Evaluating the Impact of Participation in the Fresh Fruit and Vegetable Program on Childhood Obesity Using Synthetic Difference-in-Difference Method

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Introduction

Based on data from the 2011-2012 National Health and Nutrition Examination Survey (NHANES), about 16.9 percent of children and adolescents (ages 2 to 19) were obese in the United States (Ogden et al., 2014). As the factors commonly associated with obesity (e.g. racial/ethnic composition, household income, health behavior, neighborhood amenities, etc.) often vary greatly across states, there is considerable state disparities in childhood obesity prevalence (Bethell et al., 2010). According to the 2011 National Survey of Children's Health (NSCH), about 20% of children ages 10 to 17 in Arkansas were obese, which was almost 10 percentage points higher than the states with lowest childhood obesity rates (Levi et al., 2014).

Although obesity results from complex processes, one straightforward explanation comes from the energy imbalance between caloric intake and expenditure through physical activities and metabolic processes. Studies have shown that increased consumption of fruits and vegetables are associated with decreased fat and sugar intake, thus reducing the overall calorie intake (Epstein et al., 2001). However, U.S. children only take about 3.5 servings of fruits and vegetables per day on average, which is far below the recommended 6-13 servings by USDA (Jamelske et al., 2008). Although total fruits intake among children increased significantly from 2003 to 2010, total vegetables intake did not change over the same period (Kim et al., 2014).

The USDA Fresh Fruit and Vegetable Program (FFVP) is designed to promote fruit and vegetable consumption among children in eligible schools by reimbursing schools for offering free fruit and vegetable throughout the day and separately from lunch and breakfast meals. In order to participate in FFVP, schools must participate in the National School Lunch Program (NSLP), and the percentage of students eligible for the free and reduced lunches must be at least 50%. Prior studies suggest that FFVP has successfully increased fruit and vegetable consumption among children in participating schools, without increasing total energy intake (Bartlett et al., 2013). In fact, a recent study finds that participation in FFVP is associated with reduced obesity risk, using quasi-experimental methods (Qian et al., 2015), but this study was only able to assess the short term impacts of the program. There is a need to understand how exposure to the FFVP program may affect risk of excess weight gain through childhood and into adolescence. Building on Qian et al. (2015), this study intends to re-assess the impact of FFVP on childhood obesity, using a 12-year panel dataset for Arkansas (school years 2003/2004 through 2014/2015). The FFVP program has expanded substantially in Arkansas since it was last evaluated in Qian et al. (2015) which used data for FFVP in academic years 2008/2009 and 2009/2010. This study utilizes FFVP data from academic year 2008/2009 through 2014/2015. Coupling the FFVP data with the 12-year BMI data, we are able to assess the long-term effects of FFVP on obesity risk among multiple cohorts of children in the BMI dataset.

Data and Methods

Due to concerns over the rise in childhood obesity, the Arkansas General Assembly passed Act 1220 of 2003, which required that schools conduct annual BMI screenings. From school years 2003/2004 through 2006/2007, all public school children from kindergarten through 12th grade in the state of Arkansas were screened, but since school year 2007/2008, only children in even grades (K, 2, 4, 6, 8, 10) were screened. The height and weight measurements of schoolchildren were collected by trained personnel who followed statewide protocols to ensure uniformity in both measurement procedures and equipment. BMI is calculated as a ratio ([weight in pounds / (height in inches)^2] × 703) and is then converted to age-gender specific z-scores following guidelines from the Centers for Disease Control and Prevention. The Arkansas BMI dataset is confidential and is maintained by the Arkansas Center for Health Improvement (ACHI).

This study intends to estimate the causal effects of FFVP via quasi-experimental methods. One of the challenges facing this program evaluation is non-random selection into the treated group, as schools participating in FFVP must also participate in NSLP and at least 50% of students must be eligible for free or reduced price lunches. As such, the first step of this study is to find a comparable control group. Existing literature offers a couple of ways to construct a comparable control group such as propensity score matching (Rosenbaum and Rubin, 1983 and 1985) and synthetic control method (Abadie and Gardeazabal, 2003).

