CESifo WORKING PAPERS

8523
2020

August 2020

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

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
Editor: Clemens Fuest
https://www.cesifo.org/en/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: https://www.cesifo.org/en/wp

CESifo *Working Paper No. 8523*

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

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. Across the United States, 19th century urban heights and weights were lower than their rural counterparts, while urban BMIs were higher. However, as the ratio of weight to height, higher urban BMIs reflect shorter urban statures, indicating there was a willingness-to-accept poorer cumulative urban health and net nutrition in exchange for urban economic opportunity. 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: C100, C400, D100, I100, N300.

Keywords: urbanization, stature variation, cumulative net nutrition, nativity, race.

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

I appreciate comments from John Komlos, Lee Carson, and Paul Hodges. Shahil Sharma, Chinuedu Akah, Meekam Okeke, Ryan Keifer, Tiffany Grant, Bryce Harper, Greg Davis, and Kellye Manning provided research assistance.

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, 19^{th} century 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;

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

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 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 greater weights than rural farmers and workers in other occupations, indicating urban agricultural net nutrition was lower than rural locations.

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. 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). 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.

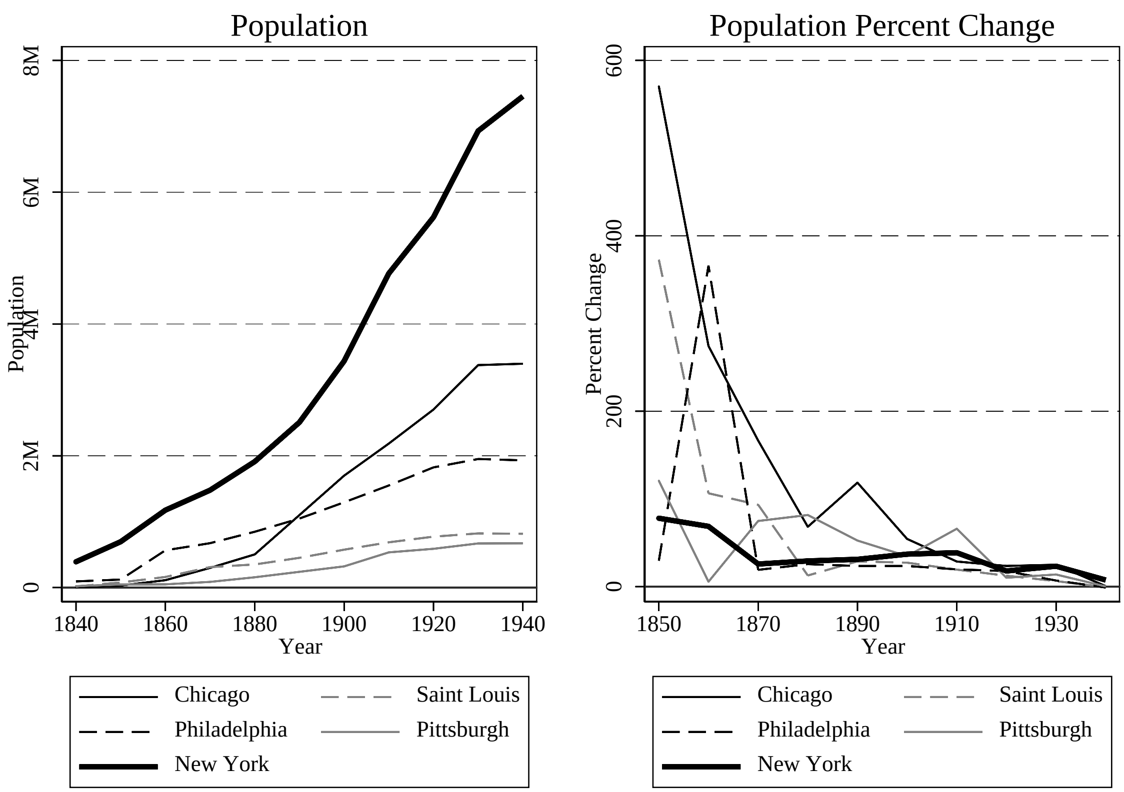

Figure 1, Large Late 19th and Early 20th Century Urban Centers: Chicago, Saint Louis, Philadelphia, Pittsburgh, and New York

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).

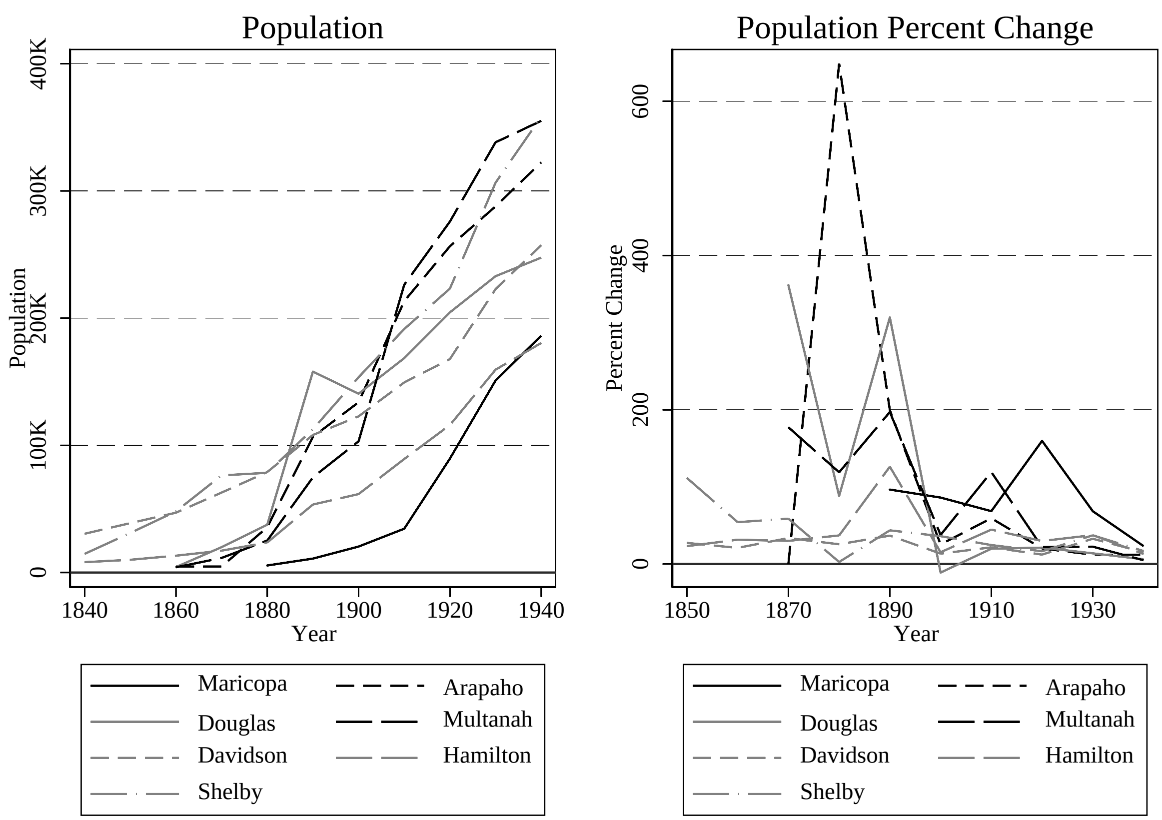

Figure 2, Small Late 19th and Early 20th Century Growing Urban Centers: Maracopa (Pheonix), Arapaho (Denver), Douglas (Omaha), Multanah (Portland), Davidson (Nashville), Hamilton (Chatanooga), and Shelby (Memphis)

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 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 short-comings. 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).

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.

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

	Urban		*Rural*	
	N	Percent	N	Percent
Ages				
Teens	5,282	12.07	22,992	14.51
20s	21,847	49.92	78,766	49.72
30s	10,031	22.92	33,182	20.95
40s	4,283	9.79	14,585	9.21
50s	1,704	3.89	6,320	3.99
60s	515	1.18	2,146	1.35
70s	87	.20	393	.25
80s	13	.03	40	.03
Occupations				
White-Collar	5,589	12.77	11,927	7.53
Skilled	10,719	24.49	25,786	16.28
Farmer	1,125	2.57	20,551	12.97
Unskilled	15,160	34.64	84,537	53.36
No Occupations	11,169	25.52	15,623	9.86
Ethnicity				
Native American	10	.02	426	.27
Asian	13	.03	104	.07
Black	9,243	21.12	34,989	22.09
Mexican	64	.15	7,301	4.61
Mixed-Race	7,297	16.67	22,152	13.98
White	27,135	62.01	93,452	58.99
Nativity				
International				
Africa	25	.06	52	.03
Asia	148	.34	274	.17
Australia	26	.06	112	.07
Canada	431	.98	1,433	.90
Europe	3,768	8.61	7,059	4.46
Great Britain	2,123	4.85	4,135	2.61
Latin America	93	.21	204	.13
Mexico	452	1.03	6,382	4.03
National				
Far West	711	1.62	4,865	3.07
Great Lakes	4,866	11.12	12,951	8.17
Middle Atlantic	11,146	25.47	14,562	9.19

Northeast	611	1.40	1,710	1.08
Plains	4,221	9.65	20,747	13.10
Southeast	14,354	32.80	50,516	31.89
Southwest	787	1.80	33,422	21.10
Residence				
Arizona	912	2.08	3,414	2.15
Colorado	1,962	4.48	4,807	3.03
Idaho			767	.48
Illinois	7,400	16.91	4,622	2.92
Kentucky			13,713	8.66
Missouri	2,931	6.70	18,199	11.49
Mississippi			2,298	1.45
Montana			10,924	6.90
Nebraska	2,842	6.49	7,679	4.85
New Mexico			3,683	2.32
Oregon	753	1.72	1,774	1.12
PA, East	3,598	8.22	5,551	3.50
PA, West	1,993	4.55	6,120	3.86
Philadelphia	8,748	19.99		
Tennessee	12,623	28.84	19,516	12.32
Texas			50,208	31.69
Utah			4,581	2.89
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.

