 %	1·3	564	52·7 %	1·4	
		Mean	SE		Mean	SE	*P*-value
Age		9·7	0·1		9·6	0·1	0·155
Site-level characteristics‡							
		Mean	SD		Mean	SD	*P*-value
Total enrolment		505	158·4		509·9	156·9	0·911
		n	%		*n*	%	*P*-value
Urbanicity							
Rural		6	11·8		5	27·8	0·140
Urban		45	88·2		13	72·2	
School free and reduced price meals (FRPM) level							
At/below state average FRPM§		26	50·98		7	38·89	0·420
Above state average FRPM§		25	49·02		11	61·11	

*Student characteristics were self-reported.
†*P*-values derived from chi-square and Fisher's exact tests for categorical characteristics, and *t* tests for continuous characteristics, and accounted for clustering by site.
‡*P*-values derived from Wilcoxon–Mann–Whitney tests for continuous characteristics and from Fisher's exact test, for categorical characteristics.
§Among CalFresh Healthy Living-eligible schools.

Baseline differences in dietary and physical activity outcomes by student and school characteristics

There were many statistically significant differences in dietary intake frequencies and PA among the total sample by student (Table 4) and school (Table 5) characteristics at baseline. Consumption frequencies of water ($P = 0·020$), total SSB ($P = 0·005$), SSB excluding flavoured milk ($P = 0·004$), total fruit ($P = 0·027$), 100 % fruit juice ($P = 0·005$), starchy vegetables ($P = 0·040$), salad/green vegetables ($P = 0·013$) and beans ($P < 0·001$) were statistically significantly different by student race/ethnicity at baseline. Students identifying as 'another race' had the lowest average intake frequencies of water (2·10 times/d (SE = 0·16)), total fruit (2·19 times/d (SE = 0·31)) and salad/green vegetables (0·65 times/d (SE = 0·14)); Black students had the highest average intake frequency of total SSB (3·32 times/d (SE = 0·37)); Asian students had the lowest average intake frequencies of 100 % fruit juice (0·68 times/d (SE = 0·08)) and beans (0·10 times/d (SE = 0·04)) and the second lowest for total fruit (2·22 times/d (SE = 0·15)); White students had the lowest average intake frequency of starchy vegetables (0·46 times/d (SE = 0·05)). The average number of days with at least 60 min of MVPA also differed by student race/ethnicity ($P = 0·001$), with students identifying as another race or Asian having the lowest values (2·23 d (SE = 0·34) and 2·55 d (SE = 0·16), respectively).

There were also many differences in dietary intake frequencies and PA behaviours by student gender at baseline. Specifically, compared to females, males had higher consumption frequency of total SSB (3·11 *v.* 2·77 times/d, $P = 0·002$) and SSB excluding flavoured milk (2·31 *v.* 2·05 times/d, $P = 0·006$) and lower consumption frequencies of whole fruit (1·56 *v.* 1·69 times/d, $P = 0·047$), total vegetables (2·90 *v.* 3·20 times/d, $P = 0·008$), starchy vegetables (0·58 *v.* 0·67 times/d, $P = 0·016$), salad/green vegetables (0·68 *v.* 0·77 times/d, $P = 0·013$) and other vegetables (0·69 *v.* 0·81 times/d, $P = 0·003$). Females had fewer days with at least 60 min of MVPA compared to males (2·83 *v.* 3·12, $P = 0·002$), but a greater percent of females reported being physically active during PE class than males (53·5 % *v.* 46·5 %, $P = 0·008$).

Students in schools with FRPM eligibility above the state average tended to have higher consumption frequencies of total SSB (3·18 *v.* 2·58 times/d, $P = 0·001$) and SSB excluding flavoured milk (2·39 *v.* 1·88 times/d, $P = 0·001$), 100 % fruit juice (1·00 *v.* 0·87

https://doi.org/10.1017/S136898002510092X Published online by Cambridge University Press

Table 2. Nutrition and/or physical activity curricula delivered by intervention schools, 2021–2022 school year

Nutrition and/or physical activity curricula* (*n* 51)	Number of schools	%
Let's Eat Healthy (Dairy Council)	23	45 %
Coordinated Approach to Child Health (CATCH)	8	16 %
Serving Up MyPlate: A Yummy Curriculum (USDA)	8	16 %
Power Play! Community Youth Organization (CYO) Kit (CDPH-CFHL)	5	10 %
Teams with Intergenerational Support (TWIGS)	3	6 %
Food Smarts for Kids (Leah's Pantry)	2	4 %
Cooking Matters for Kids (Share Our Strength)	1	2 %
Around the Table (Leah's Pantry)	1	2 %

*All curricula are approved by the United States Department of Agriculture and are reported by local health departments on an internal planning worksheet[27].

times/d, $P = 0{\cdot}013$) and fewer days with at least 60 min of MVPA (2·80 *v.* 3·21 d, $P = 0{\cdot}020$). A much smaller percent of students in rural schools reported being physically active at least 50 % of the time in PE class compared to those in urban schools (24·5 % *v.* 75·5 %, $P = 0{\cdot}001$).

