How "Unhealthy" is Unhealthy Weight?:

Variation in BMI-associated Premature Mortality by Gender, Race/Ethnicity, and Education

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Defining “Unhealthy” Weight

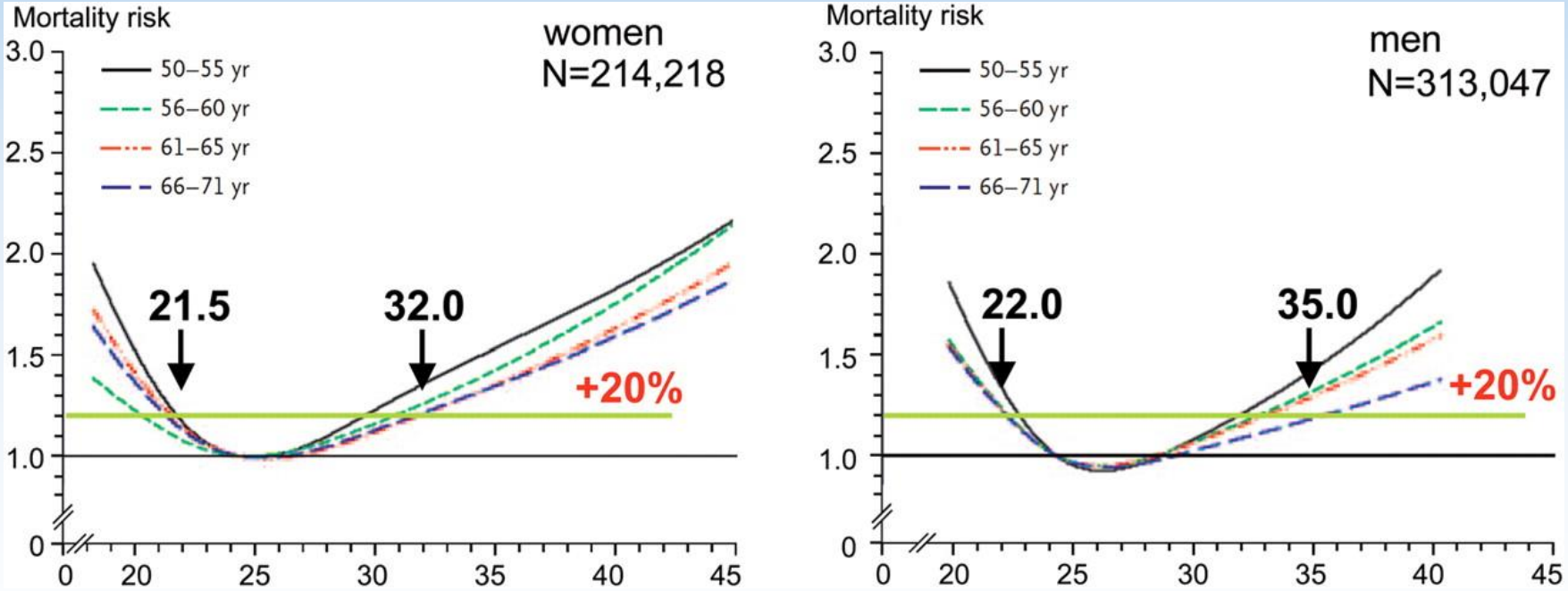
- BMI = $\frac{mass(kg)}{height(m)^2}$
- Over 67% of US adults classified as overweight or obese (Ogden et al. 2014), with rates doubling over last 30-40 years (Fryar et al. 2014)
- BMI associated with a variety of adverse health conditions including cardiovascular disease, diabetes, many forms of cancer, and other chronic conditions (Must et al. 1999; Field et al. 2001)

Category	BMI range – kg/m^2
Very severely underweight	less than 15
Severely underweight	from 15.0 to 16.0
Underweight	from 16.0 to 18.5
Normal (healthy weight)	from 18.5 to 25
Overweight	from 25 to 30
Obese Class I (Moderately obese)	from 30 to 35
Obese Class II (Severely obese)	from 35 to 40
Obese Class III (Very severely obese)	over 40

“Obesity Paradox”

