

High School Physical Activity and Nutrition Policy: Summarizing Changes Over Time Using Latent Class Analysis



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Introduction: High school physical activity and nutrition policies can substantially affect student behavior and outcomes. Although public health officials and legislators have advocated for policy improvements, the extent to which policies have changed at local levels is not well understood. This study identifies latent classes of physical activity and nutrition policy environments and explores changes in prevalence of these classes from 2000 to 2016.

Methods: Data from the School Health Policies and Practices Study, a repeated cross-sectional survey from the Centers for Disease Control and Prevention administered at the school district level in 2000, 2006, 2012, and 2016, were analyzed in 2018. Using latent class analysis, policy environment subgroups were identified, described, and then dichotomized based on satisfaction in meeting recommendations. Associations of latent classes with year and urbanicity were evaluated using logistic regression.

Results: Five latent classes were identified each for physical activity and nutrition policy environments, all with distinct characteristics. Physical activity policies improved from 2000 to 2006 ($p < 0.001$) and then plateaued until 2016, whereas nutrition policies improved consistently from 2000 to 2016 ($p < 0.001$, $p = 0.011$, $p < 0.001$). Though significant disparities between urban and rural school districts were found, these disparities narrowed during the studied years, particularly for physical activity policies.

Conclusions: The estimated proportion of school districts with satisfactory physical activity and nutrition policy environments increased from 2000 to 2016, possibly because of legislative and policy advocacy efforts. However, many areas for improvement remain. Unsatisfactory latent classes that remained prevalent though 2016 may highlight policy domains that should be targeted by future interventions or subject to further research.

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INTRODUCTION

High schools are a critical environment for addressing obesity.¹ Adolescents spend a significant proportion of their time in high school, during which they obtain food and engage in obesity-related physical activity and dietary education. Furthermore, research has indicated that school policies and practices (e.g., restrictions on sugar-sweetened beverages, physical education requirements) are associated with students' physical activity and eating behaviors.^{2–4} Therefore, lawmakers and authorities from the public health, food service, agriculture, and education sectors have collaborated to review evidence and issue recommendations

for policies and practices in schools to promote physical activity and healthy eating.^{5–7}

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The recommendations cover domains including educational curricula, school meals and competitive foods, staff training, and collaboration, each of which may be influenced by policies at the federal, state, and local levels. Federal policies cover some, but not all, domains. For example, the U.S. Department of Agriculture sets standards for nutritional content of lunch and breakfast for public schools, nonprofit private schools, and residential childcare institutions that participate in the national school meal program. Of note, the Healthy and Hunger-Free Kids Act of 2010⁸ provided more structure to wellness policy implementation and changed meal and nutrient standards. By contrast, there is no federal legislation that governs school physical activity requirements. Previous research has indicated that leadership in policy development and implementation is primarily situated at the school district level⁹ (a geographic unit for local administration of U.S. schools), although federal and state levels also yield influence, including through pre-emption of policies at lower levels.¹⁰ In this paper, data on policies at the school district level are used, which should capture some, but perhaps not all, policies required at higher levels.

This paper focuses on changes in the U.S. high school nutrition and physical activity policy environments, namely the collection of relevant policy actions that can influence eating and physical activity behaviors. According to the Obesity Policy Action Framework, policy actions involve socioecologic (targeting physical, social, and economic environments), lifestyle (directly targeting diet and physical activity), and health services (supporting health programs) approaches.¹¹ Summarizing changes over time of such a diverse array of actions is inherently difficult. A few studies have explored whether a small number of specific school policies have changed over time^{12,13} or described a vast array of policies and practices (e.g., “Bridging the Gap,” a report analyzing hundreds of heterogeneous policies). Neither of these approaches concisely summarized how the policy environments have changed over time.

The U.S. and its school districts are geographically diverse and rural–urban variation in school policies is of particular interest in addressing the obesity epidemic. Notably, rural youth have a 26% higher risk of obesity than urban youth,¹⁴ and although evidence is mixed, multiple studies have identified differences in physical activity and eating behaviors between rural and urban youth.¹⁵ Rural–urban differences in school policies, if present, may contribute to disparities in obesity prevalence.

