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RESEARCH ARTICLE

Biological Differences between Late 19th and Early 20th Century Urban and Rural Residence

Scott Alan Carson

University of Texas, Permian Basin, 4901 East University, Odessa, TX 79762 and Research Fellow, University of Münich and CESifo, Shackstrasse 4, 80539 Münich, Germany
E-mail: Carson_S@utpb.edu

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Abstract

Communities urbanize when the net benefits to urbanization exceed rural areas. Body mass, height, and weight are biological welfare measures that reflect the net difference between calories consumed and calories required for work and to withstand the physical environment. Individuals of African-decent had greater BMIs, heavier weights, and shorter statures. Urban farmers had lower BMIs, shorter statures, and lower weight than rural farmers. Over the late 19th and early 20th centuries, urban and rural BMIs, height, and weight were constant, and rural farmers had greater BMIs, taller statures, and heavier weights than urban farmers and workers in other occupations.

JEL Codes: C1; C4; D1; I1; N3

Key Words: Urbanization; Stature Variation; Cumulative Net Nutrition; Nativity; Race

I. Introduction

Health is related to urbanization and industrialization, which varied with economic development, and workers urbanize when the additional net benefits from urban living exceed rural conditions. There are external effects associated with urbanization, and high population density increases the relative price of food and prevalence of disease (Haines, Craig, and Weiss, 2003; Koepke and Baten, 2008; Bereczki et al., 2018, p. 187-189; Marquez et al., 2018, p. 158). However, if urban markets extended the quality and quantity of nutrition from external effects, urban health and net nutrition may have improved relative to rural health (Higgs, 1977, pp. 33-35; Bereczki et al., 2018, p. 186-189). Nineteenth century US urban health and net nutrition were related to four factors: rapid urbanization that was not accompanied by a corresponding growth in public health and sanitation systems, a growing dependence on wage labor at the same time that wealth and income inequality increased, a transportation revolution with accompanying agricultural commercialization, and a deteriorating disease environment (Komlos, 1987; Haines, 2004, pp. 251-252; McGuire and Coelho, 2000; Steckel, 2000; McGuire and Coelho, 2011; Ferrie and Troesken, 2008; Smith 2013, pp. 295-299; Atack and Bateman, 1994, pp. 143-173, 427-455; Carson, 2009; Carson, 2009; Carson, 2010; Carson, 2010; Carson, 2013; Carson and Hodges, 2014). Despite the potentially harmful health effects associated with urbanization, 19th century

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US households continued to relocate and remain in urban centers because the net benefits of urban living remained positive (Meizner et al., 2018, p. 242).

In the absence of direct measures for material welfare, the body mass index (BMI), height, and weight reflect net nutrition, material welfare, and health. Average BMI reflects the current net difference between calories consumed and calories required for work and to withstand claims from the physical environment.[1] Nonetheless, BMI variation depends on when privation occurs. For example, if an individual receives sufficient net nutrition during their youth, they are more likely to reach taller statures and have lower BMIs in later life because weight is distributed over greater physical dimensions. Zehetmeyer (2011), Carson (2008, pp. 366-368), and Carson and Hodges (2014) illustrate that urban statures were shorter than rural statures, indicating that urban BMIs may have been high because of short urban statures. Average stature reflects the cumulative net difference between calories consumed, less calories required to withstand the physical environment, and calories required for work. Because weight is more plastic and responsive to the immediate effects of privation, weight after controlling for height reflects current net nutrition, and because weight and height have opposing effects when measuring BMI, weight as a measure for current net nutrition is a complement to BMI that accounts for the lagged or mismatched affect between BMIs and height.

The stature–urbanization relationship was noticed early (Fogel et al. 1979; Komlos, 1987), and various studies show a net urban height penalty (Margo and Steckel, 1983, Steckel and Haurin, 1994; Komlos, 1998; Haines et al. 2003; Sunder, 2004; Zehetmeyer, 2011; Zehetmeyer, 2013; Marques et al., 2019, pp. 140-147; Bereczi et al., 2019, pp. 186-189; Carson and Hodges, 2012). However, urban medical intervention and treatment were more readily accessible, and mortality and death rates are inversely related to net nutrition (Zehetmeyer, 2013; Haines, Craig, and Weiss, 2003). Urban locations also provide positive net nutritional benefits when individuals purchase higher quality nutrition with greater incomes and wealth. Urban occupations may have created greater access to relative net nutrition, and urban residents may have had sufficient access to animal proteins to offset the negative agglomeration effects of urbanization (Hammond and O'Connor, 2013; Müldner and Richards, 2007; Higgs, 1977, p. 33-35; Papathanasiou et al., 2018, p. 224). Alternatively, because of higher relative food prices, urban environments put stress on diets, had higher disease rates, and pollution levels (Komlos, 1987; Kopke and Baten, 2008; Carson, 2008; Carson, 2010; Berecaki et al., 2019, pp. 186-189; Marques et al., 2019; Haines, 2001). However, Carson and Hodges (2014) show that urban BMIs and weight were lower than individuals in rural locations, indicating positive agglomeration effects need not extend to net nutrition and health. In sum, a considerable amount of research illustrates the relationship between urbanization and height (Fogel et al., 1979; Margo and Steckel, 1983; Sunder, 2007; Carson and Hodges, 1914, Carson, 2015); however, less is known about the late 19th and 20th century relationship between urbanization, BMI, height, and weight.

Urban agglomeration effects may have been related to individuals of African and mixed-race ancestry. Higgs (1977, pp. 33-35) indicates early that African-American urbanization was better because of nutrition, social institutions, and medical care. Fogel et al (1982) and Komlos (1987) find that stature and net nutrition are positively related, and urban net nutrition varied by race, indicating that African-Americans historically benefited from urbanization (Johnson, 1941, pp. 256-257; Fogel and Engerman, 1974, p. 132). Cities may have provided blacks greater consumption and investment opportunities not available in rural locations (Higgs 1977, pp. 32-35). Moreover, urban blacks were less likely to be exposed to racial intimidation and violence because they were in close proximity to other blacks, decreasing the likelihood of white on black violence. Urban African-American education opportunities were better, and black urban housing was more easily obtained (Wang and Zuo, 1999, p. 276). Urban transaction costs were lower, and urban

[1] $BMI = \frac{x(kg)}{h(m)^2} \Rightarrow \quad \ln \quad BMI = \ln w - 2\ln h. \quad \varepsilon_{BMI,w} = \frac{d\ln BMI}{d\ln w} = 1; \quad \varepsilon_{BMI,h} = \frac{d\ln BMI}{d\ln h} = -2.$ BMI increases, $\frac{d\ln BMI}{d\ln w} > 0 \Rightarrow \ln w > 2\ln h.$ BMI decreases, $\frac{d\ln BMI}{d\ln w} < 0 \Rightarrow \ln w < 2\ln h.$

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blacks may have found an abundance and variety of nutrition. Subsequently, rather than urban locations imposing negative externalities on black health, African-Americans may have received positive spill-over effects from urban living.

It is against this backdrop that this study considers three paths of inquiry into the relationship between late 19th and early 20th century urbanization, net nutrition, and health. First, how did BMI, stature, and weight vary by urban status and how did they vary over time? BMIs were higher, heights were shorter, and weights were lower in urban locations. Second, how did biological markers and net nutrition vary by complexion between urban and rural residence and nativity? Blacks had greater BMIs, heavier weights, and shorter statures in general, and county-level patterns indicates urban blacks had shorter statures. Third, how did urban and rural net nutrition vary by socioeconomic status? Urban farmers had lower BMIs, shorter statures, and lower weights than rural farmers and workers in other occupations, indicating urban agricultural net nutrition was lower than rural locations. Section 2 compares the relevant urban US and urban populations in this analysis, while section 3 presents the data. Sections 4 evaluates BMI, height, and weight by urban and rural status by demographics, nativity, residence, and socioeconomic status for US natives, native whites, native blacks, youths, and adults. In Section 5, BMI, height, and weight differences are decomposed by urban-rural status and race. Section 6 summarizes the study's contributions.

II. Nineteenth Century United States Urbanization

Evaluating late 19th and early 20th century urban net nutrition offers insight into economic development, and the relative urban population size within the US reflects urbanization's effect on material welfare during economic development (Gordan, 2015, p. 30). Urbanization in the United States began during the mid-19th century along its eastern seaboard, and the US Northeast was the first urban region (Smith, 2013, p. 295; Troesken, 2003; Haines, 2004). By 1870, 25 percent of US residents lived in urban locations (Haines, 2000, p. 156, Table 4.2). In 1840, New York City was the largest urban area and the first US city to surpass 300,000 people. New Orleans and Charleston were the only two large 19th century top-10 largest US cities in the South, indicating that urbanization was localized to the North. By modern standards, Chicago, Saint Louis, Philadelphia, and Pittsburgh were large urban centers and are included in this study. Individuals from Philadelphia and Chicago experienced conditions affected by large-scale urbanization from rising relative food prices associated with the separation of food production from food consumption, whereas the number of persons incarcerated from smaller counties that later urbanized shows how biological welfare varied as smaller populations concentrated during early development.

Since its founding, Philadelphia was a key US urban and political center and until 1790, was the largest urban center. Relative to the largest US city—New York City—Chicago's Cook County, Illinois is the largest urban center in the prison sample (Figure 1). Through 1930, Saint Louis was the fourth largest US city, and Pittsburgh was an early industrial center, with a population similar in size to Saint Louis throughout the period under study. Because of their mid-western locations in the late 19th century, Chicago and Saint Louis populations were important centers as the US developed economically and demographically. However, larger urban center growth rates converged by 1900 (Figure 1; Panel B).

Smaller urban areas are those that have high percentage incarcerations within each state prison and include counties with towns that would grow to be large cities: Marcopa (Phoenix), Arapaho (Denver), Douglas (Omaha), Multanah (Portland), Davidson (Nashville), Hamilton (Chatanooga), and Shelby (Memphis). These small municipal populations enter the sample at various dates; however, each grew to comparable population sizes by 1940 (Figure 2, Panel A). Hamilton and Chattanooga Tennessee were large populations early but were rapidly overtaken

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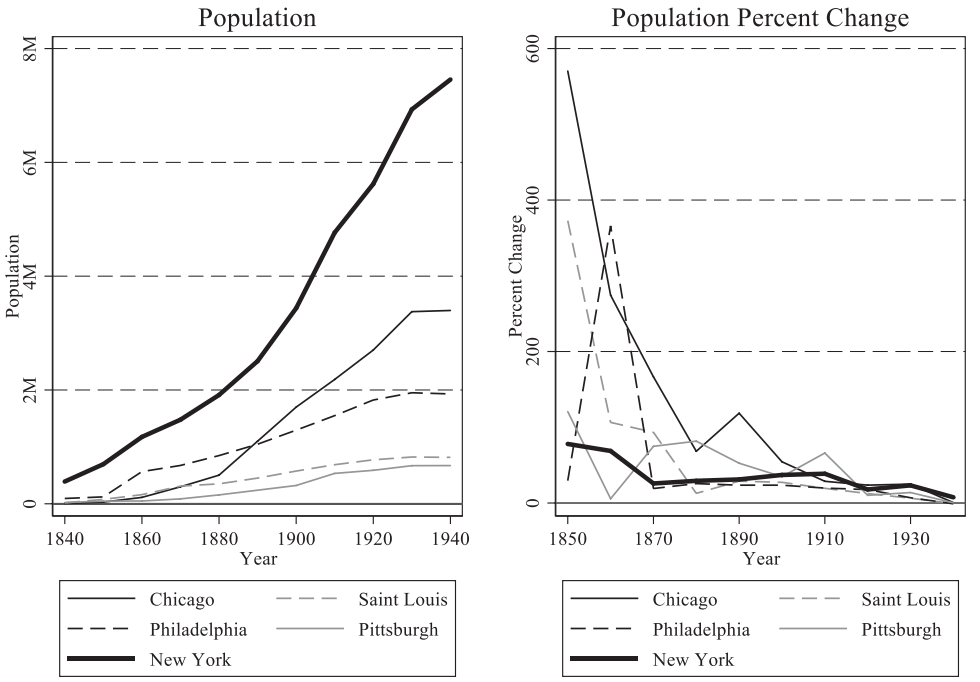

Figure 1. Large Late 19th and Early 20th Century Urban Centers: Chicago, Saint Louis, Philadelphia, Pittsburgh, and New York.

