

Early life risk factors for childhood obesity among Mexican-American children

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Outline

- Background on childhood obesity
 - Measurement
 - Determinants of childhood obesity
 - Child
 - Parents and families
 - Community, demographic, society
- Early life risk factors for childhood obesity

Obesity: a working definition

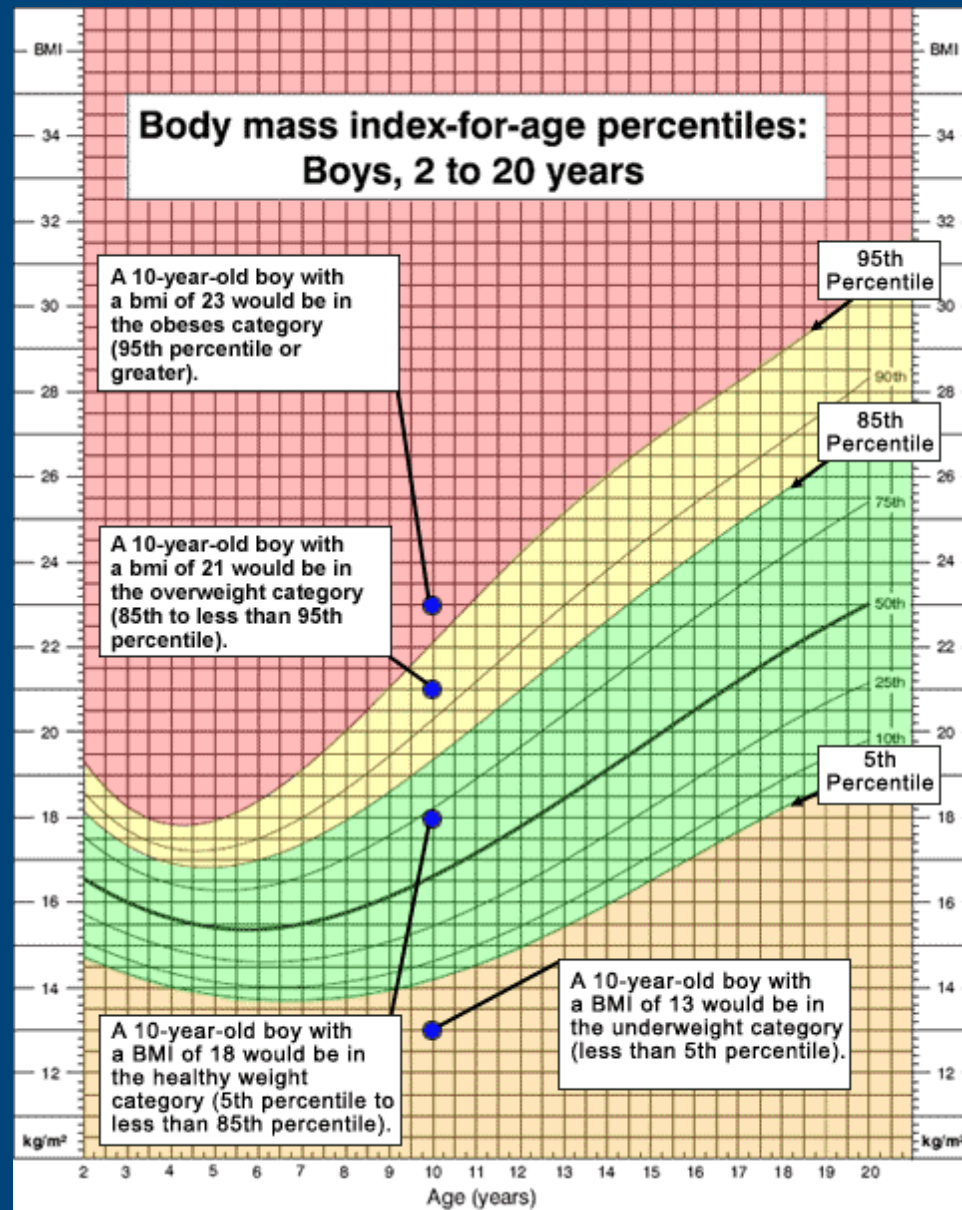
- Obesity refers to *excess fat*
- Obesity is measured as *excess weight*
- In adults: Body Mass Index (kg/m²):
 - 25: overweight
 - 30: obese

Determined by associations with morbidity and mortality
- In children.....

Childhood obesity: a definition

- No fixed cut-offs based on outcomes of morbidity and mortality:
 - Children's adiposity levels necessarily change throughout childhood
 - Little research on associations with morbidity and mortality in children

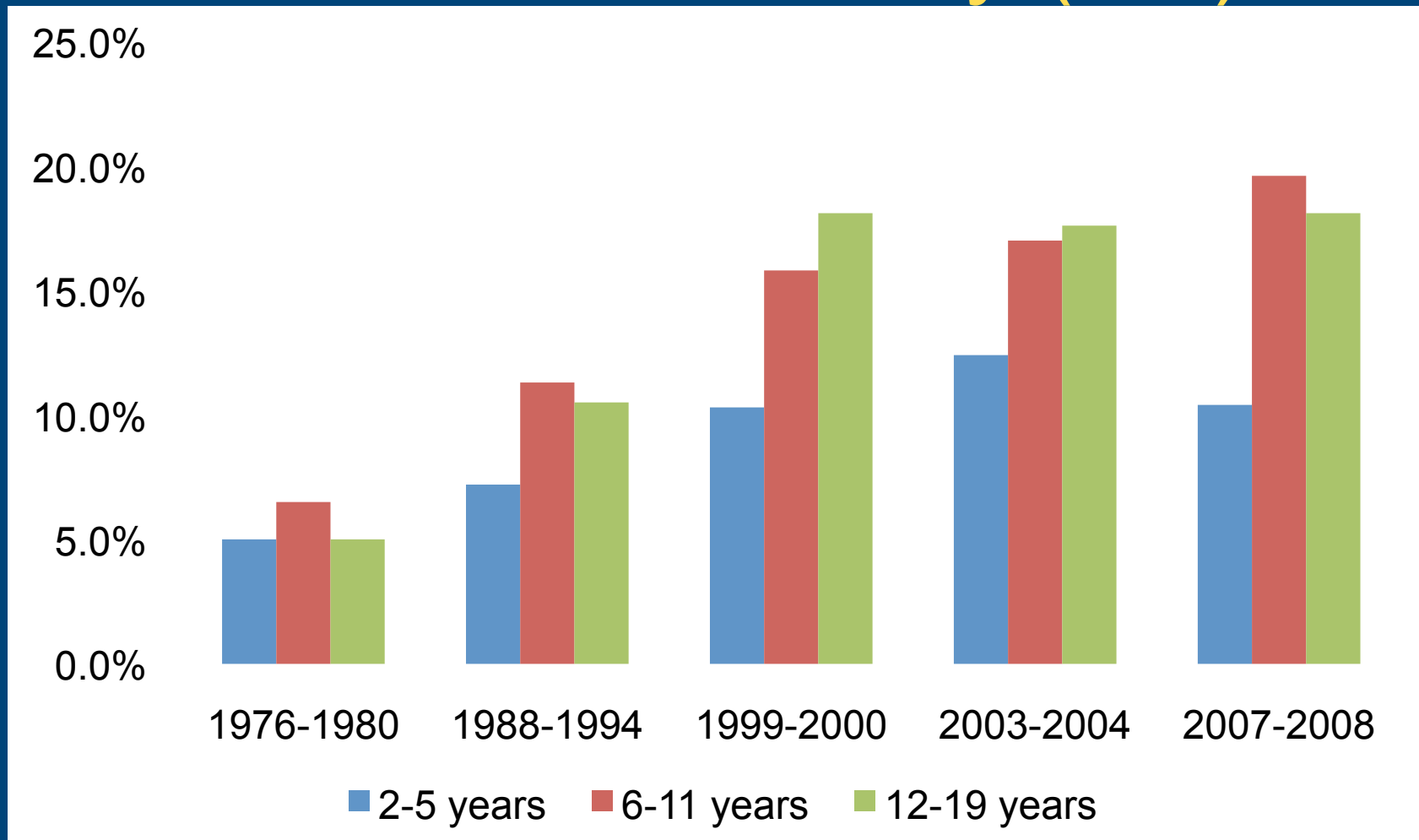




US and International definitions

US terminology	US definitions	IOTF terminology	IOTF definition
Overweight <i>formerly “at risk for overweight”</i>	Age- & sex-specific BMI between the 85 th and 95 th percentile from 2000 CDC growth chart	Overweight	Between age- & sex-specific BMI cut-offs from BMI curves based on 6 nationally representative surveys related to BMIs of 25 and 30 at age 18
Obese <i>formerly “overweight”</i>	Age & sex-specific BMI above the 95 th percentile from the 2000 CDC growth chart	Obese	Above age- & sex-specific BMI cut-off from BMI curve based on 6 nationally representative surveys related to BMI of 30 at age 18

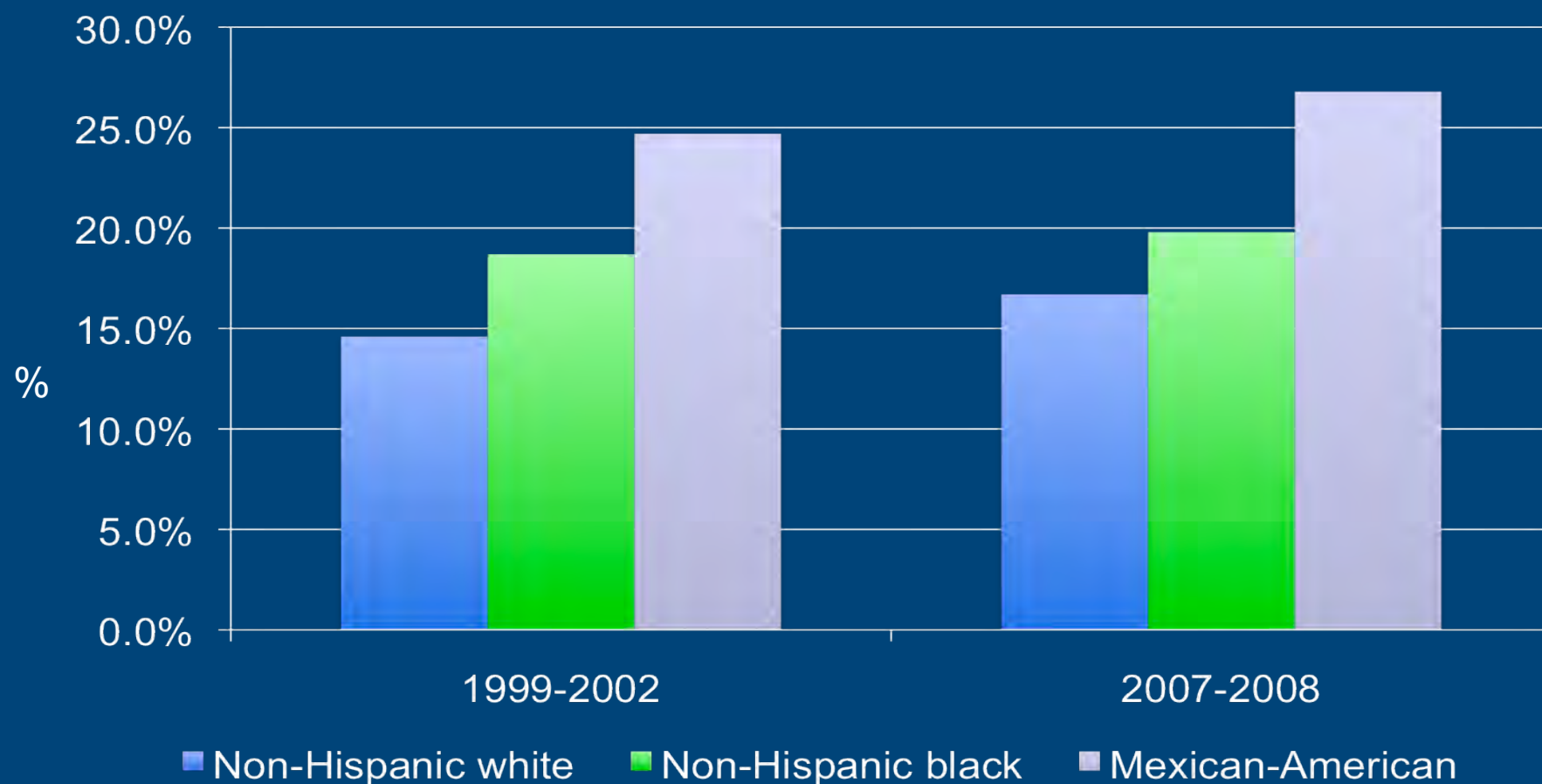
Prevalence obesity (US)