Effect modification by student and school characteristics on intervention impacts

Student gender, school urbanicity and school FRPM level statistically significantly modified the intervention impacts on certain dietary and/or PA outcomes. While there was no statistically significant overall effect of CDPH-CFHL interventions on frequency of student consumption of water, student gender modified the association between intervention and the change in consumption frequency of water ($\beta_{\text{interaction}}$ (95 % CI) = –0·14 (–0·23, –0·05)) (Table 6). While there was no statistically significant intervention effect among males nor among females, it did trend in opposite directions for males *v.* females (Table 7). Whereas male students exposed to CDPH-CFHL intervention tended to report increased water consumption frequency compared to male students in comparison schools ($\beta_{\text{intervention}}$ (95 % CI) = 0·05 (–0·02, 0·12)), female students in intervention schools tended to report decreased water consumption frequency compared to their female counterparts in comparison schools ($\beta_{\text{intervention}}$ (95 % CI) = –0·06 (–0·15, 0·03)).

School urbanicity modified the impact of intervention on change in student consumption frequency of total vegetables ($\beta_{\text{interaction}}$ (95 % CI) = 0·67 (0·15, 1·20)) (Table 6). Whereas in urban schools, intervention students reported increased total vegetable consumption frequency compared to comparison students ($\beta_{\text{intervention}}$ (95 % CI) = 0·48 (0·21, 0·74)), in rural schools, intervention students reported decreased vegetable consumption compared to comparison students ($\beta_{\text{intervention}}$ (95 % CI) = –0·31 (–0·65, 0·02)) (Table 7).

The school's FRPM level modified the relationships between intervention and changes in consumption frequencies of total fruit, fruit excluding 100 % juice and salad/green vegetables. There were no statistically significant intervention effects on change in consumption frequencies of total fruit, fruit excluding 100 % juice or salad/green vegetables in schools with FRPM at or below the state average. In contrast, intervention students in schools with FRPM above the state average reported greater increases in consumption frequencies of total fruit ($\beta_{\text{intervention}}$ (95 % CI) = 0·35 (0·13, 0·56)), fruit excluding 100 % juice ($\beta_{\text{intervention}}$ (95 % CI) = 0·22 (0·06, 0·37)) and salad/green vegetables ($\beta_{\text{intervention}}$ (95 % CI) = 0·16 (0·06, 0·27)), compared to comparison students.

The proportion of students eligible for FRPM also modified the relationship between interventions and change in the number of days with at least 60 min of MVPA. Whereas intervention students in schools with FRPM at or below the state average reported greater decreases in average days with at least 60 min of MVPA compared to comparison students ($\beta_{\text{intervention}}$ (95 % CI) = –0·49 (–0·96, –0·03)), intervention students in schools with FRPM above the state average reported greater increases in average days with at least 60 min of MVPA compared to comparison students ($\beta_{\text{intervention}}$ (95 % CI) = 0·37 (0·11, 0·63)).

Discussion

This study advances previous research evaluating CDPH-CFHL's impact on student diet and PA behaviours during COVID-19-related school closures[19] by assessing whether interventions had similar impacts post-closures. It also adds an equity lens to the evaluation by identifying disparities in baseline health behaviours by student and school characteristics and examining whether CDPH-CFHL interventions may be addressing those disparities.

Results from this study of school-based CDPH-CFHL interventions during the 2021–2022 school year, when students returned to in-person learning, showed similar improvements in FV intake to those from the evaluation of interventions in the 2020–2021 school year, when COVID-19 kept many California schools closed for the majority of the year[19]. In both studies, intervention students reported a significantly greater increase in consumption frequency of total fruit compared to students in comparison schools, driven primarily by an increase in 100 % fruit juice. Encouragingly, in both years, intervention students reported a significantly greater increase in total vegetable consumption frequency than comparison students, and intervention students reported increased, whereas comparison students reported decreased, consumption frequencies for many of the vegetable subtypes. Given baseline intakes of 3·1 times per d for vegetables and 2·6 times per d for fruit, relative increases of 0·35 and 0·19 times per d are increases of around 10 %, reflecting not only statistical significance but also significant behaviour change that when sustained over time and multiplied across students, would likely have a considerable public health impact.

While CDPH-CFHL interventions consistently showed a positive and protective effect on FV consumption, they also consistently showed no effect on SSB and water consumption, PA or PE outcomes. This lack of effect on SSB and water consumption frequencies is not surprising given that 78 % of intervention schools implemented curricula lacking content related to healthy beverage choices, and only one school implemented PSE approaches focused on water access and appeal. However, while it was reasonable to expect minimal effects on PA and PE outcomes when students were learning online, due to increased screen time, no or less structured PE, and less exposure to PSE interventions, the lack of effect on PA outcomes after students returned to

https://doi.org/10.1017/S136898002510092X Published online by Cambridge University Press

Table 3. Adjusted* change in dietary intake frequencies and physical activity behaviours among sampled students, by intervention status, 2021–2022 school year