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.

Table 2, Biological Inequality by Residence

	Urban		*Rural*	
	Mean	SD	Mean	SD
BMI	23.05	2.54	23.08	2.50
Centimeters	169.22	6.73	171.20	6.98
Kilograms	66.05	8.55	67.66	8.26
	CV	Gini	CV	Gini
BMI	.110	.060	.108	.059
Centimeters	.040	.022	.041	.023
Kilograms	.130	.071	.125	.069

Source: See Table 1.

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 and follows a normal distribution and is less sensitive to net nutrition variation (Sokoloff and Vilaflour, 1982, p. 456). Alternatively, BMI and weight are not as genetically determined and vary with the immediate effects of the physical environment. Rural BMIs and weight were distributed more equally than 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.

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 ith 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.

Body Mass Index

$$BMI_i = \theta_0 + \theta_c Centimeters_i + \sum_{e=1}^{5}\theta_e Race_i + \sum_{a=1}^{3}\theta_a Age_i^a + \sum_{n=1}^{14}\theta_n Nativity_i + \sum_{j=1}^{4}\theta_j Occupations_i$$

$$+\sum_{r=1}^{10}\theta_r Decade\,\mathrm{Re}\,ceived_i + \sum_{m=1}^{11}\theta_m Urban_i + \sum_{s=1}^{16}\theta_s\,\mathrm{Re}\,sidence + \varepsilon_i \qquad (1)$$

Height

$$Centimeters_i = \theta_0 + \sum_{e=1}^{5}\theta_e Race_i + \sum_{a=1}^{3}\theta_a Age_i^a + \sum_{n=1}^{14}\theta_n Nativity_i + \sum_{j=1}^{4}\theta_j Occupations_i$$

$$+\sum_{r=1}^{10}\theta_r Decade\,\mathrm{Re}\,ceived_i + \sum_{m=1}^{11}\theta_m Urban_i + \sum_{s=1}^{16}\theta_s\,\mathrm{Re}\,sidence + \varepsilon_i \qquad (2)$$

Weight

$$Kilograms_i = q_0 + q_c Centimeters_i + \sum_{e=1}^{5} q_e Race_i + \sum_{a=1}^{3} q_a Age_i^a + \sum_{n=1}^{14} q_n Nativity_i + \sum_{j=1}^{4} q_j Occupations_i$$

$$+\sum_{r=1}^{10}\theta_r Decade\,\mathrm{Re}\,ceived_i + \sum_{m=1}^{11}\theta_m Urban_i + \sum_{s=1}^{16}\theta_s\,\mathrm{Re}\,sidence + \varepsilon_i \qquad (3)$$

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 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, 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.

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

	Total	*Native Only*	*Native Whites*	*Native Blacks*	*Total Youth*	*Total Adult*
Intercept	32.77***	32.85***	30.92***	35.84***	33.86***	32.21***
Height						
Centimeters	-.059***	-.059***	-.049***	-.071***	-.067***	-.055***
Ethnicity						
White	Reference	Reference			Reference	Reference
Black	1.14***	1.16***		.312***	.999***	1.20***
Mulatto	.876***	.896***		Reference	.704***	.967***
Native America	.466***	.458***			.361*	.508***
Mexican	.062	.008			-.013	.088*

Asian	-.154	-.500*			-1.03***	.065
Ages						
12	-4.63***	-4.61***	-4.10***	-5.02***	-4.61***	
13	-4.26***	-4.29***	-2.60***	-4.84***	-4.22***	
14	-3.41***	-3.39***	-2.67***	-3.75***	-3.33***	
15	-2.78***	-2.79***	-2.15***	-3.16***	-2.69***	
16	-2.07***	-2.09***	-1.69***	-2.40***	-1.95***	
17	-1.48***	-1.47***	-1.22***	-1.72***	-1.34***	
18	-1.09***	-1.09***	-.866***	-1.33***	-.948***	
19	-.714***	-.702***	-.569***	-.857***	-.561***	
20	-.423***	-.428***	-.327***	-.565***	-.262***	
21	-.274***	-.269***	-.234***	-.326***	-.108***	
22	-.170***	-.162***	-.153***	-.192***	Reference	
23-29	Reference	Reference	Reference	Reference		Reference
30s	.223***	.218***	.246***	.192***		.222***
40s	.463***	.469***	.561***	.303***		.464***
50s	.565***	.584***	.700***	.351***		.570***
60s	.450***	.404***	.565***	.095		.458***
70s	.235	.238	.466**	-.175		.245*
80s	-.538	-1.04***	-.671	-1.51***		-.512
Nativity						
International						
Africa	.257				.604	.168
Asia	-2.20***				-1.09***	-2.41***
Australia	-.236				.490	-.359*
Canada	.001				.113	-.020
Europe	.671***				.867***	.635***
Britain	.011				.010	-.020
Latin America	-.454***				-.253	-.526***
Mexico	-.291***				-.043	-.341***
National						
Northeast	Reference	Reference	Reference	Reference	Reference	Reference
Middle East	-.113**	-.093*	-.050	-.336*	.061	-.137**
Great Lakes	-.001	-7.26^{-4}	.006	-.230	.199*	-.035
Plains	.025	.004	-.007	-.031	.249**	-.021
Southeast	-.150***	-.178***	-.232***	-.121	.191*	-.248***
Southwest	-.125**	-.160***	-.197***	-.148	.158	-.199***
Far West	-.174***	-.178***	-.204***	-.227	.142	-.243***
Occupation						
White Collar	.022	.019	.119***	-.198***	-.062	.015
Skilled	.046**	.058**	.133***	.024	.108***	.006
Farmer	.341***	.336***	.307***	.310***	.459***	.274***
Unskilled	.146***	.132***	.209***	.116***	.172***	.118***
No Occupation	Reference	Reference	Reference	Reference	Reference	Reference

Decade Received						
1840s	1.42***	1.53***	1.62***	1.15***	1.25***	1.47***
1850s	.573***	.595***	.595***	.707*	.414***	.657***
1860s	.707***	.712***	.748***	.622***	.610***	.777***
1870s	.391***	.434***	.245***	.564***	.424***	.369***
1880s	.135***	.133***	.125***	.111***	.070**	.169***
1890s	.144***	.149***	.146***	.155***	.134***	.149***
1900s	Reference	Reference	Reference	Reference	Reference	Reference
1910s	-.052***	-.056***	5.62^{-4}	-.141***	-.038	-.057***
1920s	.083**	.079**	.175***	-.136**	.067	.092**
1930s	-.159***	.152**	.223***	-.246	-.021	.177***
1940s	-.002	-.044	-.048	-.163	.093	-.032
Counties						
Rural	Reference	Reference	Reference	Reference	Reference	Reference
Maricopa, AZ	.016	.012	-.017	.082	-.163	.072
Arapaho, CO	-.173***	-.153**	-.199**	.135	-.410***	-..125
Cook, IL	-.100**	-.106*	-.061	-.052	-.072	-.102*
Saint Louis, MO	.062	.069	.175***	-.068	.096	.054
Douglas, NE	-.230***	-.657***	-.131*	-.014	-.007	-.294***
Multanah, OH	-.358***	-.306**	-.299**	-.088	-.341**	-.365***
Philadelphia, PA	-.390***	-.409***	-.474***	-.158	-.502***	-.370***
Alleghany, PA	-.246***	-.282***	-.302***	-.190	-.408***	-.185***
Davidson, TN	-.010	-.002***	.054	-.066	-.117*	.087
Hamilton, TN	-.462***	-.464***	-.383***	-.520***	-.580***	-.363***
Shelby, TN	-.132***	-.464***	-.116	-.211***	-.245***	-.042
Residence						
Arizona	.038	.052	.183**	-.431**	.009	.029
Colorado	.549***	.503***	.600***	.227*	.509***	.572***
Idaho	.196**	.208**	.233**	.029	.153	.209**
Illinois	-.021	-.092*	.036	-.435***	-.166*	.013
Kentucky	-.446***	-.472***	-.357***	-.572***	-.448***	-.467***
Missouri	-.736***	-.750***	-.651***	-.838***	-.737***	-.735***
Montana	.763***	.741***	.811***	.249**	.697***	.786***
Mississippi	-.212***	-.223***	-.259**	-.303***	-.243***	-.207***
Nebraska	-.496***	-.473***	-.415***	-.952***	-.652***	-.442***
New Mexico	.225***	.217***	.372***	-.003	.368***	.185***
Oregon	.858***	.838***	.967***	.615	.834***	.855***

East, PA	-.293***	-.339***	-.125**	-.725***	-.367***	-.267***
West, PA	.486***	.431***	.541***	.414***	.568***	.463***
Philadelphia	-.203***	-.307***	-.112	-.549***	-.448***	-.079
Tennessee	.419***	.397***	.446***	.379***	.471***	.350***
Texas	Reference	Reference	Reference	Reference	Reference	Reference
Utah	.200***	.146***	.225***		-.200***	.299***
Washington	-.100	-.250**	-.158	-.392	-.120	-.097
N	202,186	175,469	99,303	72,645	63,263	138,923
R^2	.1264	.1285	.0804	.1346	.1668	.0944
RMSE	2.34	2.34	2.38	2.29	2.11	2.11

Source: See Table 1.

