Disparities in the Availability and Price of Low-Fat and Higher-Fat Milk in US Food Stores by Community Characteristics

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ABSTRACT

Background National surveillance data identify disparities in low-fat milk consumption by race/ethnicity and income. Some localized studies have shown disparities in access to low-fat milk by community characteristics.

Objective Our aim was to assess the availability and price of low-fat and higher-fat milk in food stores throughout the United States and examine associations with community characteristics.

Design We conducted a cross-sectional study involving observational data collection in 2010, 2011, and 2012.

Participants/settings The study included 8,959 food stores in 468 communities where nationally representative samples of students attending traditional public middle and high schools resided.

Main outcome measures We studied the availability and price of whole, 2%, 1%, and skim milk.

Statistical analyses performed Multivariate logistic regression and ordinary least squares regression analyses were performed. Models included store type, race/ethnicity, median household income, urbanicity, US Census division, and year of data collection.

Results Less than half of all stores carried 1% and skim milk, and more than three-quarters of stores carried whole and 2% milk. Regression results indicated that the odds of carrying any type of milk were 31% to 67% lower in stores in majority black and 26% to 45% lower in other/mixed race compared with majority white communities. The odds of carrying specifically low-fat milk were 50% to 58% lower in majority Hispanic compared with majority white communities, and 32% to 44% lower in low-income compared with high-income communities. Some significant differences in milk prices by community characteristics were observed in grocery and limited-service stores. On average, low-fat milk options were more expensive in grocery stores in majority black and rural and suburban communities compared with such stores in majority white and urban communities.

Conclusions This is the first nationwide study to examine the availability and price of low-fat and higher-fat milk in food stores and show disparities in access by community characteristics. Policies and programs can play a role in increasing accessibility of low-fat milk in stores in nonwhite and low-income communities.
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THE 2010 DIETARY GUIDELINES FOR AMERICANS recommend that Americans aged 2 years and older increase their intake of fat-free or low-fat milk and milk products in order to ensure intake of key nutrients (eg, calcium, vitamin D, potassium) without contributing to excessive fat and calorie intake.[1] Data from the National

Health and Nutrition Examination Survey 2007-2008 show that low-fat milk (1% or skim) is reported as the type of milk usually consumed among only 20.2% of 2- to 19-year-olds, and that there is significant variation in consumption patterns by race and income.[2] By race, low-fat milk was the milk type usually consumed by 27.9% of non-Hispanic white, 9.9% of Hispanic, and 5.2% of non-Hispanic black children and adolescents (2 to 19 years old). By income, 38.1% of children and adolescents with household income ≥350% of the federal poverty level, 14.4% of those at 130% to 349% federal poverty level, and 9.4% of those <130% federal poverty level reported low-fat milk as the usual milk type consumed. These findings

are consistent with data from the School Nutrition Dietary Assessment Study III.[3] Similar consumption patterns by race were observed in adults.[4]

Environmental factors, such as food and beverage product availability and pricing, can influence individuals' dietary behaviors and contribute to the differential consumption patterns observed by race/ethnicity and socioeconomic status.[5-8] For example, previous research has shown that low-fat milk is often less available in retail food stores than higher-fat versions, particularly in smaller stores like convenience stores, corner stores, and bodegas.[9-19] In addition, parallel to differential consumption patterns, some studies have shown that low-fat milk is less available in nonwhite communities[6,13,20,21] and in lower-income communities[6,9,11,16,21] compared with their white and higher-income counterparts.

Some limited research has demonstrated higher prices for low-fat compared to higher-fat versions of milk within the same community,[22] while several other studies have found either no significant differences in price between low-fat and higher-fat versions[10-12] or lower prices for lower-fat versions.[14] More research has demonstrated price differences for low-fat milk by store type, with these products generally being less expensive in supermarkets compared to convenience stores.[12,14,16] At least one study comparing two communities in New York demonstrated some differences in the price of low-fat milk across communities by racial composition,[20] with a significantly higher mean price for a gallon of low-fat milk in a predominately minority compared with a predominantly white community, while another study conducted in one Florida county found no relationship between the price of low-fat milk and neighborhood race or income.[16] This is the first nationwide study to examine the availability and price of milk in food stores in communities throughout the United States and to identify whether differences exist by store type and community characteristics (eg, racial/ethnic composition, socioeconomic status, and urbanicity).

METHODS

Data collection occurred in the spring and summer months of 2010, 2011, and 2012, in a total of 469 communities spanning 46 states. Communities observed in this study were defined by the school enrollment zones for students surveyed as part of the Monitoring the Future study and were nationally representative of where 8th, 10th, and 12th grade (traditional) public school students reside. Monitoring the Future uses a multistage sampling procedure that takes into consideration a number of factors, including region, metropolitan status, urbanicity, size, and public or private status of the schools.[23] Each year, food stores were identified in each community using two commercial business lists, Dun & Bradstreet and InfoUSA, based on relevant Standard Industrial Classification codes and specific key words (eg, *dollar* and *discount*) in the store names within some categories.[24] Stores were screened by telephone to confirm their existence and eligibility (ie, sold snacks and drinks at a minimum) and to obtain additional information for initial store classification (eg, store name, sale of fresh meat, and presence of butcher, bakery, and/or deli counters).[25] From these screened and eligible stores, representative samples of supermarkets, grocery stores, and limited-service stores (eg, convenience stores, drug stores, dollar stores) were drawn,

using power calculations from a pilot study. Considering limitations previously identified in commercial business lists,[26] additional food stores not found on the business list were added to our sample through field discovery. This resulted in a total of 9,226 food stores sampled and eligible for observation across 468 communities (ie, one community was dropped because its store was declared ineligible for the study following data collection); 6,602 (71.6%) originated from the business lists, while 2,624 (28.4%) were identified through field discovery. A total of 8,793 stores (95.3%) were fully assessed and 166 (1.8%) were partially assessed across the 3 years. The vast majority of these partially assessed observations (154 of 166 stores) were not completed because store personnel asked the field staff to leave. The remaining 267 stores (2.9%) were not at all assessed, most commonly because store personnel asked field staff to leave (n=222), the store was temporarily inaccessible (n=18), or the business was not located where it was originally confirmed (n=16).

