BODY WEIGHT TRAJECTORIES AND MORTALITY AMONG OLDER ADULTS.

Anna Zajacova, University of Wyoming

Jennifer Ailshire, University of Southern California

Extended abstract prepared for submission to the Annual Meeting of the Population Association of America, Washington DC, 2011.

The majority of American adults are overweight or obese, as defined by a body mass index above 25kg/m^2 (Hedley, Ogden et al. 2004; Flegal, Carroll et al. 2010). An accurate understanding of how body weight is associated with health and mortality is therefore crucial for clinical practice and public health policy. Numerous studies have examined the association between body weight and mortality (Flegal, Graubard et al. 2007; Mehta and Chang 2009; Prospective Studies 2009; Berraho, Nejjari et al. 2010). These studies have consistently shown a U-shaped relationship where both obese and underweight adults had significantly higher mortality than adults in the normal-weight category. Somewhat surprisingly, the studies have also reported that overweight adults had mortality risks comparable to --or lower-- than the risks of normal-weight adults (Troiano, Frongillo et al. 1996; Flegal, Graubard et al. 2005; McGee 2005; Adams, Schatzkin et al. 2006; Flegal, Graubard et al. 2007; Janssen 2007; Mehta and Chang 2009; Berraho, Nejjari et al. 2010; Flicker, McCaul et al. 2010).

In the public discourse, the association between overweight and lower mortality risk has been understood as causal and even generalized to health, with the implication that carrying extra body weight does not impair health. For instance, an article in the *New York Times* noted that "chubby...may be the new healthy" when reporting on a recent study of BMI and *mortality* (Kolata 2007). The mortality results and their interpretation by the media have attracted wide attention due to their seeming contradiction with clinical and public health messages about the health risks associated with excess body weight.

Researchers have long suspected that the U-shaped relationship between BMI and mortality risk is a result of 'reverse causality,' or confounding by preexisting disease (Allison, Heo et al. 1997; Greenberg 2001; Bales and Ritchie 2002; Greenberg 2006). This confounding would mean that low BMI does not capture a healthy, lean body composition but instead may be a consequence of weight loss from disease processes leading to death. To address this 'reverse causality' problem, investigators have eliminated study subjects who died within the first several years after the measurement of body weight, in order to exclude individuals who possibly have lost weight due to serious illness (Greenberg 2001; Zhang, Shu et al. 2008). These adjustments often shifted the nadir of the mortality curve so that the optimal BMI for longevity was in the normal range (Zamboni 2005; Adams, Schatzkin et al. 2006; Freedman, Ron et al. 2006; Greenberg 2006; Gronniger 2006; Greenberg, Fontaine et al. 2007). However, this solution has come at the expense of excluding a large portion of the study sample, limiting the generalizability of the findings.

A better approach to capturing an unbiased relationship between body weight and mortality is to follow adults for an extended period of time to determine what changes in body weight are associated with high risks of dying. This project uses 16 years of data from a large, nationally representative sample of older adults with BMI information collected every two years and reliable mortality follow-up to determine typical classes of body weight changes over time, and how the different trajectories affect mortality hazard.

DATA and METHOD

Data Source

Data are from the Health and Retirement Survey (HRS) (Juster and Suzman 1995; Hodes and Suzman 2007),[1] a nationally representative longitudinal study of older Americans born between 1931 and 1941 that has been conducted continuously since 1992 by the Institute for Social Research at the University of Michigan. The HRS was designed to study the economic and health consequences of the transition to retirement. The original HRS cohort was first interviewed in 1992 and re-interviewed every two year thereafter to 2008, for a total of 16 years of follow-up or 9 waves of data We use the 2008 version of the HRS data available from the RAND Corp. (RAND Corp. 2010).

The HRS sample was selected using a multi-stage clustered sampling design with oversamples of black and Hispanic adults and Florida residents. We take the design into account using appropriate estimators for descriptive and inferential statistics. The collected data span a broad range of core and special-module topics from general, physical, mental, and cognitive health, to employment, economic, social, demographic, retirement-related, health insurance, health care, and lifestyle variables. Respondent-level response rates exceed 80% across all waves and there was relatively low attrition between 1992 and 2008.