	Intervention students		Comparison students		Adjusted mean difference in change baseline to follow-up between intervention and comparison students		
Outcomes	*n*	Adjusted mean change baseline to follow-up	*n*	Adjusted mean change baseline to follow-up	*β*	95 % CI	*P*-value
Dietary intake frequencies (times in past day)							
Water	2043	0·04	1057	0·04	−0·01	−0·08, 0·06	0·829
SSB, including flavoured milks	2018	−0·13	1050	−0·13	0·01	−0·22, 0·23	0·956
SSB, excluding flavoured milks	2027	−0·05	1052	−0·11	0·06	−0·10, 0·22	0·473
Fruit drinks	2043	−0·02	1056	−0·03	0·01	−0·07, 0·09	0·855
Sports drinks	2045	0·04	1060	−0·01	0·05	−0·01, 0·12	0·103
Regular soda	2043	−0·04	1059	−0·02	−0·02	−0·08, 0·04	0·490
Energy drinks	2042	0·00	1062	−0·03	0·03	−0·02, 0·07	0·203
Sweetened coffee/tea	2051	−0·03	1059	−0·04	0·00	−0·05, 0·05	0·879
Flavoured milk	2042	−0·08	1059	−0·04	−0·04	−0·15, 0·06	0·419
Fruit, including 100 % fruit juice	2044	0·12	1062	−0·07	0·19	0·04, 0·34	**0·015**
Fruit, excluding 100 % fruit juice	2049	0·07	1065	−0·02	0·10	−0·02, 0·21	0·092
100 % fruit juice	2052	0·04	1062	−0·06	0·10	0·02, 0·18	**0·012**
Vegetables, including beans	2038	0·20	1046	−0·14	0·35	0·10, 0·59	**0·006**
Vegetables, excluding beans	2042	0·22	1050	−0·09	0·30	0·08, 0·53	**0·009**
Starchy vegetables (e.g. potatoes, corn, peas)	2059	0·08	1066	−0·02	0·10	0·03, 0·17	**0·005**
Orange vegetables	2049	−0·02	1067	−0·08	0·07	0·00, 0·13	**0·043**
Salad/green vegetables	2055	0·09	1059	0·01	0·08	−0·01, 0·18	0·080
Other vegetables	2054	0·08	1062	−0·01	0·08	−0·0008, 0·1690	0·052
Beans	2053	−0·02	1064	−0·07	0·05	−0·01, 0·11	0·138
Physical activity outcomes (number of days in last week)							
Days with 60+ min MVPA	2037	0·49	1054	0·45	0·04	−0·27, 0·34	0·819
Days with PE	2026	−0·02	1041	0·08	−0·10	−0·50, 0·29	0·604

	n	Percent change baseline to follow-up	*n*	Percent change baseline to follow-up	Adjusted difference in percent change baseline to follow-up between intervention and comparison students	Adjusted *P*-value
Physical activity outcomes (yes/no)						
Spent half or more of PE class being physically active	1504	5·14 %	825	−2·82 %	7·96 %	0·097

SSB, sugar-sweetened beverages; MVPA.

*Models adjusted for school total enrolment, student age, sex, race/ethnicity and outcome at pre-test and accounted for clustering by school for continuous outcomes. Models adjusted for school total enrolment, student age, sex and race/ethnicity and accounted for clustering by school for binary outcomes.

in-person instruction, especially given the high adoption of PA-related PSE strategies in 2021–2022, was surprising[28].

We identified four key findings as it pertained to effect modification of student and school characteristics on intervention impacts. First, while student gender modified the association between intervention and the change in consumption frequency of water, the intervention's impact was not statistically significant for the group as a whole. Though water consumption by gender was not a disparity identified at baseline, which is supported by the literature[29], the lack of overall intervention impact on water consumption frequency highlights an opportunity for enhanced programmatic efforts. While children aged 9–13 years require 7–8 cups of water per d[30], boys and girls in our study reported drinking water an average of 2·36 and 2·39 times/d, respectively. This is likely insufficient and suggests that hydration needs were not being met or were met with calorically dense and/or less

https://doi.org/10.1017/S136898002510092X Published online by Cambridge University Press

Table 4. Baseline differences* in student dietary and physical activity outcomes by student characteristics, 2021–2022 school year

