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THE MEXICAN CALORIE ALLOCATION AMONG THE WORKING CLASS IN THE AMERICAN WEST, 1870-1920

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When measures for material conditions are sparse or unreliable, height and weight measurements are now widely accepted proxies that reflect changing economic conditions. This study uses two biological measurements related to height and weight: the basal metabolic rate (BMR) and calorie accounting. BMRs and calories of Mexicans in the American West remained constant, indicating that their diets did not vary with United States economic development, but Mexican BMRs and diets varied with occupations. Farmers and unskilled workers had greater BMRs and received more calories per day than workers in other occupations. During much of the late 19th and early 20th centuries, Mexicans born in Mexico received fewer calories in the US than Mexicans born in the West. Mexican nutrition and diets also did not vary by residence within the US, indicating that Mexican diets were similar across western states.

When traditional economic measurements for material welfare are sparse or unreliable, the use of height and weight to measure living standards is now a well-established method in economics and development studies (Robert Fogel, 1994, p. 138; Richard Steckel, 1995; Angus Deaton, 2008; Ann Case and Christina Paxson, 2008; Deaton, 2013). Stature measures the net cumulative nutrition between calories consumed and calories devoted for work and to fend off disease. A population's average Body Mass Index (BMI) measures the net current difference between the same variables. However, interpreting BMIs is more difficult than interpreting stature because BMI reflects both current and cumulative biological conditions. For example, if people are poorly nourished during their youth, their statures may be stunted, their frames smaller, and their basal metabolic needs may be low. If their nutrition improves in later life, it results in greater BMI values because shorter statures require the same weight to be distributed over smaller body frames (Herbert, Patricia, Janet Richards-Edwards, JoAnn Manson, Paul Ridker, Nancy Cook, Gerald O'Conner, Julie Buring, and Charles Hennekens, 1993, p. 1438). However, stature and BMIs are not the only measures that reflect a population's net biological conditions, and two less frequently used measures are the basal metabolic rate (BMR) and estimated calories. BMRs provide physical activity measures, and greater BMRs indicate greater physical activity. Calories per day reflect current nutritional adequacy and are then estimated by multiplying BMRs by appropriate activity levels.

There is active research considering late 19th and early 20th century biological measurements for Mexicans born in Mexico and Mexicans who migrated into the American West. Moramay López-Alonso and Raúl Condey (2003) show that 19th century Mexican soldier heights in Mexico stagnated, while Mexican elite heights increased slightly. Scott Carson (2005) finds that late 19th century Mexican statures for those imprisoned in the American West also did not change, even though Mexico experienced considerable political instability. Carson (2007) shows that the majority of Mexican prisoner BMIs in the American West were in modern normal BMI categories, and underweight Mexicans were practically non-existent. Mexican BMIs in the American West also did not change appreciably over time (Carson, 2007, p. 42). However, less is known about Mexican net physical activity and the calories they consumed in the 19th century American West as development occurred.

It is against this backdrop that this study considers three paths of inquiry into 19th century physical activity levels and nutrition for Mexicans living in the American West. First, how did Mexican BMRs and calories vary throughout the late 19th and early 20th centuries?

Second, how did BMRs and calories vary by socioeconomic status? Third, how did Mexican BMRs and calories vary by residence, and was there a BMR or calorie penalty for Mexican birth? Consistent with 19th century Mexicans occupying a lower socioeconomic status, there was little variation in Mexican BMRs and calories over time. Mexicans in the American West were in lower socioeconomic groups, and farmers and unskilled workers had greater BMRs and received more calories per day than physically less active, market oriented workers. Mexican-born migrant BMRs and calories varied little across the US and Mexican birth was associated with lower BMRs and reduced calorie allocations in the US.

Basal Metabolic Rate and Calorie Accounting

The basal metabolic rate is the daily amount of calories required by the human body to maintain vital organ function, while at rest, awake, and in a warm climate. The BMR is equivalent to one kilocalorie per minute or about 1,400 kilocalories per day. BMRs and calories are also related with physical activity and fitness through fat-free mass, which is the percentage of a person's bone, sinew, water, and muscle.[1] There is a positive relationship between physical activity, fat-free mass, and metabolic rates (Eric Poehlman, Christopher Melby, Stephen Badylak, 1988, Eric Poehlman, Christopher Melby, Stephen Badyla, and Jorge Calles, 1989, Heide Byrne and Jack Wilmore, 2001, Richard Speakman and Colin Selman, 2003, Takoko Koshimishu, Yoshiko Matshushima, Yukari Yokota, Kae Yanagisawa, Satsuki Nagai, Koji Okamura, Yutaka and Komatsu, and Takashi Kawahara, 2012), and BMRs increase with age through the early 20s and decrease at older ages. However, factors beyond age slow BMR. For example, receiving an insufficient number of calories during one period slows BMRs because the body comes to expect fewer calories in future periods and effectively stores current calories for future consumption (James Neel, 1962, Andrew Prentice, 2005, Andrew Prentice, B.J. Hennig, and A.J. Fulford, 2008).

