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ORIGINAL ARTICLE

Student experiences with traffic-light labels at college cafeterias: a mixed methods study

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Summary

Objective

To assess student perceptions of traffic-light labels (TLLs) in college cafeterias.

Design

Cross-sectional, mixed-methods study.

Setting

One northeastern US college.

Participants

A total of 1,294 survey respondents; 57 focus group participants.

Interventions

Seven-week traffic-light labelling (green = 'nutrient-rich', yellow = 'less nutrient-rich', red = 'more nutrient-rich choice in green or yellow') intervention at two college cafeterias.

Main Outcome Measure(s)

Perceptions of TLLs and food labelling; disordered eating behaviours.

Analysis

Performed χ^2 analyses to test for differences between pre-intervention and postintervention responses, and between postintervention subgroups stratified by site, gender, weight status and varsity athlete status. Qualitative analysis based on the immersion-crystallization method.

Results

In postintervention surveys, 60% found TLLs helpful, and 57% used them a few times a week. When asked whether TLLs increased risk of developing eating disorders, 16% of participants said they did and 47% said TLLs might exacerbate existing eating disorders. In focus groups, some students thought the red 'colour seemed jarring', but the vast majority agreed 'the more nutrition information available, the better'.

Conclusions and Implications

Students generally supported TLLs, but future college-based interventions should address eating disorder concerns. Labels that incorporate nutrition information and education, and avoid negative messaging or judgment of what students eat, may be more acceptable.

Keywords: Feeding and eating disorders, food labelling, qualitative research, universities.

Introduction

In the United States, 37% of college students were overweight or were affected by obesity in 2016 according to the American College Health Association (1). Rising obesity rates among adolescents and young adults are particularly concerning because 80% of adolescents with obesity continue to be affected by obesity as adults (2). One of the contributing factors to obesity among young people is poor dietary quality and few meet dietary guidelines (3–6). Nutrition labelling in campus food services settings may help students eat more healthfully; however, limited research is available regarding how students perceive labelling and whether labelling could have unintended consequences.

One method of labelling, traffic-light labels (TLLs), classifies food and beverages from green (most healthy) to red (least healthy) and provides information quickly and visibly at the point of sale (7). A previous study in 2010 at a hospital cafeteria found that TLLs, as well as a choice architecture intervention (improving the visibility and convenience of healthy foods), increased the number of healthy items purchased and decreased the number of unhealthy items purchased at one hospital cafeteria (7). Other field experiments including a 2013 study in a restaurant found no effect of TLLs on total calories purchased (8). A 2015 study in a recreation and sport facility found increased sales of healthy items and reduced sales of unhealthy items after implementation of TLLs (9). An online workplace lunch order and a food lab study also found that TLLs improved food choices (10,11). However, there is no consensus on whether TLLs are an appropriate way to encourage healthy eating in college students (12), and there are no qualitative studies on experiences with TLLs. Furthermore, college-aged women are an at-risk population for eating disorders, and nutrition labelling interventions could increase that risk (13,14). Yet there are no studies on whether TLLs might contribute to eating disorders among college students.

Researchers have raised concerns that obesity prevention efforts might increase the risk of developing eating disorders or exacerbating them (15,16), through unintended negative effects on the eating behaviours or emotional state of people at risk for disordered eating (16,17). Concerns regarding eating disorders on college campuses have affected decisions about nutrition labelling in college cafeterias. For example, in 2008, Harvard University Dining Services removed nutrition information from cafeteria food labels, in part as a response to

feedback from students and student organizations that labels could lead to unhealthy restrictive eating patterns (18). A 2013 survey at Yale found that almost one-third of students thought calorie labelling could worsen eating disorder symptoms (14). Therefore, it is useful to learn how students feel about labels to help guide decision-making for campus dining.

Only two studies have examined the effect of food labelling specifically on people with symptoms of disordered eating. The first study in 2015 found no change in disordered eating, body image, mood or anxiety after the introduction of calorie labelling in a cafeteria (19). A second study in 2017 randomized women to calorie-labelled or non-labelled menus when ordering food. Compared with women with these same conditions who were randomized to receive a non-labelled menu, women with anorexia nervosa or bulimia nervosa receiving the calorie-labelled menu ordered significantly fewer calories, and women with binge-eating disorder ordered significantly more calories (20).

In a prior study, a 7-week TLL and choice architecture intervention did not demonstrate clear improvements in dietary choices among students at Harvard University cafeterias (21). This study used surveys and focus groups to examine how students perceived TLLs at these cafeterias. Investigators hypothesized that students would find TLLs informative and helpful in making nutrition decisions but that perceptions of the labels would differ by subpopulation, particularly for women.

Materials and methods

As described in the prior study (21), the interventions took place at Harvard University, where over 97% of undergraduates live on campus for all 4 years (22). A survey that included 80% of first year students from the class of 2017 ($n = 1,311$) found 50% of students were female and 50% were male. Sixty-two percent of students were White, 25% Asian, 11% Hispanic or Latino, 10% Black or African American, 4% Indian, 2.5% American Indian and 2.5% Alaska Native or Pacific Islander (23). Fifteen percent reported family incomes below \$40,000, 15% between \$40,000 and \$80,000, 18% between \$80,000 and \$125,000 and 52% over \$125,000 (23).

At this college, sophomore, junior and senior students live in 1 of 12 residential houses of approximately 400 students, and each residential house includes a cafeteria. Students at each house were representative of the entire student body because the college randomly assigns

residential houses. Although students may occasionally eat a meal outside of their residential house cafeterias, college policies limited it by prohibiting students from dining outside of their residential house cafeterias during some meals every week and by allowing students to bring only one guest from another residential house to their residential house cafeteria at other meals.

Traffic-light labelling

The Institutional Review Board of Harvard University approved the study. The study implemented TLLs on all food and beverages in two cafeterias (Figure 1a–c). Investigators selected the two cafeterias for TLL placement based on the willingness of the cafeteria leadership to participate in the interventions. A prior traffic-light labelling study identified five positive and six negative criteria to define the TLLs using data linking nutrition to health outcomes (e.g. vegetable source for positive; saturated fat over 5 g for negative) (21). Green-labelled items included those with more positive than negative criteria, red had more negative than positive and yellow had equal numbers of positive and negative criteria. This study refined criteria for a college setting to emphasize diet quality over weight loss; the labels did not include calories as a criterion.

