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ORIGINAL PAPER

Predictors of Obesity in a Cohort of Children Enrolled in WIC as Infants and Retained to 3 Years of Age

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Abstract This longitudinal study of children enrolled as infants in the New York State (NYS) Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) examined predictors of obesity (body mass index ≥ 95th percentile) at 3 years of age. NYS WIC administrative data which included information from parent interviews and measured heights and weights for children were used. All 50,589 children enrolled as infants in WIC between July to December 2008 and July to December 2009 and retained in WIC through age three were included. At 3 years of age, 15.1 % of children were obese. Multiple logistic regression analysis showed that children of mothers who received the Full Breastfeeding Food Package when their infant was enrolled in WIC (adjusted OR = 0.52) and children with ≤2 h screen time daily at age 3 (adjusted OR = 0.88) were significantly less likely to be obese ($p < 0.001$) controlling for race/ethnicity, birth weight, and birthplace. In this cohort of NYS WIC participants, maternal receipt of the Full Breastfeeding Food Package (a surrogate measure of exclusive breastfeeding) is associated with lower levels of obesity in their children at age 3. The relationships between participation in WIC, exclusive breastfeeding, and obesity prevention merit further study.

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Introduction

While the most recent US data show a decrease in obesity (body mass index ≥95th percentile) among children 2–5 years old from 11.1 % in 1999–2000 to 8.0 % in 2011–2012 [1], this decline masks the enormous racial/ethnic disparities in obesity that exist. Non- Hispanic White children have the lowest prevalence of obesity at 3.5 % compared to 11.3 % in non-Hispanic Black children and a high of 16.7 % in Hispanic children [1]. Given the potentially serious consequences of early childhood obesity, including obesity later in life and the development of chronic diseases such as diabetes and cardiovascular disease, it is important to identify specific characteristics and behaviors that prevent children from becoming overweight or obese [2–4].

Many local and national programs address the obesity epidemic. The United States Department of Agriculture (USDA) WIC Program is one such program that reaches nearly one half of all babies born in the US. Monthly, WIC serves nearly eight million low income pregnant and postpartum women, infants and children through 4 years of age [5]. Following recommendations by the Institute of Medicine [6], the USDA revised the WIC food package in 2009 to enhance its potential impact on reducing early childhood obesity. Fruits, vegetables, and whole grains were added to the WIC food package for the first time. It further limited children ≥2 years of age to 1 % or non-fat milk, and required breastfeeding promotion and support including breastfeeding peer counseling [7]. The New York State (NYS) WIC Program has been actively and

progressively promoting these and other healthy living activities since 1997 [8, 9], and the NYS WIC program was the first in the nation to implement the required USDA food package changes in January 2009.

Shortly after implementation of the revised WIC food package, modest changes in food consumption and purchasing patterns among WIC participants in NYS [10], and elsewhere around the country [11–16] were observed in cross-sectional studies. The current longitudinal study examines breastfeeding and other food consumption patterns in relation to the prevalence of obesity at 3 years of age in a cohort of children enrolled in the NYS WIC Program as infants in 2008–2009.

Methods

The cohort was composed of all infants enrolled at birth or shortly thereafter in the NYS WIC Program between July 1 and December 31, 2008 and July 1 and December 31, 2009. Infants enrolled during the 6 month implementation period (i.e. January 1 to June 30, 2009) for the revised package were excluded from the cohort to enable us to test for differences in obesity at age 3 between children who were and were not exposed to the 2009 food package as infants. Participant records were obtained from data extracts of the WIC Statewide Information System (WICSIS), an automated database housed within the NYS Department of Health that captures administrative and behavioral data for WIC. Behavioral data were routinely obtained by WIC staff through parent/caregiver interviews during initial enrollment and regular re-enrollment visits (mandatory certification and mid-certification visits) and entered into WICSIS. On average, there was a 6-month interval between each child certification and mid-certification visit. Records for infants and children participating during the study period were extracted quarterly from the WICSIS database. All personal identifiers were removed and potentially identifying data elements were re-coded to further protect anonymity of participants prior to delivery of data to research staff. The unique, non-identifying, code assigned to each infant at initial entry into the WIC Program and retained throughout WIC participation was used for matching.