A second novel approach regarding BMRs is their use in estimating calories required to maintain physical dimensions. There is an extensive history of deriving calories from physical descriptions using standardized equations, and estimated calories are derived here using height, weight, physical activity, and age (J. Authur Harris and Francis G. Benedict, 1919; Mark Mifflin, Sachiko St Jeor, Lisa Hill, Barbara Scott, Sandra Daugherty and Young Koh, 1990, David Frankenfield, Lori Rath-Yousey, 2005, Peter Weijs, Hinke Kruisenga, Aimee van Dijk, Barbara van der Meij, Jacquiine Langius, Dirk Knol, Robert Strack van Schijndeln, and Marian van Bokhorst-devan der Schueren, 2008). Numerous equations have been proposed to measure BMRs, and the Mifflin et al. equations (hereinafter Mifflin equations) represent a reasonable approximation for estimating historical BMRs and calories because the population used to estimate Mifflin equations are similar to 19th century prisons in western states (Mifflin et al., 1990, p. 247; Harris and Benedict, 1919; Carson, 2009; Carson, 2012).[2]

$$BMR_{Male}=5+10\times\text{Weight (kgs)}+6.25\times\text{Height (cms)}-5\times\text{Age} \quad \text{(Eq. 1)}$$

$$BMR_{Female}=-161+10\times\text{Weight (kgs)}+6.25\times\text{Height (cms)}-5\times\text{Age} \quad \text{(Eq. 2)}$$

These Mifflin equations (Eqs. 1 and 2) predict resting BMRs for individuals in healthy, normal to moderately overweight men and women. This normal weight range assumption is important because the majority of 19th century males were in normal weight ranges (Mifflin et al., 1990, p. 247; Weijs, 2008, p. 156; Carson, 2007). Total calorie estimates are then calculated by multiplying BMRs by reasonable activity ratios.[3] The majority of 19th century US workers were in agricultural occupations (Rosenbloom, 2002, p. 88), and farmers were more physically active than workers in other occupations. For example, a man’s BMR increases by 10 calories for every pound they gain and by 6.25 calories for each additional inch in stature. Even if some individual workers did not indicate farming as their primary occupation, the majority of workers remained in physically active agricultural occupations, if only to maintain their households. Therefore, to estimate 19th century Mexican activity levels, each individual’s imputed BMR is calculated, sorted by occupations, and standardized relative to imputed farmer values. White collar worker imputed values are 0.9713 of imputed farmer values; skilled worker imputed values are 0.9750; unskilled imputed values are 0.9900; workers with no occupations are 0.9885. To calculate calories, these farmer-weighted imputed ratios are then multiplied by BMRs with extra active physical activity ratios of 1.90 assigned to farmers.[4] Mifflin equations then offer a flexible means to assess how individual BMRs and calories were distributed, which provides insight into a population's diet and net nutrition.

Nineteenth Century Mexican Calories in the United States

Nineteenth century North America is one time and place where many Mexican-born immigrants and US born Mexicans lived in the western United States, and much of mid-19th century Mexican immigration was motivated by their efforts to realize the economic opportunities in the American West. For example, between 1821 and 1876, multiple groups within Mexico struggled for political, military, and economic control. From 1864 through the end of the 19th century, Emperor Maximilian (1864-1867) and later Porfirio Diaz (1876-1911) introduced economic and political reforms that changed Mexico's political institutions and economy, and these political disruptions had economic consequences. However, with greater time in the US, Mexican immigrant diets may have converged with Mexicans born in the US as they acclimated into the Southwestern economy. This study, therefore, uses late 19th and early 20th century height and weight measures of Mexican inmates in US western prisons to estimate calories for Mexicans born in the American West and their counterparts born in Mexico but who later migrated north.

BMRs and estimated calories have been used to uncover important historical nutritional and biological patterns, and there are several ways to estimate calories available to a population, such as national food balance sheets, consumption surveys, health food provider records, poor house, military, and slave plantation records (Stacey Rosen, 1999, Rodrick Floud, Robert Fogel, Bernard Harris, and Sok Chul Hong, 2011, pp. 46-47).[5] Calories from energy equations also provide a useful means to measure calorie variation by personal characteristics, which is not possible with aggregated food balance sheet records. National food balance sheets provide estimates for gross calories available, while calories from energy equations provide estimates for net calories consumed. Therefore, BMRs and estimated calories provide important insights on physical activity and nutritional adequacy for Mexican diets during US economic development.

Nineteenth Century Mexican Prison Data

Data to analyze nutritional trends for Mexicans living in the western United States are collected from the four western state prisons that recorded both height and weight between 1871 and 1925: Arizona, Colorado, New Mexico, and Texas. Brian Gratton and Myron Gutmann (2000) report that Hispanics in the United States were less than one percent of the US population during the 19th century and grew to a little over 1.20 percent by 1920. At the time of incarceration, US prison officials routinely recorded age, place of birth, crime, occupation, height, and weight. Since age, socioeconomic status, and biological measurements were recorded at time of entry, they reflect pre-incarceration conditions and not conditions within prisons. While some female heights and weights were recorded, there were few of them, so only Mexican male inmates are considered here. Mexican ethnicity for this study is determined by self-declared birth within Mexico and Mexican complexion as recorded by US prison enumerators. Both are included in this study. The Arizona prison is the only prison that recorded complexions with photographs, and it is clear from these photographs that Mexican complexions as recorded by prison enumerators reflect Mexican ethnicity.

