CESifo WORKING PAPERS

6932
2018

February 2018

The 19th Century Net Nutrition Transition from Free to Bound Labor: A Difference-in-Decompositions Approach

Scott Alan Carson

CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
Editors: Clemens Fuest, Oliver Falck, Jasmin Gröschl
www.cesifo-group.org/wp

An electronic version of the paper may be downloaded
· from the SSRN website: www.SSRN.com
· from the RePEc website: www.RePEc.org
· from the CESifo website: www.CESifo-group.org/wp

CESifo *Working Paper No. 6932*
Category 4: Labour Markets

The 19th Century Net Nutrition Transition from Free to Bound Labor: A Difference-in-Decompositions Approach

Abstract

The body mass index (BMI) reflects current net nutrition and health during economic development. This study introduces a difference-in-decompositions approach to show that although 19th century African-American current net nutrition was comparable to working class whites, it was made worse-off with the transition to free-labor. BMI reflects net nutrition over the life-course, and like stature, slave children's BMIs increased more than whites as they approached entry into the adult slave labor force. Agricultural worker's net nutrition was better than workers in other occupations but was worse-off under free-labor and industrialization. Within-group BMI variation was greater than across-group variation, and white within-group variation associated with socioeconomic status was greater than African-Americans.

JEL-Codes: C100, C400, D100, I100, N300.

Keywords: BMI variation, current net nutrition, Oaxaca decomposition.

Scott Alan Carson
University of Texas, Permian Basin
4901 East University
USA – Odessa, TX 79762
Carson_S@utpb.edu

I appreciate comments from Doug Henderson, Shahil Sharma, Chinuedu Akah, Meekam Okeke, Lee Carson, Joe Beene, and Paul Hodges.

I. Introduction

Nineteenth century US economic development was related to increasing incomes, wealth, and wages; however, economic development was associated with other factors, such as higher relative food prices and environmental disamenities. Development was also related to immigration, and the late 19th and early 20th century US received considerable in-migration from Europe, Britain, and Latin America. Economic development and migration are, in turn, related to health, and when traditional measures for health and economic welfare are scarce or unreliable, statures and the body mass index (BMI) are two common measures that reflect health and net nutrition. Average stature reflects the cumulative net difference between calories consumed, less calories required for work and to withstand the physical environment (Fogel et. 1978; Fogel et al. 1979; Fogel et al. 1982). BMI is weight in kilograms divided by height in meters squared and reflects the current net difference between the same variables (Fogel, 1994).[1] However, interpreting BMI variation is more problematic than interpreting statures because BMI depends on when privation occurs. For example, if an individual is poorly nourished in their youth, they are less likely to reach their genetically pre-determined statures.[2] If short stature

---

[1] If adequate nutrition is restored before growth comes to an end, a person experiences catch-up growth, which allows them to return to their genetically pre-determined growth profile (Karlberg, and Albersson-Wikland, 1995; Cole 2003). In developing economies, BMIs are high for well-nourished populations and low for poorly nourished ones (Zagorsky, 2016).

[2] There is a complex relationship between stature, economics development, and stature. In developed, nearly 80 percent of stature is determined by stature; however, only 60percent of stature is determined by genetics in developed economics (Cho et al. 2009; Lai et al. 2006; Luke et al. 2001; Visscher, 2008, p. 489).

persists and a person receives abundant calories in adult ages, they are more likely to have high adult BMIs because they have lower metabolisms and greater weight is distributed over smaller physical dimensions (Schnieder, 2017, pp. 4-7; Herbert et al. 1993, p. 1438; Carson, 2009a; Carson, 2012a; Komlos and Carson, 2017). On the other hand, adults with adequate childhood nutrition are more likely to reach their genetically pre-determined stature, have higher metabolisms, and because their weight is distributed over larger physical dimensions, have low BMIs in later life (Nystrom-Peck, 1994; Nystrom-Peck and Lundberg, 1995; Rahkonen et al. 1997). Accounting for this lagged relationship between current and cumulative net nutrition is especially relevant with late 19th and early 20th century migration to the US because immigrants may have received poorer net nutrition prior to migration that improved upon arrival (Dirks, 2016, pp. 128-130).

Table 1 Research in 19th and early 20th Century BMIs

Study	*Sample*	*Observation Period*	*BMI Δ by Centimeter*	*BMI Δ Over Time*	*Mixed-race Δ Compared to Blacks*	*Δ Farmer*
Cuff, 1993	White, West Point cadets	1860-1885		.800		
Colanis and Komlos, 1995	White, The Citadel	1830-1930		1.70		
Carson, 2009a	Texas Prison	1870-1920		Black -.386 White .240	-.334	.200 .100
Carson, 2012	United States Prisons	1850-1929	Black Youth, -.072	Black Youth, -1.06	-.400	.400
			White Youth, -.054	White Youth, -1.05		.500
			Black Adult, -.061	Black Adult, -2.30	-.400	.200
			White Adult, -.047	White Adult, -2.00		.300
Carson and Hodges, 2012	Philadelphia Prison	1870-1910	Black and White Combined, -.038	Black and White Combined, .949	-.370	.104
Carson, 2012b	United States Prisons	1840-1920	Black and Mixed Race -.069	-1.44	-.344	
Carson, 2013c	United States Prisons	1840-1920	-.061	Black and White Combined, -3.50	-.413	.362
Carson, 2014a	Nebraska Prison	1900-1940	Black .048 White -.052	Black -.131 White -.480	-.167	Black .435 White .343
Carson, 2014b	Southern States Prisons	1840-1920	-.069	Black -1.30 White -1.90	-.300	Black .200 White .200
Carson and Hodges, 2014	United States Prisons	1860-1870	-.070	Black and White Combined, .100		.200

Carson, 2015c	United States Prisons	1840-1920	Black -.070 Mixed-Race -.066 White -.051	Black -1.20 Mixed-Race -2.30 White -1.1		Black .308 Mixed-Race, .505 White, .391
Komlos and Carson, 2017	Northwestern Whites	1882-1937		-1.01		.370

Source: Cuff, T. (1993); Coclanis, P. A., & Komlos, J. (1995); Carson, S. A. (2009a); Carson, S A. (2012a); Carson, S. A. and P. Hodges. (2012); Carson, S. A. (2012b); Carson, S. A. (2013c); Carson (2014a); Carson (2014b); Carson and Hodges (2014); Carson (2015c); Komlos and Carson (2017).

Historical BMI studies provide insight into how net nutrition varied with economic development, by ethnic status, and socioeconomic conditions, and a considerable body of research shows that African-American and white BMIs stagnated throughout the late 19th and early 20th centuries (Table 1). Agricultural workers were in close proximity to rural diets, with mild disease environments, and high BMIs. Moreover, individuals with dark complexions had greater BMIs than individuals with fairer complexions (Aloi et al 1997). These studies are well-established for populations within the US. However, little is known about how BMIs varied for immigrants to the US after their arrival.

It is against this back drop that this study considers three paths of inquiry into late 19th and early 20th century BMI variation for both US natives and immigrants. First, how did BMIs vary by nativity and residence? Net nutrition within the US varied regionally, and individual's residing in the Far West had higher BMIs, while those native to the Northeast and Central

Europe had higher BMIs; immigrants from Latin America and China had the lowest. Second, how did African-American, mixed-race, and white BMIs compare? Individuals with darker complexions had higher BMIs than mixed-race and whites, and individuals of African descent in the US had higher BMIs than Africans born elsewhere. Third, how did BMIs in the US compare by socioeconomic status? Agricultural workers' BMIs were greater than workers in other occupations, which is robust across ethnic status and nativity.

II. Late 19th and Early 20th Century BMI Data

Because the institutions and methods to collect randomized samples were yet to develop, all historical data reflect the purposes for which the data were collected. The data used here is the culmination of an extensive effort to organize and report the weights and heights of individuals in late 19th and early 20th century US prisons. Each state prison was contacted multiple times, and available prison records were acquired and entered into a comprehensive data set.[3] Prisons used here are Arizona, Colorado, Idaho, Illinois, Kentucky, Mississippi, Montana, Nebraska, New Mexico, Oregon, Pennsylvania, Philadelphia, Tennessee, Texas, Utah, and Washington.

Military and prison records are the most common source of late 19th and early 20th century weight and height data. Military records likely represent conditions among individuals with greater socioeconomic status because physical fitness as represented by weight and height were likely sought and preferred among military recruits (Sokoloff and Vilaflor, 1982, pp. 456-

[3]The total prison sample includes Arizona, California, Colorado, Idaho, Illinois, Kentucky, Maryland, Mississippi, Missouri, Montana, Nebraska, New Mexico, Ohio, Oregon, Pennsylvania, Philadelphia, Tennessee, Texas, Utah, and Washington.

458; Ellis, 2004; Coclanis and Komlos, 1995, p. 93). However, because soldiers and cavalrymen had to meet minimum stature requirements for service, they are not representative of the general population. Fortunately, prisoners were not targeted by enlistment officers and do not suffer from this arbitrary stature requirement.[4] However, prison records are not above reproach. For example, if law enforcement officials were trained to infer guilt from taller statures, it is uncertain which segment of society inmates represent because taller inmates may be more likely to be incarcerated. On the other hand, inmates may represent the least physically fit segment of society, and low weights and short statures may reflect poor net nutrition among lower socioeconomic status individuals who turned to crime out of privation (Floud et al. 2011, pp. 62-63). Because they had less income and wealth at the time of incarceration, prison records may also represent conditions among lower segments of society who were unable to afford legal counsel at trial. In sum, weight and height records from US prisons likely represent conditions among the working class and provide valuable insight into net nutrition during economic development.

Prison enumerators classified complexions into various categories from which ethnicity is inferred.[5] Individuals of African ancestry in the prison registries were recorded as black, dark black, and various shades of mulatto. Individuals of European ancestry were recorded as fair, light, medium, and dark. These fair complexion descriptions are supported further because immigrants from European countries were also recorded in US prison records as fair, light,

---

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

[5] The Arizona and Montana prisons are the only two prisons that took an individual's photograph and attached a complexion category, and it is reasonably clear that recorded classification reflects ethnic status.

medium, and dark. Until the 1930s in both the US federal census and prison records, individuals of mixed African and European ancestry were referred to as 'mulattos' but are referred to here as 'mixed-race'.[6] Prison enumerators also recorded complexions as Asian, Mexican, and Native-American, which are included to illustrate how current net nutrition varied across ethnicities.

Body mass was related to socio-economic status, and enumerators recorded over 200 different occupations, which are classified here into seven broad categories: white-collar, skilled, general farmers, ranchers, farm laborers, common laborers, and individuals with no listed occupations. Merchants, bankers, government administrators, and the clergy are classified as white-collar workers. Craftsman, butchers, and tailors are classified as skilled workers. Farmers and dairymen are classified as general farmers. Ranchers and stockmen are classified as ranchers. There were farm laborers who likely came to maturity in rural agricultural areas, where nutrition was abundant and physical activity levels high. There were also non-agricultural unskilled workers who were more likely to reach maturity in urban environments, where access to nutrition was limited (Komlos, 1987, p. 918; Carson, 2008a, pp. 366-368; Zehetmeyer, 2011, p. 318). A residual occupational category is included to account for individuals with no recorded occupation at time of measurement.

Table 2, Late 19th and Early 20th Century US Prison Descriptive Statistics

[6] There are various definitions used for mixed-race individuals within the prison records and the decennial US population censuses. A quadroon is a person with one quarter African ancestry, whereas a person with one-eighth African ancestry were recorded as octoroons, and these definitions were official descriptions in the US population surveys until the 1930s. Arizona and Montana are the only prisons that recorded both photographs and written descriptions, and it is clear from the Arizona and Montana prison photographs that these recordings were used consistently across prisons to reflect mixed-race ancestry.