For the present analyses, we merged 6-month data extracts using the unique code assigned to each child. After merging eight, 6-month extracts of data for the two enrollment periods, July 1, 2008–June 30, 2012 and July 1, 2009–June 30, 2013, we retained only those children who had a certification after their third birthday and who had enrolled as infants in one of the two required 6-month periods. Each infant/child record contained the following information: gender, age, birth weight (categorized as very low birth weight < 1500 g, low birth weight ≥ 1500 to < 2500 g, normal birth weight ≥ 2500 to < 4000 g or high ≥ 4000 g) and race/ethnicity (categorized as Hispanic, non-Hispanic Black [Black], non-Hispanic White [White], Asian, and other).

Height or length and weight were measured by trained WIC staff according to standard protocol [17] or at physicians' offices within 60 days of WIC certification. Height or length was recorded to the nearest 1/4 inch and weight to the nearest 1/4 pound. Biologically implausible values for height or weight (approximately 1 % of the sample) based on Centers for Disease Control and Prevention (CDC) criteria were excluded [18]. For children 2 years of age and older, recorded measures of height and weight were converted to metric equivalents and body mass index (BMI) was computed as weight in kilograms divided by height in meters squared. Age- and sex-specific percentiles for BMI were computed based on the reference population for the 2000 CDC growth charts for US children. Overweight was defined as a sex-specific-BMI-for-age $\geq$85th and $<$95th percentile, and obesity as sex-specific-BMI-for-age $\geq$95th percentile. For infants and children less than 2 years of age, sex-and age-specific percentiles for weight-for-recumbent length were computed based on the 2000 CDC growth charts for US children [19].

The breastfeeding variable used in these analyses was derived from the food package assigned to the mother at infant enrollment as recorded in WICSIS and categorized as full (no infant formula), partial (partial allotment of infant formula), or none (complete infant formula allotment). Parents/caregivers were asked about the following behaviors during certification and recertification visits: the child's daily consumption of any serving(s) of fruits excluding juice (Y, N), vegetables (Y, N), and whole grains (Y, N); the type of milk the child drank most often (15 choices, collapsed into two categories: low (1 %)/non- fat, all others). A composite variable, healthy foods, was constructed with healthy foods equaling yes (Y) for any daily consumption of fruits, vegetables, whole grains, and low/no fat milk and no (N) for all others. Lastly, the daily numbers of hours the caregiver/child sat and watched TV, videos, DVDs (categorical 0–5+ hours/day) and the daily numbers of hours the caregiver and child sat and used the computer and/or played computer video games (categorical 0 to 5+ hours/day) were obtained. Screen time was calculated as total time spent watching TV, videos, DVDs or using the computer. It was defined as the proportion of children meeting the age-specific guidelines for screen time: $\leq$2 h/day for 2–4-year-olds and no screen time for $0 <$ 2-year-olds.). For each child, the most recently recorded value was used for each variable. Physical activity measures were excluded from this analysis because data

were collected by family activity and not at the individual level.

Data were analyzed using SPSS 20 and SAS version 9.2. Because the demographic characteristics and birthweight distributions of the infants enrolled in 2008 and 2009 were nearly identical, they were combined into a single cohort. Obesity was the primary outcome examined for those participants who stayed in WIC until 3 years of age. For categorical bivariate analyses Chi squared tests were used. Multiple logistic regression models were employed to examine joint associations and adjusted effects of central variables for race, New York City residence, mother's breastfeeding package, birth weight, and year of WIC enrollment on obesity at age 3. Only differences reaching a p value less than or equal to 0.001 and corresponding 99.9 % confidence intervals were considered statistically significant to reduce the likelihood of Type 1 error in this very large sample of children.

This study was approved by the Institutional Review Boards of Public Health Solutions, Columbia University, and the NYS Department of Health.

Results

A total of 140,510 infants were enrolled in WIC during the two time periods of interest and 50,589 children had certification or recertification data in WICSIS at 3 years of age. (Table 1). Among those enrolling in WIC during the designated periods, 51 % were male. About 36 % were Hispanic, 28 % White, 26 % Black and the remaining 10 % Asian and other races. Most infants (84 %) were of normal birth weight. At WIC enrollment, 8.4 % of mothers received the Full Breastfeeding Package. Receipt of the Full Breastfeeding Package varied by race/ethnicity of the mother from 23.5 % of Whites, to 5.3 % of Hispanics, to 4.2 % of Blacks, and to 4.1 % of Asians (data not shown).

