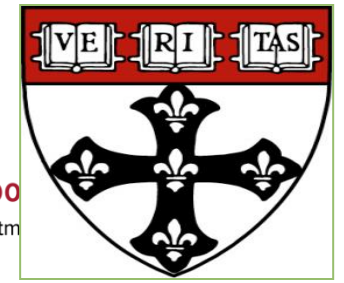
Epidemiology of Adult and Pediatric Obesity

Frank Hu, MD, PhD
Professor and Chair
Dept. of Nutrition
Harvard School of Public Health
Professor of Medicine
Harvard Medical School



Outline

- Assessment of obesity: Anthropometry and imaging methods
- Adult and pediatric obesity time trends and epidemiologic characteristics
- Obesity-related health risks
- Genetic, environmental, and behavioral determinants of obesity
- Treatment options for obesity

Body mass index (person's weight in kilograms divided by the square of height in meters)

- Uncorrelated with height
- Highly correlated with:
  - FM and % body fat
  - Adipocyte-secreted hormones
- Correlated with health risks

HARVARD T.H. CHAN
SCHOOL OF PUBLIC HEALTH
Department of Nutrition

What is Obesity? (Adults)

	Body Mass Index (BMI) (kg/m^2)
Underweight	< 18.5
Normal range	18.5 – 24.9
Overweight	25 – 29.9
Obese	≥ 30
Severe Obesity	≥ 40

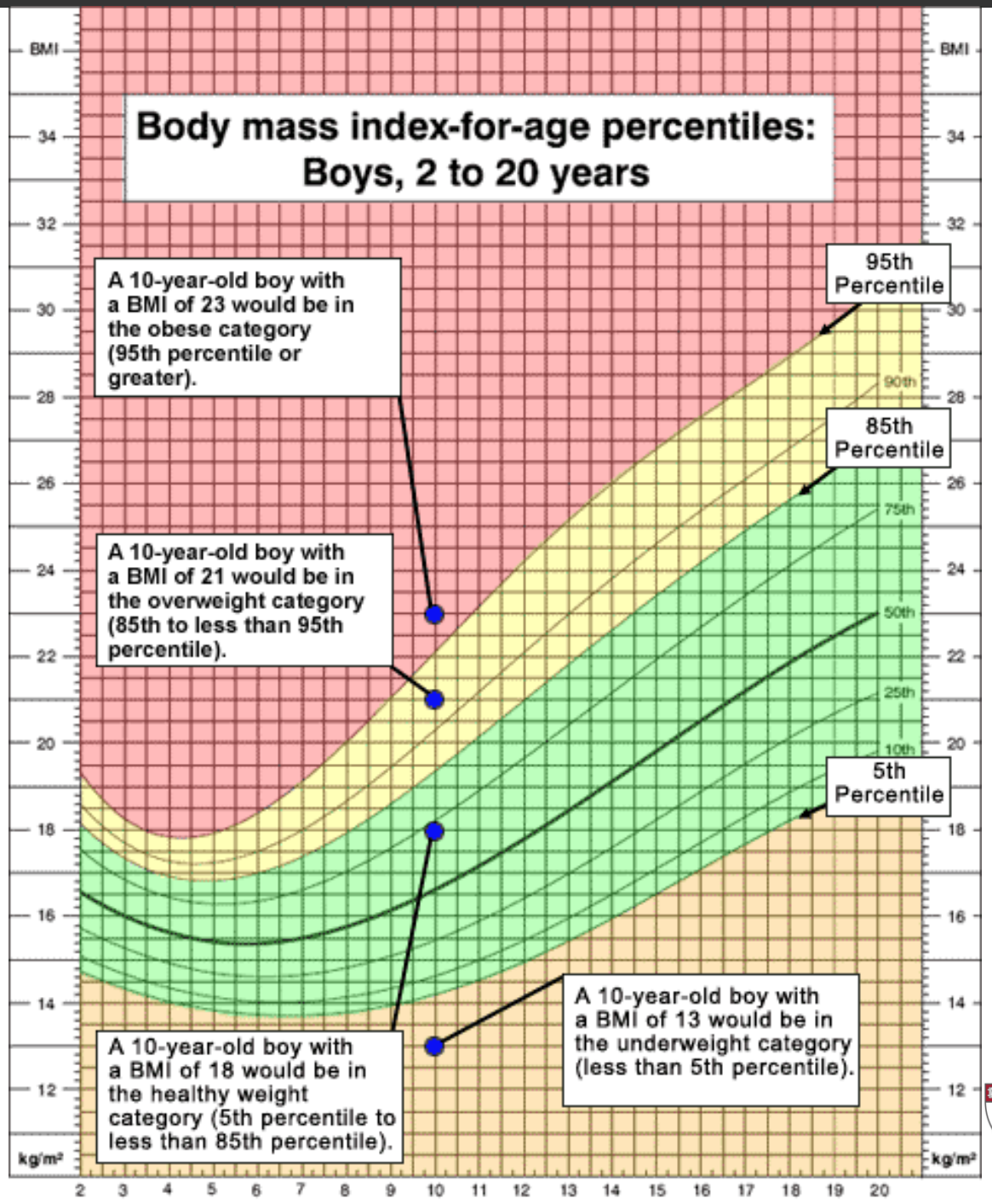
World Health Organization 1995

What is Obesity? (Children)

	BMI-for-age percentile
Underweight	< 5th percentile
Healthy weight	5th - <85th percentile
Overweight *	≥ 85th and < 95th percentile
Obesity *	≥ 95th percentile
Severe Obesity	≥ 120% of 95th percentile

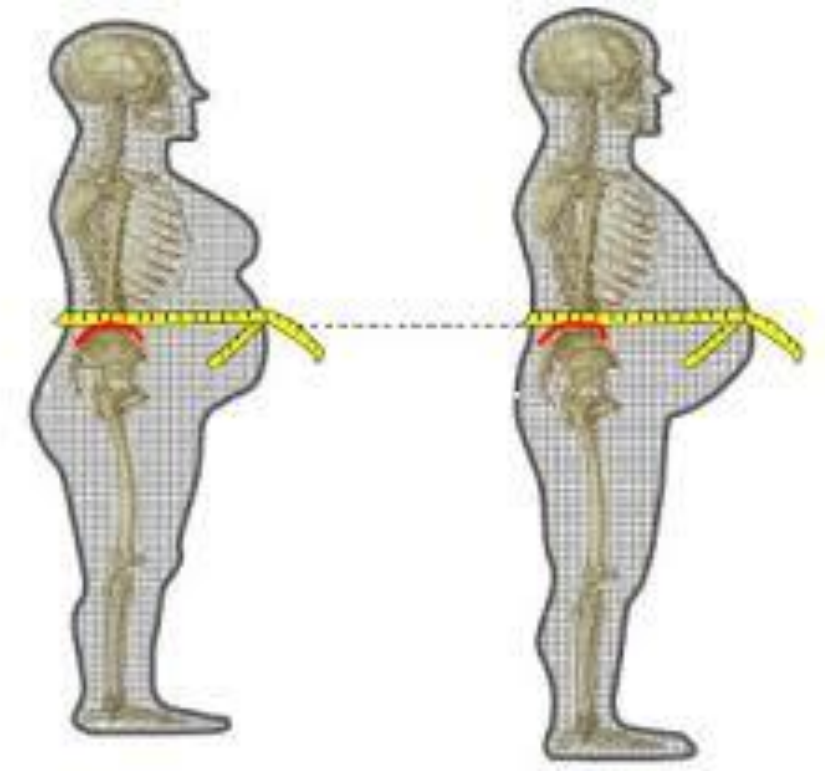
Barlow SE and Expert Committee. Pediatrics 2007

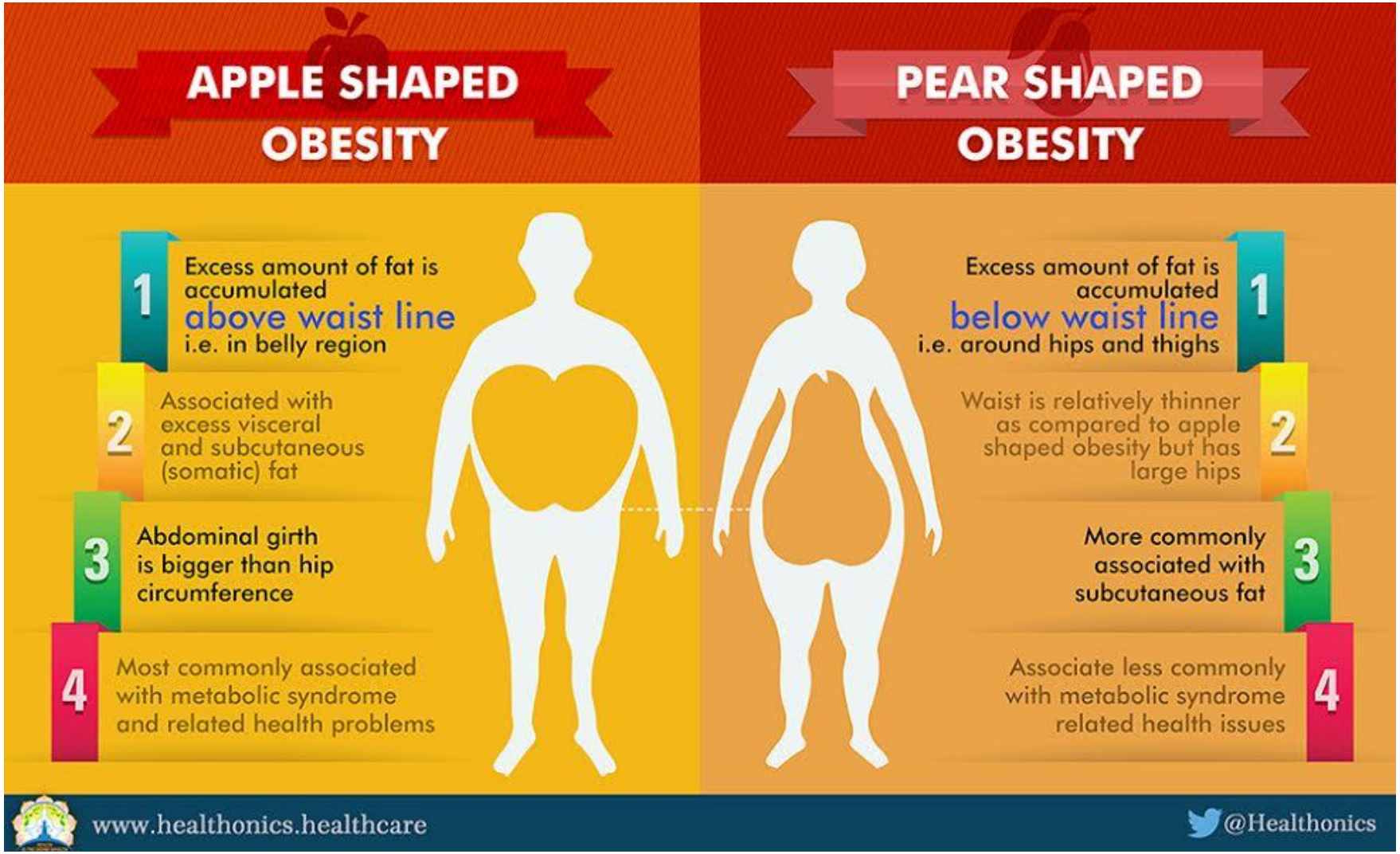
Children's body composition varies as they age and varies between boys and girls. Therefore, BMI levels among children and teens are expressed relative to other children of the same age and sex- -CDC.


