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Abstract

When traditional measures for economic welfare are scarce or unreliable, stature and the body mass index (BMI) are now widely-accepted measures that reflect economic conditions. However, little work exists for late 19th and early 20th century women's BMIs in the US and how they varied with economic development. This study shows that after controlling for characteristics, African-American women had greater BMIs than lighter complexioned black and white women. Women from the Southwest were taller and had lower BMIs than women born elsewhere within the US. However, women's BMIs did not vary by occupations. Women's BMIs decreased throughout the late 19th and early 20th centuries, which may have implications for the health and cognitive development of lower socioeconomic status children who reached maturity in the mid-20th century.

JEL-Codes: N310, N320, I120, J150.

Keywords: late 19th and early 20th century women's BMIs, ethnicity and BMI, women's health during economic development.

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I. Introduction

The health and nutrition of late 19th and early 20th century women in the US offers insight into economic conditions and health during development. Two commonly used measures for health and net nutrition are stature and the body mass index (BMI). Average stature measures the cumulative net difference between calories consumed and calories required for work and to withstand the physical environment. Sunder (2011), Carson (2011), and Carson (2013) demonstrate that US women's average statures were roughly constant throughout the antebellum period but increased during the second half of the 19th century. The body mass index measures current net nutrition (Komlos, 1987; Fogel, 1994, pp. 157-158),[1] and while important progress has been made in understanding late 19th and early 20th century male BMI variation, little is known about how black and white women's BMIs varied with US economic development (Carson, 2009; Carson, 2012). Moreover, women's BMI variation not only reflects their current net nutrition but the health, cognitive development, and future labor market productivity of their off-spring (Sørensen et al, 1997, p. 402; Risnes et al. 2011; Case and Paxson, 2008a; Carson and Paxson, 2008b).

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[1] Interpreting BMI variation is more complicated than evaluating stature variation because BMI is the ratio of weight in kilograms divided by height in meters squared. Interpreting BMI variation is also more difficult than interpreting stature variation because BMI variation depends on when privation occurs. For example, if an individual receives insufficient calories nutrition in their youth, they are less likely to reach their genetically predetermined stature, and their BMIs will be high if they receive excess calories as an adult because greater weight is distributed over smaller physical dimensions (Herbert et al.. 1993, p. 1438; Sorkin et al., 1999; Sorkin et al., Sorkin et al., 1999).

In both historic and modern populations, BMI variation reflects multiple health conditions, and individuals with low BMIs are more likely to have poor net nutrition throughout life and experience infectious and respiratory diseases (Calle et al. 1999, p. 1001; Jee et al. 2006, p. 783). Individuals with high BMIs are at greater risk for all-source morbidities and mortalities (Waaler, 1984; Koch, 2011; Meyer et al. 2003), and obese individuals are more likely to develop diabetes, cardiovascular disease, and stroke (Monson et al. 1990; Monson et al. 1991; Herbert et al. 1993; Must et al. 1999). For overweight and obese individuals, health studies also demonstrate that there are significant benefits associated with weight loss (Wing and Phelan, 2005) and weight loss is most beneficial if it occurs over prolonged periods (Guth, 2014).

Women are more likely to be obese then men, and multiple explanations account for the difference (Must and Evans, 2011; Ogden et al.2006; Flegal et al. 2010). For example, the distribution of women's fat may have played an evolutionary role in their sexual attractiveness and reproductive success (Dunbar, 2013, p. 56; Symons, 1995; Tovée et al. 1998, p. 548), and women need more stored calories to fuel the development of large-brain offspring (Dunbar, 2013, p. 55). During pregnancy, women are more likely to put on excess weight that can be difficult to lose after child-birth (Leiberman, 2000, p. 1064). Obesity is inversely related with stature, and women reach shorter statures than men (Sorkin et al. 1999a; Brownson, Boehmer, and Luke, 2005, p. 425; Herbert et al. 1993, p. 1438). There is also the psycho-social relationship between gender and obesity, and women are more likely than men to be depressed and obese (Rosmund and Bjürnturp, 1999; Granberg, 2011, p. 330; Belue, Francis, and Calaco, 2009; Ge, Elder, Regnerus, and Cox, 2001; Needham and Crosnoe, 2005). There is also an inter-generational effect, where a mother's weight status is related to the cognitive development and later-life health of her off-spring (Risnes et al. 2011). Furthermore, failure to put on sufficient weight during pregnancy has detrimental health consequences for her off-spring, and underweight women are more likely to experience pre-term labor and delivery, give birth to low birth-weight babies, experience maternal fever, encounter perinatal complications, and experience fetal growth restriction (Doherity, et al., 2006; Abrams et al, 2000; Yan, 2015; Rode et al. 2007; Ehrenberg et al. 2003, pp. 1728-1729). For pregnant women, failure to gain weight during pregnancy may impede the cognitive development to her off-spring (Abrams et al. 2000; Sørensen et al, 1997, p. 402).

Nevertheless, wide-spread obesity is a recent phenomenon and was not common until the mid-20th century (Carson, 2009a; Komlos and Brabec, 2010; Carson, 2012a). To better understand the modern obesity epidemic, observing women's BMI variation before modern economic conditions transitioned to the modern diet with less physical activity levels sheds light on how female BMIs have changed over time. Furthermore, an unanswered question in health studies is how women's 19th century BMIs varied over time, with economic development, and how this may have been related to their off-spring's current and future health (Barker, 1992; Osmania and Sen, 2003; Risnes et al, 2011). Given US family calorie priorities, historical labor market segregation meant that more calories were devoted to men, who did a greater share of field work and consumed a longer share of calories within the household. Women's net nutritional needs during economic development may have, therefore, been queued behind men because men had greater physical strength and required more calories within the household (Osmani and Sen, 2003; Burnette, 2013, p. 306).

