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First-Year Results of an Obesity Prevention Program at The Dow Chemical Company

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Learning Objectives

- Review the evidence regarding the effects of the environment on the risk of obesity and overweight, and the rationale for applying environmental modifications to workplace settings.
- Discuss the interim findings of the obesity prevention program described by Goetzel et al, including the effects on body weight, obesity rates, blood glucose levels, etc.
- Summarize the implications for introduction of environmental modifications in environmental settings, including comparison with individually oriented health promotion interventions.

Abstract

Objective: *To examine first-year results from a workplace environmental obesity prevention program at The Dow Chemical Company.* ***Methods:*** *A quasi-experimental cohort study was conducted among employees at nine treatment worksites (*n = 8013*) who received environmental weight management interventions and three control worksites (*n = 2269*). Changes in employees' weight, body mass index (BMI), and other health risks were examined using* χ^2 *and* t*-tests.* ***Results:*** *After 1 year, a modest treatment effect was observed for weight and BMI largely because the control group subjects gained weight; however, no effect was observed for overweight and obesity prevalence. Other risk factors (tobacco use, high blood pressure, and systolic and diastolic blood pressure values) decreased significantly, although blood glucose (high risk prevalence and values) increased.* ***Conclusions:*** *Environmental changes to the workplace can achieve modest improvements in employees' health risks, including weight and BMI measures, in 1 year.* (J Occup Environ Med. *2009;51:125–138*)

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Over 66% of American adults are overweight or obese[1] placing them at increased risk for developing a number of disorders including type 2 diabetes, cardiovascular disease, stroke, some forms of cancer, osteoarthritis, depression, gallbladder disease, and respiratory disorders.[2,3] It is estimated that health problems related to excess weight may lead to an estimated 280,000 to 325,000 premature deaths each year in the US.[4]

Employed adults spend nearly a quarter of their lives at work. Unfortunately, certain aspects of the work environment, and its associated pressures and time demands, have been shown to negatively affect employee lifestyle and behavior patterns including poor eating habits and inactivity, which may lead to overweight and obesity.[5–10] Obesity can be costly to organizations. Obese employees take more sick leave than their non-obese counterparts and are twice as likely to experience high levels of absenteeism.[11]

Although precise estimates of the medical costs associated with overweight and obesity vary, the relative amount of costs incurred by obese workers when compared with their non-obese counterparts is large.[12–17] The Centers for Disease Control and Prevention estimates the combined annual direct and indirect national medical cost burden attributable to overweight and obesity to be $117 billion (in 2000 dollars).[16] Approximately $75 billion of that amount is spent on treating medical conditions related to obesity.[17] Strum estimated annual excess medical costs attributable to obesity and overweight to be

36% higher for health care, and 77% higher for medications, compared with those of normal weight.[18]

When Goetzel et al analyzed person-level medical claims and health risk data for approximately 46,000 employees of six large private and public sector organizations, annual excess direct medical costs of being obese were estimated to be 21% higher for obese workers compared with those of normal weight.[19] In total, obesity-related disorders cost employers an estimated 39.3 million lost workdays, 239 million restricted activity days, and 62.7 million visits to the doctor annually.[17]

Physical inactivity and unhealthy eating habits have long been associated with obesity. Recently, researchers have begun to explore obesity using a social-ecological framework, suggesting that varying degrees of biological, psychological, behavioral, and environmental factors are associated with obesity and overweight in otherwise healthy adults.[20] Although there is not an extensive body of literature on the environment as a determinant of obesity or overweight, there is research to support the contention that accessibility of sidewalks, street lights, fitness facilities, parks,[21] cycling paths,[22] and overall esthetics[23] are associated with increased physical activity. Feeling safe in one's neighborhood is also positively associated with increased physical activity.[24] Conversely, negative perceptions of the environment,[25,26] lack of sidewalks,[24] sedentary jobs, decreased household physical activity, easy accessibility of restaurants,[27] and leisure time spent watching TV or surfing the Internet[24] are associated with a decrease in physical activity among American adults.[25]