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

Table 4, Late 19th and Early 20th Century Urban and Rural Height by Characteristics

	Total	Native Only	Native White	Native Black	Total Youth	Total Adult
Intercept	175.13***	175.32***	176.22***	172.14***	176.44***	174.88***
Ethnicity						
White	Residence	Residence			Residence	Residence
Black	-2.21***	-2.29***		-.723***	-2.50***	-2.05***
Mulatto	-1.61***	-1.64***		Residence	-1.81***	-1.51***
Native-America	-1.63***	-2.09***			-1.83***	-1.52***
Mexican	-4.15***	-5.15***			-4.57***	-3.94***
Asian	-2.94***	-3.55***			-3.07***	-2.85***
Age						
12	-20.99***	-20.90***	-21.90***	-20.81***	-20.69***	
13	-15.43***	-15.57***	-13.78***	-15.80***	-15.12***	
14	-11.66***	-11.83***	-12.85***	-11.66***	-11.36***	
15	-8.16***	-8.23***	-8.48***	-8.22***	-7.89***	
16	-5.27***	-5.30***	-5.17***	-5.42***	-5.02***	
17	-3.23***	-3.23***	-3.02***	-3.42***	-2.99***	
18	-2.01***	-2.00***	-1.71***	-2.30***	-1.78***	
19	-1.22***	-1.25***	-1.11***	-1.39***	-.987***	
20	-.521***	-.522***	-.415***	-.608***	-.318***	
21	-.249***	-.212***	-.168*	-.303***	-.044	
22	-.200***	-.191***	-.107	-.264***	Residence	
23-29	Residence	Residence	Residence	Residence		Residence
30s	-.078*	-.012	-.059	.119		-.041
40s	-.713***	-.618***	-.505***	-.698***		-.639***
50s	-1.46***	-1.41***	-1.30***	-1.53***		-1.36***
60s	-2.42***	-2.44***	-2.45***	-2.07***		-2.27***
70s	-3.35***	-3.43***	-3.24***	-3.17***		-3.16***
80s	-4.88***	-4.85***	-4.24***	-4.42***		-4.67***
Nativity						
International						
Africa	-1.47**				-3.62***	-.815
Asia	-5.87***				-6.62***	-5.91***
Australia	-.558				-1.02	-.476
Canada	-.258				-.077	-.284
Europe	-2.46***				-1.95***	-2.54***
Britain	-1.35***				-1.19**	-1.37***
Latin America	.277				-2.02**	.790*
Mexico	-1.89***				-1.28***	-2.12***
United States						
Northeast	Residence	Residence	Residence	Residence	Residence	Residence

Middle Atlantic	-.199	-.273*	-.249*	-.595	-.035	-.227
Great Lakes	.813***	.828***	.894***	.112	.709**	.864***
Plains	1.29***	1.32***	1.46***	.191	1.48***	1.24***
Southeast	1.74***	1.79***	1.88***	.923*	1.87***	1.70***
Southwest	1.84***	2.03***	1.86***	1.54***	2.05***	1.72***
Far West	1.09***	1.14***	1.21***	.580	1.23***	1.02***
Occupations						
White Collar	-.011	-.034	-.067	-.270*	.071	-.144
Skilled	-.150***	-.152**	-.260***	-.062	.139	-.326***
Farmers	.893***	.920***	.789***	1.04***	1.32***	.654***
Unskilled	.107*	.166***	-.009	.398***	.436***	-.096
No Occupations	Residence	Residence	Residence	Residence	Residence	Residence
Birth Decade						
1790s	Residence	Residence	Residence	Residence		Residence
1800s	.517	.436	.219	.064		.587
1810s	-.301	-.129	-.448	.841	2.54***	-.173
1820s	-1.07	-1.10	-1.18	-.331	Residence	-.984
1830s	-1.96**	-2.28**	-2.49*	-1.10	-3.20***	-1.73*
1840s	-2.20***	-2.54**	-3.00**	-.854	-3.80***	-1.91**
1850s	-2.37***	-2.70***	-3.50***	-.528	-4.05***	-2.04**
1860s	-2.46***	-2.78***	-3.51***	-.742	-4.02***	-2.17**
1870s	-2.73***	-3.07***	-3.70***	-1.19	-4.39***	-2.40***
1880s	-3.00***	-3.35***	-4.02***	-1.42	-4.81***	-2.59***
1890s	-2.71***	-3.01***	-3.75***	-.973	-4.55***	-2.21**
1900s	-2.04***	-2.34**	-3.12**	-.165	-4.05***	-1.31
1910s	-.457***	-.730	-1.45	1.56	-2.26**	.092
1920s	1.46	1.25	.560	3.04	-.352	3.52*
Urban						
Rural	Residence	Residence	Residence	Residence	Residence	Residence
Maricopa, AZ	-.055	.045	-.052	.817	.475	-.238
Arapaho, CO	-.018	-.138	-.061	-.813	.169	-.078
Cook, IL	-.410***	-.435***	-.680***	.262	.072	-.501***
Saint Louis, MO	-.978***	-1.01***	-.721***	-1.50***	-1.10***	-.965***
Douglas, NE	-.473***	-.300**	-.024**	-.486	.083	-.629***
Multanah, OH	-.540**	-.825**	-.953***	1.23	-.898	-.422***
Philadelphia, PA	-.754***	-.759***	-.656***	-1.18***	-1.15***	-.672***
Alleghany, PA	-1.14***	-1.18***	-1.28***	-1.09**	-1.30***	-1.08***
Davidson,	-1.09***	-1.08***	-1.03***	-1.02***	-1.16***	-1.01***

TN						
Hamilton, TN	-.401***	-.444***	-1.34***	-.083	-.360*	-.416*
Shelby, TN	-1.40***	-1.43***	-1.88***	-1.24***	-1.60***	-1.23***
State Residence						
Arizona	-2.25***	-1.90***	-2.18***	.211	-2.68***	-2.06***
Colorado	-1.82***	-1.71***	-2.02***	-.222	-1.64***	-1.83***
Idaho	-.259	-.157	-.286	-.281	-.215	-.262
Illinois	-1.04***	-1.30***	-1.48***	-1.02***	-1.86***	-1.30***
Kentucky	-2.03***	-1.94***	-2.09***	-1.78***	-2.41***	-1.81***
Missouri	-1.59***	-1.52***	-1.74***	-1.06***	-1.73***	-1.52***
Montana	1.27***	1.33***	1.12***	1.86***	1.09***	1.35***
Mississippi	.262*	.349**	.940***	.551***	.580**	.091
Nebraska	-.387***	-.357***	-.584***	.439	-.774***	-.382***
New Mexico	-.865***	-.741***	-.927***	.388	-.784***	-.868***
Oregon	-2.15***	-1.94***	-2.10***	-1.93**	-1.85***	-2.23***
East, PA	-3.07***	-2.75***	-3.16***	-1.96***	-3.07***	-3.04***
West, PA	-2.09***	-1.80***	-2.07***	-1.05	-2.36***	-1.97***
Philadelphia	-1.67***	-1.57***	-2.05***	-.752*	-1.52***	-1.63***
Tennessee	-1.75***	-1.65***	-1.77***	-1.29***	-1.64***	-1.81***
Texas	Residence	Residence	Residence	Residence	Residence	Residence
Utah	-.432***	-.420***	-.639***		-.860***	-.254**
Washington	-2.24***	-2.45***	-2.59***	-.402**	-2.70***	-2.07***
N	202,186	175,469	99,303	72,645	63,263	138,923
R^2	.1319	.1220	.0939	.1248	.1870	.0974
RMSE	6.50	6.49	6.33	6.67	6.48	6.51

Source: See Table 1.