After data collection, using information gathered in the field, classification of all food stores was confirmed based on operational definitions derived from the Food Marketing Institute and previous observational studies.[27] Supermarkets were defined as stores that sold fresh meat (not frozen, processed, or cooked), had four or more cash registers, and had at least two of three specific service counters (eg, butcher, bakery, and/or deli). Grocery stores sold fresh meat, but did not meet the full criteria to qualify as a supermarket. Limited-service stores did not sell fresh meat and included outlets such as convenience stores, dollar stores, drug stores, food marts, independent corner stores, and general merchandise stores.

Measures

Community characteristics were measured using American Community Survey 5-year (2007 to 2011) estimate data aggregated based on Census block groups intersecting the communities. Racial/ethnic composition was classified as majority white ($\geq$50% non-Hispanic white), majority black ($\geq$50% non-Hispanic black), majority Hispanic ($\geq$50% Hispanic or Latino), or other/mixed race (no non-Hispanic white, non-Hispanic black, or Hispanic majority). Socioeconomic status was defined based on median household income tertiles. Urbanicity was categorized based on National Center for Education Statistics urban-centric locale codes as urban (small, midsize, and large cities), suburban (small, midsize, and large suburbs plus distant and fringe towns), or rural (distant, fringe, and remote rural areas plus remote towns).

Data collectors were trained each year using a standardized protocol. For the purposes of the food store observation, all data collectors participated in 2.5 days of training involving both classroom instruction and field practice. In each store visited, data collectors collectively completed a 10-page observation form, assessing food and beverage product availability, pricing, and promotion.[25] As part of the assessment, data collectors recorded the availability in any package size of whole, 2%, 1%, and skim (fat-free) milk. Only white, unflavored milk was included. Alternative types of milk (eg, soy, almond, lactose-free) were not assessed in this study, given the length of the data-collection instrument and scope of the overall project. Where available, the price for 1 gallon of the least expensive brand of milk was recorded for each

type of milk. The study was deemed exempt from human subjects review by the University of Illinois at Chicago Institutional Review Board.

Data Analysis

The unit of analysis for the study was the store. Prevalence of each milk type was calculated among all food stores and by store type (supermarket, grocery store, limited-service store). Multivariate logistic regression and ordinary least squares regression analyses were performed for each of the four milk availability outcomes and each of the four milk price outcomes, respectively, to examine their associations with community demographic and socioeconomic characteristics, controlling for US Census Division, year of data collection, and store type. Associations with P values <0.05 were considered statistically significant. We also examined the sensitivity of these results to use of aggregated variables for high-fat (whole and 2%) and low-fat (skim and 1%) milk. For regression analyses on the associations with availability, listwise deletion was used when there were missing data for any of the four milk availability measures (1.5% of eligible stores), resulting in an analytic sample of 8,826 food stores (including 955 supermarkets, 855 grocery stores, and 7,016 limited-service stores). For regression analyses on the associations with price, pairwise deletion was used when there were missing data for any of the four milk price measures in order to obtain the maximum sample size possible for each milk type. Samples for price analyses were therefore dependent on the number of stores in which each product was available, where gallons were sold, and where there were non-missing values for price. The resulting analytical samples for price measures were 6,247 food stores for whole milk, 5,707 for 2% milk, 2,857 for 1% milk, and 3,204 for skim milk. Analyses were conducted in STATA software, version 12 (2011, StataCorp) using a complex survey design procedure, adjusting for clustering at the community level. Sampling weights were used to account for the probability of selection of communities and stores clustered within communities (svy commands in STATA), to obtain nationally representative results for food stores in communities where 8th, 10th, and 12th grade (traditional) public school students reside in the continental United States.

RESULTS

Table 1 displays descriptive statistics of all explanatory variables included in the milk availability and milk price analyses, across all 3 years of data collection. The majority of stores in the sample were limited-service stores, and more than two-thirds of all stores were located in majority white communities. All nine US Census divisions were represented in the sample as were urban, suburban, and rural communities.

Milk Availability

Figure 1 shows the availability of each milk type among all stores and by store type. As shown, whole and 2% milk were much more commonly available (in 80.9% and 75.1% of all stores, respectively) than 1% and skim milk (in 35.4% and 42.1% of all stores, respectively). All four types of milk were available in >97% of supermarkets. However, both 1% and skim milk were significantly less available than whole and 2% milk in grocery stores and limited-service stores.

