The Effect of School Lunch on Early Teenagers' Body Weight

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Abstract

Previous findings on the effects of school meal on child obesity are highly mixed. We examine the causal effect of school lunch on Japanese junior high school students based on municipality-level variation in school lunch provision. Unlike in previously studies, individual selection into school lunch participation and stigma induced under-reporting of participation are not issues in this study. We use individual level data drawn from the 1975-1994 National Nutrition Survey (NNS). To account for possible endogeneity of municipal provision of school lunch, we employ difference in differences (DID) framework and compare differences between junior high school students and elementary school students between areas with and without school lunch at junior high schools. We find no evidence that school lunch affects body weight in the full sample analyses. However, in subsample analyses of children with below median per-capita household expenditure, we find significant negative effect of school lunch on Body Mass Index (BMI) and overweight. These findings are robust to trimming based on propensity scores for ensuring sufficient overlap of characteristics between areas with and without school lunch at municipal junior high schools. Additionally, municipal school lunch provision at junior high school is not significantly associated with height, BMI, or eating habits of local pre-school and elementary school children, which does not support the reverse causality.

1. Introduction

Child obesity is growing rapidly around the world, just like adult obesity (Ng et al. 2014), and its adverse health consequences are well established (e.g., Biro and Wien 2010; Reilly and Kelly 2011; Pulgarón 2013). As a part of public health intervention against obesity, school lunch reforms are recently enacted in the US and the UK: stricter nutritional standards were introduced in the US, England, and Scotland, and eligibility for free school lunch was significantly expanded in England and Scotland (Scottish Government 2014; Woo-Baidal and Taveras 2014; Long 2015). These reforms are, however, under heated debate due to their high costs and uncertainties regarding the effectiveness (Woo Baidal and Taveras 2014). There are two remaining questions that are closely related to this controversy. First, school meal participation has been scrutinized as a risk factor of obesity but previous findings are mixed, with some studies finding support for this hypothesis for the US (Whitmore-Schanzenbach 2009; Millimet et al 2010; Hernandez et al. 2011), and others not finding support for the US (Gundersen et al. 2012; Mirtcheva and Powell 2013) and for the UK (Rona et al., 1983; Rona and Chinn, 1989; von Hinke Kessler Scholder 2013). Gundersen et al. (2012) point out that the assessment of the causal effect of school meal participation on obesity is made difficult by the combination of endogenous individual selection into participation and significant underreporting of participation. In their nonparametric bounds analysis possibility of large and systematic underreporting prevents definitive conclusion. Second, while some nutrition scholars argue that high-quality school meal is an effective tool against obesity (Woo Baidal and Taveras 2014; Kaneda and Yamamoto 2015), evidence of successful cases is scarce.

This study examines the causal effect of school lunch on Japanese junior high school students based on municipality-level variation in school lunch provision from 1975 to 1994. In our sample school lunch is provided at almost all municipal elementary schools and at about 80% of municipal junior high schools. There are no eligibility restrictions, and on the contrary, at municipal schools that provide school lunch, students are not allowed to bring food to school and in principle all students must eat school lunch. Thus, unlike in previously studies, individual selection and under-reporting arising from stigma are irrelevant to this study. We use individual level data drawn from the National Nutrition Survey (NNS), a nationally representative, annual household survey with measured height and weight data and nutritionist-assisted food records. To account for the possibility that unobserved municipal characteristics affect both children's body weight and municipal decision to provide school lunch, we employ difference in differences (DID) framework and compare differences between junior high school students and children in higher grades of elementary school between areas with and without school lunch at junior high schools.

We find no evidence that school lunch affects body weight in full sample analyses. However, in subsample analyses of children with low per-capita household expenditure, we find significant negative effect of school lunch on BMI and overweight. These findings are robust to trimming based on propensity scores for ensuring sufficient overlap of observed area characteristics between areas with and without school lunch at municipal junior high schools. Additionally, municipal school lunch provision at junior high school is not significantly associated with either height, BMI, or eating habits of local pre-school and elementary school children, implying that growth and weight problems among local children has little effects on municipal decision to provide school lunch.