Body mass index-for-age percentiles:
Boys, 2 to 20 years
BMI
kg/m²
95th Percentile
90th
85th Percentile
75th
50th
25th
10th
5th Percentile
A 10-year-old boy with a BMI of 23 would be in the obese category (95th percentile or greater).
A 10-year-old boy with a BMI of 21 would be in the overweight category (85th to less than 95th percentile).
A 10-year-old boy with a BMI of 18 would be in the healthy weight category (5th percentile to less than 85th percentile).
A 10-year-old boy with a BMI of 13 would be in the underweight category (less than 5th percentile).

Abdominal obesity

- One limitation of BMI is that it does not assess fat distribution.
- Abdominal obesity is metabolically important.
- The simplest and most often used measure of abdominal obesity is waist size.
- Abdominal obesity is defined as a waist size of 35 inches or higher in women and a waist size of 40 inches or higher in men in the US.



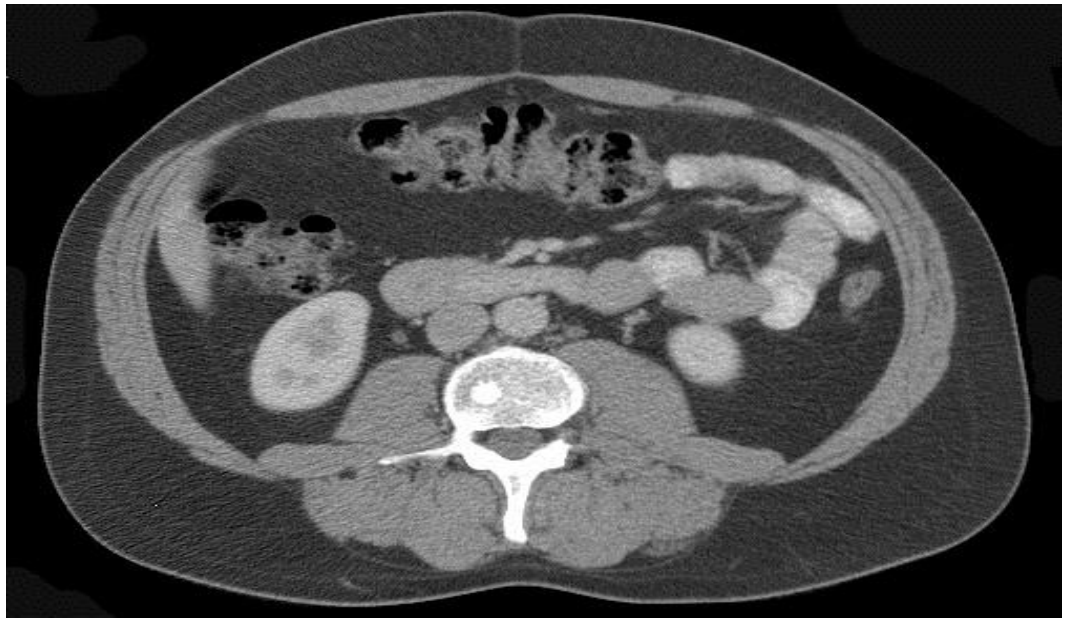

APPLE SHAPED OBESITY
PEAR SHAPED OBESITY
1
Excess amount of fat is accumulated above waist line i.e. in belly region
2
Associated with excess visceral and subcutaneous (somatic) fat
3
Abdominal girth is bigger than hip circumference
4
Most commonly associated with metabolic syndrome and related health problems
Excess amount of fat is accumulated below waist line i.e. around hips and thighs
1
Waist is relatively thinner as compared to apple shaped obesity but has large hips
2
More commonly associated with subcutaneous fat
3
Associate less commonly with metabolic syndrome related health issues
4
www.healthonics.healthcare
@Healthonics

DEXA (Dual-energy X-ray absorptiometry)

- Accurate estimates of FM, FFM and BMD
- Allows body composition analysis of specific body regions
- High correlations with reference methods (densitometry/CT)
- Minimal radiation: safe for children
- Does not accommodate severely obese
- Expensive, immobile equipment

Imaging (CT and MRI)

- Current "Gold Standard": most accurate methods for total fat, fat distribution, and fat depot
- Cross-section of tissues allows:
  - Differentiation of subcutaneous and intra-abdominal fat
  - Estimation of fat content of solid organs (e.g. liver)
  - Direct measurement of muscle mass
- MRI suitable for children and pregnant women
- Expensive and not widely available, but optimal for validation of other methods



Bioelectric Impedance Analysis (BIA)

- FFM conducts electricity better than FM
- Estimate of total body fat using prediction equations
- Low cost, portable, simple to operate, low risk
- Overestimates %fat in lean; underestimates in obese
- Not superior to anthropometry predicting CVD risk factors

Surveillance systems in the US

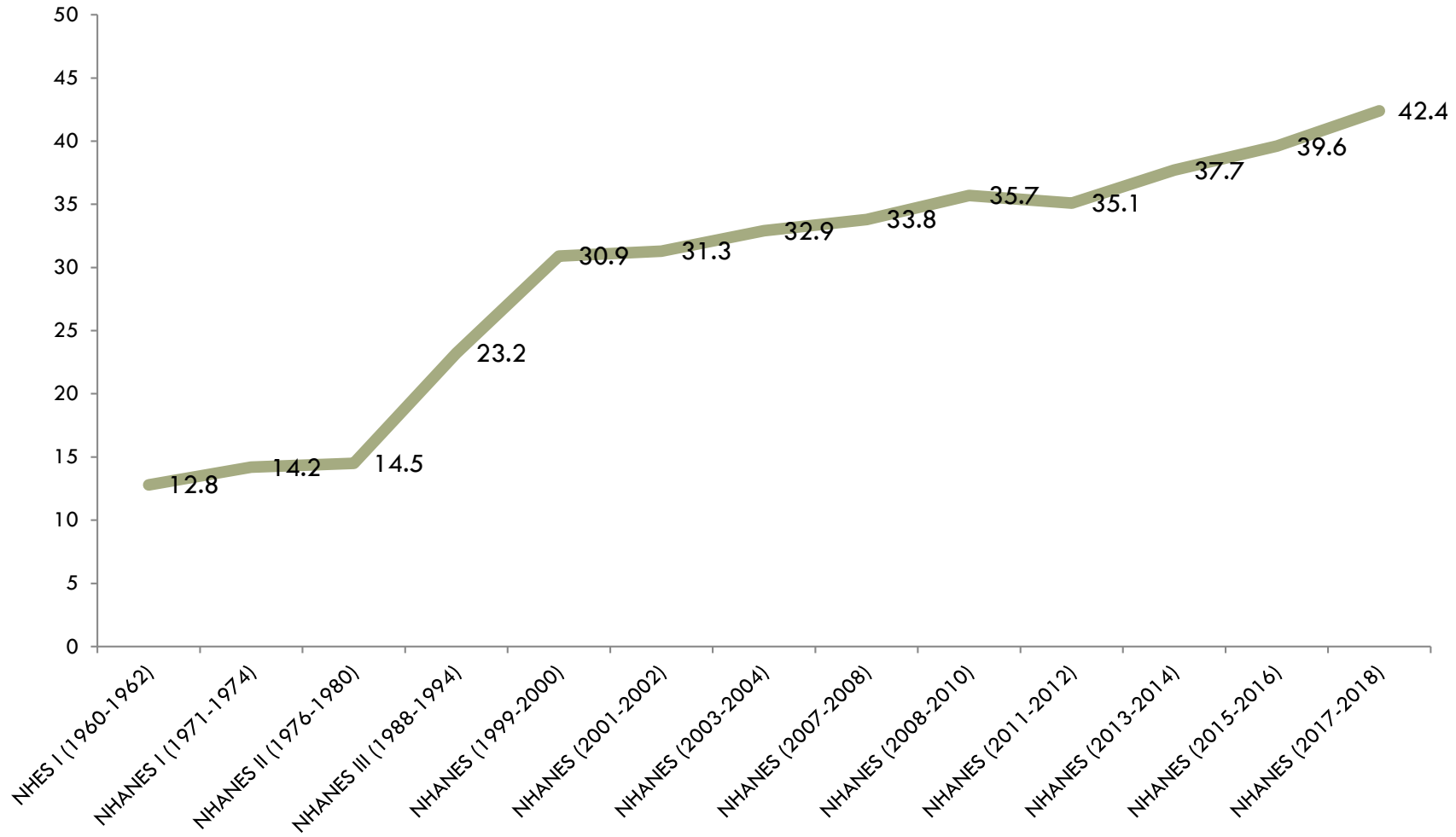
NHANES

- Cross-sectional
- Nationally representative
- In-person interview and physical exam
- Continuous since 1999