	Race/ethnicity														Gender					
		Asian		Black		Latino		White		Another race		Multiracial		*P*-value	*n*	Male		Female		*P*-value
	n	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE			Mean	SE	Mean	SE	
Dietary intake frequencies (times in past day)																				
Water	3200	2·41	0·07	2·40	0·10	2·33	0·03	2·45	0·05	2·10	0·16	2·45	0·03	**0·020**	3127	2·36	0·03	2·39	0·03	0·286
Total SSB	3181	2·43	0·19	3·32	0·37	2·96	0·09	2·41	0·18	2·97	0·41	3·09	0·12	**0·005**	3108	3·11	0·11	2·77	0·09	**0·002**
SSB, excluding flavored milk	3183	1·73	0·19	2·65	0·30	2·22	0·08	1·72	0·14	2·29	0·36	2·27	0·10	**0·004**	3110	2·31	0·09	2·05	0·07	**0·006**
Total fruit	3203	2·22	0·15	2·69	0·17	2·57	0·06	2·46	0·12	2·19	0·31	2·69	0·07	**0·027**	3129	2·53	0·07	2·61	0·05	0·348
Fruit, excluding 100 % juice	3206	1·54	0·13	1·54	0·12	1·62	0·04	1·69	0·10	1·29	0·19	1·70	0·06	0·379	3132	1·56	0·05	1·69	0·04	**0·047**
100 % fruit juice	3209	0·68	0·08	1·15	0·08	0·95	0·03	0·77	0·06	0·90	0·20	1·00	0·04	**0·005**	3135	0·97	0·03	0·92	0·03	0·145
Total vegetables	3185	3·07	0·26	2·96	0·26	3·05	0·08	2·82	0·20	2·90	0·57	3·22	0·11	0·456	3111	2·90	0·09	3·20	0·09	**0·008**
Starchy vegetables (e.g. potatoes, corn, peas)	3209	0·70	0·09	0·66	0·09	0·63	0·03	0·46	0·05	0·68	0·16	0·67	0·03	**0·040**	3135	0·58	0·03	0·67	0·03	**0·016**
Orange vegetables	3203	0·64	0·07	0·55	0·07	0·60	0·02	0·54	0·06	0·73	0·16	0·59	0·03	0·786	3129	0·58	0·03	0·60	0·02	0·371
Salad/green vegetables	3205	0·88	0·08	0·87	0·09	0·67	0·02	0·75	0·05	0·65	0·14	0·79	0·03	**0·013**	3131	0·68	0·02	0·77	0·03	**0·013**
Other vegetables	3202	0·74	0·07	0·60	0·08	0·73	0·02	0·85	0·08	0·61	0·15	0·80	0·05	0·431	3128	0·69	0·03	0·81	0·04	**0·003**
Beans	3208	0·10	0·04	0·31	0·06	0·41	0·02	0·22	0·03	0·26	0·10	0·37	0·03	**<·001**	3134	0·37	0·02	0·35	0·02	0·537
Physical activity outcomes (number of days in last week)																				
Days with 60+ min MVPA	3196	2·55	0·16	3·20	0·25	2·82	0·11	3·31	0·16	2·23	0·34	3·16	0·08	**0·001**	3122	3·12	0·11	2·83	0·08	**0·002**
Days with PE	3180	1·90	0·27	2·04	0·26	2·10	0·15	2·10	0·14	2·39	0·27	2·11	0·11	0·810	3106	2·11	0·12	2·09	0·13	0·669

	Total *n*	*n*	%	SE	*n*	%	SE	*n*	%	SE	*n*	%	SE	*n*	%	SE	*n*	%	SE	*P*-value	Total *n*	*n*	%	SE	*n*	%	SE	*P*-value
Physical activity outcomes (yes/no)																												
Spent half or more of PE class being physically active	2783	81	3·84 %	1·00	90	4·27 %	0·73	1099	52·16 %	2·87	204	9·68 %	1·53	20	0·95 %	0·22	613	29·09 %	1·83	0·825	2719	959	46·51 %	1·14	1103	53·49 %	1·14	**0·008**

MVPA, moderate-to-vigorous PA. Boldface type indicates statistical significance (*P*<0.05).
*All tests were adjusted for clustering by site.

Table 5. Baseline differences* in student dietary and physical activity outcomes by school characteristics, 2021–2022 school year

	Total enrolment				Urbanicity						School free and reduced price meals (FRPM) level					
						Urban		Rural				At/below state average FRPM†		Above state average FRPM†		
	n	*β*	SE	*P*-value	*n*	Mean	SE	Mean	SE	*P*-value	*n*	Mean	SE	Mean	SE	*P*-value
Dietary intake frequencies (times in past day)																
Water	3200	0·00	0·01	0·828	3200	2·39	0·03	2·35	0·05	0·481	3200	2·43	0·03	2·34	0·04	0·073
Total SSB	3181	0·00	0·05	0·954	3181	2·90	0·08	3·10	0·25	0·451	3181	2·58	0·11	3·18	0·10	**0·001**
SSB, excluding flavoured milk	3183	−0·02	0·04	0·721	3183	2·14	0·07	2·34	0·20	0·356	3183	1·88	0·09	2·39	0·08	**0·001**
Total fruit	3203	0·04	0·02	0·126	3203	2·60	0·05	2·53	0·11	0·568	3203	2·51	0·06	2·63	0·07	0·196
Fruit, excluding 100 % juice	3206	0·02	0·02	0·276	3206	1·64	0·04	1·63	0·05	0·868	3206	1·64	0·04	1·63	0·05	0·897
100 % fruit juice	3209	0·02	0·01	0·197	3209	0·96	0·03	0·90	0·07	0·474	3209	0·87	0·04	1	0·03	**0·013**
Total vegetables	3185	−0·02	0·03	0·537	3185	3·07	0·08	3·08	0·15	0·956	3185	3·01	0·11	3·12	0·09	0·464
Starchy vegetables (e.g. potatoes, corn, peas)	3209	0·00	0·01	0·687	3209	0·64	0·02	0·62	0·04	0·718	3209	0·6	0·03	0·65	0·03	0·198
Orange vegetables	3203	−0·01	0·01	0·200	3203	0·60	0·02	0·57	0·05	0·622	3203	0·57	0·03	0·6	0·03	0·482
Salad/green vegetables	3205	0·00	0·01	0·786	3205	0·74	0·02	0·69	0·03	0·216	3205	0·73	0·03	0·73	0·02	0·904
Other vegetables	3202	0·00	0·01	0·948	3202	0·75	0·03	0·78	0·03	0·466	3202	0·78	0·04	0·74	0·03	0·513
Beans	3208	−0·01	0·01	0·541	3208	0·35	0·02	0·42	0·04	0·110	3208	0·33	0·03	0·38	0·02	0·091
Physical activity outcomes (number of days in last week)																
Days with 60+ min MVPA	3196	0·03	0·04	0·549	3196	2·88	0·09	3·28	0·19	0·113	3196	3·21	0·12	2·8	0·10	**0·020**
Days with PE	3180	0·05	0·07	0·448	3180	2·06	0·15	2·23	0·16	0·453	3180	2·17	0·12	2·05	0·19	0·602

	n	*β*	SE	*P*-value	Total *n*	*n*	%	SE	*n*	%	SE	*P*-value	Total *n*	*n*	%	SE	*n*	%	SE	*P*-value
Physical activity outcomes (yes/no)																				
Spent half or more of PE class being physically active	2783	0·09	0·06	0·248	2783	1591	75·51	6·90	516	24·49	6·90	**0·001**	2783	855	40·58	7·31	1252	59·42	7·31	0·425