Business leaders are becoming increasingly aware of the human and economic burden that poor health imposes on their workers and companies. Many employers have invested in health promotion and disease prevention programs to reduce the prevalence of obesity in the workplace by encouraging physical activity, healthy diet, and improved management of related health risk factors.[28–30] Employers continue to seek innovative and evidence-based interventions that can be applied in the workplace to address the growing public health epidemic of obesity and its concomitant effects on worker productivity. A large body of literature supports the application of individualized health promotion interventions to achieve reductions in employees' health risks, including overweight and obesity.[1,31–36] There is also growing interest in interventions that may yield further health and economic returns by creating work environments that promote healthy lifestyles.[37] However, since long-term weight loss is difficult to maintain, questions remain about the return-on-investment of weight control programs.[38]

Studies have shown that simple modifications to the physical environment can be important in increasing physical activity[39–43] and altering dietary habits.[39,44–49] For example, signs prompting staircase use led to an increase in stairway use in a train station by 63%,[42,43] in a shopping mall by 113%,[43] and in a library by 5.5%.[40]

Further, there is evidence that reducing the price of healthy foods in vending machines increases sales of those foods by 78%,[46] and reducing the price of healthy foods in cafeterias produces similar results.[44,46,47] In addition, studies by Sorensen et al and Zifferblatt et al found that caloric intake decreased by 5%[49] and fat consumption was lowered by 5%[48] when food labels were displayed in cafeterias.

Many of these environmental modifications can be applied to workplace settings. For example, a recent study examining the effects of a program designed to increase organizational support for employee heart health in 20 companies found that training sessions for managers, focused on health promotion management, proved cost-efficient and improved managers' perceptions of the program.[50] Research also supports the use of individual and group competitions, financial incentives,[51,52] and goal setting at the workplace to increase participation in employer-sponsored weight loss programs.[53] A combination of individual and environmental interventions can be particularly powerful, whereas programs that only rely on individual motivation and engagement are less successful than those that blend educational with environmental strategies.[34,44,50,53–55]

To date, there has been a paucity of research on the effects of environmental and policy changes at the workplace and whether they can produce a substantial impact on outcomes such as improved worker health, reduced utilization of health care services, and improved productivity. Responding to this knowledge gap, the National Heart, Lung, and Blood Institute (NHLBI) funded seven research centers to study the impact of innovative workplace health improvement programs that emphasize environmental interventions, or a combination of environmental and individual approaches, to prevent and manage obesity in adult workers. One of these centers, housed originally at Cornell University and now at Emory University, is evaluating the effects of environmental interventions at The Dow Chemical Company (Dow). The 4-year study is testing two levels of environmental interventions: 1) a moderate-level treatment that introduces an array of inexpensive environmental changes focused primarily on the physical environment, and 2) an intensive-level treatment that requires a higher level of commitment especially among site leaders.

In this paper, we present results for the first year after Dow's introduction of environmental interventions at the workplace aimed at improving employees' health risks, especially those related to overweight and obesity. Data for employees at nine Dow sites where environmental interventions were introduced are compared with those of employees at three sites that served as controls. Biometric and behavioral risk factor changes after 1 year results are presented for a cohort of employees who participated in baseline and follow-up assessments.

Methods

Objectives

Our aim was to test the primary hypothesis that, relative to a status quo condition where only individual interventions are provided to employees, workplace environmental interventions, in addition to individual interventions, reduce the prevalence of overweight and obesity among employees at sites exposed to those interventions and positively affect other weight-related health risk factors. Research questions related to program effects on health care utilization and employee productivity will be examined in future papers.