Prison	*N*	*Percent*	*Average BMI*	*Standard Deviation*
Arizona	4,326	2.14	22.86	2.30
Colorado,	6,769	3.35	23.52	2.52
Idaho	767	.38	22.95	2.36
Illinois	12,022	5.95	23.13	2.65
Kentucky	13,713	6.78	22.83	2.53
Mississippi	2,298	1.14	23.06	2.50
Missouri	21,130	10.45	22.38	2.43
Montana	10,924	5.40	23.56	2.30
Nebraska	10,521	5.20	22.43	2.64
New Mexico	3,683	1.82	23.12	2.53
Oregon	2,527	1.25	23.68	2.33
Pennsylvania, East	9,149	4.53	22.81	2.51
Pennsylvania, West	8,113	4.01	23.58	2.33
Philadelphia	8,748	4.33	22.59	2.37
Tennessee	32,139	15.90	23.48	2.48
Texas	50,208	24.83	23.15	2.48
Utah	4,581	2.27	23.16	2.56
Washington	568	.28	22.90	2.24
Ethnicity				
American Indian	436	.22	23.38	2.56
Asian	117	.06	21.92	2.15
Black	44,232	21.88	23.64	2.46
Mexican	7,365	3.64	22.93	2.34
Mixed-Race	29,449	14.57	23.45	2.45
White	120,587	59.64	22.78	2.50
Decade Received				
1840s	233	.12	23.49	2.47
1850s	1,201	.59	22.75	2.23
1860s	2,625	1.30	23.30	2.51
1870s	15,029	7.43	23.33	2.57
1880s	30,208	14.94	23.16	2.43
1890s	38,810	19.20	23.19	2.44
1900s	51,954	25.70	23.00	2.49
1910s	49,538	24.50	22.98	2.53
1920s	7,902	3.91	23.06	2.71
1930s	3,621	1.79	22.55	2.82
1940s	1,065	.53	22.25	2.67
Ages				
Teens	28,274	13.98	22.18	2.30
20s	100,613	49.76	23.07	2.33

30s	43,213	21.37	23.29	2.59
40s	18,868	9.33	23.55	2.82
50s	8,024	3.97	23.70	2.97
60s	2,661	1.32	23.63	3.13
70s	480	.24	23.48	3.20
80s	53	.03	22.90	3.08
Occupations				
White-Collar	17,491	8.65	22.88	2.86
Skilled	36,422	18.01	22.97	2.52
Farmer	19,527	9.66	23.20	2.53
Rancher	1,340	.66	23.57	2.36
Farm Laborer	913	.45	23.51	2.60
Common Laborer	99,701	49.31	23.06	2.43
No Occupation	16,792	13.25	23.25	2.48
Nativity				
United States				
Northeast	2,321	1.15	23.09	2.63
Middle Atlantic	25,708	12.72	22.87	2.45
Great Lakes	17,817	8.81	22.90	2.54
Plains	24,968	12.35	22.64	2.52
Southeast	67,870	32.08	23.24	2.43
Southwest	34,209	16.92	23.11	2.46
Far West	5,576	2.76	22.86	2.34
International				
Africa	77	.04	23.36	2.62
Asia	422	.21	22.02	2.27
Australia	138	.07	22.98	2.11
Canada	1,864	.92	23.23	2.55
Europe	10,827	5.35	23.83	2.53
Great Britain	6,258	3.10	23.20	2.47
Latin America	297	.15	23.05	2.31
Mexico	6,834	3.38	22.94	2.26
Total	202,186	100.00	23.07	2.51

Source: Source: Arizona State Library, Archives and Public Records, 1700 W. Washington, Phoenix, AZ 85007; Colorado State Archives, 1313 Sherman Street, Room 120, Denver, CO 80203; Idaho State Archives, 2205 Old Penitentiary Road, Boise, Idaho 83712; Illinois State Archives, Margaret Cross Norton Building, Capital Complex, Springfield, IL 62756; 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; Montana State Archives, 225 North

Roberts, Helena, MT, 59620; Nebraska State Historical Society, 1500 R Street, Lincoln, Nebraska, 68501; New Mexico State Records and Archives, 1205 Camino Carlos Rey, Santa Fe, NM 87507Oregon State Archives, 800 Summer Street, Salem, OR 97310; Pennsylvania Historical and Museum Commission, 350 North Street, Harrisburg, PA 17120; Philadelphia City Archives, 3101 Market Street, Philadelphia, PA 19104; Tennessee State Library and Archives, 403 7th Avenue North, Nashville, TN 37243; Texas State Library and Archives Commission, 1201 Brazos St., Austin TX 78701; Utah State Archives, 346 South Rio Grande Street, Salt Lake City, UT 84101; Washington State Archives, 1129 Washington Street Southeast, Olympia, WA 98504.

Table 2 presents inmate residence, ethnicity, observation period, age, occupations, and nativity. Most inmates were incarcerated in the South, but there were sizeable proportions in the Northeast and Plains. While never a large part of the prison sample, there were also individuals in the Far West. Most complexions were consistent with African and European ancestry, but there were Asians, Native-Americans and Latin-Americans in the sample. Most inmates were received between the 1840s and the 1940s. Common ages were the teens and 20s, but there were individuals in older age categories (Hirschi and Gottfredson, 1983; Gottfredson and Hirsch, 1990, pp. 128-144; Freeman 1993; Carson, 2009c). Nearly half of pre-incarceration occupations were common laborers, but there are white-collar and skilled workers in the sample.[7] General

[7] There is some concern regarding how prison unskilled workers compared to the general population. As expected, the percent of unskilled workers in the prison sample is greater than the percent in the general population, indicating the prison population represents conditions among the working class.

farmers were the most common agricultural occupation. Within the prison sample, most native-born individuals were from the Southeast, but there were individuals born-in the Middle Atlantic, Great Lakes, and Plains states.[8] Common international nativities were from Continental Europe, the British Isles, and Mexico. The US had only recently been settled, and individuals born in the early 19th century were foreign-born, whereas individuals born later were US natives. While there were both men and women in US prisons, the purpose of this study is to evaluate late 19th and early 20th century male BMIs, and female BMIs are considered elsewhere (Carson, 2011a; Carson, 2013a; Carson, 2016).

Year	*US Population*	*Prisoners*
1850s		32.9
1860s		58.2
1870s	31.9	52.6
1880s	30.4	47.5
1890s		52.0
1900s	33.1	52.3
1910s	29.5	46.9
1920s	23.6	37.8

Source: US general population estimates are from Rosenbloom, 2002, p. 88.

[8] Carlino and Sill, 2000. The geographical scheme is New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. Middle Atlantic states include Delaware, Maryland, New Jersey, New York, Pennsylvania, and Washington DC. Great Lakes states are Illinois, Indiana, Michigan, Ohio, and Wisconsin. Plains states include Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota. Southeast states include Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. South Western States include Arizona, New Mexico, Oklahoma, and Texas. For Western states include California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming.

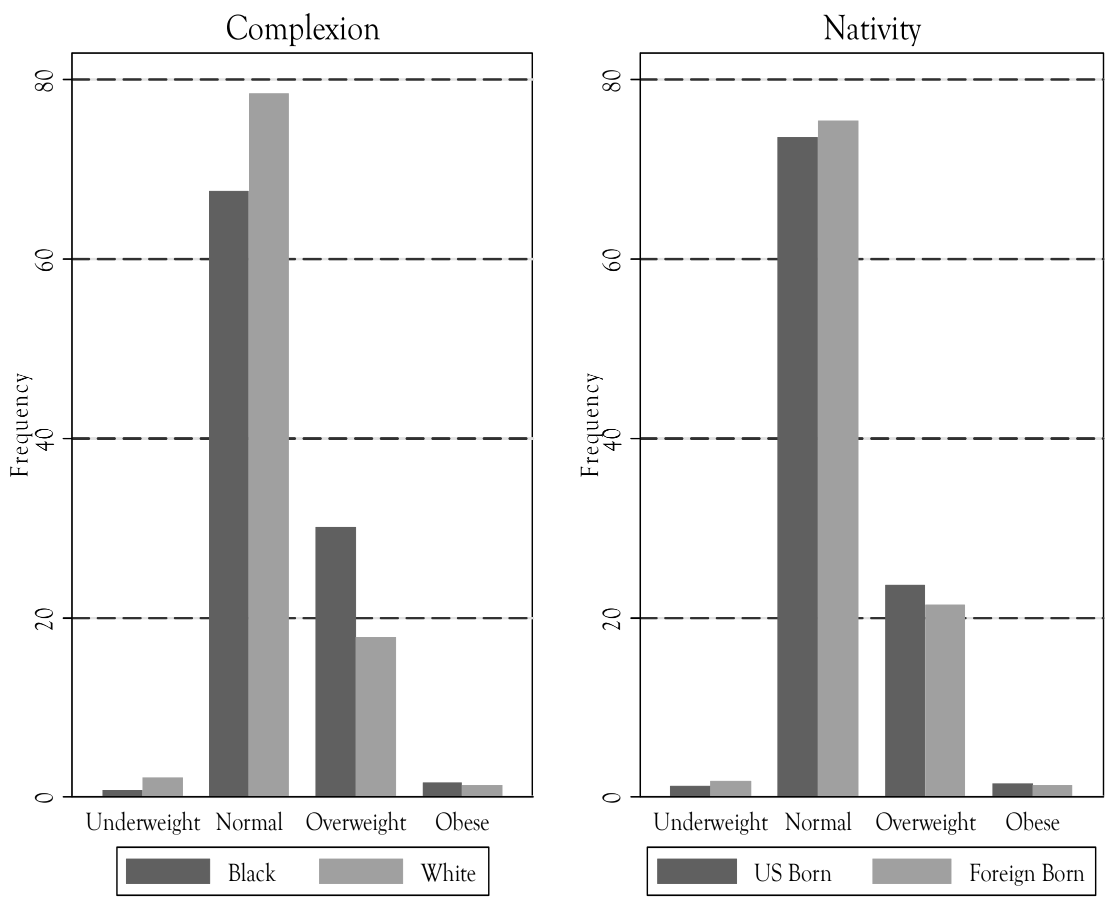

Figure 1, Late 19th and Early 20th Century BMI Distributions by Complexions and Nativity

Source: See Table 2.