There was some differential loss to follow-up between enrollment and final follow-up at 3 years of age (Table 1). Hispanic children were somewhat more likely to remain in WIC until age 3 while Black children were more likely to drop out, as were children who lived outside New York City, and those whose mothers received the non- breastfeeding food package. All differences were small (<8 %).

As shown in Table 2, by the time the children were age 2, daily consumption of fruits was almost universal (91.8 %), high (80.3 %) for vegetables, and moderate for whole grains (64.6 %). Between ages 2 and 3 these dietary consumption patterns changed relatively little. However, between ages 2 and 3 consumption of low/non-fat milk rose significantly from 47.9 to 76.3 %. Mothers of nearly three-fourths of all children ages 2 and 3 reported the recommended amount of screen time, 2 h per day or less. The proportion of children who were under or normal weight declined slightly from 71.7 % among 2- year-olds to 67.8 % among 3-year-olds, with a corresponding increase in the proportion of children overweight or obese, which rose from 28.3 % among 2-year-olds to 32.2 % among 3-year-olds. Obesity increased from 12.3 % at age 2 to 15.1 % at age 3.

Bivariate unadjusted and multiple logistic regression analyses of predictors of obesity at age 3 are shown in Table 3. Bivariate unadjusted logistic regression analyses showed that being Hispanic, living outside of NYC, having a high birth weight, maternal receipt of the Partial or No Breastfeeding Package, more than 2 h of screen time per day, consuming whole grains daily, consuming low/non-fat milk daily, and the composite variable—consuming healthy foods daily—were all associated with an increased risk of obesity at age 3. However, after adjusting for all covariates, the remaining significant predictors of obesity at age 3 eliminated several of the intermediate consumption and behavioral variables. After adjustment for other predictors, Hispanic ethnicity and birth weight of 4000 g or more were strongly associated with obesity and daily consumption of healthy foods was moderately associated with obesity, while children whose birth weights were low or very low were less likely to be obese at age 3. After adjusting for all other effects, children whose mothers had received the Full Breastfeeding Food Package were 0.51 times less likely to be obese. Those living in New York City were 0.73 times less likely to be obese, and those who reported $\leq$2 h of screen time were 0.87 times less likely to be obese. The results were virtually identical whether or not the enrollment period (2008 or 2009) was included in the analyses.

Discussion

This longitudinal study examined the relationship of feeding practices, behaviors, and demographics to BMI among children enrolled in the NYS WIC Program as infants and retained in the program until they reached their third birthday. By age 3, 15.1 % of the children in the cohort were obese. In multiple logistic regression, obesity at 3 years of age was lowest (adjusted OR = 0.51) in children whose mothers received the Full Breastfeeding Food Package (a surrogate measure of exclusive breastfeeding) at their infant's WIC enrollment. Lower rates of obesity were also seen in children living in New York City, children with a low or very low birth weight, and those reporting 2 h or less of screen time per day. Hispanic children and those with birth weights of 4000 g or more were significantly more likely to be obese while, unexpectedly, those reporting daily consumption of healthy

Table 1 Characteristics of a cohort of children in the New York State WIC program at enrollment and at 3 years of age

Characteristic	Enrollment in WIC n (%)	Retained at 3 year of age n (%)
Gender		
Male	71,697 (51.0)	25,691 (50.8)
Female	68,813 (49.0)	24,898 (49.2)
Race/ethnicity		
Black	36,743 (26.1)	11,390 (22.6)
White	38,818 (27.6)	13,610 (26.9)
Hispanic	50,388 (35.9)	20,457 (40.4)
Asian	11,327 (8.1)	4070 (8.0)
Other	3234 (2.3)	1062 (2.1)
Residence		
New York City	79,018 (56.5)	30,228 (59.8)
Rest of State	60,877 (43.5)	20,354 (40.2)
Birthweight (grams)		
Very Low (<500)	2185 (1.5)	831 (1.6)
Low (1500 $\leq$ 2500)	10,748 (7.7)	3867 (7.7)
Normal (2500–3999)	117,628 (84.1)	42,347 (84.0)
High (4000+)	9363 (6.7)	3364 (6.7)
Breastfeeding package		
None	60,954 (43.7)	18,128 (36.0)
Partial	66,900 (47.9)	27,173 (54.0)
Full	11,775 (8.4)	4986 (10.0)

Enrolled July 1, 2008—December 31, 2008 and July 1, 2009—December 31, 2009

Table 2 Dietary intake, behavior, and body mass index of a cohort of children retained in New York State WIC at age 2 and 3 years of age

