Using Cumulative Risk Models to Link Social Disadvantage to Obesity Risk in the Transition to Young Adulthood

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Abstract

I assess the relationship between social disadvantage in childhood and adolescence and obesity trajectories from adolescence into young adulthood using cumulative risk models and nationally representative data from the National Longitudinal Study of Adolescent Health (Add Health). The cumulative risk model assumes that it is the accumulation of risk factors across a variety of domains, rather than a single risk factor that is important in adversely impacting child developmental and health outcomes. I utilize multiple measures of health/obesity risk and multinomial logistic regression models to investigate what factors place individuals at risk for obesity, which populations (defined by sex, race/ethnicity and poverty) face greater levels of cumulative risk, if risk factors operate in a cumulative manner (where higher levels of risk are associated with higher levels of obesity risk) and if cumulative risk measures mediate the relationship between poverty status and obesity and ethnic minority status and obesity.

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The prevalence of obesity/overweight in the U.S. has dramatically risen in both children and adults in the past four decades (Ogden et al. 2002). This rise in overweight has become a serious public health concern, especially as it relates to children. Obesity/overweight is now the second leading cause of death for all age groups in the U.S. (Mokdad et al. 2004). Overweight children are likely to become overweight adults (Dietz 1998; Reilly et al. 2003; Serdula et al. 1993; Whitaker et al. 1997). Obesity in adulthood is a risk factor for a number of chronic diseases and disorders such as type 2 diabetes, heart disease, stroke, respiratory disorders, some cancers and infertility (Willet, Dietz and Colditz 1999). Overweight/obese children may also experience hypertension, high cholesterol, and abnormal glucose tolerance, risk factors for cardiovascular disease and diabetes. Obesity/overweight in adolescence is also related to a number of negative social and economic outcomes. Overweight adolescents may endure prejudice and suffer from low self-esteem (Dietz 1998; Reilly et al. 2003). They also complete fewer years of education, are less likely to marry, and have a lower household income as adults, independent of their family's socioeconomic status (Gortmaker et al. 1993; Sobal and Stunkard 1989).

The highest rates of obesity occur among the most disadvantaged population groups, those with the highest poverty rates and the least education (Drewnowski and Specter 2004; Schoenborn, Adams and Barnes 2002; DHHS 2000). Although there is a general positive relationship between socioeconomic disadvantage and obesity (Flegal et al. 1998, Flegal et al. 2002)[1], what is less understood are the aspects of social disadvantage that contribute to the risk of obesity. In other words, although researchers know that being poor, black, and/or Hispanic places an individual at risk for obesity (Drewnowski and Specter 2004; Gordon-Larsen et al. 2003; Kimm et al. 1996; Patterson et al.1997; Schoenborn, Adams and Barnes 2002), researchers are less clear about what factors place

[1] The relationship between socioeconomic status and obesity is less consistent for males (Flegal et al. 2002).

these population groups at a higher risk for obesity than other population groups.

There has been an extensive amount of research in both the social science and public health arenas that attempts to measure socioeconomic status (SES) (see Bravemen et al. 2005 for a review), as well as socioeconomic disadvantage (e.g. Brooks-Gunn and Duncan 1997; Duncan, Brooks-Gunn and Klebanov 1994; Duncan et al. 1998), especially as it relates to health and important child developmental outcomes. One theme that can be drawn from this research is that SES is a complex, multidimensional construct that is comprised of diverse factors (e.g. economic resources, education, prestige, power), operating at different levels (e.g. individual, family, neighborhood), and working through different causal pathways (e.g. via direct causal effects, determining vulnerabilities or exposures) (Bravemen et al. 2005). Therefore, a better understanding of the relationship between socioeconomic disadvantage and obesity will entail capturing the many factors that comprise this construct.

The argument that SES (or disadvantage) is a complex, multidimensional construct is not new. The life course (Elder et al. 1995; Elder, Nguyen and Caspi 1985) and ecological perspectives (Bronfrenbrenner 2005; Bronfrenbrenner and Morris 1998) both contain arguments that social disadvantage should be measured at multiple ecological levels, over time, and via different processes. Capturing the complex and dynamic nature of the social context of disadvantage is especially important when studying the transition to adulthood (Elder 1997; Shanahan 2000) as well as health development, including the development of chronic diseases such as obesity (Ben-Schlomo and Kuh 2000; Halfon and Hochstein 2002; Lynch and Smith 2005). In addition, the transition period from adolescence to young adulthood has been shown to be a lifecycle period of particular risk for the development of obesity (Gordon-Larsen et al. 2004a; McTigue, Garrett and Popkin, 2002).

A related argument originating from the ecological perspective (Bronfrenbrenner and Morris 1998) and life course literature (Elder 1998), is the idea that social disadvantage may be cumulative. Social disadvantage is related to the accumulation of multiple environmental and social risk factors

rather than a singular exposure (Evans 2004; Rutter 1979; Sameroff 1987a). Socially disadvantaged groups may be at higher risk for adverse health outcomes because they are exposed to a larger proportion of adverse social and physical environmental conditions than advantaged groups (Evans 2004).

This paper investigates the relationship between social disadvantage in childhood and adolescence and obesity trajectories from adolescence into young adulthood using cumulative risk models (e.g. Rutter 1979; Sameroff 1987a) and nationally representative data from the National Longitudinal Study of Adolescent Health (Add Health). These models have mainly been used in human development and epidemiological research examining child outcomes such as cognitive development, mental health and behavior problems (e.g. Appleyard et al. 2005; Jones et al. 2002; Rutter 1979; Sameroff 1987a). They have recently been used to investigate child health outcomes (Bauman, Silver and Stein 2006; Evans 2003). This will be the first time these models will be used to examine the relationship between social disadvantage and obesity. Although, a large and growing body of research has investigated the relationship between SES and obesity among adults (e.g. Casas et al. 2001; Drewnowski and Specter 2004; Flegal et al.1998; Kuczmarski et al. 1994; Must, Gortmaker and Dietz 1994; Paeratakul et al. 2002; Sobal and Stunkard 1989; Stunkard 1993; Sundquist and Johansson 1998; Zhang and Wang 2003), and among children and adolescents (e.g. Gibson 2004; Goodman 1999; Gordon-Larsen, Adair and Popkin 2003; Haas et al. 2003; Kimm et al. 1996; McMurray et al. 2000; Nelson, Chiasson and Ford 2004; Wang 2001; Winkleby et al. 1999), no research to date has employed the use of cumulative risk models to investigate this relationship.

Background

The Cumulative Risk Model

A "risk factor" is a term used in epidemiology to define a characteristic that is either directly or indirectly associated with risk of disease or other adverse health outcomes. Risk factors can be fixed at

birth (such as sex and race) or acquired via the social and physical environment as a person proceeds through their life (such as exposure to violence). "Risk profiles" are produced by creating a multifactorial model that represents the interplay of these multiple fixed and acquired factors. These profiles can be used to identify vulnerable members of our population, on whom prevention strategies and disease treatment can be focused (Risch et al. 2002).

Human development and sociological research on disadvantage, more specifically the ecological and life course paradigms, also emphasizes the idea that disadvantage is defined by multiple risks (Bronfrenbrenner 2005; Bronfrenbrenner and Morris 1998; Elder et al. 1985, 1995). Multiple risks co-occur across multiple domains of social context and accumulate over time in disadvantaged populations, with serious implications for future life chances and other developmental outcomes. The most disadvantaged individuals are those who are not only of low socioeconomic status measured in terms of family income or welfare receipt, but individuals who are also living in unstable families and poor and socially disorganized neighborhoods (Elder et al. 1985, 1995; Furstenberg et al. 1999).

The cumulative risk model assumes that it is the accumulation of risk factors across a variety of domains, rather than a single risk factor that is important in adversely impacting the developmental outcomes of children (e.g. Rutter 1979; Rutter and Quinton 1977; Sameroff 2000). As the number of risk factors increase, regardless of the specific risk factor, child development becomes increasingly compromised (Jones et al. 2002).

Cumulative risk models have their origin in human development and epidemiological research that investigates the effects of risk factors on child psychiatric disorders and cognitive development. The most notable studies that find evidence of cumulative risk on child outcomes are the Isle of Wight studies (Rutter 1979; Rutter et al. 1975, 1976) and the Rochester Longitudinal Study (Sameroff 2000; Sameroff et al. 1987a, 1987b, 1998).

Rutter and colleagues (1975) investigated the prevalence of mental disorders in 10-year old children in the Isle of Wight and the inner borough of London, England. They determined six risk

factors within the family environment that significantly correlated with childhood psychiatric disorders including: (1) severe marital discord; (2) low social status; (3) large family size or overcrowding; (4) paternal criminality; (5) maternal mental disorder and (6) foster placement. A direct association was found between the number of risk factors for child psychiatric disorder and the odds of a child having a clinical problem. While no single risk factor significantly increased risk for disorder, the presence of multiple risk factors contributed to increases in the likelihood of mental disorder in a linear fashion. In particular, a single risk factor did not considerably increase the risk of mental disorder in children, while the presence of two risk factors increased the likelihood of mental disorders four-fold and the presence of four risk factors increased the likelihood of mental disorders ten-fold. Rutter (1979) has argued that multiple risk factors "potentiated" each other so that the risk factors yielded much more of an impact when they were combined than when each risk factor was considered independently.

Sameroff and colleagues (1987b) collected data over a 20-year period in Rochester, New York to investigate the development of a group of children from the prenatal period through their early childhood. The focus of the study was to investigate the impact of parental schizophrenia on child development. They identified ten environmental risk factors [(1) maternal mental disorder; (2) high maternal anxiety; (3) rigid parental attitudes, beliefs, and values about child development; (4) observations of few positive parent–child interactions; (5) unskilled occupational status; (6) low maternal educational status; (7) minority group status; (8) single parenthood as a measure of low family social support; (9) stressful life events; and (10) large family size] which were combined to create a multiple risk score for each child. Similar to Rutter's study (1975), they found that the number of risk factors was associated with concurrent behavior problems in preschool (Sameroff et al. 1987b) and with later problem behavior, adolescent mental health and academic problems (Sameroff et al. 1998).

More recent research on risks finds that cumulative risk is associated with numerous negative child outcomes in mental health, behavior problems and cognitive and language development (e.g.

Appleyard et al. 2005; Atzaba-Poria, Pike and Deater-Deckard 2004; Burchinal et al. 2000; Carta et al. 2001; Deater-Deckard et al.1998; Dekovic 1999; Garbarino and Kostelny 1996; Jones et al. 2002; Liaw and Brooks-Gunn 1994; Stanton-Chapman 2004). Two recent studies have also found associations between cumulative risk and child health outcomes, such as stress, measured by cardiovascular and neuroendocrine parameters, body fat and allostatic load (Evans 2003) and overall health, activity limitation and rates of chronic conditions (Bauman et al. 2006). Taken together, these studies suggest that it is the number of factors in one's background, rather than a particular risk factor that potentially influences child development and health.

Advantages of Cumulative Risk Model

Cumulative risk models are an innovative way to measure social disadvantage as it relates to obesity transition for a number of reasons. As discussed earlier, contextual risk factors usually do not occur in isolation (Duncan et al. 1994, 1997; Evans 2004; Rutter 1979; Sameroff et al. 1987a, 1987b; Moore, Vandivere and Ehrle 2000). Contextual risk factors can be defined as aspects of an individual's environment that are associated with a higher likelihood of poor or negative outcomes such as compromised health. Disadvantaged children are usually exposed to a number of multiple environmental risk factors rather than to a singular exposure (Evans 2004). Concentrations of social and physical risk are usually centered on the poor and ethnic minorities (Schell 1997). For example poverty, poor housing quality, unemployment, father absence, family turmoil, violence and stressful life events are highly interrelated (Evans 2004; Chase-Lansdale and Brooks-Gunn 1995; McLoyd 1990; Wilson 1987). Important health conditions may arise from cumulative risk exposure, especially for low-income populations, that may not be observed by focusing on a singular risk factor in isolation (Evans and Marcynyszyn 2004). In addition, human development is shaped by these multiple and interrelated contextual factors and personal relationships (Bronfrenbrenner and Morris 1998; Elder 1998).