Most 19th century western state prisons did not systematically document inmates' Mexican city of birth, only their state or country of origin. However, the New Mexico and Arizona prisons documented the hometown of each Mexican inmate, and Mexicans claiming birth in Mexico were born within what remained of Mexico after 1848. In addition, no Mexican-born inmates claimed birth in townships that later became part of the United States, and most Mexican immigrants came from northern states and were taller than individuals from farther South in Mexico (Moramay Lopez-Alonso, 2000; Moramay Lopez-Alonso and Raúl Condey, 2003). Mexicans claiming birth in the United States were born in the American West after the 1848 border settlement. In sum, if

Mexican populations in other western American prisons were comparable to the New Mexico and Arizona prison samples, Mexican inmates were born within Mexico after the 1848 border settlement with the United States.

Almost all historical body measurement data have selection biases because collection methods that controlled for selection bias were not yet developed. The two most common sources for historical height and weight data are military and prison records. One problem with military records is a height truncation imposed by military minimum stature requirements. By arbitrarily truncating shorter individuals from military records, minimum stature requirements upwardly bias military statures because only taller people remain in military samples, and taller statures are associated with more required calories per day (Herbert et al., 1993, p. 1438; Mifflin et al., 1990). Prison records do not suffer from this bias. However, because there is uncertainty over who the prison sample represents, prison records are not above scrutiny. For example, unskilled workers were incarcerated for assault and theft crimes, while skilled and white-collar workers were incarcerated for embezzlement and fraud. It is also not clear who the prison records represent because law enforcement may have incarcerated taller, more physically fit individuals involved in assault crimes, and because they were more fit than other physical assault participants, taller workers may have been targeted for police arrest. Alternatively, law enforcement may have incarcerated many of the materially poorest individuals who resorted to crime to survive. There is also little evidence that there was a systematic relationship between height, weight, and types of crimes committed (Carson, 2005; Carson, 2007, p. 41). Because the majority of crimes were theft and assault crimes among unskilled workers, biological conditions in this prison sample likely reflects conditions among the working class.

Before photographic technologies were used more wide-spread among state prisons, prison enumerators recorded characteristics with care because physical characteristics served as a means of identifying inmates in the event that inmates escaped and were later recaptured. Enumerators recorded a broad set of occupations that were narrowly defined, which are classified here into four occupation groups. Laborers and miners are classified as unskilled workers. Unfortunately, inmate enumerators did not distinguish between common and farm laborers. Since common laborers typically came to maturity under less favorable biological conditions than farm laborers, this probably overestimates the biological benefits of being a common laborer and underestimates the biological benefits of being a farm laborer (Carson, 2013). Workers in the agricultural sector are classified as farmers; light manufacturers, craft workers, and carpenters as skilled workers; and merchants and high skilled workers as white collar workers (E. Le Roy Ladurie, 1979; Robert Margo and Richard Steckel, 1992, p. 520).

Table 1 summarizes the sample of Mexicans in US prisons and indicates that over 50 percent were incarcerated in Texas. Most of the sample is from the late 19th and early 20th centuries. Mexicans were predictably unskilled, with very few Mexicans in white-collar or without occupations; there were also few Mexican skilled workers and farmers. Consistent with most historical and modern populations, inmates were in their teens and twenties (Travis Hirschi and Michael Gottfredson, 1983; Carson, 2009). Most Mexicans lived in states that bordered Mexico, and the majority of Mexicans in the 19th century American West were born in Mexico.

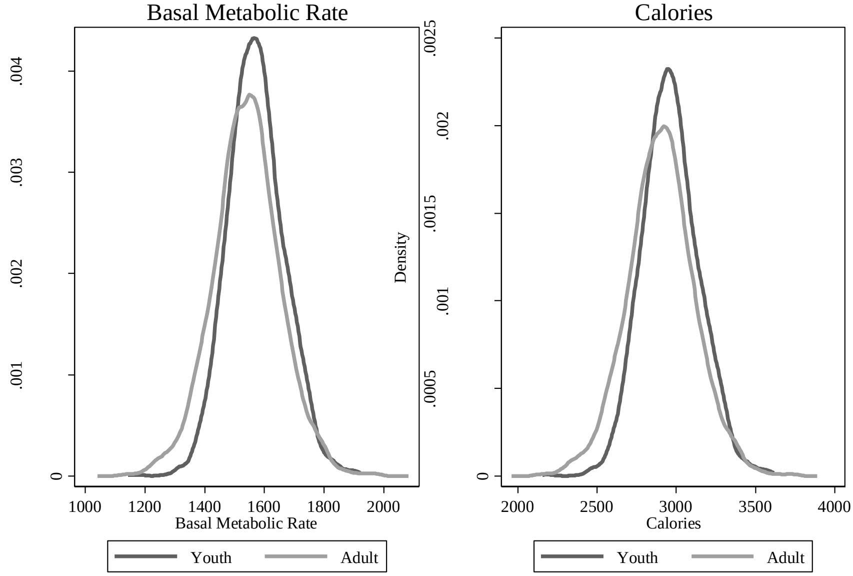
To illustrate how 19th century Mexican BMRs and calories were distributed, BMR and calorie kernel density estimates are presented in Figure 1. Mexican physical activity and net nutrition were distributed symmetrically, and Mexican calories in the 19th century US West were neither scarce nor abundant. Average Mexican youth and adult BMRs were 1,573 and 1,541, respectively; Mexican youth and adult calories were 2,964 and 2,904. By contrast, 19th century US black and white adult calorie allocations were 3,047 and 2,975 calories per day (Carson, 2014).