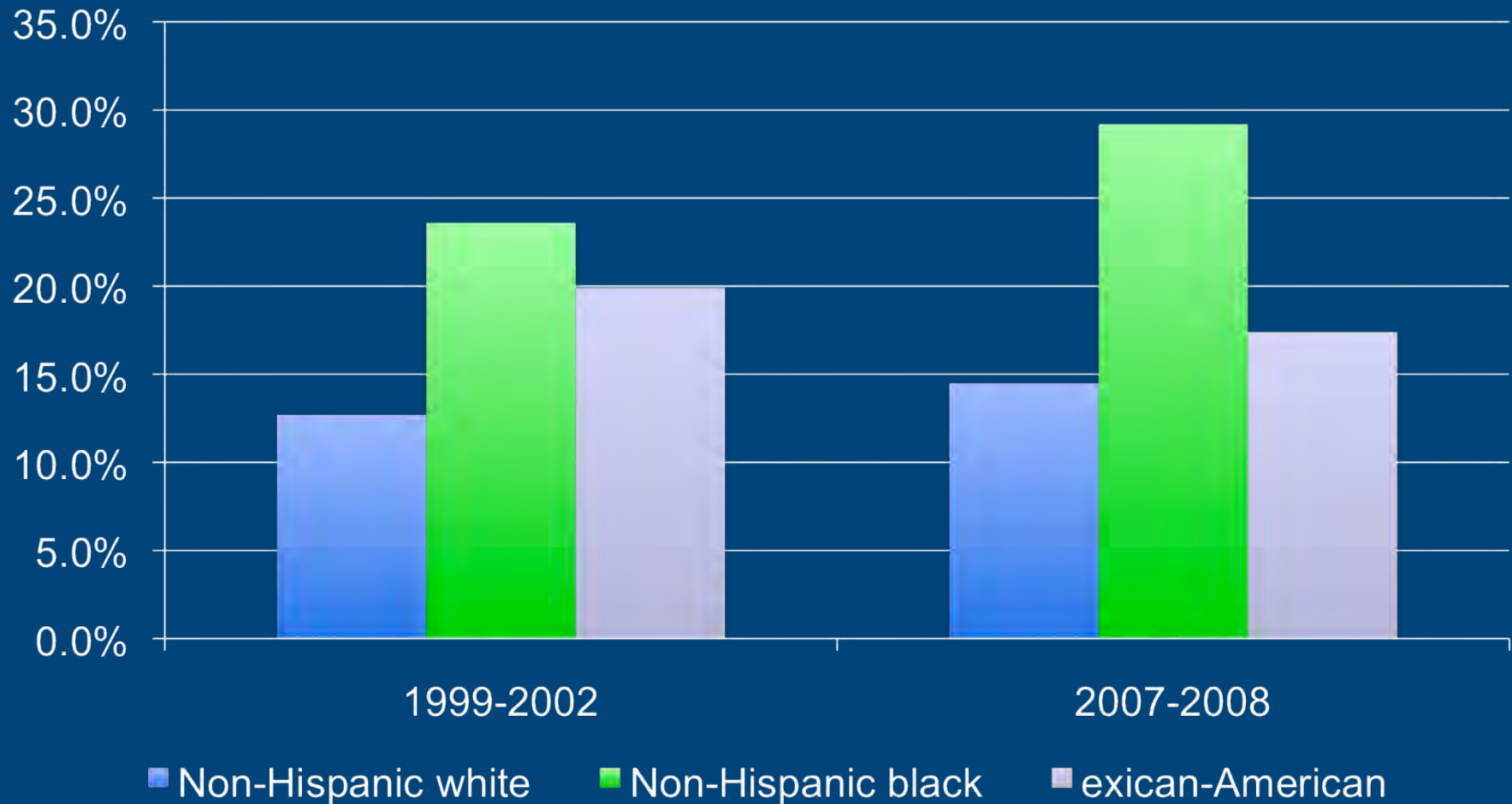
Ogden CL et al 1999–2000. *JAMA* 2002;288:1728–1732.
Hedley AA, et al 1999–2002. *JAMA* 2004;291:2847–2850.
Ogden CL, et al *JAMA* 2008;299:2401–2405.
Ogden CL, et al *JAMA* 2010; 303:242-249

Citations for next 2 slides

Adolescent Boys Prevalence of Obesity by Race/ Ethnicity (Aged 12–19 Years) National Health and Nutrition Examination Surveys

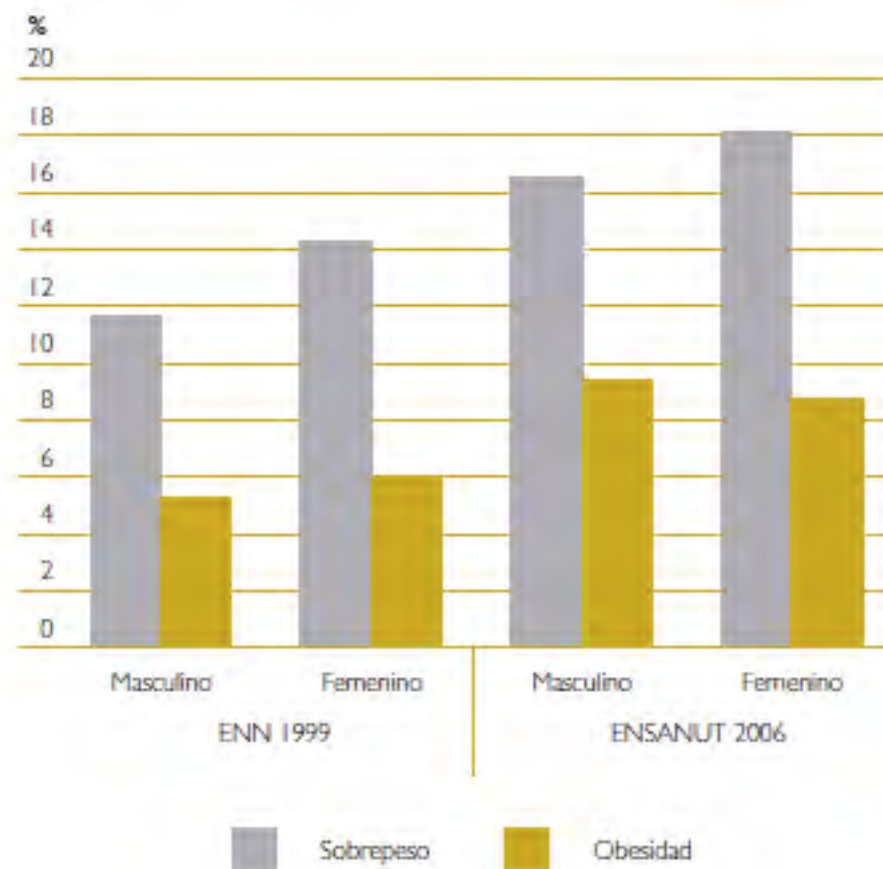


Adolescent Girls Prevalence of Obesity by Race/ Ethnicity (Aged 12–19 Years) National Health and Nutrition Examination Surveys



■ Figura 6.8

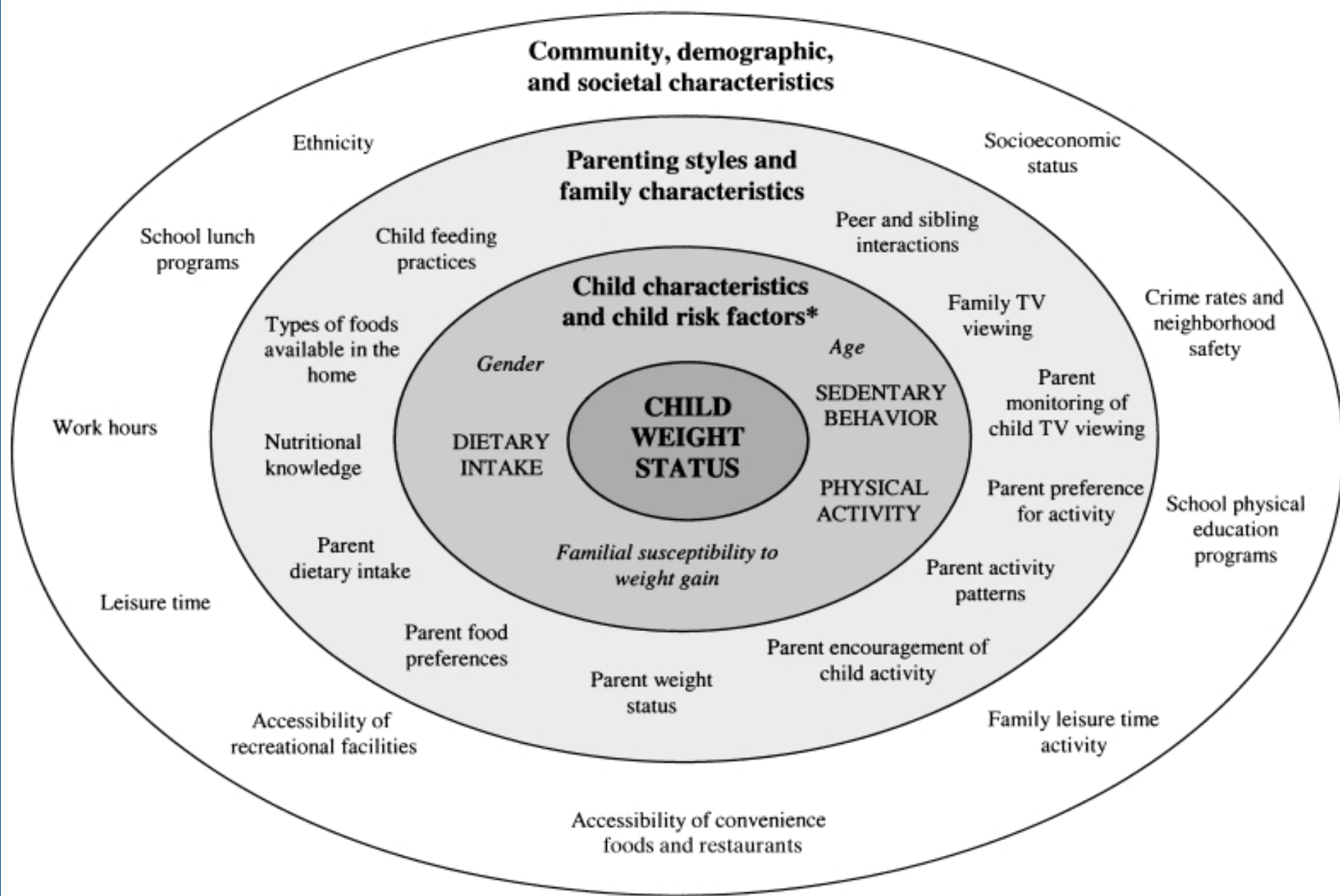
Comparativo de la prevalencia nacional de sobrepeso y obesidad en población de 5 a 11 años de edad de la ENN 1999 y ENSANUT 2006, por sexo, de acuerdo con los criterios propuestos por el International Obesity Task Force (IOTF). México