2. Background

2.1 Obesity in Japan

In Japan, despite the low average BMI and the low prevalence of obesity with BMI 30 or over (less than 3% among adults), the prevalence of obesity-related diseases such as diabetes is close to that in other developed countries with significantly higher prevalence of obesity (Guariguata et al. 2014), pausing a serious public health issue (McCurry 2007). Because the rise in obesity-related health risks starts at lower BMI among Asians including Japanese than among Caucasians, since 2000 the Japan Society for the Study of Obesity advocates defining obesity as BMI of 25 or over, as opposed to the WHO benchmark of BMI 30. Under this criterion about 20% of Japanese men and women are obese since the 1950s (Kanazawa et al. 2002; Kodama et al. 2013). Both obesity prevalence and mean BMI have significantly increased among Japanese children from the late 1970s to around 2000 in Japan (Matsushita et al. 2004; Yoshinaga et al. 2010; Maruyama and Nakamura 2015). Japanese studies have found that child obesity is a strong predictor of adult obesity (Togashi et al. 2002; Ge et al. 2011) and causes child metabolic syndrome (Yoshinaga et al. 2005). Until the paradigm shift occurred in the 2000s, however, few Japanese pediatricians were concerned about mild obesity or metabolic syndrome in childhood (Yoshinaga 2012). Thus, our study period from 1975 to 1994 corresponds to the time when child obesity was growing but little attention was paid to obesity, even less to child obesity in Japan, which reduces concerns for reverse causality from local prevalence of obesity to municipal school lunch provision.

2.2 The School Lunch Program

In Japan government subsidized school lunch program for elementary school children with low-income background started in 1932, but were interrupted due the deterioration in the war situation in 1944. Large-scale provision of school lunch without eligibility restrictions started right after the WWII under American occupation as a measure against child malnutrition resulting from severe food shortage. School lunch for elementary school children was resumed in Tokyo in 1946, and was gradually expanded to nationwide by 1951. The nutritional and sanitary guidelines became the School Lunch Law in 1954, and the law was revised to include junior high schools in 1956 (National Institute for Educational Policy Research (NIEPR), 2013). The law obliges municipalities only to "make effort" to provide school lunch at its municipal elementary and junior-high schools, allowing municipalities' discretion. Despite this municipal variation, because school lunch is regarded as a part of education in Japan, at schools with school lunch bringing food to school is not allowed and all students must eat school lunch, except for students with special dietary needs such as food allergy (Ono 2007). Under the law municipalities pay the labor costs and the cost of construction and maintenance of facilities, guardians pay ingredient costs and energy bills, and the national treasury subsidizes facility construction (NIEPR, 2013). As a result, households' payment for school lunch has been kept to a relatively low level. In 2013, for example, the average monthly school lunch fee is about

4,200 yen for elementary schools and about 4,800 yen for junior high schools (MEXT 2015). Payments are exempted for children from low-income households, and all but few municipalities provide school lunch to all students regardless of fee payment (Fujisawa 2008).

Since the enactment of School Lunch Law in 1954, Ministry of Education has set nutritional standards for school lunch, including target values for energy, protein, total fat, calcium, and vitamin (Nozue 2011). The standards are overall stricter than their counterparts in the US and UK. In particular, in the US even current federal requirements lack target values for protein, total fat, calcium, and vitamin, and there were no maximum requirements for energy supply until 2012 (Woo-Baidal and Taveras 2014). In England and Scotland there have been no legally binding nutrition requirements for school lunch until the mid-2000s, although current nutrition requirements are similar to the Japanese standards in many ways (Scottish Government 2008; Dimbleby and Vincent 2013). Since 1954 the standards have been revised eight times, mostly for minor changes. During our study period the revision occurred only once in 1986. In the 1986 revision target values for fat was replaced with the maximum percentage of energy intake from fat of 30 percent, and the target amount for energy and protein were slightly reduced (Nozue 2011).[1] Nevertheless, apparently the revision did not cause significant changes either in energy supply or in fat supply from 1985 to 1990 (Narusaka 1996).

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[1] Other changes include the introduction of target value for iron, reductions in the target values for calcium, vitamins A, B_1, and B_2, and an increase in the target value for vitamin C (Nozue 2011).

The School Lunch Law lists educational goals of the school lunch program, such as to encourage good eating habits, foster sociability, promote health, and gain knowledge on foods. Since 1958 Ministry of Education placed the school lunch program as a part of the curriculum, and instructed teachers to guide table manners and discourage picky eating. Since 1970, Ministry of Education encourages each municipal school to hire a licensed nutritionist for nutrition planning, supervision over food preparation and hygiene control, and guidance to students on desirable diet (NIEPR, 2013).

While some speculate that the school lunch program has contributed to the lower prevalence of obesity in Japan to the school lunch program (Fisher 2013; Kaneda and Yamamoto 2015), we know of no study that examines the causal effect of Japanese school lunch program on child obesity. Previous studies find significant positive association between school lunch and intake of vegetables and dairy products by comparing food intake in weekdays and weekends among students of elementary schools with school lunch (Nozue et al. 2010) and comparing junior high school students attending municipal schools with and without school lunch (Kawaraya and Mori 2009).