This study placed TLLs above serving lines and on beverage dispensers. Posters defined green labels as a 'Nutrient-Rich Choice', yellow labels as a 'Nutrient-Neutral Choice' and red labels as a 'More Nutrient-Rich Choice in Green or Yellow' (Figure 2). The Harvard University Dining Services displayed the labels in cafeterias. The TLLs started at the first full-intervention cafeteria on October 12, 2014 and continued until December 2, 2014, a total of 7 weeks and 3 days. The TLLs started at the second full-intervention cafeteria a week later on October 19, 2014 and continued until December 1, 2014, a total of 6 weeks and 2 days. Delays in study approval at the intervention cafeterias led to staggered initiation.

Data collection and measures

Surveys

From October 6, 2014 to October 12, 2014, at baseline, online surveys of students queried how and whether they used available nutrition information to guide choices and asked if they wanted to have nutritional labels and what information should be on those labels (Appendix 1). At baseline and follow-up, students received invitations to the online survey via student e-mail discussion lists that included all sophomore, junior and senior students (785 living in two dorms that housed the two cafeterias with

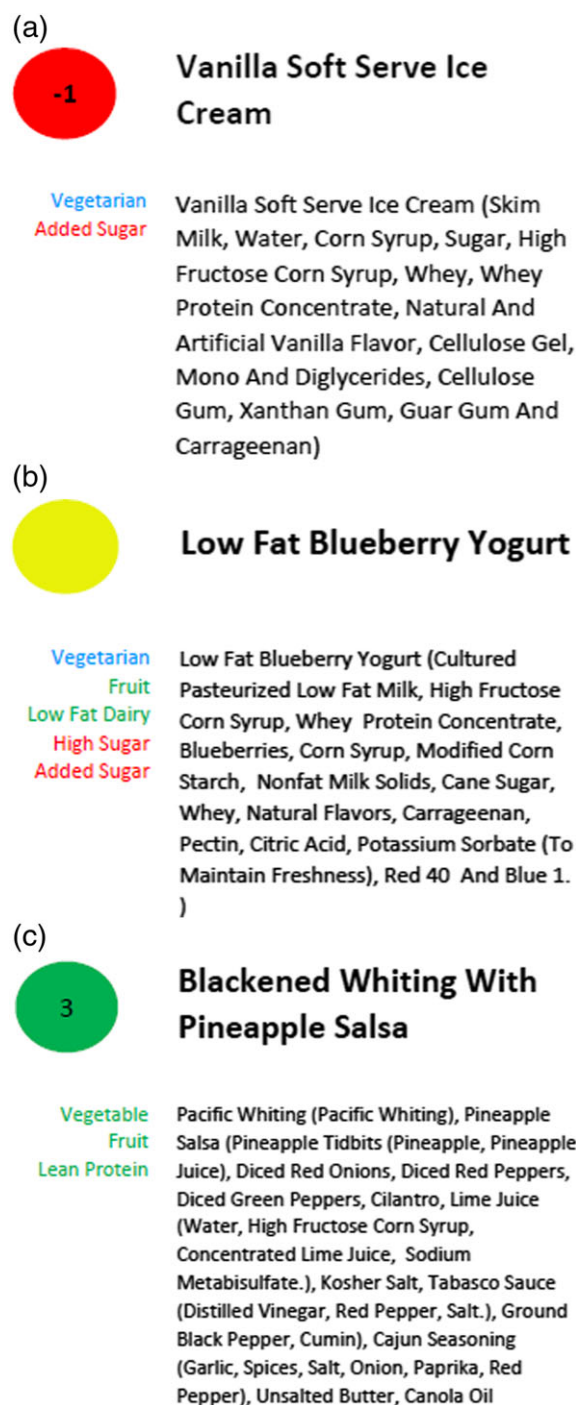


Figure 1 Examples of (a) red, (b) yellow and (c) green traffic-light food labels.

labels – 'intervention'; 4,065 living in dorms that housed any of the other 10 cafeterias without labels – 'comparison'). First year students lived in residential houses separate from the rest of the student body and primarily used a first-year-only cafeteria; they were therefore not included

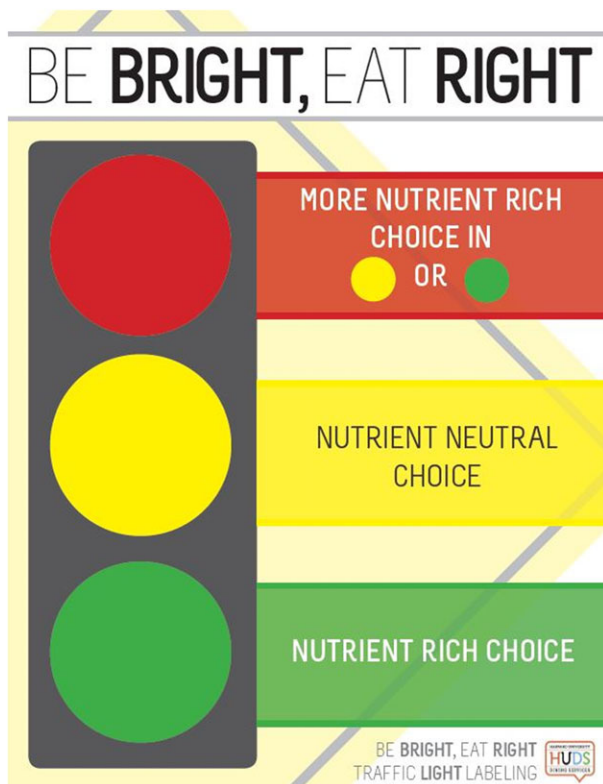


Figure 2 Posters defined green labels as 'nutrient rich choice', yellow labels as 'nutrient neutral choice' and red labels as 'more nutrient rich choice in yellow or green'.

in this study because there was no appropriate comparator site. To aid survey participation, participants could voluntarily enter into a separate, independent lottery for a \$100 cash prize at the end of the surveys.

From December 5, 2014 to December 12, 2014, after labelling ended, investigators repeated the survey and again sent it to non-first year students. This postintervention survey repeated all pre-intervention survey questions and additionally asked all students if they noticed TLLs. If students responded that they did notice the TLLs, they were also asked how often they used them, and about TLLs and disordered eating behaviours (Appendix 1). Survey questions were adapted from a survey previously used with college students eating in cafeterias with calorie labels (14) and from the Eating Disorder Examination Questionnaire (24). Because investigators expected few comparison students to use the TLLs, the survey included pictures of three example labels (red, yellow and green) before the three questions specifically asking about eating disorders. Surveys also asked several additional questions about the TLLs only to students who said they noticed the labels. Because the majority of comparison students did not notice the labels as expected, this resulted in a smaller comparison sample size for these

additional questions about the TLLs. The tables in the 'Results' are organized to reflect this difference in sample size.