MVPA, moderate-to-vigorous PA. Boldface type indicates statistical significance (*P*<0.05).
*All tests were adjusted for clustering by site.
†Among CalFresh Healthy Living-eligible schools.

Table 6. Interactions between student gender and school characteristics and intervention status on change in student diet and physical activity outcomes among sampled students, school year 2021–2022

	Student gender*				School urbanicity†				School total enrolment‡				School free and reduced price meals (FRPM) level§			
		Interaction term between student gender and intervention status				Interaction term between school urbanicity and intervention status				Interaction term between school total enrolment and intervention status				Interaction term between school FRPM level and intervention status		
	n	*β*	95 % CI	*P*-value	*n*	*β*	95 % CI	*P*-value	*n*	*β*	95 % CI	*P*-value	*n*	*β*	95 % CI	*P*-value
Change in dietary intake frequencies (change in times in past day baseline to follow-up)																
Water	3100	−0·14	−0·23, −0·05	**0·008**	3100	0·09	−0·07, 0·26	0·295	3100	0·03	0, 0·06	0·097	3100	0·06	−0·08, 0·20	0·383
Total SSB	3068	0·19	−0·14, 0·52	0·263	3068	−0·22	−0·87, 0·43	0·500	3068	−0·00	−0·11, 0·10	0·937	3068	0·25	−0·22, 0·72	0·317
SSB, excluding flavoured milk	3079	0·13	−0·16, 0·42	0·379	3079	−0·26	−0·67, 0·16	0·230	3079	0·02	−0·07, 0·11	0·681	3079	0·17	−0·16, 0·50	0·316
Total fruit	3106	0·02	−0·26, 0·31	0·869	3106	0·09	−0·23, 0·41	0·593	3106	0·06	−0·04, 0·16	0·248	3106	0·37	0·07, 0·66	**0·024**
Fruit, excluding 100 % juice	3114	0·01	−0·20, 0·22	0·911	3114	0·09	−0·18, 0·36	0·519	3114	0·01	−0·05, 0·08	0·695	3114	0·27	0·06, 0·48	**0·022**
100 % fruit juice	3114	0·02	−0·10, 0·14	0·726	3114	−0·03	−0·17, 0·12	0·715	3114	0·05	−0·01, 0·10	0·137	3114	0·06	−0·10, 0·21	0·477
Total vegetables	3084	−0·22	−0·63, 0·18	0·291	3084	0·67	0·15, 1·2	**0·033**	3084	0·09	−0·04, 0·23	0·186	3084	0·34	−0·14, 0·82	0·175
Starchy vegetables, e.g. potatoes, corn, peas)	3125	−0·02	−0·17, 0·12	0·748	3125	0·05	−0·08, 0·17	0·569	3125	0·03	−0·02, 0·07	0·294	3125	0·05	−0·09, 0·20	0·468
Orange vegetables	3116	−0·08	−0·20, 0·05	0·248	3116	0·14	0·00, 0·29	0·073	3116	0·02	−0·02, 0·06	0·234	3116	−0·03	−0·16, 0·10	0·656
Salad/green vegetables	3114	−0·03	−0·18, 0·12	0·704	3114	0·18	−0·05, 0·40	0·158	3114	0·05	0·00, 0·10	0·100	3114	0·20	0·04, 0·36	**0·025**
Other vegetables	3116	−0·05	−0·16, 0·07	0·420	3116	0·18	−0·02, 0·38	0·086	3116	−0·00	−0·06, 0·05	0·924	3116	−0·02	−0·17, 0·13	0·805
Beans	3117	−0·03	−0·13, 0·07	0·548	3117	0·06	−0·10, 0·21	0·494	3117	0·01	−0·02, 0·03	0·653	3117	0·11	0·00, 0·23	0·082
Physical activity outcomes (number of days in last week)																
Average days with 60+ min MVPA	3091	0·28	−0·08, 0·63	0·144	3091	−0·14	−0·78, 0·49	0·660	3091	−0·00	−0·18, 0·17	0·965	3091	0·86	0·33, 1·39	**0·010**
Average days with PE	3067	−0·05	−0·25, 0·14	0·587	3067	−0·16	−0·88, 0·56	0·670	3067	−0·04	−0·37, 0·29	0·824	3067	0·49	−0·29, 1·26	0·229
		Interaction term between student gender, intervention status and time‖				Interaction term between school urbanicity, intervention status and time¶				Interaction term between school total enrolment, intervention status and time**				Interaction term between school FRPM level, intervention status and time††		
	n	*β*	95 % CI	*P*-value	*n*	*β*	95 % CI	*P*-value	*n*	*β*	95 % CI	*P*-value	*n*	*β*	95 % CI	*P*-value
Physical activity outcomes (yes/no)																
Spent half or more of PE class being physically active	3011	0·08	−0·31, 0·46	0·711	3011	−0·27	−0·87, 0·33	0·406	3011	−0·02	−0·23, 0·20	0·885	3011	−0·15	−0·76, 0·46	0·640

SSB, sugar-sweetened beverages; MVPA, moderate-to-vigorous PA. Boldface type indicates statistical significance ($P<0.05$).