3. Data

3.1 The National Nutrition Survey

We construct a sample of 9 to 15 years old children in elementary school or junior high school using individual-level data drawn from the 1975-1994 National Nutrition Survey (NNS). The NNS is a nationally representative, annual cross-sectional survey conducted by the Ministry of Health, Labour and Welfare (MHLW) (Katanoda et al.

2005).[2] Census districts, which are subdivisions of a municipality, are cluster sampled from all 47 Japanese prefectures, and all households within the sampled districts are asked to participate in the survey. This sampling scheme fits well with this study because we exploit municipality-level variation in school lunch program. The response rate is not reported for earlier years, but in 2002, for instance, among about 5,000 households invited to the survey, 4,160 participated in the survey (MHLW 2003). Height and weight data are measured without shoes and with adjustment for the weight of clothes by health professionals, and thus are accurate and free from the reporting bias associated with self-reports (Connor Gorber et al. 2007). The NNS also contains a self-administered questionnaire on demographic and socioeconomic characteristics of the household and household members and a nutritionist-assisted questionnaire on food intake. A certified nutritionist visits each participating household to provide further guidance and correct for misreporting.

The NNS is conducted on a random subsample of the Comprehensive Survey of Living Conditions (CSLC), another annual survey conducted by the MHLW since 1986. We merge the NNS and the CSLC to utilize age in month information from the CSLC for years 1986-1994.

3.2 Municipal provision of school lunch

[2] The NNS was renamed the National Health and Nutrition Survey in 2003.

Until 1994, the NNS survey period covers three consecutive days not including Sunday, and the questionnaire asks whether the respondent had school lunch.[3] The NNS includes a masked identifier for census district, and each census district belongs to only one municipality. We categorize whether the municipality of each census district provides school lunch at its municipal junior high schools based on the majority rule; if the half or more of junior high school students with valid type of lunch information report having school lunch, then the area is regarded as providing school lunch at municipal junior high schools. We exclude areas with less than two reports, and areas with exactly two conflicting reports. We analogously categorize school lunch provision at municipal elementary schools.

There are two possible reasons for children not having school lunch during the survey period other than the municipal school not providing school lunch. First, some children might miss school lunch due to sickness or extra-curricular activities such as excursion. Our categorization based on the majority rule and exclusion of areas with insufficient information would take account of this kind of noise. Second, a nonnegligible number of children attend non-municipal schools, such as private and national schools, although children attending non-municipal elementary schools are very rare in Japan. We exclude prefectures with high rate of junior-high students attending non-municipal schools from

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[3] Since 1995, the food diary only covers one day from Monday to Saturday. Because school lunch is not served on Saturdays, if a respondent household chooses Saturday for food diary then no information is collected regarding whether children regularly have school lunch. Thus we do not use data collected after 1994.

sample.[4] The rate of junior high school students attending non-municipal schools has increased over time, so we exclude prefectures where the rate is 5% or higher in the early 1990s (Tokyo, Kochi, Nara, Kanagawa, Kyoto, Hyogo, Hiroshima, Osaka, Chiba, Mie), dropping about 35% of the observations.

3.3 Identifying elementary school and junior-high school students

The questionnaire asks if children are in compulsory education, but does not distinguish between elementary school and junior high school. Because the school grade is strictly determined by the child's age on April 1st in Japan, among children in compulsory education we categorize 6-11 year olds as elementary school students and 13-15 year olds as junior-high students. Additionally, for years 1986-1994 the birth month is available in the CSLC, so we categorize 12 year olds born between April and October as elementary school students and those born between December and March as junior high students. We exclude 12 year olds for years 1975-1985 and 12 year olds born in November for years 1986-1994 from sample, because we cannot determine whether they attend elementary school or junior high school.

3.4 Exclusion criteria

As described above, our sample consists of 9 to 15 years old children in elementary school or junior high school, excluding 12 year olds for years 1975-1985 and 12 year olds born in November for years 1986-1994, and excluding prefectures with high rate of junior-high students in non-municipal schools. These criteria lead to a sample with 13,186

[4] Information on school ownership type is not available in the NNS.

elementary school children and 11,388 junior high school children. Other exclusion criteria are as follows. We limit our sample to children with valid information on height and weight, and exclude a small number of children whose height is less than 100cm and/or whose weight is larger than 100kg as deviants. A small number of children without mother in household or without valid report on household expenditure are also excluded from sample. We further limit our sample to areas with at least one elementary school student and one junior-high school student because our identification is based on difference-in-differences. We also exclude areas with unreliable school lunch information due to too few and/or conflicting reports as described above and a small number of areas without school lunch for elementary school children. Our final sample consists of 9,633 elementary school children and 8,353 junior high school children.