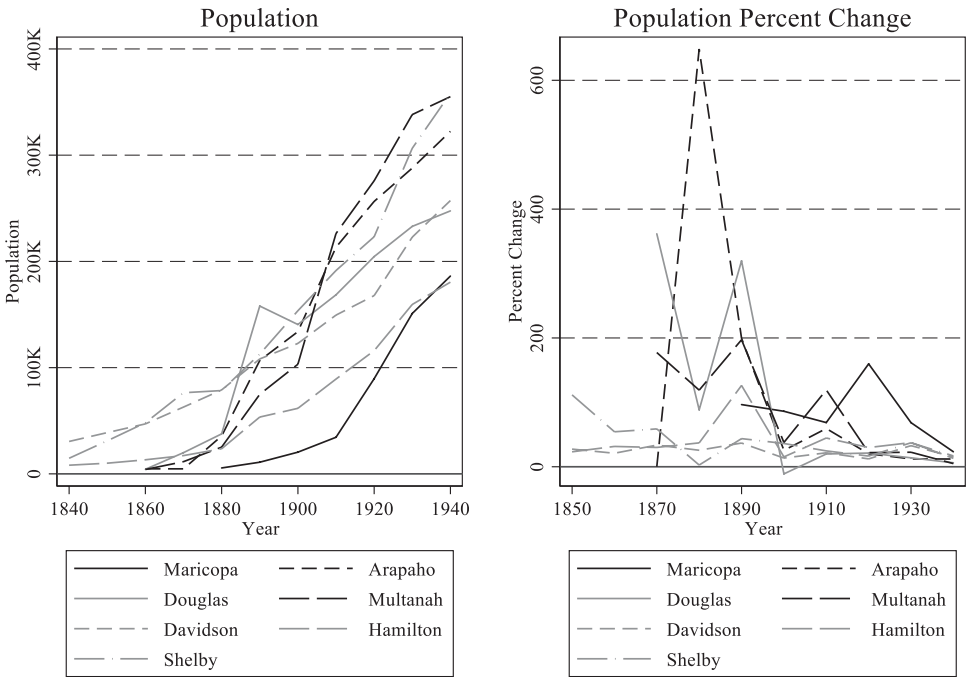

Figure 2. Small Late 19th and Early 20th Century Growing Urban Centers: Maracopa (Phoenix), Arapaho (Denver), Douglas (Omaha), Multanah (Portland), Davidson (Nashville), Hamilton (Chattanooga), and Shelby (Memphis).

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as settlers made their way West. While the Oregon Trail and the Northwest's population were early urban centers in the West, incarceration in Multanah County was comparatively small until 1900; moreover, it overtook other city populations between 1900 and 1940. Portland and Denver were sizeable municipalities, while Maricopa started with a small population but grew considerably during the early 20th century. Like larger Philadelphia, Chicago, Saint Louis, and Pittsburgh populations, smaller municipal growth rates started high and converged over time to lower growth rates (Figures 1 and 2, Panel B).

Various health measures are related to urbanization. Average urban statures were adversely effected by pollution, and pollution is related to health and net nutrition (Bailey et al 2018; Clay et al., 2018; Clay et al 2019). Individuals in high disease areas with high mortality rates had greater claims on nutrition (Pope and Miner, 1988; Pope, 1989). Although the causal link is less clear, the use of urban coal generates higher carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxides (NO_x), which are related to increased mortality and morbidity rates, and may have been related to shorter statures and poor net nutrition in urban locations (Haines, Craig, and Weiss, 2003). Moreover, use of coal in urban areas may have inhibited calcium absorption through increased atmospheric pollutants, which reduced the amount of incident solar radiation (insolation), and sunlight combined with cholesterol in the epidermis, which is the primary source of vitamin D production and is used in calcium absorption for stature growth (Carson, 2008; Carson, 2009; Carson, 2011; Carson, 2020). Still, during the 19th century, US households continued to migrate and reside in urban areas, indicating that the net-benefits of urban living remained positive, and urban economic opportunity was greater than the net nutrition and health effects that urban residents were required to accept.

III. Urban and Rural Body Mass, Height, and Weight Data

Military and prison records are two common sources for historical weight and height data. While there is abundant military stature data, military records do not contain sufficient numbers of older individuals or persons of African descent (Sokoloff and Vilaflour, 1982; Ellis, 2004; Floud et al. 2011; Meinzer et al., 2018, p. 239). Many military records also do not include weight records, further restricting the usefulness of military records when evaluating current net nutrition. Because of military stature requirements (Fogel et al. 1978, p. 85; Sokoloff and Vilaflour, 1982, p. 457, Figure 1)—typically 64 inches—taller individuals disproportionately remain in military samples, which downwardly biases BMIs in military samples because BMIs are inversely related to stature (Carson, 2009; Carson, 2012; Komlos and Carson, 2017). Prison records are an alternative to military records and provide greater insight into biological variation across age, race, and socioeconomic status. However, when used as measures for net nutrition, prison records have their own shortcomings. For example, because crime is frequently committed by individuals in lower socio-economic groups, prison records may represent individuals with lower socioeconomic status who committed crime to survive. Individuals with low income and wealth may have also been incarcerated because they lacked legal counsel at trial. As a result, it is likely that prison records represent net nutrition for individuals in lower socioeconomic status who turned to crime out of privation; however, there is greater biological variation with prison records than other sources (Carson, 2009; Carson, 2012; Ellis, 2004; Floud et al. 2011; Sokoloff and Villaflor, 1982; Bereczi, et al., 2019, p. 190).

Data used in this study are from an extensive effort to collect 19th and 20th century prison records to evaluate health and net nutrition during economic development. Records used are from the Arizona, Colorado, Idaho, Illinois, Kentucky, Missouri, Mississippi, Montana, Nebraska, New Mexico, Oregon, Pennsylvania's East and West prisons, Philadelphia, Tennessee, Texas, Utah, and Washington. Records were enumerated at the time individuals admitted into a facility, therefore, reflect pre-incarceration conditions and not conditions within prisons. Data are recorded from

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1860 through1940, and prison enumerators recorded complexion, age, gender, weight, height, period received, residence, crime, and pre-incarceration occupation. Because prison records had legal implications in case individuals escaped and were later recaptured, prison records were recorded with care. Prison records also helped identify persons within prisons. Because few females were systematically recorded, only males observations are considered in this study.

Race is classified from a complexion variable recorded as white, black, mixed-race, Native-American, Mexican, and Asian. Individuals of African descent were described as black, chocolate, light, medium, and dark black. Individuals of European descent were recorded as white, light, medium, and dark. This white complexion scheme is further supported by individuals claiming European birth in American prisons who were recorded with the same white, light, medium, and dark complexions. There was a higher proportion of blacks in the prison sample than the general population (Steckel, 2000; Haines 2000), which was attributable, in part, to vagrancy laws that incarcerated men without occupations designed to prevent recently freed-slaves from becoming dependent on society (Brands, 2010, p. 156). There were individuals of mixed African and European ancestry who were recorded as various shades of 'mulatto.' However, in the results that follow, individuals of mixed African and European ancestry are referred to as 'mixed-race.' There were individuals of mixed Native Mexican and European immigrants who were Mexican-Mestizos and are classified as Mexicans. Individuals from China, Japan, and Korea are classified as Asians.

Pre-incarceration occupations were recorded in prison registries, and five occupation categories are used to classify occupations in the late 19th and early 20th centuries. Bankers, government workers, physicians, and the clergy are classified as white-collar workers. Blacksmiths, shoemakers, and boilermakers are classified as skilled workers. Farmers include general farmers, ranchers, and stockmen. Laborers, servants, and cooks are classified as unskilled workers. Workers with no recorded or illegible occupations are classified as no specified occupation.

Individuals are partitioned in Table 1 by urban and rural location to further assess demographic and economic conditions by residence. In both historic and modern populations, crime is committed by the young (Hirschi and Gottreddson, 1983; Gottfredson and Hirschi, 1990; Carson, 2009 EHB; Carson, 2018 HM; Baten and Steckel, 2019, p. 317), and teenagers were more likely to reside in rural locations (Table 1). Individuals in their 20s and 30s were more likely to reside in urban areas; however, for older ages, results are mixed between urban and rural areas. White-collar and skilled workers were more likely to reside in urban areas, while farmers and unskilled workers were more likely to reside in rural areas (Fogel, 1974, p. 134). Race and urbanization in late 19th and early 20th century cities are well represented in the sample. Whites and mixed-race individuals were more likely to live in urban areas (Fogel, 1974, p. 132), whereas Mexicans, Native Americans, and Asians lived in rural locations. Among the native-born, individuals from the Far West, Plains, and Southwest resided in rural locations, whereas individuals' native to the Great Lakes, Middle Atlantic, Northeast, and Southeast were more likely to live in urban locations.

To the extent that BMI, stature, and weight represent biological and material inequality. Stature has been used to illustrate biological and material inequality, stature CVs and Gini Coefficients from urban centers were similar (Moradi and Baten, 2005). However, as a measure for inequality, stature is genetically determined. Stature also follows a normal distribution and is less sensitive to net nutrition variation than income distribution (Sokoloff and Vilaflour, 1982, p. 456). Rural BMIs and weight were distributed more equally than in urban areas. Rural areas were more abundant in net nutrition, disease rates were lower, and their biological and material inequality was more equal. Rural agricultural diets and close proximity to nutrition created environments where nutrition was accessible, disease environments were less virulent, and did not create as much nutritional stress. Subsequently, rural BMIs were higher, statures taller, weights heavier, and nut nutrition distributed more equally than urban areas.