*Models adjusted for student self-reported age, race/ethnicity, school total enrolment, outcome at baseline and accounted for clustering by site.

†Models adjusted for student self-reported age, gender, race/ethnicity, school total enrolment, outcome at baseline and accounted for clustering by site.

‡Models adjusted for student self-reported age, race/ethnicity, gender, outcome at baseline and accounted for clustering by school. Total enrolment is scaled by 100 students.

§Models adjusted for student self-reported age, race/ethnicity, gender, school total enrolment, outcome at baseline and accounted for clustering by school. Proportion of students eligible for free and reduced price meals (FRPM) categorised as a binary variable of whether schools had a proportion of students eligible for FRPM above the state average proportion of students eligible for FRPM among CalFresh Healthy Living-eligible schools.

‖Models adjusted for student self-reported age, race/ethnicity, school total enrolment, outcome at baseline and accounted for clustering by school.

¶Models adjusted for student self-reported age, race/ethnicity, gender, school total enrolment, outcome at baseline and accounted for clustering by school.

**Models adjusted for student self-reported age, race/ethnicity, gender, outcome at baseline and accounted for clustering by school.

††Models adjusted for student self-reported age, race/ethnicity, gender, school total enrolment, pre-test scores and accounted for clustering by school.

Table 7. Adjusted difference in change in dietary intake frequencies and physical activity behaviours between intervention and comparison students, stratified by statistically significant categorical effect modifiers, 2021–2022 school year

	Stratified by student gender*						Stratified by school urbanicity†						Stratified by school free and reduced price meals (FRPM) level‡					
	Female			Male			Urban			Rural			At/below state average FRPM†			Above state average FRPM†		
	n	Adjusted mean difference in change between intervention and comparison students	95 % CI	*n*	Adjusted mean difference in change between intervention and comparison students	95 % CI	*n*	Adjusted mean difference in change between intervention and comparison students	95 % CI	*n*	Adjusted mean difference in change between intervention and comparison students	95 % CI	*n*	Adjusted mean difference in change between intervention and comparison students	95 % CI	*n*	Adjusted mean difference in change between intervention and comparison students	95 % CI
Change in dietary intake (times in past day)																		
Water	1609	−0·06	−0·15, 0·03	1491	0·05	−0·02, 0·12	N/A	N/A		N/A	N/A		N/A	N/A		N/A	N/A	
Total fruit	N/A	N/A		N/A	N/A		N/A	N/A		N/A	N/A		1242	−0·01	−0·19, 0·18	1864	**0·35**	**0·13, 0·56**
Fruit, excluding 100 % juice	N/A	N/A		N/A	N/A		N/A	N/A		N/A	N/A		1245	−0·06	−0·19, 0·08	1869	**0·22**	**0·06, 0·37**
Total vegetables	N/A	N/A		N/A	N/A		2420	**0·48**	**0·21, 0·74**	664	−0·31	−0·65, 0·02	N/A	N/A		N/A	N/A	
Salad/ green vegetables	N/A	N/A		N/A	N/A		N/A	N/A		N/A	N/A		1246	−0·02	−0·15, 0·1	1868	**0·16**	**0·06, 0·27**
Average days with 60+ min MVPA	N/A	N/A		N/A	N/A		N/A	N/A		N/A	N/A		1241	**−0·49**	**−0·96, −0·03**	1850	**0·37**	**0·11, 0·63**

MVPA, moderate-to-vigorous physical activity. Boldface type indicates statistical significance ($P<0.05$).
*Models adjusted for student self-reported age, race/ethnicity, school total enrolment, outcome at baseline and accounted for clustering by site.
†Models adjusted for student self-reported age, gender, race/ethnicity, school total enrolment, outcome at baseline and accounted for clustering by site.
‡Models adjusted for student self-reported age, gender, race/ethnicity, school total enrolment, outcome at baseline and accounted for clustering by site. Proportion of students eligible for free and reduced price meals (FRPM) categorised as a binary variable of whether schools had a proportion of students eligible for FRPM above the state average proportion of students eligible for FRPM among CalFresh Healthy Living-eligible schools.

https://doi.org/10.1017/S136898002510092X Published online by Cambridge University Press

nutritious beverages. Given the lack of improvements in beverage-related outcomes observed in successive school years[19], this finding reinforces the need for beverage-focused curricula and implementation of PSE approaches that make water more accessible and appealing at school.