A cumulative risk index is able to capture these multiple and interrelated elements of contextual

risk in a simple yet comprehensive way. The measure is the number of risk factors that exists in a child's social environment. In addition, a cumulative risk index sidesteps the problems that arise by using correlated or overlapping contextual factors in multiple regression models. Including moderate to highly correlated parameters in a regression model can lead to deflated parameter estimates, concealing the actual statistical associations of individual predictors with the outcome variable (Kutner, Nachtsheim and Neter 2004). Using cumulative risk models allows a researcher to take advantage of a set of comprehensive measures of social context at multiple levels (e.g. individual, family, neighborhood) and over time (i.e. multiple waves of data collection) that is provided in the Add Health data. This comprehensive cumulative risk index may yield the most complete estimate of overall risk for a socially disadvantaged child (Luthar 1993). The model also has the capacity to be used by researchers and clinicians to assess the number of risks an adolescent or child can "tolerate" (Jones et al. 2002) before their risk of negative outcomes, such as obesity, increases. In addition, research has shown cumulative risk indices serve as a good control variable or succinct covariate to represent risk, when social risk is a hypothesized moderator (Burchinal et al. 2000).

Disadvantages of the Cumulative Risk Model

There are some disadvantages to using cumulative risk models. The main criticisms stem from the way that the index is constructed. A dichotomous classification of risk exposure is determined for each person either by a statistical cutoff for continuous variables (e.g. upper quartile, greater than one standard deviation above the mean) or on the basis of conceptual categorization for categorical variables (e.g. minority status, below the poverty line). These multiple risk categories are then summed to calculate cumulative risk (Rutter 1983, 1993).

Using this index assumes that environmental, social and personal risk factors are equivalent and can simply be summed to represent the accumulated amount of adversity faced by an individual (Evans 2003; Burchinal et al. 2000). This stands in stark contrast to traditional multiple regression models, which assume that the impact of each risk factor on the outcome of interest is separate, and usually

unequal or unique (Burchinal et al. 2000). However, there is evidence that shows that although each individual risk factor has a unique impact, each of these varying singular effects has much less explanatory power than a cumulative risk metric in explaining child developmental and health outcomes (e.g. Evans 2003; Rutter 1983, 1993; Sameroff 1998).

It has also been argued that cumulative risk indices cannot render information about the mechanisms through which contextual risk leads to poorer child outcomes (Ackerman et al. 1999) and, therefore, cannot be utilized for intervention or prevention efforts targeted at high risk children (Jones et al. 2002). However, this index can be used to identify high-risk children from low-risk children. In addition, this index can be used as an indicator that can be tracked over time to indicate childhood risk for obesity, similar to indices used to measure the risk of adverse child developmental outcomes (Moore et al. 2000). Lastly, this index can provide the public and policymakers with information about children whose social environments may predispose them to obesity risk.

Despite the fact that the cumulative risk model has consistently predicted negative child outcomes in previous research and may serve as a useful indicator of obesity risk, the weaknesses of the model should not be ignored. For the purposes of this analysis, cumulative risk models should not be seen as the best way to capture social risk, but as an alternative way to capture risks to health that incorporates the multidimensionality and complexity of the social world.

Research Questions and Conceptual Model

Four research questions guide the analysis of this paper and inform the conceptual model (See Figure 1).[2] Because I apply a new measurement approach (cumulative risk indices) in the investigation of obesity in adolescence and its trajectory into young adulthood, the research questions are exploratory in nature.

Question 1: ***What are the factors that place young people at risk for obesity?*** This question will be

[2] A discussion of the conceptual model is provided in the following section.

answered in two steps. First, I will identify measures of risk that have been discussed in the obesity literature as risk factors for obesity. To take advantage of the wide variety of measures available in the Add Health data, other risk factors discussed in the sociological and public health literature that have been hypothesized to be adversely related to child health will also be incorporated into the analysis. Second, I will perform bivariate analyses to test the relationship between the created risk measures and obesity in adolescence and young adulthood. Measures that are significantly related to obesity will be included in a cumulative risk index.

Question 2: ***Who faces the highest amounts of cumulative risk?*** The poverty literature indicates that the poor and ethnic minorities (i.e. Hispanics and African Americans) face higher levels of contextual risk than the non-poor and whites, respectively (Evans 2004; Chase-Lansdale and Brooks-Gunn 1995; McLoyd 1990; Wilson 1987). It has also been shown that females are more likely to be poor than males (Spraggins 2003). To answer this research question I will compare the average level of cumulative risk among these population subgroups (i.e. male, female, black, Hispanic, white, poor, non-poor) and combinations of these population subgroups (e.g. black female, Hispanic male, poor white male, non-poor Hispanic female).

Question 3: ***Do risk factors operate in a cumulative manner, such that higher levels of risk are associated with higher levels of obesity risk?*** To answer this question, I will use logistic and multinomial logistic regression to determine if the risk of obesity in adolescence and young adulthood and the risk of becoming or staying obese from adolescence into young adulthood increase, as the number of factors in the cumulative risk index increases.

Question 4: ***Do measures of cumulative risk mediate the relationship between race/ethnicity, poverty and obesity?*** I explore if cumulative risk plays a role in the relationship between poverty (and ethnic minority status) and the risk of becoming or staying obese from adolescence and into young adulthood by including the cumulative risk measure as a mediating variable in a multivariate model (see conceptual model).

Answering these questions will help to determine the utility of cumulative risk models as an indicator of obesity risk in the transition from adolescence into young adulthood. This analysis also extends the literature in multiple areas of research. It expands the application of a measure of risk traditionally used in child development and mental health literature. It supports the growing literature suggesting new directions in measuring the complexity and multidimensionality of socioeconomic status when studying health disparities (e.g. Braveman et al. 2005). Lastly, by using cumulative risk as a mediating measure, I help to better explain the relationship between minority status and obesity and poverty status and obesity.

Conceptual Model

The conceptual model (see Figure 1) provides the basic relationship between poverty status (and racial/ethnic minority status) and change in obesity status from adolescence into young adulthood. Poverty status acts as a confounder in the relationship between race/ethnicity and obesity. In this conceptual model for longitudinal analysis of Add Health data, the cumulative risk index mediates the relationship between these traditional measures of disadvantage (i.e. race/ethnicity and poverty status) and change in obesity status. Data from all three waves in Add Health are utilized, where poverty status (and race/ethnicity) is measured in childhood and adolescence, risk is measured in adolescence (Waves I and II), and obesity trajectories are constructed from data in adolescence (Wave II) and young adulthood (Wave III). All controls are measured at Wave I, the first data point in adolescence. Below the individual, family and neighborhood level factors that will be used to construct the cumulative risk index, as well as the specific theories that help to motivate these factors, will be discussed. Overall, I expect a positive relationship between minority status and obesity, and poverty and obesity in adolescence and young adulthood. I expect that poverty status to attenuate the relationship between race/ethnicity and obesity and I expect both the race/ethnicity and poverty effects on obesity will be mediated by the cumulative risk index.

Method

Data

Data come from the National Longitudinal Study of Adolescent Health (Add Health), which is an ongoing nationally representative, school-based study of adolescents in grades 7 to 12 that began in 1994. It was designed to explore the causes of health-related behaviors, with an emphasis on the influence of social context. In 1994 Add Health administered an In-School Questionnaire to every student attending school from a nationally representative sample of schools. A sample of 80 high schools and 52 middle schools from the U.S. was selected using a stratified cluster design. A subsample of individuals in these schools participated in the In-Home Interview in 1995 (Wave I), given an average of eight months after the In-School Survey, and again in 1996 (Wave II). In Wave III (2001-02), Wave I respondents were re-interviewed.

A parent, generally the mother, was also interviewed in Wave I. In-home adolescent questionnaires were administered by computer-assisted personal-interview (CAPI), as well as computer-assisted self-interview (CASI) for more sensitive questions. Ultimately, 20,745 in-home interviews were completed in Wave I; 17,713 parents answered child specific questions and 17,669 answered parent specific questions (more than one child was interviewed in some households). 14,738 in-home interviews were completed in Wave II (the seniors in Wave I were not followed). In Wave III 15,197 eligible original Wave I respondents completed the survey. In Wave I (WI), the age of participants ranged from 12 to 19 years, in Wave II (WII) from 13 to 20 years and Wave III (WIII) from 18 to 26 years.

Over 70% of the schools originally selected for the survey participated. Of the adolescents sub-sampled for the in-home questionnaires, 78.9% participated in WI. Parent interviews are available for 85% of these respondents. Of those eligible for participation in WII, 88.2% completed in-home interviews. Of those eligible for participation in WII, 77.4% completed in-home interviews.

The fact that the data set is longitudinal and nationally representative, with extensive measures

of socioeconomic status, health, race and ethnicity among other factors, makes it an ideal data set to investigate the relationship between disadvantage and obesity in adolescents. In addition, contextual data containing information on the characteristics of the neighborhoods and communities in which Add Health sample members lived in WI and WII have been linked to individual-level records. Harris and colleagues (2003) provides a more detailed description on the Add Health Study.

This study uses data from the Wave I In -Home and Parent Questionnaires as well as the follow-up Wave II and III surveys. This analysis is therefore limited to adolescents who participated in all three waves of the study, have completed Parent Questionnaires, and have complete measured height and weight data. Exclusions included seriously disabled respondents, pregnant females and racial and ethnic groups other than whites, blacks and Hispanics. After applying these data constraints and deleting the cases with missing data on covariates, the final study sample contains 6,995 (3,619 females and 3,376 males).

Measures

Table 1 provides means and standard errors of all measures used in this analysis for the full sample and by sex.

Minority Status: Race and ethnicity are self-reported at WI. Although Add Health allows for rich detail in measures of race and ethnicity, I include only non-Hispanic whites, non-Hispanic blacks and Hispanics in this analysis. Research shows that blacks and Hispanics are at a higher risk for obesity than whites and are more likely to be poor than whites. Asians do not share in this higher risk profile despite their minority status (Flegal et al. 2002). For these reasons and because of the overall focus of social disadvantage and the exploratory nature of this analysis, I limit the sample to these racial/ethnic groups. Race and ethnicity are measured in two ways. Dummy variables are used to designate black, Hispanic and white (reference group) respondents. In addition, a dummy variable is used to indicate if

an individual is either black or Hispanic (minority) or white (non-minority). Twenty-seven percent of total the sample is minority (15% are Non-Hispanic black and 12% are Hispanic).

Welfare/Poverty Status: Welfare/Poverty status is a dichotomous indicator of any welfare receipt before the age of eighteen or family income less than poverty level. This measure is constructed from data on the family's receipt of public assistance or welfare from WI and WII during adolescence in combination with a retrospective report at WIII on the receipt of welfare and public assistance prior to the age of eighteen. Using data from the WI Parent Questionnaire on reported annual income from 1994, family income is categorized as below poverty level if income was less than $16,000 (roughly the poverty level for a family of four in 1994). I chose a welfare- and income-based measure of poverty over an only income-based measure due to the large proportion of missing data on income (≈ 20%). Twenty-nine percent of the total sample received welfare prior to the age of eighteen and/or was living below poverty at WI.

Sex: A dummy variable is used to represent sex where '1' indicates female and '0' indicates male. This measure is constructed from responses in the WI In-Home Questionnaire. This measure was crosschecked with WII and WIII responses. I divide the full sample by sex for this analysis.

Urban Tract: A dummy variable is used to represent if a respondent lives in an urbanized areas using census data from WI. This measure serves as a control variable in the analysis.

Age: A continuous variables of self-reported age at WI (in years) is also used as a control variable in the analysis.

Risk Factors and Cumulative Risk Index Construction

The measures of risk used in this analysis are individual, family and neighborhood level measures that have been discussed in the sociological and public health literature as being theoretically or empirically linked to obesity or adverse child health outcomes. In order to be consistent with the cumulative risk literature (Appleyard et al. 2005), all risk variables are transformed into a dichotomous variable to

represent the presence or absence of the risk factor. For continuous variables, subjects that are in the top or bottom 20th to 30th percentile[3], depending on the measure, are coded as '1'. These fairly conservative cutoffs are used to ensure the presence of risk. The measures found to have a statistically significant relationship with obesity (excluding measures of poverty and minority status) will then be summed in a cumulative risk index (CRI) for each respondent.

Individual Level Risk Factors

I focus on individual level risk factors in the following domains: diet and eating patterns, physical activity, sleep and self-esteem. At the most basic level, weight gain is the result of calorie intake and calorie burn. Calorie intake is a function of both food quality and quantity. In general, irregular meal eating patterns and frequency (Ceru-Bjork, Andersson and Rossner 2001; Kant 1995; Speechly, Rogers and Buffstein 1999; Yang et al. 2006) and consuming restaurant and fast foods (French, Harnack and Jeffery 2000; McCrory et al. 1999) have all been found to be positively related to weight gain. Physical activity (calorie burn) and inactivity are also are important biological determinants of obesity (Epstein et al.1995, 1997). Inactivity, in particular, TV viewing, has been associated with obesity in cross-sectional studies of children, adolescents and adults (Gortmaker et al. 1996). Physical activity habits, and, specifically, inactivity, track significantly from adolescence into young adulthood (Gordon-Larsen, Nelson and Popkin 2004b; Raitakari, Porkka and Taimela 1994).