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Table 1. Urban and Rural Late 19th and Early 20th century Characteristics

	Urban		Rural	
	N	Percent	N	Percent
Ages				
Teens	5,189	11.88	22,700	14.36
20s	21,847	50.03	78,766	49.81
30s	10,031	22.97	33,182	20.98
40s	4,283	9.81	14,585	9.22
50s	1,704	3.90	6,320	4.00
60s	515	1.18	2,146	1.36
70s	87	.20	393	.25
80s	13	.03	40	.03
Occupations				
White-Collar	5,589	12.80	11,926	7.54
Skilled	10,718	24.54	25,784	16.31
Farmer	1,124	2.57	20,535	12.99
Unskilled	15,151	34.70	84,363	53.35
No Occupations	11,087	25.39	15,524	9.82
Ethnicity				
Native American	10	.02	424	.27
Asian	13	.03	104	.07
Black	9,231	21.14	34,853	22.04
Mexican	64	.15	7,297	4.61
Mixed-Race	7,223	16.54	22,036	13.94
White	27,128	62.12	93,418	59.08
Nativity				
International				
Africa	25	.06	52	.03
Asia	147	.34	274	.17
Australia	26	.06	112	.07
Canada	431	.99	1,433	.91
Europe	3,767	8.63	7,058	4.46
Great Britain	2,123	4.86	4,135	2.61
Latin America	93	.21	204	.13
Mexico	452	1.04	6,380	4.03
National				
Far West	709	1.62	4,860	3.07
Great Lakes	4,864	11.14	12,949	8.19
Middle Atlantic	11,143	25.52	14,561	9.21

(*Continued*)

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Table 1. (*Continued*)

	Urban		Rural	
	N	Percent	N	Percent
Northeast	611	1.40	1,709	1.08
Plains	4,220	9.66	20,738	13.11
Southeast	14,271	32.68	50,335	31.83
Southwest	787	1.80	33,332	21.08
Residence				
Arizona	912	2.09	3,413	2.16
Colorado	1,962	4.49	4,806	3.04
Idaho			766	.48
Illinois	7,400	16.95	4,622	2.92
Kentucky			13,659	8.64
Missouri	2,931	6.71	18,197	11.51
Mississippi			2,292	1.45
Montana			10,924	6.91
Nebraska	2,842	6.51	7,678	4.86
New Mexico			3,677	2.33
Oregon	750	1.72	1,774	1.12
PA, East	3,598	8.24	5,551	3.51
PA, West	1,993	4.56	6,120	3.87
Philadelphia	8,744	20.02		
Tennessee	12,537	28.71	19,408	12.27
Texas			50,099	31.68
Utah			4,578	2.90
Washington			568	.36

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; California State Archives, 1020 O Street, Sacramento, CA 954814; 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; Maryland State Archives, 350 Rowe Building, Annapolis, MD 21401; 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 87507; Ohio Archives Library, 800 E. 17th Avenue, Columbus, OH43211; Oregon 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 and 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.

IV. Body Mass, Height, and Weight by Demographics, Socioeconomic Status, and Urban Residence

Late 19th and early 20th century urban and rural net nutrition were related to race, demographics, and socioeconomic status. We now test which of these variables were associated with BMI, height, and weight by urban residence. To start, urban and rural BMIs and weights for the i^{th} individual are regressed on height, race, demographics, socioeconomic status, and observation period. Urban and rural heights are regressed on race, demographics, socioeconomic status, and birth period.

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Table 2. Biological Inequality by Residence

	Urban		Rural	
	Mean	SD	Mean	SD
BMI	23.05	2.54	23.08	2.50
Height (cm)	169.22	6.73	171.20	6.98
Weight (kg)	66.05	8.55	67.66	8.26
	CV	Gini	CV	Gini
BMI	.11	.06	.11	.06
Height (cm)	.04	.02	.04	.02
Weight (kg)	.13	.07	.13	.07

Source: See Table 1.

Body Mass Index

$$BMI_i = \theta_0 + \theta_c Centimeters_i + \sum_{e=1}^{5} \theta_e Race_i + \sum_{a=1}^{3} \theta_a Age_i^a + \sum_{n=1}^{14} \theta_n Nativity_i + \sum_{j=1}^{4} \theta_j Occupations_i + \sum_{r=1}^{10} \theta_r Decade\,Received_i + \sum_{m=1}^{11} \theta_m Urban_i + \sum_{s=1}^{16} \theta_s Residence + \varepsilon_i \quad (1)$$

Height

$$Centimeters_i = \theta_0 + \sum_{e=1}^{5} \theta_e Race_i + \sum_{a=1}^{3} \theta_a Age_i^a + \sum_{n=1}^{14} \theta_n Nativity_i + \sum_{j=1}^{4} \theta_j Occupations_i + \sum_{r=1}^{10} \theta_r Decade\,Received_i + \sum_{m=1}^{11} \theta_m Urban_i + \sum_{s=1}^{16} \theta_s Residence + \varepsilon_i \quad (2)$$

Weight

$$Kilograms_i = q_0 + q_c Centimeters_i + \sum_{e=1}^{5} q_e Race_i + \sum_{a=1}^{3} q_a Age_i^a + \sum_{n=1}^{14} q_n Nativity_i + \sum_{j=1}^{4} q_j Occupations_i + \sum_{r=1}^{10} \theta_r Decade\,Received_i + \sum_{m=1}^{11} \theta_m Urban_i + \sum_{s=1}^{16} \theta_s Residence + \varepsilon_i \quad (3)$$

For BMIs and weight, statures in centimeters are included to test the relationship between current and cumulative net nutrition (Carson 2009; Carson, 2012; Carson. 2015; Komlos and Carson, 2017; Carson, 2018). Complexion dummy variables are included to assess how net nutrition varied by race. Annual youth age dummy variables are included to account for how net nutrition varied during early ages, while adult birth decade dummy variables are included for how adult net nutrition varied at older ages. Nativity dummy variables are included for birth in the Northeast, Middle Atlantic, Great Lakes, Plains, Southeast, Southwest, and Far West. International nativity dummy variables are included for Africa, Asia, Australia, Canada, Europe, Great Britain, Latin America, and Mexico. To assess the relationship between net nutrition and socioeconomic status, occupation dummy variables are included for white-collar, skilled, farmer, and unskilled occupations. There are two ways to interpret BMI, height, and weight variation over time. Measured in the

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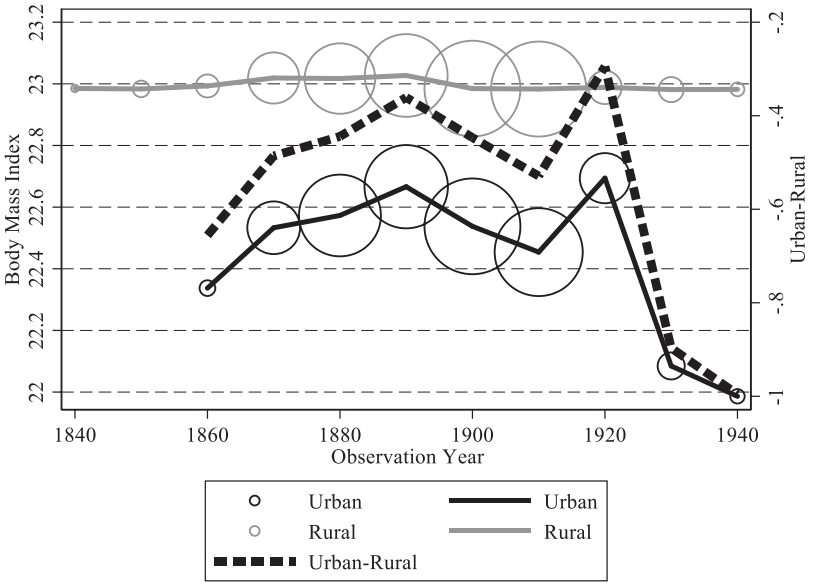

Figure 3. Late 19th and Early 20th Century Urban and Rural BMIs over Time.
Source: Stature regression coefficients from Table 6, Models 1 and 2, are weighted by sample size in Table 1.
Note: Circle size represents sample proportion.

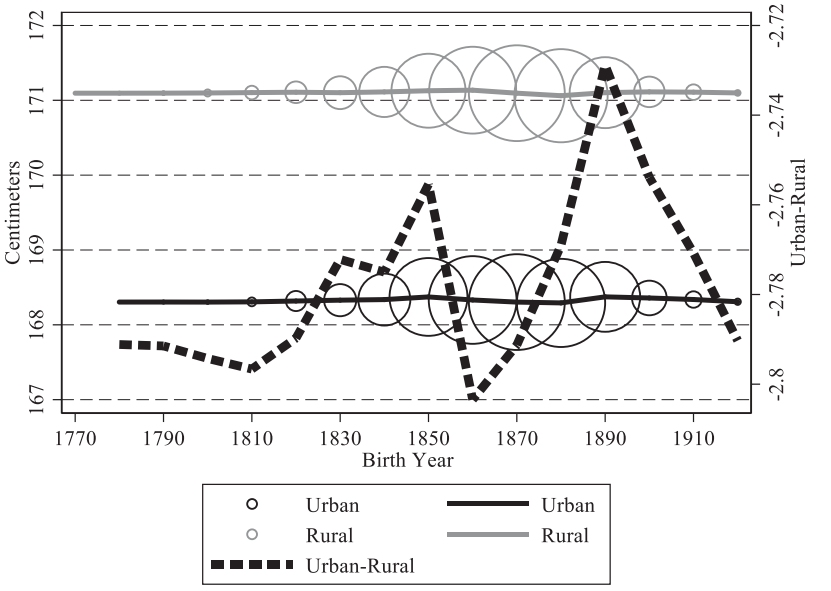

Figure 4. Late 19th and Early 20th Century Urban and Rural Heights over Time.
Source: Stature regression coefficients from Table 6, Models 3 and 4, are weighted by sample size in Table 1.
Note: Circle size represents sample proportion.

current period, BMIs and weight reflect the current net nutrition experienced by diverse cohorts at the time of measurement. Measured since birth, stature reflects how the same cohort's cumulative net nutrition varied since birth. Birth decade dummy variables are included in height regressions,

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Table 3. Late 19th and Early 20th Century Urban and Rural BMIs by Characteristics

	Model 1 Native Only	Model 2 European Only	Model 3 Native Whites	Model 4 Native Blacks	Model 5 Youth	Model 6 Adult
Intercept	**33.02**	**33.11**	**31.14**	**36.35**	**34.16**	**32.33**
Height						
Centimeters	**−.06**	**−.06**	**−.05**	**−.07**	**−.07**	**−.06**
Ethnicity						
White	Reference				Reference	Reference
Black	**1.16**			Reference.	**1.00**	**1.20**
Mulatto	**.90**			**−.31**	**.71**	**.97**
Native America	**.46**				.36	**.51**
Mexican	.011				−.009	.088
Asian	**−.49**				**−1.02**	.07
Ages						
14	**−3.40**	**−5.12**	**−2.67**	**−3.76**	**−3.34**	
15	**−2.79**	**−3.14**	**−2.15**	**−3.17**	**−2.69**	
16	**−2.09**	**−2.40**	**−1.68**	**−2.40**	**−1.96**	
17	**−1.47**	**−1.71**	**−1.22**	**−1.73**	**−1.35**	
18	**−1.09**	**−1.33**	**−.87**	**−1.33**	**−.95**	
19	**−.70**	**−.81**	**−.57**	**−.87**	**−.56**	
20	**−4.28**	**−.28**	**−.33**	**−.57**	**−.26**	
21	**−.27**	**−.38**	**−.23**	**−.33**	**−.11**	
22	**−.16**	**−.16**	**−.15**	**−.19**	**Reference**	
23-29	Reference	Reference	Reference	Reference		Reference
30s	**.22**	**.30**	**.25**	**.19**		**.22**
40s	**.47**	**.50**	**.56**	**.30**		**.46**
50s	**.58**	**.53**	**.70**	**.35**		**.57**
60s	**.40**	**.73**	**.57**	.10		**.46**
70s	.24	−.08	**.47**	−.18		.25
80s	**−1.04**	−.96	−.67	**−1.51**		−.51
Nativity						
International						
Africa					.60	.17
Asia					**−1.12**	**−2.41**
Australia					.49	−.36
Canada					.11	−.02
Europe					**.86**	**.66**
Britain					.01	−.02