- Relationship between body weight (as often measured by Body Mass Index, or BMI) and mortality is less clear
- “Normal” BMI is not necessarily associated with the lowest risk of death, whereas overweight and obese are protective of mortality
- “J”- or “U”-shaped curve with respect to how mortality risk varies as individuals’ BMI increases (Flegal et al. 2005; Fontaine et al. 2003; McGee 2005; Flegal et al. 2013; Katzmarzyk et al. 2001; Ensrud et al. 2007; Corrada et al. 2006; Price et al. 2006)

Association of BMI and mortality risk in age subgroups in men and women



Wolfram Doehner et al. Eur Heart J 2009;eurheartj.ehp339

Obesity and Health among Working-Aged Adults

- Obesity paradox typically observed among older adults
- ~40% of middle-aged adults, ages 40 to 59 are obese (Ogden et al. 2013)
- Prevalence of obesity-related diseases growing among young and middle-aged adults (WHO, 2011)
- Beginning to see effects of obesity in childhood and adolescence on adult health, especially among recent cohorts (Reily & Kelly, 2011; Park et al. 2012)

Variation in BMI-Mortality

- Race
  - Overweight and mild obesity associated with reduced mortality among African-Americans (Stevens et al. 2000; 2002)
  - Lowest mortality for black individuals corresponds with higher BMI as compared to white individuals (Durazo-Arvizu et al. 1997)
  - High BMI less strongly associated with mortality for black women compared to white women (Sanchez et al. 1999; Calle et al. 1999; Abell et al. 2008a; Abell et al. 2008b)
- Gender
  - Meta-analysis (McGee, 2005) finds similar protective effect of overweight, but less so mild obesity, for women as compared to men
- Education
  - Low-educated men have highest mortality risk at underweight;
  - Highly-educated men had lowest risk at underweight but highest risk at obese (Schnohr et al. 2004)

Research Questions

- *(R1) What is the relationship between BMI and mortality among working-aged adults*?
  - Important to ascertain the effects of BMI on mortality at earlier ages
  - Increases in prevalence of overweight and obesity, as well as chronic BMI-related diseases
- *(R2) How does the relationship between BMI and mortality vary across sociodemographic groups?*

Fundamental Cause Theory and Expectations for R2

- Per fundamental cause theory, more advantages grant access to more "flexible resources" (Link & Phelan, 1995; Link et al. 2008) and better ability to deal with consequences of unhealthy weight
- Larger education and SES gradients in mortality for causes of death for more preventable causes of death (Phelan et al. 2004; Masters et al. 2015)
- Overweight and obesity might be expected to be associated with **increased mortality risk** for women compared to men, black and/or Hispanic individuals compared to whites, and among those with lower educational attainment compared to higher