The central idea of applying PSM to our study is to find a group of students that have similar characteristics as those in FFVP schools. We first limit our analysis to both FFVP schools and eligible non-participating schools. Second, we predict individuals' propensity scores or the probabilities of participating in FFVP, based on a logit model with observed pretreatment characteristics as independent variables. Third, we match students in the treated group to those in the control group by estimating the propensity scores using Mahalanobis matching with and without calipers. We conduct imbalance test to compare covariates in the resulting control group with those in the treatment group. Based on the matched sample, we then use difference-in-difference (DID) regression to assess the impact of FFVP participation on weight outcomes represented by BMI z-scores.

On the other hand, synthetic control method aims to search for a weighted combination of eligible non-participating schools to approximate a synthetic control group that resembles participating schools in pre-treatment control and outcome variables, and in post-treatment control variables. We compare average weight outcomes for the FFVP schools with those for the synthetic control group.

There are limitations in applying DID and synthetic control method to this study. One is that standard errors may be understated because of serial correlation in the DID regression given that we are able to track children over a long period of time. The synthetic control method only allows us to create a synthetic control group based on school-level characteristics.

Given the limitations of DID and synthetic control approach, we are employing a third and a relatively new econometric method named "Synthetic Difference-in-Difference" (SDD) in this study. The SDD method takes into account multiple and heterogeneous treatment and control groups, and multiple periods (Kim and Park, 2015). Borrowing from the concept of the synthetic control method, SDD constructs a population synthetic control group based on individual and environmental characteristics, and couples it with the DID method. Results from Monte Carlo simulations show that SDD yields consistent estimates of treatment effects, and asymptotically correct standard errors of estimated treatment effects, where simple DID does not (Kim and Park, 2015).

Summary of Preliminary Results

Arkansas schools have participated in FFVP since school year 2008/2009, but the number of participating schools vary across years and schools may participate in a single year or multiple years. According to data obtained from the Arkansas Department of Education (ADE), 24, 47, 79, 115, 120, 121, and 86 schools participated in FFVP in each of the school years from 2008/2009 to 2014/2015.

After merging the list of FFVP participating schools with the enrollment data from Arkansas Department of Education (ADE), we estimated the number of students exposed to FFVP in each grade and school year since academic year 2008/2009 in Arkansas (Table 1). USDA defined an elementary school as any school with a combination of grades K-8. Thus, we summarized the estimated number of students exposed to FFVP from K to grade 8.

Table 1. Estimated number of students exposed to FFVP by grade and year

		Academic year						
		2008/2009	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015
Number of elementary schools reporting meal status		584	581	575	571	567	561	552
Number of elementary schools with 50% or more of the students eligible for free or reduced price lunch		539	472	470	470	475	471	469
Number of participating schools		24	47	79	115	120	121	86
Grade	K	1,811	3,185	4,372	6,064	7,384	7,578	5,692
	1	1,722	2,952	4,945	6,468	6,638	7,240	5,605
	2	1,727	2,766	4,517	6,091	6,344	6,035	4,901
	3	1,597	2,654	4,003	5,900	6,181	5,893	4,186
	4	1,342	2,644	4,097	5,717	5,960	5,973	3,854
	5	945	2,120	2,935	4,675	4,562	4,082	3,216
	6	479	1,838	2,484	3,481	3,817	2,742	3,142
	7	0	375	440	742	884	930	1,107
	8	0	397	381	798	726	869	646
Subtotal		9,623	18,931	28,174	39,936	42,496	41,342	32,349

The majority of elementary schools in Arkansas has 50% or more students who are eligible for free or reduced price lunches. Only 24 out of the 539 eligible elementary schools participated in the FFVP program in academic year 2008/2009. However, there was a two-fold increase in the number of FFVP participating schools from academic year 2008/2009 to 2009/2010, and from academic year 2009/2010 to 2011/2012. Following the rapid expansion of FFVP in Arkansas during the first four academic years, the number of participating schools has plateaued and even dropped in academic year 2014/2015. There were no statistically significant differences in the ratio of students eligible for free or reduced price lunches and racial composition between FFVP participating schools and eligible non-participating schools in academic years 2008/2009 and 2009/2010. Since academic year 2010/2011, FFVP participating schools had significantly higher proportions of white students and lower proportions of minority students, compared to eligible non-participating schools.