It is against this backdrop that this study considers three paths of inquiry into late 19th and early 20th century US female BMI variation. First, how were women's BMIs distributed historically by race, and were black women's BMIs greater than white women? After controlling for characteristics, darker complexioned black women had greater BMIs than fairer complexioned mixed-race women, which were, in turn, greater than white women. Second, how did black and white women's BMIs vary overtime? Between 1860 and 1930, black women's BMIs decreased by 14 percent, while white women's BMIs decreased by nearly 17 percent. Third, how did women's BMIs vary by residence? Women from the Southwest had lower BMIs than women located elsewhere within the US, while women from the Northeast and Europe had higher BMIs.

II. Late 19th and Early 20th Century Women's BMI Data

Locating data to evaluate late 19th and early 20th century women's BMIs and heights is more difficult than locating data for men because women did not participate in activities and institutions that recorded weight and height, such as the military. An alternative source for weight and height data is prisons; however, women were also less likely than men to commit and be incarcerated for criminal activity, which further limits the data available to evaluate their BMIs (Steffensmeier and Allan, 1996).[2] This study uses late 19th and early 20th century US prison data to analyze women's BMI variation during US economic development. While additional weight and height data for women's health are yet to emerge, prison data are the only source that currently exists that contains a sufficient number of observations to meaningfully consider their historical BMI variation.

Data to observe late 19th and early 20th century women's BMIs is part of a large prison data extraction project. All US prisons were contacted on multiple occasions and available records were combined into a large data set. Between 1866 and 1939, women's physical

[2] For both women and men, there were fewer 19th century weight recordings then statures (Carson, 2011; Carson, 2013).

descriptions were recorded by prison enumerators at the time of incarceration, therefore, reflects pre-incarceration conditions. Prison officials recorded inmates' gender, prison entry date, complexion, nativity, occupations, residence, and age. In this pre-photographic period, enumerators were careful when recording physical descriptions because accurate records had legal implications for inmate identification in case they escaped and were recaptured. Physical descriptions also helped identify individuals within prisons. There are 4,766 women in the data set used here. From the same prisons, there are 205,456 male inmates with weight and height data, indicating that women made up about 2.3 percent of the prison population; however, the ratio of female to male prisoners varied across prisons. For example, women were over four percent of the Colorado and Illinois state prison populations but less than .5 percent of the Oregon and Washington state prison populations.

While valuable, data from prison weight and height records are not above scrutiny. For example, law enforcement may have varied with economic and political conditions. Prison data may reflect shorter individuals who received sub-standard diets throughout their growth years and reflects poor health; therefore, women in prison may reflect conditions among poorer, lower socioeconomic status women who turned to crime for survival (Bodenhorn, Moehling, and Price, 2012). Another concern is ethnic status, where law enforcement officials and courts selectively enforced legal statutes against 19^{th} century black women and other ethnic groups relative to white women. However, there is little evidence from the prison records that physical sizes were systematically targeted for incarceration. In comparison, male prison stature and BMI variation are similar to non-prison samples, indicating that prison records are a valuable source for lower socioeconomic status women relative to the general population (Komlos, 1987; Margo and

Steckel, 1992).[3] Consequently, caution is taken when evaluating female prison records; however, to date, prison records have the greatest potential to examine late 19th and early 20th century lower socio-economic status women's BMIs and stature variation over time and across characteristics.

Complexion was an important means to identify individuals within prisons, and enumerators recorded inmate complexions in detail. Women of African descent were recorded as black, light black, dark black, and diverse shades of 'mulatto'. Women of European descent were recorded as fair, light, medium, and dark. Both in the US population census and US prisons, women of mixed African and European descent were classified as 'mulattos' but are referred to in this study as 'mixed race' (Bodenhorn, 2015, p. 5).[4] While women with mixed race complexions shared genetic traits from both African and European origin, they were treated with lower social and economic priority during the 19th century and are grouped here with black women. Mixed race complexions were defined as quadroon, who is a person with one-quarter African ancestry, and octoroon, who is a person with one-eighth African ancestry. However, parsing mixed-complexions beyond this is neither possible nor accurate. Other complexions used in the prison records for women are Native-American and Mexican.

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[3] Floud et al. (2011, p. 331) present estimates for 19th century US males. Their male stature estimates are only .5 percent taller than male prison stature estimates.

[4] Through the 1930 United States population census, the term 'mulatto' was how person's of European and African descent were referenced.