Table 1

Nineteenth Century Mexican US Prisoner Height (Cms.) and BMIs

Received	*N*	*Percent*	*Cms*	*S.D.*	*BMIs*	*S.D.*
1870s	195	2.14	166.41	7.16	23.34	2.31
1880s	945	10.35	167.92	5.93	22.81	2.27
1890s	2,582	23.35	167.71	6.77	22.93	2.26
1900s	2,582	28.28	166.97	6.45	23.06	2.29
1910s	3,134	34.33	167.29	6.51	22.73	2.33
1920s	142	1.56	165.65	6.63	23.26	2.23
Occupations						
White-Collar	149	1.63	168.02	6.09	22.41	2.60
Skilled	986	10.80	166.72	6.60	22.72	2.55
Farmer	620	6.79	168.12	6.53	23.25	2.48
Unskilled	7,176	78.60	167.34	6.51	22.92	2.23
No Occupation	199	2.18	166.62	2.78	22.60	2.34
Ages						
Teens	1,090	11.94	166.24	6.43	22.02	2.11
20s	4,712	51.61	167.67	6.39	22.85	2.18
30s	2,116	23.18	167.38	6.59	23.22	2.32
40s	824	9.03	166.21	6.40	23.38	2.47
50s	297	3.25	166.03	7.65	23.39	2.93
60s	91	1.00	164.80	5.85	22.99	2.81
Residence						
Arizona	2,149	23.54	167.09	6.38	22.80	2.15
Colorado	180	1.97	166.07	6.38	23.29	2.22
New Mexico	1,905	20.87	167.93	6.36	23.14	2.41
Texas	4,896	53.63	167.23	6.63	22.84	2.31
Nativity						
US Birth	3,418	37.44	168.42	6.49	22.87	2.40
Mexican Birth	5,712	62.56	166.66	6.46	22.93	2.24

Source: Arizona State History and Archives Division, State Capitol, Suite 342, 1700 West Washington, Phoenix, AZ 85007; Colorado State Archives, 1313 Sherman, Room 1B20, Denver, CO 80203; New Mexico State Records Center and Archives, 1205, Camino Carlos Rey, Santa Fe, New Mexico 87507; Texas State Archives Commission, P.O. Box 12927, Austin, TX 78711.



Source: See Table 1.

Figure 1

Nineteenth Century Mexican basal metabolic rate and Calories

The similarity between Mexican, black, and white calories also illustrates a unique pattern in migration studies. If working class migrant populations substitute for low skilled native labor, migrant diets must be sufficiently well compensated relative to the native population to attract and retain migrants in the receiving economy. That 19th century Mexican net nutrition was reasonably close to their black and white counterparts indicates that Mexicans in western US labor markets were at least sufficiently well compensated in net nutrition and calories to remain in the West.

Comparative Effects of Demographics, Socioeconomics, and Residence of Mexican BMRs and Calories

We now test how Mexican BMRs and calories were related to demographic, socioeconomic characteristics, and residence. To start, BMRs and calories are regressed on age, observation period, occupations, and residence. A BMR model is estimated first, and calories are then regressed on the same characteristics.

$$BMR_i = \alpha + \sum_{a=15}^{60} \beta_a Age_t + \sum_{t=1870}^{1920} \beta_t \text{Observation Period}_t + \beta_M \text{Mexican Birth}_i + \sum_{l=1}^{5} \beta_l Occupations_i + \sum_{r=1}^{3} \beta_r Residence_i + \varepsilon_i \quad \text{(Eq. 3)}$$

and

$$Calories_i = \alpha + \sum_{a=15}^{60} \beta_a Age_t + \sum_{t=1870}^{1920} \beta_t \text{Observation Period}_t + \beta_M \text{Mexican Birth}_i + \sum_{l=1}^{5} \beta_l Occupations_i + \sum_{r=1}^{3} \beta_r Residence_i + \varepsilon_i \quad \text{(Eq. 4)}$$

Youth age variables are included in one year intervals between ages 15 and 22; adult age dummy variables are included in ten year intervals for ages 30 through 60. Observation period dummy variables are included in ten year intervals to account for the relationship between BMR, calories, and nutrition over time. A Mexican nativity dummy variable is included to account for birth in Mexico. Occupation dummy variables are included for white-collar, skilled, farmers, and unskilled occupations. Prison dummy variables are included to account for the relationship between BMRs, calories, and residence at time of measurement.