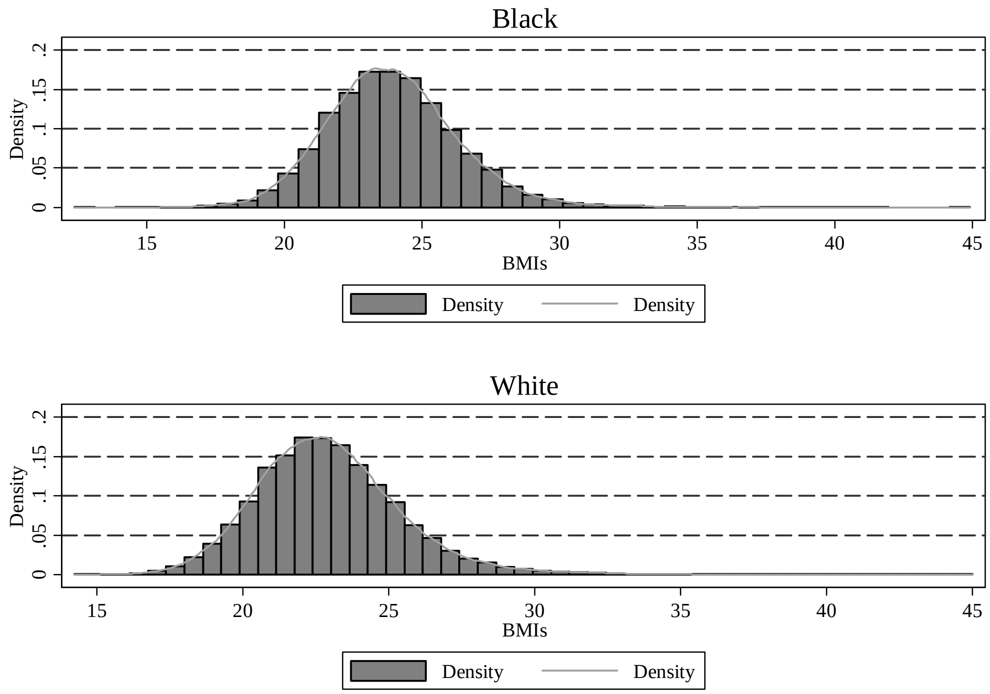

Figure 2, Late 19th and Early 20th Century Black and White BMIs

Source: See Table 2.

The shape of the BMI distribution indicates much about a population's current net nutrition. Given similar means, if the distribution is negatively skewed, the population is more likely to be overweight and to be underweight if the BMI distribution is positively skewed.[9]

[9] Using modern World Health Organization (WHO) standards, BMIs greater than 30 are classified as obese; BMIs between 29.9 and 24.9 are classified as overweight; BMIs between 24.9 and 18.9 are normal; BMIs less than 18.9 are underweight. While classifying weight is straight-forward using weight and height, it is an inaccurate measure for weight classification because it does not distinguish between fat, fat-free mass, and body composition (Burkhauser and Crawley, 2008). BMI, therefore, overestimates obesity for individuals with muscular builds and

While it is not clear how historical BMIs and health align with modern standards because of the effects of disease, Figure 1 demonstrates that late 19th and early 20th century black and white BMIs were in the normal category, and neither underweight nor overweight status was common (Figures 1 and 2; Fogel et al. 1993, p. 7; Floud et al 2011, pp. 57-61, 146-151; Carson 2009a, Carson, 2012a; Stephenson et al. 1999). Average black youth and adult BMIs were 22.53 and 23.83, respectively.[10] Average white youth and adult BMIs were 21.78 and 22.89, indicating that average black youth and adult BMIs were 3.44 and 4.11 percent higher than white BMIs. However, greater black BMIs do not necessarily indicate that African-Americans were in better physical condition than whites because BMIs are inversely related to height, and blacks were, on average, shorter than whites (Steckel, 1979; Carson, 2009c). Individuals with darker complexions also have greater protein in muscle tissue, and muscle is heavier than fat (Wagner and Heyward, 2000; Barondess et al. 1997; Aloi et al. 1997).

BMIs less than 19 are associated with increased mortality risk, and 40 percent of West Point Cadets were underweight (Cuff, 1993). However, only .84 and 2.18 percent of black and white adults in the prison sample were underweight, indicating that malnutrition in the late 19th and early 20th centuries was unlikely. Morbid obesity is defined as a BMI greater than 40, and instances of 19th century black and white adult obesity were uncommon. Only .02 percent of blacks and whites were morbidly obese. This is in marked contrast to modern populations, where 13 percent of blacks and 11 percent of adult whites are morbidity obese (Calle et al. 2011;

African-Americans. These distortions indicate that, when available, a more accurate weight classification system should be used. However, for the late 19th and early 20th centuries, BMI classification is the only available weight classification system.

[10] Youths are ages younger than 20. Adults are ages 20 and older.

Carson, 2011b, p. 15; Carson, 2016). Because BMIs were in the normal category, late 19th and early 20th century health that was poor by modern standards had little to do with BMI classification.

Body mass in the US also varied by international nativity.[11] Average US-born BMI was 23.03, while average immigrant BMI was 23.37. Only 2.12 percent of natives and 1.38 percent of immigrants were underweight, and natives were more likely to be in the normal BMI category. Nevertheless, like African-Americans, immigrants were shorter than natives with higher BMIs. For most of its history, European net nutrition stagnated but may have increased after 1860 (Koepke and Baten, 2005; Koepke and Baten, 2016). Among the foreign-born, Italians in the US were the least likely to be underweight, while the Chinese were the most likely to be underweight and short (Table 3; Carson, 2006). Russians were more likely to be overweight and obese, while Chinese and Mexicans were the least likely to be overweight. Comparable native and foreign-born BMIs indicate that wide-spread mal-nutrition among immigrants in the US was not common (Dirks, 2016, p. 106; Carson, 2009a). Subsequently, while immigrants may have encountered poor diets prior to migration, they were unlikely to have low BMIs in the US.

[11] Be it selection or poorer net nutrition prior to migration, United States' internal immigrant statures were taller than persisters (Carson, 2009c, pp. 155-156; Komlos, 1987, pp. 907-908).

Table 3, Native and Immigrant Average BMIs and Weight Classification

	N	*Percent*	*Age*	*BMI*	*Centimeters*	*Under*	*Normal*	*Over*	*Obese*
Total Sample									
Total	202,186	100.00	28.92	23.07	170.77	2.02	77.23	19.59	1.66
Native	175,469	86.79	28.28	23.03	171.14	2.12	77.57	19.18	1.62
Immigrant	26,717	13.21	33.09	23.37	168.34	1.38	74.98	22.29	1.90
Foreign-born									
Austria	977	4.09	30.91	23.78	169.43	.614	70.52	28.04	.921
British	2,337	9.79	35.70	23.02	168.68	2.10	77.36	18.91	2.18
Canada	1,864	7.81	32.49	23.22	171.06	2.41	74.68	21.51	2.09
China	309	1.29	34.08	21.82	162.97	4.85	87.70	7.44	.971
France	419	1.76	35.38	23.64	167.79	.716	71.36	25.54	2.63
Germany	4,094	17.14	35.12	23.71	168.53	.879	71.13	26.19	2.39
Ireland	2,935	12.29	36.65	23.29	169.97	1.36	76.70	20.89	1.50
Italy	1,565	6.55	30.87	24.11	164.57	.575	65.62	31.12	3.71
Mexico	6,834	28.62	29.63	22.94	166.79	1.48	81.68	16.27	.966
Russia	836	3.50	31.04	24.08	167.57	1.08	63.28	33.25	4.07
Scandinavia	998	4.18	36.11	23.91	172.00	1.20	67.44	29.76	2.10
Scotland	711	2.98	35.74	23.35	169.85	1.13	76.37	20.54	2.53

Source: See Table 2.

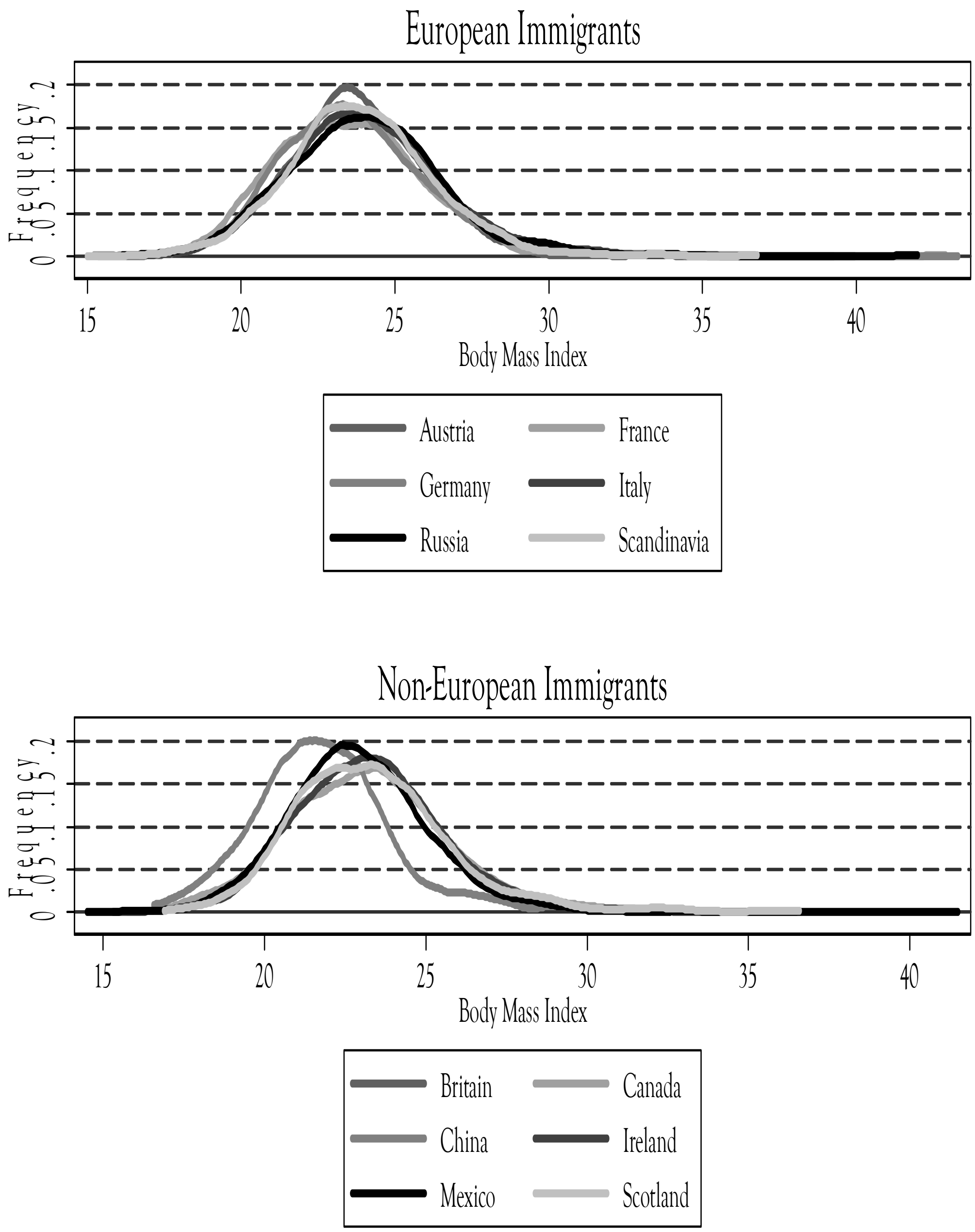

Figure 3, Late 19th and Early 20th Century Non-US BMIs

Source: See Table 2.

III. Late 19th and early 20th Century US BMIs by Demographics, Socioeconomic Status, and Residence: A Multinomial Approach

In theory and practice, the timing and extent of BMI variation is related to socioeconomic status, residence, and nativity. Multinomial BMI logit models are now estimated, and the normal category is assigned as the base category.

$$\ln\left(\frac{p_j}{p_{Normal}}\right) = \theta_0 + \theta_H Centimeters_i + \sum_{c=1}^{5}\theta_C Complexion_i + \sum_{a=1}^{17}\theta_a Age_i + \sum_{t=1}^{10}\theta_t Observation\ Period_i$$

$$+\sum_{j=1}^{6}\theta_j Occupation_i + \sum_{r=1}^{17}\theta_r Residence_i + \sum_{N=1}^{16}\theta_N Nativity_i + \varepsilon_i \qquad (1)$$

Stature in centimeters is included to account for the inverse relationship between BMI and height (Carson, 2009a; Carson, 2012a; Komlos and Carson, 2017). Complexion dummy variables are included to account for net nutrition variation by ethnicity. Annual youth age dummy variables are included to account for BMI variation at younger ages; adult decade dummy variables are included to account for BMI variation at older ages.[12] Observation decade variables are included to account for cohort BMI variation over time,[13] and occupation dummy

---

[12] John Komlos (1992, p. 300) questions whether the results in Steckel (1986a) are genuine or the result of the manifest sample's childhood participation rates. The Maryland sample supports the position that slave children were not well nourished.