Focus groups

The lead author (M. S.) conducted nine total mixed gender 1-h focus groups: four focus groups at three comparison cafeterias 1 week after interventions began and another two focus groups at each of the intervention cafeterias 1 week after labelling ended. Due to delays in study approval, the first set of focus groups included only comparison cafeterias to minimize the influence of the intervention on those discussions because TLLs were implemented at intervention cafeterias during the same week as the discussions. One focus group included cafeteria staff at one of the intervention cafeterias after labelling concluded because cafeteria staff closely monitored the food serving area and could provide insight into initial student responses to the intervention.

Students received invitations to participate in focus groups via student e-mail discussion lists and posted flyers in cafeterias. Cafeteria management recruited staff focus group participants. Each participant gave written informed consent and received \$15 in compensation. Investigators audio-recorded and transcribed the discussions. The moderator used interview guides of open-ended questions to promote candid discussion about nutrition and labelling (Table 1). The moderator asked general questions about healthy eating and the ideal food label in comparison focus groups and used intervention focus groups primarily to ask about TLLs. Prior to each postintervention focus group, participants completed a short, anonymous survey that asked sex, age and varsity athlete status.

Statistical analysis

Surveys

For surveys, χ^2 analyses in Excel 2010 (Microsoft, Redmond, WA) tested for differences between pre-intervention and postintervention responses, and between postintervention subgroups stratified by site, gender, self-reported weight status and varsity athlete status. Investigators stratified by athlete status because study focus groups revealed that athletes tended to share different attitudes toward nutrition and healthy eating than non-athletes; a systematic review also found that eating behaviours of young athletes differed from those of non-athletes (25). Because the dependent variables were categorical, investigators did not perform analysis of variance. For purposes of χ^2 analysis, investigators collapsed answers to questions with neutral responses into dichotomous outcomes in which neutral

Table 1 Interview guides used for comparison and intervention focus groups

Comparison focus group guide	
Influences on eating behaviours	(1) What motivates you to eat healthily? (2) What motivates you to eat unhealthily? (3) What would help you change your eating behaviour (to make you eat more healthily)? (4) If you wanted to be healthier in general, what would you change?
Dining Halls	(5) Are there any factors that make it particularly difficult for you to eat healthily in the dining halls? Can you give any specific examples? (6) How could the dining halls be improved to help you eat more healthily? (7) What kinds of information would you like to see posted on the food labels? What would be your ideal food label? (8) Are there any other issues related to healthy eating that you would like to discuss?
Intervention focus group guide	
Influences on eating behaviours	(1) What motivates you to eat healthily? (2) What motivates you to eat unhealthily? (3) What could help you change your eating behaviour (to make you eat more healthily)?
Interventions	(4) How do the traffic-light food labels influence your food or beverage decisions? (5) What parts of the traffic-light labels were helpful? (6) What kinds of nutrition information would you like to see posted on the dining hall food labels? (7) Can you think of any negative consequences of a traffic-light food labelling system? (8) Without identifying someone, do you know anyone who you believe changed their eating behaviour in an unhealthy way because of the nutrition interventions?
Dining halls	(9) What are the most important factors that make it easier for you to eat healthily in the dining halls? Can you give any specific examples? (10) What are the most important factors that make it particularly difficult for you to eat healthily in the dining halls? Can you give any specific examples? (11) How could the dining halls be improved to help you eat more healthily? (12) Are there any other issues related to healthy eating that you would like to discuss?

Comparison focus groups took place at comparison sites during the first week of the intervention. Intervention focus groups occurred at intervention sites 1 week after the intervention concluded.

responses were considered negative responses. For example, there were binary response categories ('changed' vs. 'not changed', collapsed from 5-item Likert responses) for the question that stated 'TLLs changed feelings about weight and shape'.

Focus groups

The lead author (M. S.) read all transcripts following the immersion-crystallization method (26). After a thorough reading of the transcripts (immersion), two of the authors (M. S. and A. C.) met frequently to discuss the transcripts to identify important themes (crystallization). Once identified, one author (M. S.) reread the transcripts and manually sorted comments into overarching themes using ATLAS.ti, version 7.5.4 (Scientific Software Development, Berlin, Germany) (27). Software coding organized themes previously identified through transcript readings, as opposed to identifying new themes with auto-coding search functions. By the fourth intervention focus group, no new themes emerged, indicating that focus groups achieved

thematic saturation because the same themes were repeated in every focus group. When describing the ideal food label during focus groups, students used one or two word phrases that made responses particularly well-suited for a word cloud representation. Word clouds size keywords alphabetically on a page according to their frequency of use and omit common words such as 'the' or 'and'. A word cloud of the 100 most frequently used words visualizes student descriptions of their ideal food label with the online generator, TagCrowd (28).

Results

Five hundred thirty and 764 students responded to pre-intervention and postintervention surveys, respectively. In the pre-intervention survey, 65% were female and 30% lived in intervention sites. In the postintervention survey, 68% were female and 30% lived in intervention sites (Table 2). Of the 785 students living in intervention sites, 20% completed pre-intervention surveys and 29% completed postintervention surveys.

Table 2 Sample characteristics from study surveys and focus groups

	Student surveys		Student focus groups	
	Pre-intervention	Postintervention	Comparison	Intervention
Sample size	530	764	22	29
Female, sex, %	65	68	82	62
Varsity athlete, %	15	23	—	34
Age, mean, years	20	20	—	20
Overweight/obese, %	—	12	—	—

Dashes indicate these questions were not asked.

Focus group discussions included 51 students and six staff (mean of six participants per focus group). In four pre-intervention groups, the moderator interviewed 22 residents at comparison cafeterias; 82% were female. In the four postintervention student groups held at intervention cafeterias, the moderator interviewed 29 students; the mean age was 20 years, 62% were female and 34% were varsity athletes (Table 2). Table 3 organizes representative quotes from topics and themes common across all focus groups.

Nutrition information

In postintervention surveys, the majority of students (62%) wanted nutrition information both online and in the cafeteria, while just 12% wanted information online only. Women were more likely than men (14% vs. 7%, $p = 0.007$) to say they want nutrition information online only. There were no significant differences between the proportions of comparison and intervention students who wanted nutrition information online only, in the cafeteria only or both online and in the cafeteria (Table 4).