Health Consequences

- Higher blood pressure
- Higher serum lipids
- Type II diabetes
- Nonalcoholic fatty liver disease
- Psychosocial issues
- Early onset of puberty?
- Obesity in adulthood

Children



“Upstream” vs. “Downstream”



Child Characteristics



Child Characteristics: Diet

- Macro, micronutrient and total energy intake
- Eating out & fast food
- Portion size
- Meal & snack patterns
- Fruit and vegetable intake

Child characteristics: Macronutrient Intake

- Energy intake: no significant trend overall

Trends in age-adjusted mean energy intake of children and adolescents in the United States¹
= Trends in age-adjusted mean energy intake of children and adolescents in the United States¹

	NHANES I (1971–1974)	NHANES II (1976–1980)	NHANES III (1988–1994)
Sex and age			
Both sexes			
2–5 y	6758 ± 74 [2355]	6353 ± 52 [3056]	6498 ± 71 [4116]
6–11 y	8553 ± 100 [2019]	8213 ± 89 [1725]	8265 ± 117 [3134]
12–19y	9726 ± 164 [2671]	9498 ± 160 [2615]	10127 ± 155 [3121]

- Significant increasing trend for adolescent females, especially blacks
- USDA survey found significant increasing trend 1977-1996
- Literature reviews: ~ child weight status

Child characteristics: Macronutrient Intake

- Fat intake

Trends in age-adjusted mean fat and saturated fat intake as a percentage of energy and in cholesterol intake of children and adolescents in the United States¹

	Total fat			Saturated fat			Cholesterol		
	NHANES I (1971–1974)	NHANES II (1976–1980)	NHANES III (1988–1994)	NHANES I (1971–1974)	NHANES II (1976–1980)	NHANES III (1988–1994)	NHANES I (1971–1974)	NHANES II (1976–1980)	NHANES III (1988–1994)
	% of energy			% of energy			mg		
Sex and age									
Both sexes									
2–5 y	36.2 ± 0.22	35.3 ± 0.27	32.8 ± 0.23	13.7 ± 0.15	13.0 ± 0.12	12.4 ± 0.10	257 ± 7	218 ± 5	193 ± 5
6–11 y	36.3 ± 0.18	35.7 ± 0.20	33.7 ± 0.23	13.9 ± 0.11	13.2 ± 0.11	12.5 ± 0.12	282 ± 7	250 ± 6	231 ± 5
12–19 y	36.8 ± 0.21	36.4 ± 0.21	33.7 ± 0.23	13.7 ± 0.14	13.4 ± 0.10	11.8 ± 0.14	340 ± 8	309 ± 7	211 ± 6

- Fat intake has declined
- Literature review: ~ child weight status

* Troiano, 2000

Child characteristics: Soda

- Strong evidence from cross-sectional, longitudinal and randomized controlled trials



Warner et al, 2007

Adjusted odds ratio for overweight, Children at 2 years, CHAMACOS

:

	aOR*	95% CI
Soda		
None	1.00	
<1/day	0.97	(0.47, 1.99)
+ 1/day	3.39	(1.43, 8.07)

* Adjusted for fast food consumption, breastfeeding, maternal BMI

Child Characteristics: Diet

1. Journal of Obesity, 2006
2. Center for Weight and Health, UCB, 2001

- Strong
 - Soda
- Moderate-weak
 - Eating out & fast food
 - Dietary fat
 - Breakfast skipping
 - Fruit & vegetable
 - Snacking
- Mixed or very weak
 - Total energy
 - Energy density
 - Fruit juice

Child Characteristics: Diet

- Why so many studies on diet inconclusive?
 - Potential confounding – parental BMI, SES, energy expenditure, physical activity
 - Difficult to identify small daily imbalance that leads to overweight
 - Limited by dietary assessment

Dietary Assessment in Children

- Sources of error:
 - Under-reporting of intake
 - Underestimation of portion sizes
 - Relying on caretakers (parents & teachers)

Many studies show no relationship between diet & children's weight status

Child characteristics: Physical activity

- Physical activity
 - Systematic review*: 50% of studies significant association with child weight status
- Sedentary behavior (TV)
 - Cross-sectional and longitudinal studies significant association**

* Sallis, 2000, ** Saelens, 2003

Child characteristics: Physical activity

- National Longitudinal Study of Adolescent Health (1995-1996) ages 12-22, OR for overweight

aOR 95% CI

Boys

TV/video >35 h/wk 1.49 (1.14, 1.97)

Moderate-vigorous physical activity bout/week 0.86 (0.81, 0.91)

Not
consistent
across all
ethnic
groups

Girls

TV/video >35 h/wk 1.43 (1.07, 1.90)

Moderate-vigorous physical activity bout/week 0.90 (0.85, 0.96)

Child Characteristics: Physical Activity

- Issues in studies of physical activity:
 - Temporality: which came first?
 - Videogame and computer time
 - Physical activity vs. sedentary activity
 - Measurement: direct vs. indirect

Child characteristics: Sleep

- Sleep important regulator of energy balance, appetite and weight maintenance
- Studies suggest less sleep associated with increase in risk of obesity in adults
- Few studies in children

TABLE 4 Sleep Duration Between 3rd and 6th Grades and Overweight in 6th Grade (*N* = 706)

Characteristic	OR (95% CI)
Sleep duration in 3rd grade, h	0.60 (0.36–0.99) ^a
Change in sleep duration between 3rd and 6th grades, h	0.68 (0.44–1.06)
Gender (female vs male)	0.82 (0.40–1.71)
Race (other vs white)	1.42 (0.54–3.73)
Maternal education, y	0.84 (0.72–0.99) ^a
BMI z score at 3rd grade	127.4 (48.0–337.8) ^b

^a *P* < .05.

^b *P* < .001.

Parent and Family Characteristics



Parent & Family: Breastfeeding

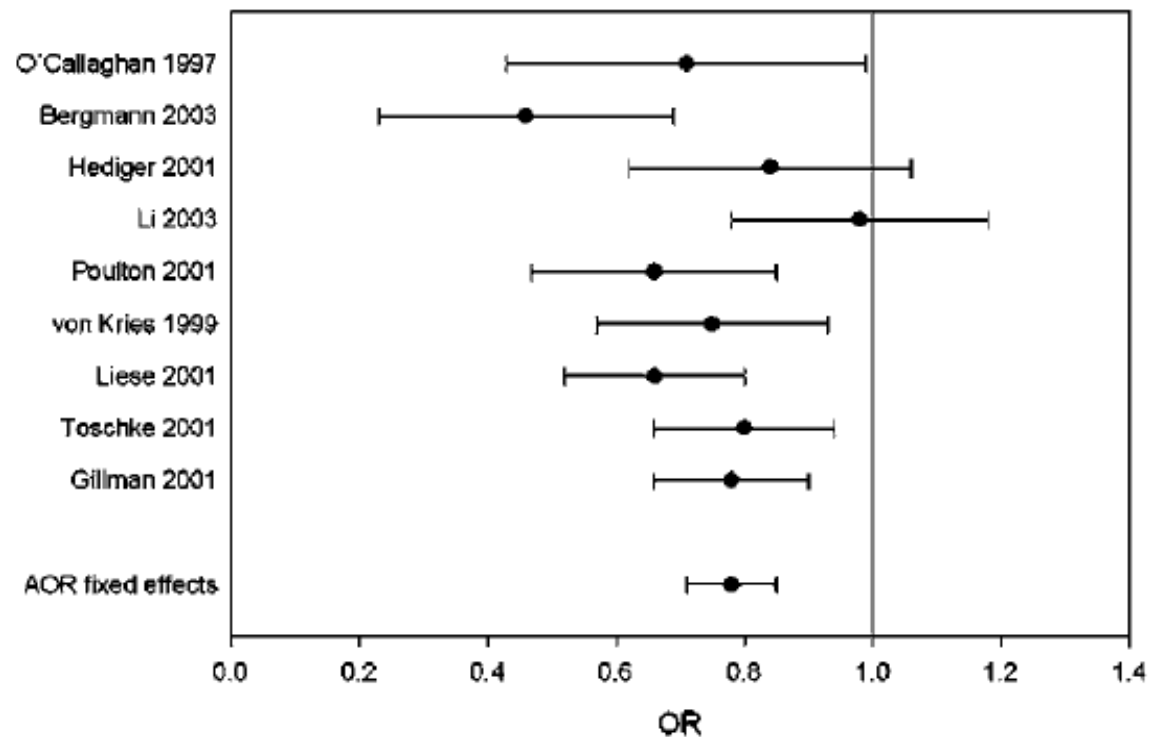


Figure 3 Effect of breast-feeding vs formula feeding on childhood obesity: covariate-adjusted odds ratios of nine studies and pooled odds ratio.

- OR 0.78*, not consistently protective across all ethnic/racial groups

Parent & Family: Food insecurity

- Adults:
 - ↑ mild-moderate household food insecurity in women

- Children

Author/year	Population	Scale	Result
Kaiser et al., 2002	211 Mexican-American children	Cornell	↑ BMI z-score
Rose et al., 2006	16,889 kindergarteners	USDA	↓ Overweight
Matheson et al., 2002	124 Hispanic 10 year olds	USDA	↑ BMI
Casey et al., 2001	5669 children & adolescents	Self report	No association

Proyecto mariposa: Binational Study Design



CHAMACOS:
Mexican mothers & 5-yr-old children

- Migrant receiving community, Salinas, CA
- Most commonly from the states of Guanajuato, Jalisco and Michoacán
- Recruited in clinics



Proyecto Mariposa:
Mothers & 5-yr-old children

- Migrant sending communities in Guanajuato, Jalisco, Michoacán
- Participants in *Oportunidades*, federal social welfare program
- Recruited in clinics