School urbanicity modified the impact of intervention on student consumption frequency of total vegetables such that CDPH-CFHL efforts yielded increases in total vegetable consumption frequency in urban intervention *v.* comparison schools but yielded decreases in rural schools. Though no disparity in vegetable consumption by school urbanicity was identified at baseline, it is concerning that consumption was reduced in rural schools receiving intervention. It is possible that rural schools continued to feel a greater impact of COVID-19-related constraints on intervention delivery, for example, remote delivery of nutrition education and fewer opportunities for PSE implementation, due to distance from the LHD. Notably, these findings counter those from a study of the effectiveness of USDA's Fresh Fruit and Vegetable Program on rural *v.* urban student FV consumption. That study found that after implementation of the programme, students in rural/town areas increased both fruit and vegetable consumption, while urban/suburban students increased only fruit intake and to a lesser degree[31]. Though our rural sample of schools was small, and despite conflicting findings regarding the effectiveness of FV-focused interventions in rural areas, these findings do suggest that CDPH-CFHL interventions may need to be tailored to better meet the unique characteristics and needs of rural schools. The unique challenges and assets rural schools have when delivering intervention should be considered. For example, rural schools often struggle with teacher and staff recruitment and retention, a lack of staff professional development opportunities, and difficulty engaging parents[32]. As such, schools in rural settings may require more direct and frequent engagement with CFHL staff, including in-person, LHD educator-led (*v.* classroom teacher-led) programme delivery, and a focus on parent outreach through indirect education materials. It may also be beneficial for interventions in rural schools to utilise community partnerships to capitalise on community assets, such as proximity to local agriculture. Careful consideration when selecting interventions, for example, choosing approaches that utilise farm-to-school programmes or highlight specific FV grown as part of the local food system, may better connect students to the food choices they make. Both garden-based nutrition education and farm-to-school connections have been shown to improve nutrition knowledge, self-efficacy, willingness to try new FV, healthy food selection during school meals and FV consumption[33,34].

School FRPM status modified the relationships between intervention and changes in consumption frequencies of total fruit and whole fruit, with interventions yielding greater relative increases among students in schools where the proportion of students eligible for FRPM was above the state average. While not identified as an area of disparity at baseline, these findings indicate CDPH-CFHL interventions were more effective in supporting healthy choices among students in lower-SES schools, a goal most fundamental to the CFHL programme. Similarly, school FRPM status modified the relationship between intervention and change in the number of days achieving PA recommendations. This was identified as a disparity at baseline, with students in the highest FRPM schools (above the state average of 78·8 %) being physically active at least 60 min daily fewer days per week than students in relatively lower FRPM schools (at or below 78·8 %). In our study, interventions were associated with a greater increase in PA among students in the highest FRPM schools, suggesting that interventions may be successfully supporting the students with the greatest need. However, we also found that interventions were associated with a decrease in the number of days students in the relatively lower FRPM schools reported being physically active at least 60 min daily. Further research is needed to understand what may be contributing to these differences, and how CFHL implementers may need to tailor interventions to meet the needs of all students. In this study, the PSE approach most utilised was promotion of PA outside of PE. Improvements in student VO_2 max observed in other studies in CFHL-eligible schools underscore the value of including PA-focused PSE interventions as part of a multicomponent approach[18,35]. Specifically, interventions focusing on improving PA opportunities coupled with comprehensive policy changes may show the most promise[35]. Given that only 27 % of intervention schools implemented a PA-focused PSE approach, this may be an area of opportunity for new and future work, especially in the highest-need schools.

There were various individual and school-level disparities identified at baseline for which we did not see any evidence of effect modification. We observed disparities in dietary intake by race/ethnicity and gender. Consistent with existing literature, we found that Black students and males had the highest average intakes of SSB[36,37]. While there were no statistically significant differences in total fruit consumption frequency by race/ethnicity, Black students had the highest consumption frequency of total fruit, which notably was driven by significantly higher 100 % juice consumption, also consistent with the literature[38]. Compared to females, males had a lower consumption frequency of both whole fruit and total vegetables. Though 100 % juice is included in our total fruit outcome, whole fruit is nutritionally superior to juice, which should be limited to eight ounces per d[39]. The observed high SSB consumption and preference for juice over whole fruit reinforces that beverage-related behaviours should be a focus of interventions delivered to these populations. The literature shows that multicomponent interventions in schools are the most effective at changing dietary behaviours[40]. As such, to address healthy beverage consumption, the topic needs to be included in not only the education delivered but also strengthened through PSE efforts. The feasibility of incorporating PSE interventions in schools continues to increase post-COVID. While beverage-focused CDPH-CFHL efforts were infrequent at the time of this study, as of federal fiscal year 2024, it is a required component of LHD work plans.

Baseline differences in PA by race/ethnicity and gender were also apparent. Students identifying as 'another race' and Asian had, on average, the lowest number of days with at least 60 min of MVPA. The composition of and small sample size for 'another race' make it difficult to draw comparisons. However, lower rates of PA among Asian youth are consistent with the literature[41]. The observed disparities in PA by student race/ethnicity did not seem to be addressed by CDPH-CFHL interventions. Additional tailoring of CDPH-CFHL to incorporate strategies more effective with Asian populations may be warranted. For example, one study of Chinese-American children found that emphasis on team sports, encouragement of school-based PA and family engagement in PA were best practices to promote PA among this population[42]. Another study found that key barriers to PA participation among South Asian children included restraints on parent/child time, limited support for PA from parents and PA being a low priority[43]. These studies emphasise the importance of extending PA promotion from the school to the home setting to increase

https://doi.org/10.1017/S136898002510092X Published online by Cambridge University Press

activity among Asian children. PSE strategies that engage parents and families and indirect education strategies, such as health promotion materials sent home, may help address barriers and mitigate disparities.