(*Continued*)

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Table 3. (*Continued*)

	Model 1 Native Only	Model 2 European Only	Model 3 Native Whites	Model 4 Native Blacks	Model 5 Youth	Model 6 Adult
Latin America					−.26	**−.53**
Mexico					−.05	**−.34**
National						
Northeast	Reference		Reference	Reference	Reference	Reference
Middle East	−.09		−.05	−.04	.06	**−.14**
Great Lakes	-1.00^{-3}		.01	−.24	.20	−.04
Plains	3.00^{-3}		−.01	−.04	**.25**	−.02
Southeast	**−.18**		**−.23**	−.13	.19	**−.25**
Southwest	**−.16**		**−.20**	−.16	.15	**−.20**
Far West	−.18		−.20	−.24	.14	**−.24**
Occupation						
White Collar	**−.12**	−.10	**−.08**	**−.32**	**−.24**	**−.10**
Skilled	**−.08**	**−.30**	**−.07**	**−.09**	−.07	**−.11**
Farmer	**.20**	−.03	**.21**	**.19**	**.28**	**.16**
Unskilled	Reference	Reference	Reference	Reference	Reference	Reference
No Occupation	**−.13**	**−.42**	**−.20**	**−.12**	**−.18**	**−.12**
Decade Received						
1840s	**1.53**	−.54	**1.62**	**1.15**	**1.25**	**1.47**
1850s	**.60**	.24	**.60**	.71	**.41**	**.66**
1860s	**.71**	.37	**.74**	**.63**	**.61**	**.78**
1870s	**.43**	−.23	**.25**	**.56**	**.42**	**.37**
1880s	**.14**	.03	**.13**	**.11**	**.08**	**.17**
1890s	**.16**	.06	**.15**	**.15**	**.13**	**.15**
1900s	Reference	Reference	Reference	Reference	Reference	Reference
1910s	**−.06**	.07	1.00^{-3}	**−.14**	−.04	**−.06**
1920s	**.08**	**.31**	**.18**	**−.14**	.07	**.09**
1930s	**.15**	.31	**.22**	−.25	−.02	**.18**
1940s	−.04	.73	−.05	−.16	.10	−.03
Counties						
Rural	Reference	Reference	Reference	Reference	Reference	Reference
Maricopa, AZ	.02	.42	−.01	.08	−.15	.07
Arapaho, CO	**−.15**	−.27	**−.20**	.15	**−.41**	−.13
Cook, IL	−.11	−.17	−.06	−.05	−.07	−.10
Saint Louis, MO	.07	−.15	**.17**	−.07	.10	.05
Douglas, NE	**−.26**	.15	−.13	−.02	−.01	**−.30**
Multanah, OH	**−.31**	.54	**−.29**	−.09	−.34	**−.37**

(*Continued*)

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Table 3. (*Continued*)

	Model 1 Native Only	Model 2 European Only	Model 3 Native Whites	Model 4 Native Blacks	Model 5 Youth	Model 6 Adult
Philadelphia, PA	**−.41**	−.30	**−.47**	−.16	**−.50**	**−.37**
Alleghany, PA	**−.28**	.02	**−.30**	−.190	**−.41**	**−.19**
Davidson, TN	.01	−.37	.06	−.06	−.10	.09
Hamilton, TN	**−.47**	−.86	**−.39**	**−.52**	**−.59**	**−.36**
Shelby, TN	**−.14**	.69	−.12	**−.21**	**−.24**	−.04
Residence						
Arizona	.05	.13	**.18**	**−.43**	.08	.03
Colorado	**.50**	**.75**	**.60**	**.21**	**.50**	**.57**
Idaho	**.20**	.22	**.22**	.03	.12	**.21**
Illinois	−.09	.23	.03	**−.44**	−.17	.01
Kentucky	**−.47**	−.16	**−.36**	**−.57**	**−.45**	**−.47**
Missouri	**−.75**	**−.55**	**−.65**	**−.84**	**−.74**	**−.74**
Montana	**.74**	**.80**	**.81**	**.25**	**.70**	**.79**
Mississippi	**−.23**	−.54	**−.27**	**−.31**	**−.25**	**−.21**
Nebraska	**−.47**	**−.93**	**−.42**	**−.95**	**−.66**	**−.44**	
New Mexico	**.21**	.05	**.37**	-3.00^{-3}	**.35**	**.19**
Oregon	**.84**	**.85**	**.97**	.61	**.83**	**.86**
East, PA	**−.34**	−.23	**−.13**	**−.73**	**−.37**	**−.27**
West, PA	**.43**	**.69**	**.54**	**.41**	**.57**	**.46**
Philadelphia	**−.31**	.26	−.11	**−.55**	**−.45**	−.08
Tennessee	**.40**	.48	**.44**	**.38**	**.47**	**.35**
Texas	Reference	Reference	Reference	Reference	Reference	Reference
Utah	**.15**	**.28**	**.23**		**−.20**	**.30**
Washington	**−.25**	.42	−.16	−.40	−.12	.10
N	175,089	10,825	99,264	72,308	62.878	138,923
R^2	.13	.09	.08	.13	.17	.09
RMSE	2.34	2.42	2.38	2.28	2.10	2.44

Source: See Table 1.
Note: Bold is significant at .05.

and observation period dummy variables are included in BMI and weight models (Carson, 2019, p. 32). For BMI, height, and weight, urban dummy variables are included to account for how net nutrition varied in larger urban relative to rural areas.

Three paths of inquiry are considered when evaluating relationships between net nutrition, demographics, socioeconomic status, and urbanization. First, the early industrial growth puzzle and antebellum paradox are the propositions that net nutrition decreased during early urbanization and industrialization (Komlos, 1987; Zehetmeyer, 2011; Carson 2008, pp. 366-368; Sunder, 2011, p. 168; Sunder, 2013, p. 248), and the pattern is robust across interdisciplinary studies (Berecski et al 2019, p. 187; Meinzer et al., 2019, p. 232; Davidson, et al., 2002, pp. 238-241). BMI, height, and weight averages are presented over time to assess net nutrition throughout

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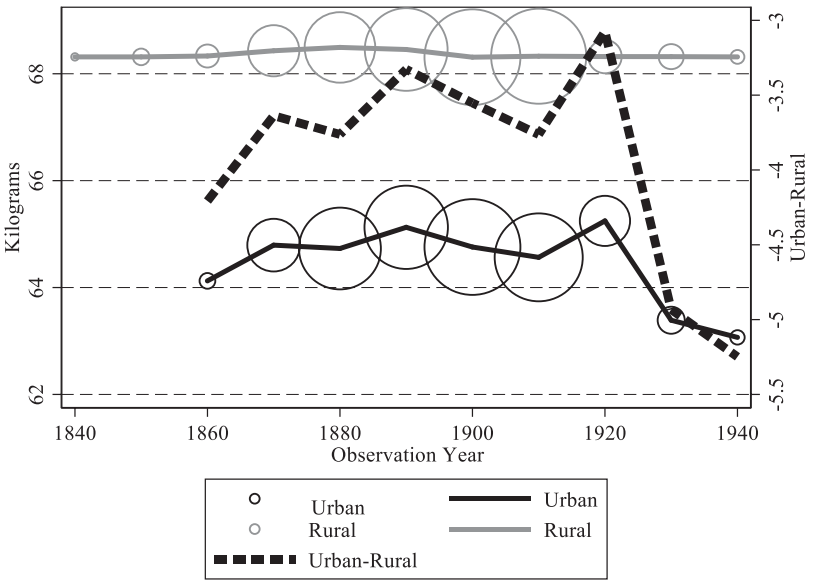

Figure 5. Late 19th and Early 20th Century Urban and Rural BMIs over Time.
Source: Stature regression coefficients from Table 6, Models 1 and 2, are weighted by sample size in Table 1.
Note: Circle size represents sample proportion.

the 19th and early 20th centuries. Because there is concern over unobserved sample selection bias, time trend weights are augmented in Figure 4 with bubble figures, where circle sizes represent sample proportions (Zimran, 2019; Meinzer, 2019, p. 235, Figure 3). Two general patterns over time are present between BMIs, heights, and weights by urban and rural locations: how they varied between urban and rural locations and how they varied over time. First, urban BMIs were comparable to rural values, which occurred because individuals in rural locations had taller statures and heavier weights, and BMIs are inversely related to height squared (Carson, 2009; Zehetmayer, 2013, pp. 161, 167, 176, and 184; Carson, 2012; Komlos and Carson, 2017). Second, throughout the 19th and early 20th centuries, urban BMIs remained approximately constant at a little over 23.1, however, increased mildly in the 1880s and 1910, while rural BMIs had a sustained decrease from 1890 through 1940. The result is that urban and rural BMIs varied with early industrialization, and the difference between the urban and rural BMIs were positive after 1880.

Net nutrition varied by urban-rural status, yet not all urban locations had the same physical environments. Tables 3, 4, and 5 further partition urban status BMI, height, and weight by county. The antebellum paradox is the contradictory result that statures decreased while wages and income increased (Libergott, 1984; Craig et al 2004; Bogart, 2009; Komlos and Coclanis, 1997, pp. 439-441; Craig, 2016). After weighting for unobservable factors, rural statures were taller than urban statures and both decreased between 1840 and 1870; however, the decrease in urban stature was deeper, and preceded the rural stature decrease (Figure 4; Zehetmayer, 2013, pp. 161, 167, 176, and 184). The greatest stature difference between urban and rural statures was during the 1870s, when households urbanized in the post-Civil War era. For example, Davidson et al. (2002) illustrates that urban statures were shorter and decreased with the separation of food production from food consumption, and European statures decreased with early industrialization (Carson, 2008; Carson and Hodges, 2014, Meinzer et al., 2019, pp. 232-244).[2] Greater population density

[2]Linares and Parejo (2021) find a rural height penalty in 19th century Extremadura, Spain because rural wealth was lower than urban wealth. Reis (2009) also finds there was no urban stature penalty but an urban height premium, likely due to stable, skilled employment and because Spanish rural conditions were poor. Puche, Ayuda, Martínez-Carrión (2018) find

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increased the relative price of food and worsened disease environments (Voth and Leunig, 1996, p. 559). Wilson (2003) illustrates that high and increasing 19th century chronic respiratory disease levels were associated with urbanization, industrialization, and pollution, and Bailey et al. (2018) indicate part of the effects of deteriorating net nutrition were due to urban atmospheric pollution associated with increased demands on net nutrition from morbidity and disease (Haines, Craig, and Weiss, 2003; Zehetmayer, 2013, pp. 161, 167, 176, and 184; Clay et al. 2018; Clay et al. 2019). Moreover, Table 3 illustrates that BMIs were lower in counties that had greater population densities, and individuals in Philadelphia—the most urban location in the sample—had lower BMIs than individuals located elsewhere in the United States (Table 4; Cuff, 2005; Hiermeyer, 2010, p. 128; Correia, Luck, and Verner, 2020).