Many students in focus groups rarely considered health and nutrition information when making food choices. Students remarked that they 'feel invincible at this age'. A student in another focus group said, 'I'm young, I'm in college, I can eat what I want with no consequences'. Students explained 'I only consider the extremely short-term which is basically how good is my food going to taste'. Some students added 'if we were 60 with diabetes then maybe we'd be more willing to make that sacrifice in our diet'. In the end, most students in focus groups agreed that taste is paramount: 'I just want something that tastes good, and if it's healthy that's great' (Table 3, Theme 1a).

If students were mindful of nutrition, they sometimes preferred 'to have the actual nutritional information so that I can gauge myself' rather than consult TLLs. Other students agreed that one cannot 'necessarily just apply what other people's scheme of healthy eating is to your own'. In

cafeteria staff focus groups, staff noted some students 'didn't want to know [from labels] what was bad to eat. They already knew' (Table 3, Theme 1b).

Ideal food label

In postintervention surveys, respondents listed the most important nutrition facts as (i) calories, (ii) ingredients and (iii) serving size. For all subgroups except athletes, calories were the most important. Athletes viewed (i) protein, (ii) ingredients and (iii) calories as the most important. While there was no significant difference between the proportions of pre-intervention and postintervention comparison students who wanted calories on labels, intervention students were less likely to want calories on labels after the intervention than before (50% vs. 61%, $p = 0.026$). Both comparison (21% vs. 14%, $p = 0.007$) and intervention (29% vs. 18%, $p = 0.017$) students were more likely to *not* want calories on labels after the intervention than before (Table 5). When asked in postintervention surveys whether students wanted a composite nutritional score representing the sum of positive and negative criteria used to assign the TLL colour for a particular item, 42% said they did while 28% said they did not.

A word cloud of postintervention focus group responses describing ideal labels indicated students preferred a combination of calories, carbohydrates, a colour-code system, ingredients, protein and serving sizes (Figure 3). Focus group participants overwhelmingly agreed labels should include 'as much information as you can get', because 'the more information that a consumer has, the better' (Table 3, Theme 2).

Traffic-light labels

Intervention students were more likely than comparison students to report noticing the labels (99% vs. 44%, $p < 0.001$) and using them at least a few times a week (57% vs. 16%, $p < 0.001$). Intervention students were more likely to say TLLs were *not* helpful compared with comparison students (25% vs. 16%, $p = 0.022$).

Table 3 Representative quotes from focus groups separated by topic and theme

Topic	Theme	Representative quotes
(1) Nutrition information	(1a) Invincibility of youth	'Feel invincible at this age'. 'I'm young, I'm in college, I can eat what I want with no consequences'. 'I only consider the extremely short-term which is basically how good is my food going to taste'. 'If we were 60 with diabetes then maybe we'd be more willing to make that sacrifice in our diet'. 'I just want something that tastes good, and if it's healthy that's great'. 'I would prefer to have the actual nutritional information so that I can gauge myself'. '[Students] didn't want to know [from labels] what was bad to eat. They already knew'. 'You have to be careful to take all advice in stride and not necessarily just apply what other people's scheme of healthy eating is to your own'. 'You can't say just be like this is unilaterally bad for every single person, and some people might be just trying to eat a lot of meat, and that's just what they want to do'.
	(1b) Healthy diets are personal diets	'As much information as you can get'. 'The more information that a consumer has, the better'.
(2) Ideal food label	(2) The more information the better	'Quick and easy' 'Simple' 'Almost everybody said [TLLs] influenced their eating decisions'. 'Before you could fool yourself into thinking a food was relatively healthy' 'Really impacted beverage intake' '[I drink] more water especially after seeing the different labels like PowerAde or Coke which I already knew were full of sugar'. 'It would take an army, or it would take someone physically restraining me from eating the unhealthy stuff, [or] an internal thing like the dots [TLLs]' 'Think twice' 'Avoid red' items '[Red] color seemed jarring'. '[Students thought labels were] in their face'. 'Going to feel bad about it? Or is it personally a healthy decision?' 'Changed grudgingly like it was a chore and not happily because it was something that they wanted to do for themselves'. 'Different interpretations of the lights' 'I feel like I'm morally judging myself and other people are judging me every time I go for a Coke or something because they're red'. 'Weight motivates me above all'. 'Don't really care [about nutrition] because they don't gain a pound'. 'I look at my plate, and [ask if] this is possibly going to make me more likely to be overweight'. 'Afraid of those extra pounds as we approach spring break'. 'Adding a color like red which just signifies "stop, don't do this," would make someone with an eating disorder feel worse'. 'If there's anyone on the brink of an eating disorder then [TLLs] could just throw them over the edge'. 'Extremely obsessed with eating very healthy'. 'It's fine to eat red every once in a while'. 'She completely stopped eating anything unless it was green ... to the point where we were concerned about her because she would not take anything that was red or yellow'.
(3) Traffic-light labels	(3a) Traffic light labels were simple and helpful	'Another coloring system that doesn't necessarily automatically symbolize "stop," "pause" and "go."'.
(4) Body image and disordered eating	(3b) Some concerned about the red traffic-light label and its moralistic overtones	
	(4a) Body weight motivates student choices above all	
	(4b) TLLs may exacerbate disordered eating for some students	
	(4c) Some students would prefer non-judgmental labelling systems	

Continues

Table 3. *Continued*

Topic	Theme	Representative quotes
	(4d) Benefits of TLLs outweigh the negatives	<p>'A "Smart Choices Made Easy" label which highlights good foods might be better than saying "this food is good" and "this food is bad."'</p> <p>'[TLLs have] a potential to make people feel a little bit down on themselves. But I think it's important that you know what you're putting in your body'.</p> <p>'People who have or had eating disorders probably know what's in their food regardless of whether or not there's a red sticker on it'.</p> <p>'Benefits of the [TLLs] definitely outweigh the negatives'.</p> <p>'There is a part of the population that selectively is very sensitive to [food labeling], I think for most of the population ... the labels make them put more thought into what they're eating'.</p>

TLLs = traffic-light labels.