At baseline, males reported higher average days of 60 min of MVPA compared to females but were significantly less active during PE. Males reporting higher quantities of daily MVPA is consistent with the literature[44]. However, published findings relating to gender and activity during PE are mixed[45,46]. One reason for mixed results could be methodological differences between studies. In our study, students self-reported the proportion of PE they spent engaging in MVPA, which may not be as accurate as objective measurements used elsewhere. Regardless, children need more time to be physically active, and the school setting is an ideal and essential place for it. The Centers for Disease Control and Prevention suggests that comprehensive school PA programmes should contain five key components: (1) quality PE; (2) PA during the school day; (3) PA before and after school; (4) staff involvement; and (5) family and community involvement[47]. This reinforces our previous recommendations for adopting more robust PA-focused PSE interventions and extending PA education to the home environment.

At baseline, rural school location was associated with lower student activity levels during PE. Notably, our study included a small number of rural schools, limiting our ability to generalise our findings pertaining to school urbanicity. However, Joens-Matre et al. similarly found that rural students were less active during PE than their urban and small city counterparts, though were more active when considering total daily PA[48]. The most effective PA interventions in rural schools have been shown to combine a classroom component with structured PE[49]. CFHL programmes are well positioned to provide this kind of support in rural schools through implementation of comprehensive evidence-based curricula, such as SPARK, which includes both PE lessons and classroom-based PA lessons and has been shown to increase MVPA among students in rural schools[50].

This study had several limitations and strengths. Due to the unique nature and LHD-specific delivery of nutrition and PA interventions and the complexities of obtaining buy-in with schools and individual classrooms, the intervention and comparison schools and classrooms were selected out of convenience and not randomly assigned. This may have resulted in selection bias and samples that are not necessarily representative of the given school. However, the inclusion of CFHL-eligible comparison schools and the quasi-experimental design of the study allowed us to examine intervention impact as opposed to only associations and is thus a strength of this study. As this study comprised a convenience sample of lower income schools, results may not be generalisable to all schools in California, schools in states demographically unlike California and higher income schools. While students' dietary and PA behaviours were self-reported, and therefore subject to recall error and/or bias, the questions used to assess these outcomes have been validated for use with elementary students[21]. To additionally minimise recall error, students were only asked to report their prior day dietary intake and prior week PA. However, it is possible that these recall periods were not fully representative of everyone's typical intake and activity.

Conclusion

This study reinforces prior research showing that school-based CDPH-CFHL interventions are effective at improving dietary behaviours, namely increasing FV consumption. In addition, our findings highlight student and school characteristics that are associated with greater intervention impact. Disparities in PA were identified at baseline, with students in the highest FRPM (i.e. lowest SES) schools reporting fewer days with at least 60 min of PA compared to students in relatively lower FRPM schools. Interventions were associated with increased PA among students in schools with the highest FRPM, which is encouraging as it suggests that interventions may be successfully supporting students with the greatest need. However, interventions were associated with a decrease in PA among students in the relatively lower FRPM schools, suggesting a potential need to tailor interventions to meet the needs of students at all CFHL-eligible schools. Similarly, greater effectiveness at urban schools may indicate a need to tailor interventions specifically to the unique needs of rural schools. Overall, these findings can be used to inform an equity-centred approach to school-based nutrition and PA programming that facilitates equal opportunities for all children to achieve good health.

Supplementary material. For supplementary material accompanying this paper visit https://doi.org/10.1017/S136898002510092X

Acknowledgements. This study would not have been possible without the commitment and hard work of our local health department partners, and school/afterschool sites, including those that administer the CalFresh Healthy Living programing and those acting in a comparison role. The authors also thank Evan Talmage, Phoebe Harpainter and Ron Strochlic for their roles in recruitment of comparison school sites.

The findings and conclusions in this article are those of the author(s) and do not necessarily represent the views or opinions of the California Department of Public Health or the California Health and Human Services Agency.

Authorship. A.L.: conceptualisation, methodology, investigation, project administration, supervision, visualisation, writing – original draft; S.C.H.: conceptualisation, methodology, formal analysis, software, data curation, visualisation, writing – original draft, and writing – review and editing; K.P.: investigation, formal analysis, data curation, visualisation, writing – review and editing; C.D.R.: writing – original draft and writing – review and editing; G.W.L: conceptualisation, methodology and funding acquisition; M.W.: conceptualisation, methodology, resources, writing – original draft, writing – review and editing, supervision, and funding acquisition.

Financial support. This study was conducted as part of a contract with the California Department of Public Health with funding from USDA's Supplemental Nutrition Assistance Program Education. These institutions are equal opportunity providers and employers. The views expressed are those of the authors and not necessarily those of the funders.

Competing interests. None (applicable to all authors).

Ethics of human subject participation. This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved by the Committee for the Protection of Human Subjects (CPHS), California Health and Human Services (CalHHS), Center for Data Insights and Innovation (CDII) that determined the study was exempt. Passive informed consent was obtained from all subjects. Passive parental consent was obtained by distributing an opt-out form two weeks prior to survey administration, and students were given the opportunity to opt out of the evaluation on the day of survey administration.

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https://doi.org/10.1017/S136898002510092X Published online by Cambridge University Press

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