Despite the call for improvements to school physical activity and nutrition policies, there is limited knowledge of the extent of change. A major gap in the literature is the

classification of policies in a meaningful way to evaluate how the policy environment has evolved over time and differed by urbanicity/rurality. The main contribution of this paper is to classify these policy environments at the school district level with latent class analysis (LCA) and use these latent variables to succinctly evaluate changes over time. The objectives of this paper are the following: (1) to classify school districts by their patterns of nutrition and physical activity policies using LCA and (2) to explore how the prevalence in the resulting classes have changed from 2000 to 2016 and by rural–urban subgroups.

METHODS

Study Sample

The School Health Policies and Practices Study (SHPPS) is a nationally representative repeated cross-sectional study¹⁶ that was conducted at the district level in 2000, 2006, 2012, and 2016. The number of participating districts with data available for policies of interest was 541, 455, 660, and 599 for each of the years, respectively. SHPPS was reviewed by an IRB at the Centers for Disease Control and Prevention and determined to be exempt. Although it contains rich data on policies and practices, particularly for high schools, it does not contain data on student behaviors or outcomes.

Measures

Variables of physical activity and nutrition policies to include in the LCA were developed from SHPPS survey items that pertained to high schools. To refine the inputs for the LCA, survey items were combined into variables chosen to reflect national guidelines for school physical activity and nutrition policies.^{17,18} Altogether, 8 composite variables were constructed for physical activity and 10 for nutrition policies (replicable derivations are provided in [Appendix Tables 1 and 2](#), available online). All variables had low, medium, and high values unless indicated otherwise.

Physical activity variables included the following: (1) adherence to national standards for physical education curricula (yes/no), (2) implementation of physical education adaptations for students with disabilities, (3) use of written and/or skills testing in physical education, (4) prohibition/discouragement of physical activity as punishment, (5) staff training/credentialing, (6) funding of physical activity education/programs, (7) internal collaboration (with organizations inside the school district), and (8) external collaboration (with organizations outside the school district).

Nutrition variables included the following: (1) use of healthy substitutes in school meals, (2) reduction of fat/sugar/salt in school meals, (3) internal collaboration, (4) external collaboration, (5) promotion of food services to students/families (low/high), (6) staff training/credentialing, (7) funding of nutrition education/programs, (8) provision of choice of entrée, vegetable, and fruit with each school meal (yes/no), (9) restriction of junk and fast foods, and (10) allowance of food rewards (allowed or discouraged/prohibited).

Statistical Analysis

The following analysis steps were completed separately for the physical activity and nutrition variables. First, LCA was performed

with data from all years combined into one data set using the procedure developed by Lanza et al.¹⁹ LCA is a method used to identify unobserved subpopulations, in this case different policy combinations or patterns, using the observed data. Survey weights were accounted for using the procedure's weighting functionality (21 districts from year 2000 were excluded because of missing weights). The latent class models were fit using up to 6 classes, and the number of classes for the final models was chosen based on substantive interpretation and fit statistics. Model fit was assessed by comparing G^2 , Akaike information criterion, and Bayesian information criterion values for each model. Classes were labeled based on their respective distributions of input variables and further categorized into satisfactory or unsatisfactory in meeting recommendations.

The best-fitting latent class for each school district was output for further analysis (e.g., if the model estimated that a district had 70% probability of being in Class 1 and 30% in Class 2, the district was assigned to Class 1). Changes in latent class distributions over time were evaluated by comparing probabilities of membership for each class by year and urbanicity (defined in SHPPS data as urban/rural in 2000, 2006, and 2012 and as city/suburb/town/rural in 2016, where city, suburb, and town were considered urban). A multinomial logistic regression model was fit with latent class as the outcome variable and survey year, district urbanicity, and the interaction of urbanicity and year as covariates. Type III p -values were calculated for the overall effect of each covariate. To assess improvements in districts meeting recommendations, ORs of being in a satisfactory class in each survey administration year versus the previous administration year and in urban versus rural districts at each year were calculated using logistic regression models. Interaction terms were included to account for potential differences across year between urban and rural districts. Although a small number of districts were included in each administration of the survey, they were not identified, and the analyses assumed that data of repeated districts were not correlated across years. Analyses were completed in 2018 using SAS, version 9.4, and R, version 3.4.1.

RESULTS

Descriptive statistics for the input variables for the physical activity and nutrition analyses are presented in [Appendix Tables 3 and 4](#) (available online), respectively.

