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Abstract

The body mass index (BMI) is the primary means of classifying obesity and reflects a complex set of interactions related to the institution of marriage and household characteristics. There is an inverse relationship between BMI and height, and height reflects the cumulative price of net nutrition during childhood and resources devoted to an off-spring's health from care-givers. There are gender specific relationships between BMI and marital status, and after controlling for height, single women have lower BMIs than women in other household relationships. While causal mechanisms may have changed over time, there is a positive relationship between BMIs and household size.

JEL-Codes: D130, I120, J120, J130.

Keywords: family structure, obesity, marital status, net nutrition.

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1. Introduction

In recent years, the economics profession has expressed renewed interest in health, family economics, and early childhood conditions, which are related to current marital and family status (Barker, 1992; Barker, 1997; Barker, 1998).[1] Individuals exist and are reared in the economic institution of a household, which reflects economic conditions throughout life and is related to early life conditions, current marital, and family status. The relationship between current body mass index (BMI), marital status, and household size is also a dynamic and changing relationship throughout life that varies with the stages of economic development. For example, household heads in developed economies are less likely to make fertility decisions with the expectation that their off-spring are future labor inputs (Luke et al., 2001; Cho et al. 2009). An important relationship between health and social relationships is obesity, and despite the many studies devoted to obesity and household formation, research that addresses early life conditions, marital status, and household size continues to evolve. This study, therefore, considers economic factors associated with BMIs, early life conditions, marital status, and current household size to highlight health variation throughout life.

When traditional measures for economic welfare are scarce or unreliable, stature and BMI are two measures that reflect economic conditions and health (Case, 2010); they are compliments to traditional measures when they are available. Stature measures cumulative net nutrition, and BMI reflects the current net nutrition facing a population. BMIs – weight in

[1] For example, mortality rates among unmarried individuals are higher than unmarried individuals (Berkman and Syme, 1979; Blazer, 1982; House, Robbins, and Mezer, 1982).

kilograms divided by height in meters squared – is also the primary means of classifying obesity and are high for populations that have an excess of calories consumed relative to calories required for work and to fend off disease.[2] However, BMI is also more difficult to interpret than stature because its variation depends on when privation occurs. For example, if an individual is poorly-nourished as a child, they are less likely to reach their genetically pre-determined stature, and if this short stature persists, they are more likely to be obese as adults because greater weight is distributed over smaller physical dimensions (Herbert et al. 1993, p. 1438; Costa and Steckel, 1997, p. 56; Sorkin et al. 1999, p. 257; Sorkin et al, 1999, pp. 969 and 973-975; Carson, 2009; Carson, 2012c; Komlos and Carson, 2017). On the other hand, a well-fed child is more likely to reach their genetically pre-determined stature and have lower BMIs in later life because their weight is distributed over larger physical dimensions (Nyström-Peck, 1994; Nyström-Peck and Lefgren, 1995).

In study and practice, BMIs are related to health, mortality, and morbidity. Waaler (1984) finds a U-shaped relationship between mortality risk and BMI, and subsequent studies show that relative mortality risk is high for individuals with BMIs above 27 (Koch, 2013). Costa (1993, p. 442) and Murray (1997, p. 599) show that the U-shaped relationship with mortality risk is constant overtime, while Jee et al. (2006) demonstrate the relationship is similar across ethnic groups. Individuals with BMIs less than 19 are more likely to have malnutrition, infectious diseases, and respiratory conditions (Calle et al., 1999, p. 1001; Jee et al., 2006, p. 783), while diabetes, heart disease, stroke, and certain cancers are more common for individuals with higher

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[2] Ideally, obesity is classified under controlled conditions using modern magnetic resonance imaging or dual x-ray absorption. Moreover, during the 19th century, equipment to estimate percent body fat was yet to develop, and BMIs have become the standard for weight classification in historical and modern populations.

BMIs (Eckel et al. 2005, pp. 1417-1421; Popkin, 2009, p. 113; McPherson et al. 2007; McLannahan and Clifton, 2008, p. 18; Atlas, 2011, p. 105). This mortality risk in BMI is similar across gender; however, women's mortality rates are higher away from the minimum mortality risk BMI of 25. Moreover, BMIs vary with the types of calories consumed, and diets high in complex carbohydrates and proteins have transitioned to modern diets high in sugar and saturated fats (Popkin, 1993, pp. 145-148; Popkin, 2009).