A growing number of epidemiological studies observe an association between short sleep duration and obesity (Gangwisch et al. 2005; Kohatsu et al. 2006; Patel et al. 2006; Reilly et al. 2005). Low levels of sleep have also been physiologically linked to heavier weight. Studies have demonstrated possible hormonal mechanisms that act via increased ghrelin and decreased leptin levels, which are positively linked with hunger and satiety, respectively (Spiegel et al. 2004a, 2004b; Taheri 2004). Low self-esteem has also been found to be positively related to obesity in adolescents (e.g.

[3] This cutoff serves as a rough guideline for the creation of risk measures.

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Poor Diet: Using responses from the WII In-Home Questionnaire, a dummy variable was created to indicate if the respondent ate at a "fast food type place—McDonald's, Kentucky Fried Chicken, Pizza Hut, Taco Bell, etc." at least three or more times in the seven days prior to their interview. Thirty-five percent of the respondents ate fast food at least three times in the week prior to their interview.

Skips Breakfast: Using responses from the WI and WII In-Home Questionnaires, a dummy variable was created to indicate whether the respondent skips breakfast. This variable indicated whether the respondent reported usually eating nothing for breakfast at WI and eating breakfast zero to two times in the seven days prior to their interview at WII. Eleven percent of respondents skip breakfast.

Lack of Physical Activity: Physical activity is measured by a standard physical activity behavior recall in Add Health that is similar, although not identical, to other self-report questionnaires that have been used and validated in other large scale epidemiological studies (e.g. Andersen et al. 1998). In WI and WII, a series of questions ask about participation in moderate to vigorous physical activity, including skating and cycling, exercise and active sports (5-8 metabolic equivalents or METs), in units of times per week. One MET represents the energy expenditure associated with quiet sitting. Respondents indicated the number of times in which they engaged in moderate to vigorous physical activity for each set of activities according to the following four categories: 0; 1-2; 3-4; and 5+ times per week. I sum the number of times that the respondent engaged in moderate to vigorous physical activity across the three categories of activities at each wave and then average the number of times across WI and WII to create a measure of the average number of bouts of physical activity during adolescence. This measure ranges from 0 to 18 bouts, with a mean of 6 bouts among females and almost 8 bouts among males. Individuals with 4.5 bouts or lower are categorized as being physically inactive. Females are more likely to be inactive (38%) than males (22%).

Inadequate Sleep: Using responses from the WI and WII In-Home Questionnaires, a dummy variable

is created to indicate whether the respondent reported usually sleeping less than 7 hours a week at both waves. A higher percentage of females (27%) experience short sleep duration than males (21%).

Low Self-Esteem: Self-esteem is measured from responses in the WI In-Home Questionnaire. Respondents were asked a series of six questions measuring the extent to which a respondent believes he/she feels loved and wanted, feels socially acceptable, likes himself/herself just the way he/she is, is doing everything right, has a lot to be proud of, believes he/she has a lot of good qualities. Respondents answered each question using a 5-point Likert Scale (Alpha=0.85). The answers to these questions are combined in a scale ranging from 1 (low self esteem) to 5 (high self esteem). The respondents with a score of 3.8 or less for reported self-esteem are classified as having low self-esteem. Females are also more likely to have low self-esteem (27%) than males (16%).

Family Level Risk Factors

I focus on family level risk factors in the following domains: cyclical income, health insurance status, family structure, parental education, number of siblings, parental monitoring and care of children and parental obesity. Trouble paying bills is a proxy for the cyclical income effect that is common in poor, usually welfare or food stamp reliant, households. If parents do not have enough money to pay family bills, and bills are due at the end of each month, this may indicate episodic food shortages with food restriction when money runs low and food binging of calorically-dense foods when money is again available leading to weight gain over time (Townsend et al. 2001). Health policy analysts have also identified lack of access to health care as a possible explanation for social class disparities in child health (Newacheck et al. 2000).

Studies have found that parental monitoring has an influence on children's food selections which impacts childhood obesity (e.g., Brown and Ogden 2004; Klesges et al. 1991; Robinson et al. 2001; Seibold, Knafl and Grey 2003). Poor parents are less able to monitor their children's diet and physical activity due to stress, lack of emotional resources, and time constraints if they work. Family

structure is highly correlated with poverty and is thought to be associated with parental monitoring as well (Hogan and Kitagawa 1985; McLanahan 1995). Parental education, related to poverty and family structure, may also affect parental monitoring, with less-educated parents monitoring their children less than higher-educated parents (Lareau 2002, 2003). Parental monitoring may also be compromised in large families. Research from a number of disciplines contain arguments that an increase in the number of siblings diminishes the time and material resources that parents can provide to each child, which can negatively affect child outcomes (see Heer 1986 for a review).

The quality of parent-child relationships has also been linked to adolescent obesity outcomes (e.g. Crossman et al. In Press). In addition, child maltreatment has been linked to a number of child developmental outcomes (see Crouch and Milner 1993 for a review) as well as obesity (Gustafson and Sarwer 2004; Selway 2006; Wiederman, Sansone and Sansone; Williamson et al. 2002). Previous research has also found significant positive relationships between adolescent obesity and parental obesity status, which can be contributed to parental role modeling of lifestyle and eating behavior, as well as genetic inheritance (Agras et al. 2004; Whitaker et al. 1997).

Trouble Paying Bills: Using data from the WI Parent Questionnaire, a dichotomous variable is created to indicate whether the respondent's parent reported having trouble paying bills. This measure is a proxy for cyclical income and is experienced by 17% of the sample.

No Health Insurance: Using data from the WI Parent Questionnaire, a dichotomous variable is created to indicate whether the respondent's parent reported that the respondent had health insurance. Eleven percent of respondents had no health insurance.

Single-Parent or Surrogate Parent Family: Rich detail is available on adolescents' living arrangements. Because risk factors need to be dichotomized, I classify adolescents into two categories. The "at risk" category consists of individual living in single mother, single father and surrogate parent (no biological parent in the household) families. Surrogate families include foster parents, stepparents,

grandparents, aunts, uncles, siblings, or other adults who act as parent figures. The "non risk" category consists of two biological or adoptive parents and stepfamilies that include a biological parent. Twenty-four percent of the sample lives in this "at risk" family arrangement.

Parental Education Less than High School: Using data from the WI Parent, In-Home and In-School Questionnaires, parents' education is measured as the higher of either mother's or father's education. The "at risk" category consists of parents with less than a high school degree or GED. Ten percent of the sample has a parent with less than a high school degree.

Large Number of Siblings: Respondents are coded as having a large number of siblings if they reported living with more than two siblings at WI (14% of respondents).

Unshared Family Meal Times: Data from WI was used to create a measure of whether a parent regularly eats the dinner meal with the adolescent during the week. Based on the question, "On how many of the past 7 days was at least one of your parents in the room with you while you ate your evening meal?" Responses of less than 4 days per week were coded as '1', for not eating dinner together regularly. Twenty six percent of the sample did not eat dinner regularly with their parent(s).

Lack of Parental TV and Food Monitoring: This measure involves adolescents' TV viewing (inactivity) and food consumption. Parental monitoring of TV viewing is also measured at WI by adolescent responses to the question, "Do your parents let you make your own decisions about how much television you watch?" Parental monitoring of eating is also measured at WI by adolescent responses to the question, "Do your parents let you make your own decisions about what you eat?" Respondents were coded as experiencing a lack of monitoring if the parent did not make the decision about the amount of adolescent TV viewing and food consumption. More than half (68%) the sample had parents who did not monitor their eating or TV habits.

No Curfew: This measure also uses data from WI adolescent responses to the question, "Do your parents let you make your own decisions about the time you must be home on weekend nights?" Respondent were coded as having no curfew if they answered the question affirmatively. A higher

percentage of males (34%) than females (25%) have no curfew.

High Parent-Child Conflict: High parent child conflict is measured at WI and WII by adolescent reports of whether they had a serious argument about their behavior with their mother or father within the last four weeks. If respondents reported having this type of argument in both WI and WII, I code high parent-child conflict as '1'. High conflict is evidenced in twenty four percent of the sample.

Lack of Parental Presence: This measure is constructed from respondent reports of the frequency with which their parents were home when they left for school, when they returned from school and when they went to bed (ranging from "never" to "always") at WI. Respondents were coded as having a lack of parental presence if a parent was reported as never being present for one or more of these three daily activities (25% of respondents).

Lack of Parent-Child Interaction: Parent-child interaction is created from data at WI. Respondents were asked to report the activities they engaged in with each parent in the past four weeks. Respondents could report up to nine activities ranging from going shopping to working on a school project. Respondents were reported as having a lack of parent-child interaction if the average number of activities they engaged in with their parent(s) was less than two in the past four weeks (30% of respondents).

Physical Abuse: Physical abuse is measured using reports from WIII Questionnaire. Respondents are classified as being physically abused if they reported that their parent or other adult caregivers had ever "slapped, hit, or kicked" them. Twenty-eight percent of the sample reported physical abuse.

Sexual Abuse: Sexual abuse is also measured using reports from WIII Questionnaire. Respondents are classified as being sexually abused if they reported that their parent or other adult caregivers had "touched [them] in a sexual way, forced [them] to touch [their parent or caregiver] in a sexual way, or forced [them] to have sexual relations." Four percent of the sample reported sexual abuse.

Parent Obese: Using reports from the Parent In-Home Questionnaire, a respondent was coded as having an obese parent if either their biological mother and/or biological father were reported as being

obese. Twenty four percent of the sample has an obese parent.

Neighborhood Level Risk Factors

I focus on neighborhood level risk factors in the following domains: family structure, poverty, unemployment, housing quality, crime and safety. Studies have found that neighborhood poverty is related to physical activity, and, therefore, obesity (e.g. Gordon-Larsen Nelson and Popkin 2006). Low-SES neighborhoods have reduced access to recreational facilities (Gordon-Larsen et al. 2006) and higher crime rates (e.g. Hannon 2005; Kling, Ludwig, and Katz, 2005), which limit physical activity (Gordon-Larsen, McMurray and Popkin 2000). The measures of risk used in this analysis try to capture the neighborhood context of social disadvantage.

High Proportion of Female Headed Households in Neighborhood: Neighborhood family structure comes from census data that is attached to the adolescent's home address at WI. I have chosen the census tract as the spatial unit most appropriate for the concept of neighborhood and use a measure of the percentage of households in the census tract that are female-headed with own children under the age of 18. The respondents living in neighborhood where 25% or more of the family households are female-headed households are coded as having a high level of female-headed households in their neighborhood. Twenty-one percent of the respondents in this sample live in this type of neighborhood.

High Neighborhood Poverty: Neighborhood poverty also comes from WI census tract measures. It is a measure of the proportion of families with income in 1989 below poverty level. The respondents living in neighborhoods where the proportion of families below poverty level in their neighborhood equals or exceeds 20% are coded as having a high level of neighborhood poverty. Twenty one percent of the respondents in this sample live in this type of neighborhood.

High Neighborhood Unemployment: Neighborhood unemployment also comes from WI census tract measures. It is a measure of the total unemployment rate. The respondents living in

neighborhoods where the unemployment rate in their neighborhood equals or exceeds 10% are coded as having a high level of unemployment (20% of respondents).

Low Neighborhood Housing Quality: Neighborhood housing quality comes from WI census tract measures. It is a measure of the proportion of vacant housing units. Respondents living in neighborhoods where 10% or more of the housing units are vacant are coded as having a low level of housing quality (29% of respondents).

High County-Level Crime: County crime comes from WI county level measures. It is a measure of the total crime rate per 100,000 in the reporting county. Respondents living in counties where the total crime rate exceeds or equals 7,500/100,000 are coded as having a high level of crime.[4] Nineteen percent of respondents in this sample live in counties of this type.

Unsafe Neighborhood: A measure of the respondent's perception of his/her neighborhood being unsafe to a respondent was created by responses to the question: "Do you usually feel safe in your neighborhood?" at WI. Nine percent of respondents felt unsafe in their neighborhood.

Outcome Variable

Obesity and Obesity Trajectories

Body mass index or BMI is used to measure obesity. BMI is a tool for indicating weight status in adults, computed by dividing an individual's body weight in kilograms by the square of his or her height in meters (i.e. weight/(height)^2). BMI is more highly correlated with body fat than any other indicator of height and weight (CDC and DHHS 2006). For adults over 20 years old, BMI falls into one of four categories: underweight, normal, overweight and obese. Adults with a BMI of 25 to 29.9 are categorized as overweight. Adults with a BMI of 30 or more are considered obese (NHLBI 1998, WHO 2000).