For the physical activity data, a latent class model with 5 classes provided the best fit. Labels for each latent class were ascribed as follows: (1) Gold Standard—districts had strong policies in all considered domains; (2) Moderate (Strong Rule Focus)—districts had generally strong policies related to curricular standards and classroom policies (i.e., rules), and were moderate in terms of staff training, funding, and collaboration; (3) Weak (Modest Rule Focus)—districts had average policies related to curricular standards and classroom policies, but had weak or limited staff training, funding, and collaboration policies; (4) Weak (Modest Support Focus)—districts had weak or limited policies related to curricular standards and classroom policies, and were average in staff

training, funding, and collaboration; and (5) Poor—districts had weak or limited policies overall.

[Figure 1](#) ([Appendix Table 5](#), available online) provides the distribution of the 8 policy variables for each latent class. This figure can be used to interpret latent class differences; for example, most of the districts in the Gold Standard class had high levels of funding and collaboration, but this is not true for any other class. For logistic regression analyses, the first 2 classes were categorized as satisfactory and the final 3 as unsatisfactory with regard to recommendations.

For the nutrition policies, a latent class model with 5 classes provided the best fit. Labels for each latent class were ascribed as follows: (1) Gold Standard—districts had strong policies in all considered domains; (2) Moderate (Strong Meal Preparation Focus)—districts had moderate policies in terms of food promotion and restrictions, staff training, funding and collaboration, and strong meal preparation practices; (3) Moderate (Strong Food Promotion Focus)—districts had moderate policies in terms of meal preparation, staff training, funding and collaboration, and strong food promotion and restriction policies; (4) Weak (Modest Support Focus)—districts were weak in most policies with the exception of average staff training, collaboration and funding policies; and (5) Poor—districts had weak or limited policies overall.

[Figure 2](#) ([Appendix Table 6](#), available online) provides the distribution of the 10 policy variables for each latent class. For logistic regression analyses, the first 3 classes were categorized as satisfactory and the final 2 as unsatisfactory with regard to recommendations.

[Figure 3](#) shows the prevalence of the physical activity and nutrition policy classes over time and by urbanicity. For physical activity, there were substantial changes from 2000 to 2006 for both urban and rural districts. Specifically, the Gold Standard and Moderate (Strong Rule Focus) classes increased in prevalence whereas the 3 unsatisfactory classes all decreased. Notably, 10% of all districts were in the Poor class in 2000, but that decreased to 0.5% in 2006. There was little subsequent change from 2006 to 2016. By contrast, there were continuous changes in the prevalence of school districts in the nutrition policy classes across all survey years for both urban and rural districts. Across all districts, the Gold Standard went from the least to second most prevalent class by 2016. The Moderate (Strong Meal Preparation Focus) class also increased and was the most prevalent overall in each of the 4 studied years. The other 3 classes decreased from 2000 to 2016.

The ORs of being in a satisfactory physical activity and nutrition class for each year (compared with the previous survey administration year) are shown in