It is against this backdrop that this study considers three paths of inquiry into modern BMI variation. First, what is the relationship between adult BMI and early-life conditions? There is an inverse relationship between BMI, height, and cumulative net nutrition, and because men are, on average, taller than women, women have lower BMIs once height is accounted for. Second, what is the relationship between BMI and marital status? There are gender specific relationships between BMI and marital status, and after controlling for height, single women have lower BMIs than women in other relationships. Third, what is the relationship between BMI and family size? While causal mechanisms may have changed over time, there is a positive relationship between BMIs and the number of persons in a household.

2. The 1979 National Longitudinal Survey of Youth Survey

Data to analyze the relationships between body mass, early life conditions, family size, and marital status requires a comprehensive BMI data set. The 1979 National Longitudinal Survey of Youth (NLSY79) is one data set used for the purpose of analyzing the American labor market and is an on-going nationally representative sample of African-Americans, Hispanics, and Non-black/non-Hispanics. Along with several variables related to labor market outcomes, the NLSY79 survey designers collected weight and height from which BMIs are constructed.

Individuals were interviewed every two years between 1979 and 2010, and each individual's characteristics were updated every other year.[3] In 1979, the Bureau of Labor Statistics collected 12,686 young males and females ages 14 to 22 born between 1957 and 1964. In 2010, these respondents were between ages 45 and 54. Of the 12,686 individuals in the initial survey, 6,403 are males and 6,283 are females. There are 7,510 mostly white, non-black/non-Hispanics, 3,174 African-Americans, and 2,002 Hispanic/Latino. Members within each cross-section were available to be interviewed across multiple follow up surveys; nevertheless, in no year after 1979 are all individuals available, and successful linkages decrease over time.

Annual update questions include demographic variables, educational attainment, training updates, job and residential status, and various health conditions. Height was recorded in 1985, 2008, and 2010. For years between 1985 and 2004, height in year 1985 is used to calculate BMIs; annual heights are used when reported in 2008 and 2010. Only observations after 1985 are included in the sample who had reached adult terminal stature. Additional variables related to BMI values included in this study are age, marital status, and family size.

[3] Random annual surveys were also conducted in in 1985 and 1993. There are concerns over 2006 sampling, so results for that year are excluded from this analysis (NLSY79, p. 5).

Table 1, Late 20th and Early 21st Century NLSY Demographics, Residence, and Family Composition

	1985	*1986*	*1988*	*1990*	*1992*	*1994*	*1996*	*1998*	*2000*	*2002*	*2004*	*2006*	*2008*	*2010*
BMI	23.76	24.19	24.83	25.41	26.11	26.51	26.95	27.38	27.38	28.27	28.37	28.58	29.04	29.30
Stature														
Centimeters	170.43	170.35	170.37	170.37	170.40	170.46	170.55	170.55	170.39	170.48	170.42	170.73	170.59	170.58
Early Life Conditions														
Underweight 1982	.066	.059	.060	.059	.055	.054	.056	.055	.055	.055	.055	.055	.053	.053
Obese 1982	.049	.050	.049	.049	.050	.048	.047	.047	.048	.050	.049	.049	.051	.051
Difference in Difference														
Male	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Female	.506	.508	.509	.509	.503	.496	.494	.497	.507	.505	.508	.508	.513	.508
Marital Status														
Not Married	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Married	.359	.404	.481	.524	.540	.558	.570	.583	.590	.592	.591	.589	.572	.560
Treatment														
Male, Divorced	.016	.021	.032	.039	.045	.054	.061	.066	.065	.072	.078	.080	.084	.091
Male, Not Divorced	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Female, Divorced	.031	.036	.049	.057	.060	.065	.070	.077	.083	.089	.096	.100	.109	.114
Female, Married	.211	.231	.263	.281	.278	.283	.286	.292	.298	.295	.294	.291	.283	.275
Current Family Size														
Family Size	3.25	3.14	3.06	3.11	3.21	3.25	3.31	3.34	3.30	3.23	3.12	3.02	2.88	2.77
Ethnicity														
Non-Black, Non-Hispanic	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Black	.263	.263	.263	.263	.300	.301	.301	.300	.302	.305	.304	.304	.305	.311
Hispanic	.162	.161	.157	.159	.189	.187	.185	.186	.181	.178	.180	.180	.184	.184
Age	23.58	24.66	27.07	29.07	30.92	32.93	34.81	36.79	38.95	40.85	43.13	44.68	46.61	48.53

N	10,346	10,078	9,593	9,472	8,049	7,994	7,747	7,404	6,899	6,961	6,265	6,265	6,608	6,703

Source: National Longitudinal Surveys, Youth , 1979.