3.5 Outcome measures

As outcome measures we use height, BMI, and overweight. We use several definitions for overweight. First, for comparability with other studies we use “international definition” (Cole et al. 2000): based on the estimated gender-specific BMI distribution for the Japanese by Kato et al. (2011), we use the percentage corresponding to BMI 25 at age 17.5 as the cutoff value for overweight. Second, we also use a modified version of weight for height called “percentage of overweight” (POW), which is widely used in Japan: Children whose measured weight exceeds the standard weight for height by more than 20% are categorized as overweight. We use the standard weight for height by age and gender estimated by Murata and Ito (2003). POW has an advantage over BMI-based measures in that BMI increases with height for children in puberty and because reliable estimate of standard weight is available for Japanese children due to little ethnic heterogeneity and the availability of high quality data (Sugiura and Murata 2011; Dobashi 2016). The first point is particularly relevant to this study because we compare junior high school students with elementary school students.

3.6 Individual characteristics

As demographic characteristics we control for age and gender. To allow for gender specific age effects, we include dummy variables for the interaction of gender and age. We also control for various parental and household characteristics, including presence of father, grandfather, grandmother in household, parental age, parental height and BMI (in z-scores by gender, age, and five year cohort), parental occupations (laborer, white collar worker, self-employed, agriculture, other), the number of children (17 years old or younger) in household, and the percentage ranking of total monthly household expenditure per capita.[5] The household expenditure is reported by eight categories, and the categorization varies by survey year. Thus we calculate the percentage rank of each category by survey year over all households.[6]

3.7 Area characteristics

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[5] A small number of children without mothers in household are excluded from sample. Household members 27-59 years old are regarded as parents and those aged 60 or older are regarded as grandparents. Mean values are used in the case of multiple “fathers” or “mothers”.

[6] Mean values of categories are used in the case of conflicting reports within household.

In the analysis of determinants of municipal school lunch provision at junior high schools we control for various area characteristics, including geographic characteristics and NNS-based aggregate values. Geographic characteristics include prefecture specific effects or regional block specific effects (Hokkaido and Tohoku, Kanto, Chubu, Kinki, Chugoku and Shikoku, Kyushu and Okinawa), dummies for municipal size (town and village, cities with less than 50 thousand population, cities with 50-150 thousand population, cities with more than 150 thousand population, 11 largest cities), and annual prefectural population density obtained from Statistics Bureau (2012). NNS-based aggregate values include mean age, median percentage ranking of per-capita household expenditure, mean household size, means of height and BMI among adults (in z-scores by age, gender, and five year cohort), mean frequencies of dining out and breakfast skipping among adults, and occupational composition among 23-54 year olds (laborer, white collar worker, self-employed, agriculture, other).

4. Estimation Strategy

We examine the effect of *not* having school lunch at junior high school on children's BMI and overweight status, because children in census districts with school lunch at municipal junior high schools (the control areas) outnumber those without (the treatment areas). Cross sectional comparison between junior high school students who have and do not have school lunch would be problematic if there are systematic differences in local obesogenic environment between municipalities that provide and do not provide school lunch. Community characteristics, such as availability of healthy and unhealthy food, urban sprawl, access to parks and sports facilities, and transportation systems are significantly associated with local obesity prevalence (Booth et al. 2005, Lake and Townshend 2006). To account for possible unobserved heterogeneity, we use difference in differences (DID) framework and compare differences in body weight measures between the target and control areas. Specifically, using a sample of junior high school students and elementary school students in higher grades, we estimate a linear regression model in which outcome measures are regressed on the interaction of *Junior High* dummy, indicating that a child is a junior high school student, and *No School Lunch Area* dummy, a dummy variable indicating no school lunch for junior high school in the census district, individual characteristics, and census district specific effects.[7] To allow for correlation of the error term within each census district, we cluster standard errors at census district level.

DID framework relies on the assumption that unobserved differences in area characteristics between the target and control areas have similar effects on both elementary school students and junior high school students. This assumption would be violated if there are systematic differences in the growth pattern, in particular in the timing of puberty onset, between the target and control areas, although the use of POW-based obesity definitions would mitigate this potential issue. To examine this possibility we include height as a regressand in DID analyses as a placebo test. Because height is determined primarily by genetic factors and early-life environment (Beard and Blaser 2002), school lunch is unlikely to have a strong, immediate effect on height. At the same time, if the timing of puberty onset differs between the target and control areas, then the coefficient of on the

[7] Year effects and area characteristics are absorbed in census district specific effects.

interaction of *Junior High* dummy and *No School Lunch Area* dummy would capture that effect.