BRFSS

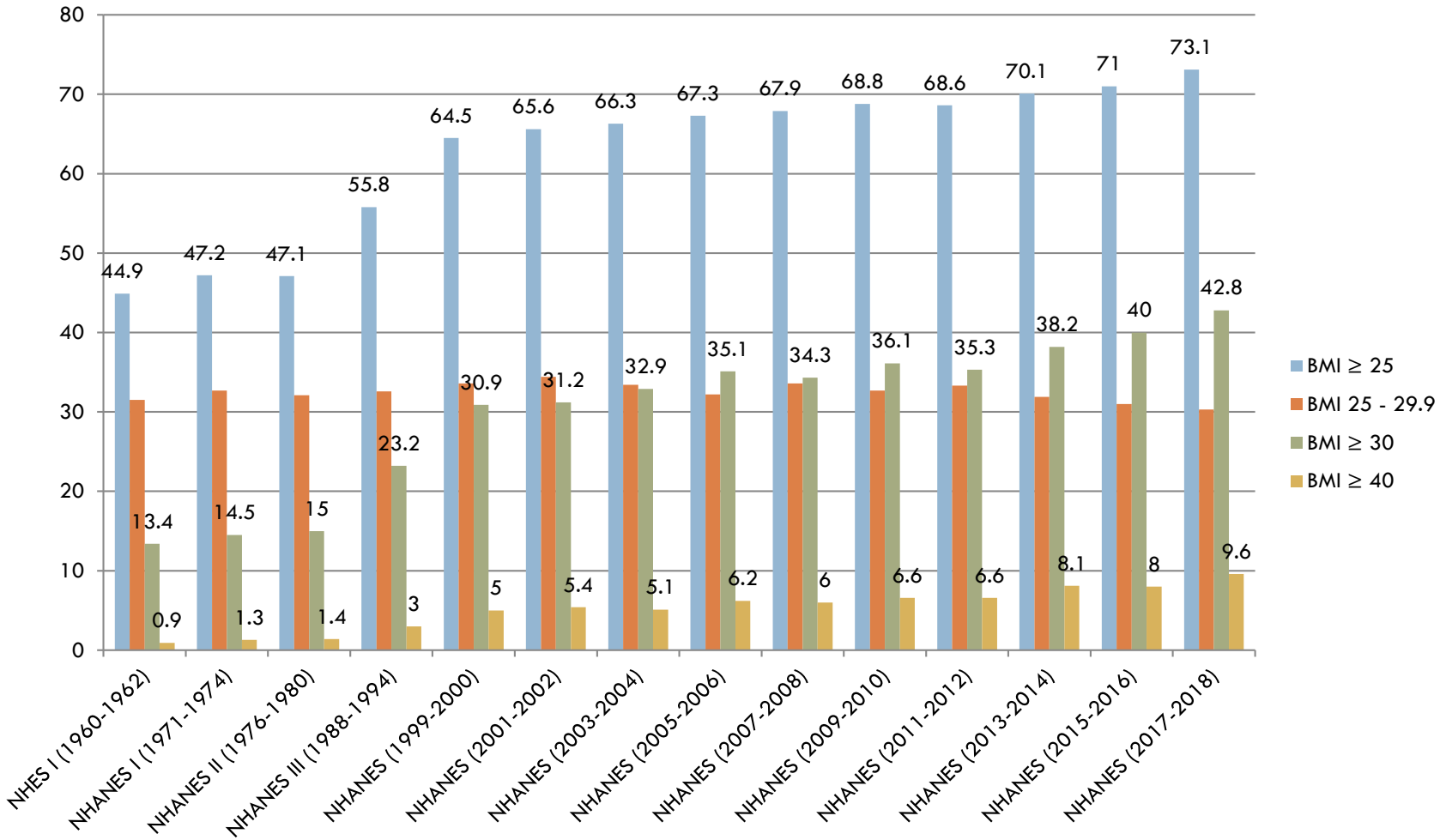
- Cross-sectional
- State based (representative)
- Telephone survey of adults (cell phones since 2011)
- All states and D.C. participate since 1994

Trends in adult obesity NHANES



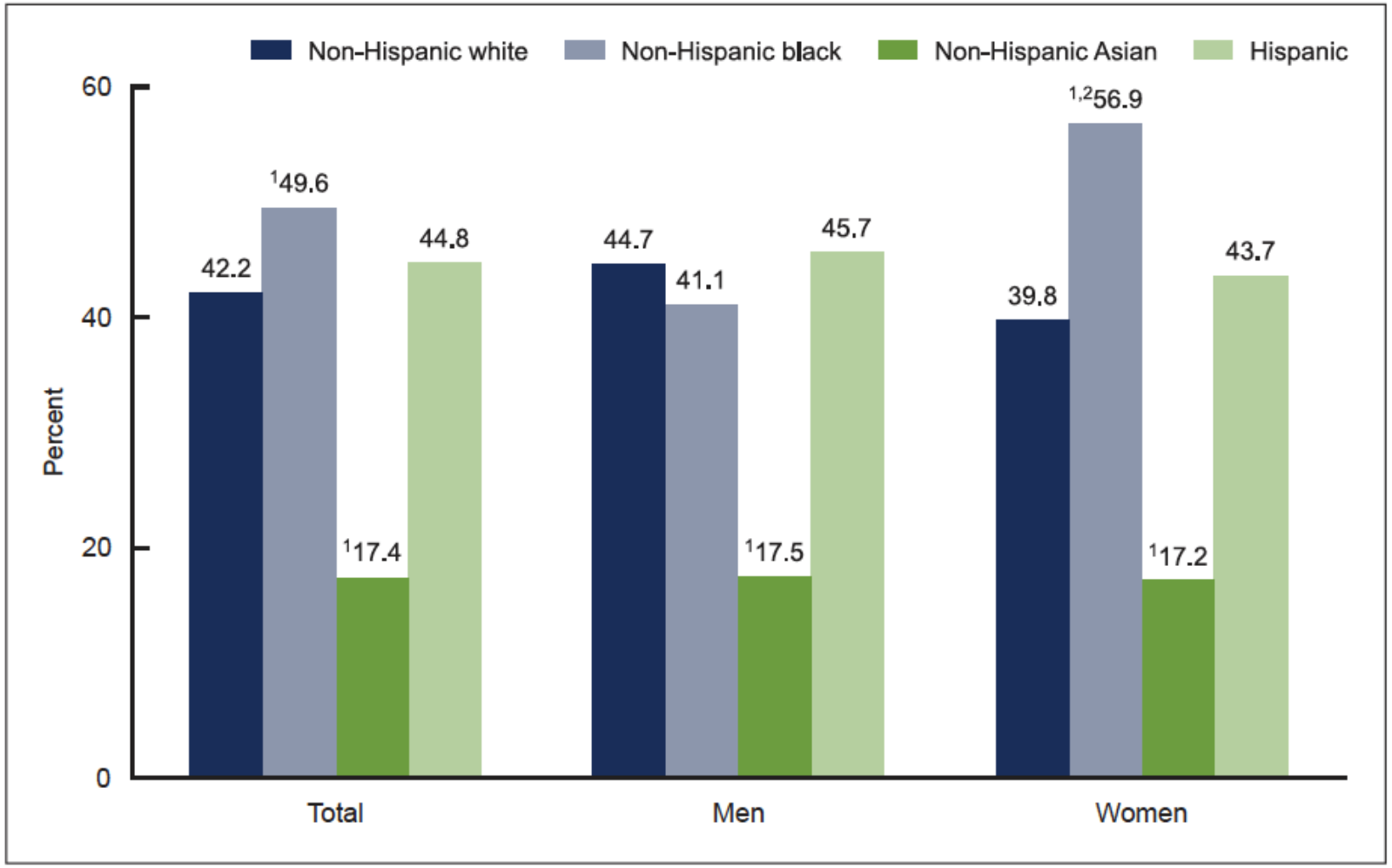
Flegal, Ogden IJO 1998, JAMA 2006, 2010, 2012, 2014, 2016, 2018, NCHS 2020