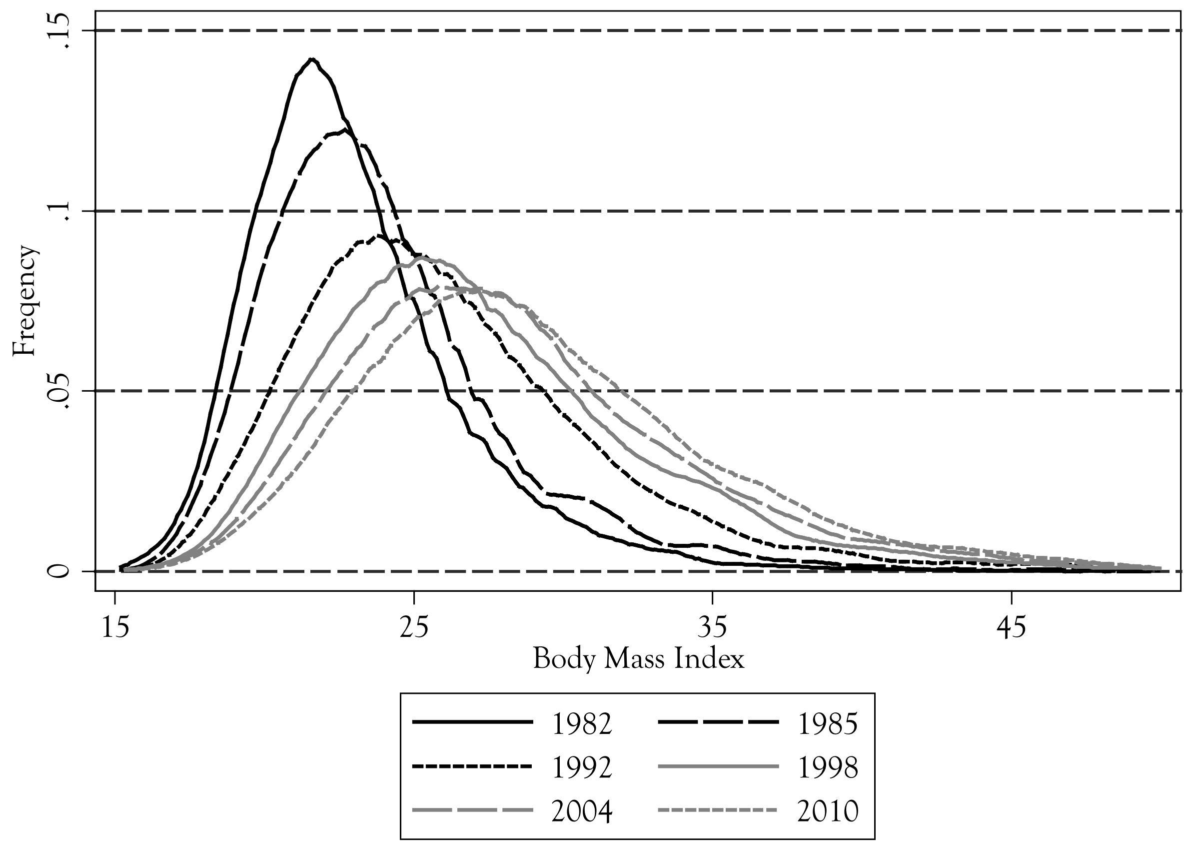
This longitudinal sample allows for detailed comparison across time and space (Table 1). Blacks and Hispanics were smaller portions of the population; however, their composition of the sample increased overtime. In 1982, six percent of the population was underweight with approximately the same percent recorded as obese. Average age increased overtime, and the percent of married individuals increased through the 1990s and leveled-off in the 2000s. The sample is nearly equally split between females and males, and the share of married individuals increased until the late 2000s. However, the share of divorced females and males predictably increased over time. Household size increased after 1990, but the decrease in family size among 1985 and 1988 indicates that early household members include individuals continued to live with their parents in the late 1980s. The percent Latino/Hispanic varied over time between 15.7 and 18.9 percent. Blacks represented a quarter of the sample during the 1980s and increased to over 30 percent.