Table 1. Black and White Female Demographics, Residence, and Occupations

Nativity	**N**	**Percent**	**Prison**	**N**	**Percent**
Northeastern	19	.40	Arizona	26	.55
Middle Atlantic	563	11.81	Colorado	308	6.46
Great Lakes	407	8.54	Idaho	12	.25
Plains	536	11.25	Illinois	510	10.70
Southeast	1,711	35.90	Kentucky	124	2.60
Southwest	925	19.41	Mississippi	49	1.03
Far West	91	1.91	Missouri	496	10.41
Foreign Born			Montana	86	1.80
British	186	3.90	Nebraska	113	2.37
Canada	34	.71	New Mexico	56	1.17
Europe	150	3.15	Oregon	3	.06
Latin America	85	1.78	Pennsylvania, East	218	4.57
Unknown	59	1.24	Pennsylvania, West	184	3.86
Ages			Philadelphia	377	7.91
Teens	1,094	22.95	Tennessee	1,055	22.14
Twenties	2,231	46.81	Texas	1,087	22.81
Thirties	911	19.11	Utah	59	1.24
Forties	354	7.43	Washington	3	.06
Fifties	126	2.64	**Occupation**		
Sixties	43	.90	Skilled	433	9.09
Seventies	7	.15	Unskilled	583	12.23
Birth Decade			Domestic	2,481	52.06
1810s	11	.23	No Occupations	1,269	26.63
1820s	40	.84	**Decade Received**		
1830s	103	2.16	1860s	20	.42
1840s	253	5.31	1870s	318	6.67
1850s	472	9.90	1880s	896	18.80
1860s	822	17.25	1890s	868	18.21
1870s	1,222	25.64	1900s	1.323	27.76
1880s	1,144	24.00	1910s	1,064	22.32
1890s	582	12.21	1920s	252	5.29
1900s	117	2.45	1930s	25	.52
Ethnicity					
Native American	5	.10			
Black	1,786	37.47			
Mixed-Race	1,144	24.00			
Mexican	86	1.80			

White	1,660	34.83
Unknown Complexion	85	1.78

Source: Arizona State Library, Archives and Public Records, 1700 W. Washington, Phoenix, AZ 85007; Kentucky Department for Libraries and Archives, 300 Coffee Tree Road, Frankfort, KY 40602; Missouri State Archives, 600 West Main Street, Jefferson City, MO 65102; William F. Winter Archives and History Building, 200 North St., Jackson, MS 39201; New Mexico State Records and Archives, 1205 Camino Carlos Rey, Santa Fe, NM 87507; Tennessee State Library and Archives, 403 7th Avenue North, Nashville, TN 37243 and Texas State Library and Archives Commission, 1201 Brazos St., Austin TX 78701.

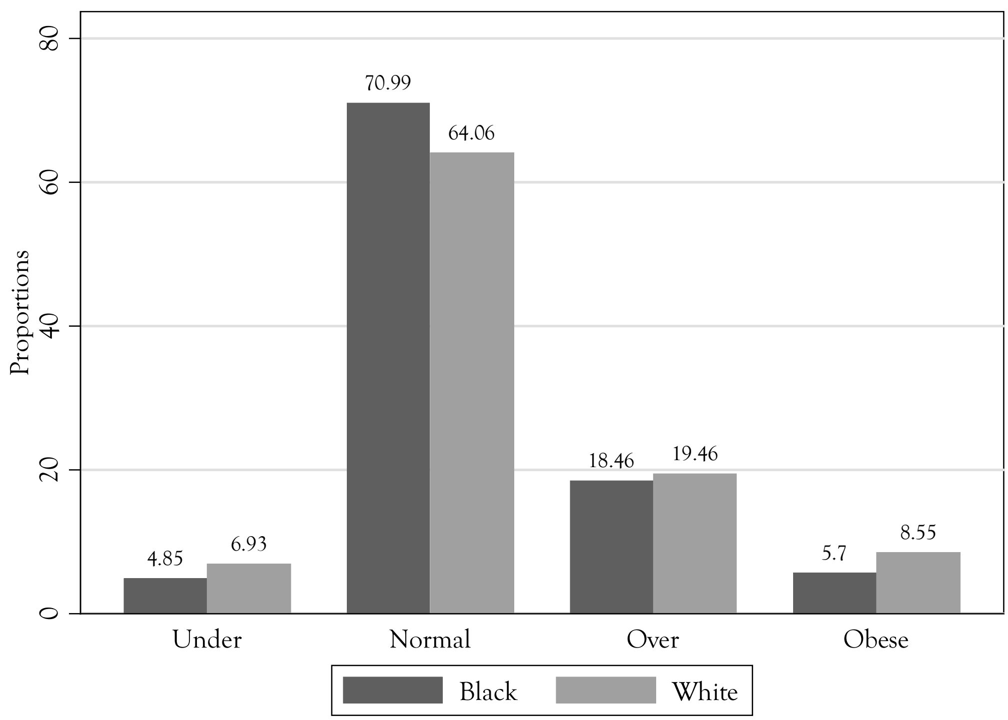
Enumerators recorded a broad set of occupations and defined them narrowly, and enumerators used over 200 occupations to classify pre-incarceration occupations. Women's occupations are classified here into four categories. The most prominent 19th century occupation for women was domestic laborer, such as cooks and household laborers. Women were also in low skilled occupations, such as waitresses and laborers. Women found limited access into skilled occupations, such as dressmakers and nurses; however, late 19th and early 20th century women's skilled occupations were those that served other women (Golden, 1990; Burnette, 2013, pp. 306-307). A final occupation is used for women who reported no occupation to prison enumerators. Subsequently, women within US prisons likely represented lower socioeconomic groups, but there is occupational and regional representation within the sample.

Most women in the sample were born in the South; however, there were sizeable portions from Middle Atlantic, Plains, and Great Lake states (Table 1). The largest cohort of women's international nativity was from the United Kingdom and Continental Europe (Cohn, 2009). Latin American and Canadian women are also in the sample but made-up smaller proportions.