Table 4 Postintervention survey results (%) by site, gender and weight status

	Comparison					Intervention				
	Total comparison	Men	Women	Normal weight	Overweight/obese	Total intervention	Men	Women	Normal weight	Overweight/obese
	(N = 514), %	(N = 150), %	(N = 362), %	(N = 429), %	(N = 58), %	(N = 229), %	(N = 85), %	(N = 143), %	(N = 192), %	(N = 29), %
Postintervention questions										
Check nutrition facts online or on mobile app daily	9	5	10	8	11	9	6	11	9	10
Want nutrient information on labels	67	67	67	68	62	72	74	70	72	69
Do not want nutrient information on labels	12	9	13	11	17	15	10	18	15	17
Want nutrition information online only	11	4	13	12	6	15	11	17	17	4
Want nutrition information in cafeteria only	9	16	7	10	4	8	9	7	8	7
Want nutrition information both online and in cafeteria	60	57	62	58	77	66	65	66	65	68
Currently trying to lose weight	53	28	63	52	90	51	32	63	49	75

There were no statistically significant differences ($p < 0.05$) between comparison-intervention pairs.

Intervention women (28% vs. 17%, $p = 0.024$) and intervention normal weight students (25% vs. 16%, $p = 0.038$) were also more likely to say TLLs were *not* helpful compared with comparison women and comparison normal weight students. Half (50%) of intervention students thought TLLs should continue in the cafeterias, while 31% thought the labels should not (Table 6).

Athletes were more likely than non-athletes to say TLLs were helpful (70% vs. 55%, $p = 0.005$). When stratified by site, comparison athletes were more likely than comparison non-athletes (77% vs. 49%, $p < 0.001$) and intervention athletes (77% vs. 59%, $p = 0.037$) to say TLLs were helpful. Intervention athletes were more likely than

comparison athletes to say TLLs were *not* helpful (20% vs. 5%, $p = 0.018$) and to say that TLLs should *not* continue (27% vs. 8%, $p = 0.007$) (Table 7).

In focus groups, the majority liked TLLs, calling them 'quick and easy', or 'simple', and students noticed 'almost everybody said [TLLs] influenced their eating decisions'. One student asserted, 'Before you could fool yourself into thinking a food was relatively healthy', but several said labels 'really impacted beverage intake', and many said they drink 'more water especially after seeing the different labels like PowerAde or Coke which I already knew were full of sugar'. One student proclaimed 'it would take an army, or it would take someone physically restraining

Table 5 Pre-intervention and postintervention survey results (%) by site

Pre-intervention and postintervention questions	Comparison		Intervention	
	Pre (N = 370), %	Post (N = 514), %	Pre (N = 160), %	Post (N = 229), %
Consider nutrition information (ingredients or nutrition facts) daily	57	54	54	51
Check nutrition facts online or on mobile app daily	9	9	10	9
Consider posted ingredients information daily	35	33	29	28
Want calories on labels	62	59	61*	50*
Do not want calories on labels	14**	21**	18*	29*
Want nutrient information on labels	72	67	68	72
Do not want nutrient information on labels	9	12	9	15
Currently trying to lose weight	56	53	56	51
Eating with others impacts food or beverage choices	50	53	49	47
Eat more healthily with peers	30	32	27	28

Boldface indicates statistical significance within a pre-post pair.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.



Figure 3 A word cloud representation of student descriptions in focus groups of an ideal nutrition label highlights words of high frequency.

me' to avoid eating tasty unhealthy food but agreed with other students that 'an internal thing like the dots [TLLs]' could make them 'think twice' and 'avoid red' items (Table 3, Theme 3a).

While the vast majority of student focus group participants thought labels were helpful, a few students in

each focus group were concerned the red 'colour seemed jarring', or thought that other students would find the labels 'jarring'. In the staff focus group, staff said some students thought labels were 'in their face'. Students wondered if peers avoided red items because they are 'going to feel bad about it? Or is it personally a healthy decision?' Other students agreed, noticing some 'changed grudgingly like it was a chore and not happily because it was something that they wanted to do for themselves'. Some got 'different interpretations of the lights', and one female student said 'I feel like I'm morally judging myself and other people are judging me every time I go for a Coke or something because they're red' (Table 3, Theme 3b).

Body image and disordered eating

In postintervention surveys, 79% of men and 85% of women considered themselves to be of normal weight, but women were more than twice as likely as men (63% vs. 29%, $p < 0.001$) to report currently trying to lose weight. Focus group participants frequently stated 'weight motivates me above all'. In fact, one female student observed many students 'don't really care [about nutrition] because they don't gain a pound'. One female student said 'I look at my plate, and [ask if] this is possibly going to make me more likely to be overweight'. Another female student said she ate healthily because she was 'afraid of those extra pounds as we approach spring break' (Table 3, Theme 4a).

In surveys, some respondents thought TLLs put people at risk for developing eating disorders (16%) or exacerbating eating disorders (47%); 35% believed TLLs make

Table 6 Postintervention survey results (%) by site, gender and weight status

Postintervention questions	Comparison				Intervention					
	Total comparison (N = 514), %	Men (N = 150), %	Women (N = 362), %	Normal weight (N = 429), %	Overweight/ obese (N = 88), %	Total intervention (N = 229), %	Men (N = 85), %	Women (N = 143), %	Normal weight (N = 192), %	Overweight/ obese (N = 29), %
Noticed the TLLs in the intervention dining halls	44***	43***	44***	46***	37***	99***	99***	99***	99***	100***
Used TLLs at least a few times a week	16***	15***	17***	16***	17***	57***	57***	58***	58***	54***
TLLs put people at risk for developing eating disorders†	13**	10	15*	15*	6*	22**	18	24*	21*	25*
TLLs put people at risk for exacerbating eating disorders†	44*	25	51*	46	37	53*	35	63*	52	54
TLLs make recovery from an eating disorder more difficult†	32*	17	38*	34*	23	42*	25	51*	42*	39
TLLs were helpful	(n = 210), % 59	(n = 58), % 62	(n = 152), % 58	(n = 183), % 58	(n = 19), % 68	(n = 213), % 60	(n = 78), % 63	(n = 134), % 59	(n = 178), % 62	(n = 28), % 50
TLLs were not helpful	16*	16	17*	16*	21	25*	21	28*	25*	29
TLLs should continue to be used	52	57	50	51	53	50	56	47	53	29
TLLs should not continue to be used	22	17	25	23	21	31	22	35	30	36
TLLs change perceptions about the healthfulness of specific foods	61	59	62	59	68	63	64	63	66	46
TLLs change feelings about weight and shape	21	17	23	21	26	22	13	28	22	21
TLLs make me more likely to restrict the amount of food I eat to influence my shape or weight	45**	34	49**	48**	32	30**	24	34**	33**	18
TLLs make me more likely to feel guilty about my shape or weight	20	10	23	19	32	23	12	29	22	29
TLLs make me more likely to feel guilty about my food choices	36	21	41	34	53	38	19	49	38	43
TLLs make me more likely to avoid eating foods which I like to influence my shape or weight	46	36	49*	45	47	36	36	37*	37	32
TLLs make me more likely to eat in secret	4	2	5	4	11	7	5	8	7	11

Boldface indicates statistical significance within a comparison-intervention subgroup pair.