Setting

Dow is a leading science and technology company headquartered in Midland, MI. With annual sales of $54 billion and 46,000 employees worldwide, Dow is a diversified chemical company that combines science and technology with what it refers to as the "human element" to "constantly improve what is essential to human progress."[56–58] The Company delivers a broad range of products and services to customers in 160 countries, connecting chemistry, innovation, and principles of sustainability to provide fresh water, food, pharmaceuticals, paints, packaging, and personal care products. The average age of a Dow employee in the US is 43, and about 75% of the company's US workers are male. Dow has a low voluntary attrition rate (less than 5%). The racial composition of the workforce is 82% Caucasian, 8% African-American, 6% Hispanic, 3% Asian, and about 1% "other." In terms of job categories, 54% of Dow's US employees are laborers, clerical, or technical workers; 44% are professionals or managers; and 2% are in sales.

Approximately 15,000 employees work in Texas and Louisiana, where many of the intervention sites are located. Before the study, Dow had extensive individually-focused employee health promotion programs in place at all of the study sites and this program continued throughout the study at all study sites. For this study, newly developed environmental interventions directed at reducing overweight and obesity, described below were only implemented at the intervention sites.

Study Design

This is a quasi-experimental study in which results from employees located at the nine treatment sites were compared with those of employees at three control sites at baseline, and 1 year after the environmental interventions were introduced. Of the 12 sites chosen by Dow's leaders to participate in the study, eight were located in Texas, two in Louisiana, one in New Jersey, and one in West Virginia. Eight sites were manufacturing facilities; two focused on research, development, and administrative functions; and two housed manufacturing, research and development, and administrative staff. Most of the sites were large (ranging in size from 57 to 5000 acres) and operated multiple business units. Since the interventions were directed at organizational and environmental changes, all of the employees at the study sites were designated as participants in the study.

The decision to assign sites to treatment or control conditions was made by Dow's senior leaders. However, the remaining nine treatment sites were randomly assigned to moderate or intense conditions (ie, four sites into moderate and five into intense condition categories). The interventions involved changing the worksite environment to support an increase in employees' physical activity, improve their eating habits, and manage their weight, while the control sites did not introduce any new environmental interventions. Although the researchers and site leaders were aware of their assignment into treatment or control conditions, most employees were unaware of their site's study designation.

Four sites implemented moderate environmental interventions, in addition to Dow's individually-focused health promotion programs. In addition to the moderate and individually-focused health promotion programs, five sites also implemented more intensive environmental interventions, designed to elicit greater leadership engagement and commitment to a culture of wellness that included health goals embedded within each site's business goals.

All employees at the 12 study sites (treatment and control) were eligible to participate in the health risk assessment (HRA) and biometric screening programs, which provided feedback to all participants on their health risks, and were the source of the data analyzed in this study. The procedures employed in our study were reviewed and approved by Institutional Review Boards at Cornell University, Emory University, the Health Services Review Board at Dow, and the Data Safety Monitoring Board—an external panel of experts approved by the NHLBI.

To reduce the complexity of our analysis, and to avoid overwhelming the reader with voluminous data, we combined the experience for all treatment sites (regardless of moderate or intense condition) and compared their aggregate data to those of control sites. This was done because the first year results did not conclusively differentiate the effects of moderate and intense interventions when contrasted to the control sites. A breakdown of results by treatment condition (moderate and intense vs. control) is available upon request. Future studies will examine the differential effects of moderate and intense environmental interventions when more data are available for analysis.

Interventions

The environmental interventions, termed LightenUP, were directed at the energy intake-energy expenditure dimensions of weight management (ie, decreasing the number of calories consumed and increasing the number of calories expended), and were implemented beginning in March 2006. The selection and design of environmental interventions was guided by the following principles: use components that are evidence-based, inexpensive, and can be broadly applied and sustained in a variety of work settings.

Individually-focused interventions, applied at all study and control sites, included all elements of Dow's core health promotion program, which aims to improve employees' health behaviors through a combination of education and behavior change efforts. Dow's core program includes dissemination of multiple health education materials (newsletters, intranet site, posters, and home mailings); leadership training; physical activity and weight management programs; health assessments and individual consultations; on-line behavior change programs; reimbursements for participating in weight management, tobacco cessation, and diabetes education programs in the community (up to a set limit); and preventive screening reimbursements.