Crime is committed by younger individuals, and women in their teens and twenties made up the largest share of the 19th century US prison population (Hirschi and Gottfredson, 1983; Carson, 2009b). The complexion of most women in the sample was of African ancestry, and disproportionate representation for women of African descent may indicate selective law enforcement and incarceration because of social processes that disproportionately targeted black women. Alternatively, disproportionate representation for women of African descent may be the result of women having less income and wealth, which made them more likely to commit crime and be incarcerated. Black women also had less income and wealth, which made them more likely to work outside the home than white women, which put then into environments where crime was more likely (Sunstrum, 2013, p. 332; Bodenhorn, 2015, pp. 144-166). Lower income and wealth also meant black women were less able to afford legal counsel at trial (Walker, 1988). By residence, most women were from Tennessee and Texas, but there were also women from further north in Illinois and Pennsylvania. One half of women's occupations were in domestic labor. Most women in the sample were born between the 1870s and 1880s, and incarcerated between 1900 and 1920.

There are various ways to classify weight status, and BMI has emerged as the primary means of to classify weight across modern and historical populations. Individuals with BMIs greater than 29.9 are classified as obese. Individuals with BMIs between 29.9 and 24.9 are overweight; individuals with BMIs between 24.9 and 18.5 are normal; individuals with BMIs less than 18.5 are underweight. While BMIs allow for easy weight classification, there are various short-comings when using BMIs to classify weight status (Burkhauser and Cawley, 2008). For example, BMIs does not distinguish between fat and fat-free mass, which means that muscular individuals and African-Americans are more likely to be classified as obese when, in fact, their weight is appropriate for their height and fat-free composition. Nevertheless, weight classification using BMIs is useful in both modern and historic populations and reflects health conditions in the late 19th and early 20th centuries (Zimmerman et al. 2004; WHO, 1985; Garrow and Webster, 1985).

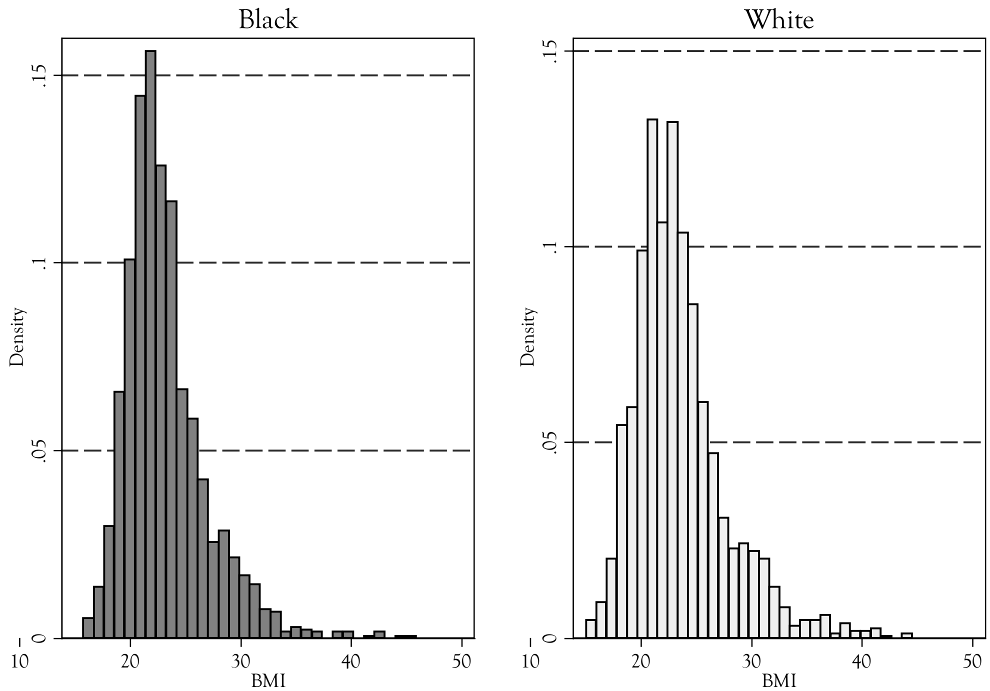
Figure 1, Late 19th and Early 20th Century Women's BMI Classifications



Source: See Table 1.

How BMIs are distributed indicates much about a population's net nutrition, and given similar means, if the distribution is positively skewed, there is a disproportionate number of underweight individuals. If the distribution is negatively skewed, there is a disproportionate number of overweight and obese individuals. Early British and European male workers did not receive sufficient net calories per day to accumulate excess weight relative to calories expended and likely had low BMIs (Fogel, 1994, p. 372; Fogel, 2004, p. 9). However, late 19th and early 20th century US male BMIs were in normal categories (Carson, 2009; Carson, 2012).

Figure 2, Late 19th and Early 20th Century Women's BMIs



Source: See Table 1.

Women's BMI distributions reflect their current health and the health of their off-spring. Modern research in women's health indicates that underweight women give birth to children with low birth weights that have short gestation periods (Abrams et al., 2000, p. 1235s and 1240s). Late 19th and early 20th century women's BMIs were in the normal category (Figure 1), and the percent of women in the underweight category was surprisingly low (Figure 2). Only 4.85 percent of black women and 6.93 percent of white women were in the underweight category, and white women were 42.89 percent more likely to be underweight compared to black women. Nearly 71 percent of black women and 65 percent of white women were in the normal BMI category. Around 19 percent of black women and 20 percent of white women were overweight, while 5.8 percent of black women and 8.6 percent of white women were obese.