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

Table 5, Late 19th and Early 20th Century Urban and Rural Weight by Characteristics

	Total	*Native Only*	*Native Whites*	*Native Blacks*	*Total Youth*	*Total Adult*
Intercept	-10.26***	-40.03***	-43.65***	-33.83***	-34.27***	-43.22***
Height						
Centimeters	.623***	.622***	.640***	.604***	.582***	.641***
Ethnicity						
White	Reference	Reference			Reference	Reference
Black	3.35***	3.41***		.919***	2.92***	3.54***
Mulatto	2.59***	2.65***		Reference	2.07***	2.86***
Native America	1.39***	1.38***			1.02*	1.54***
Mexican	.262**	.119			.065	.316**
Asian	-.356	-1.35*			-2.79***	.263
Ages						
12	-10.33***	-10.35***	-8.78***	-11.26***	-10.63***	
13	-10.35***	-10.43***	-5.88***	-11.79***	-10.47***	
14	-8.71***	-8.67***	-6.44***	-9.62***	-8.64***	
15	-7.47***	-7.48***	-5.68***	-8.48***	-7.28***	
16	-5.73***	-5.80***	-4.67***	-6.66***	-5.45***	
17	-4.20***	-4.21***	-3.47***	-4.90***	-3.83***	
18	-3.13***	-3.14***	-2.50***	-3.82***	-2.73***	
19	-2.08***	-2.05***	-1.67***	-2.53***	-1.63***	
20	-1.24***	-1.26***	-.961***	-1.66***	-.751***	
21	-.800***	-.788***	-.689***	-.957***	.296***	
22	-.515***	-.495	-.474***	-.580***	Reference	
23-29	Reference	Reference	Reference	Reference		Reference
30s	.660***	.649***	.739***	.558***		.659***
40s	1.36***	1.40***	1.68***	.885***		1.37***
50s	1.64***	1.71***	2.06***	.988***		1.67***
60s	1.32***	1.19***	1.67***	.235		1.35***
70s	.699*	.691	1.35**	-.495		.747*
80s	-1.38	-2.93***	-1.92	-4.22***		-1.28
Nativity						
International						
Africa	.727				1.80	.435
Asia	-.602***				-2.96***	-6.56***
Australia	-.569				1.43	-.908
Canada	.027				.373	-.037
Europe	1.94***				2.50***	1.85***
Britain	.055				.060	-.020
Latin America	-1.33***				-.717	-1.57***

Mexico	-.798***				-.134	-.912***
National						
Northeast	Reference	Reference	Reference	Reference	Reference	Reference
Middle East	-.297*	-.241	-.117	-.956*	.167	-.369**
Great Lakes	.026	.032	.0668	-.653	.561*	-.072
Plains	.077	.026	.015	-.079	.698**	-.053
Southeast	-.435***	-.515***	-.649***	-.347	.525*	-.718***
Southwest	-.368**	-.463***	-.554***	-.445	.427	-.569***
Far West	-.517***	-.527***	-.584***	-.668	.393	-.715***
Occupation						
White Collar	.055	.048	.334***	-.585***	-.199	.048
Skilled	.122*	.157**	.366***	.069	.313***	.018
Farmer	.985***	.971***	1.19***	.879***	1.31***	.809***
Unskilled	.409***	.373***	.563***	.328***	.481***	.341***
No Occupation	Reference	Reference	Reference	Reference	Reference	Reference
Decade Received						
1840s	4.23***	4.56***	4.88***	3.45***	3.70***	4.40***
1850s	1.70***	1.77***	1.81***	1.94*	1.23***	1.95***
1860s	2.06***	2.08***	2.24***	1.77***	1.75***	2.29***
1870s	1.12***	1.25***	.706***	1.62***	1.25***	1.04***
1880s	.392***	.391***	.371***	.314***	.210***	.487***
1890s	.412***	.457***	.424***	.445***	.385***	.426***
1900s	Reference	Reference	Reference	Reference	Reference	Reference
1910s	-.156***	-.170***	-.003	-.423***	-.120	-.171***
1920s	.218**	.215**	.498***	-.418**	.196	.234*
1930s	.426**	.402**	.629***	-.815	-.145	.469**
1940s	-.112	-.243	-.219	-.061	.076	-.204
Counties						
Rural	Reference	Reference	Reference	Reference	Reference	Reference
Maricopa, AZ	.053	.053	-.039	.320	-.444	.215
Arapaho, CO	-.494**	-.442*	-.573**	.363	-1.26***	-.337
Cook, IL	-.260*	-.289*	-.163	-.140	-.184	-.259*
Saint Louis, MO	.211	.227	.542***	-.175	.282	.197
Douglas, NE	-.669***	-.750***	-.394*	-.038	-.002	-.850***
Multanah, OH	-1.02***	-.900***	-.889**	-.100	-.974*	-.104***
Philadelphia, PA	-1.09***	-1.15***	-1.34***	-.421	-1.38***	-1.04***
Alleghany, PA	-.720***	-.804***	-.865***	-.543	-1.18***	-.554***
Davidson,	.031	.054	.192	-.107	-.261	.289*

TN						
Hamilton, TN	-1.32***	-1.33***	-1.11***	-1.49***	-1.68***	-1.04***
Shelby, TN	-.348***	-.385***	-.304	.549***	-.667***	-.104
Residence						
Arizona	.192	.214	.585***	-1.18**	.330	.158
Colorado	1.65***	1.53***	1.81***	.681*	1.57***	1.71***
Idaho	.602**	.633**	.721**	.050	.446	.645**
Illinois	-.028	-.226	1.39	-1.22***	-.422	.065
Kentucky	-1.26***	-1.34***	-1.02***	-1.61***	-1.24***	-1.34***
Missouri	-2.10***	-2.14***	-1.87***	-2.37***	-2.09***	-2.10***
Montana	2.32***	2.28***	2.51***	.718**	2.12***	2.38***
Mississippi	-.676***	-.704***	-.804**	-.959***	-.755***	-.651***
Nebraska	-1.41***	-1.35***	-1.19***	-2.74***	-1.89***	-1.25***
New Mexico	.639***	.617***	1.07***	-.054	1.08***	.514***
Oregon	2.57***	2.54***	2.91***	1.67	2.50***	2.56***
East, PA	-.757***	-.886***	-.271*	-2.03***	-.966***	-.684***
West, PA	1.47***	1.33***	1.64***	1.24***	1.70***	1.41***
Philadelphia	-.536***	-.821***	-.252	-1.54***	-1.23***	-.196
Tennessee	1.21***	1.16***	1.30***	1.10***	1.36***	1.03***
Texas	Reference	Reference	Reference	Reference	Reference	Reference
Utah	.671***	.522***	.758***		-.486**	.945***
Washington	-.191	-.614*	-.372	-.708	-.217	-.196
N	202,186	175,469	99,303	72,645	63,263	138,923
R^2	.3606	.3593	.3229	.4068	.4367	.3099
RMSE	6.81	6.83	7.03	6.56	6.01	7.13

Source: See Table 1.

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

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), 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 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 (Bodenhorn, Guinine, and Mroz, 2017, p. 173; 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 (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.

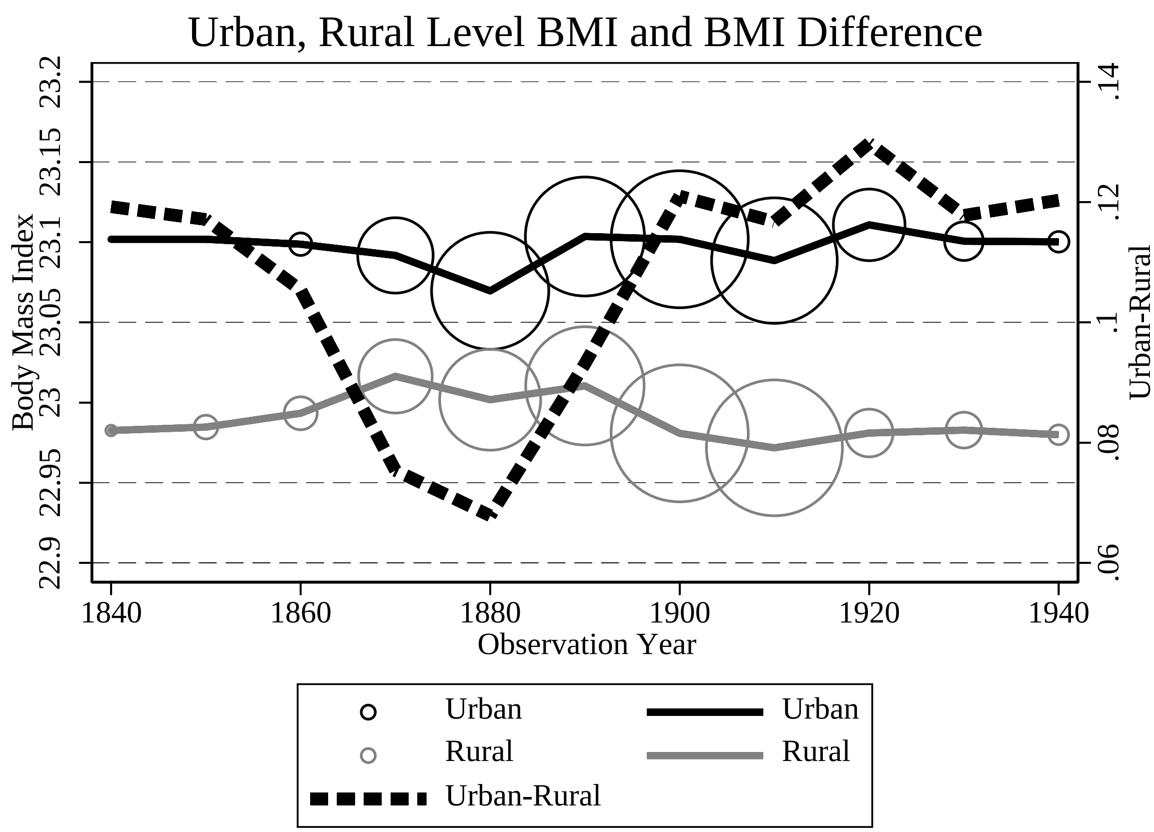

Figure 3, Late 19th and Early 20th Century Urban and Rural BMIs over Time

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 at the same time that wages and income increased (Libergott, 1984; Craig et al 2004; Bogart, 2009). 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). Greater population density increased the relative price of food and worsened disease environments (Voth and Lueinig, 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; Correia, Luck, and Verner, 2020).