Table 2 reports the odds ratios from multivariate logistic regressions showing the associations between the availability of each milk type and community characteristics (ie, race/ethnicity, median household income, and urbanicity) among all stores and by store type. After controlling for store type and other confounders, the odds of carrying any of the four milk types were 31% to 67% lower in majority black and 26% to 45% lower in other/mixed race communities compared with majority white communities. The odds of carrying low-fat (but not higher-fat) milks were 50% to 58% lower in majority Hispanic compared with majority white communities and 32% to 44% lower in low-income compared with high-income communities. No significant differences were found in the association between milk availability and urbanicity for any of the four milk types.

Differences in milk availability by community characteristics were examined further in grocery and limited-service stores; similar analyses were not conducted for supermarkets because of lack of variability in the data. Among grocery stores, being in a majority Hispanic or other/mixed race community was associated with 68% and 47% lower odds, respectively, of carrying skim milk compared with being in a majority white community. Grocery stores in low-income communities had more than three times the odds of carrying whole and nearly twice the odds of carrying 2% milk than such stores in high-income communities. Suburban grocery stores had 71% and 84% greater odds of carrying 2% milk and skim milk, respectively, than urban grocery stores. Finally, rural grocery stores had twice to 3.5 times the odds of carrying all four types of milk compared with urban grocery stores. Results of analyses examining associations between community characteristics and milk availability using aggregated variables for high-fat (whole and 2%) and low-fat (skim and 1%) milk availability were generally consistent. High-fat milk, however, was more available in stores in rural communities compared with urban communities (data not shown).

Among limited-service stores, being in a majority black or other/mixed race community was associated with significantly lower odds of carrying any of the four types of milk compared with being in a majority white community (odds ratio range from 0.29 to 0.66 for majority black and odds ratio range from 0.56 to 0.75 for other/mixed race). Limited-service stores in majority Hispanic communities had 49% lower odds of carrying 1% and 55% lower odds of carrying skim milk compared with such stores in white communities. Similarly, limited-service stores in low-income communities had 50% and 36% lower odds of carrying 1% and skim milk, respectively, compared with limited-service stores in high-income communities.

Milk Pricing

Figure 2 shows descriptive results for the mean price per gallon of each milk type across all stores and by store type. Prices in supermarkets did not vary greatly by milk type; however, the mean price of skim milk was significantly lower than the mean price of whole milk in these stores. In grocery stores and limited-service stores, both 1% and skim milk were significantly less expensive than whole and 2% milk, on average. A gallon of skim milk among these stores was approximately 10% less expensive than a gallon of whole

Table 1. Descriptive characteristics of a representative nationwide sample of US food stores for milk availability and price analyses, 2010 to 2012[a]

Explanatory variables[b]	Milk availability analysis (n=8,826)	Milk Price Analysis			
		Whole milk (n=6,247)	2% Milk (n=5,707)	1% Milk (n=2,857)	Skim milk (n=3,204)
Store type					
Supermarket	8.6	11.7	12.8	26.3	23.7
Grocery stores	7.3	8.2	8.2	9.2	9.4
Limited-service stores	84.1	80.1	79.0	64.4	66.9
Race/ethnicity					
Majority[c] non-Hispanic white[d]	69.3	70.3	72.4	77.1	80.7
Majority non-Hispanic black	4.8	4.1	3.0	2.5	2.3
Majority Hispanic	9.3	10.0	9.7	6.1	4.8
Majority non-Hispanic mixed[e]/other races	16.6	15.6	14.9	14.3	12.1
Median household income[f]					
Low income	31.3	31.0	30.3	24.4	24.3
Middle income	32.7	33.5	33.6	30.4	32.2
High income[d]	36.1	35.6	36.1	45.2	43.4
Urbanicity[g]					
Urban[d]	41.5	40.5	39.1	36.0	33.8
Suburban	40.5	41.3	42.5	47.7	48.7
Rural	17.9	18.2	18.4	16.2	17.6
US Census divisions					
New England	5.8	6.0	5.8	11.7	6.4
Middle Atlantic	11.9	11.7	10.6	17.7	14.8
East North Central	10.9	11.3	12.7	11.6	15.7
West North Central	4.9	4.8	5.8	6.7	7.9
South Atlantic[d]	24.8	23.5	22.7	20.2	21.7
East South Central	5.4	5.3	5.1	2.9	4.5
West South Central	16.2	16.9	16.2	6.8	10.4
Mountain	4.1	4.3	4.6	5.8	4.7
Pacific	16.0	16.2	16.5	16.7	13.9
Year of survey					
Year 2010[d]	33.2	33.5	33.8	36.2	33.6
Year 2011	35.0	35.2	35.6	32.8	35.4
Year 2012	31.8	31.3	30.6	30.9	31.0

[a]All summary statistics are weighted.

[b]Summary statistics reported for explanatory variables are prevalence numbers stated as percents.

[c]Majority is defined as ≥50% of a community's population.

[d]Denotes omitted reference categories in regression analysis.

[e]Mixed/other races refers to racial/ethnic categorization of a community in which there is no majority (defined as ≥50%) of non-Hispanic white, non-Hispanic black, or Hispanic populations or there is no majority of any race.

[f]Median household income categories are in tertiles. Weighted summary statistics for mean number of dollars of median household income (and standard deviation [SD]) for the milk availability analysis sample (n=8,826) are as follows: low income (mean=$38,951; SD=$5,544); middle income (mean=$52,831; SD=$5,318); and high income (mean=$79,182; SD=$16,710).