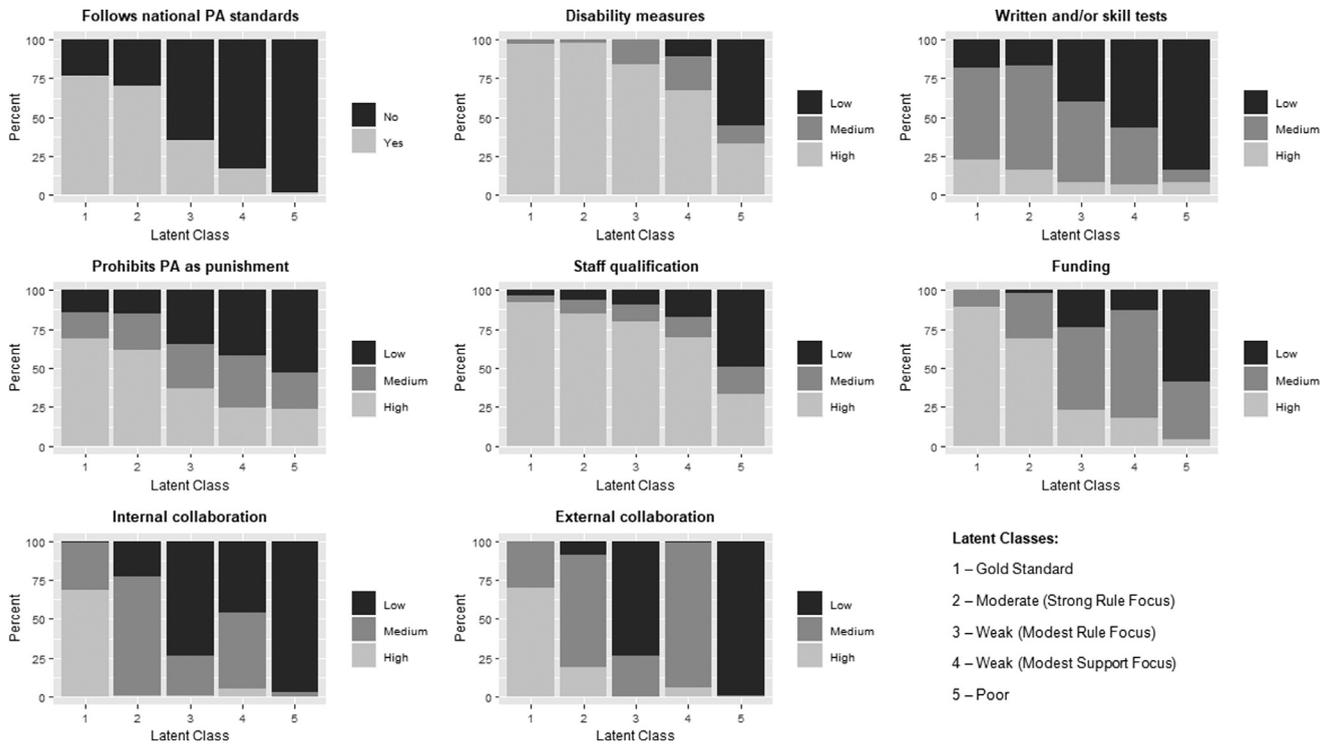


Figure 1. Distribution of policies by latent class for PA. PA, physical activity.