Our analysis sample is defined as all respondents from the original HRS cohort, born between 1931 and 1941, provided that they had valid education information and at least one data point on self-rated health (N=10,132). This narrow set of birth cohorts helps minimize the age/period/cohort identification problems by isolating the health changes as being mainly a function of aging, rather than cohort differences.

[1] Complete information about HRS, its design, documentation, and all public data are available at http://hrsonline.isr.umich.edu/.

Measures

Key variables. Body mass index (BMI) information is available at all nine waves of the data. At the baseline, respondents were asked to report their height and weight. In subsequent waves, respondents were only asked to report their current. BMI is calculated at weight (in kilograms) divided by height squared (in meters).

Survival has been ascertained at every wave. The HRS has conducts on-going tracking of all respondents and includes information on respondent vital status that indicates whether the respondent is still living, presumed alive, or presumed at each wave. Those missing an interview or considered lost to follow up (LTF) are coded as missing for the relevant wave.

Demographic and socioeconomic profile. Year of birth is measured in single years and is centered around the sample mean in all multivariate analyses. Gender is dichotomous, with male treated as the reference. Categories of race/ethnicity include non-Hispanic white (reference), non-Hispanic black, Hispanic, and other. Census region where the respondent resided at the initial interview in 1992 is coded as Northeast (reference), Midwest, South, and West. Baseline marital status is dichotomized to distinguish between those who were married (reference) and those who were not married in 1992. All controls are based on baseline information and are treated as time-invariant covariates in the analysis to keep the modeling approach parsimonious. There is no missing data on the control variables except for marital status where fewer than 0.5% are missing. Educational attainment is measured as the highest grade of school or college completed, and ranges from no formal education to post-baccalaureate level. The modal educational attainment for the sample is a high school diploma; there were fewer than 0.6% missing values for this variable. The observations with missing educational attainment are excluded from analyses.

Analytic approach

Our modeling strategy comprises two parts: first, we estimate the growth mixture models (GMM) of BMI trajectories; second, we predict survival as a function of membership in different BMI trajectory classes.

The GMM is a longitudinal model that aims to capture population heterogeneity in how a latent variable changes over time. The simplest case of a GMM is a latent growth model, where all individual in a population are assumed to follow the same general trajectory. Latent class growth model allows for heterogeneity in a population’s growth trajectory: each individual is 'sorted' into a specific class, and the model estimate its mean trajectory. Finally, GMM also estimate variation of trajectories within each class.

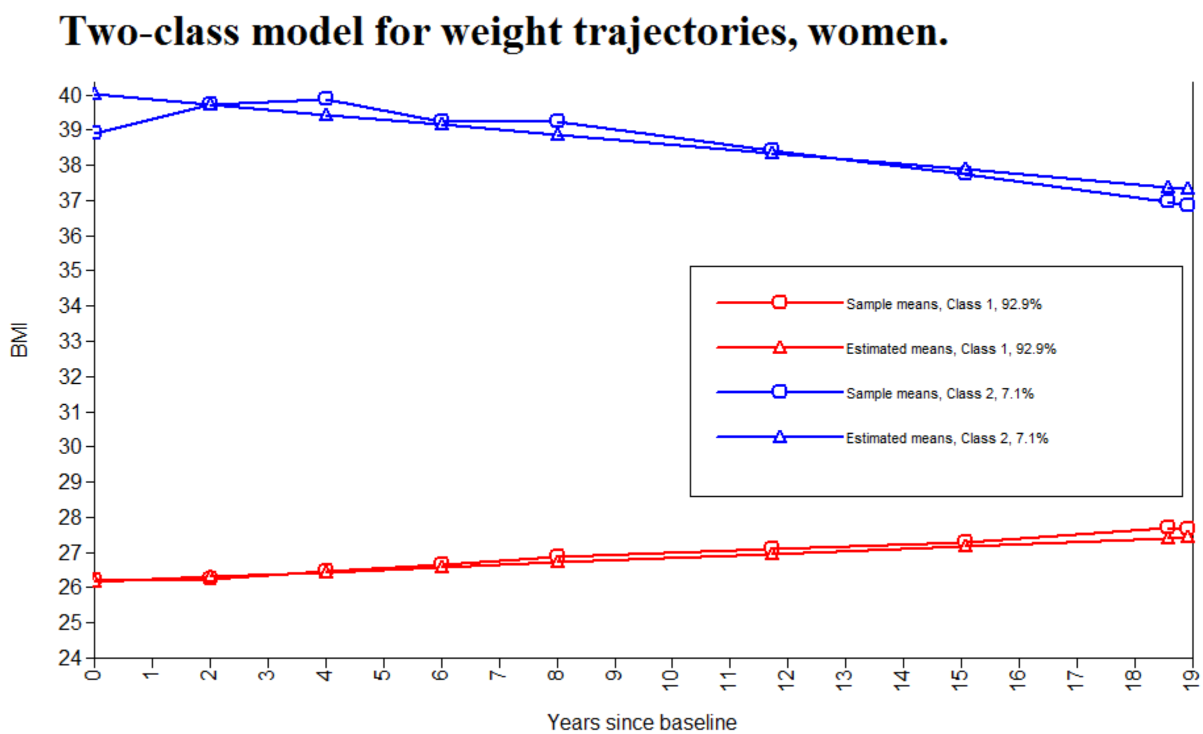
The second part of the modeling is a Cox proportional hazard model, estimating the time to death as a function of membership in a specific BMI trajectory class, controlling on a set of basic sociodemographic correlates.