Ideally obesity would be classified with percent body fat; however, because evaluating obesity with advanced techniques is expensive and difficult to acquire, this information is non-existent for most populations. The body mass index is a widely accepted means of assessing whether a person is obese, and the World Health Organization established thresholds to classify obesity status.[4] As a result, BMI is the standard obesity measure because it only requires weight and height. Nonetheless, when other means of classifying obesity are unavailable, weight status from BMI is a reasonable approximation for obese and overweight status. However, as a measure, BMI is not without difficulties. For example, African-Americans have greater protein

[4] Underweight is classified as a BMI under 18.5. Normal weight is a BMI greater or equal to 18.5 but less than 24.9. Overweight is a BMI of 24.9 and less than 29.9. Obesity is a BMI over 29.9. A BMI is classified as morbidly obese if it is over 40.

and percent muscle mass than white and Asian populations, and BMI overestimates weight and obesity for individuals with greater muscular builds (Barondess et al. 1997; Wagner and Heyword, 2000; Aloi et al. 1997). As a result, black BMIs, are over-stated using modern WHO standards (Burkhauser and Cawley, 2008, pp. 519-520).

Figure 1, Late 20th and Early 21st Century BMIs through Time



Source: See Table 1.

Note: Data set in 2010 observing observations in 1982, 1985, 1992 1998 2004, and 2010.

Obesity as a health dilemma is a recent phenomenon, and historical US populations were in the normal BMI category. The shape of the BMI distribution indicates much about a population's current net nutrition. BMIs increase with age; however, the percent of individuals that are obese have increased more rapidly than is accounted for by increases in age (Figure, 1). For example, between 1982 and 2010, the percent in the obese category increased by 493 percent, while average age only increased by 136 percent. In sum, BMIs have shifted right, become more symmetric, and the increase in obesity exceeds that which is explained by only the increase in age and demographic characteristics.

3. BMI Variation with Family Status over Time

We now consider factors associated with BMI variation and how these relationships changed between 1985 and 2010. To start, the BMI of the i^{th} individual is regressed on height, marital status, household size, and demographics.

$$BMI_i = \theta_0 + \theta_h Centimeters_i + \theta_{UW} Early\,Underweight_i + \theta_{EO} Early\,Obese_i + \theta_F Female_i + \theta_M Married_i$$

$$+ \theta_{MD} Male\,Divorced_i + \theta_{FD} Female\,Divorced_i + \theta_{FM} Female\,Married_i + \theta_{FS} Family\,Size_i$$

$$+ \sum_{c=1}^{2} \theta_c Complexion_i + \theta_a Age_i + \varepsilon$$

Stature in centimeters is included to measure the relationship between current and cumulative net nutrition. Early life conditions are measured with dummy variables for childhood underweight and obese status in 1982 (Baird et al. 2005, p. 930). A continuous variable for household size is included to account for the relationship between BMI and the number of persons in a household. Black and Hispanic complexion dummy variables are included to account for how BMIs varied with ethnic status (Barondess et al., 1997; Wagner and Heyward, 2000). A continuous age variable is included to account for how BMIs varied over the life course.

Table 2, Late 20th and Early 21st Century NLSY Demographics, Residence, and Family Composition BMI Regression Models