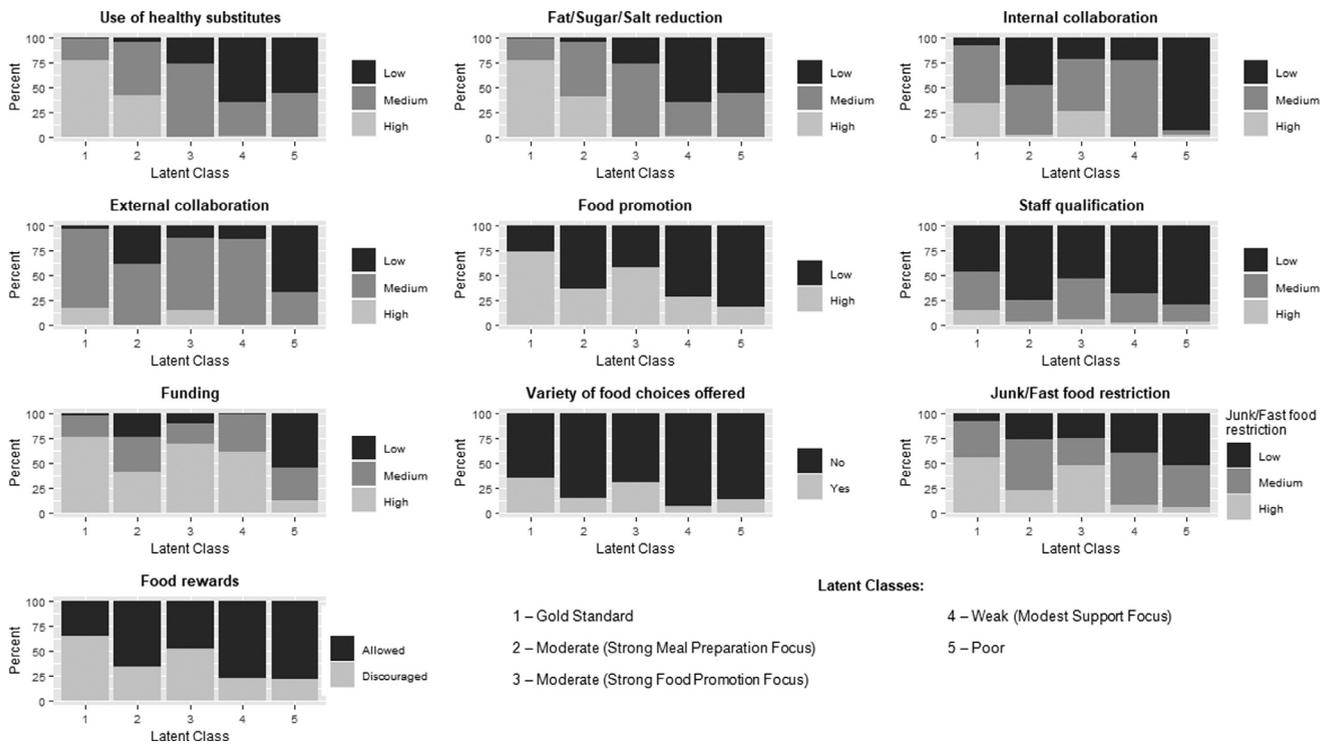


Figure 2. Distribution of policies by latent class for nutrition.

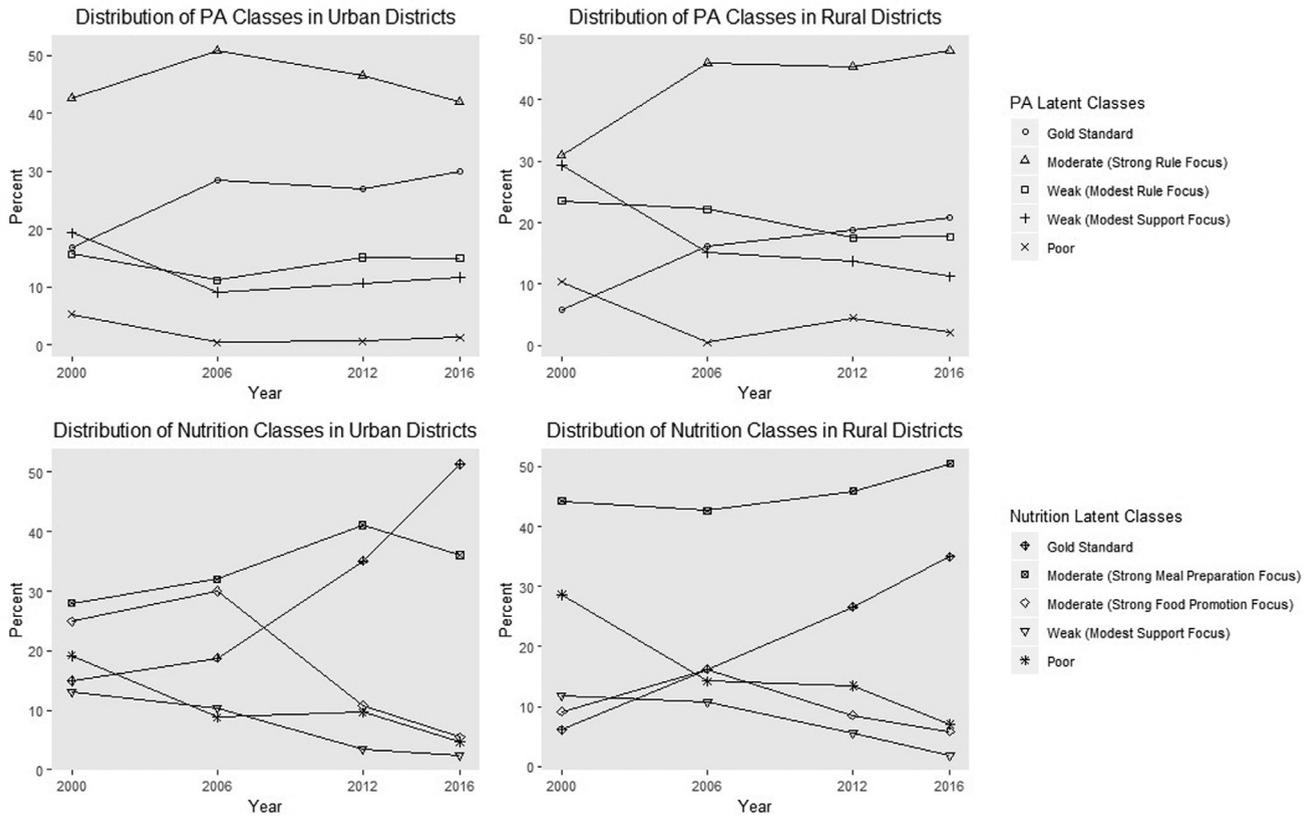


Figure 3. Prevalence of latent classes by year and urbanicity for PA and nutrition. PA, physical activity.