If the nutritional content of lunch children bring from home to school in the absence of school lunch varies with socioeconomic status (SES), the effect of school lunch on body weight could also differ by SES.[8] Japanese school lunch is universal in that regardless of household income all children eat school lunch at municipal schools with school lunch, whereas in the previously studied countries school lunch participation is more prevalent among children from low income families due to income based subsidies. This might lead to a greater heterogeneity in the effect of school lunch in Japan than in those countries. To examine this possibility we conduct a subsample analysis of children with lower per capita household expenditure than the median.

Because linear regression adjustment is not robust to nonlinearity, we trim the sample based on propensity scores to ensure sufficient overlap in characteristics between the target and control areas for a robustness check. Using a logistic regression model we regress *No School Lunch Area* dummy on the area characteristics described above to obtain propensity scores.[9] For each of the target and control groups we define the support as the interval

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[8] The literature indicates inverse association between SES and child obesity in developed countries (Mclaren 2007; Shrewsbury and Wardle 2008). Findings of socioeconomic gradient of obesity in childhood and adolescent in Japan are mixed, and there are no studies based on a large scale, individual level data (Sakai 2013; Kachi et al. 2015).

[9] Following Imbens (2015), to increase the matching quality we reduce the number of regressors and also add the interaction terms of important variables to the regressors.

between the first and 99th percentiles of the estimated propensity scores, and exclude observations outside the common support (Stuart 2010). We also exclude observations whose estimated propensity score is smaller than 0.1 or larger than 0.9 (Imbens 2015). It turned out that this trimming reduces the absolute standardized difference of all the explanatory variables except for prefecture dummies between the target and control areas to less than 0.25 for both the full and sub samples, where the values above 0.25 are considered as problematic (Rubin 2001).

Another possible source of endogeneity is the reverse causality from child obesity and other growth problems to school lunch provision. To examine this possibility we regress *No School Lunch Area* dummy on mean height and mean BMI (in z-scores by gender, age, and five year cohort), the mean frequencies of restaurant dinner and breakfast skipping during the survey period of elementary and preschool children, as well as other area characteristics using census district level, aggregate data.[10] We estimate both OLS and logistic regression models.

5. Results

Summary statistics for the full sample are shown in Table 1. About 79% of children live in areas with school lunch at municipal junior high schools. 7.7% of elementary school

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Specifically, we replace year dummies with a linear time trend and replace prefecture dummies with regional block dummies. We also add interaction terms of municipal size dummies and annual prefectural population density.

[10] We exclude districts with less than five elementary school or preschool children.

students and 6.7% of junior high school students are overweight according to the POW, and 7.7% of elementary school students and 5.9% of junior high school students are overweight according to the international definition, which is based on the percentage of individuals with BMI 25 or over at age 17.5. Children whose POW exceeds 30% or whose BMI percentile exceeds the threshold corresponding to BMI 30 at age 17.5 are rare. Comparing the treatment and control areas, overweight among elementary school children is more prevalent in the control areas than in the treatment areas but overweight among junior high school children is more prevalent in the treatment areas than in the control areas for both POW and the international standard. On the other hand, the differences in height are small for both elementary school children and junior high school children. Additionally, the majority of children in the target group live in cities with 50,000 population or more, whereas the majority of children in the control group live in towns, villages, or small cities with less than 50,000 population.

Table 2 shows the summary statistics of outcome measures for the subsample of children with below median per capita total household expenditure. For both elementary school students and junior high school students there are little differences in the means of any of the outcome measures between the subsample and the full sample shown in Table 1. Comparison between the target and control areas yields similar observations to those from the full sample: greater overweight prevalence among elementary school children in the control areas than in the treatment areas, greater overweight prevalence among junior high school children in the treatment areas than in the control areas, and small differences in height for both elementary school children and junior high school children.

Results of the regression of *No School Lunch* Area dummy, i.e., *lack* of school lunch provision at municipal junior high schools at the census district, are shown in Table 3. Model 1 and Model 2 are linear regression models, and Model 3 and Model 4 are Logit models. Estimated coefficients are shown for linear regression models, and odds ratios are shown for logit models. Model 1 and Model 3 control for prefecture fixed effects and Mode 2 and Model 4 control for regional block fixed effects instead of prefecture fixed effects. In all specifications means of height, BMI, frequencies of breakfast skipping and restaurant dinner among elementary school and preschool children are both independently and jointly insignificant, implying that municipal provision of school lunch at junior high school is not influenced by obesity prevalence or other problems related to growth and eating habits of elementary school and preschool children. In addition, few of the aggregate area characteristics are significant. Major determinants of school lunch are the municipal size: the likelihood of school lunch provision sharply decreases with the municipal population size. The estimated coefficients of year dummies are omitted for space reasons, but the results indicate that school lunch provision has only weakly increased over time.