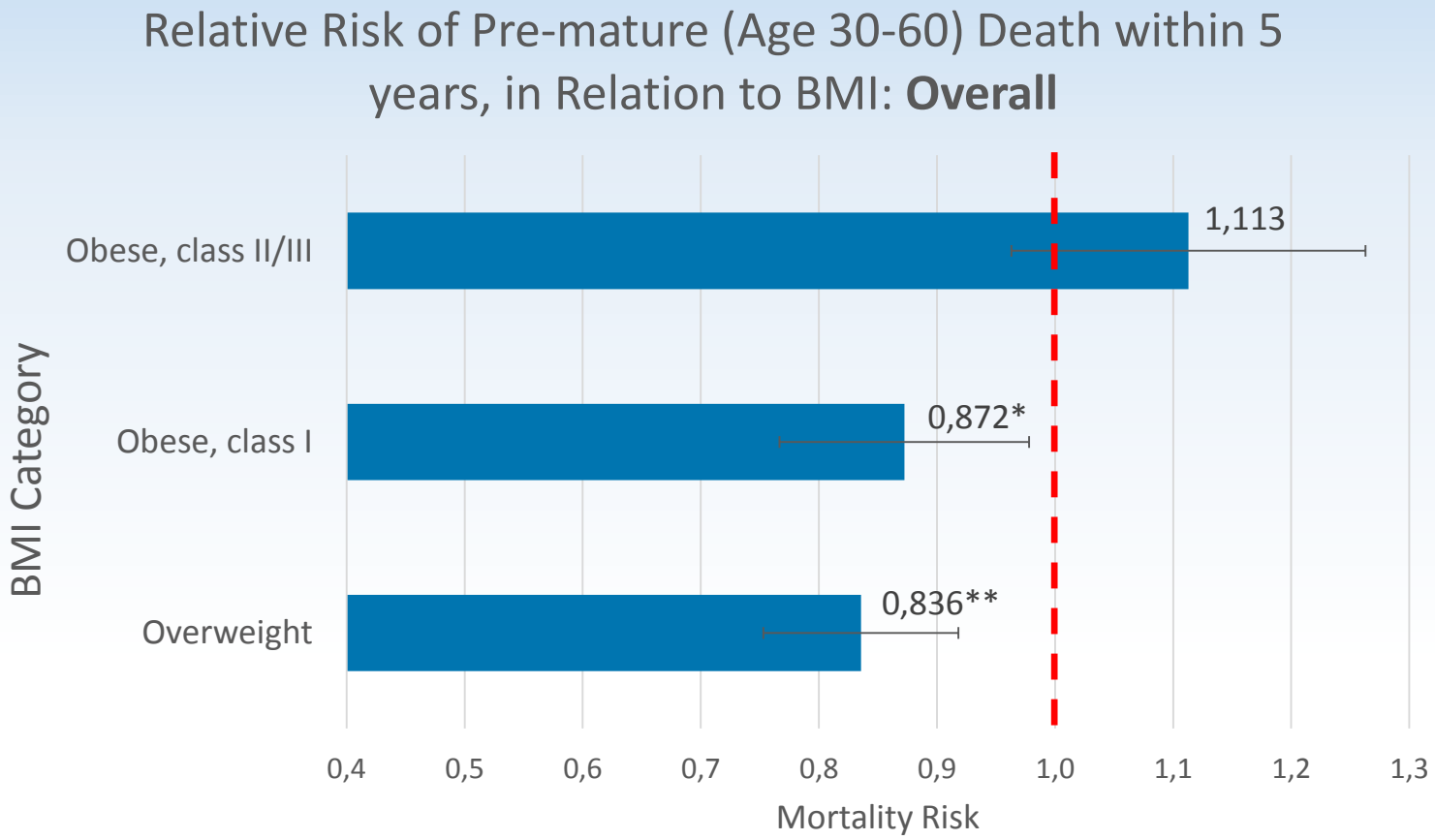
Data and Measures

- National Health Interview Survey (NHIS)
  - "Principal source of information on the health of the civilian noninstitutionalized population of the United States"
  - Integrated Health Interview Series
- Linked death records from the National Death Index (referred to as the NHIS-Linked Mortality File, or NHIS-LMF), includes mortality data up through December 31, 2011
- The integrated series spanning 1997-2009
- Mortality status; BMI; Age; Gender; Race; Foreign born status; Education; Self-rated health; Alcohol use; and Smoking status
- Ages 30 to 60
- N=195,232
  - N=3,657 deaths within 5 years of interview

Cox Proportional Hazard Models

- Failure event as death within five years (Folsom et al. 1993; Diehr et al. 1998; Fried et al. 1998), with study time as age (calculated as a function of their age upon entry and subsequent person-years contributed the study)
- Normal weight used as reference with a default hazard ratio of 1.00 (Masters et al. 2013a; Masters et al. 2013b; Adams et al. 2006)
- Separate models by gender, race, and education to examine differences in BMI-mortality within sociodemographic groups