Throughout the late 19th and early 20th centuries, average rural weight was greater than urban weight, and rural current net nutrition exceeded urban net nutrition (Figure 5). Both urban and rural weight temporarily increased during the late 19th century and returned to pre-1800 average weights. Nevertheless, the urban-rural average weight difference decreased between 1850 and 1870 but experienced a sustained trend-reversal in 1870. Moreover, it was not simply urbanization, but the size and magnitude of stature by residence differences. Individuals in larger urban centers were mostly made worse-off with urbanization and had a greater willingness to accept diminished urban health in exchange for economic opportunity (Tables, 2, 3, and 4). Subsequently, rural current and cumulative net nutrition exceeded urban net nutrition, and the two varied in different ways during early urbanization and industrialization.

Second, considerable research illustrates stature differences by race, which varied between urban and rural locations. Steckel (1979) was the first to demonstrate taller statures for individuals with fairer complexions. Johnson (1941, pp. 256-257) and Fogel and Engerman (1974, p. 132) show that individuals of mixed African and European ancestry with fairer complexions were more common in urban areas. Because there were external urban agglomeration effects that may have varied by race, higher concentrations of fairer complexioned Africans in urban locations may have also been associated with better living conditions and net nutrition (Higgs, 1977, pp. 35-37). Bodenhorn (2002, pp. 23, 30, and 43) attributes taller statures for Africans with fairer complexions to 19th century social preference. However, if taller statures accrued to fairer complexioned blacks because of social preferences, whites should have had greater BMIs and heavier weights than individuals with darker complexions. In fact, the opposite is true, and individuals with darker complexions had higher BMIs and heavier weights than individuals with fairer complexions (Carson, 2015a; Carson, 2015b). Higgs (1977, pp. 33-35) suggests that urban black net nutrition may have been better relative to rural black workers if there was greater access to low-priced urban diets and more progressive urban institutions that shielded urban blacks from racial prejudice prominent in rural communities. Urban blacks, should have, therefore, had higher BMIs, taller statures, and heavier weights than blacks in rural locations. Alternatively, black net nutrition may have been worse than whites if urban economic and social conditions put pressure on urban net nutrition that foreclosed lower socioeconomic blacks from opportunity. However, darker complexioned blacks had shorter statures than fairer complexioned whites and mixed-race individuals, yet had higher BMIs and heaver weights (Higgs, 1977, p. 31, 34, and 37). Higher BMIs and heavier weights are associated with shorter statures and poorer net nutrition (Carson, 2009; Carson, 2015; Carson, 2008). Subsequently, urban blacks had poorer cumulative net nutrition but greater BMIs and heavier weight.

Third, biological markers were related to socioeconomic status, and late 19th and early 20th century agricultural workers consistently had greater BMIs, taller statures, and heavier weights than workers in other occupations (Cuff, 1993, p. 177; Craig, Weiss, and Haines, 2003, p. 406;

significantly taller statures for individuals from irrigated regions relative to regions that relied on rainfed agriculture. Puche, Ayuda, and Martinez–Carrion (2018) using Spanish military records find that conscripts from irrigated areas were taller than conscripts measured in dryland areas.

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Table 4. Late 19th and Early 20th Century Urban and Rural Height in Centimeters by Characteristics

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Native Only	European Only	Native White	Native Black	*Youth*	*Adult*
Intercept	**172.41**	**170.18**	**172.51**	**170.61**	**172.51**	**172.39**
Ethnicity						
White	Reference				Reference	Reference
Black	**−2.29**			Reference	**−2.51**	**−2.05**
Mulatto	**−1.64**			**.73**	**−1.81**	**−1.51**
Native−America	**−2.08**				**−1.79**	**−1.52**
Mexican	**−5.15**				**−4.59**	**−3.94**
Asian	**−3.55**				**−3.00**	**−2.85**
Age						
14	**−11.84**	**−12.21**	**−12.85**	**−11.66**	**−11.38**	
15	**−8.23**	**−5.74**	**−8.48**	**−8.22**	**−7.91**	
16	**−5.29**	**−5.75**	**−5.17**	**−5.42**	**−5.04**	
17	**−3.23**	**−3.64**	**−3.02**	**−3.41**	**−3.00**	
18	**−2.00**	**−1.26**	**−1.71**	**−2.30**	**−1.79**	
19	**−1.25**	−.21	**−1.11**	**−1.39**	**−.99**	
20	**−.52**	−.36	**−.42**	**−.61**	**−.32**	
21	**−.21**	−.27	−.17	**−.30**	−.04	
22	**−.19**	−.54	−.11	**−.26**	Reference	
23-29	Reference	Reference	Reference	Reference		Reference
30s	−.01	−.63	−.06	.12		−.04
40s	**−.62**	**−1.38**	**−.51**	**−.70**		**−.64**

(*Continued*)

Table 4. (*Continued*)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
50s	**−1.41**	**−2.05**	**−1.30**	**−1.52**		**−1.36**
60s	**−2.44**	**−2.87**	**−2.45**	**−2.07**		**−2.28**
70s	**−3.42**	**−3.75**	**−3.23**	**−3.17**		**−3.16**
80s	**−4.85**	**−9.49**	**−4.24**	**−4.41**		**−4.43**
Nativity						
International						
Africa					**−3.61**	−.815
Asia					**−6.80**	**−5.79**
Australia					−1.02	−.48
Canada					−.08	−.28
Europe					**−1.96**	**−2.54**
Britain					**−1.18**	**−1.37**
Latin America					**−2.01**	**.79**
Mexico					**−1.27**	**−2.12**
United States						
Northeast	Reference	Reference	Reference	Reference	Reference	Reference
Middle Atlantic	−.27		−.25	−.59	−.03	−.23
Great Lakes	**.83**		**.89**	.11	**.71**	**.86**
Plains	**1.32**		**1.46**	.19	**1.48**	**1.24**
Southeast	**1.79**		**1.88**	.92	**1.86**	**1.70**
Southwest	**2.03**		**1.86**	**1.54**	**2.05**	**1.72**
Far West	**1.15**		**1.22**	.58	**1.24**	**1.02**
Occupations						
White Collar	**−.20**	.16	−.06	**−.67**	**−.36**	−.05

(*Continued*)

Table 4. (*Continued*)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Skilled	**−.32**	.14	**−.25**	**−.46**	**−.29**	**−.23**
Farmers	**.75**	**.71**	**.79**	**.63**	**.87**	**.75**
Unskilled	Reference	Reference	Reference	Reference	Reference	Reference
No Occupations	−.16	**.96**	.01	**−.39**	**−.36**	.10
Birth Decade						
1770s	2.56		1.48	**5.28**		2.07
1780s	−.36		−.67	−.60		−.44
1790s	**3.53**	−.47	**4.51**	1.10		**2.78**
1800s	**3.49**	**2.89**	**3.90**	1.24		**2.98**
1810s	**2.93**	.07	**3.24**	**2.03**		**2.23**
1820s	**1.96**	.59	**2.52**	**.86**	**6.76**	**1.45**
1830s	**.79**	**.85**	**1.21**	.09	**1.04**	**.67**
1840s	**.53**	**.81**	**.70**	**.34**	**.51**	**.49**
1850s	**.37**	.20	**.20**	**.67**	**.30**	**.36**
1860s	**.29**	−.11	**.20**	**.45**	**.35**	**.23**
1870s	Reference	Reference	Reference	Reference	Reference	Reference
1880s	**−.28**	−.27	**−.31**	**−.23**	**−.45**	**−.18**
1890s	.06	−.31	−.05	**.22**	**−.19**	**.19**
1900s	**.71**	.79	**.58**	**.98**	.29	**1.09**
1910s	**2.33**	−.39	**2.25**	**2.76**	**2.11**	**2.49**
1920s	**4.32**	**2.14**	**4.26**	4.22	**4.01**	**5.92**
Urban						
Rural	Reference	Reference	Reference	Reference	Reference	Reference
Maricopa, AZ	.05	−2.15	−.04	.82	.50	−.24

(*Continued*)

Table 4. (*Continued*)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Arapaho, CO	−.14	−.03	−.06	−.80	.17	−.08
Cook, IL	**−.44**	−.11	**−.68**	.26	.07	**−.50**
Saint Louis, MO	**−1.01**	−.24	**−.72**	**−1.49**	**−1.09**	**−.97**
Douglas, NE	**−.30**	**−2.51**	**−.43**	−.48	.10	**−.63**
Multanah, OH	**−.82**	.51	**−.94**	1.23	−.92	−.42
Philadelphia, PA	**−.76**	−.60	**−.66**	**−1.18**	**−1.15**	**−.671**
Alleghany, PA	**−1.18**	**−1.22**	**−1.28**	**−1.09**	**−1.30**	**−1.08**
Davidson, TN	**−1.06**	.581	**−1.01**	**−1.01**	**−1.13**	**−1.01**
Hamilton, TN	**−.45**	.30	**−1.37**	−.08	−.37	−.42
Shelby, TN	**−1.43**	.73	**−1.88**	**−1.25**	**−1.61**	**−1.23**
State Residence						
Arizona	**−1.91**	.49	**−2.19**	.21	**−2.71**	**−2.06**
Colorado	**−1.71**	**−1.47**	**−2.02**	−.23	**−1.64**	**−1.83**
Idaho	−.17	−.37	−.30	−.28	−.25	−.26
Illinois	**−1.30**	**−1.58**	**−1.48**	**−1.02**	**−1.87**	**−1.30**
Kentucky	**−1.93**	**−2.46**	**−2.08**	**−1.78**	**−2.32**	**−1.81**
Missouri	**−1.52**	**−1.4**	**−1.74**	**−1.06**	**−1.73**	**−1.52**
Montana	**1.33**	**1.87**	**1.12**	**1.86**	**1.08**	**1.35**
Mississippi	**.35**	1.32	**.96**	**.54**	**.59**	.09
Nebraska	**−.35**	.80	**−.58**	.45	**−.78**	**−.38**
New Mexico	**−.73**	**−1.69**	**−.92**	.39	**−.75**	**−.87**
Oregon	**−1.94**	**−2.52**	**−2.10**	**−1.93**	**−1.88**	**−2.23**
East, PA	**−2.75**	**−4.05**	**−3.16**	**−1.96**	**−3.09**	**−3.04**
West, PA	**−1.80**	**−2.40**	**−2.07**	**−1.05**	**−2.37**	**−1.97**

(*Continued*)

Table 4. (*Continued*)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Philadelphia	**−1.57**	**−1.86**	**−2.04**	**−.75**	**−1.55**	**−1.63**
Tennessee	**−1.65**	**−3.38**	**−1.77**	**−1.29**	**−1.68**	**−1.81**
Texas	Reference	Reference	Reference	Reference	Reference	Reference
Utah	**−.414**	.63	**−.64**		**−.86**	**−.25**
Washington	**−2.45**	−1.25	**−2.59**	**−4.03**	**−2.74**	**−2.07**
N	175,089	10,825	99,264	72,308	62,878	138.923
R^2	.11	.08	.09	.10	.16	.10
RMSE	6.48	6.59	6.33	6.66	6.46	6.50

Source: See Table 1.
Note: Bold is significant at .05.