In the late 19th and early 20th centuries, black and white women were fecund between the ages of 15 and 42 (Steckel, 1986b, p. 451), and the average fecund black women's BMI was 23.13 with 4.46 percent underweight. The average white fecund women's BMI was 23.29 with 6.70 percent underweight. To the extent that mother's average BMI and weight classification represent in-utero conditions, average white women's BMIs were greater but there was a greater share of white women in the underweight category, indicating that lower socioeconomic status white women were more likely to have low birth weight babies that were small for gestation compared to historical black women. Nineteenth century women's BMIs also reflect the neo-natal conditions of their off-spring. During slavery, black children had greater mortality rates than other children within the US, which indicates that in-utero black conditions for underweight black mothers may be the reason for high black childhood mortality rates (Steckel, 1986, p. 727). That late 19th and early 20th century white women in lower socioeconomic statuses were more likely to be underweight than black women indicates disproportionately high slave and black child mortality rates were likely due to conditions after birth than in-utero conditions. (Steckel, 1986b, pp. 450-453). Women who are overweight and obese are more likely to experience adverse reproductive health complications compared to women in normal BMI categories (Siega-Riz, Siega-Riz, and Laraia, 2006). Morbid obesity is defined as a BMI greater than 40, and only .28 percent of black women, and .78 percent of white women were morbidly obese. This compares to modern samples, where 17.70 percent of black women and 19.12 percent of white women are morbidly obese, indicating that late 19th and early 20th century women were unlikely to give birth to obese children and experience health consequences associated with obesity.

III. Women's BMIs by Socioeconomic Status, Residence, and Observation Period

BMI distributions reflect whether a population is underweight or obese. They do not, however, indicate how BMIs varied over time and with characteristics. To start, BMIs are assumed to be related to height, age, complexion, nativity, residence, occupation, and decade of measurement. Ordinary least squares is used to assess how women's BMIs varied with characteristics. Multinomial obesity regression models are used to assess the relative risk of being in a given BMI category relative to the normal category.

$$\ln\left(\frac{p_j}{p_{Normal}}\right) = \theta_0 + \theta_H Centimeters_i + \sum_{a=\text{Preteen}}^{70s}\theta_a Ages_i + \sum_{c=1}^{5}\theta_c Complexion_i + \sum_{n=1}^{11}\theta_n Nativity_i + \sum_{p=1}^{16}\theta_p Residence_i + \sum_{l=1}^{3}\theta_l Occupation_i + \sum_{t=1860s}^{1930s}\theta_t Observation\ Decade_i + \varepsilon_i$$

Stature in centimeters is included to account for the inverse relationship between BMIs and height. To account for how women's BMIs increased with age, annual youth dummy variables are included for women's ages 13 through 19. Ten year adult age dummy variables are included for women in their 30s through 70s. Complexion dummy variables are included for Native-Americans, black, mixed-race, Mexican, and an unspecified complexion group. To account for net cumulative nutrition since birth, US and international nativity dummy variables are included to measure the relationship between BMI and regional conditions at the time of birth. US residence dummy variables are included to account for current conditions facing a woman at the time of measurement. Occupation dummy variables are included to account for how BMIs varied by socioeconomic status, and observation period dummy variables are included to consider how women's BMI varied overtime.

Table 2's Model 1 presents least squares BMI estimates for the total sample. Models 2 through 4 present multinomial models in relative risk rates for underweight, overweight, and obese categories relative to the normal category. Model 5 presents least squares estimates for black women born in the US, while Model 6 does the same for US-born white women.

Table 2, Late 19th and early 20th Century Women's BMIs by Characteristics

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
	Total BMI Sample	**Underweight**	**Overweight**	**Obese**	**Black**	**White**
Intercept	40.95***	8.21^{-5}***	931.19***	11010.60***	42.95***	40.95***
Height						
Centimeters	-.116***	1.05***	.947***	.922***	-.125***	-.120***
Ages						
Preteen	-5.56***	65.14***	.305	2.58^{-13}***		
13	-4.83***	2.64	8.66^{-8}***	1.44^{-7}***		
14	-3.29***	10.41***	.086**	.417	-3.28***	-2.64***
15	-2.72***	5.74***	.275**	2.50^{-7}***	-2.46***	-3.37***
16	-1.33***	1.25	.461***	.107**	-1.31***	-1.57**
17	-1.22***	1.61*	.401***	.096**	-1.45***	.111
18	-.731***	1.17	.575***	.362**	-.478**	-.929***
19	-.565***	.696	.560***	.470**	-.676***	-.550
20s	Reference	Reference	Reference	Reference	Reference	Reference
30s	1.27***	.863	1.48***	2.99***	1.74***	.882***
40s	1.71***	1.07	1.80***	3.99***	1.09***	2.28***
50s	1.61***	1.83*	2.08***	4.28***	1.13**	2.54***
60s	1.64**	.530	1.26***	5.79***	2.66**	1.66***
70s	4.58***	2.04^{-7}***	3.11*	10.77**	2.94	6.70***
Ethnicity						
White	Reference	Reference	Reference	Reference	Reference	Reference
Native American	1.16*	2.49^{-7}***	1.89	3.19^{-7}***		
Black	.493***	.496***	1.36**	1.14		
Mixed-Race	.422**	.574***	1.33**	1.21		
Mexican	-.278	1.18	1.27	.753		
Uncertain Complexion	.606	2.40	.516	2.79		
Nativity						
Northeast	1.81*	1.33	2.40	2.62	1.06	2.30
Middle Atlantic	.194	.934	.884	1.21	.450	.061
Great Lakes	.337	1.05	1.30	1.06	.152	.418
Plains	.179	1.36	1.00	1.26	.184	.374
Southeast	-.109	.977	1.09	.837	.092	-.748
Southwest	Reference	Reference	Reference	Reference	Reference	Reference
Far West	.023	2.91**	1.40	1.22	.817	-.265
British	.006	.841	1.67*	.219**		
European	1.05**	.620	1.07	1.15		
Canada	.408	.540	.823	1.29		
Latin	-.388	.455	.561*	.656		