Age-adjusted trends in adult obesity



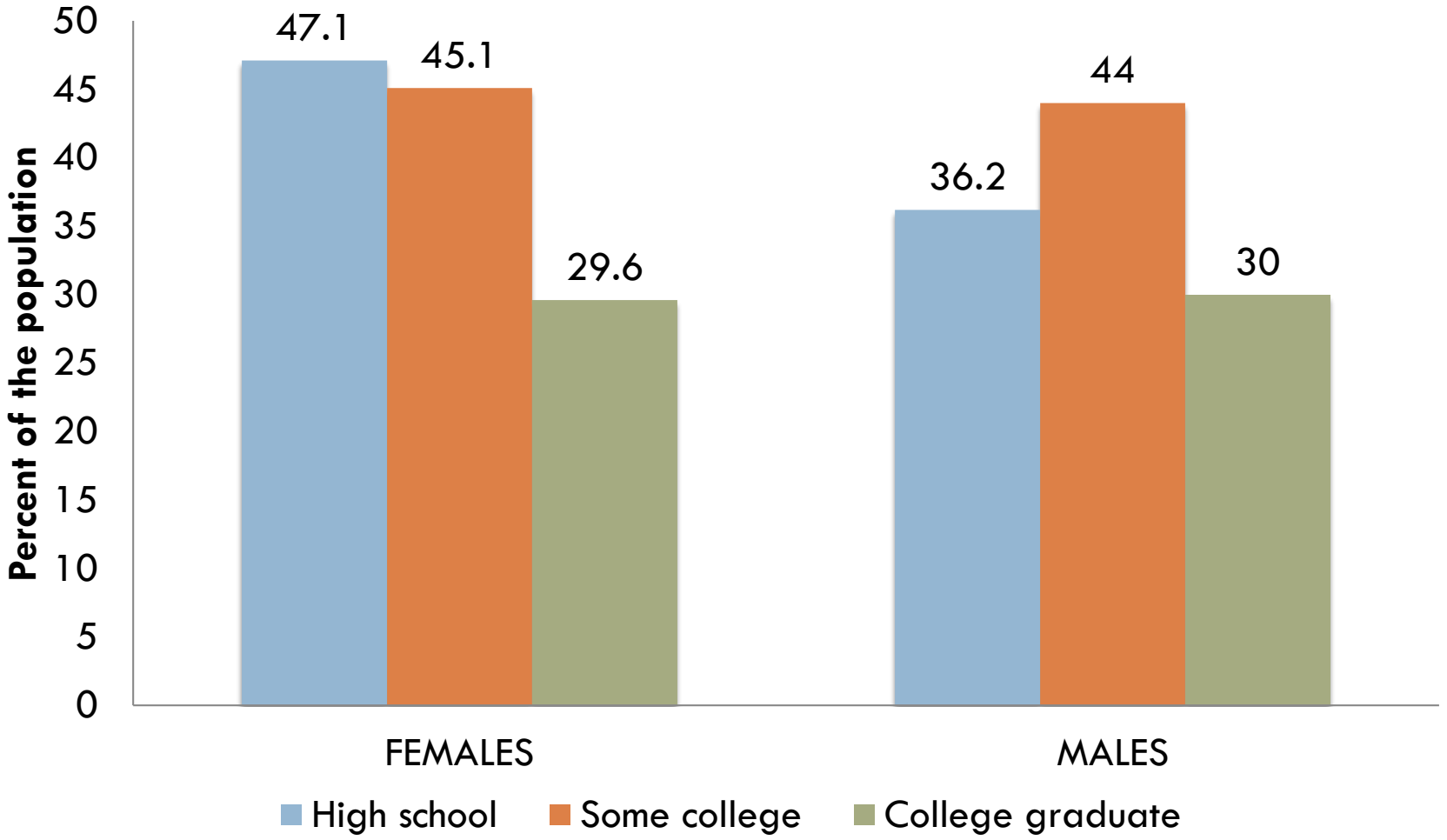
Fryar et al. NCHS Health E-Stats 2020

Obesity by sex and race/ethnicity



Hales et al. NCHS Data Brief No. 360. Feb 2020

Obesity by sex and education

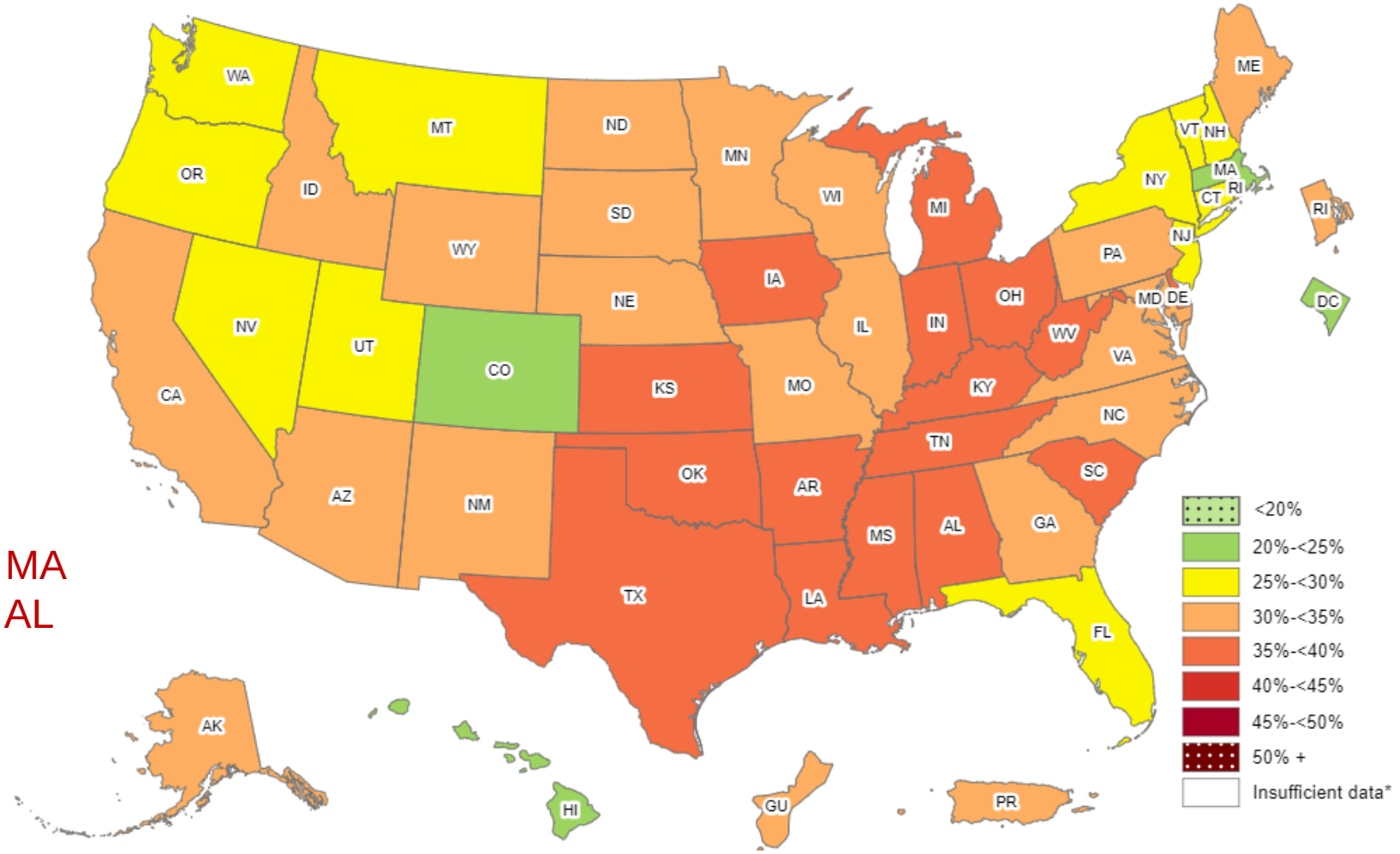


Hales et al. JAMA 2018

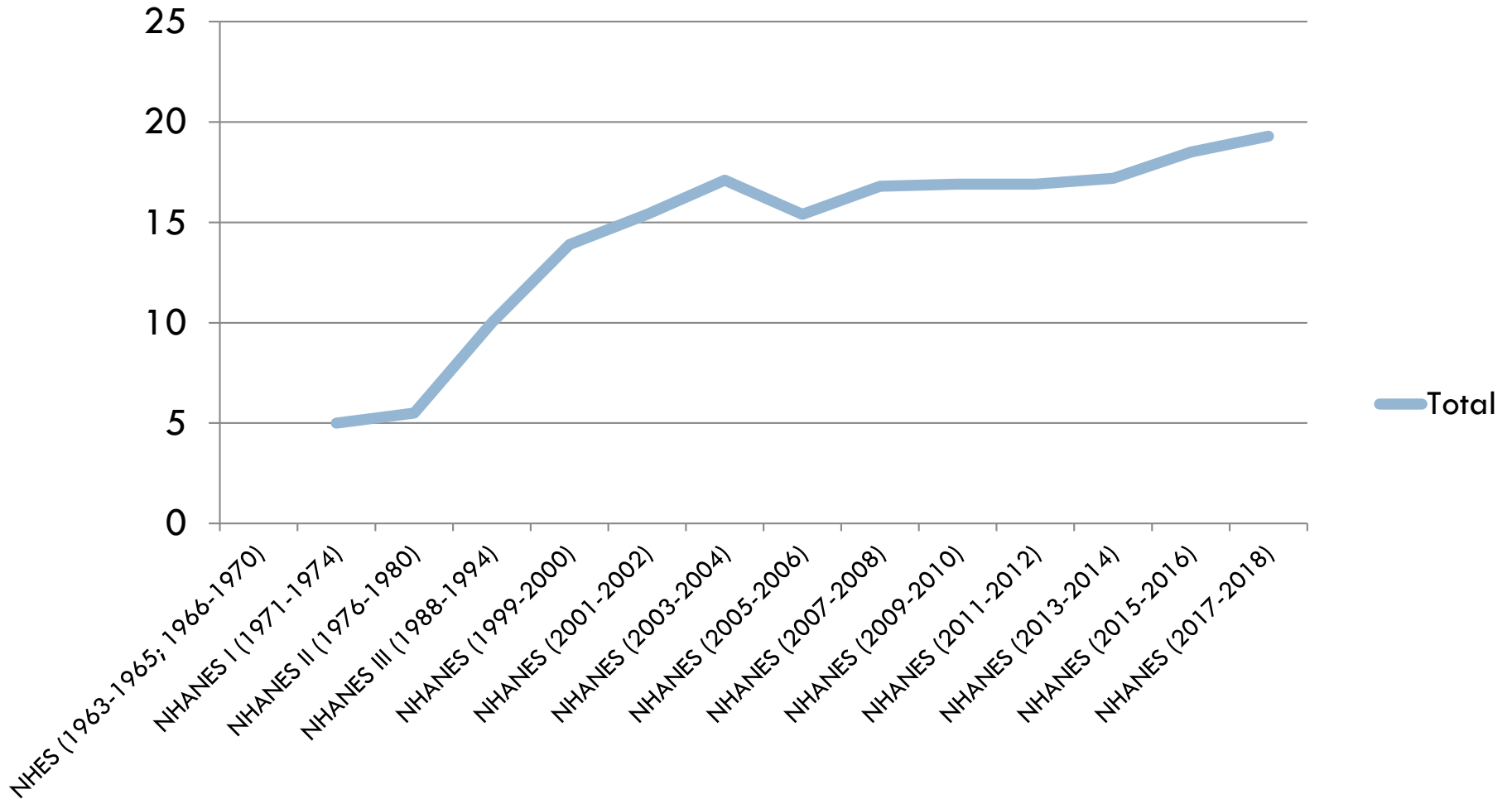
Obesity Trends* Among U.S. Adults

BRFSS, 2020

9 States > 35%
Lowest : CO, DC, MA
Highest: MS, WV, AL

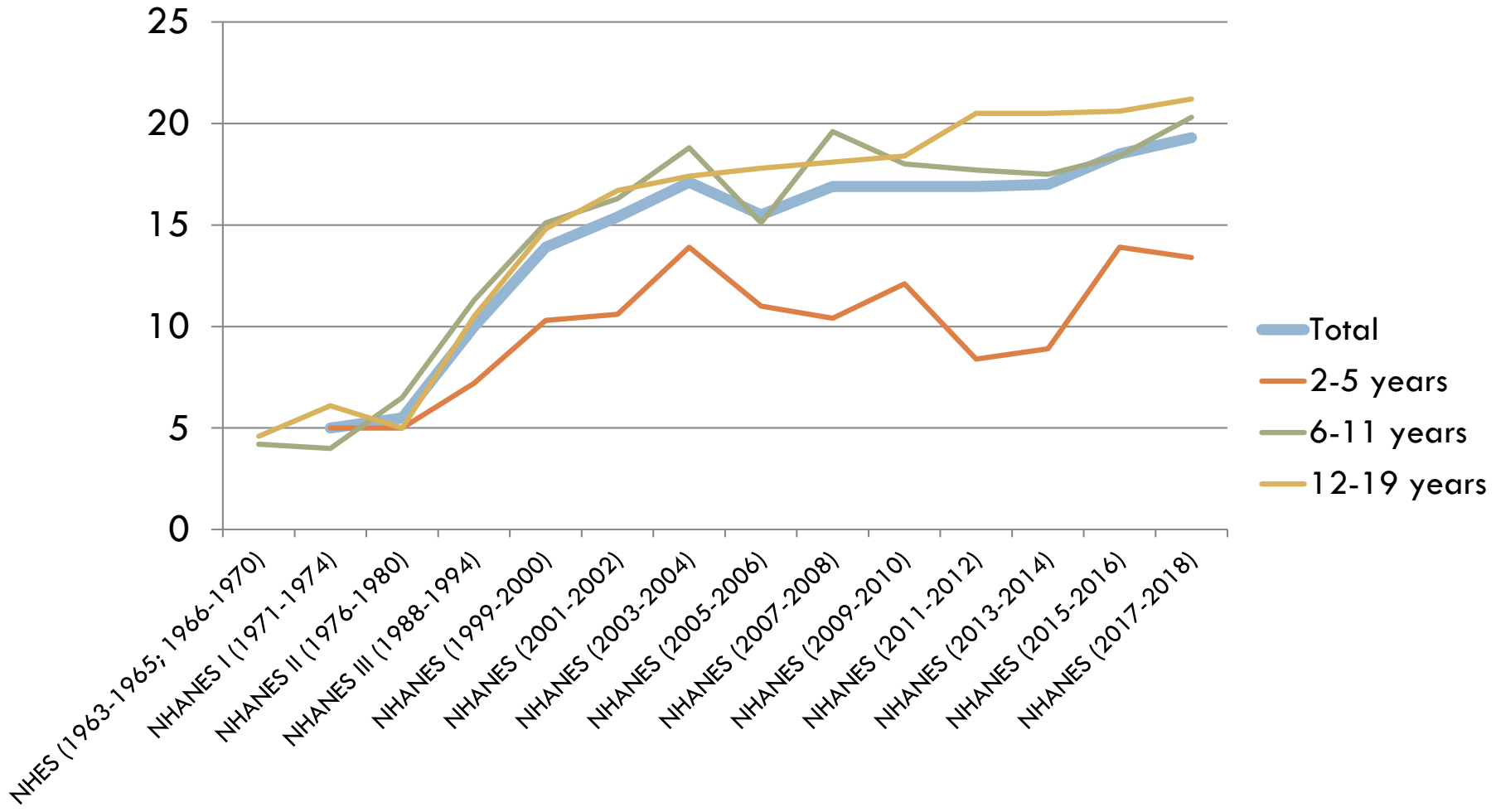


Childhood obesity trends



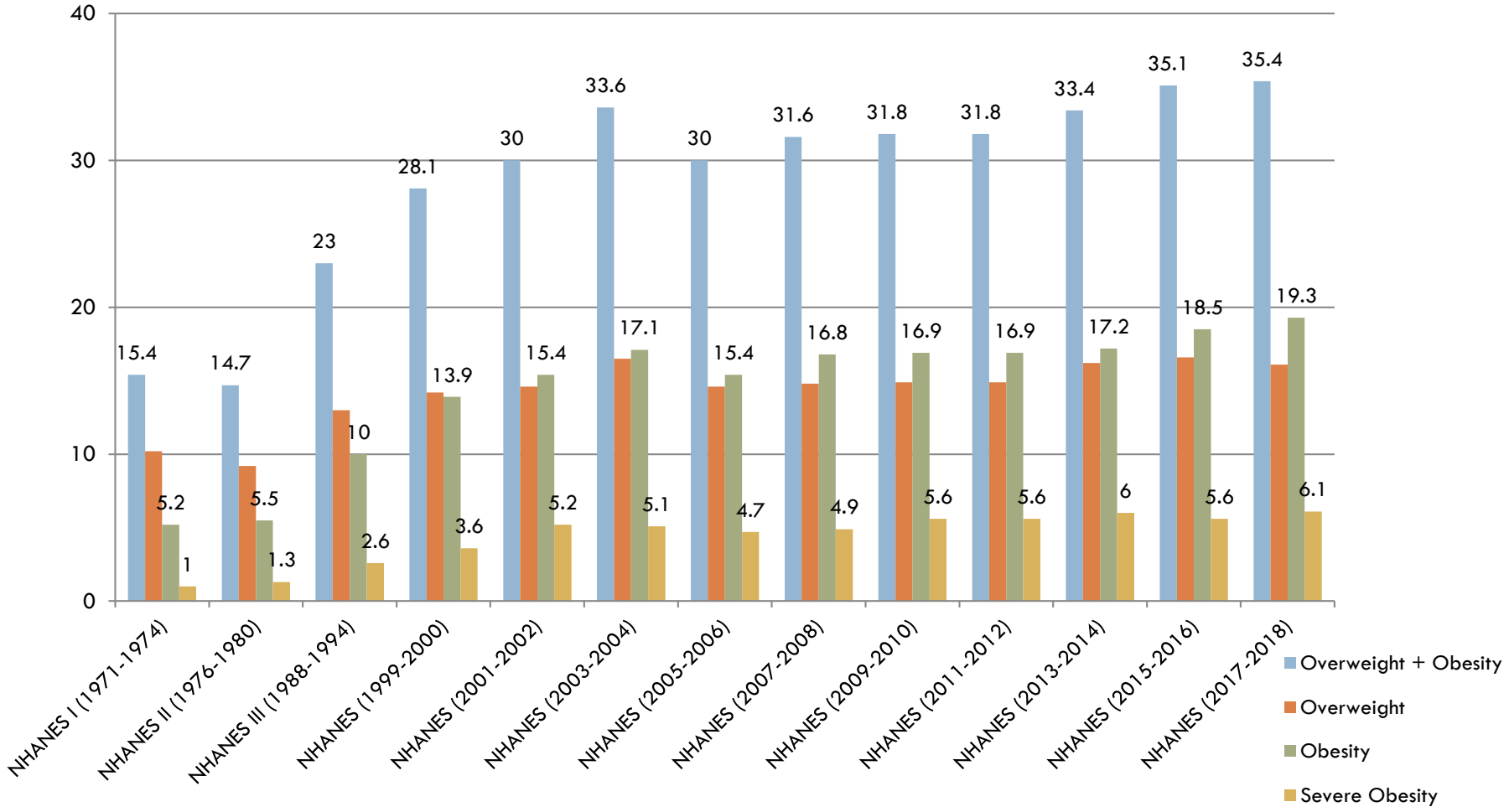
Fryar et al. NCHS Health E-Stats 2020

Childhood obesity trends



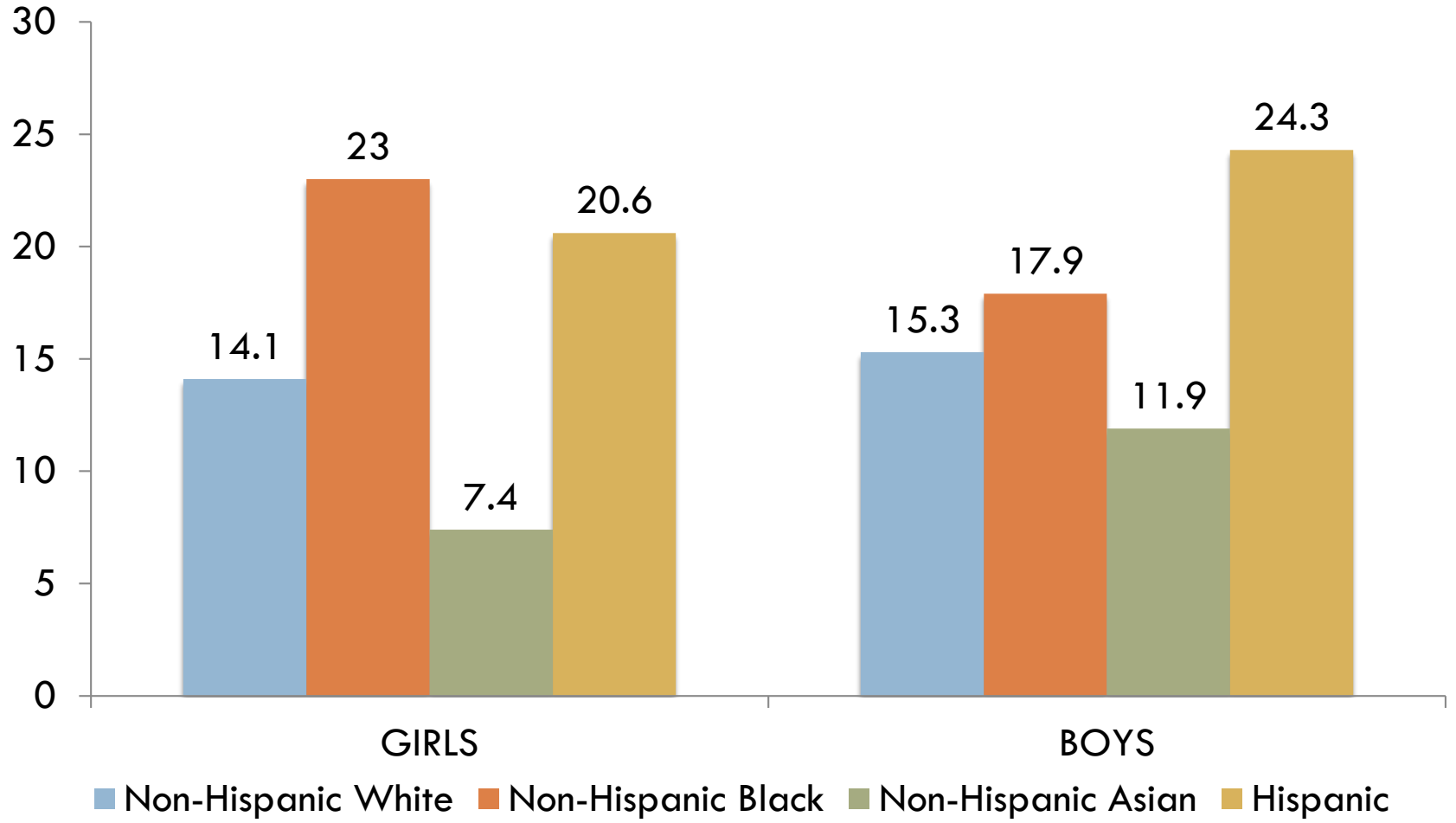
Fryar et al. NCHS Health E-Stats 2020

Childhood obesity trends