Table 5. Late 19th and Early 20th Century Urban and Rural Weight in Kilograms by Characteristics

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Native Only	European Only	Native Whites	Native Blacks	Youth	Adult
Intercept	**−39.64**	**−42.02**	**−43.06**	**−32.53**	**−33.64**	**−42.88**
Height						
Centimeters	**.62**	**.65**	**.64**	**.60**	**.58**	**.64**
Ethnicity						
White	Reference				Reference	Reference
Black	**3.41**			Reference	**2.92**	**3.54**
Mulatto	**2.65**			**−.92**	**2.08**	**2.86**
Native America	**1.37**				1.00	**1.54**
Mexican	.13				.08	**.32**
Asian	−1.33				**−2.75**	.263
Ages						
14	**−8.67**	**−12.05**	**−6.44**	**−9.62**	**−8.65**	
15	**−7.48**	**−8.17**	**−5.68**	**−8.49**	**−7.29**	
16	**−5.80**	**−6.06**	**−4.67**	**−6.66**	**−5.46**	
17	**−4.21**	**−4.57**	**−3.47**	**−4.90**	**−3.84**	
18	**−3.14**	**−3.68**	**−2.50**	**−3.82**	**−2.73**	
19	**−2.05**	**−2.32**	**−1.67**	**−2.53**	**−1.63**	
20	**−1.26**	**−.80**	**−.96**	**−1.66**	**−.75**	
21	**−.79**	**−1.06**	**−.69**	**−.96**	**−.30**	
22	**−.50**	**−.48**	**−.47**	**−.58**	Reference	
23-29	Reference	Reference	Reference	Reference		Reference
30s	**.68**	**.89**	**.74**	**.56**		**.70**

(*Continued*)

Table 5. (*Continued*)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
40s	**1.40**	**1.42**	**1.68**	**.89**		**1.37**
50s	**1.71**	**1.47**	**−2.06**	**.99**		**1.67**
60s	**1.19**	**2.06**	**1.67**	.24		**1.35**
70s	.69	−.04	**1.35**	−.49		.75
80s	**−2.93**	−2.04	−1.92	**−4.22**		−1.28
Nativity						
International						
Africa					1.78	.44
Asia					**−3.01**	**−6.56**
Australia					1.42	−.91
Canada					.36	−.04
Europe					**2.48**	**1.85**
Britain					.05	−.02
Latin America					−.73	**−1.57**
Mexico					−1.47	**−.91**
National						
Northeast	Reference		Reference	Reference	Reference	Reference
Middle East	−.24		−.12	−.987	.184	**−.37**
Great Lakes	.03		.07	−.68	.55	−.07
Plains	.02		.02	−.11	**.69**	−.05
Southeast	**−.52**		**−.65**	−.38	.51	**−.72**
Southwest	**−.47**		**−.56**	−.47	.41	**−.57**
Far West	**−.53**		**−.58**	−.69	.38	**−.72**

(*Continued*)

Table 5. (*Continued*)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Occupation						
White Collar	**−.33**	−.27	**−.23**	**−.92**	**−.68**	**−.29**
Skilled	**−.22**	**−.82**	**−.20**	**−.26**	**−.17**	**−.32**
Farmer	**.59**	−.07	**.62**	**.53**	**.81**	**.47**
Unskilled	Reference	Reference	Reference	Reference	Reference	Reference
No Occupation	**−.38**	**−1.14**	**−.56**	**−.34**	**−.49**	**−.34**
Decade Received						
1840s	**4.57**	−1.63	**4.88**	**3.46**	**3.71**	**4.40**
1850s	**1.77**	.63	**1.81**	1.94	**1.23**	**1.95**
1860s	**2.08**	.98	**2.23**	**1.79**	**1.75**	**2.29**
1870s	**1.24**	−.71	**.71**	**1.61**	**1.23**	**1.04**
1880s	**.40**	.06	**.37**	**.32**	**.22**	**.49**
1890s	**.46**	.17	**.43**	**.44**	**.38**	**.43**
1900s	Reference	Reference	Reference	Reference	Reference	Reference
1910s	**−.17**	.18	-2.00^{-3}	**−.43**	−.12	**−.17**
1920s	**.22**	**.79**	**.50**	**−.42**	.20	.23
1930s	**.40**	.90	**.63**	−.82	−.13	**.50**
1940s	−.24	2.47	−.22	−.60	.09	−.20
Counties						
Rural	Reference	Reference	Reference	Reference	Reference	Reference
Maricopa, AZ	.06	1.19	−.03	.32	−.04	.22
Arapaho, CO	−.44	−.72	**−.57**	.40	**−1.25**	−.34
Cook, IL	−.29	−.45	−.16	−.14	−.19	−.26

(*Continued*)

Table 5. (*Continued*)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Saint Louis, MO	.23	−.42	**.54**	−.18	.28	.20
Douglas, NE	**−.75**	.45	−.39	−.04	2.00^{-3}	**−.85**
Multanah, OH	**−.90**	1.54	**−.87**	−.100	−.98	**−1.04**
Philadelphia, PA	**−1.15**	**−.83**	**−1.34**	−.42	**−1.38**	**−1.03**
Alleghany, PA	**−.80**	.01	**−.87**	−.54	**−1.18**	**−.55**
Davidson, TN	.07	−.90	.20	−.09	−.23	.29
Hamilton, TN	**−1.34**	−2.49	**−1.14**	**−1.49**	**−1.70**	**−1.04**
Shelby, TN	**−.37**	1.87	−.31	**−.54**	**−.64**	−.10
Residence						
Arizona	.20	3.52	.58	**−1.18**	.31	.16
Colorado	**1.53**	**2.13**	**1.81**	.65	**1.55**	**1.71**
Idaho	**.61**	.69	**.70**	.05	.36	**.65**
Illinois	−.23	.66	.14	**−1.22**	−.43	.07
Kentucky	**−1.34**	−.40	**−1.02**	**−1.61**	**−1.25**	**−1.34**
Missouri	**−2.14**	**−1.51**	**−1.87**	**−2.37**	**−2.10**	**−2.10**
Montana	**2.28**	**2.35**	**2.51**	**.72**	**2.12**	**2.38**
Mississippi	**−.71**	−1.55	**−.80**	**−.96**	**−.77**	**−.65**
Nebraska	**−1.35**	**−2.66**	**−1.19**	**−2.73**	**−1.90**	**−1.25**
New Mexico	**.60**	.11	**1.06**	−.05	**1.04**	**.51**
Oregon	**2.53**	**2.42**	**2.90**	1.67	**2.49**	**2.56**
East, PA	**−.89**	−.53	−.28	**−2.03**	**−.99**	**−.68**
West, PA	**1.32**	**2.00**	**1.64**	**1.24**	**1.69**	**1.41**
Philadelphia	**−.83**	.76	−.26	**−1.54**	**−1.24**	−.20

(*Continued*)

Table 5. (*Continued*)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Tennessee	**1.15**	1.30	**1.30**	**1.10**	**1.36**	**1.03**
Texas	Reference	Reference	Reference	Reference	Reference	Reference
Utah	**.52**	**.85**	**.76**		**−.49**	**.95**
Washington	−.62	1.17	−.38	−.72	−.22	−.20
N	175,089	10,825	99,264	72,308	62,878	138,923
R^2	.35	.34	.32	.39	.42	.31
RMSE	6.83	6.86	7.00	6.56	6.00	7.13

Source: See Table 1.
Note: Bold is significant at .05.

Carson, 2017, pp. 26-27; Carson, 2009, pp. 154-155; Carson, 2015, pp. 951-955). However, because their physical sizes had greater returns in physically demanding agricultural occupations, greater BMIs, taller statures, and heavier weights reflect both net nutrition and occupation comparative advantage, where taller, larger individuals were in agricultural occupations (Margo and Steckel, 1992, p. 518; Steckel and Haurin, 1994, pp. 120-122). Table 6 partitions rural and urban workers and illustrates that urban farmer BMIs were greater than rural values (Gordan, 2015, p. 55). White-collar and skilled rural weights were lower than workers with no occupations, indicating that rural workers with no occupation were probably in agricultural occupations, faced low net prices for nutrition, and benefited from sparse population densities (Table 6, Church et al., 2011). Therefore, after controlling for residence, rural agricultural workers had better net nutrition and had taller statures than workers in other occupations.

Other patterns are consistent with expectations. Nativity within the US indicates that native Northeastern blacks had shorter statures, and early Northeastern urban residence was associated with lower cumulative net nutrition for both blacks and whites (Zehetmayer, 2013, pp. 161, 167, 176, and 184). However, blacks and whites from the Northeast had the heaviest weight. After controlling for observable characteristics and urban residence, men native to the Middle Atlantic, South, and West had lower BMIs than men in other US locations. Lower Northeast and Middle-Atlantic BMIs were attributable to lower weights and current net nutrition, whereas lower Southern BMIs were attributable to taller statures and greater Southern cumulative net nutrition (Carson, 2008; Carson, 2009; Hilliard, 1972). International nativity demonstrates that urban and rural Asians and Latin Americans had lower BMIs, shorter height, and lower weight independent of urban-rural nativity.

V. Decomposing the Urban-Rural BMI, Height, and Weight Difference

Decompositions further illustrate net nutritional differences by urban-rural locations. Oaxaca decompositions are a statistical technique used to partition dependent variable differences into structural and compositional differences. To isolate how 19th and early 20th century urban and rural net nutrition varied by characteristics, let γ_h and γ_l be BMI, height, and weight dependent variable values. θ_{0h} and θ_{0l} are non-identifiable high and low value characteristics in the BMI, height, and weight components intercept. θ_{1h} and θ_{1l} are high and low coefficients associated with returns to characteristics. $\overline{X}_h$ and $\overline{X}_l$ are high and low characteristic matrices. High and low BMI, height, and weight are expressed in vectors.

$$\gamma_h = \theta_{0h} + \theta_{1h}\overline{X}_h \tag{4}$$

and

$$\gamma_l = \theta_{0l} + \theta_{1l}\overline{X}_l \tag{5}$$

High and low response variable gaps are differenced and the counter-factual $-\theta_{1h}\overline{X}_l + \theta_{1h}\overline{X}_l$ is added.

$$\Delta\gamma = \gamma_h - \gamma_l = \theta_{0h} + \theta_{1h}\bar{X}_h - \theta_{1h}\bar{X}_l + \theta_{1h}\bar{X}_l - \theta_{0l} - \theta_{1l}\bar{X}_{1l} \tag{6}$$

which is rearranged into the decompositions:

$$\gamma_h - \gamma_l = (\theta_{0h} - \theta_{0l}) + (\theta_{1h} - \theta_{1l})\overline{X}_l + \left(\overline{X}_h - \overline{X}_l\right)\theta_h \tag{7}$$

$$\gamma_h - \gamma_l = (\theta_{0h} - \theta_{0l}) + (\theta_{1h} - \theta_{1l})\bar{X}_h + \left(\bar{X}_h - \bar{X}_l\right)\theta_l \tag{8}$$