Overall BMI-Mortality Relationship

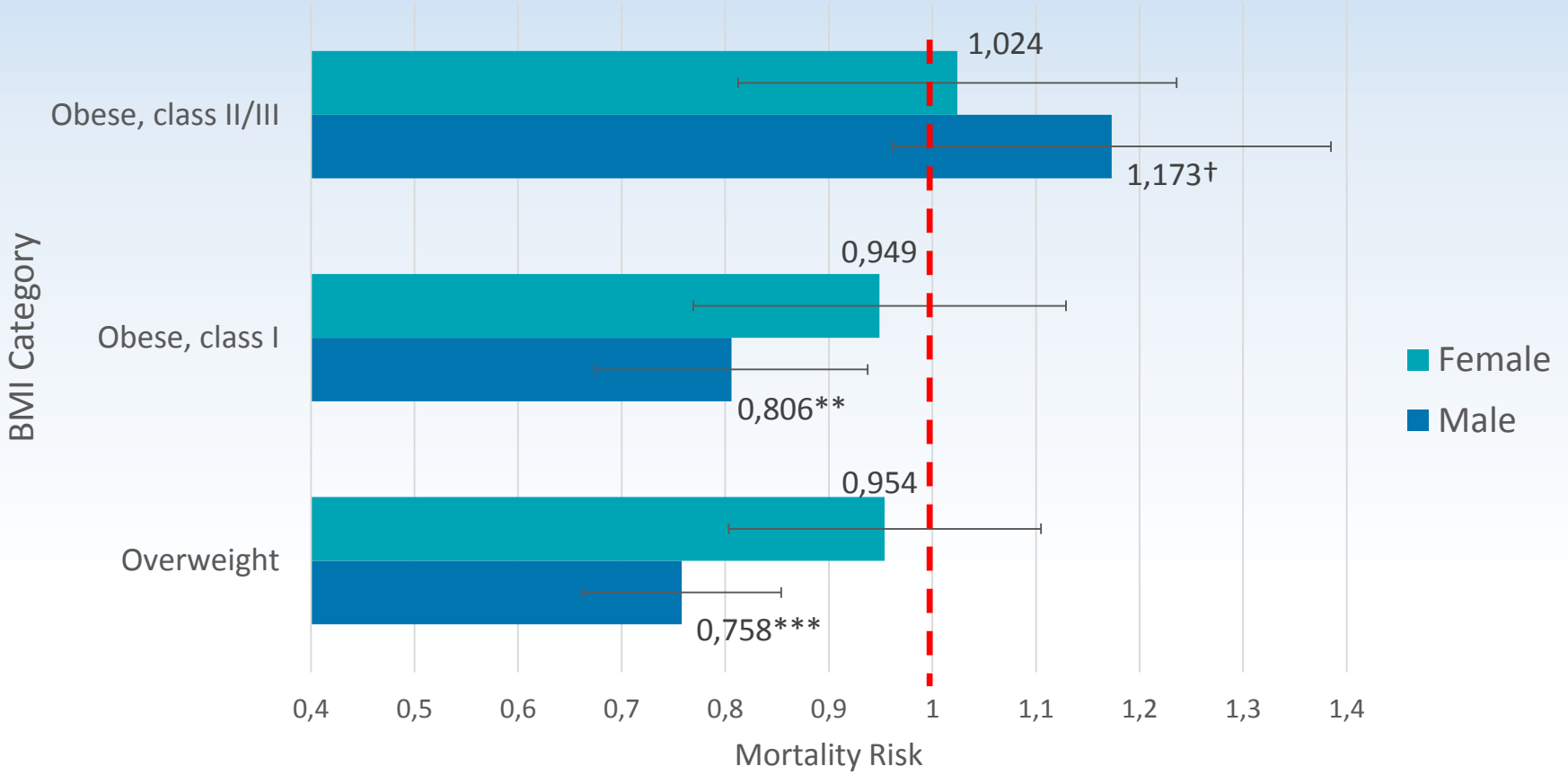


† for p<0.10; * for p<0.05; ** for p<0.01; *** for p<0.001

Underweight (HR=2.648) is excluded to more clearly show the effects of overweight and obese

Variation by Gender

Relative Risk of Pre-mature (Age 30-60) Death within 5 years, in Relation to BMI: **Gender**