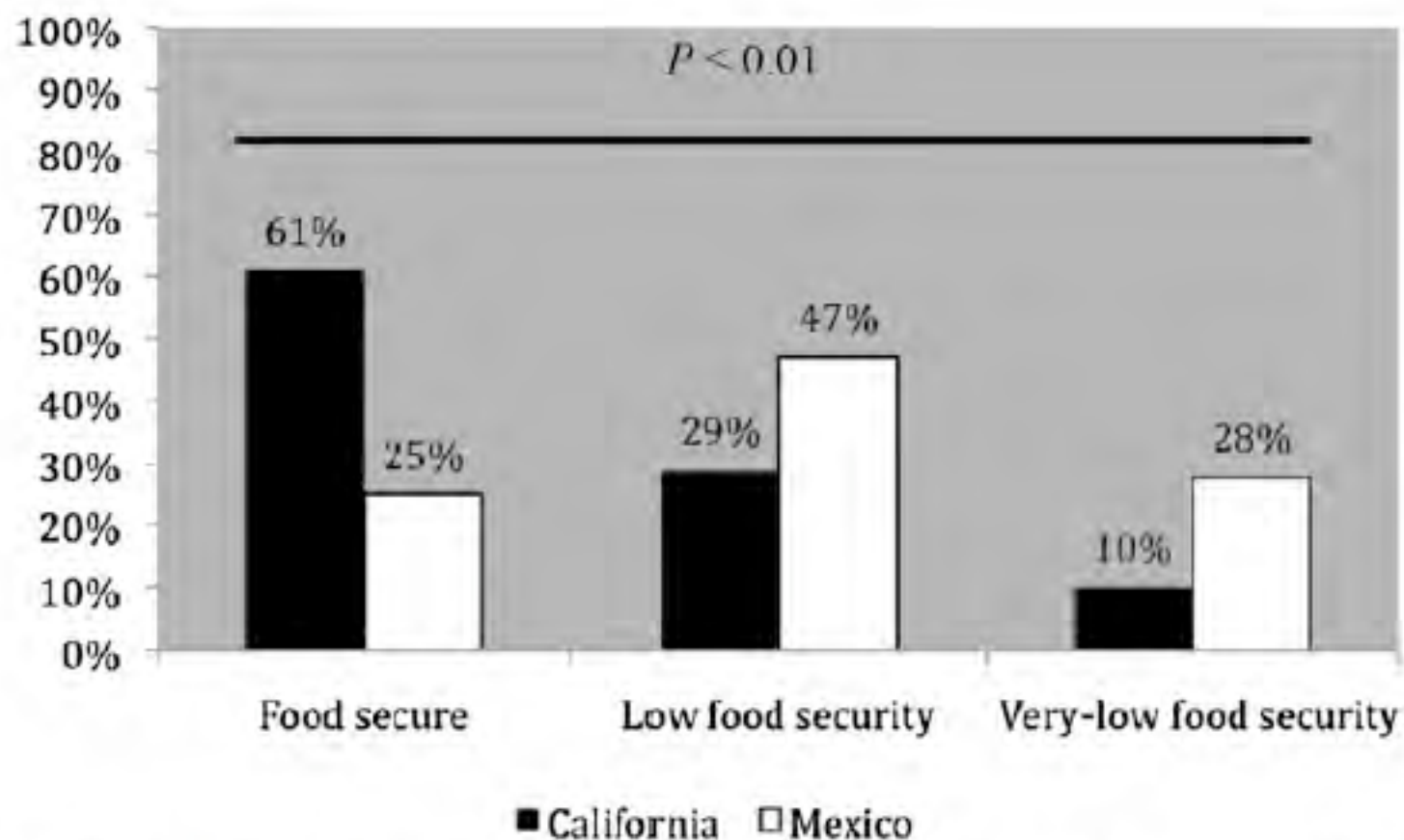


Figure. Household food security status for households with 5-year-old children in California (Salinas, CA) and Mexico (Guanajuato, Jalisco, and Michoacán, Mexico) in 2006. NOTE: Information from this figure is available online at www.adajournal.org as part of a PowerPoint presentation.

Food security status & macronutrients: California (n=301)

Daily nutrient intake (Median)	Secure	Insecure without hunger	Insecure with hunger	ANOVA	Adjusted ANOVA
Energy (kcal)	1897.3	2114.2	2042.4	*	
Fat (g)	61.0	68.2	71.5	*	*
Saturated Fat (g)	23.3	26.3	27.6	*	*
Carbohydrate (g)	275.8	309.2	291.7		
Protein (g)	66.9	73.0	68.2		

- Adjusted for SES, maternal education, receiving food assistance and mother currently working in farmwork
- Test for trend significant for all above nutrients

* Significant $p < 0.05$

Food security status & macronutrients: Mexico (n=301)

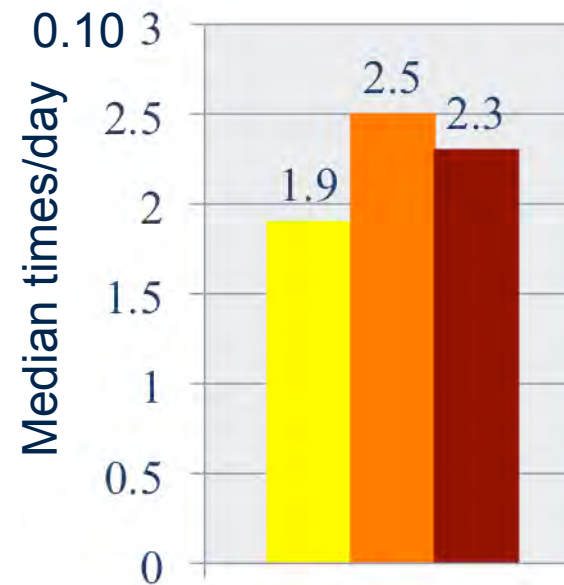
Daily nutrient intake (Median)	Secure	Insecure without hunger	Insecure with hunger	ANOVA	Adjusted ANOVA
Energy (kcal)	1631.7	1521.9	1356.6	*	
Fat (g)	45.5	41.5	39.3		
Saturated Fat (g)	12.2	11.1	9.8		
Carbohydrate (g)	277.3	244.2	219.6	*	*
Protein (g)	44.4	42.7	39.2		

- Adjusted for SES and maternal education
- Test for trend significant for all above nutrients

* Significant $p < 0.05$

Food Security & food groups: California & Mexico

ANOVA $p < 0.01$



Sweets & Snacks

California

Secure Insecure without hunger Insecure with hunger

Parent & Family: Parenting styles

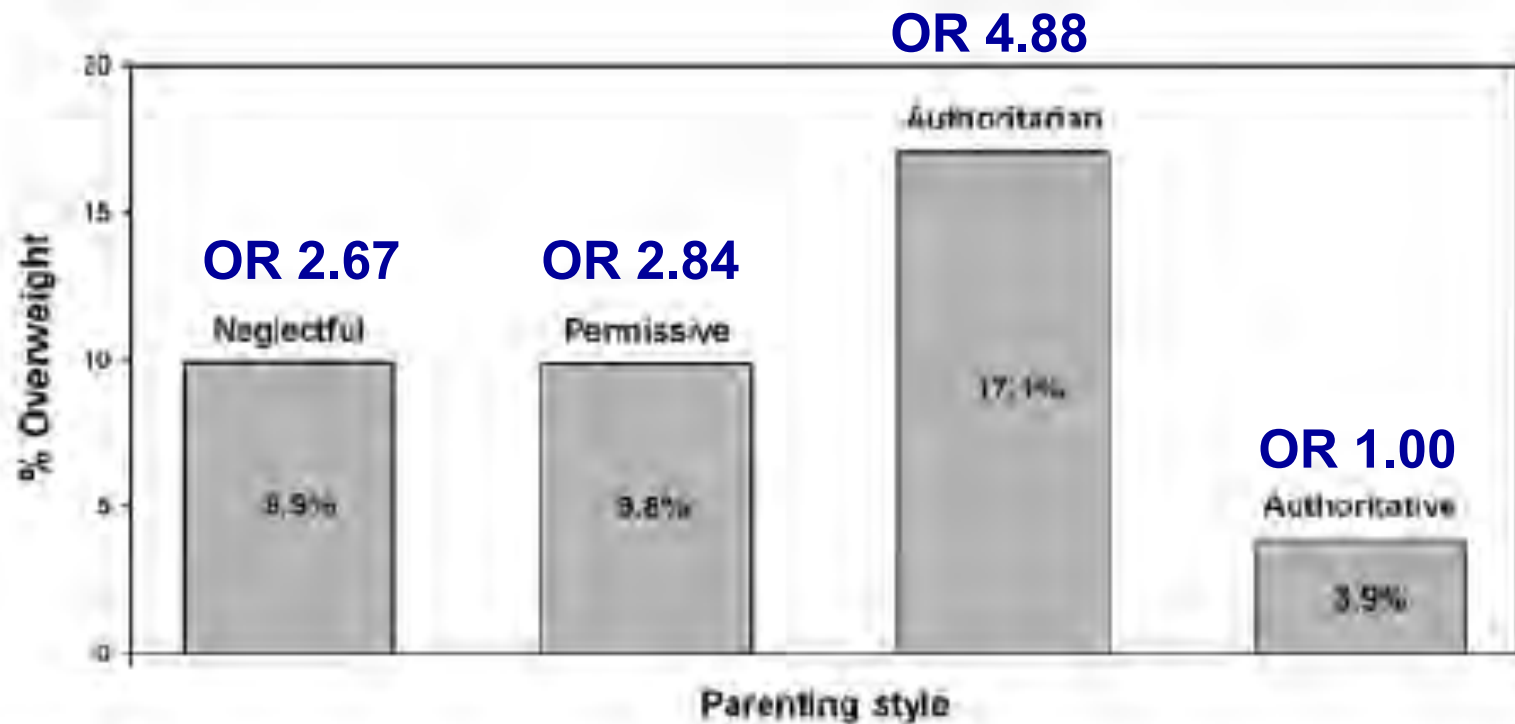


FIGURE 2

Prevalence of overweight according to parenting style, adjusted for income/needs ratio and race.

Parent & Family: Feeding practices

- Restriction
 - ↑ preference for restricted foods
 - ↑ child overweight
- Pressure to eat
 - ↑ calories
 - ↑ child overweight
- Food as reward
 - ↑ sweet consumption
 - ↓ preference for healthy foods
 - ↑ child overweight (moderate)

Parent & Family: Feeding behaviors

Table 2. Spearman correlations between food-related parenting attitudes and practices and children's food intakes, energy intake, and BMI in food-secure and food-insecure households

	Total Daily Intake						
	Fruit (servings)	Vegetables (servings)	Sweets and snacks (servings)	Energy (kcal)	% Energy from fat	Energy density (kcal/g food)	BMI percentile
Food-secure households (n=68)							
Pressure to eat	-0.09	0.23 ^a	-0.05	0.05	-0.07	-0.03	-0.48 ^{***}
Restriction	-0.18	0.20	-0.05	0.05	-0.08	0.00	-0.02
Attitudes about making healthful foods available	0.39 ^{***}	0.09	-0.10	0.03 ^a	-0.30 [*]	-0.18	-0.13
Modeling	0.01	0.13	-0.21	0.01	-0.20	-0.31 [*]	0.12
Food-insecure households (n=40)							
Pressure to eat	-0.13	-0.15 ^a	0.11	-0.13	-0.22	0.00	-0.41 ^{**}
Restriction	0.23	0.10	-0.25	0.02	-0.27	-0.21	-0.27
Attitudes about making healthful foods available	0.20	-0.12	-0.23	-0.34 ^a	-0.09	-0.10	-0.30 [*]
Modeling	0.27	0.07	0.05	-0.01	-0.17	-0.06	0.11

^aCorrelations between food-secure and food-insecure households differ from each other based on *t* tests for dependent correlations, $P < 0.05$.
^{*} $P < 0.05$.
^{**} $P < 0.01$.
^{***} $P < 0.001$.