Tables 2 and 3 present BMR and calorie models (Eqs. 3 and 4) for race, age, occupation, and residence. The unrestricted Model 1 includes race, demographic, occupation, and residence. To determine the collective significance of Mexican characteristics associated with BMRs and calories, restricted models are presented in Models 2 through 6 for demographics, observation period, occupations, and residence (Ed Leamer, 1983; Joshua Angrist and Jörn-Steffen Pishke, 2010; Leamer, 2010).

Table 2

Nineteenth Century Mexican Basal Metabolic Rate
by Demographics, Residence, and Occupations

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
	Unrestricted	Age Restricted	Years Restricted	Mexican Restricted	Occupation Restricted	Residence Restricted
Intercept	1583.11***	1578.68***	1,573.96***	1,565.59***	1,593.31***	1583.09***
Ages						
15	-77.87***		-76.78***	-73.92***	-79.00***	-77.84***
16	-29.71***		-29.95***	-27.72***	-29.71***	-30.76***
17	-20.79**		-22.43***	-18.37**	-21.64***	-21.49***
18	-8.74*		-9.82**	-5.88	-8.76*	-9.58*
19	-4.73		-5.56	-3.05	-4.93	-5.24
20	13.37***		13.14***	14.16***	13.59***	12.88***
21	8.12*		7.51	9.72*	8.44*	8.02
22	7.28*		6.88	7.84*	7.32*	7.12*
23-29	Reference		Reference	Reference	Reference	Reference
30s	-41.14***		-41.18***	-42.38***	-40.90***	-40.91***
40s	-102.92***		-102.89***	-105.23***	-102.26***	-102.55***
50s	-51.78***		-155.30***	-157.89***	-153.71***	-154.15***
60s	-234.43***		-236.14***	237.97****	-233.04***	-234.15***
Received						
1870s	Reference	Reference		Reference	Reference	Reference
1880s	-.070	-6.92		1.57	1.37	.785
1890s	-1.49	-17.18**		2.29	-.995	-.074
1900s	-7.97	-24.67***		-3.81	-7.38	-6.27
1910s	-11.64	-24.10***		-6.85	-11.15	-10.02
1920s	-24.56	-22.48		-26.16	-25.72	-17.23*
Nativity						
Mexico	-22.91***	-33.72***	-22.19***		-23.87***	-25.04***
United States	Reference	Reference	Reference		Reference	Reference
Occupations						
White-Collar	8.94	6.57	10.67	8.29		10.40
Skilled	-1.99	-.541	.371	-4.90		-.496
Farmer	28.50***	20.43**	30.52***	29.38***		29.83***
Unskilled	10.74	12.10	14.38*	8.87		12.70*
No Occupations	Reference	Reference	Reference	Reference		Reference
Residence						
Arizona	1.12	.175	-2.20	-1.89	.573	
Colorado	9.70	6.48	-14.66*	13.44	12.74	
New Mexico	7.62***	-.892	6.32**	16.47***	7.75***	
Texas	Reference	Reference	Reference	Reference	Reference	
N	9,130	9,130	9,130	9,130	9,130	9,130
R^2	.1915	.0267	.1898	.1831	.1881	.1908
F	99.32	108.9	99.40	99.83	99.50	99.34