[g]Urbanicity categories are based on the locale definitions obtained from the National Center for Education Statistics.
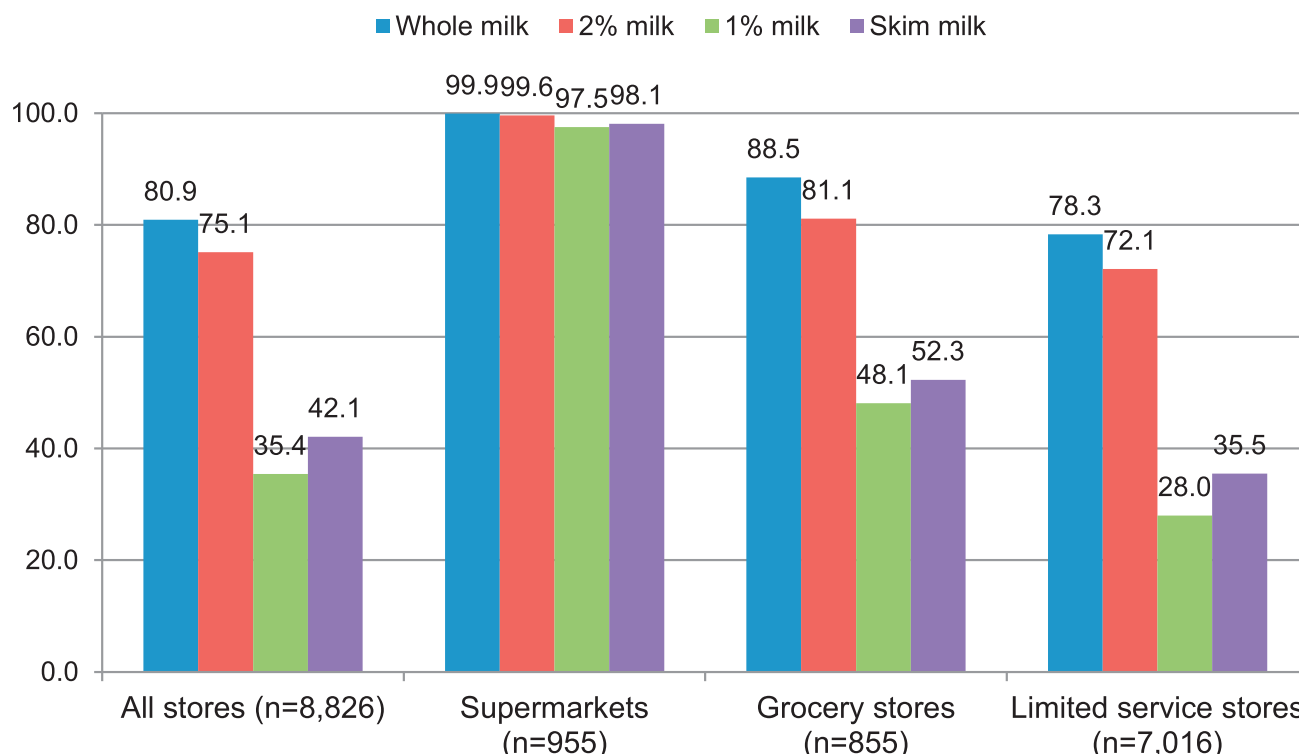
Figure 1. Mean availability (%) of milk in a representative nationwide sample of US food stores, by store type. Availability of any package size was recorded for each milk type. The following differences were significant at $P<0.05$: supermarkets: whole vs 1%, whole vs skim, 2% vs 1%, and 2% vs skim; grocery stores: whole vs 2%, whole vs 1%, whole vs skim, 2% vs 1%, 2% vs skim, and 1% vs skim; limited-service stores: whole vs 2%, whole vs 1%, whole vs skim, 2% vs 1%, 2% vs skim, and 1% vs skim.

milk. Comparing across store types, supermarket prices for all milk types were 4% to 11% lower than those in grocery stores, and 9% to 18% lower than those in limited-service stores. Prices in grocery stores were also 6% to 7% lower than those in limited-service stores for all milk types except 1% milk.

Table 3 shows coefficients obtained from ordinary least squares regressions examining the associations between price per gallon of each milk type and community characteristics, for all stores and by store type. Considering the full sample of stores, the only significant difference in price found by community race/ethnicity was a significantly lower mean price for 2% milk in majority black compared with majority white communities. In terms of community socioeconomic status, the mean price of whole milk was $0.09 higher in low-income communities than in high-income communities. Mean prices of whole and 1% milk were also significantly higher ($0.09 and $0.11 higher, respectively) in suburban compared with urban stores. In analysis limited to super-markets, no statistically significant relationships were found between price and community characteristics for any milk type. Limiting the analysis to grocery stores, we found that being in a majority black community was associated with significantly higher prices of both 1% and skim milk (on average $0.38 and $0.50 higher, respectively) compared with being in a majority white community. In addition, grocery stores located in other/mixed race communities had higher mean prices for whole, 2%, and 1% milk ($0.26, $0.26, and $0.25 higher, respectively) compared with similar stores located in majority white communities. The mean price of 1%

milk was higher in grocery stores in medium- and low-income compared with high-income communities ($0.22 and $0.21 higher, respectively). Prices of both 2% and 1% milk were significantly higher in suburban grocery store ($0.18 and $0.43 higher, respectively) and prices of 1% and skim milk were significantly higher in rural grocery stores ($0.42 and $0.30 higher, respectively) compared with prices in ur-ban grocery stores. Finally, among limited-service stores, the price of 2% milk was $0.17 lower on average in majority black compared with majority white communities, and the price of whole milk was $0.09 higher in low- compared with high-income communities. By urbanicity, prices of whole and skim milk were $0.09 and $0.11 higher, respectively, in sub-urban compared with urban communities, and whole and 2% milk prices were both $0.12 higher per gallon in rural compared with urban communities. Results of analyses examining associations between community characteristics and milk prices based on aggregated measures of high-fat (whole and 2% combined) and low-fat (skim and 1% com-bined) milk prices were generally consistent. High-fat milk, however, was more expensive in suburban compared with urban communities (data not shown).