BMI is defined differently for children and adults. Age- and sex-specific BMI percentiles are used as growth references during childhood and adolescence because BMI changes at different rates by

[4] Add Health contains no neighborhood level measure of crime.

age and sex during normal developmental growth. In the United States, the 85th and 95th percentiles, based on nationally representative data from the 2000 growth curves of the Centers for Disease Control and Prevention (CDC), have been recommended for use in classifying persons as being overweight or at risk of overweight (CDC 2004). However, definitions of overweight based on these percentiles are not directly comparable to the adult definitions of obesity using specified cut points (NHLBI 1998, WHO 2000).

The ability to generate comparable prevalence measures between adult and adolescent measures of obesity or to calculate obesity incidence over the transition period from adolescence to young adulthood is limited by discrepancies between adolescent and adult definitions. The International Obesity Task Force (IOTF) developed BMI curves, which link childhood and adolescent BMI centiles to adult cut off points of BMI of 25 and 30 kg/m^2, and thus, allow greater consistency in the youth versus adult definitions. The BMI curves provide good comparative reference data during this transitional period (Cole et al. 2000). Because this analysis investigates the incidence of obesity from adolescence to young adulthood, the IOTF measures are used to determine obesity status among adolescents and young adults.

Obesity is measured at WII and WIII using BMI calculated from measured height and weight[5] using the IOTF cutoffs. Individuals are classified as obese if their BMI falls above the age- and sex-specific, IOTF 30 kg/m^2 cutpoint in adolescence at WII. For the young adults at WIII, the adult BMI cut point of 30 kg/m^2 is used. A 2X2 table of obesity status at WII by obesity status at WIII is then created to identify trajectories of obesity from adolescence into young adulthood. The dependent variable contains four trajectories that capture change and continuity in obesity status from Wave II to Wave III: *Become Obese* (respondent not obese at WII but obese at WIII); *Stay Obese* (obese at both WII and WIII); *Reduce Obesity* (obese at WII but not obese at WIII); and *Stay Non-Obese* (not obese at both waves). Because the proportion of individuals in the trajectory of reduce obesity is too small to

[5] Height and weight are self-reported at Wave I.

analyze and has a similar relationship with poverty, I combine this trajectory with the stay non-obese trajectory. The *Reduce Obesity*/*Stay Non-Obese* trajectory will serve as the reference category in analysis using obesity trajectories as outcomes. Table 1 shows that 12% of the sample became obese, 10% of the sample stayed obese and 77% of the sample either stayed non-obese or became non-obese at WIII. At WII 11% of the sample was obese and at WIII 22% of the sample was obesity, indicating a doubling in the prevalence of obesity in this sample in only 2 years.

Analysis

Analysis is guided by the four research questions discussed above. Analysis begins with examination of the bivariate relationship between risk factor measures and obesity outcomes using logistic regression in samples divided by sex.[6] Measures found to be significant will be included in a cumulative risk index (CRI). If bivariate relationships differ by sex, a separate CRI will be created for males and females.

The mean level of cumulative risk for female, male, white, black, Hispanic, poor, and non-poor population subgroups and combinations of these populations will be calculated to determine which population subgroup faces the highest amount of cumulative risk. The statistical significance of the difference between means will also be tested.

Exploratory analysis continues by using logistic and multinomial logistic regression models to test if the risk of obesity in adolescence and young adulthood and the risk of becoming or staying obese[7] from adolescence into young adulthood increases as the number of risk factors increases. Each level of risk will be entered into regression models as a dummy variable, using zero risks as the reference category. Regression models will control for age of respondent and urbanicity. The bivariate relationship between accumulated risk and obesity will also be investigated using cross

[6] Previous research using the Add Health data has shown that there are strong sex differences in the relationship between poverty and obesity, which suggests that the sample should be separated by sex (Lee, Harris and Gordon-Larsen 2005).
[7] This is compared to the trajectory of reducing from obese or staying non-obese.

tabulations with chi-squared tests used to determine statistical significance.

Multinomial logistic regression is then employed to examine the relationships displayed in the conceptual model (see Figure 1). Multinomial regression is appropriate when the dependent variable is an unordered nominal variable with n categories. The procedure estimates the log of the ratio of the probability of being in the n^{th} category relative to a base category (stay non-obese/reduce obesity), where the effects of independent variables are measured by the relative risk or odds (Long 1997). The fundamental model takes the form: $\text{logit}(P_j) = \log\left[\frac{P_j}{P_0}\right] = \beta'_{j0} + \beta_{j1}X_1 + \beta_{j2}X_2 + \beta_{j3}X_3 + \beta_{j4}X_4 ..... + \beta_{jk}X_k$ Multivariate analysis begins with a baseline model of the relationship between race/ethnicity and obesity trajectories. Model 2 enters welfare/poverty status. Model 3 enters the cumulative risk index as the intervening mechanism displayed in Figure 1. Model 4 enters control measures for age and urbanicity. To the extent that cumulative risk mediates the effects of poverty and race/ethnicity, we add to our understanding of the ways in which social disadvantage influences obesity trajectories from adolescence into young adulthood. Analysis adjusts for design effects inherent in the complex stratified cluster sampling used by Add Health.

Results and Conclusion

Results

What are the factors that place young people at risk for obesity?

Table 2 shows the relationship between measures of risk and obesity status at WII and WIII for the total sample and for females and males. Minority and welfare/poverty status are only related to obesity in the female sample, supporting previous research (Lee et al. 2005). Females are more likely to be obese at WII and WIII if they are black or Hispanic (versus white) and if they were poor and/or received welfare in childhood (versus no poverty or welfare receipt in childhood). More specifically, female minorities are 84% more likely to be obese at WII and 74% more likely to be obese at WIII than whites. Female respondents who were poor or received welfare in childhood are 93% more likely

to be obese at WII and 87% more likely to be obese at WIII than female respondents who wer not poor or did not receive welfare in childhood.

Among individual level risk factors, skipping breakfast, lack of physical activity and inadequate sleep all increase the likelihood of obesity at WII or WIII for both males and females. There is a particularly strong relationship between skipping breakfast and obesity at WIII for males. Males who skip breakfast at WI and WII are 165% more likely to be obese at WIII than makes who did not skip breakfast. There is a significant relationship between poor diet and obesity at WII for males, but the relationship is in an unexpected direction. Males who consumed fast food meals three or more times in the seven days prior to their interview are 32% less likely to be obese at WII than males who consumed fast food less than three times in the week prior to their interview. This measure may serve as an inadequate proxy to measure poor diet. Multiple 24-hour recalls or multiple days of diet records provide a more accurate assessment of dietary intake (Willet 1998). Low self-esteem increases the likelihood of obesity for females.

Among family level risks factors, only parental obesity, cyclical income and having no curfew were significantly related to obesity status at WII or WIII for both males and females. A strong relationship between parental obesity and child obesity exists for both males and females. Males and females having an obese parent are more than 100% more likely to be obese at WII or WIII than males and females who do not have an obese parent. Other measures of family risk are significantly related to obesity for females, including single of surrogate family structure, low parent education, lack of parent-child interaction and physical abuse. A significant relationship also exists between having a large number of siblings and obesity status for males, but it is in an unexpected direction. Males who have more than two siblings are less likely to be obese at WII than males with fewer siblings. This could be explained by the fact that Add Health only contains information on siblings currently living in the respondent's household. Therefore, this measure could be capturing families with younger children overall who are more active than families with older children who have left the family

household. There is also a significant relationship between having no health insurance and obesity at WII in the full sample that is not evidenced in the male and female samples. Interestingly, measures of lack of parental monitoring other than low interaction and having no curfew, were not significantly related to obesity. Not sharing regular meals with parents, lack of parental monitoring of what respondent eats or TV viewing and lack of parental presence when the respondent goes to school, comes home or goes to bed are not significantly related to obesity. High parent-child conflict and sexual abuse are also not significantly related to obesity in the male or female samples.

Although most measures of social disadvantage at the individual and family level (i.e. minority status, poverty status, low parent education) only increase risk of obesity for females, disadvantage at the neighborhood level increases risk of obesity for both males and females. A high percentage of female-headed families, high neighborhood poverty and high neighborhood unemployment are significantly related to obesity for both males and females. Low neighborhood housing quality is also significantly related to obesity for females. County level measures of crime and reports of neighborhood safety are not significantly related to obesity.

Because the relationship between the specified risk factors and obesity operate differently for males and females, separate indices are created for each group. Each index contains all significant risk factor relationships with obesity at WII or WIII for each sex group. The female cumulative risk index (F-CRI) includes fifteen risk factors: (1) skipping breakfast; (2) lack of physical activity; (3) inadequate sleep; (4) low self-esteem; (5) parental obesity; (6) trouble paying bills (cyclical income); (7) single or surrogate parent family; (8) low parent education; (9) no curfew; (10) lack of parent-child interaction; (11) physical abuse; (12) high percentage female headed households in neighborhood; (13) high neighborhood poverty; (14) high neighborhood unemployment and (15) low neighborhood housing quality.[8] The male cumulative risk index (M-CRI) contains a subset of the measures in the F-

[8] Correlations across all risk factor measures do not exceed 0.35 except for correlations between neighborhood female-headed households, poverty and unemployment, which range from 0.71 to 0.79 (Results not shown).

CRI including: (1) skipping breakfast; (2) lack of physical activity; (3) inadequate sleep; (4) parental obesity; (5) trouble paying bills (cyclical income); (6) no curfew; (7) high percentage female headed households in neighborhood; (8) high neighborhood poverty and (9) high neighborhood unemployment.[9] Having no health insurance is not included in the indices because it was not significantly related to obesity in the male or female samples.

No single respondent experiences all of the risk factors that are entered into the indices. The maximum number of risks experienced by a female is twelve (out of fifteen) and the maximum number of risks experienced by a male is eight (out of nine). Table 3 provides the percentage of individuals that fall into each level of risk. For the F-CRI, female respondents experiencing seven or more risk factors are collapsed into one category due to the small percentage of individuals experiencing seven or more risks. For the M-CRI, male respondents experiencing five or more risk factors are collapsed into one category. The distributions show that a majority of respondents experience at least one risk, with fewer respondents experiencing very high levels of risk or no risks. The mean level of risk experienced by females is about three risks (out of fifteen risks). The mean level of risk experienced by males is about two risks (out of nine risks).

Who faces the highest amounts of cumulative risk? [10]

Table 4 displays the mean level of cumulative risk out of the fifteen risk factors in the F-CRI[11] by sex, race/ethnicity and poverty status subgroups. In general, females experience a slightly higher level of risk than males, despite poverty status or race/ethnicity. Blacks experience the highest levels of risk, with poor blacks experiencing the largest mean levels of risk compared to all other sex, race/ethnicity

[9] Although poor diet and high siblings is significantly related to obesity for males, the relationship is in the opposite direction, and, therefore, is not included in the M-CRI.
[10] All differences in mean levels of risk discussed in this paper are significant to the $p<0.05$ level or less, unless stated otherwise.
[11] Mean risk out of the fifteen risk factors of the F-CRI is calculated for male subgroups for comparison purposes.

and poverty status subgroup combinations.[12] In addition, non-poor blacks face levels of risk similar to poor whites. The mean level of risk among non-poor blacks is 4.51 compared to 4.15 among poor whites. Hispanics also face higher levels of risks than whites. These patterns support previous research findings that the poor and minorities face multiple risks and experience more risks than the non-poor and non-minorities, respectively (e.g. Evans 2004). Similar patterns are evidenced when comparing the mean levels of cumulative risk out of the nine risk factors in the M-CRI (see Table 4A).

Do risk factors operate in a cumulative manner, such that higher levels of risk are associated with higher levels of obesity risk?

Table 5 shows the results of the logistic and multinomial logistic regression models of the relationship between the number of risks in the CRI and obesity status at WII and WIII and change in obesity status from WII to WIII for female, male and full samples.[13] The table also displays the percent of respondents who are obese at each wave or become or stay obese from WII to WIII as a function of the number risks in the CRI.