Community, Demographic, Societal Characteristics



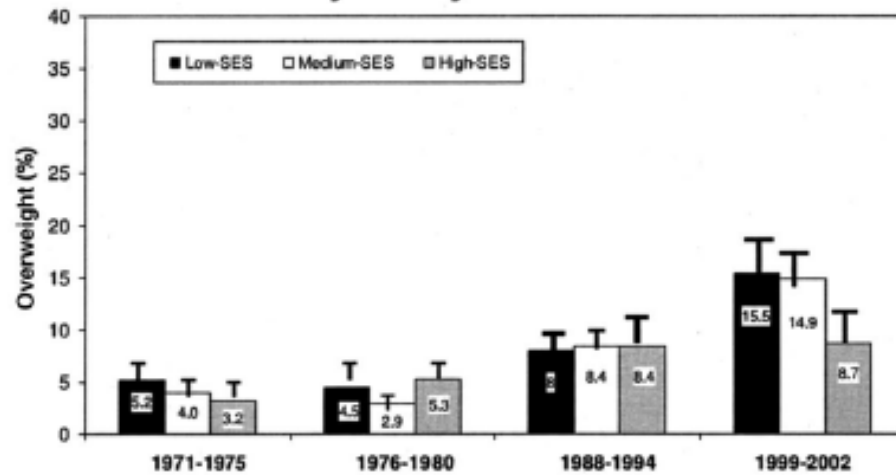
Community, Demographic, Societal: SES

- Evidence of an association in adults, less known in children
- From NHANES*: Not all low-SES groups at increased risk
 - Differs by sex, age and race/ethnicity
 - ↑ Low SES white girl adolescents
 - ↑ High SES black girl adolescents
 - No association in Mexican-American
 - Associations have changed over time