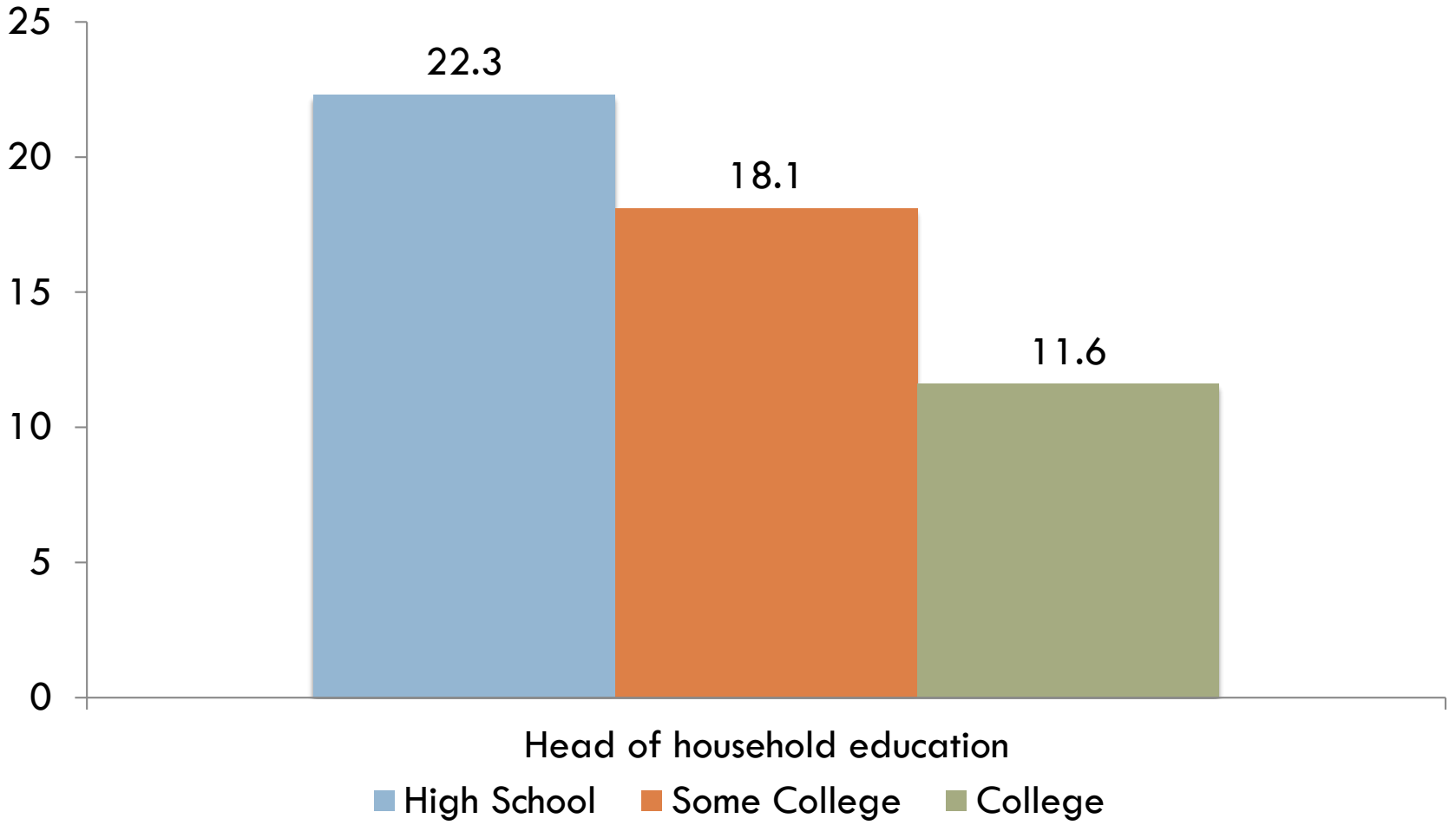
Fryar et al. NCHS Health E-Stats 2020

Childhood obesity



Ogden et al. JAMA 2018

Childhood obesity by education of household head



Ogden et al. JAMA 2018

Racial/ethnic differences in body composition

- Asians, especially South Asians, are more likely to have less muscle and more abdominal fat than whites with the same BMI.
- Asians tend to develop diabetes and other metabolic disease at lower BMI levels
- Lower BMI cutoff points are used to define overweight and obesity in Asian populations

- Worldwide obesity has nearly tripled since 1975.
- In 2016, more than 1.9 billion adults, were overweight or obese (650 million were obese).
- In 2016, 39% of adults were overweight or obese (13% were obese).