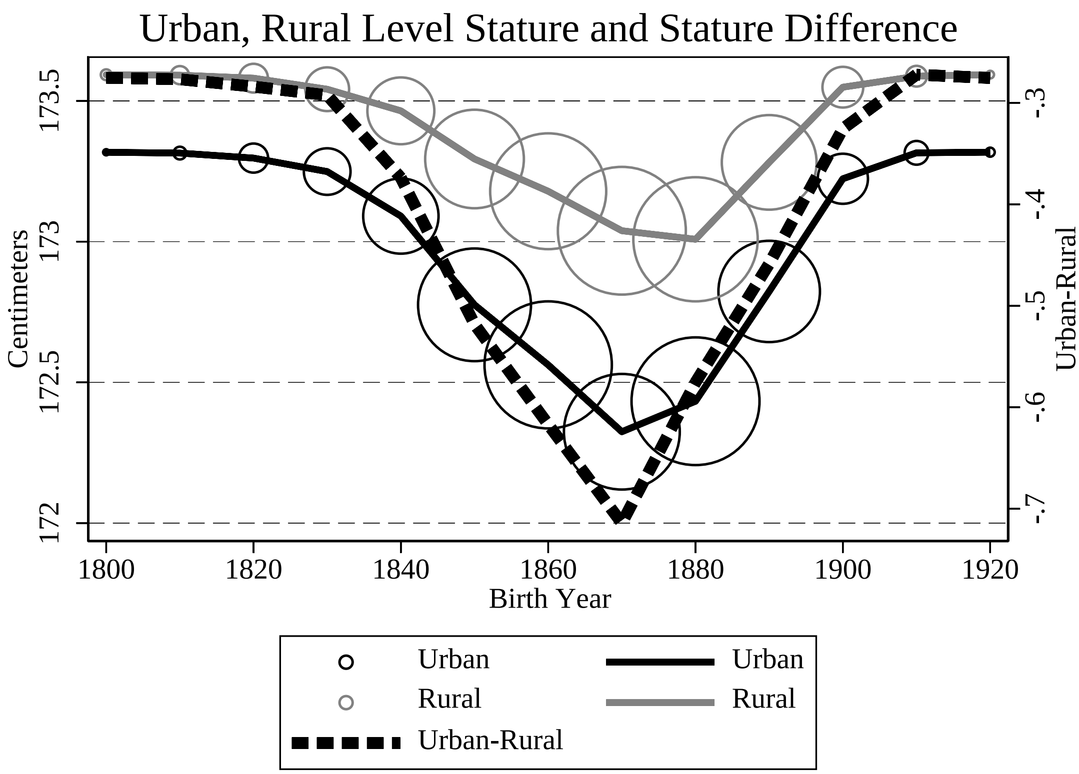

Figure 4, Late 19th and Early 20th Century Urban and Rural Heights over Time

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.

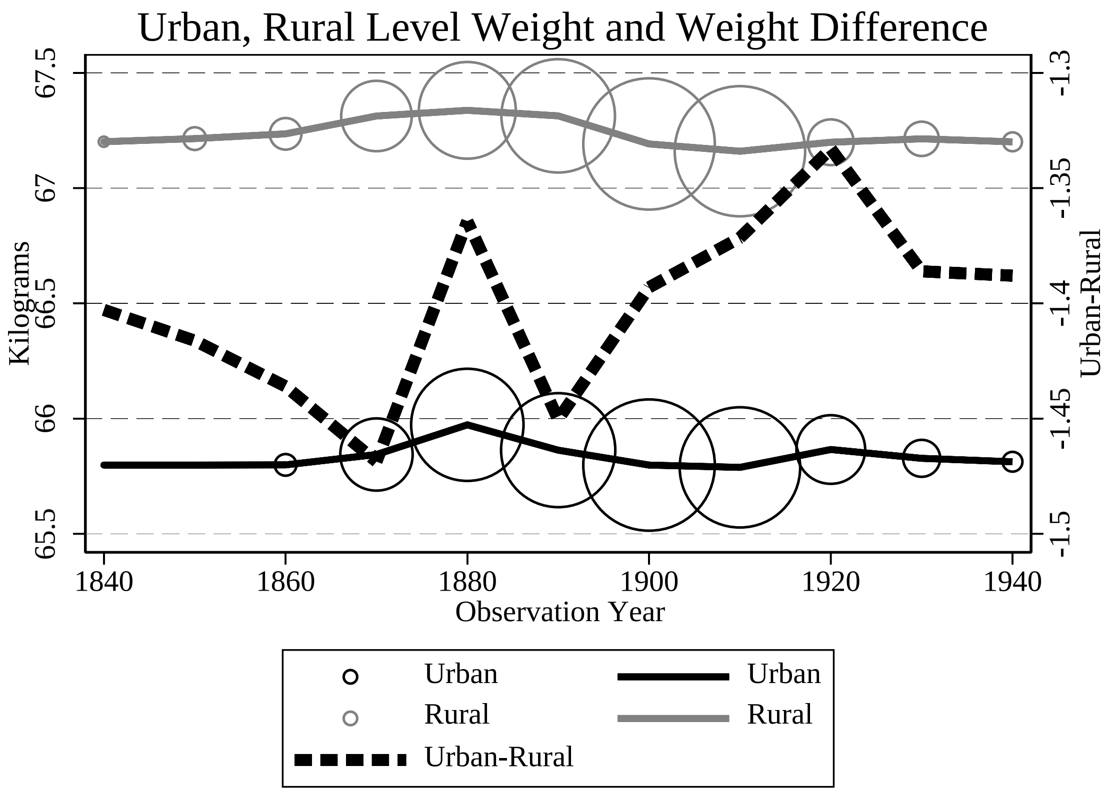

Figure 5, Late 19th and Early 20th Century Urban and Rural BMIs over Time

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.

[Insert Table 6 here]

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 (Craig, Weiss, and Haines, 2003, p. 406; 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. 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. $\bar{X}_h$ and $\bar{X}_l$ are high and low characteristic matrices. High and low BMI, height, and weight are expressed in vectors.

$$\gamma_h = \theta_{0h} + \theta_{1h}\bar{X}_h \qquad (4)$$

and

$$\gamma_l = \theta_{0l} + \theta_{1l}\bar{X}_l \qquad (5)$$

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

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

which is rearranged into the decompositions:

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

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

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, $\left(\theta_{0h} - \theta_{0l}\right)$, is the difference in the autonomous differences due to non-identifiable characteristics, such as wealth, disease, and diet. The second right hand side element, $\left(\theta_{1h} - \theta_{1l}\right)\bar{X}_l$, is the structural returns difference due to characteristics. The third right-hand side element, $\left(\bar{X}_h - \bar{X}_l\right)\theta_h$, 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 6, Late 19th and Early 20th Century Urban and Rural BMI, Height, and Weight by Characteristics

	Urban BMI	*Rural BMI*	*Urban Height*	*Rural Height*	*Urban Weight (kg)*	*Rural Weight (kg)*
Intercept	30.66***	33.31***	173.33***	172.97***	-45.33***	-38.91***
Height						
Centimeter	-.046***	-.059***			.654***	.625***
Complexion						
White	Reference	Reference	Reference	Reference	Reference	Reference
Black	.831***	1.07***	-1.79***	-2.27***	2.41***	3.16***
Mixed Race	.990***	.831***	-1.21***	-1.72***	2.86***	2.45***
Native America	.278	.663***	1.86**	-1.15***	.813	1.97***
Mexican	.098	.077**	-4.43***	-3.91***	.354	.283***
Asian	-.759	-.180	.026	-2.29***	-2.04	-.465
Age						
12	-5.61***	-4.22***	-21.97***	-20.74***	-12.14***	-9.52***
13	-4.04***	-4.25***	-16.36***	-15.39***	-9.59***	-10.36***
14	-3.34***	-3.38***	-11.95***	-11.70***	-8.24***	-8.72***
15	-3.03***	-2.68***	-8.59***	-8.17***	-7.83***	-7.26***