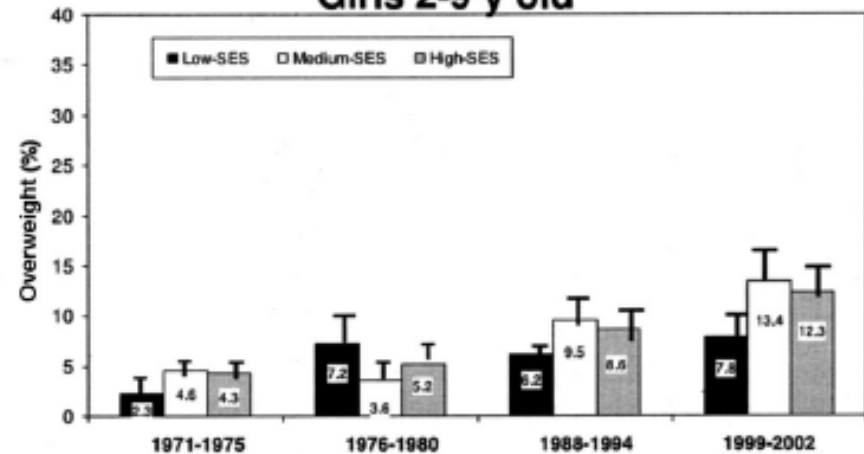
*Wang & Zhang, 2006

White

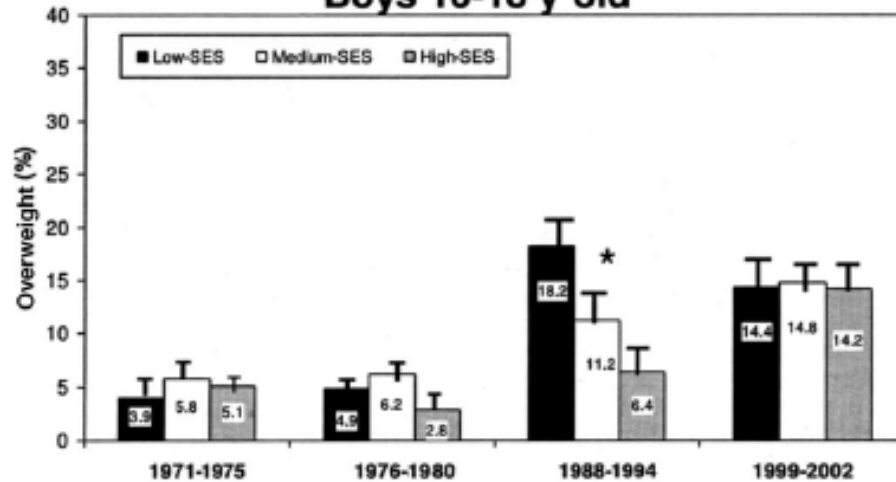
Boys 2-9 y old



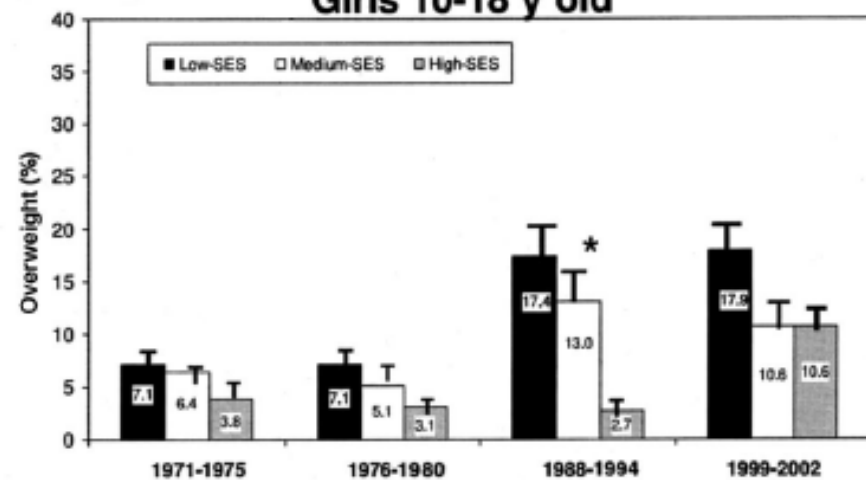
Girls 2-9 y old



Boys 10-18 y old

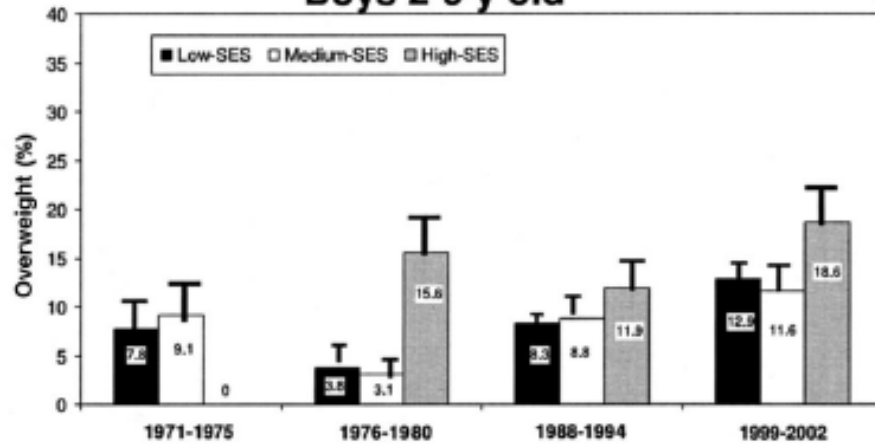


Girls 10-18 y old

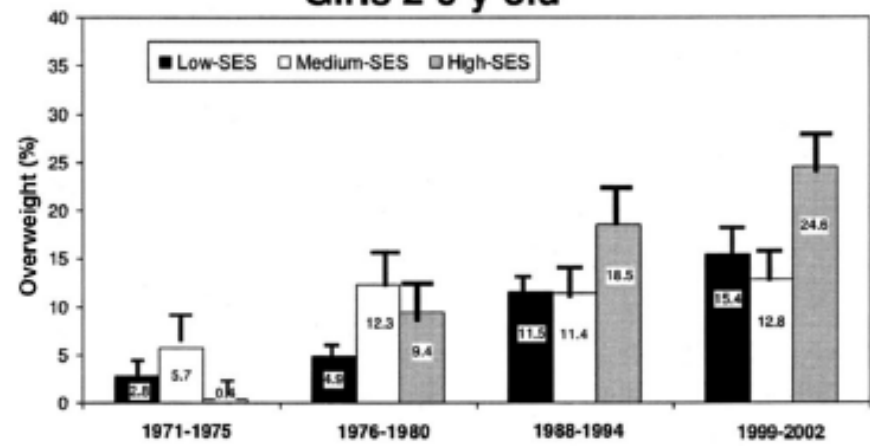


Black

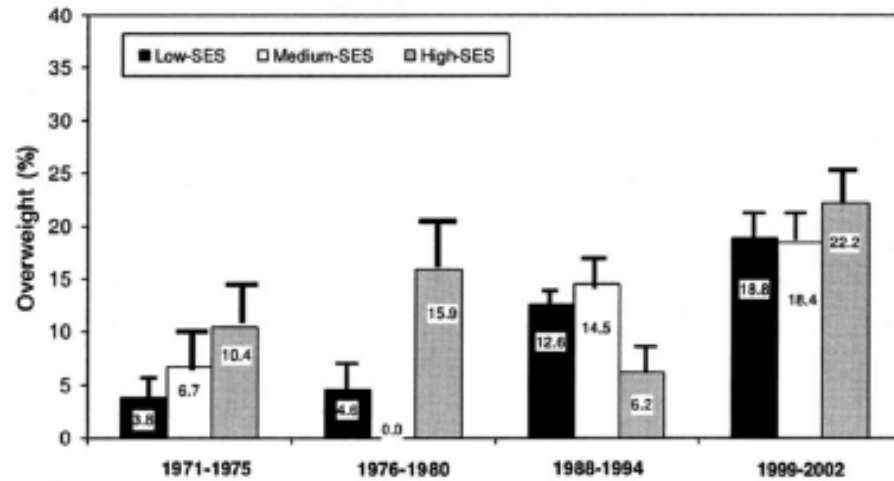
Boys 2-9 y old



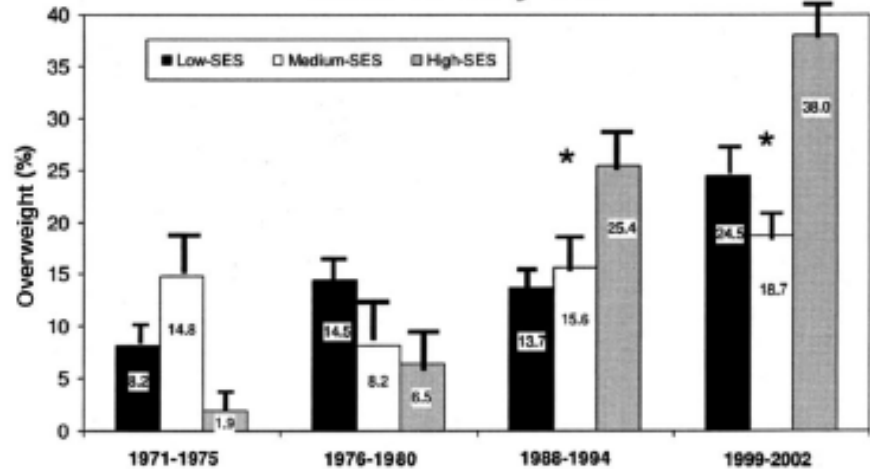
Girls 2-9 y old



Boys 10-18 y old

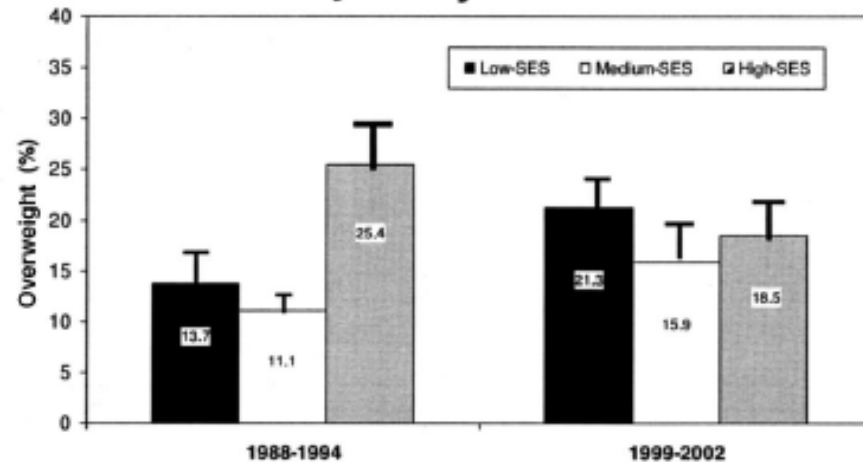


Girls 10-18 y old

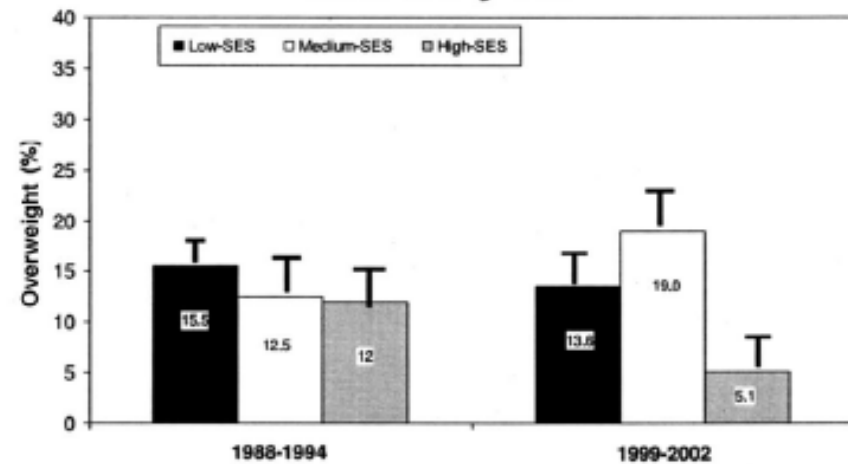


Mexican American

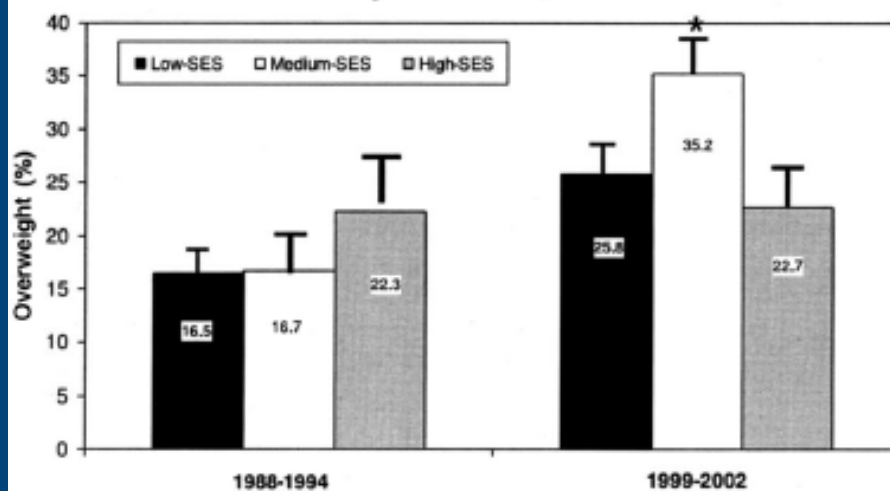
Boys 2-9 y old



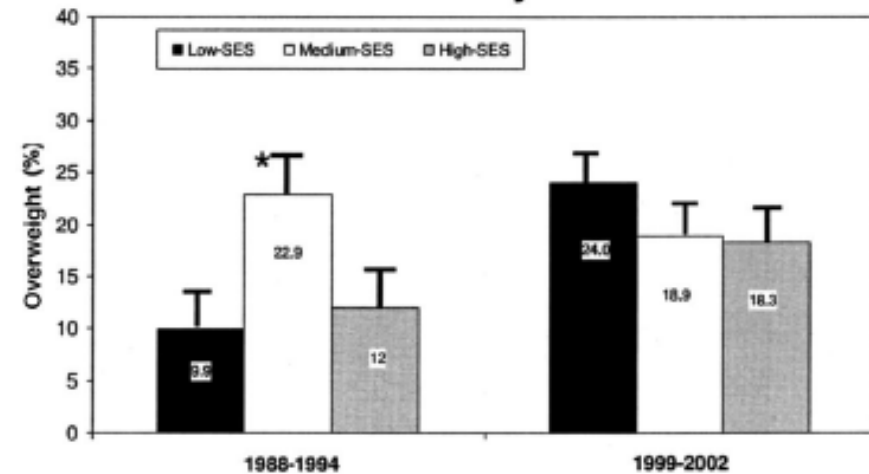
Girls 2-9 y old



Boys 10-18 y old



Girls 10-18 y old



Community, Demographic, Societal: SES

- Proyecto Mariposa, 5-year-old children, migrant communities in Mexico
- Recruited from Oportunidades

	OR	95% CI
SES		
Low	Ref	
Middle	2.0	(0.8, 4.9)
High	3.1	(1.3, 7.5)

- Adjusted for maternal weight status, sex, food insecurity

Community, Demographic, Societal: Race/ethnicity

- Mexican-American at increased risk

Table 6. Logistic Regression of Overweight in Children and Adolescents and Obesity in Adults*		
	Odds Ratio (95% Confidence Interval)	
	Male	Female
Overweight in Children and Adolescents		
Race/ethnicity		
Non-Hispanic white	1.00	1.00
Mexican American	1.73 (1.42-2.10)	1.56 (1.29-1.88)
Non-Hispanic black	1.13 (0.91-1.40)	1.46 (1.22-1.73)

- Data from NAHANES1999-2004, adjusted for age

Community, Demographic, Societal: Body Image

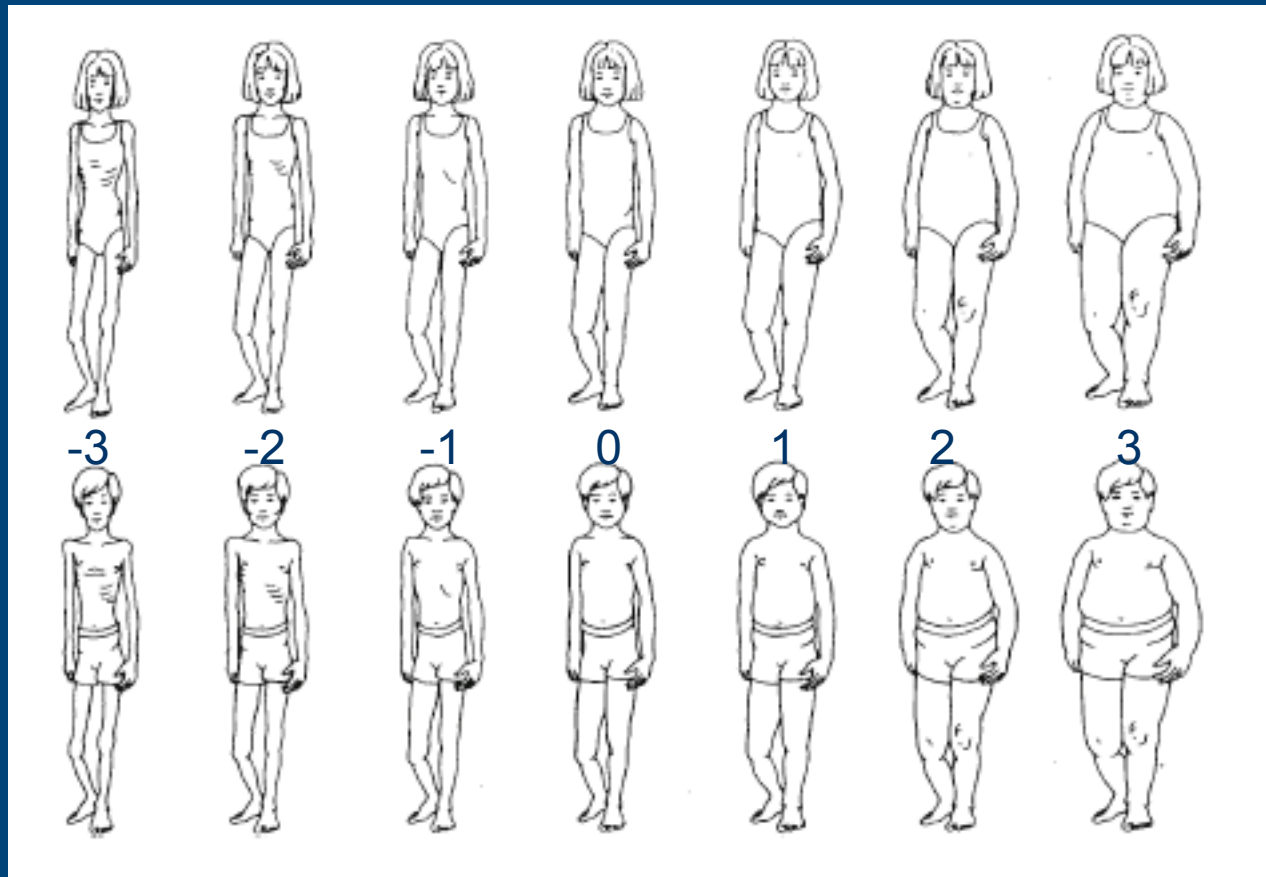


Table 3 Ideal weight z-scores, perceived and actual satisfaction scores for California and Mexico

	California <i>n</i> = 60				Mexico <i>n</i> = 314			
	Ideal weight z-score ^a		Satisfaction score ^c		Ideal weight z-score ^a		Satisfaction score ^c	
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Child weight status (CDC criteria)								
Normal	-0.5	(0.6)	0.7	(1.0)	0.1	(0.7)	0.7	(1.0)
At risk for overweight	-0.2	(1.0)	0.3	(1.2)	-0.1	(0.6)	-0.3	(0.8)
Overweight	0.0	(0.8)	-0.9	(1.1)	0.0	(0.7)	-1.1	(1.0)

- Ideal weight did not differ according to child weight status in CA of MX
- Satisfaction score = ideal-perceived
- Satisfaction score significantly differed by child weight status in both countries



Availability of low-fat milk relative to high-fat milk in a store



Purchases of low-fat milk relative to high-fat milk



Consumption of low-fat milk relative to high-fat milk



Fat content of the diet of store customers



Population-level disease related to fat in the diet

Figure 1. Example of causal model linking an environmental attribute with population-level disease

From: Lytle, 2009 AJPM 36:S134-S144



“High Walkable”
**High density, street connectivity, and
mixed land use**

Slide provided by Abby C. King

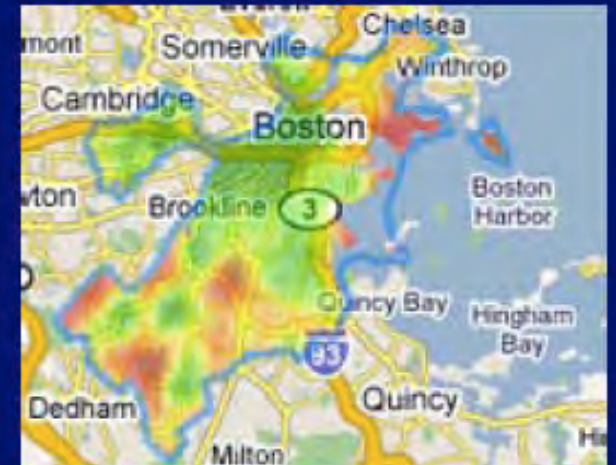


“Lower Walkable”

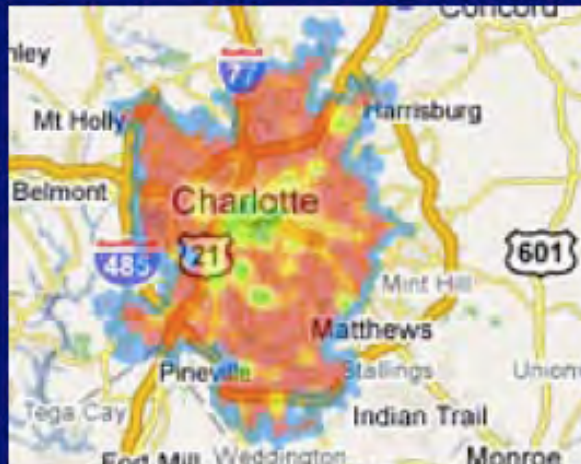
**Not dense, no street connectivity, and
residential only**