EMERGING PROBLEMS

THE WORLD IS FAT

More people in the developing world are now overweight than hungry. How can the poorest countries fight obesity?

KEY CONCEPTS

- As globalization arrives in the Third World, so does the unhealthy Western diet. Over the past 20 years, poor people in developing countries have greatly increased their consumption of sweetened beverages, vegetable oils and animal-source foods (meat, poultry, fish, eggs and dairy products).
- People in the developing world are also adopting Western lifestyles that contribute to obesity.
- No country in modern times has successfully reduced its number of overweight citizens, but governments and aid programs are considering various interventions.

—*The Editors*

By Barry M. Popkin

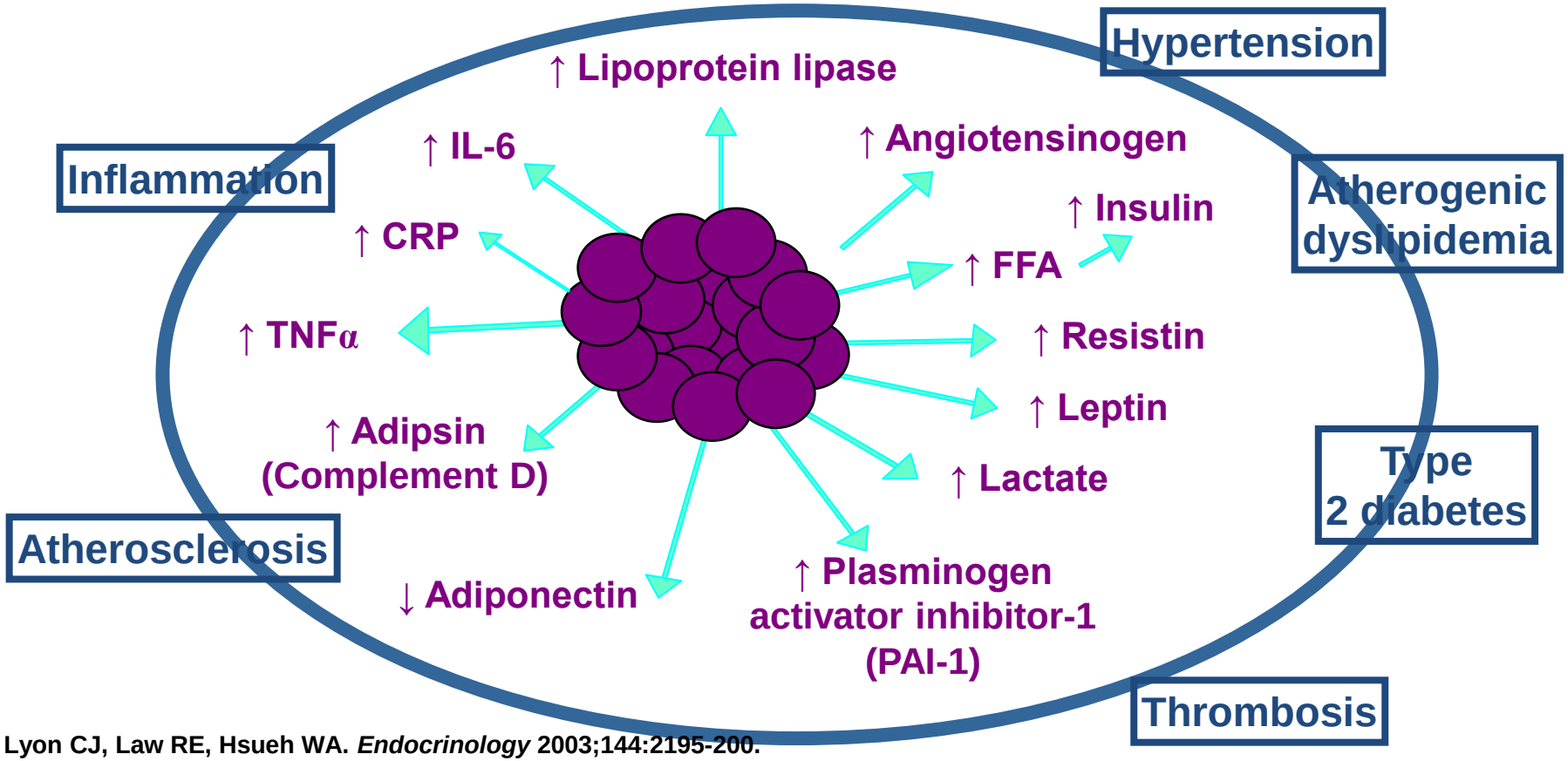
Over the past 20 years a dramatic transition has altered the diet and health of hundreds of millions of people across the Third World. For most developing nations, obesity has emerged as a more serious health threat than hunger. In countries such as Mexico, Egypt and South Africa, more than half the adults are either overweight (possessing a body mass index, or BMI, of 25 or higher) or obese (possessing a BMI of 30 or higher). In virtually all of Latin America and much of the Middle East and North Africa, at least one out of four adults is overweight. Although undernutrition and famine remain significant problems in sub-Saharan Africa and South Asia, even desperately poor countries such as Nigeria and Uganda are wrestling with the dilemma of obesity. Worldwide, more than 1.3 billion people are overweight, whereas only about 800 million are underweight—and these statistics are diverging rapidly.

The obesity rates in many developing countries now rival those in the U.S. and other high-income nations. What is more, the shift from undernutrition to overnutrition—often called the nutrition transition—has occurred in less than a generation. When I return to villages that I visited 15 years ago in India, China, Mexico and the Philippines, I see enormous changes: kids guzzle soft drinks and watch television, adults ride mopeds instead of walking and buy their food from supermarkets. In addition to adopting more sedentary lifestyles, people in the developing world are also consuming more caloric sweeteners, vegetable oils and animal-source foods (meat, poultry, fish, eggs and dairy products). The combination of lifestyle and dietary changes has paved the way for a public

88 SCIENTIFIC AMERICAN September 2007

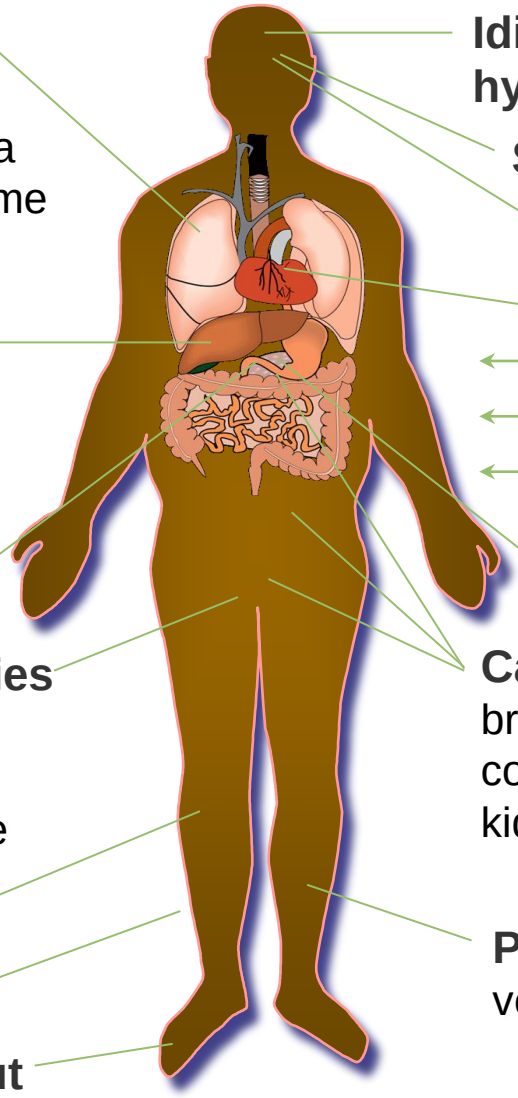
http://www.who.int/mediacentre/factsheets/fs311/en/

Adipose Tissue as an Endocrine Organ



Lyon CJ, Law RE, Hsueh WA. *Endocrinology* 2003;144:2195-200.
Trayhurn P, Wood IS. *Br J Nutr* 2004;92:347-55.
Eckel RH, Grundy SM, Zimmet PZ. *Lancet.* 2005;365:1415-28.

Medical complications of obesity



Pulmonary disease
abnormal function
obstructive sleep apnea
hypoventilation syndrome

Nonalcoholic fatty liver disease
steatosis
steatohepatitis
cirrhosis

Gall bladder disease

Gynecologic abnormalities
abnormal menses
infertility
polycystic ovarian syndrome