America						
Uncertain	.521	3.52**	2.60***	1.55		
Residence						
Arizona	.802	.761	2.18	1.83		
Colorado	.094	.614	1.61**	.653		
Idaho	1.08	.932	.974	2.04		
Illinois	.473	.785	1.13	1.66*	.318	.850
Kentucky	.255	.907	1.36	.874	.313	.595
Mississippi	.167	.460	1.49	4.02^{-7}***	.164	2.08*
Missouri	.382	.939	1.20	1.53	.110	.927
Montana	.133	1.31	1.43	1.18		
Nebraska	-.089	.998	1.45	.617	-.262	.494
New Mexico	-.426	.639	1.15	3.05^{-7}***		
Oregon	-.236	8.19^{-8}***	1.78	2.08^{-7}***		
Pennsylvania	.913**	.675	1.68**	1.99*	.769	1.07
Philadelphia	-1.21***	1.31	.741	.265**	-1.40**	-.655
Tennessee	.182	.794	1.03	1.06	-.094	-.655
Texas	Reference	Reference	Reference	Reference	Reference	Reference
Utah	-.462	447497.20***	1.45	.473		
Washington	.209	1.15^{-6}***	6.52	8.79^{-8}***		
West					.583	.728
Occupations						
Skilled	.314	1.77**	1.32	2.25**	.080	.847
Unskilled	.268	.801	1.04	2.08*	.229	.186
Domestic	.237	1.13	1.14	1.74*	.157	.335
No Occupation	Reference	Reference	Reference	Reference	Reference	Reference
Received						
1860s	2.05**	4.75^{-7}***	2.22	6.48**	2.24**	4.31***
1870s	.744***	.810	1.27	2.39***	.589**	.464
1880s	.180	.778	1.09	.882	.201	.202
1890s	-.303*	1.14	.937	.934	-.522***	.433
1900s	Reference	Reference	Reference	Reference	Reference	Reference
1910s	.653***	.947	1.28**	2.49***	.647***	.343
1920s	.390	.700	.985	2.36***	-.060	.539
1930s	.304	1.33	.793	4.09*	-1.31	.009
N	4,766	4,766	4,766	4,766	2,841	1,285
R^2	.1373	.0961	.0961	.0961	.1569	.1175

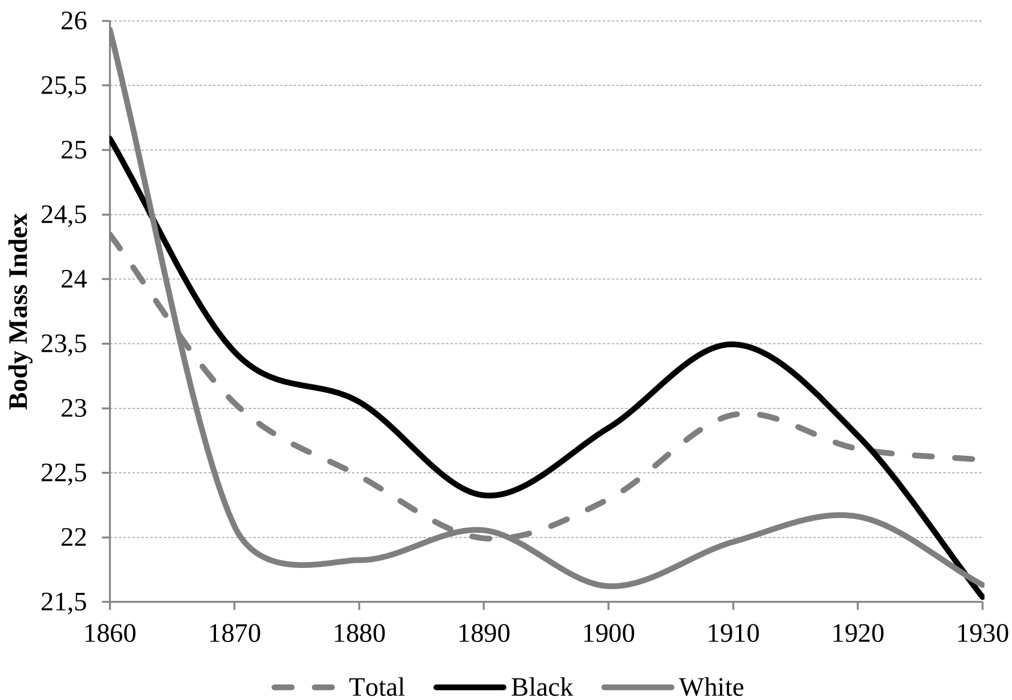
Source: See Table 1.

Note: *** significant at .01; ** significant at .05; * significant at .10.

Three paths of inquiry are considered when evaluating women's late 19th and early 20th century BMIs and weight classification. First, 19th century male statures varied by complexion (Steckel, 1979; Carson, 2008a), and fairer complexioned males were taller than their darker complexioned counterparts, a pattern known as the 'mulatto advantage' (Bodenhorn, 1999). This stature by complexion relationship has been attributed to 19th century social preferences that favored individuals with fairer to darker complexions (Bodenhorn, 1999, pp. 994-995; Bodenhorn, 2001). However, if this stature advantage was due to social preferences, white women should have had greater BMIs than mixed-race women, who should have had greater BMIs than darker complexioned black women. In fact, the opposite is true (Table 3), and after accounting for characteristics, darker complexioned black women had greater BMI values than fairer complexioned white women, which indicates that social preferences favoring fairer complexioned blacks is not likely the primary explanation for mixed-race and having greater BMIs or whites being taller than darker complexioned blacks (Carson, 2008; Carson, 2009; Carson, 2015).