In the female sample, there is a strong and significant gradient in the percentage of respondents who are obese at WII or WIII as the number of risks in the F-CRI increases. Among respondents with no risk factors, 2% were obese at WII and 8% were obese at WIII. Among respondents with seven or more risk factors, 25% and 41% were obese at WII and WIII, respectively. A similar gradient can be evidenced among those who become obese or stay obese from WII to WIII (compared to those who reduce or stay-non obese).[14] The gradient is not as strong for those who become obese as a function of the number of risks in the F-CRI. Odd ratios follow a similar gradient that is also strong and significant. Because experiencing one risk was not significantly different from experiencing zero risks

[12] The difference between mean risk of poor black males and poor black females is not significant.
[13] Models control for age and urbanicity.
[14] In the discussion of results when "become obese" or "stay obese" are used it is assumed that this state is compared to the reference category of "reduce obese or stay non-obese."

in determining the odds of obesity at either wave in the female sample, the odds ratios were also calculated with experiencing zero or one risk factor as the reference group (see Table 5A). Compared with respondents with zero or one risk factor the, the odds of being obese at WIII increases from 1.99 (2 risks) to 2.28 (3 risks) to 2.94 (4 risks) to 4.28 (5 risks) to 5.65 (6 risks) to 6.73 (7 or more risks) in the female sample. The stepwise increase in odds for each additional risk factor is statistically significant in the female sample for all obesity outcomes.[15] This increase in odds is substantial. For females, respondents experiencing seven or more risk were 740% more likely to be obese at WII, 573% more likely to be obese at WIII, 381% more likely to become obese and 904% more likely to stay obese from WII to WIII than individuals experiencing zero or one risk. Similar gradients are evidenced in the full sample, which also uses the F-CRI.

Gradients in the relationship between obesity and number of risks in the male sample are less apparent than they are in the female or full samples, with variations in statistical significance and strength depending on the obesity outcome. The percent of respondents who are obese at each wave as a function of the number risks in the M-CRI does not steadily increase. This is also the case for those who become obese from WII to WIII. Gradients are clearer in the relationship between number of risks and obesity at WII and staying obese from WII to WIII. Despite the less clear gradients in the male sample, in general, the larger the number risks experienced by male respondents, the higher the likelihood that they will be obese at WII or WIII and become obese or stay obese from WII to WIII.

Do measures of cumulative risk mediate the relationship between race/ethnicity, poverty and obesity?

Tables 6A to 6C present the estimated odds ratios for multinomial logistic regression models that examine the relationships displayed in the conceptual model (see Figure 1) for female, male and full

[15] It should be noted that experiencing two risks was not statistically significant from experiencing zero or one risk for "stay obese" (versus reduce obese/stay non-obese) in the female sample.

samples, respectively. In model 1 for the female sample (see Table 6A), there is a significant relationship between being black and the likelihood of becoming obese and staying obese from WII to WIII. Black female respondents are 81% more likely to become obese and 129% more likely to stay obese than white female respondents. Hispanic females are also 61% more likely to stay obese compared to white females. When welfare/poverty status is added in model 2, the relationship between Hispanic ethnicity and stay obese becomes insignificant and the relationship between black and becoming or staying obese is slightly reduced. Poverty status acts as a confounder in the relationship between minority status and obesity as put forth in the conceptual model. Poverty status is significantly related to both becoming obese and staying obese from WII to WIII. Poor females are 68% more likely to become obese and 67% more likely to stay obese from WII to WIII. When the F-CRI is included in model 3, the relationship between black and obesity status and poverty status and obesity status becomes insignificant. This suggests that cumulative risk mediates the relationship between these traditional measures of disadvantage and obesity. Model 4 includes controls for age and urbanicity. The relationship between cumulative risk and obesity status remains the same. For each increase in risk in the F-CRI, a female's odds of becoming obese and staying obese from Wave II to Wave III increases by 20% and 35%, respectively.

Multinomial logistic regression results for the full sample, which also uses the F-CRI as the mediating cumulative risk measure, provides similar results (see Table 6C). However, Hispanic is not significantly related to staying obese in the full sample.

Table 6B provides multinomial logistic regression results for the male sample. Neither race/ethnicity nor poverty status are significantly related to the obesity trajectories. However, the M-CRI is significantly related to both becoming obese and staying obese. In the final model (model 4), for each increase in risk in the M-CRI, a male's odds of becoming obese and staying obese from Wave II to Wave III increases by 22% and 51%, respectively. In these models, the M-CRI cannot be classified as a mediating measure given that race/ethnicity and poverty status are not significantly

related to obesity for males.[16]

Discussion and Conclusion

Using nationally representative data, I assessed the relationship between cumulative representations of risk in childhood and adolescence and obesity trajectories from adolescence into young adulthood. This research is one of the few studies to examine the relationship between models of cumulative risk and health outcomes beyond mental or psychiatric disorders. To my knowledge, it is also the first time these models are used to examine the relationship between social disadvantage and obesity. This analysis contributes to the research on obesity among children and adolescents by using a longitudinal design that allows for the tracking of obesity trajectories beginning in adolescence and continuing through the transition to young adulthood. This longitudinal design is used to sort out the temporal ordering of the effects by measuring poverty and race/ethnicity in childhood and adolescence, the intervening mechanisms (i.e. mechanisms included in the cumulative risk index) of the ways in which poverty may operate on obesity also during adolescence, and obesity outcomes as trajectories from adolescence to young adulthood. This design is effective for examining prior effects on subsequent outcomes through time.[17] Finally, this analysis uses dynamic measures of both poverty and obesity, and a measure of cumulative risk that attempt to capture the multi-factorial causes of obesity.

The analysis reveals that numerous individual, family and neighborhood level factor serve as significant risk factors for obesity in adolescence and young adulthood. The relationship between risk factors and obesity operates differently for males and females, necessitating the construction of separate cumulative risk indices for females (F-CRI) and males (M-CRI). A larger number of risk factors were significantly related to obesity outcomes for females than for males. The M-CRI was

[16] Estimated regression coefficients for multinomial models are presented in the Appendix in Tables 7A to 7C.
[17] It should be noted that this model is not able to establish causal relationships.

actually made up of a subset of the fifteen risk factors that made up the F-CRI. Females' obesity status is vulnerable to many aspects of the family environment such as low parent education, single or surrogate family structure, lack of parent-child interaction and physical abuse where is not for males. Interestingly, although family level poverty status was not significantly related to obesity in males, neighborhood poverty was significantly related to obesity in males.

Further analysis showed that females experience slightly higher levels of risk than males. In addition, the poor face higher levels of risk than the non-poor. However, it is blacks who experience the highest levels of risk, especially poor blacks. Non-poor blacks face levels of risk equivalent to poor whites, highlighting the vulnerability of this racial/ethnic group and reinforcing notions that the poor and ethnic minorities face multiple risks and experience more risks the non-poor and whites, respectively.

Analysis found that risk factors do operate in a cumulative manner, such that higher levels of risk are associated with higher levels of obesity risk. This relationship is more apparent and stronger for females than for males. The gradient between increasing number of risks and likelihood of obesity is also more apparent for staying obese than for becoming obese from WII to WII (versus stay non-obese or reduce obese). The fact that cumulative risk models work better in determining risk of obesity for females than for males is an interesting finding that deserves further research, as does the lack of a significant relationship between traditional measures of disadvantage (i.e. racial/ethnic minority status and welfare/poverty status) and obesity in males.

Cumulative risk indices also completely mediated the relationships between race (being black) and poverty status with obesity in the female sample. This means that the experiences captured in the F-CRI serve as intervening mechanisms through which poverty affects obesity and through which race is related to obesity. The relationship between Hispanic ethnicity and staying obese from adolescence into young adulthood is due to the higher rates of poverty among Hispanic females. The M-CRI was also significant in the male samples but did not serve as an intervening mechanism due to the fact that

race/ethnicity and poverty were not significantly related to obesity. This provides evidence that the cumulative risk model is able to capture experiences at the individual, family and neighborhood level faced by adolescents that place them at risk for obesity. The evidence is quite clear, however, that it is the poor and racial/ethnic minorities who will face more of these risks than other groups.

By utilizing the cumulative risk model as an intervening mechanism through which poverty and race are related to obesity, this research contributes to an understanding of the processes of obesity development during childhood. The cumulative risk model provides evidence that individuals facing multiple risks at multiple levels of social context are most vulnerable to becoming obese and staying obese from adolescence and into young adulthood. Although one of the weaknesses of the cumulative risk model is that is cannot identify which aspect of a individual's social context make them most vulnerable to obesity, it does indicate that as the number of risk factors (in a CRI) experienced by a individual increases, the higher the likelihood that individual will become or stay obese in young adulthood.

Despite weaknesses in the cumulative risk model noted previously, this analysis illustrates its utility as an overall indicator of risk for obesity. In addition, the cumulative risk model is able to use the numerous measures available in Add Health at multiple levels of social context in a way that cannot be not be done in a traditional multivariate model where each measure would be a separate predictor. The cumulative risk indicator also contributes to racial/ethnic health disparities research. African Americans may face higher levels of obesity risk because they experience a higher level of contextual risk factors compared to other races, regardless of poverty status. Lifestyle and other modifiable risk factors included in the cumulative risk index, such no curfew, short sleep duration, lack of physical activity and skipping breakfast could be targeted as possible interventions since they work cumulatively, along with other factors to increase obesity risk. In sum, cumulative risk models provide an alternative and useful approach to capture risks to health that incorporate the multidimensionality and complexity of the social world.