Source: See Table 1
*** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 3

Nineteenth Century Mexican Calories
by Demographics, Residence, and Occupations

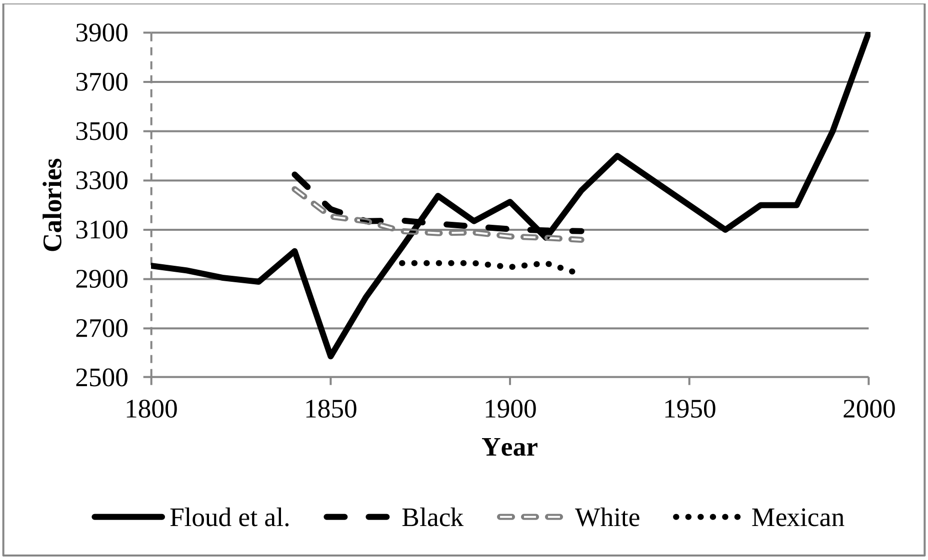
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
	Unrestricted	Age Restricted	Years Restricted	Mexican Restricted	Occupation Restricted	Residence Restricted
Intercept	2964.17***	2955.81***	2946.83***	2931.15***	3003.***	2964.14***
Ages						
15	-146.75***		-144.69***	-139.30***	-150.13***	-146.69***
16	-55.99***		-56.45***	-52.58***	-55.29***	-57.98***
17	-39.19***		-42.30***	-34.61*	-41.42***	-40.50***
18	-16.47*		-18.51**	-11.08	-16.18*	-18.05*
19	-8.94		-10.52	-5.79	-9.33	-9.90
20	25.19***		24.75***	26.68***	26.31***	24.26***
21	15.37*		14.20	18.38**	16.65*	15.17
22	13.72*		12.97	14.77*	14.10*	13.42*
23-29	Reference		Reference	Reference	Reference	Reference
30s	-77.55***		-77.62***	-79.88***	-76.76***	-77.12***
40s	-193.97***		-193.92***	-198.32***	-191.80***	-193.27***
50s	-291.63***		-292.76***	-297.64***	-288.36***	-290.59***
60s	-442.14***		-445.37***	-448.81	-437.11***	-441.60***
Received						
1870s	Reference	Reference		Reference	Reference	Reference
1880s	-.189	-13.11		2.91	4.30	1.42
1890s	-2.83	-32.43***		4.27	-1.70	-.180
1900s	-15.14	-46.61***		-7.28	-13.85	-11.92
1910s	-22.06	-45.54***		-13.02	-22.07	-19.01
1920s	-46.58	-42.66***		-49.60	-50.34	-32.68**
Nativity						
Mexico	-43.17***	-63.54***	-41.73***		-46.47***	-47.18***
United States	Reference	Reference	Reference		Reference	Reference
Occupations						
White-Collar	27.86	23.39	31.13	26.64		30.61
Skilled	-12.21	-9.49	-7.76	-17.71		-9.41
Farmer	97.21***	82.01***	101.03***	98.88***		99.72***
Unskilled	41.86***	44.43***	48.75***	38.33***		45.55***
No Occupations	Reference	Reference	Reference	Reference		Reference
Residence						
Arizona	2.09	.314	-4.18	-3.59	.904	
Colorado	18.37	12.49	-27.81*	25.82	28.97	
New Mexico	14.35	-1.70	11.88**	31.02***	15.61***	
Texas	Reference	Reference	Reference	Reference	Reference	
N	9,130	9,130	9,130	9,130	9,130	9,130
R^2	.1992	.0359	.1975	.1909	.1867	.1986
F	82.36	26.16	100.95	80.80	188.59	92.70

Source: See Table 1.

*** denotes significance at the 1% level, ** at the 5% level, and * at the 10% level.

Three paths of inquiry are considered when addressing 19th century Mexican BMRs and calories, and the individual relationships between physical activity and calories and demographics, socioeconomic status, and residence are noteworthy. First, the results in Table 3, Model 1 show that there was little variation in Mexican BMRs and calories over time and neither improved during the late 19th and early 20th centuries, indicating that Mexican nutritional status in the American West did not improve with economic development (John Super, 2000, p. 1252). Nineteenth century working class Mexicans in the US consumed diets high in complex carbohydrates but low in animal proteins. Primary staples in Mexican diets were beans and rice, two dietary sources rich in complex carbohydrates but without animal proteins and fats (Manuel Gamio, 1969, pp. 140-147). This Mexican diet was associated with lower BMI values, which are associated with lower levels of chronic health conditions, such as diabetes and heart disease. Subsequently, any change in 19th century Mexican health related to nutrition was limited by low net nutrition. This is in marked contrast with modern obesity trends, where 21st century US citizens of Mexican descent have among the highest obesity rates (Ogden et al., 2012; Ogden et al., 2014, p. 810). The difference is explained, in part, by the modern nutritional transition, and the diets of modern Mexicans in the US having become more calorie dense with simple sugars and saturated fats (Barry Popkin, 1993, Katherine Flegal, Margaret Carroll, Brain Kit, and Cynthia Ogden, 2012, pp. 493-494, Cynthia Ogden, Margaret Carroll, Brian Kit, Katherine Flegal, 2012, pp. 486). Collective relationships between physical activity and calories are important, and a joint test on observation period shows that Mexican calories were jointly significant in nutritional status.[6] However, when observation period is omitted, other variables' slope coefficients do not change.

