Determining the Feasibility of Milk Vending Machines to Improve Calcium Intake Among College Students

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Calcium intake declines from late adolescence to young adulthood, in part, due to decreases in accessibility to milk and dairy products. While milk vending has shown demonstrated success in secondary schools, no studies have examined whether milk vending improves calcium intake among college students. We hypothesized that milk and calcium intake would be higher among college students given access to milk vending in their dormitory (milk vending consumers) compared to those lacking access in their dormitory (non-milk vending consumers). Milk vending machines were installed in two dormitories, and two dormitories having non-milk beverage vending served as comparison sites. Students completed a calcium intake questionnaire at the point of milk (n = 73) or non-milk (n = 79) beverage vending purchases. Mean total calcium intake was higher in milk vending consumers (1245 $\pm$ 543 mg/d) compared to non-milk vending consumers (1042 $\pm$ 447 mg/d) (p = 0.01). Adjusting for gender and milk vending consumer status, there was a positive association between past month milk vending purchases and daily calcium intake from milk (p < 0.001). Fifty-seven students without in-dormitory access to milk vending reported an interest in milk vending if made available. Milk vending may serve as a novel approach for improving calcium intake in college students.

Keywords: milk, calcium, vending machines, students, college students

Introduction

Milk and other dairy products account for over 70% of dietary calcium in the U.S. (Committee to Review Dietary Reference Intakes for Vitamin D and Calcium, Food and Nutrition Board, 2011). Dietary calcium plays a critical role in the prevention of osteoporosis and potentially other chronic illnesses (e.g., hypertension, obesity, and certain cancers; Nicklas, 2003). Achieving an adequate intake of calcium is especially important during adolescence and young adulthood to

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reach peak bone mass and reduce the risk for osteoporotic fracture later in life (Committee to Review Dietary Reference Intakes for Vitamin D and Calcium, Food and Nutrition Board, 2011). Unfortunately, only 42.8% of men and 37.6% of women in the U.S. between 19 and 50 years of age meet the Recommended Dietary Allowance (RDA) of 1,000 mg daily intake of calcium (Ma, Johns, & Stafford, 2007).

During the transition from late adolescence to early adulthood, diet quality deteriorates in many young adults (Bowman, 2002; Larson et al., 2009; Nelson, Neumark-Sztainer, Hannan, & Story, 2009; Storey, Forshee, & Anderson, 2000), which may have a detrimental impact on life-long dietary practices (Harris, Gordon-Larsen, Chantala, & Udry, 2006). Findings of a longitudinal study demonstrate that dairy and calcium intake decrease in both men and women from late adolescence to young adulthood. In the same study, it was also shown that the availability of milk at meals during late adolescence is a positive determinant of calcium intake in the young adulthood period (Larson et al., 2009). In many college students, particularly those living on campus, habits shift from consuming healthy foods once readily available in the home to easily accessed, nutrient poor, energy dense convenience foods offered on campus (Buscher, Martin, & Crocker, 2001; Strong, Parks, Anderson, Winett, & Davy, 2008). To this end, the typical dormitory room contains over 22,000 kcals from foods and beverages, including an average of 8.5 dessert/candy items and 5.7 sugar sweetened beverages, but less than one dairy item (Nelson & Story, 2009).

Due to demanding schedules and unstructured lifestyles, it is common for college students to rely on vending machines for purchasing convenience foods, which tend to be low in nutrient density and high in calories (Byrd-Bredbenner et al., 2012; Hoerr & Louden, 1993; Levitsky, Halbmaier, & Mrdjenovic, 2004; Quintiliani, Bishop, Greaney, & Whiteley, 2012). Paradoxically, vending machines offer a unique opportunity to positively impact dietary changes because of their location (i.e., vending machines are placed in highly trafficked areas, such as work sites, schools, and college campuses) and the vendor's ability to tightly control the foods and beverages offered in the machines (i.e., nutrient poor, energy dense foods and beverages can be exchanged for healthy ones at the discretion of the vendor) while closely monitoring sales of foods and beverages purchased (i.e., opportunity to observe how changes in foods and beverages offerings are received by vending purchasers via sales data) (French et al., 2001). Milk and dairy vending machines have been successfully introduced into some settings (e.g., secondary schools; National Dairy Council, 2002). However, adaptation has been limited, and their presence is lacking in other places that could benefit, such as college campuses.