*p < 0.05.

**p < 0.01.

***p < 0.001.

†A picture of three example labels (red, yellow and green) preceded these questions. TLLs = traffic-light labels.

Table 7 Postintervention survey results (%) by site and varsity athlete status

Postintervention Questions	Comparison		Intervention	
	Non-athlete (N = 514), %	Athlete (N = 150), %	Non-athlete (N = 362), %	Athlete (N = 429), %
Check nutrition facts online or on mobile app daily	9	8	9	10
Want nutrient information on labels	66	73	68	88
Do not want nutrient information on labels	13	8	18	5
Want nutrition information online only	13	5	16	10
Want nutrition information in cafeteria only	9	10	7	12
Want nutrition information both online and in cafeteria	61	59	64	71
Currently trying to lose weight	55	47	55	36
Noticed the TLLs in the intervention dining halls	37***	66***	99***	100***
Used TLLs at least a few times a week	10***	36	59***	51
TLLs put people at risk for developing eating disorders [†]	15	7***	21	28***
TLLs put people at risk for exacerbating eating disorders [†]	47	36	55	43
TLLs make recovery from an eating disorder more difficult [†]	35	24*	41	43*
	(n = 136), %	(n = 74), %	(n = 172), %	(n = 41), %
TLLs were helpful	49*	77*	60*	59*
TLLs were not helpful	22	5*	27	20*
TLLs should continue to be used	44	66	48	61
TLLs should not continue to be used	30	8**	31	27**
TLLs change perceptions about the healthfulness of specific foods	53	76	61	71
TLLs change feelings about weight and shape	24	15	21	27
TLLs make me more likely to restrict the amount of food I eat to influence my shape or weight	44*	47	30*	29
TLLs make me more likely to feel guilty about my shape or weight	27	7**	23	24**
TLLs make me more likely to feel guilty about my food choices	41	26	40	32
TLLs make me more likely to avoid eating foods which I like to influence my shape or weight	43	51	36	37
TLLs make me more likely to eat in secret	7	0	8	5

Boldface indicates statistical significance within a comparison-intervention subgroup pair.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

[†]A picture of three example labels (red, yellow and green) preceded these questions.

TLLs = traffic-light labels.

recovery from an eating disorder more difficult. Women were almost twice as likely as men to report TLLs put people at risk for exacerbating eating disorders (54% vs. 29%, $p < 0.001$) or make recovery from them more difficult (42% vs. 20%, $p < 0.001$). Intervention women were more likely than comparison women (24% vs. 15%, $p = 0.014$) to say TLLs put people at risk for developing eating disorders. Comparison women (49% vs. 34%, $p = 0.008$) and comparison normal weight students (48% vs. 33%, $p = 0.004$) were more likely than each of their intervention counterparts to say TLLs made them more likely to restrict the amount of food they eat to influence shape or weight. Likewise, comparison women were also more likely than intervention women to say TLLs make them avoid eating foods they like to influence shape or weight (49% vs. 37%, $p = 0.034$) (Table 6). Athletes were less likely than non-athletes to say TLLs make them feel guilty

about weight or shape (13% vs. 25%, $p = 0.010$), or feel guilty about food choices (28% vs. 40%, $p = 0.018$).

In focus group discussions, very few participants said they knew someone who changed eating behaviours in an unhealthy way because of TLLs, but several acknowledged the possibility that students could react this way. One male student felt 'adding a color like red which just signifies 'stop, don't do this,' would make someone with an eating disorder feel worse', and that 'if there's anyone on the brink of an eating disorder then [TLLs] could just throw them over the edge'. One female student said she became 'extremely obsessed with eating very healthy', and one male student mentioned he had female friends he felt needed to be told 'it's fine to eat red every once in a while'. One female student mentioned her friend 'completely stopped eating anything unless it was green ... to the point where we were concerned about her

because she would not take anything that was red or yellow' (Table 3, Theme 4b).

Considering these concerns, some students suggested 'another coloring system that doesn't necessarily automatically symbolize "stop," "pause" and "go."' Another student said 'a "Smart Choices Made Easy" label which highlights good foods might be better than saying "this food is good" and "this food is bad"' (Table 3, Theme 4c).

Overall, the majority felt TLLs have 'a potential to make people feel a little bit down on themselves. But I think it's important that you know what you're putting in your body'. Many students said 'people who have or had eating disorders probably know what's in their food regardless of whether or not there's a red sticker on it'. Therefore, most argued the 'benefits of the [TLLs] definitely outweigh the negatives' and recognized that although 'there is a part of the population that selectively is very sensitive to [food labeling], I think for most of the population ... the labels make them put more thought into what they're eating' (Table 3, Theme 4d).

Discussion

This is the first study of how college students perceive TLLs, incorporating mixed methods with both surveys and focus groups. This study also is the first to examine the relationship between eating disorders and TLLs using surveys and focus groups. Students overwhelmingly wanted nutrition information displayed in cafeterias and most thought TLLs were helpful. Students occasionally got 'different interpretations of the lights', potentially making some feel 'down on themselves', but most agreed benefits of TLLs 'definitely outweigh the negatives'. A small but important number of students raised concerns about disordered eating behaviours related to the TLLs. These concerns varied significantly by gender and varsity athletic status with women generally having more concerns and athletes having fewer.

Comprehensive reviews of major nutrition labels place labels on a spectrum from pure factual/numerical information to pure evaluation/recommendation (29–31). However, there is no research on perceptions of what Lytton (2010) describes as a label's *character*: a dimension that describes if an evaluation is positive (Smart Choices, Guiding Stars), negative (very rare) or both (TLLs) (32). The concerns about the character of TLLs, especially among women, underscore the need for future research on label character with a particular focus on negative messaging and how to address these perceptions. Policymakers should select labels with character appropriate for the target population when selecting a specific food labelling system. For example, a study at a sports facility found TLLs improved dietary choices (9).

This study, along with our findings that athletes had fewer concerns about TLLs, suggests that athletic facilities could be an effective and acceptable site for TLLs.