On the other hand, multiple explanations account for why black women had greater BMIs than white women. Black women may have had greater BMIs because individuals with darker complexions have more protein in muscle tissue, and muscle is heavier than fat (Barondess et al. 1997; Wagner and Heyward, 2000). Nineteenth century African-American households also devoted a greater share of their incomes to food than whites, and although black household incomes were lower than whites, black inter-family calorie and nutrition allocation may have allowed black women to gain more weight than whites (Higgs, 1977, p. 105; Bodenhorn, 2015, pp. 144-166). To the degree that female BMIs represent in-utero conditions of their children, greater African-American women BMIs indicate that in-utero conditions may not have been an impediment to early black childhood survival compared to white children and that it was conditions after birth that were responsible for high black childhood mortality rates. In sum, women with darker complexions had greater BMIs than women with fairer complexions, and black in-utero conditions may be an unlikely explanation for later life health for the children of darker complexioned women.

Figure 3, Late 19th and Early 20th Century BMIs by Observation Period



Source: See Table 1 and 3.

Second, women's BMIs varied over time, and between 1860 and 1930, the BMIs of African-American women decreased by 14.2 percent, while white women's BMIs decreased by 17 percent. Komlos (1987) and Carson (2008b) show that nutrition decreased with the separation of food consumption from food production, which increased the relative price of nutrition. Much of this decrease may have been associated with agricultural commercialization and industrialization. In 1800, most US agriculture was produced on single family farms that produced food and dairy products for household consumption; little surplus was left over for market transactions. During this pre-refrigeration period, the integrity of animal proteins and dairy products were also degraded when the distance between agricultural production and household consumption increased (Komlos, 1987; Craig et al. 2008; Carson, 2008, pp. 367-368). Moreover, during the mid-19th century, storage techniques to preserve dairy products used tin cans to store fluid milk, which compromised dairy quality when it was transported from rural to urban locations (Fletcher, 1955, p. 165; Cochrane, 1979, pp. 76-77). By 1910, much of US agriculture transformed into a highly commercial industry, which separated food consumption from production, and increased the relative price of nutrition. This separation of agricultural consumption from production increased the relative cost of net nutrition and put stress on women's current net nutrition (Kiple and King, 1981, p. 83; Komlos, 1987; Carson, 2008b). There was a mild increase in black women's BMIs around 1900; white women experienced a smaller, slight increase around 1910, yet the overall trend in women's BMIs decreased. Subsequently, unlike modern samples, throughout the late 19th and early 20th centuries, there was no trend toward female obesity, and like men, women's BMIs decreased throughout the late 19th and early 20th centuries (Carson, 2008a; Carson, 2009a; Carson, 2016).

Third, there was little BMI variation within the US by residence, and women in rural Pennsylvania had greater BMIs and were more likely to be overweight and obese than women elsewhere within the US. Residents in rural Pennsylvania lived in the dairy producing counties of Bucks, Chester, and Lancaster counties (Carson, 2008b, pp. 367-368), indicating that women in dairy producing regions faced lower relative food prices in close proximity to dairy production. Alternatively, women in urban Philadelphia faced relatively high net nutrition prices and had lower BMIs than women elsewhere within the US. Women in the South were tall and had larger physical dimensions to distribute weight, which was associated with low BMIs (Sorkin et al. 1999a; Sorkin et al. 1999b; Carson, 2011; Carson, 2013). Within the South, white women in Mississippi were the only Southern women to have significantly greater BMIs than women observed elsewhere within the US, and Southern whites had greater access to diverse diets that had more calories, which included corn, pork, beef, and Irish potatoes (Hilliard, 1972). Patterns for non-US born women in the US are also noteworthy, and after accounting for shorter statures, British women had BMIs comparable to Southern US women and may have been more likely to be overweight but not obese. Women with other international nativities were not significantly different from Southern US women.

Other patterns are consistent with expectations. BMIs varied by age, and after controlling for characteristics, white women's BMIs increased with age more than black women, indicating that young white women had greater access to net nutrition during their youth. Although maternal social position is related to off-spring birth size, women's occupations were mostly not related to BMIs. In sum, there were complex interactions between the late 19th and early 20th century women's net nutritional conditions, and after controlling for observable characteristics, black women had higher BMIs than white women.

IV. Explaining the Difference between Late 19th and Early 20th Century Women's BMIs

To more fully account for US black and white women's BMI differential and to assess the relative magnitudes of characteristic relationships, a black-white female Blinder-Oaxaca decomposition is constructed (Oaxaca, 1973). A Blinder-Oaxaca decomposition partitions the difference between samples that accrue to returns to characteristics and differences that accrue to average characteristics. Let BMI_b and BMI_w represent the body mass of black and white women, respectively. θ_{0b} and θ_{0w} are the autonomous body mass components that accrue to black and white women. θ_{1b} and θ_{1w} are the BMI returns associated with black and white characteristics, such as age and occupation. Characteristic matrices $\overline{X}_b$ and $\overline{X}_w$ are average characteristic matrices, and average black women's BMI are assumed to be the base structure.