Because so many college students fail to meet the recommended intakes for essential nutrients, including calcium (Burke, Reilly, Morrell, & Lofgren, 2009; Ouellette et al., 2012; Poddar, Hosig, Anderson-Bill, Nickols-Richardson, & Duncan, 2012), there is a critical need to develop novel strategies to improve calcium intake. We therefore conducted a study in college

dormitories to determine the extent to which installation of milk vending machines would improve milk and calcium intakes in students, compared to students living in dormitories limited to non-milk vended beverages. We hypothesized that milk and calcium intakes would be higher among college students given access to milk vending in their dormitory (milk vending consumers) compared to those lacking access in their dormitory (non-milk vending consumers).

Methods and Materials

This study was approved by the Institutional Review Board at The Ohio State University (OSU). In coordination with the OSU Office of Business and Finance and the campus vending contractor, milk vending machines were installed in two main campus undergraduate dormitories (one milk vending machine per dormitory; referred to as milk vending dormitories). Two other main campus undergraduate dormitories with beverage vending machines available, but not milk vending, served as comparison sites (referred to as non-milk vending dormitories). Non-milk and milk vending dormitories were selected on the basis of their similarities in size, gender, and class rank.

Study participants were sampled at the point of milk vending or non-milk vending purchase. Students living in the milk vending dormitories who made non-milk vending purchases were not surveyed since the primary study focus was individuals who would purchase from milk vending if the option were made available. Study participants having access to and purchasing from milk vending in their dormitory are referred to as milk vending consumers; the comparison group of participants who did not have access to milk vending in their dormitory are referred to as non-milk vending consumers. Data collection was initiated one month after the start of the autumn quarter (mid-October) to allow sufficient time for students to establish on-campus dietary habits (Wood, Tam, & Witt, 2005). To capture natural vending behaviors, data were collected daily over two weeks (including weekdays and weekend days), during 2-hour time blocks in the morning, afternoon, and evening. Trained data collectors observed and recorded purchase data made by potential participants (date, time, location, product purchased, gender of purchaser). After a vending purchase was made, the data collector approached the purchaser to inform him or her about the study (e.g., the study is voluntary, no unique identifying data are collected, 10-15 minutes are needed to complete the survey, and cash incentive is offered for participating). Eligibility criteria required participants to be at least 18 years of age, a resident of the dormitory in which the survey study was taking place, time and ability to complete the survey on-the-spot, and a first time study participant. Verbal informed consent was obtained from interested and eligible participants. Data collectors then guided participants through the survey, and subsequently verified surveys for completeness in the presence of the participant.

Beverage Vending Options

The milk vending machines offered milk beverages only, including six varieties of low-fat flavored milk (chocolate, double chocolate, vanilla, banana, banana strawberry, and strawberry) and one fat-free flavored milk option (chocolate). All milk products were sold in 16 ounce plastic resealable bottles for $1.75. The non-milk vending machines offered soda (regular and diet), water, energy drinks, sports drinks, fruit juice, flavored water, iced tea, and fruit drinks. Non-milk beverages ranged in size (16-20 ounces) and price ($1.25-$2.00).

Without coordination with the current study, three other milk vending machines were installed on campus in non-dormitory settings. All study participants had access to these other machines during the study period.

Short Calcium Questionnaire

A Short Calcium Questionnaire was utilized to assess calcium and milk intake from foods and beverages in a typical week (Sebring et al., 2007). An accompanying portion size guide was provided to assist participants in estimating serving sizes. The Short Calcium Questionnaire was previously validated against 7-day (d) food records of 341 individuals, demonstrating that mean calcium intakes from the food record did not differ from those of the Short Calcium Questionnaire (Sebring et al., 2007). This survey was specifically utilized in the current study due to the type of food and beverage items included (commonly consumed), characteristics of the validation sample, layout, length (one page, 25 items), and self-report design. An additional 200 mg/day calcium has been proposed as a correction factor to account for sources of calcium that may not be listed on the questionnaire (Sebring et al., 2007). However, in the current study, unadjusted calcium intake from foods and beverages are reported.