[13] To measure how net nutrition and health vary with current local conditions, BMIs are generally measured by observation period and current residence. However, BMI can also be meaningfully measured by birth year and nativity. BMIs by observation period summarize the current net nutrition of different cohorts at a point in time. Alternatively, measured from birth period, BMIs summarize the cumulative net nutrition facing a population as it ages. Moreover, as the ratio of weight to height, BMI represents the lagged or mismatched effect of the timing of

variables are included to account for how net nutrition varied by socioeconomic status. Residence dummy variables are included to account for the relative access to food by geographic location within the US, while nativity variables account for net nutrition during an individual's youth.

Table 4, Model 1 presents least squares BMI estimates for the entire sample. Models 2 through 4 are multinomial logit models for underweight, overweight, and obese status relative to the normal BMI category. Coefficients are reported as relative risk ratios. Model 5 presents least squares estimates for only blacks born in the US, while Model 6 does the same for whites.

Table 4, Late 19th and Early 20th Century BMI and Obesity Multinomial Logit Models by Ethnic Status

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
	Total	Underweight	Overweight	Obese	Black	White
Intercept	32.73***				36.12***	30.86***
Height						
Centimeters	-.059***	1.05***	.963***	.894***	-.070***	-.049***
Ethnicity						
White	Reference	Reference	Reference	Reference		
Black	1.13***	.408***	2.36***	1.65***	Reference	
Mixed-race	.867***	.542***	1.95***	.143***	-.310***	
Native American	.476***	.834	2.07***	1.17		
Asian	-.121	.676	.473	.971		
Mexican	.059**	1.01	1.10*	.548***		
Ages						
12	-4.61***	140.88***	.147***	.320*	-5.00***	-4.09***

privation and may not be as good of measure for current net nutrition as weight after controlling for height (Gluckman and Hanson, 2006, p. 10; Carson, 2015b; Schnieder, 2017, p. 7; Carson, 2017). Nonetheless, BMI has been shown to be a robust measure for mortality risk (Waller, 1984; Koch, 2011). Subsequently, BMI is an established measure for mortality risk, whereas weight after controlling for height is an alternative measure for current net nutrition.

13	-4.25***	48.49***	.054***	.333**	-4.83***	-2.61***
14	-3.40***	22.88***	.105***	.209***	-3.75***	-2.67***
15	-2.78***	10.08***	.109***	.328***	-3.16***	-2.14***
16	-2.06***	5.61***	.176***	.176***	-2.39***	-1.68***
17	-1.47***	2.93***	.259***	.281***	-1.72***	-1.22***
18	-1.09***	1.97***	.373***	.282***	-1.32***	-.865***
19	-.713***	1.59***	.527***	.422***	-.861***	-.271***
20	-.423***	1.09***	.642***	.499***	-.566***	-.325***
21	-.275***	1.08***	.765***	.626***	-.328***	-.235***
22	-.171***	1.04***	.836***	.719***	-.194***	-.154***
23-29	Reference	Reference	Reference	Reference	Reference	Reference
30s	.222***	1.07***	1.21***	2.07***	.190***	.246***
40s	.465***	1.15***	1.43***	3.67***	.302***	.564***
50s	.570***	1.22***	1.59***	4.18***	.353***	.707***
60s	.458***	1.83***	1.53***	4.34***	.089***	.576***
70s	.244***	3.36***	1.44***	4.47***	-.172***	.474***
80s	-.531***	4.21***	.508***	3.34***	-1.50***	-.680***
Observation Period						
1840s	1.41***	.310***	2.36***	2.46*	1.13***	1.62***
1850s	.567***	.381***	1.30***	.331*	.698	.593***
1860s	.708***	.583***	1.56***	1.73*	.633***	.744***
1870s	.393***	.821**	1.34***	1.81***	.573***	.243***
1880s	.128***	.918	1.10***	.977	.118***	.104**
1890s	.141***	.784***	1.05**	1.15**	.156***	.138***
1900s	Reference	Reference	Reference	Reference	Reference	Reference
1910s	-.055***	1.13**	.933***	1.08**	-.148***	-1.85^{-4}
1920s	.071***	1.16*	.984	1.60***	-.156**	.169***
1930s	.168**	1.06	1.04	1.99***	-.257	.229**
1940s	.006	1.27	1.12	1.76	-.177	-.045
Occupations						
White-Collar	.008	1.19*	1.05	2.22***	-.225***	.118
Skilled	.004	.788***	.993	1.23***	-.005	.137***
Farmers	.332***	.537***	1.21***	1.37***	.308***	.387***
Ranchers	.504***	.629***	1.37***	1.80***	.076	.633***
Farm Laborers	.682***	.436	1.52***	3.40***	.726	.828***
Unskilled	.143***	.717***	1.08***	1.10	.090***	.210***
No Occupations	Reference	Reference	Reference	Reference	Reference	Reference
Residence						
Arizona	.034	.653***	.882***	.775	-.408***	.170***
Colorado	.494***	.401***	1.30***	1.19*	.288***	.531***
Idaho	.194**	.468**	1.06	.803	.042	.229**
Illinois	-.083	.950	.889**	1.15	-.459***	-9.0^{-5}
Kentucky	-.448***	1.62***	.772***	.653***	-.571***	-.361***

Missouri	-.729***	1.60***	.535***	.522***	-.841***	-.633***
Mississippi	-.213***	1.43**	.912**	.581***	-.306***	-.262
Montana	.744***	.289***	1.52***	1.39***	.254**	.785***
Nebraska	-.566***	1.44***	.658***	.721**	-.945***	-.450***
New Mexico	.212***	1.03	1.14***	1.41***	.012	.345***
Oregon	.756***	.435**	1.67***	1.06	.583*	.901***
PA, East	-.445***	1.33**	.680***	.842	-.790***	-.303***
PA, West	-.420***	.399***	1.31***	.842	.351***	.476***
Philadelphia	-.593***	1.29	.583***	.555***	-.714***	-.578***
Tennessee	.359***	.612***	1.30***	1.04	.262***	.421***
Texas	Reference	Reference	Reference	Reference	Reference	Reference
Utah	.199**	.907	1.12*	1.12		.224***
Washington	-.098	.835	.954	3.79^{-7}***	-.385	-.151*
Nativity						
Northeast	Reference	Reference	Reference	Reference	Reference	Reference
Middle Atlantic	-.104	1.22	.938**	.644***	-.327	-.044
Great Lakes	.007	1.06	1.01	1.05	-.230	.012
Plains	.037	1.09	1.06***	.988	-.023	.003
Southeast	-.140**	1.40*	.920*	.889	-.113	-.223***
Southwest	-.116*	1.13	.919***	1.03	-.140	-.194***
Far West	-.169***	1.23	.909**	.642	-.212	-.202***
International						
Africa	.262	2.61	1.43*	1.50		
Asia	-2.24***	6.17***	.189***	.039***		
Australia	-.226	.522	.751*	.407		
Canada	.003	1.73***	1.09**	.807		
Europe	.677***	.584***	1.71***	.876		
Great Britain	.008	.998	1.01	.664**		
Latin American	-.451***	1.41	.674***	.542**		
Mexico	-.280***	1.02	.759***	.370***		
N	202,186	202,186	202,186	202,186	72,645	99,307
R^2	.1256	.0691	.0691	.0691	.1336	.0795

Source: See Table 2.

Note: Standard errors clustered on age. *** significant at .01.; ** significant at .05; significant.

Three paths of inquiry are considered when evaluating late 19th and early 20th century BMI variation. First, BMI was related to net nutrition by residence within the US, which reflected the relative price and access to nutrition by different cohorts at the time of measurement. The 19th century South was agriculturally productive, and Southern net nutrition exceeded nutrition elsewhere within the US (Hilliard, 1972; Ransom and Sutch, 1977, pp. 151-156; Carson, 2014c; Dirks, 2016). The Far West was in the process of early economic development and individuals born elsewhere but who later immigrated to the West received poor net nutrition prior to migration and were shorter but received sufficient nutrition after arrival. Western agricultural workers were also more physically active because westward expansion required clearing farms and other agricultural activities, which required physical activity, muscle mass, and muscle is heavier than fat (Atack and Bateman, 1987; Carson, 2014d, p. 774-775; Rosenblum, 2002, pp. 123-124). On the other hand, individuals native to the Northeast, Middle Atlantic, and upper South were shorter and had higher BMIs (Ransom and Sutch, 1977; Carson, 2009a; Carson, 2012a; Dirks, 2016, pp. 77-89).

Patterns for international migration are also noteworthy. If prior to migration, an individual received poor childhood net nutrition but their nutrition improved upon arrival in the US, they are more likely to have higher adult BMIs because they were short, had lower metabolisms, and had higher BMIs in later life because weight was distributed over smaller physical dimensions.

Table 5, Late 19th and Early 20th Century BMI and Obesity Multinomial Logit Models by Nativity

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
	OLS	Under	Over	Obese	US-Native	Foreign Born
Intercept	32.19***				32.14***	31.71***
Height						
Centimeters	-.055***	1.04***	.966***	.899***	-.055***	-.052***
Ethnicity						
White	Reference	Reference	Reference	Reference	Reference	Reference
Black	1.03***	.458***	2.19***	1.70***	1.07***	-.202***
Mixed-race	.892***	.544***	1.99***	1.58***	.920***	-.617***
Native American	.735***	.646	2.43***	1.38	.733***	.667
Asian	-.440**	.814	.368	.623	-.275	-2.16***
Mexican	.127***	1.05	1.19***	.805	.161***	-.514***
Ages						
12	-4.48***	125.04***	.166	.391	-4.46***	-7.06***
13	-4.14***	44.23***	.061***	.391*	-4.17***	-3.16***
14	-3.31***	21.47***	.117***	.246***	-3.29***	-4.32***
15	-2.71***	9.63***	.119***	.374***	-2.70***	-3.02***
16	-2.02***	5.50***	.186***	.193***	-2.03***	-1.68***
17	-1.48***	2.96***	.265***	.291***	-1.47***	-1.53***
18	-1.11***	2.03***	.377***	.285***	-1.10***	-1.17***
19	-.734***	1.64***	.529***	.415***	-.719***	-.901***
20	-.433***	1.11***	.646***	.499***	-.434***	-.417***
21	-.284***	1.09***	.766***	.627***	-.276***	-.337***
22	-.177	1.05***	.836***	.726***	-.165***	-.288***
23-29	Reference	Reference	Reference	Reference	Reference	Reference
30s	.231***	1.07***	1.21***	2.05***	.224***	.257***
40s	.484***	1.15***	144***	3.64***	.483***	.460***
50s	.594***	1.25***	1.62***	4.16***	.609***	.497***
60s	.497***	1.86***	1.58***	4.37***	.443***	.558***
70s	.266***	3.47***	1.48***	4.50***	.265***	.178***
80s	-.503***	4.36***	.536***	3.46***	-1.00***	.735***
Observation Period						
1840s	.785***	.698	1.63***	1.63	.879***	.419
1850s	.072	.758	.999	.237**	.090*	.083
1860s	.522***	.852	1.48***	1.43	.532***	.361***
1870s	.388***	.903	1.38***	1.67	.429***	-.033
1880s	.209***	.861*	1.19***	.941	.209***	.081
1890s	.217***	.753***	1.12***	1.12**	.228***	.091*
1900s	Reference	Reference	Reference	Reference	Reference	Reference