	1985	*1986*	*1988*	*1990*	*1992*	*1994*	*1996*	*1998*	*2000*	*2002*	*2004*	*2006*	*2008*	*2010*
Intercept	**24.90**	**29.68**	**30.59**	**30.71**	**33.89**	**34.46**	**34.36**	**36.02**	**39.66**	**37.75**	**40.32**	**38.36**	**30.28**	**30.77**
Stature														
Centimeters	**-.017**	**-.042**	**-.040**	**-.037**	**-.048**	**-.051**	**-.048**	**-.050**	**-.055**	**-.055**	**-.066**	**-.062**	-.002	-.005
Early Life Conditions														
Underweight 1982	**-4.11**	**-3.46**	**-3.85**	**-3.99**	**-4.49**	**-4.35**	**-4.24**	**-4.75**	**-3.89**	**-4.46**	**-4.24**	**-4.48**	**-4.63**	**-4.53**
Obese 1982	**10.26**	**10.01**	**10.40**	**10.36**	**10.65**	**10.88**	**10.85**	**10.73**	**10.05**	**10.95**	**10.32**	**9.87**	**10.32**	**10.15**
Difference in Difference														
Male	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Female	**-1.14**	**-1.47**	**1.04**	**-.687**	**-.575**	-.405	.123	.141	-.526	**.736**	.401	.652†	**1.77**	**1.78**
Marital Status														
Not Married	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Married	**.557**	**.549**	**.597**	**.535**	**.480**	**.519**	**.693**	**.680**	**.920**	**.925**	**1.02**	**1.19**	**1.41**	**1.33**
Treatment														
Male, Divorced	.186	.329	.207	.263	.118	.216	.204	.183	.146	.177	.253	.206	**.671**	**.638**
Male, Not Divorced	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Female, Divorced	**-.569**	**-.618**	**-.975**	**-1.09**	**-1.25**	**-1.64**	**-2.01**	**-1.67**	**-1.95**	**-1.73**	**-1.30**	**-1.14**	**-1.46**	**-1.19**
Female, Married	**-.357**	-.223	**-.653**	**-.943**	**-1.16**	**-1.40**	**-1.87**	**-1.71**	**-2.20**	**-2.33**	**-2.26**	**-2.47**	**-2.53**	**-2.26**
Current Family Size														
Family Size	.019	**.061**	**.117**	**.134**	**.206**	**.155**	**.146**	**.099**	.040	**.139**	.054	.077	.011	.005
Ethnicity														
Non-Black, Non-Hispanic	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Black	**.601**	**.659**	**.948**	**1.22**	**1.23**	**1.35**	**1.45**	**1.60**	**1.61**	**1.84**	**1.95**	**1.86**	**1.98**	**2.06**
Hispanic	**.505**	**.576**	**.732**	**.852**	**.828**	**.696**	**1.02**	**.870**	**.831**	**1.12**	**1.20**	**1.22**	**1.35**	**1.32**
Age	**.069**	**.062**	.018	.009	-.019	-.008	-.010	-.030	-.088	-.041	-.046	-.017	**-.063**	-.057†
N	10,346	10,078	9,593	9,472	8,049	7,994	7,747	7,404	6,899	6,961	6,265	6,265	6,608	6,703
R^2	.4121	.3517	.3185	.3030	.2975	.2828	.2646	.2565	.1614	.2431	.2233	.2078	.2044	.1986

Source: National Longitudinal Surveys, Youth , 1979.

Notes: Bold is significant at .05. † is significant at .10. Robust standard errors are used to estimate t-statistics.

Three paths of inquiry are considered when evaluating modern BMIs and household status. First, except 1985, BMI and height are inversely related across all periods, presenting strong evidence that there is an inverse relationship between BMI and height through intergenerational transfers (Behrman, 2016). Higher relative food prices and fewer household resources devoted to off-spring health are related to shorter statures and higher BMIs for adults (Nyström-Peck, 1994; Nyström-Peck and Lundberg, 1995; Rahkonen et al. 1997). If individuals receive poor childhood net nutrition and fail to develop, it persists throughout life in their statures and obesity. Moreover, in each cross section, the effect of early life conditions is also represented by an individual's youth weight status, and a person who was underweight in 1982 had lower BMIs throughout life, while individuals classified as obese in 1982 had greater BMIs in each subsequent cross section (Baird et al. 2005, p. 930). Obesity reflects early life conditions, and care-givers influence preference formation and time allocation that lasts throughout life. Moreover, these early life imprints may have later-life consequences, as underweight, overweight, and obese individuals may be more likely to experience cognitive decline relative to individuals in normal BMI categories (Xiang and An, 2015, pp. 396-398; Khanam an Njhjem, 2016). In sum, there is an inverse relationship between BMI and early life conditions through height, and BMI status in early life lasts throughout life.

Second, to isolate the effects of BMI and marital status by gender, a quasi-experimental difference-in-differences model is constructed for the relationship between BMI, gender, and marital status. Female gender is the treatment group, and male gender is the control group. Married is the post-event outcome. The average causal effect is the gender and marital status interactive term. Several studies show that women are more likely to be obese than men (Komlos and Brabec, 2010; Must and Evans, 2011, pp. 16-18; Himes, 2011, p. 40). However, individual BMIs are inversely related to stature (Carson, 2009; Carson, 2012c), and women are, on average, shorter than men (Table 2). Moreover, existing studies that show women are more likely to be obese than men do not account for shorter female statures (McLannahan and Clifton, 2008, pp. 23-24). After controlling for height, women have lower BMIs than men in younger ages but greater BMIs at older ages (Table 2; McLannahan and Clifton, 2008, pp. 3, 13, and 23; Komlos and Brabec, 2010, p. 631), indicating the gender, obesity, and BMI relationship is more complicated than simply categorizing BMI classification by gender.