Vending Surveys

Survey design experts in the OSU Office of Statistical Consulting assisted in the development of two separate vending surveys to collect data from milk vending consumers and non-milk vending consumers. Questions were identical between the two surveys with the exception of an additional brief series of questions on the non-milk vending survey to assess interest in milk vending machines if made available within the dormitory. Surveys were designed to evaluate participants': (1) milk vending purchase habits over the past month (frequency response scales of *Zero times per month* to *Three or more times per week* with an option to choose *I don't know* or *Not applicable*), (2) likelihood of purchasing from milk vending machines if made available in dormitories (non-milk surveys only; forced-choice with options of *Yes*, *No*, *I don't know*), (3) taste preference for milk (4-point Likert scale from *Strongly disagree* to *Strongly agree* with option to choose *I don't know* or *Not applicable*), and (4) demographics.

Statistical Analyses

A statistical power analysis to detect a predicted difference of 150 mg/day of calcium (Bowman, 2002) between milk and non-milk vending consumers (within-group standard deviation of 312.19 mg/day), at 80% power, produced a necessary sample size of 140 participants (70 milk vending, 70 non-milk vending). Stratification by gender was factored into the analysis.

All data analysis was performed in PASW statistical software version eighteen (SPSS, IBM Corporation, Chicago, IL, U.S.). Differences at $p < 0.05$ were considered significant. For analysis, only students who purchased vended milk within their dormitory (and not at other on-campus vending locations) were considered milk vending consumers. Chi-square analyses were used to examine differences in demographics and purchase behaviors between milk and non-milk vending consumers. *T*-tests and means $\pm$ standard deviation differences were used to compare calcium intake between milk and non-milk vending consumers or males and females. Analyses of covariance (ANCOVA) models were used to perform testing while controlling for confounding variables in two cases. When investigating the association between milk vending purchase habits and intake variables [total calcium intake from foods and beverages (mg/d), calcium from milk (mg/d), and servings of milk (cup equivalents)], we included gender and access to milk vending as control variables; when investigating the association between access groups (milk or non-milk vending consumer) and intake variables (calcium and milk intakes), we included gender as a control variable. Calcium and calcium from milk (mg/d) and milk servings per day were reported as means $\pm$ standard error in ANCOVA analyses.

Results

The final sample included 152 undergraduate students, of which 73 were milk vending consumers and 79 were non-milk vending consumers (Table 1). In general, participant demographics reflected those of the broader university. To this end, study participants were between the ages of 18 and 22 years. Similar numbers of males and females were recruited (54% males) and the ratio of males to females did not differ between milk and non-milk vending groups. Most participants self-identified as non-Hispanic White (83%) and in-state residents (81%). Over half of the students sampled were in their freshman year (56%). Despite specifically selecting test sites that were matched for demographics on the basis of university housing data, participants in the milk vending group were older ($p < 0.001$), more likely to be non-Hispanic White ($p = 0.04$), and of higher class rank ($p < 0.001$).

Table 1. Participant Demographics, Purchase Habits, and Intent to Purchase

Characteristics	Milk Vending Consumers (*n* = 73), *n* (%)	Non-Milk Vending Consumers (*n* = 79), *n* (%)	*p*
Age (years)			< 0.001
18	16 (21.9)[a]	51 (64.6)	
19-20	49 (67.1)	25 (31.6)	
21-22	8 (11.0)	3 (3.8)	
Gender			0.52
Male	37 (50.7)	45 (57.0)	
Female	36 (49.3)	34 (43.0)	
Race			0.04
Non-Hispanic White	62 (84.9)	64 (81.0)	
African American	6 (8.2)	1 (1.3)	
Hispanic	1 (1.4)	5 (6.3)	
Asian/Pacific Islander	4 (5.5)	5 (6.3)	
Other	0 (0)	4 (5.1)	
Class Rank			< 0.001
Freshman	21 (28.8)	64 (81.0)	
Sophomore	36 (49.3)	11 (13.9)	
Junior	11 (15.1)	3 (3.8)	
Senior	5 (6.8)	1 (1.3)	
Purchased from Milk Vending Over Past Month	46 (63.0)	8 (10.2)	< 0.001
3+ times per week	2 (4.3)	1 (12.5)	
1-3 times per week	7 (15.2)	3 (37.5)	
2 times last month	8 (17.4)	1 (12.5)	
1 time last month	29 (63.0)	3 (37.5)	
Where is Milk Purchased/Obtained[b]			
Grocery Store	49 (68.1)	48 (61.5)	0.40
Milk Vending	41 (56.9)	5 (6.4)	< 0.001
Dining Hall	56 (77.8)	58 (74.4)	0.62
Restaurant	17 (23.6)	18 (23.1)	0.94
Convenience Store	37 (51.4)	35 (44.9)	0.43
Would Purchase from Milk Vending if Installed in Dormitory			
Yes	N/A	45 (57.0)	
No	N/A	19 (24.1)	
I don't know/Not applicable	N/A	15 (18.9)	

[a]Values are number of consumers and within group percentage. Significant differences ($p < 0.05$) between milk and non-milk vending consumers determined by chi-square.