Characteristic	Age 2 years (n = 73,161) n (%)	Age 3 years (n = 50,589) n (%)
Milk consumption, daily		
Any lowfat or skim milk	30,454 (47.9)	38,317 (76.3)
No lowfat or skim milk	33,054 (52.1)	11,912 (23.7)
Fruit consumption, daily		
Any serving(s)	58,746 (91.8)	46,777 (92.5)
No serving	5238 (8.2)	3799 (7.5)
Vegetable consumption, daily		
Any serving(s)	51,406 (80.3)	40,733 (80.5)
No serving	12,576 (19.7)	9839 (19.5)
Whole grain consumption, daily		
Any serving(s)	41,286 (64.6)	32,982 (65.3)
No serving	22,602 (35.4)	17,509 (34.7)
Screen time, daily		
<= 2 h	47,158 (74.1)	35,202 (70.0)
More than 2 h	16,480 (25.9)	15,106 (30.0)
Body mass index (BMI)		
BMI < 5th percentile	2608 (4.1)	1711 (3.4)
BMI 5 $\leq$ 85th percentile	42,496 (67.6)	32,184 (64.4)
BMI 85 $\leq$ 95th percentile	10,072 (16.0)	8550 (17.1)
BMI 95th+ percentile	7710 (12.3)	7548 (15.1)

Enrolled July 1, 2008—December 31, 2008 and July 1, 2009—December 31, 2009

Table 3 Predictors of Obesity (BMI ≥95th percentile) at age 3 years among New York State WIC participants

Characteristic	BMI ≥ 95th percentile		Unadjusted		Adjusted	
	Yes (n = 7388) n (%)	No (n = 39,899) n (%)	OR (99.9 % CI)	*p*	AOR (99.9 % CI)	*p*
Race						
White	1690 (22.9)	11,415 (28.6)	0.75 (0.68–0.82)	<.001	Ref	
Black	1421 (19.2)	9313 (23.3)	0.77 (0.69–0.85)	<0.001	1.04 (0.91–1.19)	0.33
Hispanic	3841 (52.0)	15,779 (39.5)	1.68 (1.55–1.83)	<0.001	1.71 (1.52–1.92)	<.001
Asian	436 (5.9)	3392 (8.5)	0.66 (0.56–0.78)	<0.001	0.96 (0.79–1.18)	0.54
Residence						
NYC	4112 (55.7)	23,925 (60.0)	0.83 (0.76–0.90)	<0.001	0.73 (0.68–0.83)	<.001
Rest of State	3276 (44.3)	15,967 (40.0)	Ref		Ref	
Birthweight (grams)						
Very low birthweight (<1500)	91 (1.2)	634 (1.6)	0.72 (0.49–1.03)	0.02	0.75 (0.51–1.09)	0.01
Low birthweight (1500 ≤ 2500)	400 (5.4)	3096 (7.8)	0.66 (0.66–0.81)	<0.001	0.69 (0.58–0.83)	<.001
Normal birthweight (2500–3999)	6081 (82.6)	33,642 (84.6)	0.88 (0.79–0.99)	<0.001	Ref	
High (4000+)	788 (10.7)	2390 (6.0)	1.92 (1.67–2.21)	<0.001	1.89 (1.63–2.18)	<.001
Breastfeeding package						
None	2724 (37.1)	14,209 (35.8)	1.05 (0.97–1.15)	0.05	Ref	
Partial	4203 (57.2)	21,130 (53.3)	1.17 (1.08–1.27)	<0.001	0.97 (0.89–1.07)	0.36
Full	424 (5.8)	4317 (10.9)	0.51 (0.43–0.60)	<0.001	0.51 (0.43–0.62)	<.001
Exposure to new WIC food package						
Yes	3690 (49.9)	19,816 (49.7)	1.01 (0.93–1.10)	0.65	1.02 (0.94–1.11)	0.42
No	3698 (50.1)	20,083 (50.3)	Ref		Ref	
Screen time						
≤2 h daily	4940 (67.3)	28,108 (70.8)	0.85 (0.77–0.93)	<.001	0.87 (0.79–0.95)	<.001
>2 h daily	2405 (32.7)	11,577 (29.2)	Ref		Ref	
Healthy food, daily						
Yes	3344 (45.4)	16,371 (41.2)	1.19 (1.10–1.30)	<.001	1.17 (1.07–1.28)	<.001
No	4022 (54.6)	23,343 (58.8)	Ref			
Fruit consumption, daily						
Any serving(s)	6808 (92.2)	36,951 (92.6)	0.95 (0.81–1.10)	0.17		
No serving	578 (7.8)	2938 (7.4)	Ref			
Vegetable consumption, daily						
Any serving(s)	5903 (79.9)	32,154 (80.6)	0.96 (0.86–1.06)	0.17		
No serving	1483 (20.1)	7731 (19.4)	Ref			
Whole grain consumption, daily						
Any serving(s)	4975 (67.5)	25,825 (64.8)	1.12 (1.02–1.23)	<.001		
No serving	2395 (32.5)	14,006 (35.2)	Ref			
Milk consumption, daily						
Any lowfat or skim milk	5813 (79.1)	30,157 (76.1)	1.20 (1.09–1.33)	<.001		
No lowfat or skim milk	1539 (20.9)	9485 (23.9)	Ref			