Table 1. The odds of a district belonging to a satisfactory physical activity class were 2.70 (95% CI=2.04, 3.59) times higher in 2006 than in 2000, but the odds were not significantly higher in 2012 or 2016 than in 2006 and 2012, respectively. The odds of being in a satisfactory nutrition class were significantly higher in 2006 than in 2000 (OR=2.05, 95% CI=1.54, 2.73), in 2012 than in 2006 (OR=1.49, 95% CI=1.09, 2.02), and in 2016 than in 2012 (OR=2.15, 95% CI=1.51, 3.11).

In the multinomial logistic regression model for physical activity, year and urbanicity were significant predictors of latent class membership ($p < 0.0001$), but their interaction was not ($p = 0.14$). ORs of being in a satisfactory physical activity and nutrition class for urban compared with rural districts are shown in **Table 1**. The odds of an urban district belonging to a satisfactory physical activity policy class were significantly higher than the odds for a rural district in 2000, 2006, and 2012, but not in 2016. Similarly, year and urbanicity were significant predictors of nutrition policy class membership ($p < 0.0001$), but the interaction was not ($p = 0.13$). The odds of an urban district belonging to a satisfactory nutrition policy class were higher than rural districts, with marginal significance and no clear trend across the

years. Specifically, the odds for an urban district belonging to a satisfactory class were 1.43 (95% CI=1.00, 2.05) times higher than rural districts in 2000, 1.40 (95% CI=0.90, 2.19) times higher in 2006, 1.57 (95% CI=1.03, 2.39) in 2012, and 1.26 (95% CI=0.69, 2.32) in 2016.

DISCUSSION

In this paper, LCA was used to derive classes that describe school district physical activity and nutrition policy environments. The analysis indicates that school districts can be categorized into classes that highlight differing strengths and weaknesses in specific policy areas. It also was found that school district policy environments have improved over time (the proportion of school districts belonging to satisfactory classes increased); however, although the nutrition environment continually improved, the physical activity environment did not substantially improve after 2006 (**Figure 3**). Positively, the disparity between urban and rural membership in the gold standard policy classes diminished over time (**Table 1**). More research is needed to understand whether these policy improvements correspond to improvements in adolescent behavior, but improvements in eating

Table 1. ORs (95% CI) of Satisfactory Class Membership by Year and Urbanicity

Comparison	Stratum						
	Urban	Rural	Overall	2000	2006	2012	2016
Physical activity							
2006 vs 2000	2.59 (1.73, 3.91)	2.82 (1.91, 4.21)	2.70 (2.04, 3.58)	—	—	—	—
2012 vs 2006	0.73 (0.48, 1.08)	1.09 (0.75, 1.60)	0.89 (0.68, 1.17)	—	—	—	—
2016 vs 2012	0.93 (0.64, 1.35)	1.23 (0.88, 1.72)	1.05 (0.82, 1.34)	—	—	—	—
Urban vs rural	—	—	—	2.54 (1.77, 3.67)	2.33 (1.51, 3.62)	1.55 (1.10, 2.18)	1.17 (0.81, 1.69)
Nutrition							
2006 vs 2000	2.00 (1.33, 2.74)	2.04 (1.37, 3.06)	2.05 (1.54, 2.73)	—	—	—	—
2012 vs 2006	1.59 (1.02, 2.47)	1.42 (0.92, 2.18)	1.49 (1.09, 2.02)	—	—	—	—
2016 vs 2012	1.97 (1.13, 3.57)	2.45 (1.54, 3.97)	2.15 (1.51, 3.11)	—	—	—	—
Urban vs rural	—	—	—	1.43 (1.00, 2.05)	1.40 (0.90, 2.20)	1.57 (1.03, 2.40)	1.26 (0.69, 2.36)

Note: Boldface indicates statistical significance ($p < 0.05$).

behaviors have been found over the same time period.^{20–22} Though the effects of specific efforts cannot be pinpointed, legislations like the Healthy and Hunger-Free Kids Act or the requirement for local school wellness policies in 2006 may have contributed to the policy improvements found. However, areas for development remain—many districts still belonged to unsatisfactory latent classes in 2016.