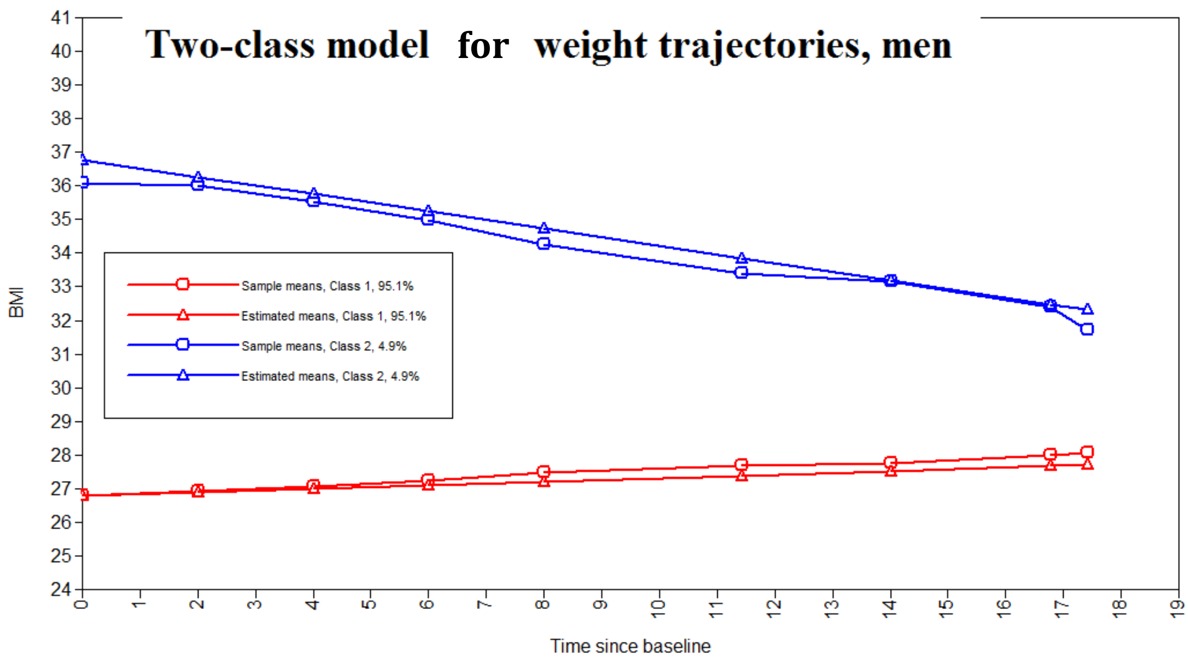
We use multiple indices to evaluate the fit of the models to the data. Chi-square serves as a formal statistical method for evaluating models: a non-significant result indicates a good fit to the data. Since this measure of model fit is sensitive to large sample sizes, we study the ratio of chi square to the degrees of freedom, which indicates a good fit to the data at values less than 2 (Mueller 1996; Hu and Bentler 1998). Additional indices include the comparative fit index (CFI), which indicates a good fit to the data at values above 0.95, while the root mean square error of approximation (RMSEA) should be less than 0.05 (see Hu and Bentler 1998). Descriptive statistics are conducted with Stata 11 (StataCorp 2009). Multivariate analyses are conducted with Mplus 5.21 (Muthén&Muthén 2009), using one of the available full-information maximum likelihood (FIML) estimators (Asparouhov 2005). We will conduct sensitivity analyses to determine the stability of findings across models calculated using different estimators. All FIML estimators accommodate missing data by calculating each model statistic using all available data for that particular statistic (Muthén and Muthén 2006). Unlike listwise deletion, FIML thus preserves information on individuals who drop out during the course of the study. Under the ignorable or missing at random (MAR) assumption (see Little and Rubin 1987), FIML produces unbiased parameter estimates (Wothke 2000).