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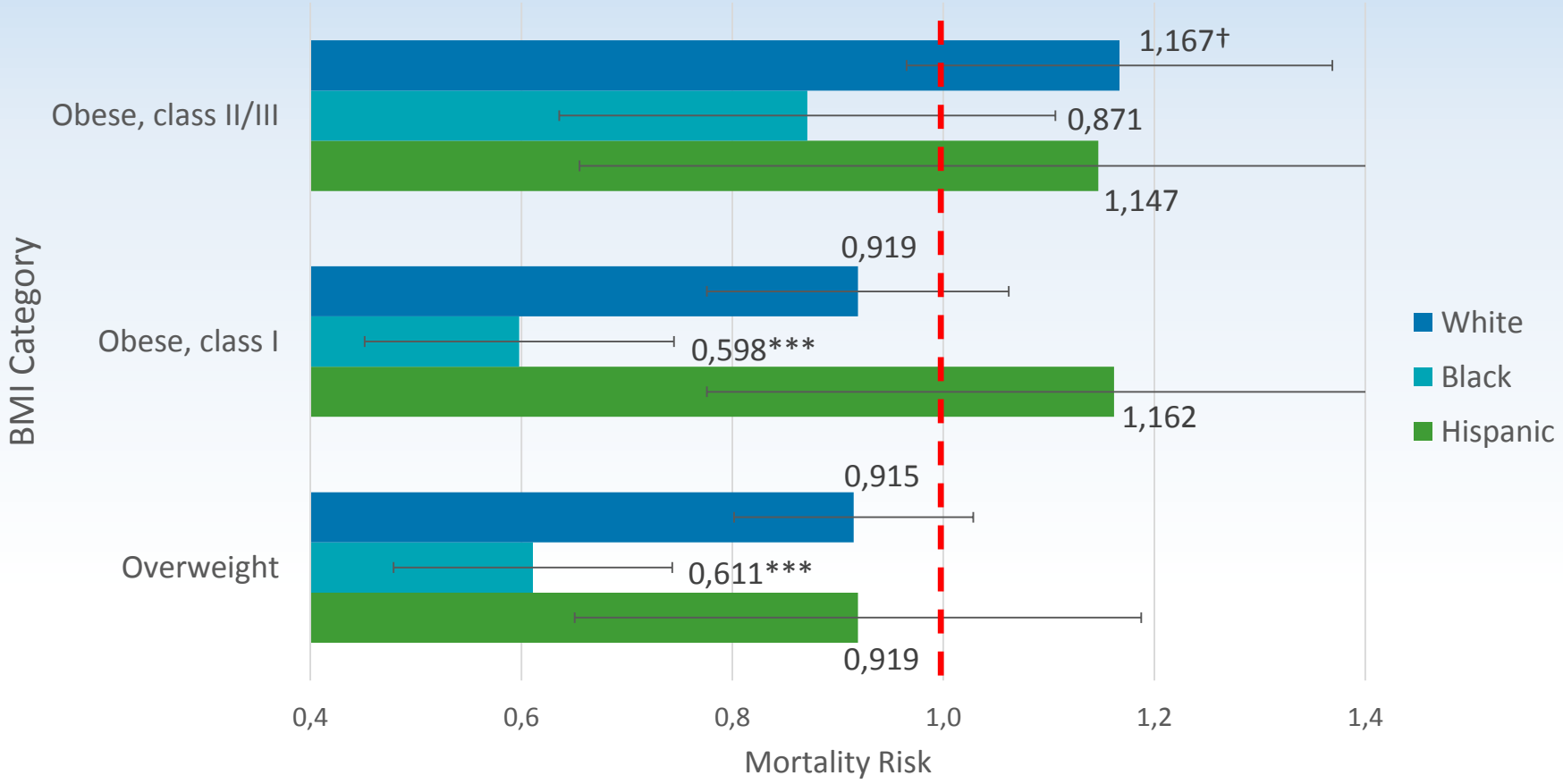
Underweight (HR=2.648) is excluded to more clearly show the effects of overweight and obese

Variation by Race/Ethnicity

Relative Risk of Pre-mature (Age 30-60) Death within 5 years, in Relation to BMI: **Race/Ethnicity**