Second, BMRs reflect physical activity, and occupations are among the best means to compare net nutrition by socioeconomic status. Mexican farmers and unskilled workers received greater calorie allotments than workers in other occupations. Part of farmers' greater physical activity and nutrition was due to occupational requirements, and to justify plentiful calorie allocations, occupations requiring greater physical activity required more calories per day. On the other hand, skilled Mexican workers were less active and had lower BMRs, which indicates that skilled workers did not receive surplus calories. Moreover, a joint test on Mexican BMRs and calories by occupations shows that occupations were not jointly related with physical activity and calories.[7] When occupations are omitted, other variables' slope coefficients do not change, and socioeconomic characteristics were only marginally related with BMR and calorie variation.



Source: Table 3, Model 1.
Notes: Floud et al. (2011, p. 314) are estimated calories for 19th century Americans. Nineteenth century estimates for US black and white calories are also from US prison data and available from the author upon request (Carson, 2014). Greater calorie variation for Floud et al.'s American calorie estimates may be attributable to how their calories are estimated. American calorie estimates from Floud et al. are from per capita crop production estimates, while black and white prisoner calorie estimates are based on inmates' physical dimensions.

Figure 2
Nineteenth Century Mexican Calories over Time in the US

Third, late 19th and early 20th century Mexican BMRs and calories varied by residence. The negative and statistically significant coefficients on "Mexico" across all models in Tables 2 and 3 suggests that Mexicans born in Mexico who later emigrated north had lower BMRs and received fewer calories per day than Mexicans born in the American West. While testing the pre and post migration effects with diet requires a richer 19th century Mexican panel data that records physical activity and nutrition before and after migration, these residence effects may indicate that Mexican diets improved with migration in the American West. Diets in 19th century Mexico were largely vegetarian, containing little nutrition from animal proteins, but were plentiful in beans, rice, and chilies; dairy was not a significant dietary source in Mexico. However, the diets of Mexicans in the United States augmented beans and rice with and had greater access to pork and dairy products (Gamio, 1969, pp. 140-147). Mexican nutritional status in Texas was among the lowest in all Southwestern states, and social and economic conditions facing Mexicans in Texas were among the most austere in the US. As recent migrants, many Mexicans did not become proficient in English, and immigrants who do not learn the host-country language suffer from additional economic barriers (Daniel Sellen, Alison Tedstone, and Jacquiline Frize, 2002). Moreover, a joint test on Mexican residence shows that BMRs and calories were jointly related with residence ($F(4, 9104)=8.55$, $p=0.0000$), but residence omissions do not significantly alter other variables' slope coefficients.[8]

Other patterns are consistent with expectations. Children and teenage diets were the most affected by conditions in the American West (Sellen et al., 2002), and Mexican-born teenagers had lower BMRs and received fewer calories per day than adult Mexican workers in their early 20s. Fifteen year olds' BMRs and calorie allocations were 95 percent of 23 to 29 year old values, and 60-year olds' BMRs and calories were 85 and 92 percent of 23 to 29-year olds' values.[9] A joint test on Mexican ages also shows that BMRs and calories were jointly related with age, and the effect of omitting age with stature downwardly biases the effect of birth period and residence, indicating that the age of 19th century Mexicans in the American West was the primary characteristic associated with BMR and calorie variation.[10] Therefore, there were complex relationships between 19th century nutritional conditions for Mexicans living in the American West, and the most significant relationships with physical activity and nutrition were not socioeconomic but predetermined by age and nativity.

Combined Demographic, Socioeconomic, and Environmental Effects on BMI

Historical height and BMI studies consider the individual pathways by which individual characteristics were related 19th century biological conditions in the US. However, little is known regarding the collective magnitudes of 19th century BMRs and calories. F-statistics test the statistical significance of a subset of restricted variables; and observation period, residence, and age were jointly related with 19th century BMR and calorie variation. F-statistics do not, however, provide the magnitude or relative importance that each restricted set of variables had with physical activity and nutrition. To account for this magnitude, the percentage change of the restricted model sum of squared residuals is now reported relative to the unrestricted sum of squared residuals.

$$\%\Delta SSR = \frac{SSR_R - SSR_U}{SSR_U} = \frac{R_R^2 - R_U^2}{R_U^2} = \%\Delta R^2 \quad \text{(Eq. 5)}$$

where SSR_R and SSR_U are the restricted and unrestricted sum of squared residuals, respectively (Eq. 5). Factors individuals controlled were residence and their occupations. Pre-determined variables were nativity and age.

Within the category of pre-determined variables, age had the greatest magnitude of BMR and calorie variation and accounted for 86.1 and 82.0 percent of BMR and calorie variation. Mexican nativity accounted for 4.4 and 0.3 percent of the BMR and calorie difference. Of the factors that individuals could influence, occupations accounted for only two percent of BMR and six percent of calorie variation. Therefore, pre-determined characteristics had the greatest explanatory power in 19th century BMR and calorie variation; age had the greatest explanatory power among pre-determined characteristics, and occupations accounted for the greatest explanatory power among choice characteristics.