The moderate environmental interventions, introduced at moderate and intense study sites, emphasized a combination of two elements shown to be effective in altering dietary and physical activity behaviors: 1) environmental prompts that encourage employees to make healthy food choices and be physically active; and 2) point-of-choice messages to encourage healthy eating and physical activity, such as the use of signs strategically located in front of stairwells, vending machines, and cafeterias. These interventions are evidence-based and address the opportunity and motivational components of behavior change.[39–49,51,52] Specific to Dow, moderate interventions included providing healthy eating information and choices in the vending machines, cafeterias, and at all company-sponsored meetings; establishing marked walking paths at the sites; disseminating targeted messages that encouraged healthy eating and physical activity; and developing an employee recognition program that focused on healthy lifestyles. (It should be noted that not all of the sites had company cafeterias and some had on-site fitness centers, although these did not influence the site's assignment into treatment or control condition.)

The intensive environmental interventions added programs designed to increase a healthy organizational culture and leadership commitment to employee health. Specifically, at intense sites, health goals were established as part of the sites' management plans; training was provided to site leaders on health promotion topics; progress reports were sent to senior corporate leadership; and health promotion leaders (named Healthy Culture Focal Points) were trained and recognized for their efforts. These interventions were designed to garner strong leadership support, integrate the interventions into the company's established business practices, build a support structure, hold individual managers accountable for health improvements, and reward employees for progress toward their goals.

Outcome Metrics

To test our hypotheses, data from baseline and year-one biometric screenings and HRA were analyzed. Specifically, body mass index (BMI) was calculated from the height and weight measures collected during biometric screenings. Baseline height measurements were used to calculate BMI at baseline and follow-up periods. The BMI data were categorized as normal (<25.0), overweight (25.0 to 29.9), and obese (≥30.0).

In addition to weight and BMI, we also collected and analyzed data on other biometric measures (blood pressure, total cholesterol, and blood glucose), as well as certain behavioral risk factors (eating habits, physical activity, tobacco use, high alcohol use, and high stress). The operational definitions for these risk categories are shown in the Appendix. All data, including biometric measures, were collected during the same time period (first quarter of 2006 for baseline and first quarter of 2007 at follow-up) at all 12 study sites.

Data Sources. Biometric data were collected using standardized protocols developed by Dow Health Services. Behavioral risk data were collected utilizing standardized instruments applied by all research organizations participating in the NHLBI studies, and these are described in detail elsewhere.[59] HRAs were administered on-line using Dow's established Intranet survey vendor, Valtera Inc. Participants signed an electronic informed consent document before completing the HRA, and the HRA took approximately 10 to 15 minutes to complete. Employees who completed the HRA were encouraged to schedule a follow-up biometric screening at their site, and many did so.

Sample

There were 10,281 eligible employees at the 12 Dow sites participating in this study. Of these, 8013 were at treatment sites and 2268 at control sites. We excluded from our analysis pregnant women, identified as women who told the professional screeners that they were pregnant or those whose pregnancy status was deduced from medical claims data.

Statistical Methods

Differences in health risk factors and biometric measures over a 1 year period were analyzed separately for the treatment and control groups. Comparisons between treatment and control employees were also made.

To analyze the trends over time within each group of interest, paired *t*-tests were used when analyzing interval data (ie, weight, BMI, blood pressure, and cholesterol) and McNemar χ^2 tests were used when comparing changes in the proportion of employees at high versus low risk for various health behaviors (poor eating habits, inadequate physical activity, tobacco use, high alcohol use, and high stress). McNemar χ^2 tests were also used to estimate the significance of changes over time in biometric risks (being overweight or obese, or having high blood pressure, high cholesterol, or high blood glucose).