DISCUSSION

Observing 8,959 food stores of varying sizes in a diverse, national sample of 468 communities, we found that after controlling for store type, median household income, urbanicity, region, and year of data collection, the odds of a

Table 2. Results of logistic regression analyses examining community demographic and socioeconomic characteristics associated with milk availability in a representative nationwide sample of US food stores, for all stores and by store type, 2010 to 2012[a]

Store type	Characteristic	Whole milk	2% Milk	1% Milk	Skim milk
				odds ratio (95% CI)[b]		
All stores	Supermarket (ref[c])	—	—	—	—
	Grocery store	0.007*** (0.001-0.047)	0.017*** (0.004-0.080)	0.019*** (0.013-0.030)	0.021*** (0.013-0.036)
	Limited-service store	0.003*** (0.001-0.021)	0.010*** (0.002-0.049)	0.007*** (0.005-0.010)	0.009*** (0.005-0.016)
	Majority white (ref)	—	—	—	—
	Majority black	0.688* (0.507-0.932)	0.326*** (0.243-0.436)	0.477*** (0.327-0.694)	0.342*** (0.221-0.530)
	Majority Hispanic	1.241 (0.829-1.859)	0.996 (0.653-1.520)	0.495** (0.334-0.734)	0.421*** (0.287-0.617)
	Other/mixed race	0.735** (0.599-0.903)	0.700** (0.564-0.868)	0.582*** (0.447-0.759)	0.549*** (0.442-0.682)
	High income (ref)	—	—	—	—
	Medium income	1.064 (0.881-1.285)	1.046 (0.841-1.300)	0.804 (0.607-1.065)	0.884 (0.725-1.077)
	Low income	1.052 (0.869-1.273)	1.003 (0.804-1.252)	0.561*** (0.413-0.763)	0.683** (0.549-0.848)
	Urban (ref)	—	—	—	—
	Suburban	1.155 (0.975-1.368)	1.140 (0.944-1.376)	1.168 (0.883-1.545)	1.200 (0.992-1.451)
	Rural	1.195 (0.967-1.478)	1.116 (0.870-1.430)	1.131 (0.822-1.556)	1.046 (0.789-1.387)
Grocery stores	Majority white (ref)	—	—	—	—
	Majority black	1.461 (0.365-5.847)	0.708 (0.288-1.743)	1.272 (0.578-2.801)	0.666 (0.349-1.271)
	Majority Hispanic	2.778 (0.351-21.99)	1.272 (0.470-3.441)	0.591 (0.326-1.072)	0.322** (0.165-0.627)
	Other/mixed race	0.577 (0.306-1.087)	0.702 (0.417-1.182)	0.919 (0.572-1.479)	0.531* (0.320-0.881)
	High income (ref)	—	—	—	—
	Medium income	1.718 (0.928-3.179)	1.288 (0.768-2.160)	0.863 (0.545-1.367)	0.963 (0.624-1.487)
	Low income	3.416** (1.706-6.840)	1.804* (1.042-3.125)	1.066 (0.673-1.689)	1.160 (0.722-1.862)
	Urban (ref)	—	—	—	—
	Suburban	1.731 (0.963-3.113)	1.711* (1.081-2.708)	1.533 (0.983-2.391)	1.835** (1.189-2.832)
	Rural	3.472* (1.342-8.985)	2.274* (1.101-4.699)	3.279*** (2.012-5.345)	2.107** (1.302-3.409)
Limited-service stores	Majority white (ref)	—	—	—	—
	Majority black	0.660* (0.482-0.903)	0.304*** (0.218-0.423)	0.359*** (0.232-0.557)	0.291*** (0.168-0.505)
	Majority Hispanic	1.224 (0.804-1.861)	0.979 (0.637-1.505)	0.510** (0.338-0.769)	0.448*** (0.299-0.671)
	Other/mixed race	0.752** (0.610-0.926)	0.711** (0.566-0.892)	0.570*** (0.432-0.752)	0.562*** (0.449-0.705)
	High income (ref)	—	—	—	—
	Medium income	1.037 (0.851-1.264)	1.028 (0.817-1.294)	0.796 (0.592-1.072)	0.878 (0.717-1.074)
	Low income	0.996 (0.817-1.214)	0.963 (0.765-1.213)	0.503*** (0.363-0.695)	0.636*** (0.509-0.795)
	Urban (ref)	—	—	—	—
	Suburban	1.137 (0.952-1.358)	1.108 (0.912-1.348)	1.120 (0.837-1.498)	1.149 (0.947-1.395)
	Rural	1.163 (0.934-1.448)	1.082 (0.838-1.397)	1.000 (0.707-1.414)	0.980 (0.728-1.319)