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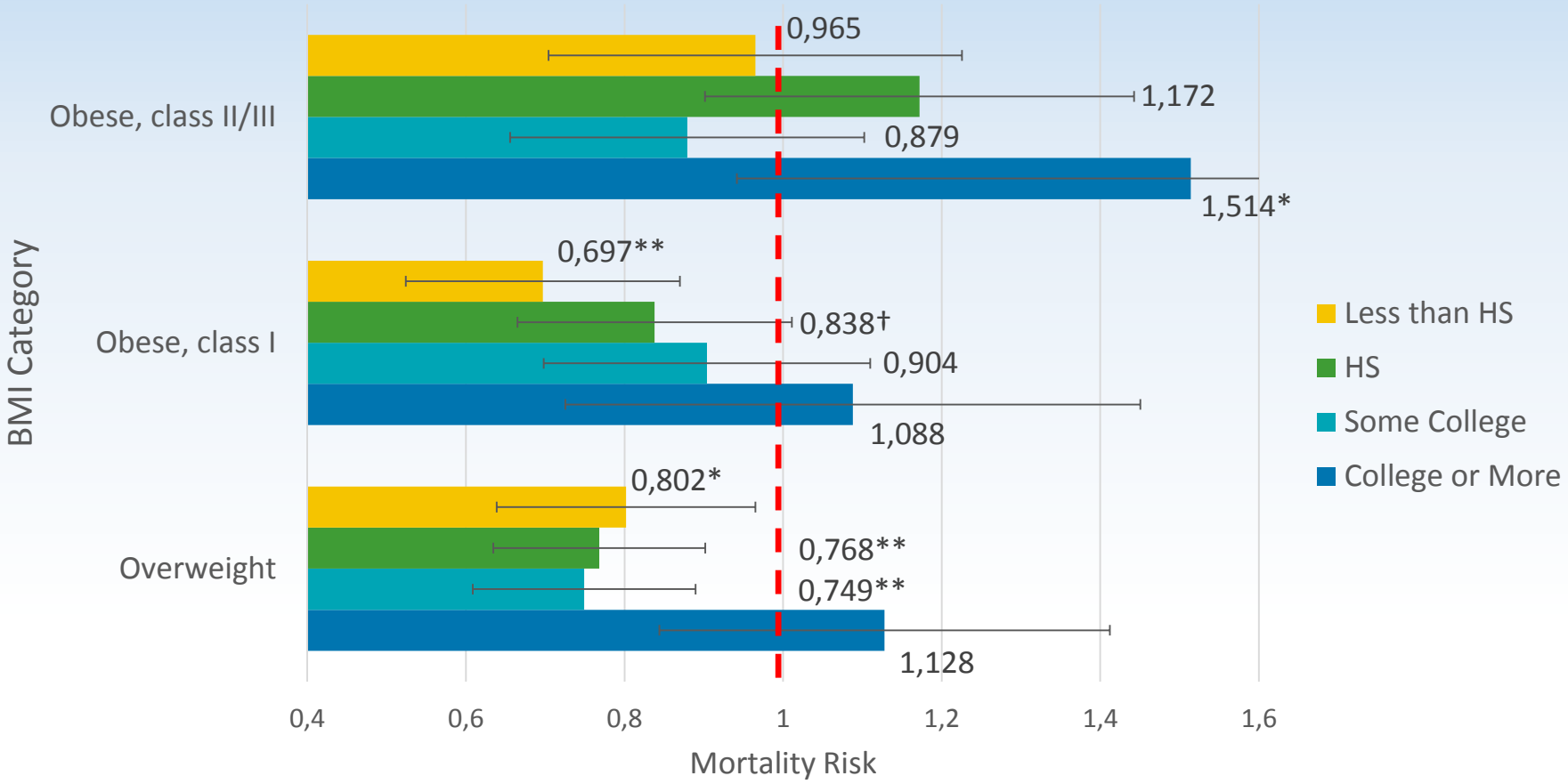
Underweight (HR=2.648) is excluded to more clearly show the effects of overweight and obese

Variation by Education

Relative Risk of Pre-mature (Age 30-60) Death within 5 years, in Relation to BMI: **Education**



† for p<0.10; * for p<0.05; ** for p<0.01; *** for p<0.001

Underweight (HR=2.648) is excluded to more clearly show the effects of overweight and obese

Summary of Results

- **Overweight and mildly obese (class I) associated with lower mortality risk for middle-aged adults**
- **Among men**, overweight and mildly obese associated with ~20% lower risk, and severely obese associated with elevated risk
- **Among black respondents**, overweight and mildly obese associated with ~40% lower risk
  - White and Hispanic see no such association, but higher risk associated with severe obesity
- **Among individuals with a high school education or less**, overweight and mild obesity associated with ~20-30% lower risk
  - For those with 16+ years of education, a BMI of 25+ associated with increased risk, especially severe obesity at ~50% greater risk

Discussion & Conclusion

- **Counterintuitive to fundamental cause theory, but not a contradiction**
- Might be seeing some "protective" effects of overweight and obesity occurring at an earlier age for black and low-educated individuals
- Possible differences in the risk associated with normal weight, especially for highly-educated and black individuals
- Consider examining other potential "moderators", such as spatial variation, family background, social support, and neighborhood characteristics
- Further work questioning assertions about BMI and obesity as indicators of unhealthiness or unhealthy behavior

Thank You!