Difference-in-differences (DID) analyses were used to compare the trends over time between treatment and control groups. Differences between Time 1 (2006) and Time 2 (2007) were calculated for interval and dichotomous variables. The difference in the interval variables was calculated as the simple difference between the values from the two periods (2007 to 2006). The differences in the dichotomous health and biometric risk variables were calculated as negative one (−1) for a decrease in risk, zero (0) for no change in risk, and positive one (+1) for an increase in risk. These differences were used as the dependent variables in independent *t*-tests (interval variables) and cumulative (ie, ordered) or multinomial logistic regression analyses (dichotomous health and biometric risk variables) comparing the differences between treatment and control employees, controlling for confounders. Cumulative logistic regressions were conducted for all dichotomous variables, and multinomial regressions were conducted for dichotomous variables that did not satisfy the proportional odds assumption for the cumulative logistic regression.[60] The cumulative logistic regression used "increased risk" as the reference group, whereas multinomial logistic regressions used "no change in risk" as the reference group; both models calculated the odds of being at increased or no risk for treatment versus control subjects.

The DID analysis allowed us to control for differences in mean baseline values that may be due to longstanding differences in site environments. To further control for other potential confounders, including employee demographics and underlying health status, we used propensity score weighting techniques described by Imbens.[61] Imbens found that if used for all study subjects, the propensity weighting process can effectively normalize the samples in different groups about the characteristics used in the analyses.

The propensity score weights were based on the predicted probability of being employed at treatment sites. A logistic regression model predicted the probability of being at a treatment site based on the employee's age, gender, ethnicity, work status, education, and disease severity (using the Charlson Comorbidity Index [CCI]).[62] The operational definitions for the control variables are found in the Appendix. The propensity score weight used in the analysis was the inverse of the predicted probability of being employed at a treatment site (ie, 1/predicted probability).

Since study attrition is a concern and a potential threat to internal validity, two methods were used to account for the effects of missing data at follow-up: non-response weighting and mean-based imputation. Non-response weighting methods were conducted using a logistic regression model to predict the probability of not responding in the program year among those with baseline data (40% of baseline respondents) based on the employee's age, gender, CCI value, education, work status, and treatment allocation. The non-response weight was then calculated as the inverse of the predicted probability of not having a missing response (ie, 1/predicted probability). The non-response weight was further multiplied by the formerly calculated propensity scores.

In addition, a mean-based imputation method was used to account for missing data points among cohort members (0.0% to 5.4% of each outcome variable). This method was applied by imputing missing values based on the mean value of the variable from the control group. For example, if a subject's BMI was missing at follow-up, the missing value was replaced with the "average BMI" of subjects from the control sites at follow up. All statistical analyses were conducted using the SAS 9.1 software package.

Results

Participant Flow

Figure 1 shows participation over time for treatment and control sub-

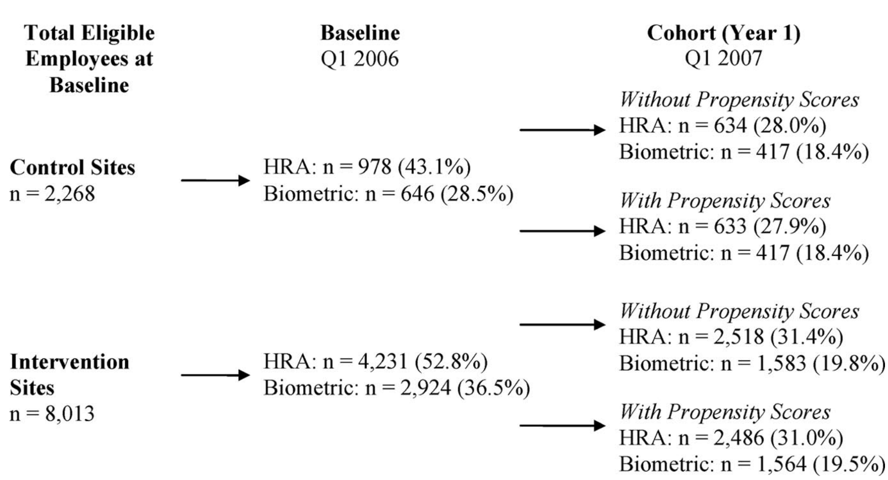

Fig. 1. Employee participation over time (Note: percents represent percent of total eligible employees at baseline).

jects. Baseline HRA and biometric screenings were conducted during the first quarter of 2006 and follow-up assessments in the first quarter of 2007. At baseline, 50.7% (n = 5209) of eligible employees participated in the HRA and 34.7% (n = 3570) participated in the biometric screenings. At the 1-year follow-up, 60.5% (n = 3152) of baseline participants completed the HRA and 56.0% (n = 2000) completed the biometric screenings.