[b]72 milk vending consumers and 78 non-milk vending consumers are included in the milk purchase location analysis.

As expected, students who resided in milk vending dormitories were more likely to report purchase from milk vending machines over the past month (63%) compared to their non-milk vending counterparts (10%) ($p < 0.001$; Table 1). Other commonly reported locations where both milk and non-milk vending consumers purchased or obtained milk were dining halls, grocery stores, and convenience stores (no significant differences between groups; Table 1). The majority (83%) of non-milk vending consumers *agreed* or *strongly agreed* that they like the taste of milk (data not shown), and 57% of non-milk vending consumers indicated that they would purchase from milk vending machines if they were installed in their dormitory (Table 1). In addition, both milk and non-milk vending consumers reported that they would be receptive to expanded dairy vending options beyond milk (e.g., yogurt, cheese; data not shown).

Total calcium intake (mg/d) among milk vending consumers was higher (1,245 $\pm$ 543) compared to non-milk vending consumers (1,042 $\pm$ 447, $p = 0.01$; Table 2). Although calcium intakes from milk (mg/d) and milk servings (1 cup equivalents/d) were approximately 31% higher among milk vending consumers compared to non-milk vending consumers, these observations occurred without any between-group differences. In equal amounts, and in descending order, milk, cheese, pizza, yogurt, and calcium-fortified juice contributed the greatest amount of dietary calcium to the diets of both milk and non-milk vending consumers (data not shown).

Table 2. Daily Calcium, Calcium from Milk, and Milk Servings by Gender for Milk Vending and Non-Milk Vending Consumers

	Calcium (mg/d)			**Calcium from milk (mg/d)**			**Milk servings (cups/d)**		
	M	***SD***	***p*[a]**	***M***	***SD***	***p***	***M***	***SD***	***p*[a]**
MV Consumers ($n = 73$)[b]	1,245	542.6	0.01	293.2	227.1	0.07	0.98	0.76	0.07
Non-MV Consumers ($n = 77$)[c]	1,042	446.5		224.3	227.2		0.75	0.76	
All Males ($n = 81$)	1,215	518.1	0.05	251.3	214.4	0.71	0.84	0.7	0.71
All Females ($n = 69$)	1,054	477.2		265.5	246.5		0.89	0.8	
MV Males ($n = 37$)	1,317	554.8	0.10	280.3	180.3	0.27	0.93	0.6	0.27
Non-MV Males ($n = 44$)	1,128	474.4		226.9	238.6		0.76	0.8	
MV Females ($n = 36$)	1,171	527.7	0.03	306.6	268.9	0.15	1.02	0.9	0.15
Non-MV Females ($n = 33$)	927	383.8		220.8	214.6		0.74	0.7	

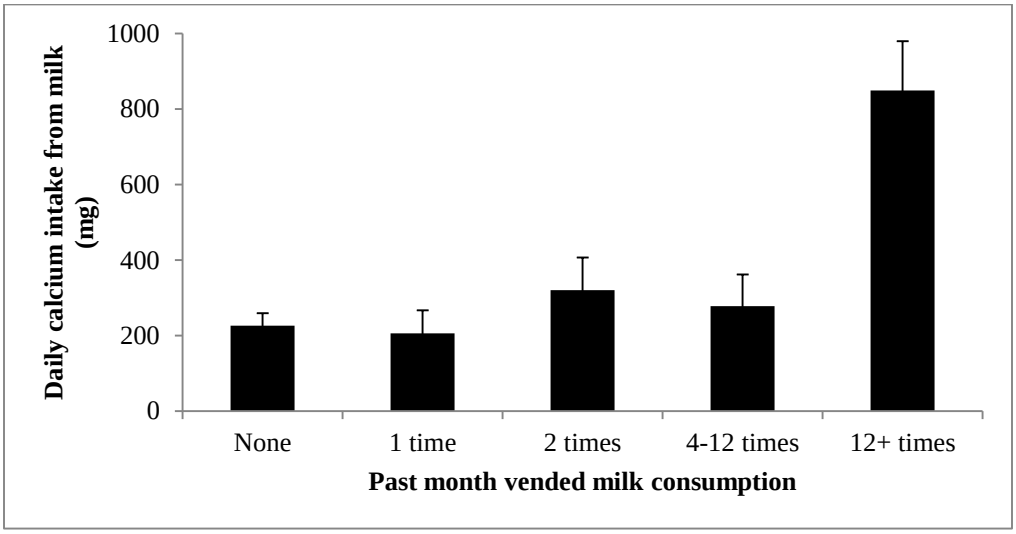
[a]Significant differences ($p < 0.05$) between groups determined by independent sample *t*-test.
[b]Milk vending (MV)
[c]Two subjects without access to milk vending machines were removed from dietary analyses due to lack of completion of questionnaire.