Osteoarthritis

Skin

Gout

Idiopathic intracranial hypertension

Stroke

Cataracts

Coronary heart disease

Diabetes

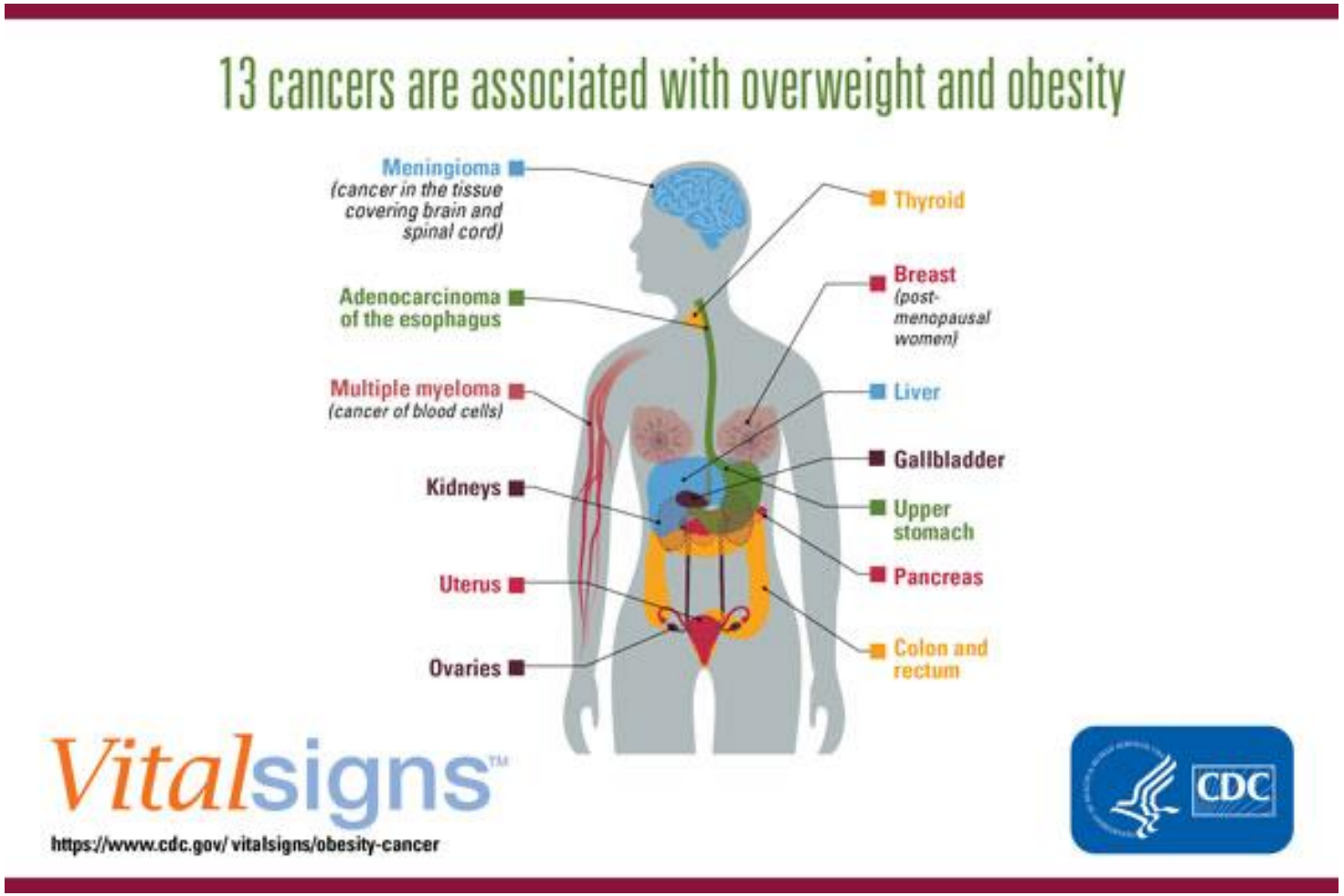
Dyslipidemia

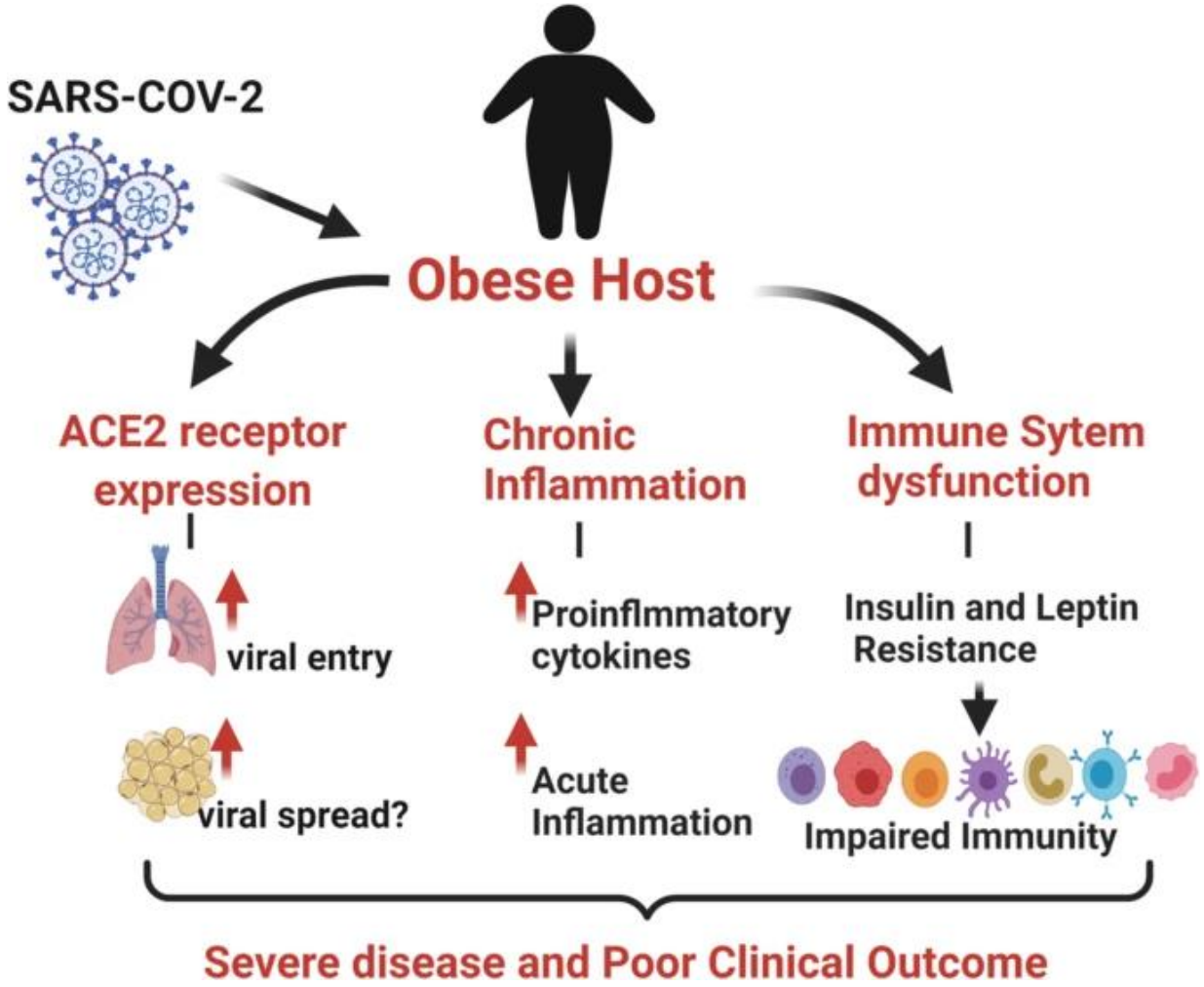
Hypertension

Cancer
breast, uterus, cervix
colon, esophagus, pancreas
kidney, prostate

Phlebitis
venous stasis

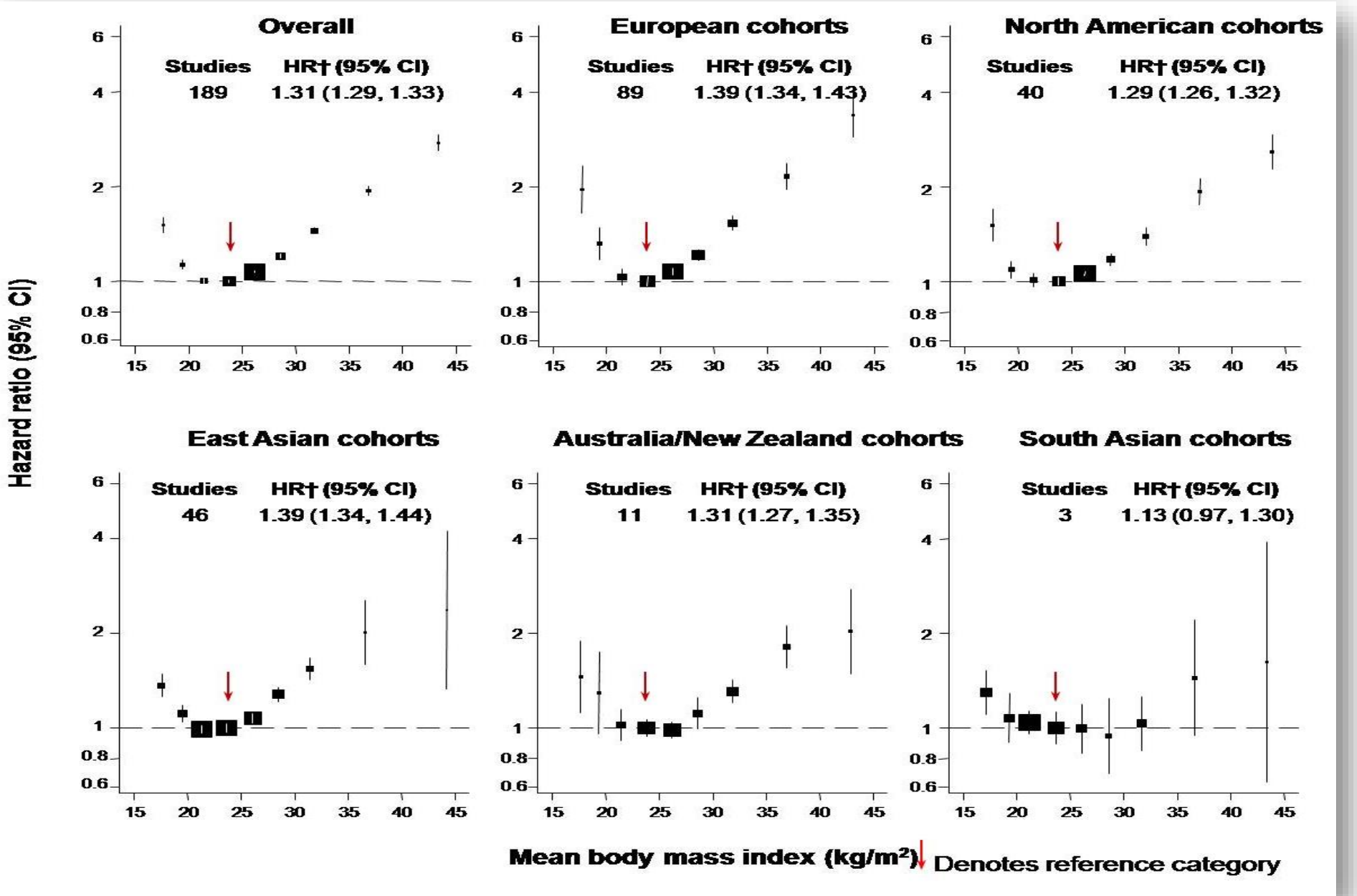
Cancers Associated with Overweight and Obesity Make up 40 percent of Cancers Diagnosed in the United States





Factors responsible for disease severity and poor outcome in obese COVID-19 patients. Obesity-associate chronic inflammation, impaired Immune function and increased ACE2 expression results in an increased disease severity and worse clinical outcome in obese subjects with COVID-19 infection (*Immunity & Ageing* **volume 18**, 2021)

HRs for all-cause mortality by pre-defined categories of BMI

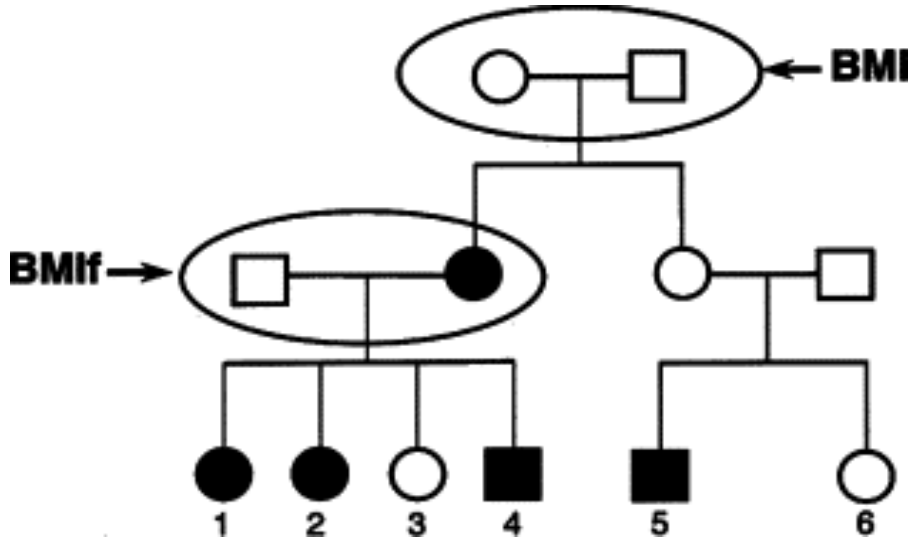


Lancet 2016

Global BMI-mortality consortium

Obesity is heritable

- Family studies, twin studies, and adoption studies have provided evidence about heritability of obesity
- The mean correlations for BMI were 0.74 for monozygotic (MZ) twins, 0.32 for dizygotic (DZ) twins, and 0.25 for siblings.