Analyses were based on the cohort of employees (n = 3152 employees) who provided data for both the baseline and year-one HRAs. Of these, 2518 (79.9%) were at treatment sites and 634 (20.1%) at control sites. Changes in biometric values were assessed for a subset cohort that participated in both the baseline and year-one biometric screenings (n = 2000), representing 63.5% of the larger cohort (1583 from treatment and 417 from control sites).

The propensity weighting process reduced the number of subjects available for the analysis because some employees were missing control variables. This resulted in a slight decrease in sample size (about one percent) because of missing responses to propensity score predictors.

Changes in Weight and Other Health Risks

The unadjusted baseline demographic characteristics of treatment and control group subjects in the cohort are shown in Table 1. Control group subjects were older than treatment group subjects by 2 years, were equally likely to be female, were healthier (ie, had fewer comorbidities as measured by the CCI), were more highly educated, more likely to be non-exempt employees, and more likely to be operators or production workers. Table 1 also presents the adjusted baseline demographic char-

TABLE 1
Baseline Demographics Characteristics of the HRA Cohort

	Unadjusted*			**Adjusted***		
	Control (n = 634)	**Intervention (n = 2518)**	***P***	**Control (n = 633)**	**Intervention (n = 2486)**	***P***
Average age†	45.8	43.8	<0.0001	44.1	44.3	0.6257
% Female‡	27.1	26.7	0.8066	25.0	26.7	0.1236
CCI (%)‡		<0.0001				0.6388
0 comorbidities	52.4	63.1		61.0	61.4	
1 comorbidities	4.3	7.4		6.7	6.9	
2 comorbidities	3.6	2.6		2.5	2.8	
3 comorbidities	0.5	1.0		1.0	0.9	
4 comorbidities	0.2	0.4		0.2	0.4	
5 or more comorbidities	0.2	0.3		0.2	0.3	
Unknown	39.0	25.4		28.5	27.4	
Ethnicity (%)‡			<0.0001			0.6492
American Indian/Alaska Native	0.8	0.2		0.2	0.3	
Asian	4.3	3.4		3.3	3.6	
Black/African American	9.9	9.4		9.1	9.4	
Hispanic/Latino	1.4	11.7		8.7	9.7	
Caucasian	83.6	75.0		78.6	77.1	
Education (%)‡			<0.0001			0.1125
Not indicated	49.1	24.7		27.1	29.4	
Less than bachelor degree	8.5	28.1		26.3	24.3	
Bachelor degree	27.0	35.7		34.6	34.0	
Masters or doctorate	15.5	11.5		12.0	12.3	
Exempt status (%)‡			<0.0001			0.7427
Exempt	0.3	0.4		0.3	0.4	
Non-exempt	27.1	36.6		35.4	35.6	
Unknown	72.6	63.1		64.3	64.0	
Work status (%)‡			<0.0001			0.5746
Officials and managers, professionals, and sales	50.8	48.6		16.5	16.4	
Technicians, office and clerical, and craft workers (skilled)	38.3	32.8		35.2	34.1	
Operatives (semi-skilled), laborers (unskilled), and service workers	10.7	17.5		48.3	49.5	

*"Unadjusted" refers to analyses conducted without using propensity score weighting methodology, whereas "Adjusted" indicates that propensity score weighting methodology was used to account for covariates.

†P-values are the results of t test between the control and intervention sites.

‡P-values are the results of χ^2 analyses between the control and intervention sites.