Sixty-three percent of milk vending consumers met or exceeded the RDA for calcium (Committee to Review Dietary Reference Intakes for Vitamin D and Calcium, Food and Nutrition Board, 2011), compared to only approximately 43% of the non-milk vending consumers, but these findings also did not reach statistical significance.

Males (n = 81) reported a higher amount of dietary calcium intake per day than females (n = 69, p = 0.05; Table 2). Female non-milk vending consumers (927 $\pm$ 384 mg/d) reported higher daily calcium intake than female milk vending consumers (1,171 $\pm$ 528 mg/d, p = 0.03). Although not statistically significant, calcium from milk (307 $\pm$ 269 vs. 221 $\pm$ 215 mg/d) and daily milk servings (1.02 $\pm$ 0.9 vs. 0.74 $\pm$ 0.7 servings/d) were higher in female milk vending consumers compared to female non-milk vending consumers. No significant differences in calcium intake, calcium intake from milk, or milk servings were observed between male milk and non-milk vending consumers.

In addition, there was an association between the frequency of past month milk vending purchases and calcium intake from milk. The association persisted after adjusting for gender and milk vending consumer status in the ANCOVA model (p < 0.001; Figure 1).

Figure 1. Calcium Intake from Milk by Frequency of Past Month Milk Vending Purchases



Note: Values are means $\pm$ standard error adjusted for gender and milk vending consumer status determined by analysis of covariance (R^2 = 0.186, p < 0.001).

Discussion

The primary aim of this study was to determine the extent to which installation of milk vending machines would improve milk and calcium intakes in students, compared to students living in dormitories limited to non-milk vended beverages. In line with the study hypothesis, it was demonstrated that daily calcium intake was higher in students who purchased from milk vending machines in their dormitories versus the comparison group having access to only non-milk vending within their dormitories. Although statistical significance was not achieved, daily calcium intake from milk and daily servings of milk were also higher in milk vending consumers. We also demonstrated a significant positive relationship between frequency of past month milk vending purchase and calcium intake from milk, adjusting for gender and milk vending consumer status. While causality cannot be inferred, this relationship provides supporting evidence of the role of campus-based milk vending as a means to improve milk/calcium intake in college vending consumers. This is of particular importance given that the calcium intakes of college students range from 806 to 927 mg/d, which is lower than the RDA (Hoffman, 1989; Horwath, 1991; Koszewksi & Kuo, 1996; Poddar et al., 2012).

We also demonstrated that overall dietary calcium intake (mg/d) was significantly higher in female milk vending consumers versus the female non-milk vending consumer comparison group. Although not statistically significant, female milk vending versus non-milk vending consumers also had higher calcium intakes from milk and daily milk servings. These data suggest that it might be beneficial to focus specifically on women – who are at greater risk for developing osteoporosis and fractures later in life due to the unavoidable drop in levels of estrogen during the postmenopausal years – as a target audience for promotion of campus milk vending (Gass & Dawson-Hughes, 2006).

In the current study, male participants had a significantly higher calcium intake than female participants. This finding is consistent with national statistics demonstrating that males are more likely than females to have adequate calcium intakes from food sources (Ervin, Wang, Wright, & Kennedy-Stephenson, 2004). The explanation for this observed gender gap in calcium intake is not fully understood, but is likely attributable to high energy intakes of males and/or dietary restriction of milk and other dairy products for dieting purposes in women (Barr, 1994; Gammage, Francoeur, Mack, & Klentrou, 2009). Future efforts should focus on elucidating the underlying explanation for this discrepancy in an effort to design interventions that are tailored with specificity to the target audience.