Results of the difference in differences regression analysis for the full sample are shown in Table 4. The estimated average treatment effects are insignificant for all of the weight measures, for both the untrimmed and trimmed samples. These results imply that the effect of school lunch for junior high school students on BMI and overweight status is insignificant on average. The estimated effect of school lunch on height is also insignificant, implying that there are no systematic differences in the growth pattern between children in areas with and without school lunch at junior high schools.

Results of the subsample analysis of children whose per capita household expenditure is below the median are shown in Table 5. In contrast to the results of the full sample analysis, the estimated average treatment effects are all significantly positive for all of the weight measures, for both the untrimmed and trimmed samples. These results imply that school lunch significantly reduces BMI and overweight status for children from less affluent households. The estimated average treatment effect (ATE) is nonnegligible: the lack of school lunch increases BMI by about 0.4, and increases overweight prevalence by about 5%. Similarly to the results of the full sample analysis the estimated effect of school lunch on height is insignificant, implying that there are no systematic differences in the growth pattern between children with low household expenditure in areas with and without school lunch at junior high schools.

6. Conclusion

We examine the causal effect of school lunch on Japanese junior high school students using individual level data drawn from the 1975-1994 National Nutrition Survey (NNS). To account for possible endogeneity of municipal provision of school lunch, we employ difference in differences (DID) framework and compare differences between junior high school students and elementary school students in higher grades between areas with and without school lunch at junior high schools. We find no evidence that school lunch affects body weight in full sample analyses. However, in subsample analyses of children with low per-capita household expenditure, we find significant negative effect of school lunch on overweight.

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Table 1. Summary statistics for the full sample.

	All		Treatment Areas (Without school lunch at junior high)		Control Areas (With school lunch at junior high)	
	Mean	SD	Mean	SD	Mean	SD
N	17986		3758		14228	
No School Lunch Area	0.209	0.407	1	1	0	0
Junior High	0.464	0.499	0.459	0.498	0.466	0.499
Height: elementary	138.454	8.549	138.523	8.369	138.436	8.597
Height: junior high	158.058	7.707	158.290	7.637	157.997	7.724
BMI: elementary	17.271	2.472	17.174	2.397	17.297	2.491
BMI: junior high	19.631	2.643	19.649	2.680	19.626	2.634
Obesity: POW 20%+: elementary	0.077	0.266	0.068	0.253	0.079	0.270
Obesity: POW 20%+: junior high	0.067	0.250	0.071	0.257	0.066	0.248
Obesity: BMI 25+ at age 17.5: elementary	0.077	0.266	0.069	0.253	0.079	0.269
Obesity: BMI 25+ at age 17.5: junior high	0.059	0.236	0.063	0.243	0.058	0.235
Obesity: POW 30%+: elementary	0.033	0.179	0.031	0.172	0.034	0.181
Obesity: POW 30%+: junior high	0.030	0.172	0.037	0.188	0.029	0.167
Obesity: BMI 30+ at age 17.5: elementary	0.004	0.067	0.004	0.063	0.005	0.068
Obesity: BMI 30+ at age 17.5: junior high	0.007	0.084	0.006	0.080	0.007	0.086
Year	1983.851	5.465	1983.092	5.561	1984.051	5.422
Male	0.516	0.500	0.520	0.500	0.515	0.500
Age	11.805	2.008	11.758	1.996	11.817	2.011
Prefectural population density	0.474	0.438	0.500	0.423	0.467	0.442
Hokkaido & Tohoku	0.177	0.382	0.170	0.376	0.179	0.383
Kanto	0.160	0.366	0.072	0.258	0.183	0.387
Chubu	0.520	0.500	0.604	0.489	0.498	0.500
Kinki	0.030	0.171	0.069	0.254	0.020	0.139
Chugoku & Shikoku	0.113	0.317	0.085	0.279	0.121	0.326
Kyushu & Okinawa	0.205	0.403	0.261	0.439	0.190	0.392
11 largest cities	0.059	0.236	0.180	0.385	0.027	0.162
Cities: 150k+ population	0.269	0.443	0.348	0.476	0.248	0.432
Cities: 50-150k population	0.220	0.414	0.236	0.425	0.215	0.411
Cities: 50k- population	0.106	0.308	0.106	0.307	0.106	0.308
Towns & villages	0.346	0.476	0.131	0.337	0.403	0.491

Table 1. Summary statistics for the full sample. (cont.)