[a]All models include control variables for region (nine Census divisions) and year of data collection. Results for supermarkets not shown due to insufficient variation.
[b]Odds ratios (ie, exponentiated coefficients) (and 95% CI) from logistic regressions are reported. Standard errors account for clustering at the community level.
[c]ref=reference.
*P<0.05.
**P<0.01.
***P<0.001.
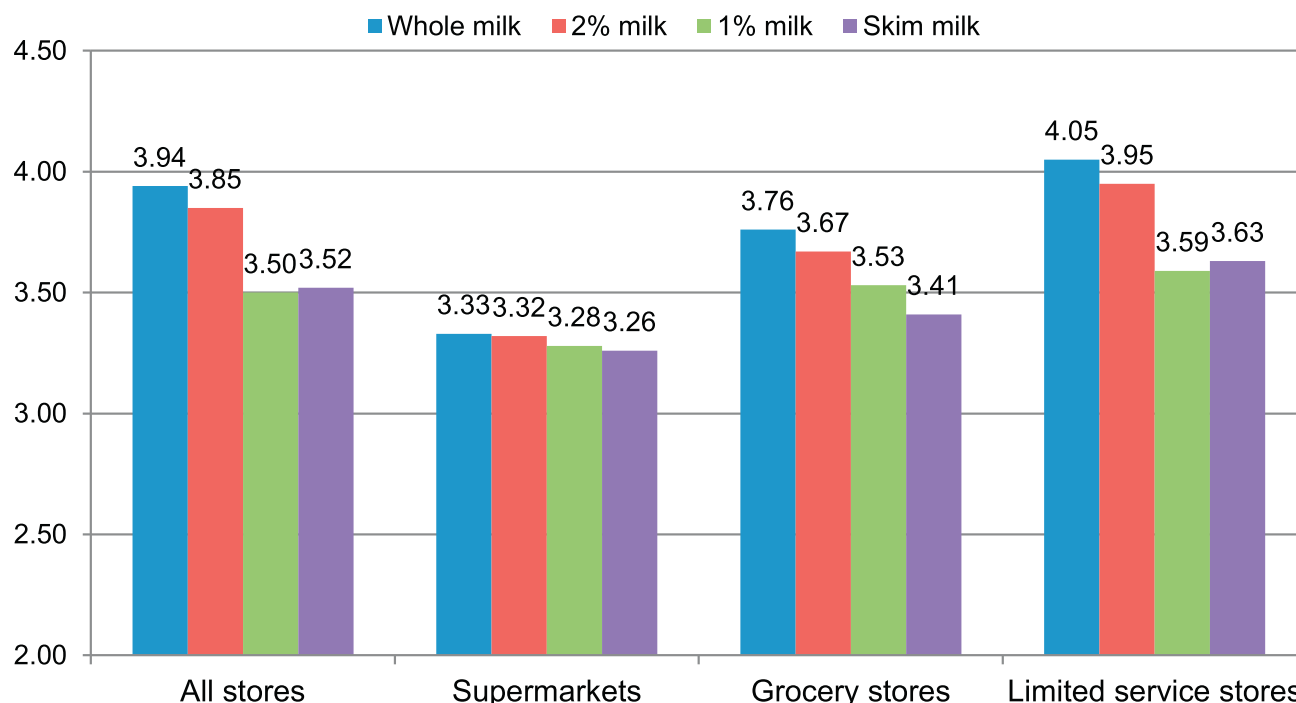
Figure 2. Mean price ($) of milk (1 gallon) in a representative nationwide sample of US food stores, by store type. Price of the least-expensive brand of milk per gallon was recorded for each milk type. Mean prices reported are real (ie, adjusted for inflation) prices stated in 2012 dollars. Sample sizes: 6,247 food stores for whole milk, 5,707 for 2% milk, 2,857 for 1% milk, and 3,204 for skim milk. The following differences were significant at $P<0.05$. Supermarkets: whole vs skim; grocery stores: whole vs 1%, whole vs skim, 2% vs 1%, and 2% vs skim. Limited service stores: whole vs 2%, whole vs 1%, whole vs skim, 2% vs 1%, 2% vs skim, and 1% vs skim. The following differences were significant at $P<0.05$: whole milk: supermarket vs grocery, supermarket vs limited-service, grocery vs limited-service; 2% milk: supermarket vs grocery, supermarket vs limited-service, grocery vs limited-service; 1% milk: supermarket vs grocery, supermarket vs limited-service; skim milk: supermarket vs grocery, supermarket vs limited-service, grocery vs limited-service.

store carrying milk of any kind were lower in majority black and other/mixed race communities compared with majority white communities, and the odds of a store carrying specifically low-fat milk (but not higher-fat milk) were lower in majority Hispanic communities. Controlling for all other covariates, including racial/ethnic composition, we also found that the availability of low-fat (1% and skim) milk was lower in low-income communities compared with their high-income counterparts. These findings parallel the differential patterns found in studies on low-fat milk consumption by race, ethnicity, and income.[2-4] Our multivariate analyses also showed that although no racial/ethnic differences were observed for prices among the full sample of stores or among supermarkets, aside from a lower mean price for 2% milk in majority black communities, there were differences among grocery stores; mean prices of low-fat milk (both 1% and skim) were significantly higher in grocery stores located in majority black compared with majority white communities. Prices of low-fat milk were also higher in rural compared with urban grocery stores. Addressing the barrier of accessibility (both availability and affordability) is a necessary step in facilitating low-fat milk consumption among low-income, nonwhite, and rural populations in accordance with current dietary guidance.