foods (fruits, vegetables, whole grains, and low/no fat milk) were somewhat more likely to be obese.

The finding that exclusive breastfeeding and ≤2 h of screen time per day were associated with lower rates of obesity at 3 years of age in this study provides important new information on modifiable risk factors for early childhood obesity. The very large, racially and ethnically diverse, low-income study population included all children enrolled as infants in the NYS WIC Program between July 1 and December 31, 2008 and July 1 and December 31,

2009 and continuing participation through age 3. Other advantages of the study design include the use of participant records from the NYC WICSIS administrative data base of behavioral data obtained prospectively from annual parent/caregiver interviews and child heights and weights measured at roughly 6 month intervals. All mothers of the children in this cohort were exposed to the revised WIC food package and associated healthy diet and lifestyle recommendations including breastfeeding promotion and support.

Breastfeeding may play an important role in preventing early childhood obesity. Exclusive breastfeeding and/or longer duration of breastfeeding have been associated with decreased rates of childhood obesity in many but not all studies [20–25], although the mechanisms of action have not been clearly delineated. USDA mandated WIC breastfeeding support programs, which include peer counseling, are intended to increase breastfeeding initiation, exclusivity, and duration, and are an important component of the revised WIC program in NYS. Studies have shown that breastfeeding initiation increases after WIC peer counselor contact [26], and both breastfeeding initiation and the prevalence of exclusive breastfeeding increased following implementation of the revisions to the WIC food package in California [27, 28] and New York [10]. In addition, messages about reducing screen time are vigorously promoted in New York [8, 9] and the proportion of WIC participants reporting two or fewer hours of screen time increased slowly but steadily in the years following implementation of the revised WIC program in New York [10].

This study has several limitations. WICSIS contained only general measures of dietary intake (daily consumption of foods in specifics categories) and no measures of food frequency. Thus, the weak positive association observed between daily consumption of healthy foods and obesity may reflect greater total food consumption by these children. In addition, neither maternal BMI, specifics on exclusive breastfeeding, nor detailed information on duration of breastfeeding was available. However, use of mother's assignment to a Full Breastfeeding Food Package as a surrogate for exclusive breastfeeding was reasonable within this low-income WIC population. Given the expense of infant formula, it was highly unlikely that mothers would have chosen a WIC food package without free formula unless they were exclusively breastfeeding. However, in the unlikely event that mothers receiving partial or full infant formula allotments were exclusively breastfeeding, this misclassification would bias the protective association observed between exclusive breastfeeding and obesity towards a null finding.

These limitations need to be addressed in subsequent longitudinal studies of children participating in WIC. Additional longitudinal studies should collect measured weight and length for infants at regular intervals from birth to 6 months of age to assess rapid early weight gain [29, 30], and detailed information about breastfeeding and other feeding practices, and maternal characteristics such as BMI and weight gain during pregnancy.

Despite its limitations, we believe that our longitudinal study of the association between exclusive breastfeeding at infant WIC enrollment and subsequent obesity reduction at age three provides important evidence of a key mechanism through which enhanced WIC breastfeeding promotion and support activities could contribute to the national effort to reduce early childhood obesity. Our findings lend support to the important role that the WIC program can play in improving the health of children through provision of education on healthy living, breastfeeding support including peer counseling, and healthy food choices to the more than eight million mothers, infants, and children who participate in the program each month.

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