This research contributes a robust exploration of changes in physical activity and nutrition policies. Previous studies have explored policies individually,¹² which can mask interactions and trends. This paper's findings underscore policy areas that should be emphasized and areas that are unlikely to be fruitful. For example, the 3 most prevalent physical activity policy classes in 2016 were rule-focused, 2 of which were weaker in funding and collaboration. Thus, mandates to improve rules (e.g., requiring skill and written physical activity tests) may not lead to widespread improvements, whereas efforts to increase physical activity funding and collaboration may increase shifts of school districts to the Gold Standard class. State and federal directives can potentially have impacts if they target domain areas where large proportions of school districts are weak. As illustrated by Boles and colleagues,¹² a state mandate in Washington that required every school district to establish nutrition and physical activity policies led to significant increases in policies such as elimination of physical education exemptions.

To the authors' knowledge, no study has described trends over time in school district physical activity and food policies using a latent variable approach. Masse et al.²³ examined changes in state laws affecting the school food environment and found that the laws significantly changed between 2003 and 2008, primarily affecting the competitive food environment. These changes were mostly in a positive direction, but still left substantial room for improvement. The Bridging the Gap project evaluated trends over time in wellness policies but did not use a latent variable approach. By contrast, using a data-driven latent variable approach, this paper identifies novel policy subgroupings and provides succinct summaries of change over time, making similar, but more specific, conclusions than earlier efforts.

This research also builds upon studies that have indicated disparities between urban and rural schools. Rural districts consistently underperformed throughout the analysis (belonged to weaker classes). Nanney and colleagues²⁴ found that rural schools had significantly fewer policies that supported healthy eating strategies. Although socioeconomic and resource availability differences likely account for much of this disparity (rural schools may not have access to the same range of healthy meal items as urban schools), other factors such as

community climate may influence the gap in policies as well. For example, Turner and Chaloupka²⁵ found that after the implementation of the National School Lunch Program in 2012, rural schools were more likely to report that students reduced consumption of and increased complaints about school meals. This suggests that rural schools may be more resistant to policy change. However, positively, there is evidence that the disparity gap between urban and rural districts has been closing since 2000, especially in relation to physical activity policies (Table 1).

Limitations

The SHPPS is a repeated cross-sectional study, and thus the districts cannot be followed longitudinally, nor can transition probabilities between classes be reported. However, it was possible to describe trends over time because the study is nationally representative. To accommodate changes in the survey's urbanicity variable between 2012 and 2016, cities, suburbs, and towns were classified as urban. This may have affected analysis of the urban–rural gap for 2016. Another important limitation of the SHPPS data is that it does not measure actual implementation or enforcement of policies. Finally, bias was potentially introduced when the questionnaires were reduced to domain areas and during the LCA procedure, which assumes missing values are missing at random.

CONCLUSIONS

Five latent classes were identified and described with respect to both physical activity and nutrition policies at the school district level, providing a more parsimonious way to describe broad changes in policy environments over time. Though policies have been improving, there is still room for growth, in particular with respect to physical activity. Policy can be an effective tool for improving outcomes by changing human behavior, especially for health outcomes such as obesity that have not improved substantially with individual-level interventions alone. Unsatisfactory latent classes that remained prevalent through 2016 highlight policy domains to target with future interventions or subject to further research.

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BSB coded all data preparation and statistical analyses, devised the statistical analysis plan, wrote the Methods and the Results sections, assisted in writing the Introduction and the Discussion sections, and prepared the final edit of the manuscript. LMF conceptualized the research question, identified policy domains and led composite variable definition based on

national physical activity and nutrition standards, wrote the Introduction, the Discussion, and the Conclusions sections, and oversaw the research project. AGH helped devise the statistical analysis plan, assisted with writing and editing the manuscript, and provided critical feedback on analysis and interpretation of results.

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SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at <https://doi.org/10.1016/j.amepre.2019.04.019>.

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