16	-2.28***	-2.00***	-5.72***	-5.29***	-6.14***	-5.60***
17	-1.65***	-1.46***	-3.67***	-3.26***	-4.60***	-4.16***
18	-1.25***	-1.08***	-2.30***	-2.08***	-3.54***	-3.14***
19	-.769***	-.729***	-1.53***	-1.30***	-2.22***	-2.13***
20	-.481***	-.427***	-.594***	-.573***	-1.38***	-1.26***
21	-.326***	-.274***	-.411***	-.294***	-.937***	-.805***
22	-.222***	-.164***	-.156	-.250***	-.657***	-.502***
23-29	Reference	Reference	Reference	Reference	Reference	Reference
30s	.236***	.234***	.259***	-.051	.695***	.686***
40s	.561***	.448***	-.447***	-.528***	1.62***	1.33***
50s	.825***	.491***	-.982***	-1.23***	2.39***	1.43***
60s	.605***	.403***	-1.70***	-2.05***	1.70***	1.20***
70s	.172	.210	-1.91***	-3.07***	6.31	.604
80s	-1.36*	-.257	-5.84***	-3.85***	-3.63*	-.612
Nativity						
International						
Africa	-.506	.461	-.978	-1.92***	-1.65	1.38
Asia	-1.91***	-1.74***	-4.88***	-7.10***	-5.16***	-4.66***
Australia	-.445	-.096	-2.84***	.127	-1.20	-.161
Canada	-.100	.186**	-.210	.214	-.233	.554**
Europe	.738***	.605***	-2.69***	-2.49***	2.09***	1.76***
Great Britain	.012	-.043	-1.49***	-1.44***	.056	-.103
Latin America	-.490**	-.467***	-.002	.246	-1.39**	-1.40***
Mexico	-.163	-.374***	-2.82***	-1.89***	-.401	-1.06***
United States						
Northeast	Reference	Reference	Reference	Reference	Reference	Reference
Middle Atlantic	-.368***	-.114*	-.753***	-.966***	-1.04***	-.299*
Great Lakes	.035	-.134**	.801***	.805***	.099	-.370**
Plains	-.181	-.427***	.908***	1.15***	-.543	-1.25***
Southeast	.213*	-.348***	1.09***	1.49***	.591*	-1.05***
Southwest	-.152	-.237***	1.50***	2.53***	-.428	-.746***
Far West	.199	-.021	1.15***	1.38***	.533	-.058
Occupations						
White-Collar	-.112**	-.451***	.536***	.336***	-.324**	-1.30***
Skilled	-.072**	-.396***	.117	.328***	-.205**	-1.15***
Farmer	.236***	-.006	1.45***	1.47***	.712***	-.016
Unskilled	-.030	-.334***	.130	.645***	-.085	-.969***
No Occupations	Reference	Reference	Reference	Reference	Reference	Reference
Decade Received						
1840s		.572***				1.77***
1850s		-.052				-.111

1860s	-.181	.570***			-.596	1.68***
1870s	-.001	.493***			-.019	1.41***
1880s	-.042	.281***			-.103	.804***
1890s	.127***	.224***			.342***	.650***
1900s	Reference	Reference			Reference	Reference
1910s	-.079**	.005			-.245**	.013
1920s	.160***	.134***			.433***	.360***
1930s	-.447***	-.089			-1.41***	-.296*
1940s	-.548***	-.265***			-1.71***	-.897***
Birth Decade						
1800s			-3.63	.712		
1810s			-2.04	-.043		
1820s			-2.08	-.764		
1830s			-.250	-1.64*		
1840s			-3.04	-1.61*		
1850s			-3.09	-1.64*		
1860s			-3.39	-1.67		
1870s			-3.54	-1.89**		
1880s			-3.59	-2.05**		
1890s			-2.96	-1.83*		
1900s			-1.65	-1.08		
1910s			1.82	.551		
1920s			1.73	3.19***		
N	43,762	158,424	43,762	158,424	43,762	158,424
R^2	.1096	.1067	.0962	.1061	.3536	.3392

Source: See Table 1.

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

Table 7, Urban and Rural Late 19th and Early 20th Century 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	.093	-.133	.204	-.244
Total		-.040		-.040
Proportion				
Intercept	-65.68		-65.68	
Centimeters	55.16	2.25	54.52	2.88
Complexion	-.768	.343	-.600	.175
Age	-.110	1.06	5.90^{-4}	.947
Nativity	5.84	.232	4.44	1.64
Occupations	6.74	-.761	5.80	.173
Decade	-3.49	.186	-3.55	.245
Received				
Sum	-2.30	3.30	-5.06	6.06
Total		1		1
Height				
Level				
Sum	1.56	.361	1.16	.76
Total		1.92		1.92
Proportion				
Intercept	-.187		-.187	
Complexion	-.085	-.093	-.097	-.080
Age	.215	.257	-.030	-.034
Nativity	.154	.072	.078	.394
Occupations	.738	-.008	.107	.119
Birth Year	.812	.188	.733	-.004
Sum	.812	.188	.604	.396
Total		1		1
Weight (kg)				
Level				
Sum	.470	1.18	.800	.846
Total		1.65		1.65
Proportion				
Intercept	3.90		3.90	
Centimeters	-3.02	.783	-2.98	.748
Complexions	.066	-.022	.055	-.011
Age	-.011	-.072	-.016	-.068

Nativity	-.424	-.017	-.314	-.127
Occupations	-.482	.055	-.414	-.012
Year	.253	-.014	.255	-.016
Observed				
Sum	.286	.714	.486	.514
Total		1		1

Source: See Tables 1 and 6.

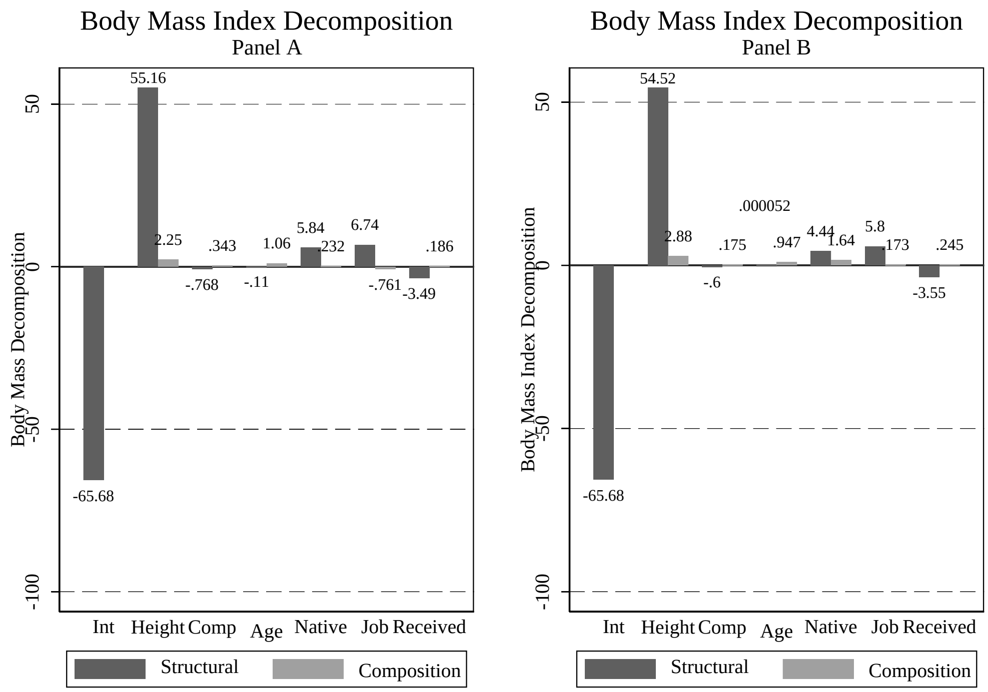

Figure 6, BMI Rural vs. Urban, Difference in Decompositions

Source: See Table 7, Panel A.

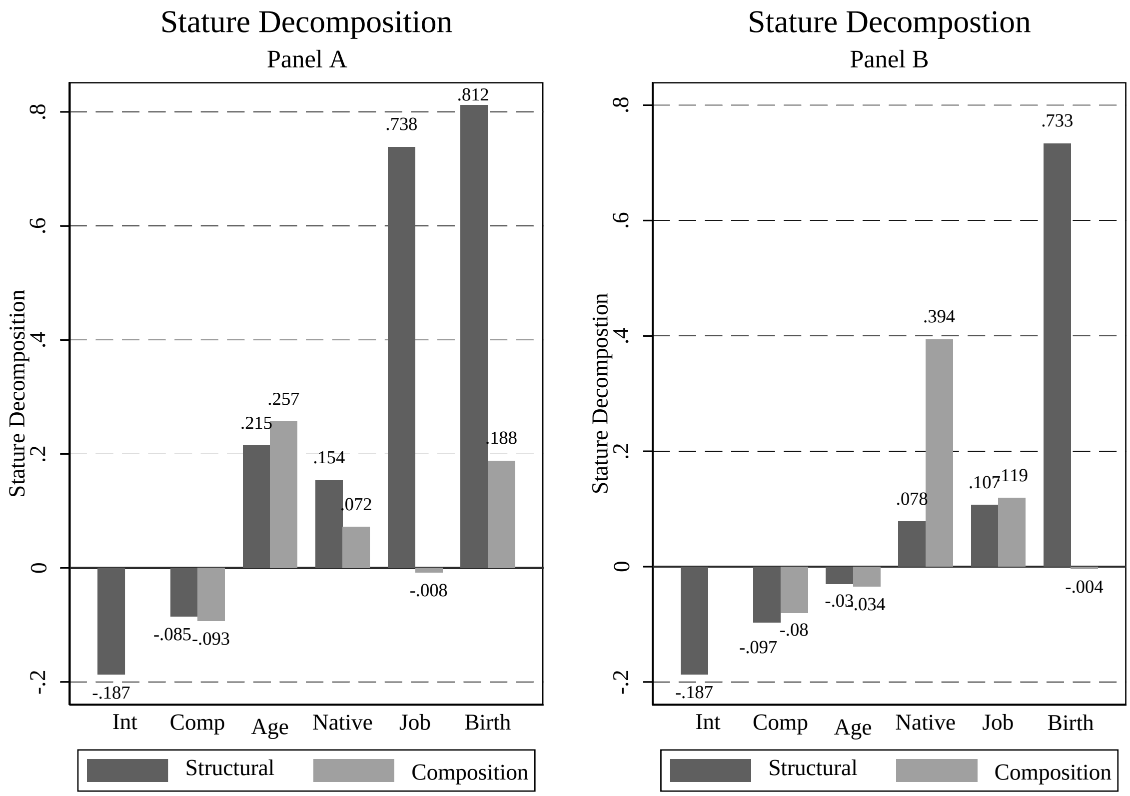

Table 7, Rural vs. Urban, Difference in Decompositions

Source: See Table 7, Panel B.