Students reported in surveys that TLLs put people at risk for developing eating disorders (16%), increase risk of exacerbating eating disorders (47%) and make recovering more difficult (35%). A study at Yale University found students thought presenting nutrition labels that included both calories and nutrients put people at moderate or high risk for developing eating disorders (9%), increase risk of exacerbating eating disorders (29%) and make recovering more difficult (34%), results that were modestly lower than in our study (14). Despite concerns about calorie labelling in the Yale study, our surveys suggest students still prioritize calories as the most important nutrition fact on a label, in accordance with previous research that found college students view calories and fat as the most important nutrition facts (33–35).

Although there was no change between baseline and follow-up surveys in the proportion of comparison students who wanted calories on labels, intervention students were less likely to want calories on labels at follow-up. Both comparison and intervention students were more likely to *not* want calories on labels at follow-up (Table 5). It is possible that the intervention successfully emphasized 'nutrient-rich choices' over calorie-based choices or that the TLLs promoted discussion about eating disorders and the impacts of labelling, including any negative perceptions of calorie labelling. Despite fewer students wanting calories on labels at follow-up, there was no significant difference in postintervention surveys between the proportions of comparison and intervention students who wanted nutrition information online only, suggesting that the intervention did not impact students' desires to have nutrition information available in cafeterias (Table 4). Choosing the right label for students may be challenging and likely will require preparatory work, including student involvement at all stages of development and implementation with iterative improvements based on periodic student feedback, to ensure students are comfortable with labels.

Findings from surveys on eating disorders versus eating behaviours yielded some unexpected results. When asked specifically about eating disorders, intervention students and particularly intervention women were more likely than comparison students and comparison women to report TLLs put people at risk for developing or exacerbating eating disorders. However, when asked about disordered eating behaviours, comparison students and comparison women were more likely than intervention students and intervention women to say TLLs make them restrict the amount of food they eat to influence shape or weight. Similarly, comparison women

were also more likely than intervention women to say TLLs make them avoid eating foods they like to influence shape or weight (Table 6). One possible explanation for these seemingly contradictory results is that students theorized that TLLs would worsen eating disorders, but when students actually experienced labels in practice, this concern did not materialize.

Some survey and focus group participants noted that a small number of students could be negatively affected by the TLLs. It was clear in focus groups that the judgmental aspect of the red coloured TLL was most troublesome and that students wanted more nutrition information available in cafeterias. Perhaps another labelling scheme or a creative choice architecture intervention that changes product placement could reduce concerns about eating disorders but still improve dietary quality. Furthermore, focus group comments about the invincibility of youth suggest nutrition education about health consequences related to eating behaviours could make labelling more effective. What is clear from our research and others is that students want point-of-purchase labels in some form.

Our online surveys and focus groups are limited by a convenience sample and were only conducted at one college. Results may vary for other college students depending on the school and location. Although voluntary response bias is always a concern with voluntary surveys, leading to potential selection bias, the postintervention survey response rate of 29% for students living in intervention sites was considerably higher than other surveys of college students that found 17% response rates (36). Thus, we believe that the inherent possibility of voluntary response bias in a college survey was lower in our study than it might have been. Another limitation is the cross-sectional design and lack of individual-level data. Due to institutional review board concerns about collecting identifying information about students, we were not able to match pre-intervention and postintervention survey responses. However, 91% of pre-intervention survey respondents entered their e-mails into a separate cash lottery form upon completion of the survey, and 61% of those e-mails were repeated on the postintervention cash lottery form, suggesting that almost two-thirds of students who took pre-intervention surveys went on to complete the postintervention survey. While students eat most of their meals in their resident cafeterias, they are still allowed to eat several meals at any cafeteria, and it is possible that students in control residential houses saw TLLs at some point and changed their eating behaviour even when dining in control cafeterias. This might bias our findings toward the null, but there was no mechanism to measure potential crossover. The focus groups at each time point did not comprise the same participants

(comparison vs. intervention students), so this study could not draw conclusions from focus groups about whether the intervention affected individuals' attitudes over time. However, the focus groups provided a more in-depth understanding of cross-sectional survey items, particularly for the ideal food label in comparison focus groups and perceptions of traffic-light labelling in intervention focus groups.

Survey and focus group participants skewed female, a group at risk for eating disorders, and this may have influenced the frequency of student concern about disordered eating. Although there was one all-female focus group, it is possible that different themes might have emerged if all of the focus groups were stratified by gender. Perceptions about the risk of disordered eating in response to labels were also reflected in a few news stories in the student newspaper, which appeared during the intervention. These news stories may have flagged the issue for postintervention surveys and focus groups, perhaps making the issue more prominent than if the stories had not been published (37–39). In focus groups and surveys, this study did not specifically recruit students with eating disorders. Focus groups and surveys also did not ask participants to state whether they exhibited an eating disorder or related symptoms because asking about personal experiences with eating disorders might prevent students from speaking freely due to fear of stigma and discomfort. Thus, some focus group participants made conjectures about the relationship between TLLs and disordered eating in their friends and classmates, rather than from personal experience. Future research should involve direct discussions with students who have eating disorders.

Survey results showed remarkable differences of opinions about TLLs, particularly between men and women. Universities should weigh concerns about TLLs and disordered eating against the strong wishes from the majority of students to increase nutrition information available in cafeterias. When considering nutrition-labelling interventions in college students, it will be important to involve eating disorder experts and students who are at risk or exhibiting eating disorders. A labelling system with positive character that incorporates more nutrition information and education and avoids messaging connoting judgment of what students are eating (e.g. red lights) may be more appropriate for college students.

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Conflict of interest statement

No conflict of interest was declared.