Most supermarkets carried all of the four milk types, suggesting that interventions bringing new, full-service

supermarkets to underserved communities, such as the Healthy Food Financing Initiative, have the potential to increase residents' access to low-fat milk, making it easier to adhere to current dietary recommendations. In addition, given that we found that the prices for all types of milk were significantly lower in supermarkets, policies and programs such as the Healthy Food Financing Initiative can help address the affordability issue, as communities lacking supermarkets and other large stores could be faced with higher milk prices if relying on smaller stores for their milk purchases.

It is also important to note the potential impact of other policy changes on product availability and pricing in the retail food environment and on consumer demand. For example, in 2009, the federal Special Supplemental Nutrition Program for Women, Infants, and Children was changed in a way that adjusted the type and amount of milk clients could purchase as part of their subsidized food packages. Revisions made whole milk allowable for only those children younger than 2 years of age, and authorized only lower-fat (2%, 1%, or skim) milk for children older than 2 years of age. Such federal policy changes have the potential to have an impact on the demand for healthy food products like low-fat milk and therefore on stores' stocking practices.[28-30]

Findings from our study suggest that more work could be done with limited-service storeowners in nonwhite and low-

Table 3. Results of ordinary least squares regression analyses examining community demographic and socioeconomic characteristics associated with milk prices in a representative nationwide sample of US food stores, for all stores and by store type, 2010 to 2012[a]

Store type	Characteristic	Whole milk	2% Milk	1% Milk	Skim milk
		←——————————————coefficient (standard error)[b]——————————————→			
All stores	Supermarket (ref[c])	—	—	—	—
	Grocery store	0.396*** (0.043)	0.326*** (0.044)	0.223*** (0.052)	0.140** (0.050)
	Limited-service store	0.675*** (0.033)	0.609*** (0.034)	0.325*** (0.036)	0.371*** (0.033)
	Majority white (ref)	—	—	—	—
	Majority black	−0.060 (0.070)	−0.106* (0.050)	0.040 (0.082)	0.034 (0.100)
	Majority Hispanic	0.031 (0.067)	0.090 (0.067)	0.115 (0.098)	0.014 (0.084)
	Other/mixed race	0.023 (0.061)	0.020 (0.050)	0.035 (0.055)	−0.018 (0.062)
	High income (ref)	—	—	—	—
	Medium income	0.067 (0.043)	0.064 (0.041)	−0.017 (0.046)	−0.008 (0.045)
	Low income	0.091* (0.042)	0.075 (0.041)	−0.006 (0.055)	−0.034 (0.047)
	Urban (ref)	—	—	—	—
	Suburban	0.089* (0.041)	0.067 (0.038)	0.114* (0.046)	0.080 (0.044)
	Rural	0.095 (0.050)	0.090 (0.055)	0.045 (0.065)	0.045 (0.055)
Supermarkets	Majority white (ref)	—	—	—	—
	Majority black	−0.150 (0.159)	−0.009 (0.157)	−0.129 (0.170)	−0.111 (0.165)
	Majority Hispanic	0.082 (0.113)	0.145 (0.119)	0.165 (0.117)	0.034 (0.129)
	Other/mixed race	0.105 (0.085)	0.094 (0.085)	0.143 (0.080)	0.105 (0.092)
	High income (ref)	—	—	—	—
	Medium income	0.091 (0.060)	0.067 (0.063)	0.084 (0.064)	0.069 (0.068)
	Low income	0.069 (0.067)	0.032 (0.067)	0.036 (0.067)	0.021 (0.070)
	Urban (ref)	—	—	—	—
	Suburban	0.041 (0.057)	0.034 (0.060)	0.047 (0.059)	−0.029 (0.065)
	Rural	−0.080 (0.080)	−0.065 (0.079)	−0.066 (0.073)	−0.105 (0.079)
Grocery stores	Majority white (ref)	—	—	—	—
	Majority black	0.301 (0.190)	0.208 (0.166)	0.380** (0.138)	0.501* (0.197)
	Majority Hispanic	0.193 (0.131)	0.174 (0.126)	0.250 (0.177)	0.175 (0.197)
	Other/mixed race	0.259* (0.117)	0.261* (0.111)	0.245* (0.113)	0.046 (0.153)
	High income (ref)	—	—	—	—
	Medium income	0.058 (0.085)	0.073 (0.086)	0.217* (0.101)	0.210 (0.108)
	Low income	0.117 (0.098)	0.122 (0.089)	0.212* (0.106)	0.153 (0.111)
	Urban (ref)	—	—	—	—
	Suburban	0.129 (0.085)	0.178* (0.085)	0.429*** (0.115)	0.229 (0.119)
	Rural	0.121 (0.109)	0.089 (0.105)	0.419*** (0.107)	0.296** (0.114)
Limited-service stores	Majority white (ref)	—	—	—	—
	Majority black	−0.093 (0.055)	−0.168** (0.057)	0.065 (0.088)	−0.034 (0.108)
	Majority Hispanic	−0.002 (0.072)	0.060 (0.074)	0.060 (0.127)	−0.071 (0.090)
	Other/mixed race	−0.019 (0.060)	−0.024 (0.052)	−0.030 (0.062)	−0.069 (0.072)
	High income (ref)	—	—	—	—

Table 3. Results of ordinary least squares regression analyses examining community demographic and socioeconomic characteristics associated with milk prices in a representative nationwide sample of US food stores, for all stores and by store type, 2010 to 2012[a] (continued)