- Special thank you to The **Young Academy** of the Austrian Academy of Sciences and The University of North Carolina-Chapel Hill for helping to support my travel

Baseline Characteristics of 1997-2011 NHIS-LMF(Ages 30-60): Full Survival vs. Less than Five Year Survival[a]

	Full Survival	<5 Year Survival
BMI Group		
Underweight (<18.0)	1.3%	3.4%
Normal (18.0-24.9)	35.5%	32.1%
Overweight (25.0-29.9)	36.4%	32.6%
Obese, class I (30.0-34.9)	16.8%	17.4%
Obese, class II/III (35.0+)	10.0%	14.5%
Sample size	191,575	3,657

[a]All estimated based on unweighted values

Baseline Characteristics of 1997-2011 NHIS-LMF(Ages 30-60): Full Survival vs. Less than Five Year Survival[a]

	Full Survival	<5 Year Survival
Age		
Mean (SD)	43.8 (8.6)	50.0 (7.7)
Gender		
Female	54.4%	43.1%
Male	45.6%	56.9%
Race/Ethnicity		
Non-HispanicWhite	64.0%	61.0%
Non-Hispanic Black	14.5%	22.4%
Hispanic	17.3%	13.5%
Foreign born		
Yes	18.3%	12.0%
Education		
Less than HS	15.5%	25.6%
HS	27.7%	32.6%
Some College	29.0%	27.2%
College +	27.8%	14.7%
Sample size	191,575	3,657

[a]All estimated based on unweighted values

Baseline Characteristics of 1997-2011 NHIS-LMF(Ages 30-60): Full Survival vs. Less than Five Year Survival[a]

	Full Survival	<5 Year Survival
Self-Rated Health		
Good/Very Good/Excellent	88.6%	55.7%
Poor/Fair	11.4%	44.4%
Alcohol Use		
Lifetime abstainer	19.0%	19.4%
Former drinker	14.3%	26.5%
Current drinker	66.7%	54.1%
Smoker status		
Never smoked	54.5%	32.9%
Former smoker	20.1%	23.4%
Current smoker	25.3%	43.8%
Sample size	191,575	3,657

[a]All estimated based on unweighted values

Weight Change and Mortality

- Using three classes of BMI trajectories –"stable overweight," "obese gaining," and "obese losing" – Zajacova and Alishire (2012) find that for both men and women the obese gaining class had approximately 50% higher mortality risk than stable overweight, while the highest mortality was found in the obese losing category (OR > 2.7)
- Zheng et al. (2013) apply latent class trajectory models to adults aged 51-77 in the US Health and Retirement Study (HRS), finding that people in the overweight stable trajectory had the highest survival rate, followed by those in the overweight obesity, normal weight upward, class I obese upward, normal weight downward, and class II/III obese upward trajectories.
  - "BMI trajectories were more predictive of mortality risk than was static BMI status", and that these later life increasing trajectories of obesity "pose a substantive threat to future gains in life expectancy."
- Also using HRS data, Myrskyla and Chang (2009) observe that weight loss is associated with excess mortality among normal, overweight, and mildly obese middle- and older-aged adults

"Overall" Model for BMI-associated Premature Mortality (Ages 30-60) within 5 Years

Variable	*Haz. Ratio*		*Std. Err.*
BMI Classification (reference: "Normal weight")			
Underweight	2.648	***	0.311
Overweight	0.836	**	0.042
Obese, class I	0.872	*	0.054
Obese, class II/III	1.113		0.077
Sociodemographic controls			
Female	0.610	***	0.026
Race/Ethnicity (reference: "White")			
Black	1.419	***	0.073
Hispanic	1.091		0.082
Coefficients on other race/ethnic groups insignificant and excluded			
Foreign born	0.831	*	0.068
Education (reference: Less than High school)			
High school	0.948		0.054
Some college	0.903	†	0.055
College or higher	0.733	***	0.056
Health Behaviors			
Positive self-rated health	0.223	***	0.011
Alcohol use (reference: Lifetime Abstainer)			
Former smoker	1.134	*	0.072
Current smoker	0.738	***	0.042
Smoker status (reference: Never smoked)			
Former smoker	1.515	***	0.086
Current smoker	1.977	***	0.102

† for p<0.10; * for p<0.05; ** for p<0.01; *** for p<0.001

N = 195,232

Multivariate Relative Risk of Pre-mature (Age 30-60) Death within 5 years, in Relation to BMI; By Gender

	Male		Female	
BMI Group				
Underweight (<18.5)	3.147	***	2.413	***
	(0.554)		(0.385)	
Overweight (25.0-29.9)	0.758	***	0.954	
	(0.049)		(0.077)	
Obese, Class I (30.0-34.9)	0.806	**	0.949	
	(0.067)		(0.092)	
Obese, Class II/III (35.0+)	1.173	†	1.024	
	(0.108)		(0.108)	
	N=89,369		N=105,863	