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Figure 1. Conceptual Model

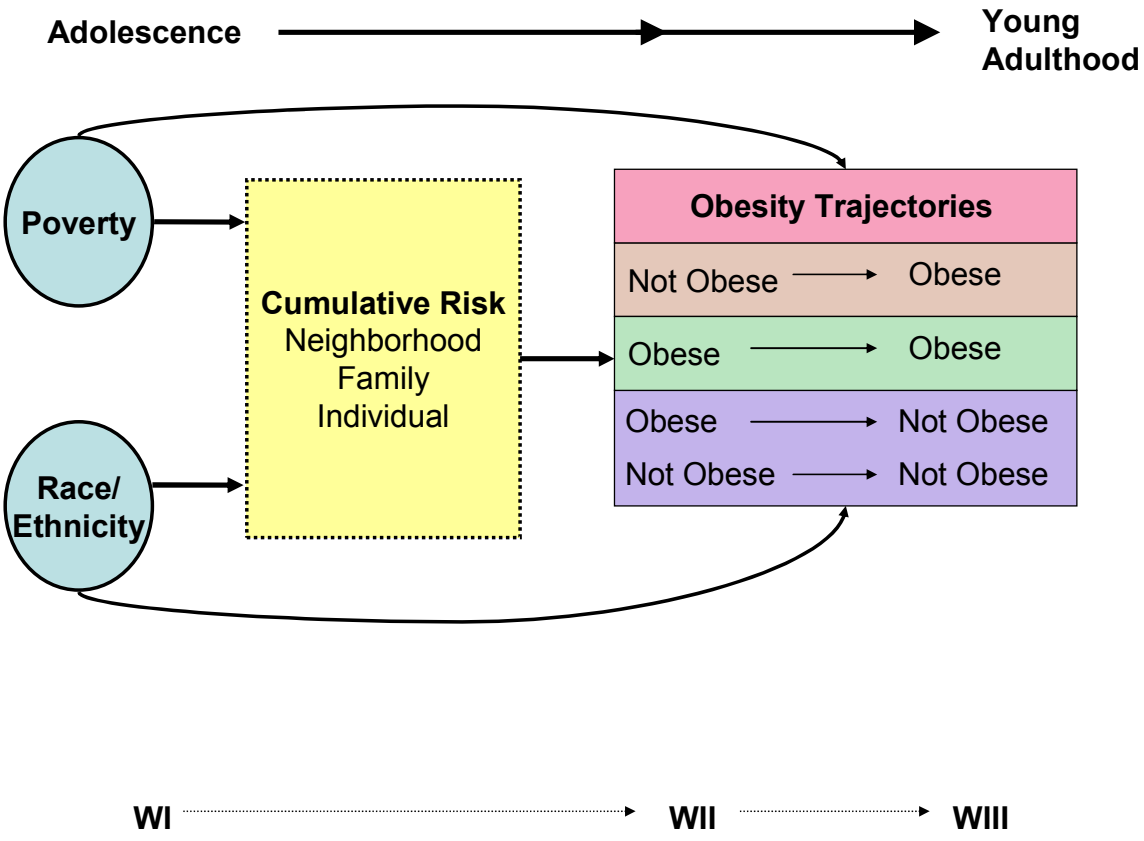

Table 1. Variable Descriptions, Means and Standard Deviations by Sex

		Female		Male		Total	
Variable	Description	Mean	SD	Mean	SD	Mean	SD
OUTCOME MEASURES							
Change in Obesity Status							
Become Obese	Not obese at WII but obese at WIII	0.13	0.009	0.11	0.007	0.12	0.006
Stay Obese	Obese at WII & obese at WIII	0.10	0.008	0.09	0.008	0.10	0.006
Reduce Obese or Stay Non-Obese	Obese at WII but not obese at WIII or Not obese at WII & not obese at WIII	0.77	0.013	0.79	0.011	0.78	0.010
Static Measures of Obesity							
Obese at Wave II	Obese at Wave II	0.11	0.009	0.12	0.008	0.11	0.007
Obese at Wave III	Obese at Wave III	0.23	0.013	0.21	0.011	0.22	0.010
SOCIAL DISADVANTAGE MEASURES							
Minority Status	Respondent reported black or Hispanic	0.26	0.029	0.27	0.029	0.27	0.028
Non-Hispanic White (Reference Category)	Respondent reported white	0.74	0.029	0.73	0.029	0.73	0.028
Non-Hispanic Black	Respondent reported black	0.15	0.022	0.15	0.022	0.15	0.021
Hispanic	Respondent reported Hispanic	0.11	0.018	0.12	0.019	0.12	0.018
Welfare/Poverty Status	Welfare receipt prior to the age of 18 and/or Family Income less than $16,000/year	0.29	0.018	0.29	0.018	0.29	0.017
RISK MEASURES							
Individual Level Risk							
Poor Diet	WII Consumption of fast food 3+ times in a week	0.32	0.013	0.37	0.015	0.35	0.012
Skips Breakfast	Respondent reported usually skips breakfast at WI and reported skips breakfast 0-2 days in a week	0.13	0.007	0.09	0.007	0.11	0.006
Lack of Physical Activity	Physically Inactive at WI and WII	0.38	0.012	0.22	0.012	0.30	0.011
Inadequate Sleep	Respondent reported usually sleeping less than 7 hours at WI and WII	0.27	0.013	0.21	0.012	0.24	0.011
Low Self Esteem	WI measure of low-self-esteem	0.27	0.010	0.16	0.009	0.21	0.007
Family Level Risk							
Parent Obese	Report of mother or father being obese	0.23	0.010	0.24	0.010	0.24	0.007
Trouble Paying Bills	Parent reports not having money to pay the bills at WI	0.17	0.012	0.16	0.013	0.17	0.010
No Health Insurance	Parent reports respondent has no health insurance at WI	0.12	0.012	0.11	0.009	0.11	0.009
Single of Surrogate Parent Family	Single mother, single father or other family structure *[**Reference Category:** 2 Biological/Adoptive parents or step family with one biological parent]*	0.24	0.012	0.25	0.015	0.24	0.112
Large Number of Siblings	Respondent has more than 2 siblings	0.14	0.012	0.14	0.008	0.14	0.008
Parent Education Less than High School	Highest educated parent completed less than high school or GED	0.10	0.011	0.09	0.012	0.10	0.010
Lack of Parent TV and Food Monitoring	Parent does not monitor how much TV respondent viewed or what respondent eats at WI	0.70	0.012	0.66	0.015	0.68	0.011
N		3,619		3,376		6,995	

Data are weighted.

Table 1 Cont. Variable Descriptions, Means and Standard Deviations by Sex

		Female		Male		Total	
Variable	Description	Mean	SD	Mean	SD	Mean	SD
RISK MEASURES							
Family Level Risk							
No Curfew	Respondent reports having no curfew at WI.	0.25	0.010	0.34	0.014	0.30	0.010
Unshared Family Meals	Parents eat with respondent less than 4 times/week at WI	0.26	0.013	0.27	0.013	0.26	0.011
Lack of Parent-Child Interaction	Respondent reports engaging in less than two activities with parent(s) in the past 4 weeks at WI	0.27	0.012	0.33	0.012	0.30	0.010
Lack of Parental Presence	Respondent reports parent not present for 1 or more of 3 daily activities: leaving/returning for/from school and going to bed	0.27	0.013	0.23	0.011	0.25	0.010
High Parent-Child Conflict	Respondent had serious argument with parent at WI and WII	0.27	0.010	0.22	0.010	0.24	0.008
Physical Abuse	Respondent reported physical abuse in childhood	0.27	0.012	0.29	0.011	0.28	0.008
Sexual Abuse	Respondent reported sexual abuse in childhood	0.04	0.005	0.04	0.005	0.04	0.003
Neighborhood Level Risk							
High Proportion of Female Headed Households	Respondents live in a census tract with 25% or more female headed household with own children < 18 yr. old at WI	0.22	0.031	0.20	0.028	0.21	0.029
High Neighborhood Poverty	Respondent lives in a census tract with 20% or more families below poverty at WI	0.21	0.031	0.21	0.029	0.21	0.029
High Neighborhood Unemployment	Respondent lives in a census tract where the total unemployment rate is greater than or equal to 10%	0.20	0.030	0.19	0.028	0.20	0.028
Low Neighborhood Housing Quality	Respondent lives in a census tract with 10% or more of the housing units are vacant at WI	0.28	0.032	0.29	0.033	0.29	0.031
High County Level Crime	Respondent lives in a county where crime rates are greater than 7,500/100,000 at WI	0.19	0.035	0.20	0.036	0.19	0.035
Neighborhood Unsafe	Respondent reports that their neighborhood is unsafe	0.10	0.009	0.09	0.009	0.09	0.008
Control Measures							
Age at Wave I	Age at WI	14.86	0.119	15.07	0.123	14.97	0.118
Urban Tract	Respondent lives in an urbanized area	0.52	0.046	0.50	0.046	0.51	0.045
N		3,619		3,376		6,995	

Data are weighted.

Table 2. Associations Between Risk Measures and Obesity Status at Waves II and III by Sex (Bivariate Odds Ratios)

	Female		Male		Total	
	Obese Wave II	**Obese Wave III**	**Obese Wave II**	**Obese Wave III**	**Obese Wave II**	**Obese Wave III**
SOCIAL DISADVANTAGE MEASURES						
Minority Status	1.84***	1.77***	1.05	1.09	1.38**	1.40**
	(0.295)	(0.227)	(0.173)	(0.142)	(0.167)	(0.146)
Welfare/Poverty Status	1.93***	1.87***	1.30	1.19	1.57****	1.50***
	(0.301)	(0.244)	(0.208)	(0.157)	(0.160)	(0.131)
RISK MEASURES						
Individual Level Risk						
Poor Diet	0.79	0.92	0.68*	0.90	0.73**	0.90
	(0.112)	(0.089)	(0.104)	(0.110)	(0.076)	(0.068)
Skips Breakfast	1.68*	1.52**	1.80*	2.65***	1.71***	1.96***
	(0.352)	(0.237)	(0.416)	(0.437)	(0.256)	(0.229)
Lack of Physical Activity	1.41*	1.37**	1.65**	1.42**	1.47***	1.41***
	(0.205)	(0.157)	(0.240)	(0.181)	(0.154)	(0.127)
Inadequate Sleep	1.16	1.39**	1.69**	1.56	1.39*	1.48***
	(0.185)	(0.140)	(0.281)	(0.203)	(0.181)	(0.124)
Low Self Esteem	1.67**	1.57***	1.36	1.12	1.49**	1.40***
	(0.270)	(0.163)	(0.259)	(0.163)	(0.189)	(0.117)
Family Level Risk						
Parent Obese	4.32***	2.70***	3.56***	2.72***	3.90***	2.71***
	(0.649)	(0.287)	(0.481)	(0.284)	(0.388)	(0.209)
Trouble Paying Bills	1.53*	1.41*	1.58*	1.17	1.56**	1.29*
	(0.305)	(0.201)	(0.364)	(0.203)	(0.238)	(0.148)
No Health Insurance	1.05	1.30	1.00	1.26	1.02	1.29*
	(0.254)	(0.189)	(0.266)	(0.24)	(0.184)	(0.150)
Single of Surrogate Parent Family	1.55**	1.48**	1.28	1.12	1.41**	1.29*
	(0.245)	(0.197)	(0.190)	(0.134)	(0.158)	(0.126)
Large Number of Siblings	1.09	1.07	0.53**	0.76	0.78	1.12
	(0.238)	(0.665)	(0.114)	(0.129)	(0.190)	(0.134)
Parent Education Less than High School	1.85**	2.15***	1.15	1.05	1.47*	1.56**
	(0.430)	(0.315)	(0.294)	(0.260)	(0.227)	(0.222)
Lack of Parent TV and Food Monitoring	1.11	1.09	1.09	1.10	1.10	1.10
	(0.210)	(0.118)	(0.160)	(0.110)	(0.116)	(0.073)
N	3,619	3,619	3,376	3,376	6,995	6,995

Data are weighted.

Standard errors are in parentheses

* significant at .05 level

** significant at .01 level

*** significant at .001 level

Table 2 Cont. Associations Between Risk Measures and Obesity Status at Waves II and III by Sex (Bivariate Odds Ratios)

	Female		Male		Total	
	Obese Wave II	**Obese Wave III**	**Obese Wave II**	**Obese Wave III**	**Obese Wave II**	**Obese Wave III**
RISK MEASURES						
Family Level Risk						
No Curfew	1.49**	1.26*	1.31*	1.11	1.39***	1.16
	(0.219)	(0.139)	(0.150)	(0.112)	(0.125)	(0.085)
Unshared Family Meals	1.18	1.01	1.06	1.15	1.11	1.07
	(0.176)	(0.111)	(0.176)	(0.164)	(0.132)	(0.102)
Lack of Parent-Child Interaction	1.35	1.30*	1.17	1.04	1.26*	1.14
	(0.212)	(0.162)	(0.198)	(0.133)	(0.134)	(0.097)
Lack of Parental Presence	1.01	1.00	1.23	1.07	1.11	1.04
	(0.175)	(0.104)	(0.206)	(0.147)	(0.150)	(0.095)
High Parent-Child Conflict	0.95	1.01	0.83	1.06	0.89	1.04
	(0.160)	(0.104)	(0.135)	(0.131)	(0.110)	(0.086)
Physical Abuse	1.18	1.31*	1.08	1.28	1.13	1.29**
	(0.206)	(0.143)	(0.203)	(0.167)	(0.148)	(0.110)
Sexual Abuse	0.78	1.36	1.93	1.51	1.29	1.44
	(0.242)	(0.346)	(0.649)	(0.450)	(0.323)	(0.264)
Neighborhood Level Risk						
High % Female Headed Households	1.98***	1.86***	1.61**	1.36	1.77***	1.60**
	(0.359)	(0.307)	(0.244)	(0.234)	(0.247)	(0.235)
High Neighborhood Poverty	2.24***	2.01***	1.75**	1.57**	1.97***	1.78***
	(0.400)	(0.304)	(0.288)	(0.261)	(0.262)	(0.243)
High Neighborhood Unemployment	2.14***	2.14***	1.31	1.46*	1.67**	1.78***
	(0.370)	(0.323)	(0.249)	(0.257)	(0.245)	(0.247)
Low Neighborhood Housing Quality	1.45*	1.45*	1.14	1.04	1.28	1.23
	(0.243)	(0.210)	(0.205)	(0.132)	(0.171)	(0.137)
High County Level Crime	1.44	1.31	1.16	1.02	1.28	1.15
	(0.270)	(0.207)	(0.174)	(0.133)	(0.164)	(0.130)
Neighborhood Unsafe	1.27	1.29	1.36	1.12	1.31	1.21
	(0.289)	(0.210)	(0.288)	(0.208)	(0.197)	(0.153)
N	3,619	3,619	3,376	3,376	6,995	6,995

Data are weighted.

Standard errors are in parentheses

* significant at .05 level

** significant at .01 level

*** significant at .001 level

Table 3. Variable Means and Standard Deviations for Cumulative Risk Index and Distributions by Sex

	Female		Male		Total	
Cumulative Risk Index	Mean	SD	Mean	SD	Mean	SD
Female Cumulative Risk Index	3.48	0.129			3.37	0.124
Number of Risk Factors						
0	0.06	0.007			0.07	0.007
1	0.14	0.012			0.15	0.010
2	0.18	0.012			0.18	0.010
3	0.17	0.009			0.17	0.008
4	0.14	0.009			0.14	0.006
5	0.12	0.008			0.11	0.007
6	0.09	0.009			0.08	0.007
7+	0.10	0.012			0.09	0.013
F-CRI	3.48	0.129			3.37	0.124
Male Cumulative Risk Index			1.86	0.093	1.96	0.092
Number of Risk Factors						
0			0.21	0.014	0.19	0.092
1			0.28	0.014	0.27	0.013
2			0.21	0.011	0.22	0.009
3			0.14	0.009	0.15	0.008
4			0.09	0.010	0.09	0.009
5+			0.07	0.013	0.08	0.012
M-CRI			1.86	0.093	1.96	0.092
	N	3,619		3,376		6,995

Data are weighted.