Slide provided by Abby C. King

Most “walkable”



Least “walkable”



Community, Demographic, Societal: Food Environment

TABLE 3—Logit and Negative Binomial Models of Association Between a School's Proximity to a Fast-Food Restaurant and Nutritional Intake Measures Among Its Students (N = 529367): California Healthy Kids Survey, 2002–2005

Nutritional Intake Measure	Negative Binomial Model, b (95% CI)	Logit Model, AOR (95% CI)	R ²
Any vegetables yesterday		0.97* (0.93, 1.00)	0.04
No. of vegetable servings yesterday	−0.02** (−0.03, 0.00)		0.06
Any fruit servings yesterday		0.97 (0.93, 1.02)	0.04
No. of fruit servings yesterday	−0.02** (−0.04, 0.00)		0.08
Any juice yesterday		0.97* (0.94, 1.00)	0.02
No. of juice servings yesterday	−0.02*** (−0.03, 0.00)		0.05
Any soda yesterday		1.05** (1.00, 1.11)	0.02
No. of soda servings yesterday	0.02 (−0.01, 0.04)		0.06
Any fried potato servings yesterday		1.01 (0.98, 1.05)	0.02
No. of fried potato servings yesterday	0.00 (−0.02, 0.02)		0.04

- Davis & Carpenter 2009
- California Healthy Kids Survey

Community, Demographic, Societal: Food Environment

TABLE 4—Association Between a School's Proximity to Other Types of Establishments and Weight Status of Students, With Student Smoking Added as a Placebo: California Healthy Kids Survey, 2002–2005

Indicator	BMI, b (95% CI)	Overweight, AOR (95% CI)	Obese, AOR (95% CI)	Smoker, AOR (95% CI)
School near fast-food restaurant	0.13*** (0.05, 0.20)	1.08*** (1.03, 1.13)	1.11*** (1.04, 1.18)	1.04 (0.97, 1.11)
School near gas station	-0.03 (-0.08, 0.03)	0.99 (0.97, 1.02)	0.98 (0.94, 1.01)	0.99 (0.94, 1.04)
School near motel	0.01 (-0.04, 0.06)	0.99 (0.97, 1.02)	0.99 (0.96, 1.03)	1.03 (0.97, 1.08)
School near grocery	-0.04 (-0.09, 0.01)	0.98 (0.95, 1.01)	0.97 (0.94, 1.01)	1.00 (0.96, 1.05)
R^2	0.10	0.08	0.08	0.05

Davis & Carpenter 2009
California Healthy Kids Survey

Early life risk factors for childhood obesity



- Two analyses:
 1. Gestational weight gain and childhood obesity
 2. Pregnancy glucose levels and childhood obesity

Gestational Weight Gain and Childhood Obesity

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Samantha F Ehrlich, MPH

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Barbara Abrams, DrPH

Robert Lustig, MD

Randall Stafford, PhD MD

Brenda Eskenazi, PhD

Background

- Developmental origins hypothesis:
 - exposure to under- or over-nutrition *in utero* may influence the development of obesity in childhood
- Literature suggests an association between gestational weight gain and subsequent adiposity during childhood at various ages
- Majority of studies examined BMI & one study has examined waist circumference (Fraser et al, 2010)
- No studies have focused on Latino or Mexican-American children

Objective

To investigate the association of weight gain during pregnancy with adiposity in children at 7 years in a Mexican-American cohort

Our study builds upon past research by:

1. Investigating the association of gestational weight gain and childhood obesity in a high-risk Mexican-American population
2. Using measured weight during pregnancy and childhood
3. Using two measures of adiposity: BMI and waist circumference

Data source

- CHAMACOS longitudinal birth cohort (n=601)



Data source

- Center for the Assessment of Mothers and Children of Salinas (CHAMACOS) longitudinal birth cohort
 - Primarily low-income women of Mexican descent residing in a farmworker community in Salinas, CA.
- 601 Pregnant women recruited during first half of pregnancy
- Eligible women were ≥ 18 years of age, eligible for California's low-income health insurance program, planning to deliver at the county medical center, and spoke Spanish or English

CHAMACOS



- Salinas Valley, CA
- Mexican immigrants
- Original study design aims
- Continual follow-up since 10/99
- Low loss to follow-up

CHAMACOS Study Population

- 92% Spanish-speaking
- 85% born in Mexico; 54% $\leq$ 5 years in U.S.
- 96% living within 200% of poverty
- 44% 6th grade education or less
- 44% worked in agriculture during pregnancy
- 84% other agricultural workers in home

Sample

526 women delivered a live born, surviving singleton

Exclude:

- Preterm deliveries (n=485)
- Medically recognized cases of diabetes mellitus (n=482)
- Final sample size included mother-child pairs with complete anthropometric data (weight, height, and waist circumference) at 5 and 7 years:
 - 60 months: waist circumference (n=302); BMI (n=301)
 - 84 months: waist circumference (n=308); BMI (n=307)

Gestational Weight Gain (GWG)

Prepregnancy BMI	BMI ⁺ (kg/m ²)	Total Weight Gain (lbs)	Rates of Weight Gain* 2nd and 3rd Trimester (lbs/week)
Underweight	<18.5	28–40	1 (1–1.3)
Normal weight	18.5–24.9	25–35	1 (0.8–1)
Overweight	25.0–29.9	15–25	0.6 (0.5–0.7)
Obese (includes all classes)	≥30.0	11–20	0.5 (0.4–0.6)

- Information was abstracted from medical records
- Modeled GWG continuously as well as categorically according to Institute of Medicine (IOM) 2009 guidelines.



Child Adiposity

- BMI z-scores by comparing with age- and sex-specific BMI percentiles from the 2000 CDC growth charts
- Modeled continuously as well as in categories of weight status (overweight and obese)
- Waist circumference was measured during routine study visits at 5 and 7 years
- Modeled continuously

Statistical analysis

- Linear and logistic regression
- Examined crude associations and adjusted for covariates
 - maternal age, smoking during pregnancy, child sex, maternal diet
- Subsequent models further adjusted for maternal pre-pregnancy BMI (continuous) and dietary intake during pregnancy
- We examined effect modification by maternal pre-pregnancy BMI

Results

- Pre-pregnancy BMI:
 - 40% overweight
 - 19% obesity
- Average GWG = 13.7 kg (SD=5.7)
- IOM GWG recommendations:
 - Less than recommended: 16%
 - Adequate: 23.6%
 - More than recommended: 60.4%

Table 2. Gestational weight gain by various characteristics in the CHAMACOS cohort

	Total gestational weight gain	Gestational weight gain by 2009 IOM recommendations			p-value
	mean SD	Inadequate n (%)	Adequate n (%)	Excessive n (%)	
Age at enrollment					0.40
18-24	14.2 (6.0)	48 (17.3)	57 (20.6)	172 (62.1)	
25-29	13.3 (5.5)	19 (11.9)	47 (29.4)	94 (58.8)	
30-34	12.4 (5.2)	12 (17.1)	19 (27.1)	39 (55.7)	
35-45	11.3 (6.0)	5 (15.2)	7 (21.2)	21 (63.6)	
Mother's years in the US					0.20
<=5	13.8 (5.6)	41 (14.3)	74 (25.8)	172 (59.9)	
6-10 years	12.7 (4.9)	17 (16.2)	26 (24.8)	62 (59.1)	
11+	11.8 (6.2)	13 (18.3)	19 (26.8)	39 (54.9)	
Entire life	15.4 (6.4)	7 (13.5)	5 (9.6)	40 (76.9)	
Mother's prepregnancy BMI category					0.00
Underweight	20.6 (2.5)			4 (100.0)	
Normal	15.5 (5.1)	42 (21.8)	60 (31.1)	91 (47.2)	
Overweigh	12.8 (5.6)	29 (14.6)	50 (25.1)	120 (60.3)	
Obese	10.9 (5.9)	12 (11.4)	19 (18.1)	74 (70.5)	
Smoking during pregnancy (any)					0.62
No	13.3 (5.7)	79 (15.6)	124 (24.5)	303 (59.9)	
Yes	15.6 (6.6)	5 (14.7)	6 (17.7)	23 (67.7)	
Delivery					0.11
Vaginal	13.3 (5.7)	70 (18.9)	104 (28.0)	197 (53.1)	
cesarean	14.0 (5.9)	14 (12.6)	26 (23.4)	71 (64.0)	
Sex					0.10
Boy	14.0 (6.0)	36 (14.9)	60 (24.8)	146 (60.3)	
Girl	12.9 (5.6)	48 (20.0)	70 (29.2)	122 (50.8)	
Birthweight for gestational age percentile					0.02
small (< 10th)	11.2 (6.6)	10 (34.5)	7 (24.1)	12 (41.4)	
Appropriate (10th-90th)	13.4 (5.6)	70 (15.3)	109 (23.8)	279 (60.9)	
Large (<90th)	15.0 (6.7)	4 (7.4)	14 (25.9)	36 (66.7)	
Duration of breastfeeding					0.02
<1 month	14.6 (6.0)	15 (14.7)	24 (23.5)	63 (61.8)	
1-6 months	13.8 (5.9)	30 (17.0)	36 (20.3)	111 (62.7)	
7-12 months	12.8 (5.9)	17 (18.7)	34 (37.4)	40 (44.0)	
>12 months	12.3 (5.2)	22 (12.9)	36 (21.1)	113 (66.1)	

Association of gestational weight gain with child BMI z-score

- Gestational weight gain was **not** associated with child BMI z-score or child weight status at 5 years or 7 years with one exception:
 - $\beta = 0.05$ (p-value 0.05) for gestational weight gain (5 lbs) and child BMI z-score controlling for child sex, maternal age at delivery, and smoking during pregnancy
 - This association was attenuated and no longer significant when adding maternal soda consumption during pregnancy to the model

Association of gestational weight gain and child waist circumference

Table 3. Crude and adjusted β coefficients from linear regression models estimating the association between gestational weight gain and child waist circumference in the CHAMACOS cohort

	Model 1		Model 2		Model 3		Model 4	
60 month waist circumference (cm)	β (SE)	p-value	β (SE)	p-value	β (SE)	p-value	β (SE)	p-value
Gestational weight gain (5lbs)	0.11 (0.19)	0.55	0.21 (0.19)	0.27	0.45 (0.19)	0.02	0.43 (0.19)	0.03
Child sex (girl)			1.87 (0.88)	0.03	1.71 (0.86)	0.05	1.82 (0.87)	0.04
Maternal age at delivery			0.17 (0.09)	0.04	0.09 (0.09)	0.31	0.10 (0.09)	0.27
Any smoking during pregnancy (yes)			2.82 (2.25)	0.21	1.88 (0.19)	0.39	2.45 (2.42)	0.31
Pre-preg BMI					0.39 (0.86)	<0.01	0.36 (0.10)	<0.01
Weekly soda consumption during pregnancy							0.02 (0.19)	0.91
84 month waist circumference (cm)								
Gestational weight gain (5lbs)	0.05 (0.23)	0.81	0.12 (0.23)	0.62	0.50 (0.23)	0.03	0.47 (0.23)	0.04
Child sex (girl)			0.84 (1.10)	0.45	0.58 (1.04)	0.57	0.72 (1.06)	0.49
Maternal age at delivery			0.19 (0.11)	0.08	0.05 (0.10)	0.62	0.07 (0.10)	0.51
Any smoking during pregnancy (yes)			3.42 (2.84)	0.23	1.35 (2.71)	0.62	1.86 (2.99)	0.53
Pre-preg BMI					0.67 (0.11)	<0.01	0.63 (0.12)	<0.01
Weekly soda consumption during pregnancy							0.08 (0.24)	0.73