BMIs and being married are positively related, and the marital status-BMI relationship increases with age over time (Table 2; Lee et al. 2004; Averett et al. 2008, pp. 338-348). Nevertheless, the BMI-marriage relationship is different across genders. After controlling for characteristics, young divorced males are not measurably different from other men until the late 2000s when divorced male BMIs increased. Alternatively, while obese people are less likely to be in relationships than non-obese populations, obese white women especially find limited relationship opportunities (Tovée et al. 1998, p. 548; Carmalt et al. 2008, p. 1294). Divorced women had lower BMIs throughout life until around age 40, and the effect for females is less at older ages. Women who experience marital status disruption by divorce or death are given to weight loss associated with grief and reduced in-take of healthy diets (Lee et al. 2005, pp. 72-73). In sum, after controlling for height, women have lower BMIs than men, unmarried women have lower BMIs, and there is no relationship between male marital statuses until older ages.

Third, the relationship between modern BMIs and household size reflects the dynamics of a changing modern US economy. In historical populations, agricultural productivity likely increased with additional household members because more household members increased household efficiency and created economies of scale within the household (Carson, 2012a;

Carson, 2012b; Carson, 2014). However, less is known about the modern relationship between BMIs, obesity, and household size. In the modern US economy, household head BMIs are greater for larger households, indicating that BMIs continued to be positively related to family size (Table 2). However, the mechanism for the positive relationship is less clear. Additional family members may be associated with higher BMIs and greater obesity because additional family members affect care-giver time-allocation and physical activity devoted to health maintenance; however, there may have been reverse causation.[5] High BMIs may signal to potential mates their health to support larger families. Alternatively, household health may have put on more weight with additional family members. Family size may also work through socioeconomic status, and individuals from large, low socioeconomic status households are more likely to be obese compared to individuals in high socioeconomic households (McClaren, 2011, p. 277; Conti and Heckman, 2010, p. 17; Danielzik et al., 2004).[6] Consequently, there is a positive relationship between BMI and household size, and the modern pathway between BMI and family size is likely related to socioeconomic status.

Other patterns are consistent with expectations. BMIs are higher for individuals with darker complexions, a pattern that has existed over prolonged periods. For example, late 19th

[5] The problem of endogenous selection into marriage markets and relationships are significant because controlling observable health characteristics is difficult to detect before or at the time of marriage (Wilson, 2016).

[6] Comparing rural households to their post-industrialized counterparts is also difficult because households are cultural as well as economic institutions, and rural households select the number of household members based on future agricultural needs, where not such expectation is formed for post-industrialized households because children are not expected to contribute to household production. Moreover, the relationship between BMI and household size may work in reverse direction because BMI is a measure for current net nutrition, and biologically stronger individuals may have been better able to sustain larger households.

and early 20th century African-Americans had greater BMIs than their fairer complexioned white counterparts (Carson, 2015b). Part of darker complexioned BMIs may be biological because individuals with darker complexions have greater protein in muscle mass, and muscle is heavier than fat (Barondess et al. 1997; Aloi et al 1997; Wagner and Heyward, 2000). Alternatively, higher BMIs for individuals with darker complexions may be related to height because BMIs are inversely related to height, and in both modern and historic populations, fairer complexioned individuals are taller than their darker complexioned counterparts. In sum, there are complex relationships between BMI and early life conditions that reflect household resources devoted to an adult during their youth, current net nutrition prices, household resources, marital status, and current household size.

4. Conclusion

BMI is now a well-accepted measure for current net nutrition and is the primary means of classifying obesity. For individuals born between 1957 and 1965, BMIs have increased over time, across genders, and ethnic groups to become more symmetric and shifted to higher BMI values (Carson, 2016). There is an inverse relationship between weight, height, and early life conditions, and this inverse relationship persists throughout life. Early weight status also has lasting effects, and childhood underweight and obese status persists throughout life, indicating that early weight interventions have long lasting effects for cognitive and non-cognitive health. BMIs are also related to marital status and are gender specific. After controlling for stature, women have lower BMIs than men, and non-married women have even lower BMIs than married women. Household heads with large families have greater BMI values in both history and the modern period. In sum, BMIs are related to early life conditions, marital status, household size, and the dynamic US labor market, and early weight classification persists throughout life.

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