Table 4. Mean Cumulative Risk Level by Sex, Race/Ethnicity and Welfare/Poverty Status

Out of 15 Risk Factor F-CRI	Female	Male	Total
Total	3.48 (0.129)	3.26 (0.128)	3.37 (0.124)
White	3.01 (0.126)	2.79 (0.115)	2.90 (0.114)
Black	5.33 (0.233)	5.04 (0.214)	5.18 (0.206)
Hispanic	4.04 (0.182)	3.93 (0.195)	3.98 (0.170)
Poor	4.89 (0.168)	4.51 (0.171)	4.70 (0.154)
Poor White	4.29 (0.194)	4.02 (0.203)	4.15 (0.178)
Poor Black	6.13 (0.287)	5.60 (0.226)	5.86 (0.225)
Poor Hispanic	5.00 (0.198)	4.61 (0.274)	4.80 (0.193)
Non-Poor	2.90 (0.104)	2.76 (0.099)	2.83 (0.096)
Non-Poor White	2.65 (0.106)	2.42 (0.086)	2.53 (0.089)
Non-Poor Black	4.50 (0.227)	4.52 (0.221)	4.51 (0.199)
Non-Poor Hispanic	3.31 (0.226)	3.48 (0.215)	3.40 (0.195)
N	3,619	3,376	6,995

Data are weighted.

Standard errors are in parentheses

Table 4A. Mean Cumulative Risk Level by Sex, Race/Ethnicity and Welfare/Poverty Status

Out of 9 Risk Factor M-CRI	Female	Male	Total
Total	2.05 (0.098)	1.86 (0.093)	1.96 (0.092)
White	1.74 (0.102)	1.55 (0.088)	1.64 (0.114)
Black	3.47 (0.150)	3.13 (0.148)	3.30 (0.136)
Hispanic	2.26 (0.127)	2.17 (0.134)	2.21 (0.117)
Poor	2.86 (0.127)	2.52 (0.134)	2.69 (0.119)
Poor White	2.44 (0.161)	2.13 (0.173)	2.28 (0.156)
Poor Black	3.86 (0.171)	3.42 (0.150)	3.64 (0.136)
Poor Hispanic	2.69 (0.137)	2.54 (0.175)	2.61 (0.098)
Non-Poor	1.73 (0.083)	1.59 (0.073)	1.66 (0.074)
Non-Poor White	1.54 (0.085)	1.37 (0.065)	1.46 (0.072)
Non-Poor Black	3.06 (0.180)	2.86 (0.172)	2.95 (0.151)
Non-Poor Hispanic	1.93 (0.152)	1.92 (0.145)	1.92 (0.126)
N	3,619	3,376	6,995

Data are weighted.

Standard errors are in parentheses

Table 5. Relationship between Cumulative Risk Index and Obesity Outcomes

					Change in Obesity From WII to WIII			
15 Item Cumulative Risk Index	Obese at WII		Obese at WIII		Become Obese		Stay Obese	
Female Sample	**%**	**OR**	**%**	**OR**	**%**	**OR**	**%**	**OR**
Number of Risk Factors								
0	***1.83***	1.00	***7.99***	1.00	***6.19***	1.00	***1.80***	1.00
(Reference Group)								
1	***4.29***	**2.36**	***10.33***	**1.33**	***6.26***	**1.05**	***4.07***	**2.29**
		(1.508)		(0.487)		(0.461)		(1.492)
2	***7.20***	**4.07***	***17.56***	**2.45***	***11.79***	**2.15***	***5.77***	**3.52**
		(2.285)		(0.840)		(0.843)		(2.039)
3	***8.49***	**4.81****	***19.52***	**2.82****	***11.69***	**2.23***	***7.83***	**4.86****
		(2.629)		(0.920)		(0.825)		(2.723)
4	***9.68***	**5.51****	***23.79***	**3.63*****	***14.85***	**3.01****	***8.93***	**5.82****
		(2.993)		(1.237)		(1.208)		(3.252)
5	***15.69***	**9.54*****	***31.19***	**5.28*****	***17.91***	**4.04*****	***13.28***	**9.57*****
		(5.264)		(1.691)		(1.543)		(5.418)
6	***19.31***	**12.32*****	***37.36***	**6.98*****	***19.33***	**4.80*****	***18.03***	**14.32*****
		(6.459)		(2.236)		(1.947)		(7.657)
7+	***24.62***	**16.55*****	***41.41***	**8.31*****	***18.46***	**4.99*****	***22.95***	**19.28*****
		(8.678)		(2.800)		(2.010)		(10.436)
N	3,619							

					Change in Obesity From WII to WIII			
9 Item Cumulative Risk Index	Obese at WII		Obese at WIII		Become Obese		Stay Obese	
Male Sample	**%**	**OR**	**%**	**OR**	**%**	**OR**	**%**	**OR**
Number of Risk Factors								
0	***3.80***	1.00	***10.90***	1.00	***7.90***	1.00	***3.01***	1.00
(Reference Group)								
1	***7.83***	**2.29***	***16.04***	**1.56***	***9.73***	**1.26**	***6.32***	**2.32***
		(0.754)		(0.317)		(0.281)		(0.828)
2	***15.22***	**5.10*****	***23.86***	**2.55*****	***11.62***	**1.61***	***12.24***	**5.11*****
		(1.522)		(0.499)		(0.364)		(1.687)
3	***15.16***	**5.17*****	***29.20***	**3.39*****	***16.37***	**2.46*****	***12.83***	**5.84*****
		(1.681)		(0.652)		(0.556)		(1.916)
4	***18.55***	**6.82*****	***26.29***	**2.95*****	***12.87***	**1.84**	***13.42***	**6.00*****
		(2.401)		(0.856)		(0.615)		(2.569)
5+	***23.04***	**9.36*****	***33.74***	**4.23*****	***14.69***	**2.30*****	***19.05***	**9.73*****
		(3.513)		(1.125)		(0.581)		(4.035)
N	3,376							

Standard errors are in parentheses
* significant at .05 level
** significant at .01 level
*** significant at .001 level

Data are weighted.
Percentages significant at p < .001 level
Reference Category for Change in Obesity is "Stay Non-Obese or Reduce Obese"
Logistic and multinomial logistic regression models control for age and urbanicity.

Table 5 Cont. Relationship between Cumulative Risk Index and Obesity Outcomes

					Change in Obesity From WII to WIII			
15 Item Cumulative Risk Index	Obese at WII		Obese at WIII		Become Obese		Stay Obese	
Full Sample	**%**	**OR**	**%**	**OR**	**%**	**OR**	**%**	**OR**
Number of Risk Factors								
0	***1.53***	1.00	***9.29***	1.00	***8.06***	1.00	***1.23***	1.00
(Reference Group)								
1	***4.31***	**2.94****	***10.67***	**1.17**	***6.61***	**0.83**	***4.06***	**3.38***
		(1.199)		(0.284)		(0.219)		(1.587)
2	***9.08***	**6.60*****	***18.63***	**2.23****	***10.96***	**1.49**	***7.67***	**7.04*****
		(2.907)		(0.565)		(0.416)		(3.365)
3	***10.86***	**8.07*****	***20.50***	**2.52*****	***11.58***	**1.63***	***8.92***	**8.40*****
		(3.596)		(0.599)		(0.398)		(4.488)
4	***11.45***	**8.69*****	***23.79***	**3.04*****	***14.07***	**2.04****	***9.72***	**9.60*****
		(3.948)		(0.729)		(0.525)		(5.160)
5	***15.87***	**12.77*****	***29.91***	**4.18*****	***16.45***	**2.61*****	***13.46***	**14.52*****
		(5.739)		(1.027)		(0.648)		(7.800)
6	***18.61***	**15.45*****	***31.56***	**4.55*****	***16.65***	**2.73*****	***14.91***	**16.48*****
		(6.989)		(1.191)		(0.764)		(8.855)
7+	***22.01***	**19.37*****	***35.47***	**5.41*****	***15.95***	**2.76*****	***19.51***	**23.03*****
		(9.000)		(1.489)		(0.782)		(12.628)
N	6,995							

Standard errors are in parentheses
* significant at .05 level
** significant at .01 level
*** significant at .001 level

Data are weighted.
Percentages significant at $p < .001$ level
Reference Category for Change in Obesity is "Stay Non-Obese or Reduce Obese"
Logistic and multinomial logistic regression models control for age and urbanicity.

Table 5A. Relationship between Cumulative Risk Index and Obesity Outcomes

Cumulative Risk Index	Obese at WII		Obese at WIII		Change in Obesity From WII to WIII: Become Obese		Change in Obesity From WII to WIII: Stay Obese	
Female Sample	**%**	**OR**	**%**	**OR**	**%**	**OR**	**%**	**OR**
Number of Risk Factors								
0 or 1 (Reference Group)	***3.58***	1.00	***9.65***	1.00	***6.24***	1.00	***3.41***	1.00
2	***7.20***	**2.07***	***17.56***	**1.99****	***11.79***	**2.07****	***5.77***	**1.84**
		(0.617)		(0.411)		(0.535)		(0.574)
3	***8.49***	**2.44***	***19.52***	**2.28*****	***11.69***	**2.15*****	***7.83***	**2.54***
		(0.908)		(0.415)		(0.456)		(0.986)
4	***9.68***	**2.80***	***23.79***	**2.94*****	***14.85***	**2.90*****	***8.93***	**3.03****
		(1.104)		(0.599)		(0.755)		(1.223)
5	***15.69***	**4.85*****	***31.19***	**4.28*****	***17.91***	**3.89*****	***13.28***	**4.99*****
		(1.688)		(0.914)		(0.912)		(1.870)
6	***19.31***	**6.26*****	***37.36***	**5.65*****	***19.33***	**4.63*****	***18.03***	**7.46*****
		(2.313)		(1.341)		(1.388)		(2.863)
7+	***24.62***	**8.40*****	***41.41***	**6.73*****	***18.46***	**4.81*****	***22.95***	**10.04*****
		(3.125)		(1.614)		(1.338)		(3.822)
N	3,619							

Cumulative Risk Index	Obese at WII		Obese at WIII		Change in Obesity From WII to WIII: Become Obese		Change in Obesity From WII to WIII: Stay Obese	
Male Sample	**%**	**OR**	**%**	**OR**	**%**	**OR**	**%**	**OR**
Number of Risk Factors								
0 or 1 (Reference Group)	***6.12***	1.00	***13.86***	1.00	***8.95***	1.00	***4.91***	1.00
2	***15.22***	**2.97*****	***23.86***	**1.93*****	***11.62***	**1.40**	***12.24***	**2.94*****
		(0.0539)		(0.276)		(0.364)		(0.587)
3	***15.16***	**3.01*****	***29.20***	**2.57*****	***16.37***	**2.13*****	***12.83***	**3.36*****
		(0.622)		(0.365)		(0.412)		(0.679)
4	***18.55***	**3.96*****	***26.29***	**2.23****	***12.87***	**1.60**	***13.42***	**3.44*****
		(0.990)		(0.538)		(0.502)		(1.041)
5+	***23.04***	**5.42*****	***33.74***	**3.19*****	***14.69***	**1.99****	***19.05***	**5.57****
		(1.468)		(0.701)		(0.441)		(1.714)
N	3,376							

Standard errors are in parentheses
* significant at .05 level
** significant at .01 level
*** significant at .001 level

Data are weighted.
Percentages significant at $p < .001$ level
Reference Category for Change in Obesity is "Stay Non-Obese or Reduce Obese"
Logistic and multinomial logistic regression models control for age and urbanicity.