$$\text{Black BMI function:} \quad \mathrm{BMI}_b = \theta_{0b} + \theta_{1b}\overline{X}_b \tag{1}$$

$$\text{White BMI function:} \quad \mathrm{BMI}_w = \theta_{0w} + \theta_{1w}\overline{X}_w \tag{2}$$

The black and white BMI gap is.

$$\Delta BMI = BMI_b - BMI_w = \theta_{0b} + \theta_{1b}\overline{X}_b - \theta_{0w} - \theta_{1w}\overline{X}_w \tag{3}$$

Adding and subtracting $\theta_b X_w$ to the right hand side of the equation and collecting like terms is

$$\Delta BMI = BMI_b - BMI_w = (\theta_{0b} - \theta_{0w}) + (\theta_{1b} - \theta_{1w})\overline{X}_b + \theta_w(\overline{X}_b - \overline{X}_w) \tag{4}$$

The first right-hand side element, $(\theta_{0b} - \theta_{0w})$, is the BMI differential due to non-identifiable sources, such as greater muscle mass and bone mineral density that favored black women (Barondess et al. 1997, Wagner and Heyward, 2000). Non-identifiable sources in the intercept also include being born a slave or not well nourished in-utero and during early childhood (Trussell and Steckel, 1992, pp. 444-449). The second right hand-side element, $(\theta_{1b} - \theta_{1w})\overline{X}_b$, is the component of the BMI differential due to BMI return differences associated with characteristics. The difference is positive if black women's BMI returns associated with characteristics is greater than for white women and negative if white women's BMI returns was greater than for black women. The third right-hand side element, $\theta_w\left(\bar{X}_b - \bar{X}_w\right)$, is the part of the BMI differential due to average characteristics. The difference is positive if average characteristics were greater than white women and negative when white average characteristics are greater than black women.

Table 3, Late 19th and early 20th Century Black-White Women's BMI Decomposition

	$(\beta_b - \beta_w)X_b$	$(X_b - X_w)\beta_w$	$(\beta_b - \beta_w)X_w$	$(X_b - X_w)\beta_b$
Levels	**Returns to Characteristics**	**Average Characteristics**	**Returns to Characteristics**	**Average Characteristics**
Levels				
Sum	1.29	-1.21	.789	-.716
Total		.073		.073
Proportions				
Intercept	27.46		27.46	
Height	-11.05	1.22	-11.10	1.27
Ages	.141	-7.30	.189	-7.35
Nativity	5.65	-4.33	3.28	-1.96
Residence	-.678	-5.29	-4.47	-1.50
Occupations	-1.82	-.920	-2.70	-.041
Observation Period	-1.97	-.117	-1.83	-.257
Sum	17.74	-16.74	10.83	-9.83
Total		1		1

Source: See Tables 1 and 3.

Using coefficients from women's BMI regressions Table 3, Models 5 and 6 indicate that in both levels and proportions, black compared to white women had considerable advantages from non-identifiable sources in the intercept, which includes greater percent protein in muscle tissue. The greatest share of the black-white difference in proportions is due to how white BMIs increased with stature relative to black women, indicating that white women's cumulative net nutritional advantage had lasting effects. White to black women's BMI advantage also extended to greater BMI returns with residence, occupations, and observation period. The BMI gap was also explained by differences in average characteristics, and white women had greater returns associated with average age, nativity, residence, occupations, and observation period. Alternatively, black women had greater BMI advantages associated with BMI returns to nativity and average heights. In sum, after controlling for characteristics, black woman historically had greater average BMIs than white women, which had implications for conditions during economic development, race relations within the 19th century US, and how resources were located during economic development.

V. Conclusion

The health and current net nutrition of women during early urbanization and industrialization indicates much about how their own health and the health of their off-spring vary with economic development (Osmania and Sen, 2003). This study demonstrates that late 19th and early 20th century black women had greater BMI values than mixed race and white women. Between 1860 and 1930, black women's BMIs decreased by 14 percent, while white women's BMIs decreased by 17 percent, indicating that decreasing women's BMIs reflect deteriorating net nutritional conditions for themselves and the fetal conditions for children born in the late 19th and early 20th centuries. The separation of food production from food production increased the relative price of food, and young women's BMIs decreased throughout the late 19th and early 20th centuries as agricultural and labor markets industrialized. This decrease in 19th century women's BMIs over time may have had inter-generational consequences. If working class women had poor current net nutrition during pregnancy, their children may have been at greater risk of heart disease, stroke, and diabetes in later-life (Yan, 2015; Richards et al, 2001, p. 201; Rode et al., 2007). Children born to mothers with poor nutrition are also more likely to have low birth weights, higher adult plasma glucose, high insulin concentrations, and type-2 diabetes (Yan, 2015; Ravelli et al., 1999; Ben-Shiromu and Smith, 1991; Kramer and Jospeh, 1996). Moreover, poor in-utero and early life conditions also reduces cognitive function during children's formative years, which impairs child later-life economic outcomes (Sørensen et al, 1997, p. 402; Richards et al. 2007; Hack et al. 2002, pp. 149 and 151; Case and Paxson, 2008a; Case and Paxson, 2008b). Women from the Southwest were taller and had lower BMIs than women located elsewhere within the US. Women from Continental Europe had greater BMIs, which is due, in part, to women reaching shorter statures who had low cumulative net nutrition that began during their European childhood, but their net nutrition improved upon migration to the US. Subsequently, during the late 19th and early 20th century, low and decreasing net nutrition for women in lower socioeconomic groups may have persisted in their off-spring into the middle of the 20th century with cognitive function, insulin resistance, and adult-onset diabetes.

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