Equation 7 evaluates dependent variable differences at low average characteristics and high returns to characteristics. Equation 8 evaluates dependent variable differences at high average characteristics and low returns to characteristics. Equations 7 and 8's first right-hand side element, $(\theta_{0h} - \theta_{0l})$, is the difference in the autonomous differences due to non-identifiable characteristics,

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Table 6. Late 19th and Early 20th Century Urban and Rural BMI, Height, and Weight by Characteristics

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Urban BMI	Rural BMI	Urban Height (cm)	Rural Height (cm)	Urban Weight (kg)	Rural Weight (kg)
Intercept	**30.65**	**33.01**	**169.92**	**171.72**	**−45.45**	**−39.85**
Height						
Centimeter	**−.05**	**−.06**			**.65**	**.63**
Complexion						
White	Reference	Reference	Reference	Reference	Reference	Reference
Black	**.83**	**1.07**	**−1.78**	**−2.27**	**2.41**	**3.17**
Mixed−Race	**.99**	**.83**	**−1.21**	**−1.72**	**2.87**	**2.46**
Native America	.28	**.66**	**1.86**	**−1.13**	.81	**1.97**
Mexican	.10	**.08**	**−4.43**	**−3.90**	.36	**.29**
Asian	−.74	−.18	.03	**−2.29**	−2.00	−.46
Age						
14	**−3.34**	**−3.38**	**−11.95**	**−11.70**	**−8.23**	**−8.72**
15	**−3.03**	**−2.68**	**−8.59**	**−8.17**	**−7.83**	**−7.26**
16	**−2.28**	**−2.00**	**−5.73**	**−5.29**	**−6.13**	**−5.60**
17	**−1.65**	**−1.46**	**−3.67**	**−3.26**	**−4.59**	**−4.17**
18	**−1.25**	**−1.09**	**−2.31**	**−2.08**	**−3.54**	**−3.14**
19	**−.77**	**−.73**	**−1.53**	**−1.30**	**−2.22**	**−2.13**
20	**−.48**	**−.43**	**−.60**	**−.57**	**−1.38**	**−1.26**
21	**−.33**	**−.27**	**−.41**	**−.29**	**−.94**	**−.81**
22	**−.22**	**−.16**	−.16	**−.25**	**−.66**	**−.50**
23-29	Reference	Reference	Reference	Reference	Reference	Reference
30s	**.24**	**.23**	**.26**	−.05	**.70**	**.67**

(*Continued*)

Table 6. (*Continued*)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
40s	**.56**	**.45**	**−.45**	**−.53**	**1.62**	**1.33**
50s	**.83**	**.49**	−.98	**−1.23**	**2.39**	**1.43**
60s	**.60**	**.40**	−1.69	**−2.05**	**1.70**	**1.20**
70s	.17	.21	−1.91	**−3.07**	.63	.61
80s	−1.36	−.26	−5.83	**−3.65**	−3.63	−.61
Nativity						
International						
Africa	−.505	.46	−.98	**−1.92**	−1.65	1.37
Asia	**−1.92**	**−1.74**	**−4.94**	**−7.10**	**−5.20**	**−4.67**
Australia	−.45	−.10	**−2.84**	.13	−1.20	−.17
Canada	−.10	**.19**	−.21	.21	−.23	**.55**
Europe	**.74**	**.60**	**−2.68**	**−2.49**	**2.09**	**1.75**
Great Britain	.01	−.05	**−1.49**	**−1.44**	.06	−.11
Latin America	**−.49**	**−.47**	-4.00^{-3}	.25	**−1.39**	**−1.40**
Mexico	−.16	**−.38**	**−2.82**	**−1.89**	−.40	**−1.06**
United States						
Northeast	Reference	Reference	Reference	Reference	Reference	Reference
Middle Atlantic	**−.37**	−.12	**−.75**	**−.97**	**−1.04**	−.30
Great Lakes	.04	**−.14**	**.80**	**.81**	.10	**−.37**
Plains	−.18	**−.43**	**.91**	**1.15**	−.54	**−1.26**
Southeast	.21	**−.35**	**1.09**	**1.49**	.59	**−1.06**
Southwest	−.15	**−.24**	**1.50**	**2.53**	−.43	**−.75**
Far West	.20	−.02	**1.15**	**1.38**	.53	**−.06**

(*Continued*)

Table 6. (*Continued*)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Occupations						
White-Collar	−.08	**−.12**	**.41**	**−.31**	−.24	**−.33**
Skilled	−.04	**−.06**	−.01	**−.32**	−.12	**−.18**
Farmer	**.27**	**.33**	**1.32**	**.82**	**.80**	**.95**
Unskilled	Reference	Reference	Reference	Reference	Reference	Reference
No Occupations	.03	**.33**	−.12	**−.64**	.08	**.97**
Decade Received						
1840s		**.57**				**1.77**
1850s		−.05				−.11
1860s	−.20	**.57**			−.64	**1.68**
1870s	-4.00^{-3}	**.49**			−.02	**1.41**
1880s	.04	**.28**			−.09	**.81**
1890s	**.13**	**.23**			**.35**	**.65**
1900s	Reference	Reference			Reference	Reference
1910s	**−.08**	4.00^{-3}			**−.24**	.01
1920s	**.16**	**.13**			**.44**	**.36**
1930s	**−.45**	−.09			**−1.41**	−.29
1940s	**−.55**	**−.26**			**−1.71**	**−.90**
Birth Decade						
1770s				1.46		
1780s			2.08	−.88		
1790s			4.01	**2.20**		
1800s			−.11	**2.60**		

(*Continued*)

Table 6. (*Continued*)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
1810s			1.50	**1.84**		
1820s			**1.46**	**1.13**		
1830s			**1.04**	**.26**		
1840s			**.51**	**.28**		
1850s			**.47**	**.25**		
1860s			.15	**.22**		
1870s			Reference	Reference		
1880s			−.06	**−.16**		
1890s			**.59**	.06		
1900s			**1.90**	**.78**		
1910s			**5.37**	**2.40**		
1920s			**5.28**	**5.08**		
N	43,669	158,132	43,669	158,132	43,669	158,132
R^2	.11	.11	.08	.10	.35	.33

Source: See Table 1.
Note: Bold is significant at .05.

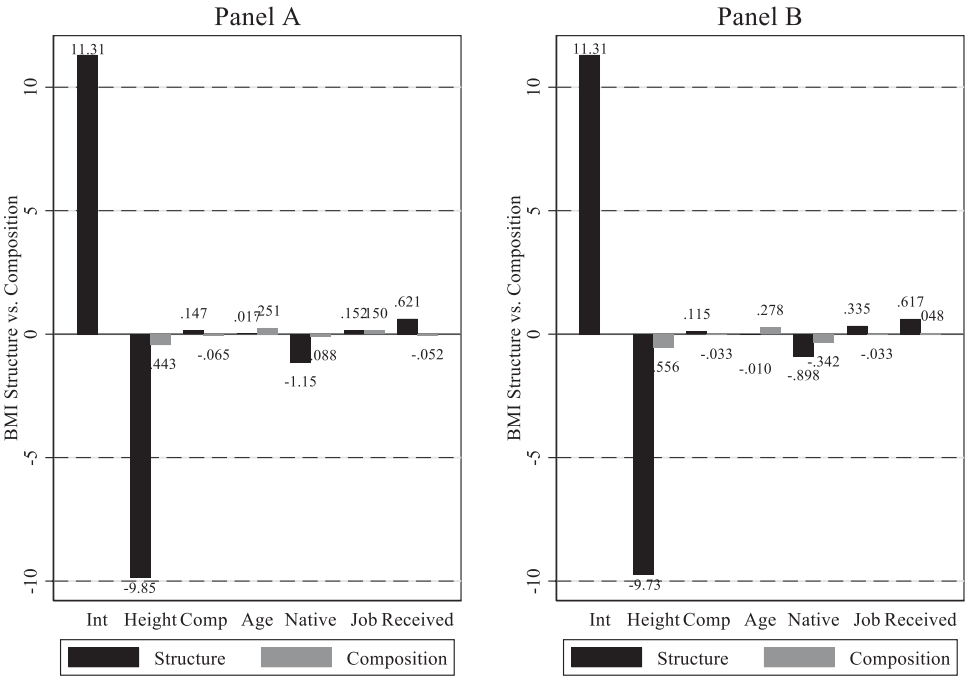

Figure 6. BMI Rural vs. Urban, Difference in Decompositions.
Source: See Table 7, Panel A and B.

such as wealth, disease, and diet. The second right hand side element, $(\theta_{1h} - \theta_{1l})\overline{X}_l$, is the structural returns difference due to characteristics. The third right-hand side element, $\left(\overline{X}_h - \overline{X}_l\right)\theta_h$, is the difference in compositional effects, and a large composition difference indicates that dependent variable differences are due to differences in sample compositions rather than returns to characteristics.

Table 7 presents the urban-rural net nutrition decompositions for late 19th and early 20th century males in the US. The proportional intercept indicates that independent of characteristics, urban BMIs were greater than rural BMIs (Figure 6). Among observable characteristics, rural stature and cumulative net nutrition had the greatest BMI return differences. Urban age, complexion, and decade received also had significant structural returns, while average compositional returns were smaller, indicating urban residential characteristics were favorable to net nutrition. Urban BMIs were greater than rural BMIs, and level returns to average characteristics were greater than returns to average characteristics, and urban BMIs were greater because of compositional rather than structural differences. Independent of characteristics, rural statures were taller than urban statures, and besides complexions, rural statures were greater than urban stature returns (Figure 7). Independent of characteristics, returns to rural weight were greater than urban weight; however, the weight returns to height were greater in urban relative to rural areas. Urban weight returns associated with height mostly offset identified sources in weight returns, followed by urban weight returns to occupations, nativity, and age. Rural weight structural returns were greater for observation period and complexions.

Table 8 presents black-white net nutrition decompositions for late 19th and early 20th century individuals in urban and rural locations. Black BMIs were greater than white BMIs, and black level returns to characteristics were greater than returns to average characteristics, indicating that returns to black characteristics were greater than average returns because of structural rather than average return differences. White BMI weight returns were greater than blacks for stature, age,

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Table 7. Late 19th and Early 20th Century Urban and Rural BMIs, Height, and Weight Decompositions by Characteristics

BMI	$(\beta_r - \beta_u)X_r$	$(X_r - X_u)\beta_u$	$(\beta_r - \beta_u)X_u$	$(X_r - X_u)\beta_r$
Level				
Sum	.261	−.052	.362	−.153
Total		.209		.209
Proportion				
Intercept	11.31		11.31	
Centimeters	−9.85	−.443	−9.73	−.556
Complexion	.147	−.065	.115	−.033
Age	.017	.251	−.010	.278
Nativity	−1.15	−.088	−.898	−.342
Occupations	.152	.150	.335	−.033
Decade Received	.621	−.052	.617	.048
Sum	1.25	−.248	1.73	−.734
Total		1		1
Height				
Level				
Sum	1.61	.315	1.20	.719
Total		1.92		1.92
Proportion				
Intercept	.078		.078	
Complexion	−.088	−.093	−.101	−.080
Age	−.028	−.063	−.034	−.057
Nativity	.215	.258	.078	.340
Occupations	−.115	.071	−.163	.119

(*Continued*)

Table 7. (*Continued*)

BMI	$(\beta_r - \beta_u)X_r$	$(X_r - X_u)\beta_u$	$(\beta_r - \beta_u)X_u$	$(X_r - X_u)\beta_r$
Birth Year	.774	−.009	.768	−.004
Sum	.836	.164	.626	.374
Total		1		1
Weight (kg)				
Level				
Sum	.529	1.38	.830	1.08
Total		1.91		1.91
Proportion				
Intercept	2.93		2.93	
Centimeters	−2.60	.674	−2.57	.644
Complexions	.058	−.019	.049	−.010
Age	−.003	.059	−.016	.072
Nativity	−.374	−.028	−.285	−.117
Occupations	.047	.049	.106	−.016
Year Observed	.216	−.012	.218	−.014
Sum	.277	.723	.435	.565
Total		1		1

Source: See Tables 1 and 6.