	All		Treatment Areas (Without school lunch at junior high)		Control Areas (With school lunch at junior high)	
	Mean	SD	Mean	SD	Mean	SD
Area: mean age	34.777	5.342	34.498	5.126	34.851	5.395
Area: HH median % ranking of HH expenditure	0.585	0.195	0.534	0.192	0.599	0.193
Area: mean HH size	4.326	0.624	4.217	0.587	4.354	0.630
Area: mean adult height (in z score)	-0.063	0.254	-0.002	0.252	-0.079	0.252
Area: mean adult BMI (in z score)	0.026	0.227	-0.008	0.225	0.035	0.227
Area: mean adult #restaurant dinner	0.253	0.148	0.249	0.153	0.254	0.147
Area: mean adult #breakfast skipped	0.221	0.163	0.244	0.164	0.215	0.162
Area: fraction of laborer	0.273	0.151	0.272	0.152	0.273	0.151
Area: fraction of white collar worker	0.284	0.148	0.288	0.148	0.283	0.148
Area: fraction of self-employed	0.146	0.122	0.156	0.123	0.144	0.121
Area: fraction of agriculture	0.081	0.154	0.056	0.135	0.087	0.158
Area: fraction of other occupation	0.216	0.106	0.228	0.100	0.213	0.107
Area: mean child height (in z score)	-0.009	0.356	0.019	0.354	-0.016	0.356
Area: mean child BMI (in z score)	0.005	0.352	-0.012	0.340	0.009	0.354
Area: mean child #restaurant dinner	0.106	0.145	0.105	0.145	0.106	0.145
Area: mean child #breakfast skipped	0.056	0.107	0.063	0.125	0.054	0.102
Father in HH	0.907	0.290	0.906	0.291	0.907	0.290
Father's age	38.113	12.945	38.178	13.024	38.095	12.924
Father's height (in z score)	-0.025	0.847	0.017	0.855	-0.036	0.844
Father's BMI (in z score)	0.008	0.851	-0.021	0.870	0.015	0.846
Father's BMI missing	0.252	0.434	0.256	0.436	0.251	0.434
Father: laborer	0.292	0.453	0.299	0.457	0.291	0.452
Father: self-employed	0.187	0.389	0.193	0.395	0.186	0.388
Father: agriculture	0.074	0.260	0.053	0.223	0.079	0.268
Father: other occupation	0.009	0.091	0.008	0.086	0.009	0.092
Father: white collar worker	0.437	0.495	0.447	0.496	0.435	0.495
Mother's age	39.558	4.385	39.550	4.315	39.560	4.403
Mother's height (in z score)	-0.063	0.976	-0.016	0.976	-0.076	0.976
Mother's BMI (in z score)	0.074	0.984	-0.003	0.927	0.094	0.997
Mother's BMI missing	0.036	0.187	0.036	0.187	0.036	0.187
Mother: laborer	0.244	0.426	0.235	0.420	0.247	0.428
Mother: white collar worker	0.162	0.365	0.170	0.372	0.160	0.363
Mother: self-employed	0.131	0.336	0.136	0.342	0.130	0.334
Mother: agriculture	0.087	0.279	0.055	0.226	0.096	0.290
Mother: other occupation	0.375	0.479	0.404	0.486	0.367	0.477
Grandfather in HH	0.196	0.397	0.165	0.371	0.204	0.403
Grandmother in HH	0.307	0.461	0.271	0.445	0.317	0.465
#child in HH	2.305	0.787	2.280	0.818	2.312	0.778
% ranking of HH expenditure	0.658	0.249	0.629	0.246	0.665	0.249

Table 2. Summary statistics of selected variables for children with low household expenditure.

	All		Treatment Areas (Without school lunch at junior high)		Control Areas (With school lunch at junior high)	
	Mean	SD	Mean	SD	Mean	SD
N	8953		1671		7282	
No School Lunch Area	0.187	0.390	1	1	0	0
Height: elementary	137.962	8.571	138.046	8.421	137.942	8.606
Height: junior high	157.650	7.761	157.809	7.614	157.614	7.795
BMI: elementary	17.250	2.488	17.136	2.326	17.276	2.523
BMI: junior high	19.670	2.712	19.764	2.844	19.648	2.681
Obesity: POW 20%+: elementary	0.079	0.270	0.065	0.247	0.082	0.274
Obesity: POW 20%+: junior high	0.069	0.254	0.093	0.290	0.064	0.245
Obesity: BMI 25+ at age 17.5: elementary	0.078	0.268	0.065	0.247	0.081	0.272
Obesity: BMI 25+ at age 17.5: junior high	0.062	0.240	0.080	0.272	0.057	0.232