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Appendix

Survey questions

Preintervention Survey

1. How old are you?
 - a. 18
 - b. 19
 - c. 20
 - d. 21
 - e. 22
 - f. 23
 - g. 24
 - h. 25
2. What year are you in school?
 - a. Freshman
 - b. Sophomore
 - c. Junior
 - d. Senior
3. I identify my gender as...
 - a. Man
 - b. Woman
 - c. Trans*
 - d. (fill in the blank)
4. What House do you live in?
 - a. Adams
 - b. Cabot
 - c. Currier
 - d. Dunster
 - e. Eliot
 - f. Kirkland
 - g. Leverett
 - h. Lowell
 - i. Mather
 - j. Pforzheimer
 - k. Quincy
 - l. Winthrop
5. Are you a varsity athlete?
 - a. Yes
 - b. No
6. At Harvard, how often do you consider nutrition information (ingredients or nutrition facts) when choosing food and beverages to eat or drink?
 - a. Never
 - b. A few times per semester/Once a month
 - c. Once a Week
 - d. 2–3 times a Week
 - e. Daily
7. At Harvard, how often do you check nutrition facts using the HUDS online menu or the HUDS mobile app?
 - a. Never
 - b. A few times per semester/Once a month
 - c. Once a Week
 - d. 2–3 times a Week
 - e. Daily

8. At Harvard, how often do you consider posted ingredients information when choosing food and beverages?
- Never
 - A few times per semester/Once a month
 - Once a Week
 - 2–3 times a Week
 - Daily
9. Would you prefer to see calories listed on Harvard dining hall food labels?
- Yes
 - No
 - No Preference
10. Would you prefer to see nutrient information such as total fat, sugar, or protein content listed on Harvard dining hall food labels? (Nutrient information does NOT include caloric content).
- Yes
 - No
 - No Preference
11. You are currently trying to...
- Gain Weight
 - Maintain Weight
 - Lose Weight
- a. Man
- b. Woman
- c. Trans*
- d. (fill in the blank)
4. I classify myself as... (Note: According to WHO definitions, underweight is a Body Mass Index (BMI) <18.5, normal weight is 18.5<BMI<25, overweight is 25<BMI<30, and obese is BMI>30. BMI is defined as a person's weight in kilograms divided by the square of height in meters (kg/m²).
- underweight.
 - normal weight.
 - overweight.
 - obese.
5. What House do you live in?
- Adams
 - Cabot
 - Currier
 - Dunster
 - Eliot
 - Kirkland
 - Leverett
 - Lowell
 - Mather
 - Pforzheimer
 - Quincy
 - Winthrop

Postintervention Survey

1. How old are you?
- 18
 - 19
 - 20
 - 21
 - 22
 - 23
 - 24
 - 25
2. What year are you in school?
- Freshman
 - Sophomore
 - Junior
 - Senior
3. I identify my gender as...
6. Are you a varsity athlete?
- Yes
 - No
7. At Harvard, how often do you consider nutrition information (ingredients or nutrition facts) when choosing food and beverages to eat or drink?
- Never
 - A few times per semester/Once a month.
 - Once a Week
 - 2–3 times a Week
 - Daily
8. At Harvard, how often do you check nutrition facts using the HUDS online menu or the HUDS mobile app?
- Never
 - A few times per semester/Once a month

- c. Once a Week
 - d. 2–3 times a Week
 - e. Daily
9. At Harvard, how often do you consider posted ingredients information when choosing food and beverages?
- a. Never
 - b. A few times per semester/Once a month
 - c. Once a Week
 - d. 2–3 times a Week
 - e. Daily
10. Would you prefer to see calories listed on Harvard dining hall food labels?
- a. Yes
 - b. No
 - c. No Preference
11. Would you prefer to see nutrient information such as total fat, sugar, or protein content listed on Harvard dining hall food labels? (Nutrient information does NOT include caloric content).
- a. Yes
 - b. No
 - c. No Preference
12. You are currently trying to...
- a. Gain Weight
 - b. Maintain Weight
 - c. Lose Weight
13. How often does nutrition information affect your...

	Never (1)	Sometimes (2)	Often (3)	Always (4)
food choices? (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
beverage choices? (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

14. Which of the following nutrition facts are most important to you? Note: 1= Most important.

Most important
<input type="checkbox"/> Serving Size (1)
<input type="checkbox"/> Calories (2)
<input type="checkbox"/> Ingredients (3)
<input type="checkbox"/> Total Fat (4)
<input type="checkbox"/> Saturated Fat (5)
<input type="checkbox"/> Cholesterol (6)
<input type="checkbox"/> Sodium (7)
<input type="checkbox"/> Total Carbohydrates (8)
<input type="checkbox"/> Sugar (9)
<input type="checkbox"/> Protein (10)
<input type="checkbox"/> Vitamins and Minerals (11)

15. You would like to see nutrition information posted...
- a. Online only.
 - b. In the dining hall only.
 - c. Both online and in the dining hall.
 - d. No preference.
16. Would you feel embarrassed holding up the dining hall line to read a nutrition information card?
- a. Yes
 - b. No
17. Did you notice the red, yellow, and green traffic light labels in the dining halls of Dunster or Mather? (Note: These labels were used from October until December 2nd)
- a. Yes
 - b. No

Answer If Did you notice the red, yellow, and green traffic light labels in the dining halls of Dunster or... Yes Is Selected

18. How often did you use the traffic-light labels when deciding what to eat or drink?

- Never (1)
- Once a week (2)
- A few times a week (3)
- Once a day (4)
- Every meal (5)

Answer If Did you notice the red, yellow, and green traffic light labels in the dining halls of Dunster or... Yes Is Selected

19. The traffic-light labels...

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
were helpful. (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
should continue to be used in the dining halls. (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
were as effective at the end of the semester as they were when the labels were introduced. (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Answer If Did you notice the red, yellow, and green traffic light labels in the dining halls of Dunster or... Yes Is Selected

20. The traffic-light labels caused you to change...

	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
the foods you selected. (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
the amount you consumed. (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
your perceptions about the healthfulness of specific foods. (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
how you feel about your weight and shape. (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Answer If Did you notice the red, yellow, and green traffic light labels in the dining halls of Dunster or... Yes Is Selected

21. Compared to before the traffic-light labels were added or compared to other dining halls without traffic-light labels...

	Strongly Disagree (1)	Disagree (2)	Neither Disagree nor Agree (3)	Agree (4)	Strongly Agree (5)
I am more likely to restrict the amount of food I eat in order to influence my shape or weight. (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am more likely to attempt to avoid eating any foods which I like in order to influence my shape or weight. (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am more likely to eat in secret. (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am more likely to feel guilty about my shape or weight. (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am more likely to feel guilty about my food choices (or the food I choose). (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

22. Do you believe presenting nutrition information through traffic-light labels puts people at risk for developing eating disorders?

- a. Yes, puts people at risk.
- b. No, does not put people at risk
- c. I'm not sure.

23. Do you believe presenting nutrition information through traffic-light labels puts people at risk for exacerbating eating disorders?

- a. Yes, puts people at risk.
- b. No, does not put people at risk
- c. I'm not sure.

24. Do you believe presenting nutrition information through traffic-light labels makes recovery from an eating disorder more difficult?

- a. Yes, makes recovery more difficult.
- b. No, does not make recovery more difficult.
- c. I'm not sure.