1910s	-.003	1.07	.968*	1.17***	-.017	.058
1920s	.145***	1.08	1.06**	1.74***	.143***	.235*
1930s	-.245***	1.40***	.788***	1.74***	-.197**	-.746***
1940s	-.415***	1.68**	.838**	1.53	-.403***	-.169
Occupations						
White-Collar	-.233**	1.51***	.873***	2.06***	-.244***	.245*
Skilled	-.190***	.987	.836***	1.14*	-.185***	.178***
Farmers	.146***	.689***	1.06***	1.37***	.122***	.706***
Ranchers	.654***	.523***	1.46***	2.20***	.658***	.988***
Farm Laborers	1.01***	.235***	1.80***	3.28***	1.05***	1.04***
Unskilled	-.122***	.948	.882***	1.02	-.158***	.399***
No Occupations	Reference	Reference	Reference	Reference	Reference	Reference
International Nativity						
US Nativity	Reference	Reference	Reference	Reference		
Africa	.339	1.97	1.42*	1.67		
Austria	.956***	.305***	2.03***	.624**		
Great Britain	-.022	.983	1.00	.875		
Canada	.312***	1.12	1.31***	1.07		
China	-1.97***	3.76***	.196***	9.58^{-8}***		
France	.513***	.365**	1.43*	1.14		
Germany	.666***	.444***	1.57***	.963		
Ireland	.226**	.670***	1.10	.733		
Italy	1.01***	.367***	2.05***	1.46***		
Mexico	-.118***	.709***	.804***	.381***		
Russian	1.18***	.599***	2.60***	1.71**		
Scandinavia	1.03***	.597**	2.10***	1.34		
Scotland	.354	.532	1.15	1.37		
N	202,186	202,186	202,186	202,186	175,469	26,717
R^2	.1010	.0566	.0566	.0566	.1038	.0609

Source: See Table 2.

Note: Standard errors clustered on age. *** significant at .01.; ** significant at .05; significant.

Independent of compositional effects, immigrants had greater BMIs than US natives (Table 5). Canadians and Europeans were shorter and had the highest BMIs (Koepke and Baten, 2005; Koepke and Baten, 2016), indicating these immigrants likely had inferior net nutrition prior to migration that improved after arrival. However, Mexicans and Asians were shorter and had low BMIs, suggesting they had poor net nutrition prior to migration, did not fully assimilate into the US economy, and had lower BMIs in the US (Table 5; Carson, 2005; Carson, 2007a; Carson, 2007b). While trend weighted BMIs and height illustrate the 1880s was the period of highest net nutrition, it decreased after 1880 among the working class by ethnic status and nativity (Figures 4, 5, and 6).

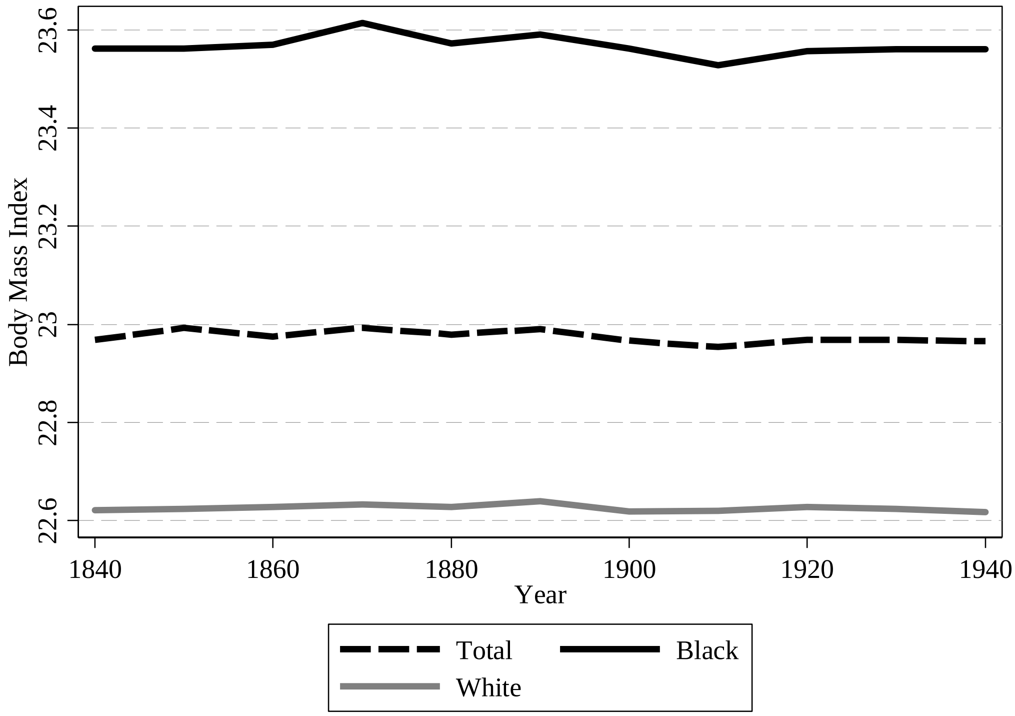

Figure 4, Late 19th and Early 20th Black and White BMIs over Time

Source: See Table 3.

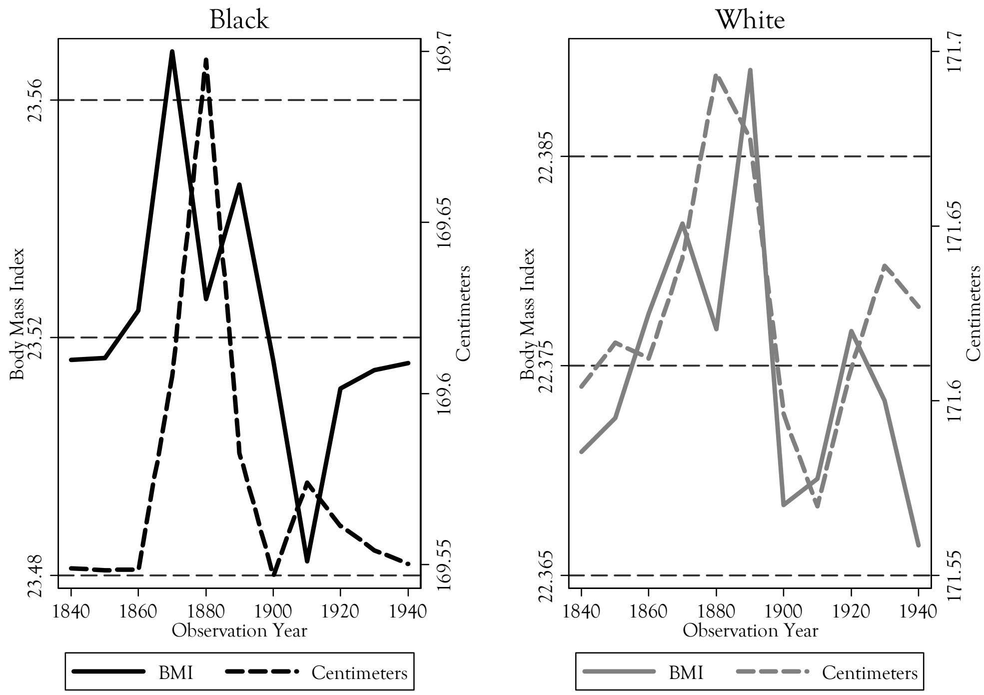

Figure 5, Late 19th and Early 20th Black and White BMIs and Height over Time

Source: See Tables 2 and 4.

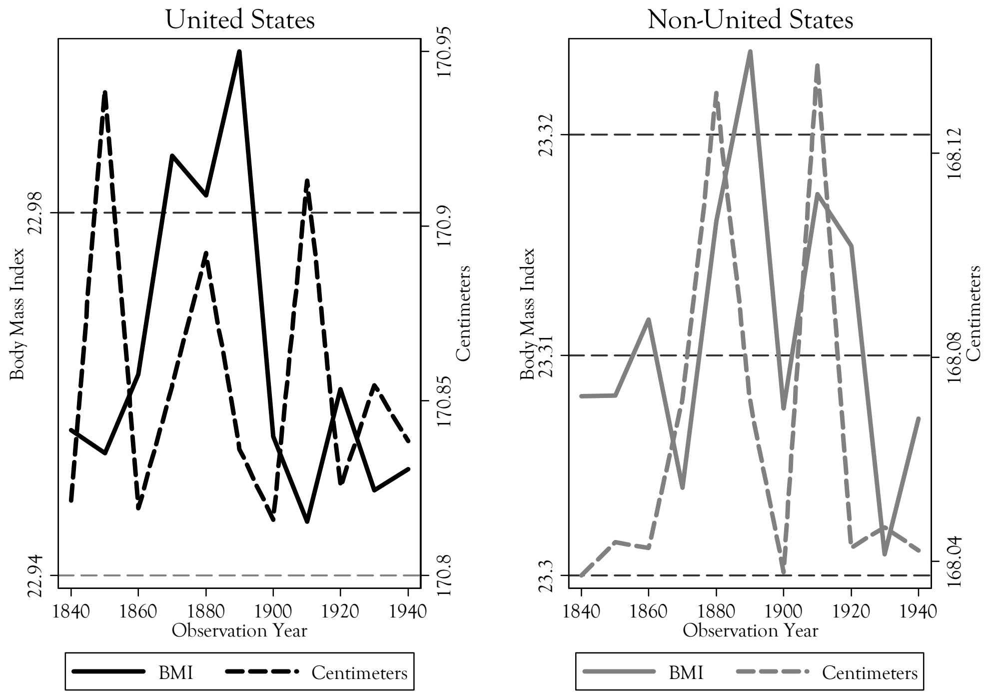

Figure 6, Late 19th and Early 20th Century US and Non-US BMIs and Height over Time

Source: See Tables 2, 3, and 5.

Second, much has been written about the persistent result that late 19th and early 20th century whites, and mixed-race individuals were taller than darker complexioned individuals (Steckel, 1979; Carson, 2008b; Carson, 2009c). A frequent explanation for the difference is due to US social-preferences that disproportionately favored fairer to darker complexions (Bodenhorn, 2002, pp. 23, 30, and 43). If these social preferences extended to BMIs, whites should have had greater BMI values than mixed-race individuals, which should have been greater than for individuals with darker complexions. However, individual's with darker s had similar average BMIs values to whites, were nearly twice as likely to be overweight and obese, and were substantially less likely to be underweight (Tables 1, 2, 4, and 5; Carson, 2015c;

Carson, 2016,). Furthermore, if US social preferences were responsible for the black-white BMI difference, foreign-born individuals with darker complexions should have had greater BMIs than their US-born counterparts. However, foreign-born individuals with darker complexions had similar BMIs compared to US-born blacks, indicating it is unlikely that late 19th and early 20th century US social preferences were the primary explanation for higher BMIs and shorter statures for darker complexioned individuals (Table 5).