Table 3. Regression results of *No School Lunch Area* dummy

	OLS Coefficients		Logit Odds Ratio	
	Model1	Model2	Model3	Model4
Prefecture dummies	Yes	No	Yes	No
Regional block dummies: reference group: Chubu				
Hokkaido & Tohoku		-0.016		0.943
Kanto		-0.090***		0.464***
Kinki		0.318***		5.858***
Chugoku & Shikoku		-0.04		0.775
Kyushu & Okinawa		0.037		1.304
Municipal size dummies: reference group: towns and villages				
11 largest cities	0.538***	0.524***	30.674***	19.501***
Cities: 150k+ population	0.190***	0.215***	5.507***	5.253***
Cities: 50-150k population	0.142***	0.163***	4.003***	4.050***
Cities: 50k- population	0.099***	0.116***	2.979***	2.915***
Population density	-0.382*	0.003	0.047*	1.065
Year dummies: reference group: Year 1975				
Year 1976	0.045	0.056	1.36	1.371
Year 1977	0.062	0.059	1.443	1.341
Year 1978	0.017	0.007	1.174	1.046
Year 1979	0.008	0.008	1.043	1.013
Year 1980	-0.017	-0.017	0.837	0.879
Year 1981	-0.013	-0.003	0.86	0.952
Year 1982	-0.026	-0.039	0.818	0.758
Year 1983	-0.119**	-0.117**	0.369**	0.402**
Year 1984	-0.061	-0.078	0.583	0.565
Year 1985	-0.058	-0.058	0.625	0.661
Year 1986	-0.111**	-0.127**	0.379**	0.390**
Year 1987	-0.068	-0.083	0.61	0.543*
Year 1988	-0.054	-0.051	0.648	0.701
Year 1989	-0.136**	-0.133**	0.329**	0.379**
Year 1990	-0.088	-0.075	0.471*	0.587
Year 1991	-0.028	-0.044	0.824	0.757
Year 1992	-0.077	-0.078	0.544	0.596
Year 1993	-0.101*	-0.111*	0.407*	0.439*
Year 1994	-0.1	-0.105*	0.433	0.455*

Table 3. Regression results of *No School Lunch Area* dummy (cont.)

	OLS Coefficients		Logit Odds Ratio	
	Model1	Model2	Model3	Model4
Area: mean age	0.003	0.002	1.017	1.012
Area: HH median % ranking of HH expenditure	-0.055	-0.101*	0.694	0.566
Area: mean HH size	-0.018	-0.004	0.896	0.931
Area: mean adult height	0.012	0.014	1.135	1.113
Area: mean adult BMI	-0.023	-0.051	0.728	0.683
Area: mean adult #restaurant dinner	-0.086	-0.142**	0.55	0.385**
Area: mean adult #breakfast skipped	0.095	0.035	1.691	1.173
Area occupation fraction: reference group: white collar workers				
Area: fraction of laborer	0.013	0.058	1.011	1.355
Area: fraction of self-employed	0.029	0.059	1.261	1.476
Area: fraction of agriculture	-0.091	-0.056	0.335	0.667
Area: fraction of other occupation	-0.089	-0.156	0.407	0.282
Area: mean child height	0.008	0.027	1.053	1.21
Area: mean child BMI	-0.007	0.009	0.897	1.048
Area: mean child #restaurant dinner	-0.019	-0.043	0.926	0.795
Area: mean child #breakfast skipped	-0.002	0.053	0.903	1.201
Constant	0.607**	0.182	4.496	0.198*
N	2080	2080	1978	2080

Notes: *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Table 4. Average treatment effects for the full sample.

	BMI		Overweight (POW)		Overweight (International Standard)		Height	
	Untrimmed sample	Trimmed sample	Untrimmed sample	Trimmed sample	Untrimmed sample	Trimmed sample	Untrimmed sample	Trimmed sample
ATE	0.103	0.137	0.009	0.014	0.011	0.012	0.264	0.280
SE	0.089	0.109	0.010	0.011	0.009	0.011	0.218	0.255
p-value	0.246	0.207	0.348	0.225	0.248	0.274	0.226	0.272
N	17986	11116	17986	11116	17986	11116	17986	11116

Table 5. Average treatment effects for children with low household expenditure.

	BMI		Overweight (POW)		Overweight (International Standard)		Height	
	Untrimmed sample	Trimmed sample	Untrimmed sample	Trimmed sample	Untrimmed sample	Trimmed sample	Untrimmed sample	Trimmed sample
ATE	0.358	0.430	0.055	0.051	0.051	0.050	0.013	0.078
SE	0.149	0.170	0.015	0.017	0.015	0.017	0.346	0.378
p-value	0.017	0.012	0.000	0.003	0.001	0.005	0.970	0.837
N	8953	5552	8953	5552	8953	5552	8953	5552