Maes et al. Behav Genet 1997 27:325-51

Monogenic obesity

- Rare forms of obesity caused by mutations in a single gene
- Such mutations have been discovered in genes that play essential roles in appetite control, food intake, and energy homeostasis
- Primarily, in genes that code for the hormone leptin, the leptin receptor, pro-opiomelanocortin (POMC), and the melanocortin-4 receptor (MC4R).

Response to leptin therapy in congenital leptin deficiency

- Leptin, a hormone produced by adipose tissue, plays a key role in regulating food intake and energy homeostasis
- *Ob*/*ob* mice with a homozygous *Lep* gene mutation exhibit leptin deficiency and early-onset morbid obesity and diabetes.
- Daily subcutaneous injection of recombinant human leptin dramatically reduced body weight in morbidly obese children with congenital leptin deficiency

Philos Trans R Soc Lond B Biol Sci., 2006

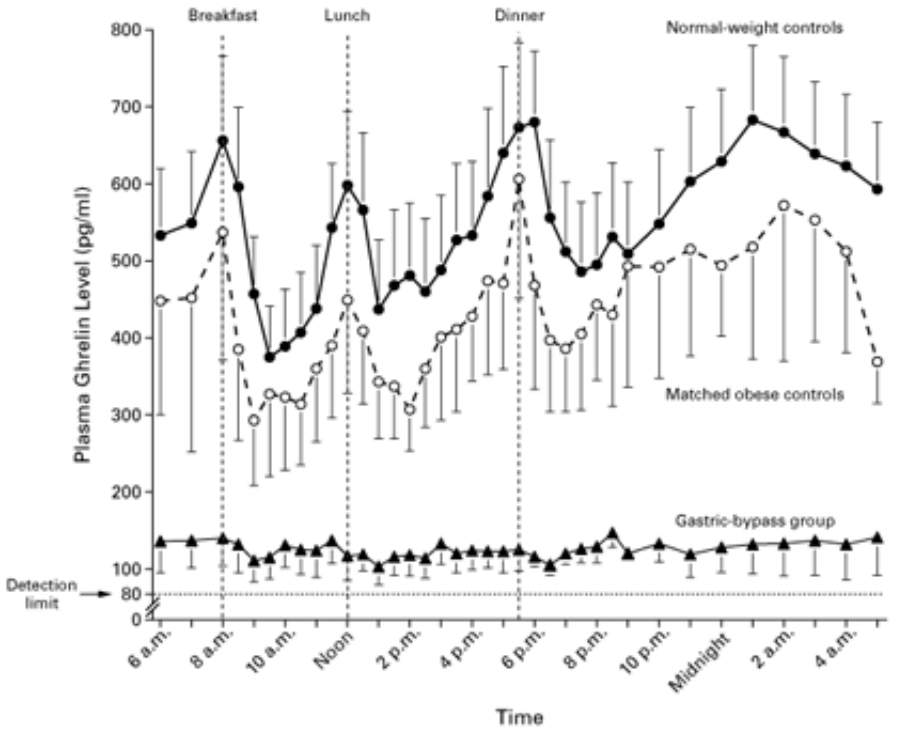
Leptin resistance in obesity

- In obese humans, leptin **is elevated** but lacks expected effect in **suppressing** appetite and controlling food intake
- Analogous to insulin resistance in type 2 diabetes
- Treatment with leptin alone is ineffective in decreasing food intake and body weight in obese humans

Trends Endocrinol Metab. 2010 Nov; 21(11): 643–651.

Ghrelin (hunger hormone)

- Ghrelin is peptide hormone produced by stomach cells
- Ghrelin ↑ before a meal and ↓ after a meal
- Ghrelin levels ↑ after diet-induced weight loss (body weight defense mechanism)
- Ghrelin levels ↓ after gastric bypass surgery



Cummings et al., NEJM, 2002

Genetics of common forms of obesity

- Using genome-wide association studies (GWAS), >500 BMI-associated genetic variants have been identified.
- The effect sizes of individual SNPs are modest
- These variants are not predictive of future risk of obesity
- Many of identified genes are expressed in hypothalamus and involved in appetite control and energy metabolism

Nature 518, 197–206 (12 February 2015)

Gene-environment interactions

- Nature (biological, genetic factors) vs. nurture (behavioral, environmental)
- Monogenic obesity is almost 100% genetic, but common forms of obesity result from interplays between genes and environment
- G X E interaction studies examine how genetic predisposition to obesity modifies the effect of the environment and how changes in diet and lifestyle influence genetic risk of obesity

Ravussin E et al. Diabetes Care 1994.

Obesogenic food environment

- Widely accessible cheap highly processed foods
- Sugar, especially beverages
- Unhealthy fats (saturated and trans fats), sodium
- Availability of convenient and fast foods
- Few vegetables, fruits, whole grains, legumes, fiber

http://www.foodispower.org/fast-food/

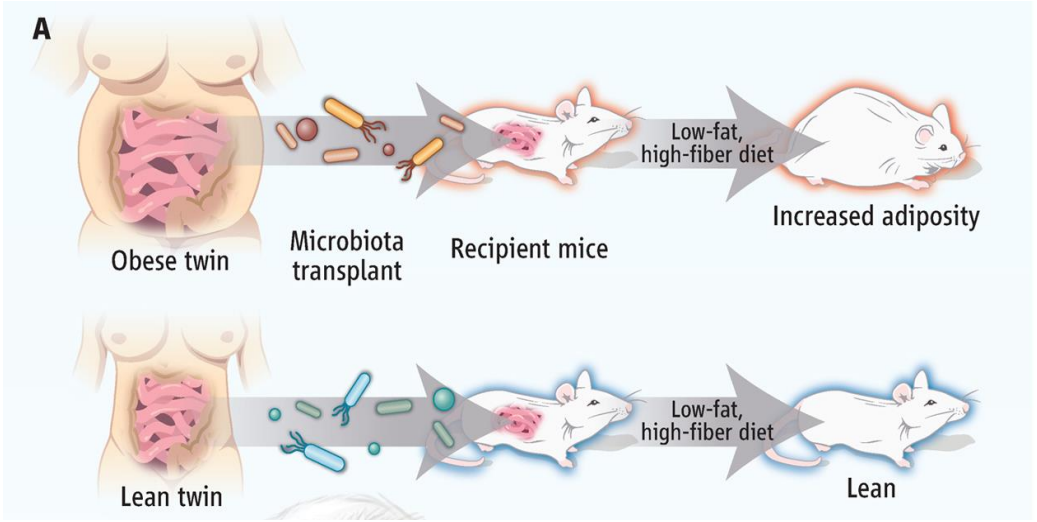
Gut microbiota and obesity

- The human gut contains about 100 trillion microorganisms, whose collective genome, the microbiome, contains 100-fold more genes than the entire human genome
- Obesity-promoting bacteria can increase dietary energy harvest, promote fat deposition, and trigger systemic inflammation
- Modulation of the gut microbiome through diet, pre- and probiotics, bariatric surgery, and fecal transplantation has the potential to prevent and treat obesity.

Tsai F and Coyle WJ. Curr Gastroenterol Rep. 2009

Gut microbiota transplant and obesity

- Transferring gut microbiota from lean or obese human twins produces the same phenotypes in mice
- Safety and long-term efficacy of fecal transplantation in obesity prevention and treatment in humans are uncertain.



Ridaura et al. Science 2013
Walker AW and Parkhill, J. Science 2013

HARVARD T.H. CHAN
SCHOOL OF PUBLIC HEALTH
Department of Nutrition

Secondary Causes of Obesity

- Hypothyroidism
- Cushing's syndrome
- Insulinoma
- Hypothalamic obesity
- Polycystic ovarian syndrome
- Genetic syndromes (Prader Willi, Alstroms, Bardet Biedl, Cohens, Borjeson Forsmsman Lehmann and Frohlich's syndrome)
- Growth hormone deficiency
- Oral contraceptive use
- Pregnancy
- Medication related
- Smoking cessation
- Eating disorders (binge eating disorder, bulimia nervosa and night eating disorder)
- Hypogonadism
- Pseudohypoparathyroidism
- Tube feeding related obesity

https://emedicine.medscape.com/article/123702-clinical

COMMON TREATMENTS FOR OBESITY

LIFESTYLE CHANGES

This typically includes weight-loss efforts designed to help people consume fewer calories and increase physical activity, sometimes directed by your doc.

PRESCRIBED NUTRITION

This is a step beyond lifestyle changes and entails a doctor-directed diet tailored to your body, including vegan eating, intermittent fasting, and others.

PHARMACOTHERAPY

When your BMI is 27 or more, you may qualify for an appetite-suppressing medication that can help you with your prescribed nutrition and exercise program.

SURGERY

Bariatric surgery is the most effective treatment for obesity, but it also carries the most risk. It's typically used in those whose BMI is 40 or higher.

healthcentral

https://www.healthcentral.com/condition/obesity

Summary

- The prevalence of obesity especially severe obesity has increased dramatically in the past several decades (10% US adults and 6% children have severe obesity).
- Obesity rates vary substantially across different racial, education, and SES groups as well as geographic locations.
- Adipose tissue is considered the largest endocrine organ secreting hormones and cytokines that increase risk of chronic diseases.
- The pathophysiology of obesity is complex involving a multitude of genetic, environmental, hormonal, and psychosocial factors. Increasing evidence indicates an important role of gut microbiome in obesity.
- More effective treatment options such as medications and metabolic surgeries have become available, but obesity prevention remains a top public health priority.