Third, BMIs in the late 19th and early 20th century US were related to occupations, and farmers had greater BMIs than workers in other occupations. Carson (2009a) demonstrates that agricultural workers in Texas had about .210 greater BMI units than unskilled workers, and Carson (2012a) illustrates that agricultural workers at the national level had around .200 BMI units higher than workers with no occupations. However, occupations reflect both health relationships related to occupations and occupational comparative advantage and selection. Margo and Steckel (1992, p. 518) propose that agricultural workers may have had higher BMIs because local conditions were conducive to greater BMIs, or individuals with high BMIs selected into agricultural occupations where physical size was required. Propensity score matching is a statistical technique used to account for the effect of treatment by accounting for how covariates predict receiving treatment. This matching procedure mimics a randomized experiment by creating a sample of units that did not receive treatment by comparing differences in outcome variables between treated and control groups and reduces potential biases. Equation 2 is treatment on the treated.

$$\Delta^T = \frac{1}{|N|}\sum_{i \in N}\left[y_i - \sum_j \frac{1}{|J_i|} y_j \right] \qquad (2)$$

where Δ^T is the value of treatment. $|N|$ is the number of units in the treatment group. J_i is the group of comparison units matched to the treatment unit i, and $|J_i|$ is the number of comparison units in J_i (Dehejia and Wahba, 2002, p. 153).[14]

Table 6, Sample Means and Standard Errors of Covariates

	Farmers		**Non-Farmers**	
	Mean	*Standard Error*	*Mean*	*Standard Error*
Intercept				
Height Centimeters	172.41	6.82	170.59	6.97
Ethnicity				
White	.607	.488	.595	.491
Black	.211	.408	.220	.414
Mixed-race	.147	.354	.146	.353
Native American	.004	.064	.002	.044
Asian	6.66^{-4}	.026	5.69^{-4}	.024
Mexican	.030	.172	.037	.189
Ages				
12	3.59^{-4}	.019	7.17^{-4}	.027
13	5.12^{-4}	.023	.001	.036
14	.002	.040	.003	.056
15	.004	.063	.006	.078

[14] Propensity score matching is not without criticism. For example, one issue with matching is that there is little guidance on the proposed independent variables (Heckman et al. 1998). There are usually diverse model specifications but no formal means to choose between alternative model specifications (DiNardo and Lee, 2011, p. 253). Although propensity score matching attempts to model causal effects, for results presented here to be interpreted as causal requires that there are no unobserved variables that influence body mass and the probability of being a farmer. There is a compelling argument that overfitting on treatment increases the bias associated with matching techniques.

16	.014	.117	.014	.119
17	.024	.154	.024	.153
18	.045	.208	.043	.203
19	.047	.211	.048	.213
20	.048	.213	.051	.219
21	.056	.231	.058	.233
22	.059	.236	.066	.248
23-29				
30s	.201	.401	.215	.410
40s	.114	.317	.091	.288
50s	.062	.240	.037	.190
60s	.024	.153	.012	.109
70s	.004	.066	.002	.046
80s	3.59^{-4}	.019	2.52^{-4}	.016
Observation Period				
1840s	0	0	.001	.036
1850s	3.07^{-4}	.018	.006	.081
1860s	6.15^{-4}	.025	.014	.119
1870s	.008	.090	.081	.274
1880s	.168	.374	.147	.355
1890s	.151	.358	.196	.397
1900s				
1910s	.318	.466	.237	.425
1920s	.079	.270	.035	.183
1930s	.042	.200	.015	.123
1940s	.011	.105	.005	.067
Residence				
Arizona	.008	.091	.023	.149
Colorado	.038	.191	.033	.078
Idaho	.004	.061	.004	.062
Illinois	.032	.177	.062	.242
Kentucky	.035	.185	.071	.257
Missouri	.092	.289	.106	.308
Mississippi	.030	.171	.009	.096
Montana	.039	.194	.056	.229
Nebraska	.109	.312	.046	.209
New Mexico	.016	.125	.019	.135
Oregon	.006	.078	.013	.114
PA, East	.007	.080	.049	.217
PA, West	.012	.110	.043	.203
Philadelphia	7.17^{-4}	.027	.048	.213
Tennessee	.185	.388	.156	.363
Texas	.342	.474	.238	.426
Utah	.043	.203	.021	.142
Washington	.002	.042	.003	.054

Nativity				
Northeast	.003	.056	.012	.111
Middle Atlantic	.030	.171	.138	.345
Great Lakes	.071	.256	.090	.286
Plains	.177	.381	.118	.322
Southeast	.353	.478	.317	.466
Southwest	.265	.441	.159	.366
Far West	.028	.166	.028	.366
International				
Africa	1.54^{-4}	.012	4.05^{-4}	.020
Asia	4.10^{-4}	.020	.002	.048
Australia	1.54^{-4}	.012	7.39^{-4}	.027
Canada	.004	.066	.010	.098
Europe	.036	.186	.056	.229
Great Britain	.016	.124	.033	.178
Latin American	2.56^{-4}	.016	.002	.040
Mexico	.017	.130	.036	.185

Source: See Table 2.

Treated and control panel balance assures dependent variable differences are to due treatment and not characteristic differences. Table 6 illustrates that farmers were on average taller than non-farmers; however, the occupation panels are, otherwise, reasonably matched. The mean impact of agricultural occupations on BMI after selection was better than nutrition for workers in other occupations (Tables 4, 5, and 6; Dirks, 2016, p. 63; Church et al. 2011). After controlling for pre-treatment characteristics, farmers had .212 unit higher BMIs than workers in other occupations, which indicates BMI regression results for occupations are reasonably accurate for the effect of agricultural environments on net nutrition after selection characteristics are considered (Table 7). White-collar and skilled workers were in physically less active occupations and had lower net nutrition (Church et al 2011; Carson, 2014d, p. 775).

Table 7, Late 19th and Early 20th Century Propensity Scores on Occupations

	BMI ATE	*BMI ATT*
Occupation		
White-Collar	-.141***	-.109***
	(.037)	(.027)
Skilled	-.127***	-.069***
	(.020)	(.018)
Farmer	.251***	.212***
	(.047)	(.023)
Unskilled	.015	.024
	(.015)	(.018)
No Occupations	-.161**	-.017
	(.065)	(.041)

Source: See Table 2. ATE is the average treatment effect. ATT is the average treatment effect on the treated.

Other patterns are consistent with expectations. To the degree that BMI represents current net nutrition, there was a period of prolonged, widespread dietary stress, and black and white BMIs stagnated throughout the 19th and early 20th centuries (Figure 4; Carson, 2009a; Carson, 2012a; Carson, 2015b). For both blacks and whites, the 1880s was the decade that trend net nutrition reached its peak and decreased thereafter. By 1900, US agriculture commercialized, and the distance between food production and consumption increased as workers urbanized and moved from farms into factories, which reflects the separation of consumption from production (Figure 4, 5, and 6; Cochrane, 1979; Dimitri et al. 2005). In sum, late 19th and early 20th century BMIs varied by residence, and individuals in the urban Northeast had greater BMIs because they were shorter. Europeans had the highest BMIs, yet the trend over time after 1880 was toward lower BMIs for all groups.

IV. Black and White Comparative Effects of Demographic, Socioeconomic, and Residence with Individual BMI

To more fully account for late 19th and early 20th century BMI differences, the black-white and US-migrant BMI differences are decomposed into returns to characteristics and average characteristics (Blinder, 1973; Oaxaca, 1973). Let BMI_h and BMI_l be high and low BMI values, respectively. θ_{0h} and θ_{0l} are the autonomous intercepts, and θ_{1h} and θ_{1l} are how BMIs varied with characteristics. X_h and X_l are average characteristic matrices.

High BMI: $BMI_h = \theta_{0h} + \theta_{1h}\overline{X}_h$ (3)

Low BMI: $BMI_l = \theta_{0l} + \theta_{1l}\overline{X}_l$ (4)

Decompositions are the difference between high and low BMI groups.

$$\Delta BMI = BMI_h - BMI_l = \theta_{0h} + \theta_{1h}\overline{X}_h - \theta_{0l} - \theta_{1l}\overline{X}_l \quad (5)$$

Adding $-\overline{\theta}_{h1}\overline{X}_l + \overline{\theta}_{h1}\overline{X}_l$ to the right-hand side of Equation 5 and collecting like terms yields,

$$\Delta BMI = BMI_h - BMI_l = (\theta_{0h} - \theta_{0l}) + (\theta_{1h} - \theta_{1l})\overline{X}_h + (\overline{X}_h - \overline{X}_l)\theta_{1l} \quad (6)$$

The first right-hand side element, $(\theta_{0h} - \theta_{0l})$, is that part of the high-low BMI difference due to non-identifiable characteristics, such as birth under free or bound labor and different access to current net nutrition. The second right-hand side element, $(\theta_{1h} - \theta_{1l})\overline{X}_h$, is a measure for how BMI returns to characteristics varied by ethnicity and nativity (Schneeweis, 2011, p.

1283). The third right hand element $\left(\overline{X}_h - \overline{X}_l\right)\theta_{1l}$, is the difference in the BMI gap associated with average characteristics and includes sample composition differences.[15]

Using coefficients from Table 4, models 5 and 6, Table 8's Panel A presents the black-white BMI decomposition, and the majority of greater black BMIs was attributable to non-identifiable characteristics in the intercept, such as lean muscle mass and greater bone mineral density that favored individuals with darker complexions (Barrondess et al. 1997; Wagner and Heyward, 2000; Flegal et al. 2010, p. 240; Carson, 2015c). The greatest source of white BMI returns to characteristics was height, with similar sample averages, indicating most of the white net nutrition advantage was due to returns to height. Whites also had greater BMI returns associated with age, observation period, residence, and occupations. Subsequently, during the late 19th and early 20th centuries, black BMIs were greater than whites because of non-identifiable characteristics in the intercept, however, whites had greater BMI returns associated with observable characteristics.

[15] There is some concern over the value of decomposing the dependent variable differences into returns to characteristics and average characteristics because returns to characteristic estimates vary with respect to the choice of reference category (Oaxaca and Ransom, 1999). There is little concern about when explaining the dependent variable gap to $\left(\overline{X}_h - \overline{X}_l\right)\theta_{1l}$. However, because the intercept is sensitive to the omitted category variable, identification of $\left(\theta_{0h} - \theta_{0l}\right) + \left(\theta_{1h} - \theta_{1l}\right)\overline{X}_h$ is less clear, and there is some degree are arbitrariness that is unavoidable (Yun, 2008; Fortin, Lemieux, and Firpo, 2011, pp. 40 and 45).

Table 8, Decomposing Late 19th and Early 20th Century BMIs by Ethnicity and Nativity

Panel A				
Ethnicity				
	$(\beta_b - \beta_w)X_b$	$(X_b - X_w)\beta_w$	$(\beta_b - \beta_w)X_w$	$(X_b - X_w)\beta_b$
Levels				
Sum	1.32	-.266	.934	.116
Total		1.05		1.05
Populations				
Intercept	5.01		5.01	
Height	-3.40	.071	-3.43	.102
Ages	-.182	-.246	-.193	-.235
Observation Period	-.004	-1.9^{-4}	-.045	.041
Occupations	-.095	-.015	-.135	.025
Residence	-.123	.020	-.244	.141
Nativity	.050	-.083	-.070	.038
Sum	1.25	-.253	.889	.111
Total		1		1
Panel B				
Nativity				
	$(\beta_N - \beta_F)X_F$	$(X_N - X_F)\beta_N$	$(\beta_N - \beta_F)X_N$	$(X_N - X_F)\beta_F$
Levels				
Sum	-.306	.006	.156	-.456
Total		-.300		-.300
Populations				
Intercept	-1.43		-1.43	
Height	1.68	.513	1.71	.485
Ethnicity	-.558	-1.19	-1.94	.193
Ages	-.044	.768	-.078	.802
Observation Period	-.196	-.004	-.240	.036
Occupations	1.57	-.107	1.46	.004
Sum	1.02	-.020	-.520	1.52
Total		1		1

Source: See Tables 2, 4, and 5.