PRELIMINARY AND EXPECTED FINDINGS

Preliminary analyses indicate that a two-class model fits the data best for both men and women. The first class is characterized by an upward trajectory that begins at a BMI level in the middle of the overweight range (BMI ~ 26.0 for women and ~27.0 for men) and increases over time toward the upper boundary of the overweight category. The second class is characterized by a downward trajectory that starts with a BMI level considered to be class II obesity (~ 39.0-40.0 for women and ~36.0-37.0 for men) and declines over time. The majority of the study subjects, over 90%, falls into the first class; only a small proportion, 3-5%, are in the second class. The estimated classes for women and men are shown in the figures below.

In the second part of the analysis, we will estimate how the membership in either BMI trajectory class influences the individual's risk of dying. We will also conduct an extensive set of diagnostics and model-specification analyses.





References.

Adams, K. F., A. Schatzkin, et al. (2006). "Overweight, Obesity, and Mortality in a Large Prospective Cohort of Persons 50 to 71 Years Old." New England Journal of Medicine **355**(8): 763-778.

Allison, D. B., M. Heo, et al. (1997). "Examination of "Early Mortality Exclusion" as an Approach to Control for Confounding by Occult Disease in Epidemiologic Studies of Mortality Risk Factors." American Journal of Epidemiology **146**(8): 672-680.

Asparouhov, T. (2005). "Sampling Weights in Latent Variable Modeling." Structural Equation Modeling: A Multidisciplinary Journal **12**(3): 411 - 434.

Bales, C. W. and C. S. Ritchie (2002). "Sarcopenia, weight loss, and nutritional frailty in the elderly." Annual Review of Nutrition **22**: 309-323.

Berraho, M., C. Nejjari, et al. (2010). "Body Mass Index, Disability, and 13-Year Mortality in Older French Adults." Journal of Aging and Health **22**(1): 68-83.

Flegal, K. M., B. I. Graubard, et al. (2007). "Cause-Specific Excess Deaths Associated With Underweight, Overweight, and Obesity." JAMA **298**(17): 2028-2037.

Flegal, K. M., B. L. Graubard, et al. (2005). "Excess Deaths Associated with Underweight, Overweight, and Obesity." JAMA **293**(15): 1861-1867.

Flegal, K. M. P., M. D. M. Carroll, et al. (2010). "Prevalence and Trends in Obesity Among US Adults, 1999-2008. ." JAMA **303**(3): 235-241.

Flicker, L., K. A. McCaul, et al. (2010). "Body Mass Index and Survival in Men and Women Aged 70 to 75." Journal of the American Geriatrics Society **58**(2): 234-241.

Freedman, D. S., E. Ron, et al. (2006). "Body Mass Index and All-cause Mortality in a Nationwide US Cohort." International Journal of Obesity **30**: 822-829.

Greenberg, J. A. (2001). "Biases in the Mortality Risk Versus Body Mass Index Relationship in the NHANES-1 Epidemiologic Follow-Up Study." International Journal of Obesity **25**(7): 1071-1078.