The inconsistency in findings in the current study (i.e., statistical significance observed in calcium intake between milk vending and non-milk vending consumers, but not calcium intake from milk or milk servings) was unexpected and potentially weakens the impact of the findings, but is offset by the following observations: 1) while significance was not achieved in calcium

intake from milk and milk servings, these outcomes trended positively in the same direction as calcium intake; 2) besides a trend towards significance in milk, there were no significant differences in other food/beverage sources of dietary calcium between milk vending and non-milk vending consumers; and 3) except milk vending, there were no significant differences between groups in the places where non-milk vending consumers and milk vending consumers reported making milk purchases. Future studies should incorporate a stronger study design (e.g., pre- and post-test) to conclusively determine the effect of milk vending on milk and calcium intake.

There are limitations in the current study that warrant discussion. First, the number of intervention sites was limited (2 dormitories). Future studies should examine whether the effectiveness of this approach (increased access to milk and dairy products via milk vending as a means to increase calcium intake) holds true on a broader scale by increasing the number of milk vending machines on a given college campus. Also, the current study was conducted on a single college campus, which limits the generalizability of findings.

Another study limitation was the difficulty in identifying a 'true' control group. The study hypothesis was that milk and calcium intake would be higher among college students given access to milk vending in their dormitory (milk vending consumers) compared to those lacking access in their dormitory (non-milk vending consumers). As noted in the methods section, without coordination with the current study, three other milk vending machines were installed on campus in non-dormitory settings during the study period, to which all study participants had access. It is possible that the non-milk vending consumers came into contact with and purchased from these other milk vending machines on campus, which might have increased their milk/calcium intake and minimized the potential difference between groups.

Also worth noting, a basic assumption was made that regardless of dormitory assignment, similarities in diet and health behaviors would exist in the students sampled in this study. It is possible, though, that the students surveyed in dormitories without milk vending machines were not regular milk drinkers, whereas the students surveyed in dormitories with milk vending machines were already consuming milk as part of their typical diet. In this case, the observed higher calcium intake in the milk vending group could be the result of a selection bias (i.e., we selected for milk drinkers in the milk vending group). It might be asserted that this particular study limitation could have been overcome by surveying students in dormitories with access to milk vending who chose to purchase non-milk vended beverages. However, the expectation was that the dietary preferences and behaviors of these students would be similar to students who would not purchase from milk vending machines, even if they had access to them in their dormitory. To this end, the majority of non-milk vending consumers agreed or strongly agreed that they like the taste of milk, and over half of students without access to milk vending within their dormitory reported that they would be interested in purchasing from milk vending if

installed. The data showing that food and beverage sources of calcium in the milk vending and non-milk vending consumers were proportionally similar provides additional evidence to offset this potential concern. Together, these findings provide evidence in favor of the conclusion that the lower milk and calcium intakes observed in the non-milk vending group relate to the lack of access to milk vending within the dormitory. Nonetheless, it might be valuable for future studies to include a survey of students who have access to, but do not purchase from, milk vending machines.

In summary, decreases in milk and calcium intake occur during the transition from late adolescence to young adulthood (Bowman, 2002; Larson et al., 2009; Nelson et al., 2009; Storey et al., 2006). One of the factors contributing to this decline is decreased accessibility of calcium-rich foods and beverages (Larson et al., 2009). In the present study, we tested the hypothesis that students who have access to and purchase from milk vending in their dormitory (milk vending consumers) would have a higher milk/calcium intake than students who do not have access to milk vending in their dormitory (non-milk vending consumers). We demonstrated a greater overall calcium intake and a marginally higher calcium intake from milk and daily servings of milk in college students who had access to and purchased from milk vending machines in their residence halls (milk vending consumers), versus the comparison group of non-milk vending consumers. Also, there was an association between the frequency of past month milk vending purchases and calcium intake from milk after adjusting for gender and access to milk vending within dormitories. In addition, female milk vending consumers had a mean calcium intake that was significantly higher than their comparison counterpart of female non-milk vending consumers. Other key findings are that many of those without access to milk vending within their dormitory (non-milk vending consumers) reported liking the taste of milk and that they would be receptive to purchasing vended milk/dairy products if made available. Furthermore, students in the current study expressed interest in expanded healthy dairy vending options. Collectively, these data suggest the value of future research dedicated to determining the potential role of campus-based milk and dairy vending to improve milk and calcium intake in college students.

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