Using coefficients from Table 5's, Models 5 and 6, Table 7's Panel B presents the native-foreign-born decompositions. Immigrants had higher BMIs than natives, primarily from autonomous BMI components in the intercept, returns from ethnic status, age, and observation period. However, native BMI returns were greater for heights and occupations.. In sum, BMIs varied by nativity, and higher BMI returns favored native white net cumulative nutrition and characteristics.

V. Conclusion

When traditional measures for economic welfare are scarce or unreliable, the body mass index is now a well-accepted measure that reflects biological conditions during economic development. To date, there is no study that compares 19^{th} century BMIs of immigrants to individuals born in the US, and immigrant BMIs were higher relative to natives. Russians in the US were the most likely to be overweight and obese, while Chinese and Mexicans were the least likely to be overweight. Part of the stature difference between fairer, and darker complexioned individuals may be attributable to 19^{th} century US social preferences by ethnic status. By extension, white BMIs should have had greater BMIs than individuals with darker complexions. However, American-born blacks had greater BMIs than whites, which persists for both blacks and whites born in the US and other countries, indicating there little evidence of a BMI "mulatto advantage," and US social preferences are an unlikely explanation for the differences between African and European BMIs in the United States. For both natives and immigrants, farmers and agricultural workers had greater BMIs than workers in other occupations, and higher socioeconomic status natives' benefitted from their economic and social standing, especially for workers with low socioeconomic standing. Both native and immigrant BMIs stagnated throughout the late 19^{th} and early 20^{th} century, which coincides with the separation of food production from food consumption. Consequently, late 19th and early 20th century BMI variation was related to a complex set of demographic and socioeconomic characteristics, and BMI studies support the finding that net nutrition in the US was better in the rural South, stagnated over time, and was better by socioeconomic status for native US populations.

References

Aloia, John, Ashok Vaswani, Reimei Ma, and Edith Flaster. (1997). "Comparison of Body Composition in Black and White Premenopausal Women." *Journal of Laboratory Clinical Medicine* 129(3), pp. 294-299.

Atack, Jeremy and Fred Bateman. (1987). *To Their Own Soil: Agriculture in the Antebellum North.* Iowa University Press: Ames, IA.

Barondess, David, Dorothy Nelson, and Sandra Schlaen (1997). "Whole Body Bone, Fat, Lean Muscle Mass in Black and White Men." *Journal of Bone and Mineral Research* 12, 6 pp. 967-971.

Blinder, Alan S. 1973. Wage discrimination: Reduced form and structural estimates. *Journal of Human Resources* 8: 436–455.

Bodenhorn, H. (2002). The mulatto advantage: the biological consequences of complexion in rural antebellum Virginia. *The Journal of interdisciplinary history*, *33*(1), 21-46.

Burkhauser, R, and Cawley, J. (2008). "Beyond BMI: The Value of More Accurate Measures of Fatness and Obesity in Social Science Research." *Journal of Health Economics* 27: 519-529.

Calle, E. M. Thun, J. Petrelli, and C. Rodriquez, and C. W. Meath (1999). "Body Mass Index and Mortality in a Perspective Cohort of U. S. Adults." *New England Journal of Medicine* 341, pp. 1097-1104.

Carlino, Gerald and Keith Sill (2001). "Regional Income Fluctuations: Common Trends and Common Cyclers." *Review of Economics and Statistics* 83, 3. pp. 446-456.

Carson, Scott Alan. (2005) "The Biological Standard of Living in 19th-Century Mexico and in the American West," *Economics and Human Biology,* Volume 3(3), pp. 405-419.

Carson, Scott Alan. (2006) "The Biological Living Conditions of 19th Century Chinese Males in America," *Journal of Interdisciplinary History,* Volume 37(2), pp. 201-217.

Carson, Scott Alan. (2006) "The Biological Living Conditions of 19th Century Chinese Males in America," *Journal of Interdisciplinary History,* Volume 37(2), pp. 201-217.

Carson, Scott Alan. (2007a) "Statures of 19th century Chinese males in America," *Annals of Human Biology,* Volume 34(2), pp. 173-182.

Carson, Scott Alan. (2007b) "Mexican Body Mass Index Values in the 19th Century American West," *Economics and Human Biology,* Volume, 5(1), pp. 37-47.

Carson, Scott Alan. (2008a) "Health during Industrialization: Evidence from the 19th Century Pennsylvania State Prison System," *Social Science History*. Volume 32(3). pp. 347-372.

Carson, Scott Alan. (2008b) "The Effect of Geography and Vitamin D on African-American Stature in the 19th Century: Evidence from Prison Records," *Journal of Economic History,* 68(3), pp. 812-830.

Carson, Scott Alan. (2009a) "Racial Differences in Body-Mass Indices of Men Imprisoned in 19th Century Texas" *Economics and Human Biology* 7, 1, pp. 121-127.

Carson, Scott Alan. (2009b) "African-American and White Inequality in the 19th Century American South: A Biological Comparison," 22(3), *Journal of Population Economics*. pp. 757-772.

Carson, Scott Alan, (2009c) "Geography, Insolation and Vitamin D in 19th Century US African-American and White Statures," 46(1), *Explorations in Economic History.* pp. 149-159.

Carson, Scott Alan. (2010), "Wealth, Inequality, and Insolation Effects across the 19th Century White US Stature Distribution," *Journal Homo of Comparative Human Biology,* 61, pp. 467-478.

Carson, Scott Alan. (2011a), "Height of Female Americans in the 19th century and the Antebellum Puzzle," *Economics and Human Biology* 9, pp. 157-164.

Carson, Scott Alan. (2011b) "Nineteenth Century African-American and White US Statures: the Primary Sources of Vitamin D and their Relationship with Height," *Journal of Bioeconomics* 13(1), pp. 1-15.

Carson, Scott Alan. (2012a), "Nineteenth Century Race, Body Mass, and Industrialization: Evidence from American Prisons," *Journal of Interdisciplinary History* 42. pp. 371-391.

Carson, Scott Alan. (2012b). "A Quantile Approach to the Demographic, Residential, and Socioeconomic Effects on 19th Century African-American Body Mass Index Values" *Cliometrica*. 6(2), pp. 193-209.

Carson, Scott Alan. (2013a). "Socioeconomic Effects on the Stature of Nineteenth Century US Women." *Feminist Economics* 19(2), pp. 122-143.

Carson, Scott Alan. (2013b). "Biological Conditions and Economic Development: Westward Expansion and Health in Late 19th and Early 20th Century Montana." *Journal of Historical Society,* 13(1), pp. 51-68.

Carson, Scott Alan (2013c). "The Significance and Relative Contributions of Demographic, Residence, and Socioeconomic Status in 19th Century US BMI Variation." *Historical Methods.* 46(2).

Carson, Scott Alan. (2014a). "Black and White Body Mass Index Values in Developing 19th Century Nebraska." *Journal of Biosocial Science.* pp. 105-119.

Carson, Scott Alan. (2014b). "The Relationship between 19th Century BMIs and Family Size: Economies of Scale and Positive Externalities." *Journal Homo of Comparative Human Biology.* 65. pp. 165-175.

Carson, Scott Alan. (2014c). "Institutional Change and 19th Century Southern Black and White BMI Variation." *Journal of Institutional and Theoretical Economics* 170 (2), pp. 296-316.

Carson, Scott Alan. (2014d). "Nineteenth Century US Black and White Working Class Physical Activity and Nutritional Trends during Economic Development." *Journal of Economic Issues,* 48(3), pp. 765-786.

Carson, Scott Alan and Paul E. Hodges. (2014). "The Relationship between Body Mass, Wealth, and Inequality across the BMI Distribution: Evidence from Nineteenth Century Prison Records." *Mathematical Population Studies*. pp. 78-94.

Carson, Scott Alan. (2015a). "Biological Conditions and Economic Development: 19th Century US Statures on the Great Plains." *Human Nature,* 26(2), pp. 123-142.

Carson, Scott Alan. (2015b). "A Weighty Issue: Diminished 19th Century Net Nutrition among the US Working Class." *Demography,* 52, 3, pp. 945-966.

Carson, Scott Alan. (2015c). "Biology, Complexion, and Socioeconomic Status: Accounting for 19th Century US BMIs by Race." *Australian Economic History Review*. 55(3), pp. 238-255.

Carson, Scott Alan (2016). "Body Mass Index through Time: Explanations, Evidence, and Future Directions." In: Komlos, John and Inas Kelly (Eds.). *Handbook of Economics and Human Biology.* Oxford: Oxford University Press, pp. 133-151.

Carson, Scott Alan. (2016). "The Lasting Effects of Maternal Net Nutrition during US Economic Development." Working Paper no. 5827. University of Munich, Center for Economic Studies and Ifo Institute for Economic Research,.

Carson, Scott Alan and Paul Hodges. (2012), “'Black and white body mass index values in 19th century developing Philadelphia County.” *Journal of Biosocial Science*. 44(3), pp. 273-288.

Carson, Scott Alan and Paul E. Hodges. (2014). “The Relationship between Body Mass, Wealth, and Inequality across the BMI Distribution: Evidence from Nineteenth Century Prison Records.” *Mathematical Population Studies*. pp. 78-94.

Cho, Y. S., Go, M. J., Kim, Y. J., Heo, J. Y., Oh, J. H., Ban, H. J., Yoon, D., Lee, M.H., Kim, D. J., Park, M., Cha, S. H., Kim, J.W., Han, B.G., Min, H., Ahn, Y., Park, M. S., Han, H. R., Jang, H. Y., Cho, E. Y., Lee, J. E., Cho, N. H., Shin, C., Park, T., Park, J. W., Lee, J. K., Cardon, L., Clarke, G., McCarthy, M., Lee, J. Y., Lee, J. K., Oh, B., and Kim, H. L. (2009). “A Large Scale Genome Wide Association Study of Asian Populations Uncovers Genetic Factors Influencing Eight Qualitative Traits.” *Nature Genetics* 41, pp. 527-534.

Church, Timothy, Diane Thomas, Catrine Tudor-Locke, Peter T. Katzmarzyk, Conrad P. Earnest, Ruben Q. Rodarte, Corby K. Martin, Steven N. Blair, and Claude Bouchard. (2011). “Trends over Five Decades in U.S. Occupation-Related Physical Activity and Their Associations with Obesity.” *PlosOne* 6, 5.

Cochrane, Willard (1979). *The Development of American Agriculture.* University of Minnesota Press: Minneapolis.

Coclanis, P. A., & Komlos, J. (1995). Nutrition and Economic Development in Post-Reconstruction South Carolina. *Social Science History*, *19*(01), 91-115.

Coelho, Philip and Robert McGuire. (2000). “Diets Versus Diseases: The Anthropometrics of Slave Children.” *Journal of Economic History* 60 (1), pp. 232-246.

Cole, Timothy (2003). “The Secular Trend in Human Physical Growth: a Biological View.”

Economics and Human Biology 1, 2, pp. 161-168.

Cuff, T. (1993). The Body Mass Index Values of Mid-Nineteenth-Century West Point Cadets: A Theoretical Application of Waaler's Curves to a Historical Population. *Historical Methods: A Journal of Quantitative and Interdisciplinary History*, *26*(4), pp. 171-182.

Davidson, James, Jerome Rose, Myron Gutman, Michael Haines, Keith Condron, and Cindy Condran. (2002). "The Quality of African-American Life in the Old Southwest near the Turn of the 20th Century." In: Richard Steckel and Jerome Rose. (Eds.). *The Backbone of History: Health and Nutrition in the Western Hemisphere.* Cambridge: Cambridge University Press. pp. 226-280.