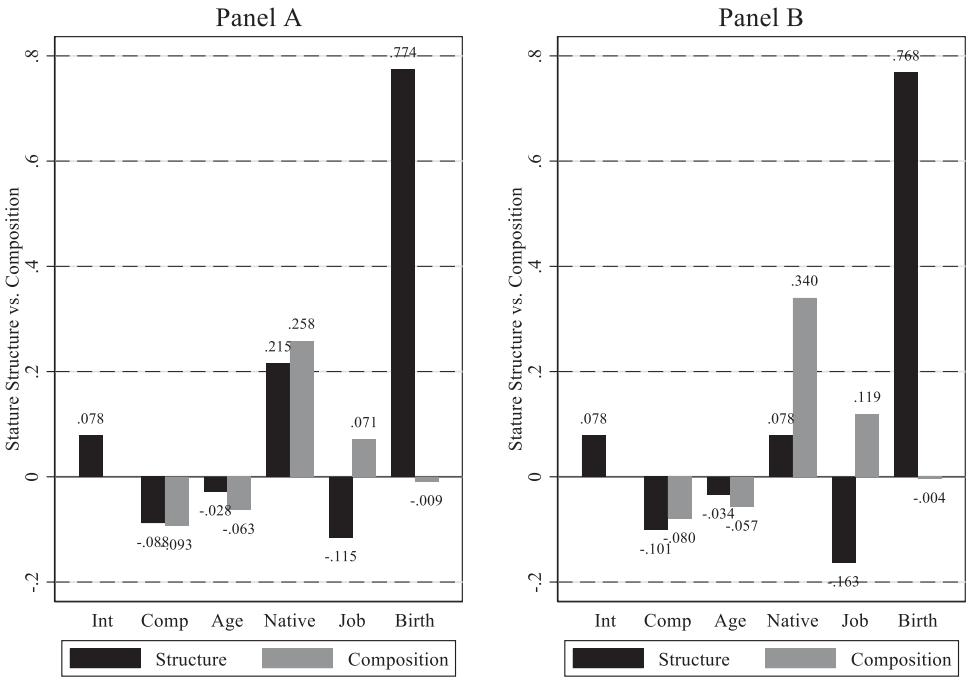

Figure 7. Rural vs. Urban Stature Difference in Decompositions.
Source: See Table 7, Panel B.

occupations, and observation decade. Subsequently, black BMIs were greater than whites associated with genetics and unobserved characteristics in the intercept, such as diets, disease, and percent protein in muscle tissue; however, whites had greater BMI returns associated with cumulative net nutrition, age, socioeconomic status, and observation period.

Blacks and whites have the potential to reach comparable statures when brought to maturity under ideal biological conditions (Tanner, 1977; Carson, 2009; Carson 2020); however, ideal net nutritional conditions and stature varied between blacks and whites. Whites were taller than blacks associated with non-observable sources in the intercept, which includes genetics and nutrition differences between blacks and whites (Carson, 2008; Carson, 2009). White returns to stature were greater than blacks associated with birth year, occupations, and urban status. Blacks had greater stature returns associated with nativity and age. Like black BMIs, black weights are greater for each unit of tissue mass because of biological differences, which includes blacks having greater protein in muscle tissue, and protein is heavier than fat (Figure 8;Wagner and Hayward, 2000; Schutte et al., 1984; Barondess et al., 1997; Aloia et al., 1997). Blacks had greater weight returns associated with genetics, nativity, and urban counties, and black stature returns to characteristics offset white stature returns to average characteristics. Whites had greater weight returns associated with stature, ages, observation year, residence, and occupations, indicating that whites had greater current net nutrition associated with cumulative net nutrition, demographics, and socioeconomic status with genetics and urban counties.

VI. Conclusion

Nineteenth and early 20th century urban residence imposed costs on worker health and net nutrition, and urban residents had a greater willingness to accept diminished urban health in exchange for economic opportunity. Stature represents cumulative net nutrition, and nativity and residence

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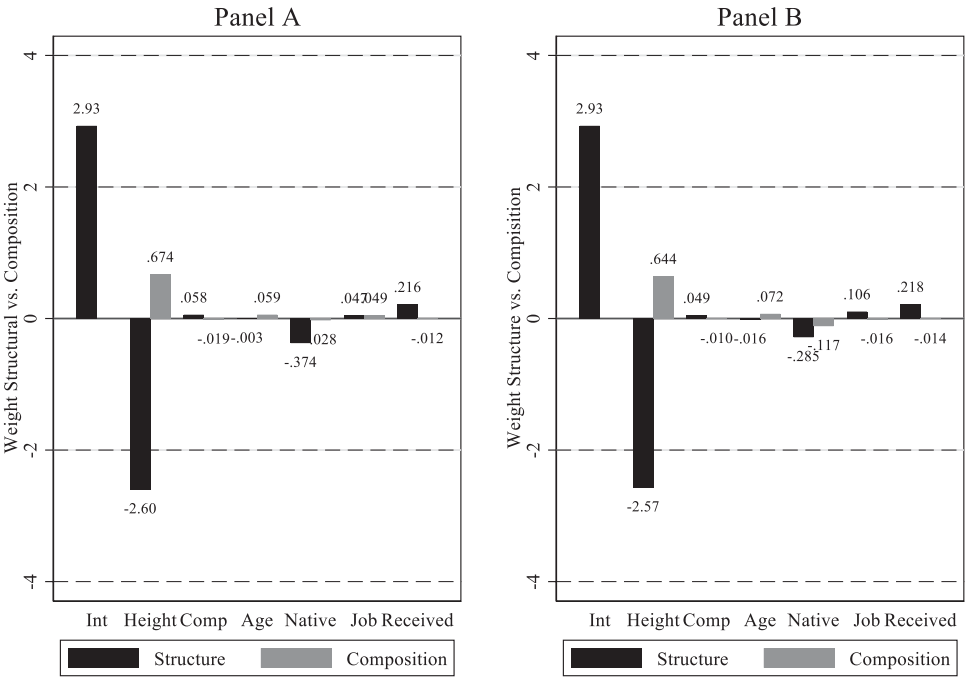

Figure 8. Rural vs. Urban Weight Difference-in-Decompositions.
Source: See Table 7, Panel C.

in large 19th century US urban areas were shorter than their rural counterparts. Despite disease, high relative food prices, and pollution, urban economic and social opportunities were greater, and the relative gains to net urban living exceeded the health negative externality associated with urban industrialization and the cost of migrating to rural areas. Urban BMIs were comparable to rural BMIs, urban heights shorter, and urban weights lower than individuals in rural locations. Net nutrition varied by race, and blacks had greater BMIs, shorter statures, and heavier weights than whites. White stature variation over time reflects access to nutrition relative to disease and environmental insults, and it is largely accepted that white-American statures stagnated between the 19th century's second and third quarters, a pattern known as the antebellum paradox. However, African-American statures did not exhibit the same stature decrease, and explanations suggest that black statures did not decline because they were not subject to the nutritional disruptions associated with industrialization and urban environmental change. Net nutrition also varied by socioeconomic status, and urban farmers had lower BMIs, shorter statures, and lower weight than rural farmers, indicating that urban agricultural net nutrition by socioeconomic status was worse than rural socioeconomic status (Gordan, 2015, p. 55). Urban nativity was the greatest source of structural returns, followed by age, and there was little compositional difference between urban and rural locations. However, there were greater returns to rural occupations, and rural returns to average characteristics offset the advantage to urban occupations, indicating little causal explanation between urban and rural statures by socioeconomic status. Despite the diminished net nutritional opportunities in urban locations, throughout the late 19th and early 20th centuries, individuals and households continued to urbanize indicating there was greater willingness-to-accept poorer urban health and net nutrition in exchange for urban economic opportunity.

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Table 8. Late 19th and Early 20th Century Black and White BMIs, Height, and Weight Decompositions by Urban-Rural Locations and Characteristics

BMI	$(\beta_b - \beta_w)X_b$	$(X_b - X_w)\beta_w$	$(\beta_b - \beta_w)X_w$	$(X_b - X_w)\beta_b$
Level				
Sum	1.24	−.189	.958	1.06
Total		1.05		1.05
Proportion				
Intercept	4.94		4.94	
Centimeters	−3.55	.081	−3.59	.118
Age	−.159	−.171	−.123	−.206
−.013Nativity	.055	−.083	−.015	−.013
Occu.021pations	.006	−.012	−.028	.021
Decade Received	−.011	.001	−.048	.038
Counties	.006	.007	.024	−.012
Residence	−.108	−.003	−.265	.154
Sum	1.18	−.180	.900	.100
Total		1		1
Height	$(\beta_w - \beta_b)X_b$	$(X_w - X_b)\beta_w$	$(\beta_w - \beta_b)X_w$	$(X_w - X_b)\beta_b$
Level				
Sum	1.76	1.25	2.69	.317
Total		3.01		3.01
Proportion				
Intercept	1.46		1.46	
Age	.017	−.104	.027	−.114
Nativity	.249	.119	.252	.196
Occupations	.060	.007	.047	.020

(*Continued*)

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Table 8. (*Continued*)

Height	$(\beta_w - \beta_b)X_b$	$(X_w - X_b)\beta_w$	$(\beta_w - \beta_b)X_w$	$(X_w - X_b)\beta_b$
Birth Year	−.966	.286	−.764	.084
Counties	−.002	−.038	−.013	−.027
Residence	−.234	.063	−.117	−.054
Sum	.586	.414	.895	.105
Total		1		1
Weight (kg)	$(\beta_b - \beta_w)X_b$	$(X_b - X_w)\beta_w$	$(\beta_b - \beta_w)X_w$	$(X_b - X_w)\beta_b$
Level				
Sum	3.78	−1.87	2.86	−.949
Total		1.91		1.91
Proportion				
Intercept	5.51		5.51	
Centimeters	−3.20	−.585	−3.24	−.552
Age	−.200	−.230	−.112	−.318
Nativity	.051	−.135	−.139	.055
Occupations	.006	−.018	−.046	.034
Year Observed	−.022	.002	−.083	.063
Counties	.011	.012	.040	−.017
Residence	−.173	−.021	−.433	.240
Sum	1.98	−.980	1.50	−.496
Total		1		1

Source: See Tables 1 and 6.

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