Association of gestational weight gain and child waist circumference stratified by pre-pregnancy weight status

Table 4. Full model stratified by mother's pre-pregnancy weight status

	Normal		Overweight/Obese	
	β (SE)	p-value	β (SE)	p-value
60 month waist circumference				
Gestational weight gain (5lbs)	-0.06 (0.32)	0.85	0.60 (0.24)	0.01
Child sex (girl)	3.25 (1.31)	0.02	1.01 (1.14)	0.38
Maternal age at delivery	-0.07 (0.15)	0.65	0.16 (0.11)	0.15
Any smoking during pregnancy (yes)	-0.53 (3.95)	0.89	3.66 (3.09)	0.24
Pre-preg BMI	0.18 (0.38)	0.63	0.37 (0.14)	0.01
Weekly soda consumption during pregnancy	-0.12 (0.31)	0.69	0.10 (0.25)	0.69
84 month waist circumference				
Gestational weight gain (5lbs)	0.21 (0.37)	0.58	0.59 (0.30)	0.05
Child sex (girl)	0.64 (1.63)	0.70	0.56 (1.39)	0.69
Maternal age at delivery	-0.06 (0.18)	0.74	0.11 (0.13)	0.39
Any smoking during pregnancy (yes)	-0.09 (5.04)	0.99	3.08 (3.80)	0.42
Pre-preg BMI	0.82 (0.48)	0.09	0.52 (0.17)	0.01
Weekly soda consumption during pregnancy	-0.11 (0.39)	0.78	0.16 (0.31)	0.60

Association of gestational weight gain with child waist circumference:

- Gestational weight gain was significantly associated with child waist circumference at 5 and 7 years
- Interaction between pre-pregnancy BMI and gestational weight gain was detected in the model for 5 years ($p=0.2$)
- When stratified by mother's pre-pregnancy weight status, gestational weight gain was significantly associated with child waist circumference among those whose mothers were overweight or obese but not among those who were normal weight (**Table 4**)

Conclusions

- Increase in gestational weight gain was associated with an increase in waist circumference in offspring at 5 and 7 years in a Mexican-American cohort controlling for important confounders
- Association was stronger among children whose mothers were overweight or obese prior to pregnancy than among children whose mothers were normal weight prior to pregnancy

Conclusions

- Consistent with past studies, although the majority of these studies found an association with child BMI while ours did not
- Pre-natal period may offer an opportunity for childhood obesity prevention through control of gestational weight gain

Possible Mechanisms

- Tracking in weight across the lifecourse
- Genetic inheritance of weight gain
- Shared environment (diet and physical activity) that promotes weight gain
- Fetal programming as a result of exposure to overnutrition *in utero*

Limitations

- **Loss to follow-up:** As this is a longitudinal birth cohort in a low-income farmworker population, there is significant loss to follow-up from birth to 7 years
- **Small sample size:** We had limited power to detect an association between gestational weight gain and childhood obesity.

Glucose level during pregnancy and childhood obesity

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Objective

- To estimate, among Mexican-American women without diabetes or gestational diabetes, the association between pregnancy glucose &:
 - BMI z-score
 - BMI z-score trajectory



2, 3.5, 5 and 7 years

Background

- Intrauterine environment may influence later development and morbidity
- Gestational diabetes has been associated with childhood obesity
- Less clear whether elevated pregnancy glucose values that are below the diagnostic levels for GDM also have an effect on offspring obesity
- Rarely studied in high-risk Mexican population

Data source

- CHAMACOS longitudinal birth cohort (n=601)



Sample

- 485 full term liveborn singleton
- Excluded
 - 12 women with DM & 29 cases of GDM
 - 113 woman whose screening tests were not performed within the recommended window
- Final sample: 266 with weight and height at 2, 3.5, 5 or 7 years

Glucose levels

- Plasma glucose was measured at the end of the second trimester in conjunction with routine prenatal care
- Measurements of plasma glucose were abstracted from the medical record by a registered nurse

Outcome: BMI z-score

- BMI Z-scores were calculated from sex-specific, BMI-for-age data issued by the Centers for Disease Control and Prevention (CDC) in 2000

Statistical analysis

- Multiple linear regression to estimate the association between pregnancy glucose level and offspring BMI z-score at 2, 3.5, 5 and 7 years
- Linear mixed effects (LME) models to estimate the association between pregnancy glucose and BMI z-score velocity over time

Statistical analysis

- Separate LME models for obese and non-obese women
- Akaike information criterion (AIC) for goodness of model fit, facilitated model selection
- Locally weighted scatterplot smoothing (LOEWESS) was used to graphically display BMI z-score trajectories by glucose tertile

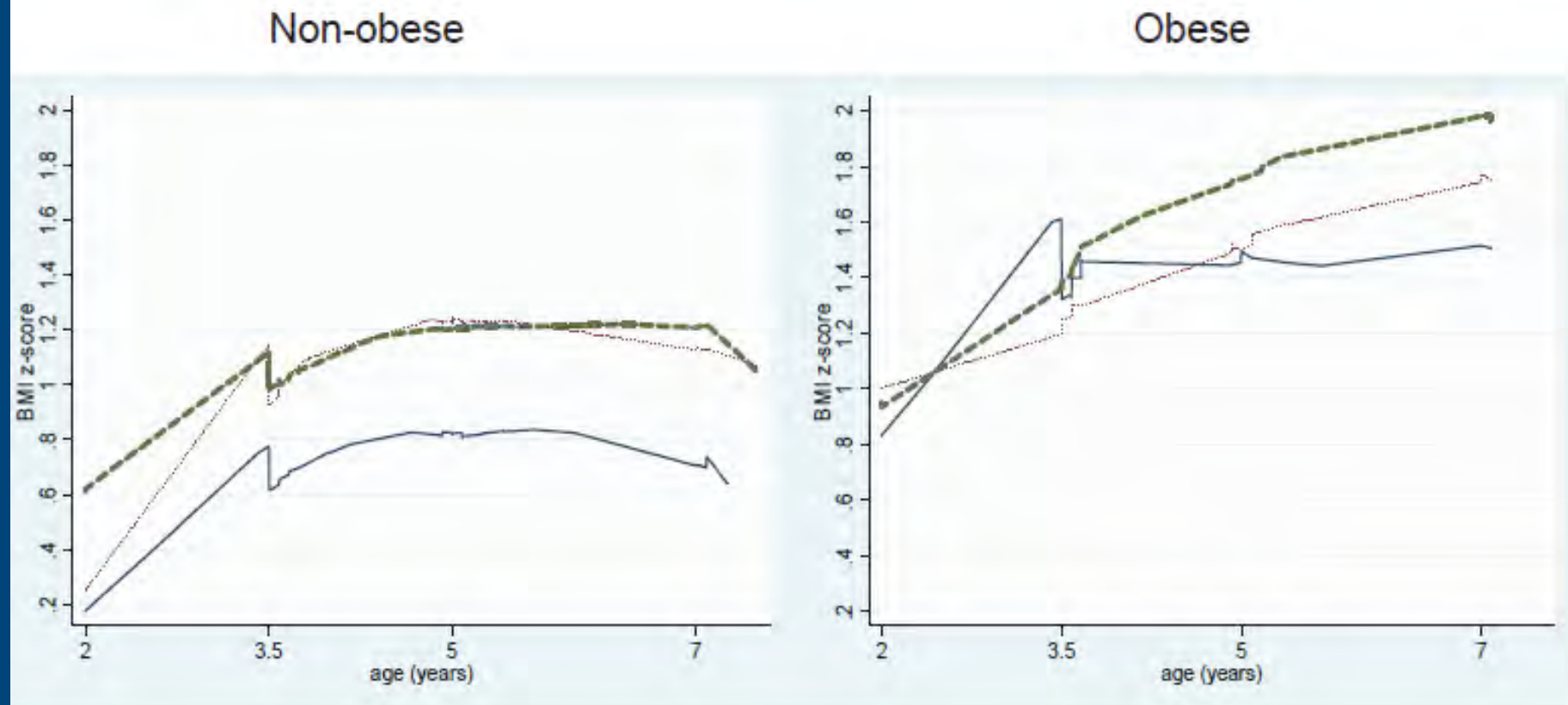
Results

- Pregnancy glucose values significantly predicted offspring BMI z-score at 7 years of age independently of pre-pregnancy obesity
- No association between pregnancy glycemia and BMI z-score at younger ages was observed.

Table 2. Linear regression coefficients, standard errors and p-values for the association between pregnancy glucose and pre-pregnancy obesity ($\geq 30 \text{ kg/m}^2$) with offspring BMI z-score at 2 years, 3.5 years, 5 years and 7 years of age

	Unadjusted n= 236	Adjusted* n= 232
2 years		
Glucose β (SE)	0.080 (0.047)	0.078 (0.047)
<i>p</i> -value	0.09	0.10
Pre-pregnancy obesity β (SE)	-	0.35 (0.18)
<i>p</i> -value		0.06
3.5 years	n= 203	n= 202
Glucose β (SE)	0.050 (0.049)	0.064 (0.051)
<i>p</i> -value	0.30	0.21
Pre-pregnancy obesity β (SE)	-	0.30 (0.20)
<i>p</i> -value		0.14
5 years	n= 206	n= 204
Glucose β (SE)	0.086 (0.047)	0.087 (0.049)
<i>p</i> -value	0.07	0.08
Pre-pregnancy obesity β (SE)	-	0.43 (0.19)
<i>p</i> -value		0.02
7 years	n= 217	n= 214
Glucose β (SE)	0.13 (0.046)	0.12 (0.045)
<i>p</i> -value	<0.01	<0.01
Pre-pregnancy obesity β (SE)	-	0.59 (0.17)
<i>p</i> -value		<0.01

Figure 1. Smoothed scatter plots of offspring BMI z-score trajectory from 2 to 7 years of age for non-obese (BMI < 30 kg/m²) and obese (BMI ≥ 30 kg/m²) women, by pregnancy glucose tertile.



Solid line (blue) is lowest tertile of pregnancy glucose:
2.9-4.9 mmol/L
Dotted line (red) is middle tertile of pregnancy glucose:
5.0-6.3 mmol/L
Dashed line (green) is upper tertile of pregnancy glucose:
6.4-10.1 mmol/L

Solid line (blue) is lowest tertile of pregnancy glucose:
3.3-5.3 mmol/L
Dotted line (red) is middle tertile of pregnancy glucose:
5.4-6.4 mmol/L
Dashed line (green) is upper tertile of pregnancy glucose:
6.8-9.8 mmol/L

Ehrlich, SF et al submitted

Conclusions

- In this population of Mexican-American women without DM or GDM, we found a significant association between increasing pregnancy plasma glucose values, assessed during a single 50-g oral glucose challenge test in mid-pregnancy, and increasing offspring BMI z-score at 7 years of age

Conclusions

- Women with mildly high pregnancy glucose levels who are free of overt disease may have children with increased body mass as a result of similar mechanisms to those hypothesized for the offspring of women with DM and GDM.

Limitations

- No data on physical activity during pregnancy
- Pre-pregnancy weight was self-reported
 - Pre-pregnancy weight was most likely underreported
 - Estimates may have been underestimated
- Sample size insufficient for linear regression analyses to be stratified by pre-pregnancy obesity at each time point

Implications

- Obesity prevention efforts targeting children of Mexican descent may begin *in utero* or prior to pregnancy
- Lifestyle interventions aimed at improving pregnancy glucose levels and reducing maternal obesity prior to pregnancy could potentially be effective in reducing offspring adiposity in late childhood