Dehejia, Rajeev H., and Sadek Wahba. (2002). "Propensity Score-Matching Methods for Nonexperimental Causal Studies." *The review of economics and statistics*, *84*(1), 151-161.

Dimitri, Carolyn, Anne Effland, and Neilson Conklin. (2005). "The 20th Century Transformation of US Agriculture and Farm Policy." United States Department of Agriculture Electronic Information Bulletin no. 3 http://ageconsearch.umn.edu/bitstream/59390/2/eib3.pdf. Accessed August 7th, 2016.

DiNardo, John and David Lee. (2011). "Program Evaluation and Research Designs." In: Orley Ashenfelter and David Card (Eds.). *Handbook in Labor Economics 4A.* Elsevier: Amsterdam. pp. 463-536.

Dirks, Robert (2016). *Food in the Gilded Age: What Ordinary Americans Ate.* Rowman and Littlefield. Lanham, MD.

Ellis, Joseph. (2004). *His Excellency George Washington.* New York: Knopf.

Flegal, Katherine, Margaret Carroll, and Cynthia Ogden. (2010). "Prevalence and Trends is

Obesity among US Adults." *Journal of the American Medical Association*. 303, 3, pp. 235-241.

Fogel, R.W., 1994. Economic Growth, Population Theory and Physiology: The Bearing of Long-Term Processes on the Making of Economic Policy. *American Economic Review* 84, 369-395.

Fogel, Robert W., Stanley Engerman, James Trussell, Roderick Floud, Clayne Pope, and Larry Wimmer (1978). "The Economics of Mortality in North America, 1650–1910: A Description of a Research Project. *Historical Methods: A Journal of Quantitative and Interdisciplinary History*, *11*(2), pp.75-108.

Fogel, Robert. W., Stanley Engerman, Roderick Floud, Richard Steckel, James Trussell, Kenneth Wachter, and Georgia Villaflor. (1979). The Economic and Demographic Significance of Secular Changes in Human Stature: The US 1750-1960. *NBER working paper*.

Fogel, Robert W., Stanley L. Engerman, and Trussell, J. (1982). Exploring the Uses of Data on Height: The Analysis of Long-term Trends in Nutrition, Labor Welfare, and Labor Productivity. *Social Science History*, *6*(4), pp. 401-421.

Fortin, Nicole, Thomas Lemieax, and Sergio Firgo. (2011). "Decomposition Methods in Economics." In: *Handbook of Labor Economics, Volume 4, Part A.* David Card and Orley Ashenfelter (Eds.). pp. 1-102.

Freeman, R. B. (1999). "The Economics of Crime." In: PRG Layard, Orley Ashefelter, and David Card. (Eds.).Handbook of Labor Economics, Vol 3c. Amsterdam, Netherlands: North Holland Publishers Chapter 52, pp. 3529-3571.

Gluckman, P. D. and M. A. Hanson (2006). "The Consequences of Being Born Small—An Adaptive Perspective." *Hormone Research.* 65, pp. 5-14.

Gottfedson, Michael and Travis Hrschi. (1990). *A General Theory of Crime.* Stanford University Press: Stanford, California.

Haines, Michael, Lee Craig, and Thomas Weiss (2003). “The Short and the Dead: Nutrition, Mortality, and the “Antebellum Puzzle” in the United States. *The Journal of Economic History*, *63*(2), pp. 382-413.

Heckman, James. H. Ichimura, and Todd Petra. (1998). “Matching as an Econometric Evaluation Estimator.” *Review of Economic Studies.* 65(2), pp. 261-294.

Herbert, P., Richards-Edwards, J., Manson, J.A., Ridker, P., Cook, N., O’Conner, G., Buring, J., and Hennekens, C. (1993) Height and incidence of cardiovascular disease in male physicians. *Circulation* 88, p. 1437-1443.

Hilliard, SB. (1972). Hog*, Meat and Hoecake: Food Supply in the Old South, 1840-1860.* Carbondale, IL: Southern Illinois University Press.

Hirshchi, T. and M. Gottfredson. (1983). “Age and the Explanation of Crime.” *American Sociological Review,* 89, 3, pp. 552-584.

Karlberg, John and Kirstin Albertsson-Wikland (1995). “Growth in Full-Term Small for Gestational Age Infants: From Birth and Final Height.” *Pediatric Research* 38(5), pp. 733-739.

Koch, Daniel (2011). Waaler revisited: the anthropometrics of mortality. *Economics and Human Biology* 9, pp. 106-17.

Koepke, Nikola and Joerg Baten (2005). “The Biological Standard of Living in Europe during the Last Two Millennia.” *European Review of Economic History 9,* pp. 61-95.

Koepke, Nikola and Joerg Baten (2016). “Global Perspective on Economics and Biology.” In: John Komlos and Inas Kelly. *Oxford Handbook of Economics and Human Biology*.

Oxford: Oxford University Press.

Komlos, J., 1987, "The Height and Weight of West Point Cadets: Dietary Change in Antebellum America." *Journal of Economic History* 47, 897-927.

Komlos, John. (1992). Toward an anthropometric history of African-Americans: the case of the free blacks in antebellum Maryland. In *Strategic factors in nineteenth century American economic history: A volume to honor Robert W. Fogel* (pp. 297-329). University of Chicago Press.

Komlos, J. and Brabec, M. (2010). "The Trend of Mean BMI Values of US Adults, Birth Cohorts 1882-1986 Indicates that the Obesity Epidemic Began Earlier than Hitherto Thought." *American Journal of Human Biology* 22: 631-638.

Komlos, John and Scott Alan Carson. (2017). "The BMI Values of the Lower Classes Likely Declined during the Great Depression." *Economics and Human Biology*, 26, pp. 137-143.

Lai, C. Q. (2006). "How Much of Human Height is Genetic and How Much is due to Nutrition?" *Scientific American* http://www.scientificamerican.com/article/how-much-of-human-height.

Luke, A., Gao, X., Adeyomo, A. A., Wilks, R., Forrester, T., Lowe, W. W., Commuzzie, A. G., and Mortoin, L. J. (2001). "Heritability of Obesity Related to Traits among Nigerians, Jamaicans, and US Black People." *International Journal of Obesity* 25, pp. 1034-1041.

Margo, Robert and Richard Steckel (1992). "The Nutrition and Health of Slaves and Antebellum Southern Whites." In: Robert Fogel and Stanly Engerman *Without Consent or Contract: Conditions of Slave Life and the Transition to Freedom, Technical Papers, Volume 2.* pp. 508-521.

Neel, J. (1962). "Diabetes Mellitus: A "Thrifty" Genotype Rendered Detrimental by "Progress"? *American Journal of American Genetics*, 14(4): 353-362.

Nyström-Peck, Maria. (1994) "The Importance of Childhood Socio-Economic Group for Adult Health." *Social Science & Medicine* 39, pp. 553-562.

Nyström-Peck, Maria and Olle Lundberg. (1995). "Short Stature as an Effect of Economic and Social Conditions in Childhood." *Social Science & Medicine* 41, pp. 733-738.

Oaxaca, Ron L. (1973) "Male Female Wage Differentials in Urban Labor Markets." *International Economic Review* XIV, 693-709.

Oaxaca, Ronald and Michael Ransom (1999). "Identification in Detailed Wage Decompositions." *Review of Economics and Statistics,* 81 (1), pp. 154-157.

Oreffice, Sonia and Climent Quintana-Domeque (2010). "Anthropometry and Socioeconomics among Couples: Evidence in the United States." *Economics & Human Biology* 8, pp. 373-384.

Osmond, C., and Barker, D. (2000). "Fetal Infant and Childhood Growth are Predictors of Coronary Heart Disease, Diabetes, and Hypertention in Adult Men and Women." *Environmental Health Perspective* 108(3): 545-553.

Ost, A, Lempradl, A., Casas, E., Weigert, M., Timko, T., Deniz, M., Pantano, L., Boenisch, E., Itscov, P., Stoeckius, M., Ruf, M., Rajewsky, N., Reuter, G., Iovino, N., Ribeiro, C., Aleniums, M., Heyne, S., Vavouri, T. J. Pospisilik, A. (2014). "Paternal Diet Defines Offspring Chromatin State and Intergenerational Obesity." *Cell*. 159 (6): 1352-1364.

Plant, Arnold. (1974). *Selected Economic Essays and Addresses.* London and Boston: Routledge.

Popkin, B. (2009). The World is Fat: The Fads, Trends Policies, and Products that are

Fattening the Human Race. New York: Avery.

Rahkonen, Ossi, Eero Lahelma, and Minna Huukka (1997). "Past or Present? Childhood Living Conditions and Current Socioeconomic Status as Determinants of Adult Health." *Social Science & Medicine* 44, pp. 327-336.

Ransom, Roger and Richard Sutch. (1977). *One Kind of Freedom: The Economic Consequences of Emancipation.* Cambridge: Cambridge University Press.

Rosenbloom, Joshua (2002). *Looking for Work, Searching for Workers: American Labor Markets during Industrialization.* Cambridge: Cambridge University Press.

Schneeweis, Nicol (2011). "Educational Institutions and Integration of Immigrants," *Journal of Population Economics*, 24, pp. 1281-1308.

Schneider, Eric (2017). "Children's Growth in an Adaptive Framework: Explaining the Growth Patterns of American Slaves and other Historical Populations." *Economic History Review* 70 (1), pp. 3-29.

Sokoloff, K. & Villaflor G. (1982). Early achievement of modern stature in America. *Social Science History*, 6, pp. 453-481.

Sorkin, John, Denis Muller, and Reubin Andres. 1999a. "Longitudinal Change in the Heights of Men and Women: Consequential Effects on Body Mass Index." *Epidemiologic Reviews.* 21, 2, pp. 247-260.

Sorkin, J. D., Muller, D. C., & Andres, R. (1999). Longitudinal Change in Height of Men and Women: Implications for Interpretation of the Body Mass Index: the Baltimore Longitudinal Study of Aging. *American Journal of Epidemiology*, *150*(9), 969-977.
in Economic History 16: 363-380.

Steckel, Richard (1986a) "A Peculiar Population: the Nutritional, Health, and Mortality of

American Slaves from Childhood to Mortality." *Journal of Economic History* 46, p. 721-741.

Steckel, Richard (1986b). "A Dreadful Childhood: Excess Mortality of American Slaves." *Social Science History* 10, pp. 427-465.

Steckel, Richard and Jerome Rose. (2002). "Patterns of Health in the Western Hemisphere." In: Richard Steckel and Jerome Rose. (Eds.). *The Backbone of History: Health and Nutrition In the Western Hemisphere.* Cambridge: Cambridge University Press. pp. 563-582.

Visshner, P. M. (2008). "Sizing up Human Height Variation." *Nature Genetics* 40, pp. 489-490.

Wagner, D. and Heyward, V. (2000) Measures of body composition in blacks and white: A comparative review. *American Journal of Clinical Nutrition*, 71:1392-1402.

Waaler, H. T. 1984 Height, weight and mortality: the Norwegian experience. Acta Medica Scandinavia, suppl. 679, pp. 1-51.

Yun, Myeung-Su. (2008). "Identification Problem and Detailed Oaxaca Decomposition: A General Solution and Inference." *Journal of Economic and Social Measurement, 33,* pp. 27-38.

Zagorsky, Jay. (2016). "Wealth and Weight." In: John Komlos and Inas Kelly (Eds.). *The Oxford Handbook of Economics and Human Biology.* Oxford: Oxford University Press.

Zehetmayer, Matthias. (2011). "The Continuation of the Antebellum Puzzle: Stature in the US, 1847-1894." *European Review of Economic History, 15*(2), pp. 313-327.