Table 5A Cont. Relationship between Cumulative Risk Index and Obesity Outcomes

					Change in Obesity From WII to WIII			
Cumulative Risk Index	**Obese at WII**		**Obese at WIII**		**Become Obese**		**Stay Obese**	
Full Sample	**%**	**OR**	**%**	**OR**	**%**	**OR**	**%**	**OR**
Number of Risk Factors								
0 or 1	***3.41***	1.00	***10.23***	1.00	***7.07***	1.00	***3.15***	1.00
(Reference Group)								
2	***9.08***	**2.87*****	***18.63***	**2.00*****	***10.96***	**1.69***	***7.67***	**2.70*****
		(0.670)		(0.339)		(0.355)		(0.689)
3	***10.86***	**3.51*****	***20.50***	**2.27*****	***11.58***	**1.84*****	***8.92***	**3.23*****
		(0.852)		(0.323)		(0.294)		(0.870)
4	***11.45***	**3.77*****	***23.79***	**2.73*****	***14.07***	**2.31*****	***9.72***	**3.68*****
		(1.000)		(0.404)		(0.392)		(1.022)
5	***15.87***	**5.55*****	***29.91***	**3.76*****	***16.45***	**2.96*****	***13.46***	**5.57*****
		(1.362)		(0.587)		(0.475)		(1.527)
6	***18.61***	**6.71*****	***31.56***	**4.09*****	***16.65***	**3.09*****	***14.91***	**6.32*****
		(1.804)		(0.757)		(0.650)		(1.848)
7+	***22.01***	**8.41*****	***35.47***	**4.87*****	***15.95***	**3.12*****	***19.51***	**8.83*****
		(2.350)		(0.975)		(0.675)		(2.714)
N	6,995							

Standard errors are in parentheses
* significant at .05 level
** significant at .01 level
*** significant at .001 level

Data are weighted.
Percentages significant at p < .001 level
Reference Category for Change in Obesity is "Stay Non-Obese or Reduce Obese"
Logistic and multinomial logistic regression models control for age and urbanicity.

Table 6A. Estimated Multinomial Odds Ratios for Obesity Trajectories for Female Sample (N=3,619)

(Reference Category is "Stay Non-Obese or Reduce Obese")

	Model 1		Model 2		Model 3		Model 4	
	Become Obese	Stay Obese	Become Obese	Stay Obese	Become Obese	Stay Obese	Become Obese	Stay Obese
Minority Status								
Black	1.81 **	2.29 ***	1.56 *	1.98 ***	1.15	1.14	1.16	1.15
	(0.337)	(0.424)	(0.292)	(0.374)	(0.229)	(0.217)	(0.233)	(0.216)
Hispanic	1.42	1.61 *	1.28	1.44	1.14	1.19	1.23	1.21
(White: Reference Category)	(0.285)	(0.356)	(0.268)	(0.321)	(0.242)	(0.268)	(0.273)	(0.284)
Welfare/Poverty Status			1.68 ***	1.67 **	1.27	1.00	1.26	1.01
			(0.249)	(0.295)	(0.192)	(0.174)	(0.193)	(0.175)
Cumulative Risk Index					1.19 ***	1.36 ***	1.20 ***	1.35 ***
					(0.043)	(0.065)	(0.042)	(0.064)
Age at WI							0.98	1.04
							(0.045)	(0.048)
Urbanicity							0.82	0.97
							(0.114)	(0.169)
Psuedo Log Likelihood	-4221424.6	-4221424.6	-4191823.4	-4191823.4	-4069512.2	-4069512.2	-4065321.5	-4065321.5
Psuedo R Squared	0.0100	0.0100	0.0169	0.0169	0.0456	0.0456	0.0466	0.0466

Data are weighted.

Standard errors are in parentheses

* significant at .05 level

** significant at .01 level

*** significant at .001 level

Table 6B. Estimated Multinomial Regression Odds Ratios for Obesity Trajectories for Male Sample (N=3,376)

(Reference Category is "Stay Non-Obese or Reduce Obese")

	Model 1		Model 2		Model 3		Model 4	
	Become Obese	**Stay Obese**	**Become Obese**	**Stay Obese**	**Become Obese**	**Stay Obese**	**Become Obese**	**Stay Obese**
Minority Status								
Black	1.19	1.30	1.17	1.20	0.86	0.70	0.88	0.68
	(0.250)	(0.260)	(0.244)	(0.262)	(0.190)	(0.174)	(0.189)	(0.174)
Hispanic	0.95	0.89	0.94	0.850	0.840	0.70	0.870	0.73
(White: Reference Category)	(0.201)	(0.223)	(0.200)	(0.215)	(0.186)	(0.183)	(0.196)	(0.203)
Welfare/Poverty Status			1.06	1.32	0.91	0.98	0.92	0.97
			(0.164)	(0.256)	(0.142)	(0.198)	(0.148)	(0.194)
Cumulative Risk Index					1.24 ***	1.47 ***	1.22 ***	1.51 ***
					(0.062)	(0.091)	(0.060)	(0.096)
Age at WI							1.08	0.92
							(0.046)	(0.054)
Urbanicity							0.89	0.88
							(0.139)	(0.150)
Psuedo Log Likelihood	-4209489.6	-4209489.6	-4205177.2	-4205177.2	-4098498.8	-4098498.8	-4085639.6	-4085639.6
Psuedo R Squared	0.0010	0.0010	0.0020	0.0020	0.0273	0.0273	0.0304	0.0304

Data are weighted.
Standard errors are in parentheses
* significant at .05 level
** significant at .01 level
*** significant at .001 level

Table 6C. Estimated Multinomial Regression Odds Ratios for Obesity Trajectories for Full Sample (N=6,995)

(Reference Category is "Stay Non-Obese or Reduce Obese")

	Model 1		Model 2		Model 3		Model 4	
	Become Obese	**Stay Obese**	**Become Obese**	**Stay Obese**	**Become Obese**	**Stay Obese**	**Become Obese**	**Stay Obese**
Minority Status								
Black	1.48 *	1.73 ***	1.36 *	1.55 **	1.02	0.95	1.03	0.95
	(0.227)	(0.246)	(0.209)	(0.236)	(0.157)	(0.166)	(0.158)	(0.167)
Hispanic	1.17	0.120	1.10	1.11	0.97	0.90	1.02	0.91
(White: Reference Category)	(0.183)	(0.197)	(0.179)	(0.188)	(0.160)	(0.150)	(0.177)	(0.175)
Welfare/Poverty Status			1.35 **	1.49 **	1.07	0.97	1.07	0.97
			(0.135)	(0.192)	(0.099)	(0.136)	(0.102)	(0.136)
Cumulative Risk Index					1.17 ***	1.31 ***	1.17 ***	1.31 ***
					(0.031)	(0.053)	(0.031)	(0.053)
Age at WI							1.03	0.99
							(0.038)	(0.039)
Urbanicity							0.87	0.96
							(0.094)	(0.135)
Psuedo Log Likelihood	-8450071.2	-8450071.2	-8423664.8	-8423664.8	-8231064.8	-8231064.8	-8225939.5	-8225939.5
Psuedo R Squared	0.0039	0.0039	0.0070	0.0070	0.0297	0.0297	0.0303	0.0303

Data are weighted.
Standard errors are in parentheses
* significant at .05 level
** significant at .01 level
*** significant at .001 level

Appendix

Table 7A. Estimated Multinomial Regression Coefficients for Obesity Trajectories for Female Sample (N=3,619)

(Reference Category is "Stay Non-Obese or Reduce Obese")

	Model 1		Model 2		Model 3		Model 4	
	Become Obese	**Stay Obese**	**Become Obese**	**Stay Obese**	**Become Obese**	**Stay Obese**	**Become Obese**	**Stay Obese**
Minority Status								
Black	0.593 **	0.828 ***	0.447 *	0.684 ***	0.143	0.134	0.149	0.140
	(0.186)	(0.185)	(0.187)	(0.189)	(0.198)	(0.190)	(0.201)	(0.188)
Hispanic	0.354	0.475 *	0.244	0.367	0.131	0.177	0.211	0.192
(White: Reference Category)	(0.200)	(0.222)	(0.210)	(0.223)	(0.212)	(0.224)	(0.221)	(0.234)
Welfare/Poverty Status			0.517 ***	0.513 **	0.242	0.004	0.233	0.008
			(0.149)	(0.177)	(0.151)	(0.174)	(0.153)	(0.174)
Cumulative Risk Index					0.172 ***	0.305 ***	0.180 ***	0.302 ***
					(0.036)	(0.048)	(0.036)	(0.048)
Age at WI							-0.021	0.036
							(0.046)	(0.046)
Urbanicity							-0.197	-0.031
							(0.139)	(0.174)
Constant	-1.913 ***	-2.282 ***	-2.042 ***	-2.410 ***	-2.522 ***	-3.333 ***	-2.147 **	-3.846 ***
	(0.097)	(0.134)	(0.098)	(0.137)	(0.129)	(0.214)	(0.701)	(0.686)
Psuedo Log Likelihood	-4221424.6	-4221424.6	-4191823.4	-4191823.4	-4069512.2	-4069512.2	-4065321.5	-4065321.5
Psuedo R Squared	0.0100	0.0100	0.0169	0.0169	0.0456	0.0456	0.0466	0.0466

Data are weighted.
Standard errors are in parentheses
* significant at .05 level
** significant at .01 level
*** significant at .001 level

Table 7B. Estimated Multinomial Regression Coefficients for Obesity Trajectories for Male Sample (N=3,376)

(Reference Category is "Stay Non-Obese or Reduce Obese")

	Model 1		Model 2		Model 3		Model 4	
	Become Obese	**Stay Obese**	**Become Obese**	**Stay Obese**	**Become Obese**	**Stay Obese**	**Become Obese**	**Stay Obese**
Minority Status								
Black	0.172	0.259	0.158	0.186	-0.151	-0.360	-0.127	-0.390
	(0.210)	(0.201)	(0.208)	(0.217)	(0.221)	(0.249)	(0.215)	(0.257)
Hispanic	-0.048	-0.111	-0.058	-0.160	-0.170	-0.357	-0.136	-0.311
(White: Reference Category)	(0.211)	(0.249)	(0.212)	(0.252)	(0.221)	(0.261)	(0.225)	(0.277)
Welfare/Poverty Status			0.056	0.277	-0.099	-0.019	-0.079	-0.030
			(0.156)	(0.194)	(0.157)	(0.201)	(0.160)	(0.200)
Cumulative Risk Index					0.216 ***	0.382 ***	0.198 ***	0.409 ***
					(0.050)	(0.062)	(0.049)	(0.064)
Age at WI							0.081	-0.081
							(0.043)	(0.059)
Urbanicity							-0.115	-0.125
							(0.156)	(0.170)
Constant	-1.970 ***	-2.170 ***	-1.983 ***	-2.239 ***	-2.298 ***	-2.860 ***	-3.445 ***	-1.632
	(0.092)	(0.119)	(0.100)	(0.121)	(0.112)	(0.147)	(0.661)	(0.920)
Psuedo Log Likelihood	-4209489.6	-4209489.6	-4205177.2	-4205177.2	-4098498.8	-4098498.8	-4085639.6	-4085639.6
Psuedo R Squared	0.0010	0.0010	0.0020	0.0020	0.0273	0.0273	0.0304	0.0304

Data are weighted.
Standard errors are in parentheses
* significant at .05 level
** significant at .01 level
*** significant at .001 level

Table 7C. Estimated Multinomial Regression Coefficients for Obesity Trajectories for Full Sample (N=6,995)

(Reference Category is "Stay Non-Obese or Reduce Obese")

	Model 1		Model 2		Model 3		Model 4	
	Become Obese	**Stay Obese**	**Become Obese**	**Stay Obese**	**Become Obese**	**Stay Obese**	**Become Obese**	**Stay Obese**
Minority Status								
Black	0.389 *	0.546 ***	0.308 *	0.438 **	0.021	-0.053	0.031	-0.053
	(0.154)	(0.142)	(0.154)	(0.152)	(0.154)	(0.175)	(0.153)	(0.176)
Hispanic	0.153	0.181	0.095	0.103	-0.028	-0.103	0.024	-0.090
(White: Reference Category)	(0.157)	(0.164)	(0.163)	(0.169)	(0.164)	(0.177)	(0.173)	(0.192)
Welfare/Poverty Status			0.300 **	0.396 **	0.063	-0.027	0.070	-0.031
			(0.100)	(0.129)	(0.093)	(0.140)	(0.095)	(0.140)
Cumulative Risk Index					0.156 ***	0.267 ***	0.154 ***	0.269 ***
					(0.027)	(0.041)	(0.026)	(0.040)
Age at WI							0.031	-0.014
							(0.032)	(0.040)
Urbanicity							-0.139	-0.039
							(0.108)	(0.140)
Constant	-1.942 ***	-2.224 ***	-2.014 ***	-2.322 ***	-2.432 ***	-3.088 ***	-2.823 ***	-2.864 ***
	(0.075)	(0.106)	(0.075)	(0.100)	(0.098)	(0.140)	(0.48)	(0.614)
Psuedo Log Likelihood	-8450071.2	-8450071.2	-8423664.8	-8423664.8	-8231064.8	-8231064.8	-8225939.5	-8225939.5
Psuedo R Squared	0.0039	0.0039	0.0070	0.0070	0.0297	0.0297	0.0303	0.0303

Data are weighted.
Standard errors are in parentheses
* significant at .05 level
** significant at .01 level
*** significant at .001 level