† for p<0.10; * for p<0.05; ** for p<0.01; *** for p<0.001

Multivariate Relative Risk of Pre-mature (Age 30-60) Death within 5 years, in Relation to BMI; By Race/Ethnicity

	White	Black	Hispanic
BMI Group			
Underweight (<18.5)	2.701***	2.769***	1.228
	(0.376)	(0.706)	(0.803)
Overweight (25.0-29.9)	0.915	0.611***	0.919
	(0.058)	(0.067)	(0.137)
Obese, Class I (30.0-34.9)	0.919	0.598***	1.162
	(0.073)	(0.075)	(0.197)
Obese, Class II/III (35.0+)	1.167†	0.871	1.147
	(0.103)	(0.120)	(0.251)
	N=124,825	N=28,652	N=33,663

† for p<0.10; * for p<0.05; ** for p<0.01; *** for p<0.001

Multivariate Relative Risk of Pre-mature (Age 30-60) Death within 5 years, in Relation to BMI; By Educational Attainment

	Less than HS	HS	Some College	College or More
BMI Group				
Underweight (<18.5)	2.759***	2.159***	2.808***	3.238***
	(0.601)	(0.472)	(0.623)	(0.978)
Overweight (25.0-29.9)	0.802*	0.768**	0.749**	1.128
	(0.083)	(0.068)	(0.072)	(0.145)
Obese, Class I (30.0-34.9)	0.697**	0.838†	0.904	1.088
	(0.088)	(0.088)	(0.105)	(0.185)
Obese, Class II/III (35.0+)	0.965	1.172	0.879	1.514*
	(0.133)	(0.138)	(0.114)	(0.292)
	N=30,669	N=54,284	N=56,529	N=53,750

† for p<0.10; * for p<0.05; ** for p<0.01; *** for p<0.001

Comparing Across Groups

Comparison of Relative Risk of Pre-mature (Age 30-60) Death within 5 years, in Relation to BMI[a]; Across Gender, Race/Ethnicity, and Education

Ratio of Risk by Group[b]	Underweight (<18.5)		Overweight (25.0-29.9)		Obese, Class I (30.0-34.9)		Obese, Class II/III (35.0+)	
	HR	*Std. Error*	*HR*	*Std. Error*	*HR*	*Std. Error*	*HR*	*Std. Error*
Female/Male	0.770	(0.183)	**1.257***	(0.129)	1.177	(0.142)	0.874	(0.122)
Black/White	1.032	(0.300)	**0.664****	(0.085)	**0.647****	(0.096)	**0.747†**	(0.122)
Hispanic/White	0.455	(0.304)	0.998	(0.161)	1.256	(0.235)	0.986	(0.233)
Hispanic/Black	0.44	(0.309)	**1.503***	(0.279)	**1.941****	(0.408)	1.319	(0.334)
HS/<HS	0.778	(0.241)	0.955	(0.130)	1.200	(0.197)	1.210	(0.219)
Some College/<HS	1.016	(0.317)	0.932	(0.131)	1.295	(0.222)	0.907	(0.171)
College+/<HS	1.156	(0.431)	**1.411***	(0.232)	**1.567***	(0.332)	**1.570†**	(0.371)
Some College/HS	1.306	(0.407)	0.975	(0.127)	1.080	(0.169)	0.75	(0.131)
College+/HS	1.485	(0.554)	**1.477***	(0.230)	1.306	(0.261)	1.298	(0.293)
College+/Some College	1.137	(0.426)	**1.514****	(0.242)	1.210	(0.249)	**1.731***	(0.401)

† for p<0.10; * for p<0.05; ** for p<0.01; *** for p<0.001

[a]Multivariate model used age as the underlying time metric and included the following combinations of covariates: gender, race/ethnicity, foreign born status, level of education, family income bracket, self-rated health, alcohol use, and smoking status.

[b]Significance level compares BMI category to reference group (Normal weight).

Limitations

- Self-reported BMI
- BMI assessed at a single point in time, and assumed to remain constant over 5 years
- Loss of statistical power among some groups due to low cell counts for death and certain BMI groups
- Specification of only five BMI categories

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