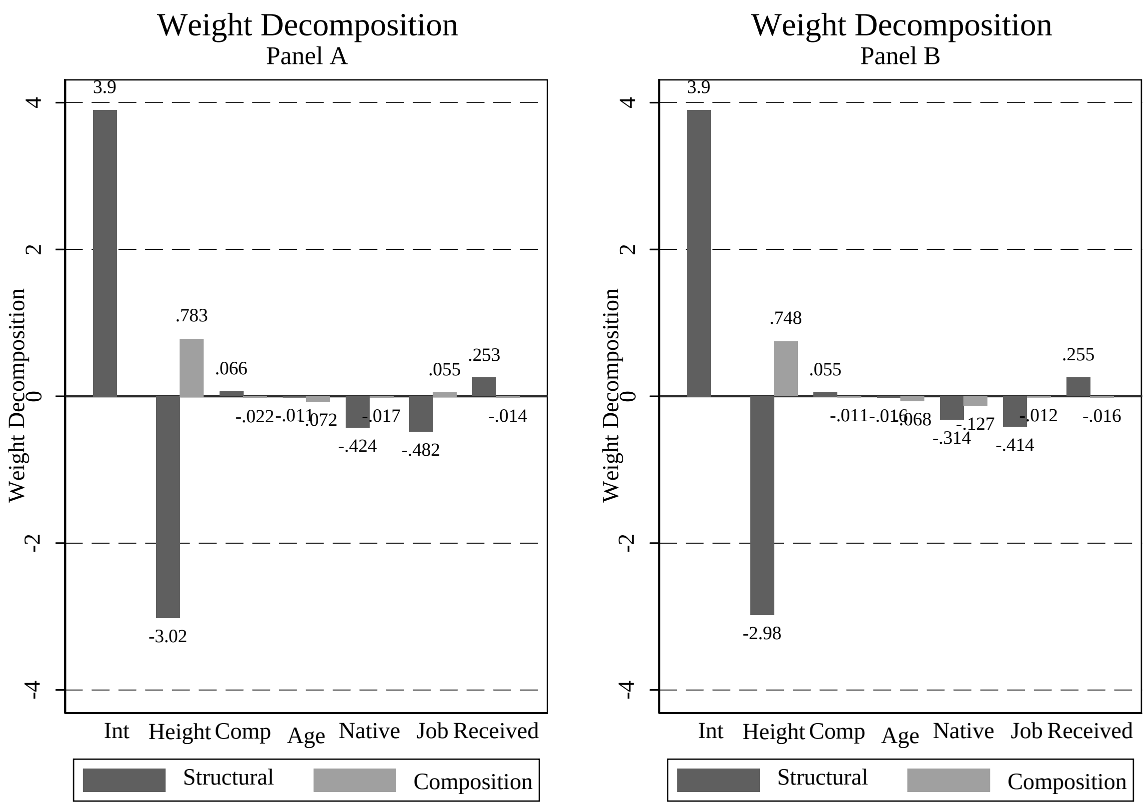

Table 8, Weight Rural vs. Urban, Difference-in-Decompositions

Source: See Table 7, Panel C.

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 (Table 7). 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. 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, 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	.856	-.189	.526	.141
Total		.667		.667
Proportion				
Intercept	7.37		7.37	
Centimeters	-5.61	.134	-5.67	.194
Age	-.259	-.289	-.194	-.354
Nativity	.078	.134	-.110	.068
Occupations	-.107	-.014	-.154	.033
Decade	-.016	.002	-.075	.061
Received				
Counties	-.005	.019	.038	-.021
Residence	-.171	-.004	-.420	.245
Sum	1.28	-.283	.788	.212
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	1.62	-.323	1.32	-.014
Total		1.30		1.30
Proportion				
Intercept	3.13		3.13	

Age	.065	.295	.039	.320
Nativity	.586	-.463	.576	-.453
Occupations	-.204	-.015	-.175	-.045
Birth Year	-2.01	.044	-2.01	.041
Counties	-.042	.033	-3.36^{-6}	.009
Residence	-.277	-.142	-.553	.135
Sum	1.25	-.247	1.01	-.011
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	2.78	-2.05	1.71	-.980
Total		.725		.725
Proportion				
Intercept	13.55		13.55	
Centimeters	-8.45	-1.61	-8.54	-1.52
Age	-.696	-.741	-.536	-.902
Nativity	.175	-.355	-.325	.144
Occupations	-.301	-.050	-.439	.089
Year Observed	-.055	.007	-.212	.163
Counties	.108	.052	.123	.036
Residence	-.500	-.131	-1.27	.637
Sum	3.83	-2.83	2.35	-1.35
Total		1		1

Source: See Tables 1 and 6.

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, 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 (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 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. 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. 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.

References

Aloia, John, Vaswani, Ashok, Ma, Reimei, Flaster Edith. 1997. Comparison of body composition in black and white premenopausal women. Journal of Laboratory Clinical Medicine 129(3), 294-299.

Atack, Jeremy and Fred Bateman. (1994). *A New Economic View of American History, 2nd Edition.* New York, W. W. Norton.

Bailey, Roy, Timothy Hatton, and Kris Inwood. (2018). "Atmospheric Pollution, Health, and Height in Late Nineteenth Century Britain." *Journal of Economic History*. 78(4), pp. 1210-1247.

Barondess, David, Nelson, Dorothy, Schlaen, Sandra. 1997. Whole body bone, fat, lean muscle mass in black and white men. Journal of Bone and Mineral Research 12(6). 967-971.

Baten, Joerg, Winny Bierman Jan Luiten van Zanden, Peter Foldvari. (2014). "Personal Security since 1820." *How Was Life? Global Well-being since 1820.* Access the complete publication at: http://dx.doi.org/10.1787/9789264214262-en

Baten, Joerg and Richard Steckel. (2018). "The Developmental Origins of Health and Disease." In: Richard Steckel, Clark Spencer Larsen, Charlotte Roberts, and Jorg Baten. *The Backbone of Europe: Health, Diet, Work and Violence Over Two Millennia.* Cambridge: Cambridge University Press, pp. 300-324.

Bereczki, Zsolt, Maria Reschler-Nicola, Atonia Marcsik, Nicholas Meinzer and Joerg Baten. (2018). "Growth Disruption in Children: Linear Enamel Hypoplasias." In: Richard Steckel, Clark Spencer Larsen, Charlotte Roberts, and Joerg Baten. *The Backbone of Europe.* Cambridge: Cambridge University Press, pp. 175-197.

Bodenhorn, Howard, Guinnane, Timothy, Mroz, Thomas. 2017. Sample selection biases and the industrialization puzzle. *Journal of Economic History* 77(1), 171-207.

Bogart, Dan (2009). "Nationalizations and the Development of the Transport Systems: Cross-Country Evidence and Railroad Networks, 1860-1912." *Journal of Economic History* 69, pp. 202-237.

Carson, Scott Alan. (2008) "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, (2009) "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. (2008) "Health during Industrialization: Evidence from the 19th Century Pennsylvania State Prison System," *Social Science History*. Volume 32(3). pp. 347-372.

Carson, Scott Alan. (2009) "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. (2009) "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, (2009) "Health, Wealth and Inequality: a Contribution to the Debate about the relationship between Inequality and Health," 42(4), *Historical Methods: A Journal of Quantitative and Interdisciplinary History*. pp. 43-56.

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. (2011) "Was the Relationship between Stature and Insolation Similar across Independent Samples: Evidence from Soldier and Prisoner Data?" *Journal of Socio-Economics.* pp. 199-207.

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

Carson, Scott Alan. (2011) "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. (2013). "Body Mass, Wealth, and Inequality in 19th century U.S. Joining the Debate Surrounding Equality and Health." *Economics and Human Biology* 11(1). pp. 90-94.

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* 21(2) pp. 78-94.

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

Carson, Scott Alan. (2017). "Health on the 19th Century US Great Plains: Opportunity or Displacement?" 48(1), *Journal of Interdisciplinary History.* 48(1), pp. 21-41

Carson, Scott Alan. (2018). "The Weight of 19th Century Mexicans in the Western United States." *Historical Methods: A Journal of Quantitative and Interdisciplinary History.* 51(1), pp. 1-12.

Carson, Scott Alan. (2019). "Late 19th, early 20th Century US, Foreign-Born Body Mass Index Values in the United States." *Economics and Human Biology* 34, pp. 26-38.

Carson, Scott Alan (2020). "Net Nutrition, Insolation, Mortality, and the Antebellum Paradox." *Journal of Bioeconomics*.