Greenberg, J. A. (2006). "Correcting Biases in Estimates of Mortality Attributable to Obesity." Obesity **14**(11): 2071-2079.

Greenberg, J. A., K. R. Fontaine, et al. (2007). "Putative Biases in Estimating Mortality Attributable to Obesity in the US Population." International Journal of Obesity **31**: 1449-1455.

Gronniger, J. T. (2006). "A Semiparametric Analysis of the Relationship of Body Mass Index to Mortality " American Journal of Public Health **96**(1): 173-178.

Hedley, A. A., C. L. Ogden, et al. (2004). "Prevalence of Overweight and Obesity Among US Children, Adolescents, and Adults, 1999-2002." JAMA **291**(23): 2847-2850.

Hodes, R. J. and R. Suzman (2007). Growing older in America: The health and retirement study. Bethesda, MD, National Institute on Aging, National Institute of Health, U.S. Department of Health and Human Services.

Hu, L.-t. and P. M. Bentler (1998). "Fit Indices in Covariance Structure Modeling: Sensitivity to Underparameterized Model Misspecification." Psychological Methods **3**(4): 424-453.

Janssen, I. (2007). "Morbidity and Mortality Risk Associated With an Overweight BMI in Older Men and Women." Obesity **15**(7): 1827-1840.

Juster, F. T. and R. Suzman (1995). "An Overview of the Health and Retirement Study." The Journal of Human Resources **30**(ArticleType: primary_article / Issue Title: Special Issue on the Health and Retirement Study: Data Quality and Early Results / Full publication date: 1995 / Copyright © 1995 The Board of Regents of the University of Wisconsin System): S7-S56.

Kolata, G. (2007). Chubby Gets a Second Look. The New York Times. New York, NY.

Little, R. J. A. and D. B. Rubin (1987). Statistical Analysis with Missing Data. New York, John Wiley.

McGee, D. L. (2005). "Body Mass Index and Mortality: A Meta-Analysis Based on Person-Level Data from Twenty-Six Observational Studies." Annals of Epidemiology **15**(2): 87-97.

Mehta, N. K. and V. W. Chang (2009). "Mortality Attributable to Obesity Among Middle-Aged Adults in the United States." Demography **46**(4): 851-872.

Mueller, R. O. (1996). Basic Principles of Structural Equation Modeling. New York, NY, Springer.

Muthén, B. and L. K. Muthén (2006). Mplus User's Guide. Los Angeles, CA, Muthén & Muthén.

Muthén&Muthén (2009). Mplus 5.21. Los Angeles, CA.

Prospective Studies, C. (2009). "Body-Mass Index and Cause-Specific Mortality in 900,000 Adults: Collaborative Analyses of 57 Prospective Studies." The Lancet **373**(9669): 1083-1096.

RAND Corp. (2010). RAND HRS Data, Version J [Data file]. Santa Monica, CA, RAND. Available from: http://www.rand.org/labor/aging/dataprod.

StataCorp (2009). Stata Statistical Software: Release 11.0. College Station, TX: StataCorp LP. College Station, TX.

Troiano, R. P., E. A. Frongillo, et al. (1996). "The Relationship Between Body Weight and Mortality: a Quantitative Analysis of Combined Information from Existing Studies." International Journal of Obesity **20**(1): 63-75.

Wothke, W. (2000). Longitudinal and Multi-Group Modeling with Missing Data. Modeling Longitudinal and Multiple Group Data: Practical Issues, Applied Approaches and Specific Examples. T. D. Little, K. U. Schnabel and J. Baumert. Mahwah, NJ, Lawrence Erlbaum Publishers**:** 219-240.

Zamboni, M. M., G.; Zoico, E.; Harris, T.B.; et al. (2005). "Health Consequences of Obesity in the Elderly: A Review of Four Unresolved Questions." International Journal of Obesity **29**(9): 1011-1029.

Zhang, X., X. O. Shu, et al. (2008). "Body mass index at various ages and mortality in Chinese women: impact of potential methodological biases." International Journal of Obesity **32**(7): 1130-1136.