As shown in Table 1, the numbers of students exposed to FFVP in grade 7 and 8 are substantially smaller than those of students from kindergarten to grade 6. This is because grades 7 and 8 are typically housed in middle and junior high schools with older, secondary schoolchildren. In fact many students in grade 5 and especially grade 6 will transition to intermediate schools in Arkansas given variation in grade configurations across the state. This is one reason why numbers of FFVP exposed children reported in table 1 start to decline after grade 4. Therefore, this study only selects the cohorts of students who can be tracked from kindergarten through grade 6. Some of the students who were kindergarteners in academic year 2008/2009 might be exposed to the FFVP program in that year and, therefore, their BMIs were not observed in the pre-intervention period (or before academic year 2008/2009). Thus, this study is focused on 5 cohorts of students who were kindergarteners in any of the academic years from 2003/2004 to 2007/2008, and who could be followed through grade 6. The grade information of the 5 cohorts of students are exhibited in Table 2.

Table 2. Academic grade by year for student cohorts included in the study

Kindergarten (K) Cohort	Academic Year										
	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
2003/2004	K	1	2	3	4	**(5)**	**6**					
2004/2005		K	1	2	(3)	**4**	**(5)**	**6**				
2005/2006			K	1	2	**(3)**	**4**	**(5)**	**6**			
2006/2007				K	(1)	**2**	**(3)**	**4**	**(5)**	**6**		
2007/2008					K	**(1)**	**2**	**(3)**	**4**	**(5)**	**6**	

Prior to academic year 2007/2008, BMI measurements take place from kindergarten (K) through grade 10. Since academic year 2007/2008, BMI is not assessed for students in odd numbered grades which are placed in parentheses. Bolded grade numbers indicate the possible grades when children are exposed to the FFVP program.

Although BMIs for students in odd-numbered grades (grades 1, 3, and 5) are missing after academic year 2007/2008, the school of attendance and other enrollment information for students in odd-numbered grades is included in the BMI dataset. This is important because it allows us to determine whether a student was exposed to the FFVP program in each year he/she was enrolled in the public school system.

Another important feature of the cohorts presented above is that they allow us to test for differences in FFVP program exposure by age of first exposure. For the cohort of students who were kindergarteners in academic year 2003/2004, the earliest point of exposure to FFVP was grade 5 unless they did not progress normally through the public school system (e.g., a small percentage of students skip grades or are required to repeat a grade). Later cohorts were first exposed to FFVP in progressively earlier grades. Since different cohorts of students might first get exposed to FFVP at different grades, the various effects of FFVP participation on weight across cohorts might partially reflect the differential impact of FFVP delivered to students at different stages of development.

The indicator for treatment measures whether a student was ever exposed to the FFVP program. For instance, a student in the 2003/2004 K cohort was considered in the treatment group, if he/she was exposed to FFVP in any of the years since academic year 2008/2009. Due to the fact that the first year of exposure differs across students even in the same cohort, we further divided the students in the same cohort into sub-cohorts, depending on the first year of exposure. Specifically, students in the 2003/2004 K cohort who were ever exposed to FFVP were classified into two groups: those who first got exposed to FFVP in academic year 2008/2009 and those who first got exposed in school year 2009/2010. Similarly, students in the 2004/2005 K cohort were divided into three sub-cohorts depending on the first year of exposure in academic years 2008/2009, 2009/2010, and 2010/2011, respectively.

For the treatment group in each sub-cohort, we used different matching methods to find a comparable control group among students in eligible but non-participating schools. That is, the control group consisted of students who were in the same cohort and never exposed to FFVP, but exhibited similar characteristics both at the individual and school levels in the year just before the first year of exposure. For example, the sub-cohort of treated students, who were in the 2003/2004 K cohort and were first exposed to FFVP in school year 2008/2009, were matched to the students in the control group in terms of individual-level and school-level characteristics in academic year 2007/2008. Specifically, these characteristics included gender, age, race/ethnicity, school meal status, and the proportion of minority children and children eligible for free or reduced price school meals. As discussed earlier in this section, FFVP participating schools differed from eligible non-participating schools in terms of the ratio of students eligible for free or reduced price lunch and racial composition since academic year 2010/2011. Therefore, students in the treatment group were matched to those in the control group on these characteristics in the pre-intervention period. The specific matching methods included various methods of propensity score matching (PSM) and coarsened exact matching (CEM). Unmatched samples were dropped from the final analyses. We conducted DID regressions with individual fixed effects on the matched samples. The independent variables in the DID included a treatment indicator (as discussed above), a post-intervention indicator, and the interaction between them.