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* 21(2) pp. 78-94.

Church, Timothy, Thomas, Diane, Tudor-Locke, Catrine, Katzmarzyk, Peter, Earnest, Conrad, Rodarte, Ruben., Martin, Corby, Blair, Steven, Bouchard C. 2011. Trends over five decades in U.S. occupation-related physical activity and their associations with obesity. *PlosOne* 6, 5.

Clay, Karen, Joshua Lewis, and Edson Severninni. (2018). "Pollution, Infectious Disease, and

Mortality: Evidence from the 1918-1919 Spanish Influenza Pandemic," *Journal of Economic History.* 78(4), pp, 1179-1209.

Clay, Karen, Joshua Lewis, and Edson Severninni. (2019). "What Explains Cross-City Variation in Mortality during the 1918 Influenza Pandemic? Evidence from 440 U.S. Cities," *Economics & Human Biology,* 35 (2019), pp. 42-50

Coelho, Philp and Robert McGuire, "Diets versus Disease: the Anthropometrics of Slave Children," *Journal of Economic History,* 60(1), March 2000, pp. 232-46.

Correia, Sergio, Stephen Luck, and Emil Verner. (2020). "Pandemics Depress the Economy, Public Health Interventions Do Not: Evidence from the 1918 Flu." *Social Science Research Network.* https://papers.ssrn.com/sol3/Papers.cfm?abstract_id=3561560. Accessed: April 8th. 2020.

Costa, Dora. (2015). "Health and the Economy of the United States from 1750 to the Present." *Journal of Economic Literature* 53, pp. 503-570.

Craig, L., Goodwin, B, and Grennes, T. (2004). "The Effect of Mechanical Refrigeration on Nutrition in the United States," *Social Science History* 28, pp. 325-336.

Davidson, James, Rose, Jerome, Gutman, Myron, Haines, Michael, Condron, Keith, Condran, Cindy. 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 University Press: Cambridge. pp. 226-280.

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

Ferrie, Joseph and Werner Troesken. (2008). "Water and Chicago's Mortality Transition." *Explorations in Economic History*, 45(1), pp, 1-16.

Floud, Roderick, Robert Fogel, Bernard Harris, and Sok Chul Hong. (2011). *The Changing Body: Health, Nutrition, and Human Development in the Western World since 1700.* Cambridge: Cambridge University Press.

Fogel, Robert W., Engerman, Stanley, Trussell, James, Floud, Roderick, Pope, Clayne, Wimmer, Larry. 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), 75-108.

Fogel, Robert. W., Engerman, Stanley, Floud, Roderick, Steckel, Richard, Trussell, James, Wachter, Kenneth Villaflor, Georgia. 1979. The economic and demographic significance of secular changes in human stature: The US 1750-1960. *NBER working paper*.

Fogel, Robert and Stanley Engerman. (1974). *Time on the Cross: The Economics of American Negro Slavery.* New York: Little Brown.

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

Haines, Michael. (2001) "The Urban Mortality Transition in the United States, 1800-1940." National Bureau of Economic Research. Historical Working Paper, num. 134.

Haines, M.R., 2004, "Growing Incomes, Shrinking People—Can Economic Development Be Hazardous to Your Health?" *Social Science History* 28, pp. 250-270.

Haines, Michael, Craig, Lee, Weiss, Thomas. 2003. The short and the dead: Nutrition, mortality, and the "antebellum puzzle" in the United States. The Journal of Economic

History, 63(2), 382-413.

Hammond, Clare and Terry O'Connor. (2013). "Pig Diet in Medieval York: Carbon and Nitrogen Stable Isotopes." *Archaeological and Anthropological Sciences. 5,* pp. 123-127.

Higgs, Robert (1977). *Competition and Coercion: Blacks and the American Economy, 1865-1914.* Chicago: University of Chicago Press.

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

Jeffrey, Robert and Jennifer Utter (2003). "The Changing Environment and Population Obesity in the United States." *Obesity: A Research Journal*11, pp. 12s-22s.

Johnson, Charles. (1941). *Growing up in the Black Belt.* American Council on Education.

Koepke, Nikola and Joerg Baten. (2008). "Agricultural Specialization and Height in Ancient and Medieval Europe." *Explorations in Economic History.45,* pp. 127-146.

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, (1998). "Shrinking in a Growing Economy? The Mystery of Physical Stature during the Industrial Revolution." *Journal of Economic History.* 58(3), pp. 779-802.

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.

Libergott, Stanley. (1984). *The Americans: An Economic Record.* New York: W. W. Norton.

Margo, Robert A. and Richard H. Steckel, (1983). "Heights of Native-Born Whites during the Antebellum Period," *Journal of Economic History*, 43, pp. 167-74.

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

Marques, Carina, Vitor Matos, and Nicholas Meinzer. (2018). "Proliferative Periosteal Reactions: Assessment of Trend in Europe over the Past Two Millennia." In: Richard Steckel, Clark Spencer Larsen, Charlotte Roberts, and Jorg Baten. *The Backbone of Europe.* Cambridge: Cambridge University Press, pp. 137-174.

McGuire, Robert and Philp Coelho. (2011). *Parasites, Pathogens, and Progress: Diseases and Economic Development.* Boston: MIT Press.

Meinzer, Nicholas, Richard Steckel, and Joerg Baten. (2018). "Agricultural Specialization, Urbanization, Workload, and Stature." In: Richard Steckel, Clark Spencer Larsen, Charlotte Roberts, and Joerg Baten. *The Backbone of Europe: Health, Diet, Work and Violence Over Two Millennia.* Cambridge: Cambridge University Press, pp. 231-252.

Moradi, Alexander and Joerg Baten (2005). "Inequality in Sub-Saharn Africa: New Data and New Insights from Anthropometrics Estimates." *World Development*, 33(8), pp. 1233-1265.

Muldner, Gundula and Michael Richards. (2007). "Stable Isotope Evidence for 1500 Years of Human Diet at the City of York, UK." *American Journal of Physical Antrhopology*,133, pp.682-697.

Papathanasiou, Anastasia, Nicholas Meinzer, Kimberly Williams, and Clark Spencer Larsen.

(2019). "History of Anemia and Related Nutritional Deficiencies: Evidence from Cranial Porosities." In: Richard Steckel, Clark Spencer Larsen, Charlotte Roberts, and Jorg Baten. *The Backbone of Europe: Health, Diet, Work and Violence Over Two Millennia.* Cambridge: Cambridge University Press, pp. 198-230.

Schutte, J. E., E. J. Townsent, J. Hugg, and R. M. Malina, and C.G. Blomquist. (1984). "Density of Lean Body Mass is Greater in Black than in Whites." *Journal of Applied Physiology* 56(6), pp. 1647-1649.

Smith, Fred (2013). "The Economic History of Urbanization." In: Robert Whaples and Randall Parker. (Eds.). *Routledge Handbook of Economic History.* Routledge, New York. pp. 192-305.

Sokoloff, K. & Villaflor, G. (1982) "Early Achievement of Modern Stature in America," *Social Science History* 6, 453-481.

Steckel, R., (1979). "Slave Height Profiles from Coastwise Manifests." *Explorations in Economic History* 16: 363-380.

Steckel, Richard. (2000). "Diets Versus Diseases in the Anthropometrics of Slave Children: A Reply." *Journal of Economic History,* 60(1), pp. 247-259.

Steckel, R. H. & Haurin, D. (1994). Health and nutrition in the American Midwest: Evidence from the height of Ohio national guardsman 1850-1910. In: J. Komlos, (Ed.), *Stature, Living Standards and Economic Development*. University Press of Chicago: Chicago, 117-128.

Sunder, Marco. (2004). "The Height of Tennessee Convicts: Another Piece of the Antebellum Puzzle." *Economics & Human Biology*. 2(1), pp. 75-86.

Tanner, James M, "Human Growth and Constitution," in Harrison, GA, Weiner, JS, Tanner, JM, and Barnicot, NA (eds) *Human Biology: an Introduction to Human Evolution, Variation, Growth and Ecology*. 1977: 301-384.

Troesken, Werner. (2003). "Municipalizing American Waterworks, 1897-1915." Journal of Law, Economics, and Organization, 19(2), pp. 373-400.

Voth, Hans-Juachim and Timothy Leunig. (1996). "Did Small Pox Reduce Height? Stature and the Standard of Living in London, 1770-1873." *Economic History Review*, 49(3) pp. 541-560.

Wang, Feng and Xuejin Zuo (1999). "Inside China's Cities: Institutional Barriers and Opportunities for Urban Migrants." *American Economic Review* 89(2) pp. 276-280.

Wilson, Sven. (2003). "The Prevalence of Chronic Respiratory Disease in the Industrial Era: The United States, 1895-1910." In: Dora Costa (Ed.). *Health and Labor Force Participation Over the Life Cycle: Evidence from the Past*. NBER and the University of Chicago Press, pp. 147.180.

Wilson, Sven. (2019). "Does Adult Height Predict Mortality?: Comparative Evidence for the Early Indicators Samples in the US." *Economics and Human Biology* 34, pp. 274-285.

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.

Zehetmayer, Matthias. (2011). "Health , Market Integration, and the Urban Height Penalty in the US, 1847- 1894." *Cliometrica.* 7, pp. 161–187.