Conclusion

Diets and nutrition vary with economic growth and development, and immigrants must be sufficiently well compensated to remain in their country of destination. Mexican BMRs and calories remained constant throughout the late 19th and 20th centuries, and stagnant Mexican nutrition allocations in the US indicate that diseases that were related with nutrition, such as infectious diseases and tuberculosis, did not improve for Mexicans in the American West. Farmer and unskilled Mexican BMRs and calories varied by socioeconomic status, and physically-active farmers had greater BMRs, which were compensated with greater calorie allocations to perform work in the western United States. BMRs and calories were also lower for Mexicans born in Mexico compared to Mexicans born in the US, and part of the difference was related to diet. While dietary staples for Mexicans born in both Mexico and the US were beans and rice, diets in the American West included greater access to animal proteins and dairy products. Greater Mexican calorie allocations may have likewise been related with labor market choices, and Mexicans who acclimated into the western US economy were at a permanent biological advantage compared with Mexicans who did not. Therefore, 19th century Mexican physical activity and nutrition were related to a broad set of demographic, occupational, and residential characteristics, and Mexican diets and nutrition in the United States were sufficient to attract and retain Mexican workers.

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NOTES

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[1] A high BMI combined with a high BMR indicates that a person is physically active, and greater BMRs require greater caloric intake to maintain health. On the other hand, an individual with a high BMI and low BMR indicates that a person is physically less active and has a diminished health status (Gordon Wardlaw, Jeffrey Hampl, and Robert Disilvestro, 2004, June Stevens, Jianwen Cai, Kelly Evenson, and

Ratna Thomas, 2002, Walker Poston and John Foreyt, 1999; Aviva Must and Whitney Evans, 2011). It is difficult to judge the adequacy of historical diets using modern standards because infectious diseases can affect the body's ability to digest nutrients. If infectious diseases are considerable, it may underestimate the nutrients consumed by up to 10 percent (Floud et al., 2011, p. 162). Because they do not provide a measure for physical activity, BMIs are incomplete measurements for health, and BMRs provide a rough approximation for physical activity.

[2] Calorie equations from height and weight were first proposed in 1919 with the Harris-Benedict equations. Harris-Benedict equations for men are:
BMR_{Males}=66.5+(13.75*weight(kg))+(5.003*height(cms))-(6.775*Age). Harris-Benedict equations for women are:
$BMR_{Females}$=655.1+(9.563* weight (kg))+(1.85*height(cms))-(4.676*Age).

[3] For modern sedentary individuals, BMR is multiplied by 1.200; for lightly active individuals, BMR is multiplied by 1.375; for moderately active individuals, BMR is multiplied by 1.550; for very active individuals, BMR is multiplied by 1.725; for extra active individuals, BMR is multiplied by 1.900 (Mifflin et al., 1990).

[4] To estimate calories, white collar BMRs are multiplied by 1.8455; skilled worker BMRs are multiplied by 1.8525; unskilled worker BMRs are multiplied by 1.8811; workers with no occupation BMRs are multiplied by 1.8781.

[5] National food balance sheets are the most frequently used method to estimate available calories, and the USDA's *Economic Research Service* compiles and publishes annual food production and disappearance tables for various food groups. The total amount of food for domestic consumption is estimated from these reports. However, USDA estimates measure domestic production, regardless of their final use (Judy Putnam, 2000, p. 10), which overestimates the number of calories consumed because USDA estimates do not account for spoilage and plate waste.

[6] The appropriate critical value for comparing observation period coefficients equal zero is from an F-Distribution with five degrees of freedom in the numerator and 9,104 degrees of freedom in the denominator. This critical value is 2.22. The calculated F-Statistic is 3.88 and means the null hypothesis that time coefficients simultaneously equal zero is rejected at the .05 level. Observation period was statistically significant in Mexican weight variation.

[7] The appropriate critical value for testing occupation coefficients are equal zero is from an F-Distribution with three degrees of freedom in the numerator and 9,104 degrees of freedom in the denominator, which is a critical value of 2.61. The estimated F-Statistic is 2.33. This means that the null hypothesis that all occupation coefficients simultaneously equals zero cannot be rejected at the .05 level. Occupations were not statistically significant in Mexican weight variation.

[8] The appropriate critical value for the hypothesis that residence coefficients equals zero is from an F-Distribution with four degrees of freedom in the numerator and 9,104 degrees of freedom in the denominator. This critical value is 2.37. The calculated F-Statistic is 8.55 and means the null hypothesis that residence coefficients simultaneously equal zero is rejected at the .05 level. State residence was statistically significant in Mexican weight variation.

[9] Estimated age related BMRs and calories for 15-year olds relative to the 23-26 omitted category are $\frac{1583.11-77.87}{1583.11}=95\%$ and $\frac{2964.17-146.75}{2964.17}=95\%$, respectively. Estimated 60-year old age related BMRs and calories are $\frac{1583.11-77.87}{1583.11}=85\%$ and $\frac{2964.17-234.43}{2964.17}=92\%$.

[10] The critical value for testing age coefficients equal zero is from an F-Distribution with 12 degrees of freedom in the numerator and 9,104 degrees of freedom in the denominator, which is a critical value of 1.75. The estimated F-Statistic is 135.27. This means that the null hypothesis that all age coefficients simultaneously equal zero is rejected at the .05 level. Ages were statistically significant in Mexican BMR and calorie variation.

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