Qian et al. (2015) focused exclusively on students who attended one of the 14 schools that participated in the FFVP program in both the academic years 2008/2009 and 2009/2010. Although our treatment measure was constructed differently from that in Qian et al. (2015), we were able to replicate their results largely using the 2003/2004 K cohort. In particular, there was evidence that children who were first exposed to FFVP in either academic year 2008/2009 or 2009/2010 had lower BMI z-scores than those in the corresponding control groups and by magnitudes similar to what was reported in this earlier paper. However, we did not find a significantly negative association between FFVP participation and BMI z-scores in later sub-cohorts. The results were quite robust to different matching methods. Similar results were obtained from analyses controlling for the intensity of exposure measured by the number of years exposed to FFVP. These conclusions were drawn based on the results from the coefficients for the interaction between the treatment indicator and the post-intervention indicator. We do not report these results in tabular form yet because release of the specific coefficients is subject to pre-publication review by personnel from ACHI. Estimation of the program effects using other methods described in the methods section is still underway.

Discussions

Building on Qian et al. (2015), this study aims to evaluate the longer-term impact of the FFVP program on obesity among 5 cohorts of children who were followed from kindergarten through 6^{th} grade. These 5 cohorts of children entered kindergarten at different years and were exposed to the FFVP program at various stages of growth. That said, the effects of FFVP might differ across cohorts and, thus, each cohort was analyzed separately using a combination of matching methods and DID regression. There was evidence suggesting a negative association between participation in FFVP and weight gain among students who were in kindergarten in academic year 2003/2004 and started getting exposure to FFVP in academic year 2008/2009. This is largely consistent with findings from Qian et al. (2015). However, we did not find a significantly negative relationship between FFVP participation and weight gain for later cohorts.

This study differs from Qian et al. (2015) in many aspects such as the scope of the data and methods. As shown in the descriptive statistics, there were 24 and 47 elementary schools in Arkansas that participated in the FFVP program in academic years 2008/2009 and 2009/2010, respectively. Qian et al. (2015) only focused on 14 schools which participated in FFVP continuously from academic year 2008/2009 to 2009/2010. This method omitted the students who might transfer from one FFVP participating school in academic year 2008/2009 to another FFVP participating school in 2009/2010. The 12-year BMI panel data allow us to examine the impact of FFVP on weight outcomes among various cohorts of students, as different cohorts of children were first exposed to FFVP at different developmental stages and were exposed at various lengths. Additionally, this study will employ results from a new estimation method that combines synthetic control method and DID approach. Nevertheless, we were able to largely replicate the results from Qian et al. (2015) using similar estimation methods for the 2003/2004 K cohort.

There might be several reasons why we did not find a significant impact of the FFVP program on the weight outcome of children in later cohorts. First, the schools that started participating in the FFVP program in early years may possess other attributes that contribute to the reduction in obesity. For instance, they may have other weight-reducing nutrition policies such as the Supplemental Nutrition Assistance Program Education, and farm-to-school programs. Second, there might be substitution effects between consumption of fruits and vegetables at school and at home. Ishdorj et al. (2013) found that students who participated in the National School Lunch Program (NSLP) tended to consume more fruits and vegetables at school, but less vegetables at home, compared to non-participants, suggesting possible substitution effects. But NSLP participants were still found to have higher overall consumption of fruits and vegetables. Due to data limitations, we were unable to test whether the FFVP program increased overall consumption of fruits and vegetables among the students who were exposed to the program. Third, even if we assume that participation in FFVP indeed increased fruits and vegetables consumption, increased fruit and vegetable consumption does not necessarily lead to lower energy intake that can ultimately result in reduced obesity risk. On the one hand, the high water and fiber content in fruits and vegetables might increase the satiety of consumption, decrease the overall energy intake, and consequently contribute to weight loss (Rolls et al., 2014). On the other hand, there are a myriad of confounding factors influencing the final weight outcomes. Most of the clinical studies suggesting a negative association between increased consumption of fruits and vegetables and weight gain were not designed to test the effects of fruit and vegetable consumption alone (Rolls et al., 2004). Rather, they often incorporated other weight management interventions such as reducing the intake of dietary fat and sugar. Nonetheless, combining the promotion of fruit and vegetable consumption with other weight-loss practices might be effective in reducing the risk of obesity.