Store type	Characteristic	Whole milk	2% Milk	1% Milk	Skim milk
		⟵————————coefficient (standard error)[b]————————⟶			
	Medium income	0.064 (0.045)	0.061 (0.044)	−0.085 (0.051)	−0.060 (0.046)
	Low income	0.092* (0.041)	0.079 (0.043)	−0.033 (0.064)	−0.075 (0.050)
	Urban (ref)	—	—	—	—
	Suburban	0.091* (0.042)	0.065 (0.040)	0.106 (0.056)	0.106* (0.048)
	Rural	0.115* (0.049)	0.118* (0.059)	0.053 (0.079)	0.089 (0.059)

[a]All models include control variables for region (nine Census divisions) and year of data collection. Dependent variables are real (ie, prices adjusted for inflation) prices of milk stated in 2012 dollars. Price comparisons were for 1 gallon of each milk type in each store. Sample sizes: 6,247 for whole milk; 5,707 for 2% milk; 2,857 for 1% milk; and 3,204 for skim milk.
[b]Coefficients (and standard errors) from ordinary least squares regressions are reported. Standard errors account for clustering at the community level.
[c]ref=reference.
*$P<0.05$.
**$P<0.01$.
***$P<0.001$.

income communities to encourage the supply of low-fat milk options. Programs such as the Healthy Bodegas Initiative in New York City have worked with small stores in target neighborhoods to increase offerings of low-fat milk and have reportedly seen a large increase in low-fat milk sales.[31] In addition to providing technical assistance and promotion support for participating stores, the New York Department of Health & Mental Hygiene collaborated with other city agencies and organizations, including milk distributors, to make it easier for bodegas to stock and sell these healthy options.[31] Considering price differences found within grocery stores, more work could be done with grocery storeowners in black and rural communities specifically to encourage more affordable pricing for low-fat milk. Providing, at least initially, discounts on low-fat milk would lower its price for consumers and hopefully increase demand. A recent intervention study in Arizona, for example, found that shoppers switched to lower fat milk after storeowners offered coupons and posted promotional signage (A. Karpyn, PhD, et al, unpublished data, 2015). Increased sales could lead to more permanent reductions in price after the discounts end.

While increasing access to healthy food options generally and to low-fat milk specifically is important from a public health vantage, an important issue to consider in the retail environment is supply vs demand. Storeowners in some areas might not carry low-fat milk because they do not see a market for it and may perceive it risky to use limited shelf space for a perishable product that will not sell.[28,32] Indeed, in their study of corner stores and patrons in Hartford, CT, Martin and colleagues[33] found that having a greater proportion of milk that was reduced-fat was not associated with a higher likelihood that customers purchased reduced-fat milk in the store. To overcome the initial hurdles of perceived demand and other infrastructure needs, incentives could be provided to storeowners to not only carry healthier options, but also make them more attractive through placement, promotional signage, or pricing, as some communities are currently doing[34,35] (and A. Karpyn, PhD, et al, unpublished data, 2015). In addition, taste testing and nutrition education to influence consumers' tastes, preferences (from higher-fat

to lower-fat milk), and health beliefs may also be needed to increase consumer demand for low-fat milk.[36] In one study, the strongest determinant of whether a child exclusively drank whole or low-fat milk was parent/guardian beliefs about which milk was healthier for children older than age 2 years and consumption of exclusively low-fat milk was significantly associated with a parent/guardian who had tried 1% milk.[37]

The present study has several limitations. Although we captured availability (in any package size) of each milk type, we did not assess the proportional shelf space allotted for each. It is possible that some milk types were available in greater quantities than others, potentially influencing and/or reflecting consumer shopping behavior. Second, given the definitions used for community demographic characteristics, we had relatively few majority black, particularly majority black and high-income, communities in this study. Finally, given that these data are cross sectional, we were unable to establish causal relationships between milk availability and pricing in food stores and community characteristics.

Despite these limitations, this study makes significant contributions to the food environment literature. This is the first known study to look at the availability and pricing of milk in food stores in communities nationwide, rather than in one or a limited number of communities. Its other strengths include a large sample size, use of a valid and reliable observation tool, and the inclusion of a broad range of store types, including some (eg, drug stores, gas station food marts, dollar stores, and general merchandise stores) that have been excluded from previous food store research.[12,13,33] Given the increasing popularity of food and beverage sales within these store types, this may provide a more inclusive and comprehensive assessment of product accessibility in the local food environment. The present study reports prevalence and pricing results for four types of milk separately, rather than in aggregated form. This allows for a more granular understanding of milk accessibility in the local food environment; for example, demonstrating that 1% milk was the type least commonly available in all types of food stores, that low-fat (but not higher-fat) milks were less available in majority Hispanic and low-income communities, that all milk types

(but to a lesser extent whole milk) were less likely to be available in majority black communities, and that prices of low-fat (but not higher-fat) milks were higher in grocery stores in black and rural communities. Finally, we also examined associations between community characteristics and milk availability and pricing using aggregated high-fat and low-fat measures, and found that high-fat milk was more available in rural compared with urban communities and more expensive in suburban compared with urban communities. Our work adds to a growing body of evidence suggesting that nonwhite and low-income, and, to some extent, rural, communities face disparities in healthy food access, and we suggest ways that policymakers and local communities can help to improve access and build demand for low-fat milk in accordance with the Dietary Guidelines for Americans. As policy and program interventions set out to improve local food environments, similar research should be conducted to evaluate the impact not only on healthy food and beverage accessibility, but on consumer purchases and diet as well.

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