Results presented in this paper are preliminary and inconclusive, and will be supplemented by results based on the newly proposed SDD method and augmented data. In particular, census block-group level data on neighborhood characteristics will be obtained from the American Community Survey and merged with the Arkansas BMI data depending on the residential location of children. Currently, children who were exposed to the FFVP program are matched to those in eligible non-participating schools in terms of individual-level and school-level characteristics in the pre-intervention period. Neighborhood features will be added to the existing group of pre-intervention characteristics in the revised analyses.

References

Abadie, A., and J. Gardeazabal. (2003). The Economic Costs of Conflict: A Case Study of the Basque Country. American Economic Review 93 (1): 113–32.

Bartlett, S., L. Olsho, J. Klerman, K. L. Patlan, M. Blocklin, P. Connor, K. Webb, L. Ritchie, and P. Wakimoto, and P. Crawford. (2013). Evaluation of the Fresh Fruit and Vegetable Program (FFVP). Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service. Available at: http://www.fns.usda.gov/sites/default/files/FFVP.pdf

Bethell, C., Simpson, L., Stumbo, S., Carle, A.C., Gombojav, N., (2010). National, state, and local disparities in childhood obesity. *Health Affairs* 29:347-56.

Epstein, L. H., C. C. Gordy, H. A. Raynor, M. Beddome, C. K. Kilanowski, and R. Paluch. (2001). Increasing Fruit and Vegetable Intake and Decreasing Fat and Sugar Intake In Families at Risk for Childhood Obesity. *Obesity Research* 9 (3): 171–78.

Ishdorj, A., Crepinsek, M. K., & Jensen, H. H. (2013). Children's Consumption of Fruits and Vegetables: Do School Environment and Policies Affect Choices at School and Away from School?. *Applied Economic Perspectives and Policy*, 35(2), 341-359.

Jamelske, E., L. A. Bica, D. J. McCarty, and A. Meinen. (2008). Preliminary Findings from an Evaluation of the USDA Fresh Fruit and Vegetable Program in Wisconsin Schools. *Wisconsin Medical Journal* 107 (5): 225–30.

Kim, B., and S. Park. (2015). Synthetic Difference-in-Difference Estimation of Treatment Effects - How to Handle Multiple Control Groups and Multiple Periods. Unpublished author manuscript.

Kim, S. A., Moore, L. V., Galuska, D., Wright, A. P., Harris, D., Grummer-Strawn, L. M., ... & Rhodes, D. G. (2014). Vital signs: fruit and vegetable intake among children—United States, 2003–2010. *MMWR Morb Mortal Wkly Rep*, 63(31), 671-6.

Levi, J., Segal, L., St Laurent, R., Rayburn, J., (2014). The state of obesity: better policies for a healthier America. Washington, DC: Trust for America's Health.

Ogden, C.L., Carroll, M.D., Kit, B.K., Flegal, K.M., (2014). Prevalence of childhood and adult obesity in the United States, 2011-2012. *Jama* 311:806-14.

Rolls, B. J., Ello-Martin, J. A., & Tohill, B. C. (2004). What can intervention studies tell us about the relationship between fruit and vegetable consumption and weight management?. *Nutrition reviews*, 62(1), 1-17.

Qian, Y., Nayga Jr, R. M., Thomsen, M. R., & Rouse, H. (2015). The Effect of the Fresh Fruit and Vegetable Program on Childhood Obesity. Applied Economic Perspectives and Policy, doi: 10.1093/aepp/ppv017

Rosenbaum, P. R., and D. B. Rubin. (1983). The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika* 70 (1): 41–55.

Rosenbaum, P. R., and D. B. Rubin. (1985). Constructing a Control Group Using Multivariate Matched Sampling Methods That Incorporate the Propensity Score. *American Statistician* 39 (1): 33–38.