TABLE 2
Outcomes for Primary Hypotheses by Intervention With Propensity Score Weighting

	Intervention (n = 2486)				Control (n = 633)				Intervention vs Control			
	% At High Risk 2006	% At High Risk 2007	% At High Risk Δ	*P*	% At High Risk 2006	% At High Risk 2007	% At High Risk Δ	*P*	Logistic Regression Model*	Odds Ratio	χ^2	*P*
Biometric screening risk												
Obese	34.4	35.0	0.6	0.2592	34.7	35.0	0.2	0.6083	Multinomial (−)	1.3	0.4	0.5322
									Multinomial (+)	1.4	0.9	0.3483
Overweight	38.8	40.5	1.7	0.0348	40.5	40.0	−0.5	0.5412	Cumulative	0.8	1.1	0.2886

	Intervention (n = 2486)				Control (n = 633)				Intervention vs Control		
	Average Value 2006	Average Value 2007	Average Value Δ	*P*	Average Value 2006	Average Value 2007	Average Value Δ	*P*	Δ b/w Treatment†	*t*	*P*
Biometric screening value											
Weight	193.6	193.6	−0.1	0.7403	191.8	193.2	1.4	0.0008	−1.5	−3.4	0.0007
BMI	28.7	28.8	0.1	0.0056	28.4	28.7	0.3	<0.0001	−0.2	−3.4	0.0006

*Multinomial models used "no change in risk" as the reference category, while cumulative models used "increased risk" as the reference group. Odds ratios represent the odds of intervention compared to control.

†"Δ b/w Treatments" was calculated as Intervention-Control.

acteristics of treatment and control subjects after weighting using propensity score methods. As shown, the weighting process proved successful as there were no statistically significant differences found between treatment and control subjects on any of the variables examined.

Changes in the Risk Profile of Cohort Participants after 1 Year

After adjusting for baseline differences, we observed no statistically significant differences in the prevalence of overweight and obesity after 1 year when comparing treatment and control subjects in a DID analysis using logistic regression. McNemar's χ^2 tests indicated that the prevalence of overweight increased significantly by 1.7% (P = 0.0348) in the treatment group, but there was no similar increase in obesity rates, whereas in the control group no significant differences were found in the prevalence of obesity or overweight rates over time (Table 2).

However, in our DID analysis, we found statistically significant differences between treatment and control subjects when examining subjects' weight, in pounds, and BMI values. Independent t-tests indicated that, on average, the treatment group lost 0.1 pounds whereas the control group gained 1.4 pounds, resulting in a net difference of 1.5 pounds between groups (P = 0.0007). In addition, independent t-tests indicated that the average BMI score for the treatment group increased 0.1 whereas the control group BMI increased 0.3, thus producing a net statistically significant difference of 0.2 (P = 0.0006).

As for other weight-related risk factors, greater improvements were found for subjects in the treatment group compared to controls. There was a statistically significant net reduction in high blood pressure risk (odds ratio [OR] = 2.8, P = 0.00399) and actual systolic ($P <$ 0.0001) and diastolic (P = 0.0004) blood pressure values for treatment subjects compared to controls. The

TABLE 3
Outcomes for Secondary Hypotheses by Intervention and Control With Propensity Scores

	Intervention (n = 2486)*				Control (n = 633)*				Intervention vs Control			
	% At High Risk 2006	% At High Risk 2007	% At High Risk Δ	P	% At High Risk 2006	% At High Risk 2007	% At High Risk Δ	P	Logistic Regression Model†	Odds Ratio	χ^2	P
Health risk												
Poor nutrition	76.4	72.8	−3.6	<.0001	73.7	72.4	−1.3	0.0825	Cumulative	1.1	1.0	0.3061
Poor physical activity	9.6	8.0	−1.6	0.0057	6.1	4.3	−1.8	0.0001	Multinomial (−)	1.3	1.4	0.2359
									Multinomial (+)	1.2	0.4	0.5295
Tobacco use	11.4	10.0	−1.4	0.0001	9.5	10.2	0.7	0.0388	Multinomial (−)	1.8	2.9	0.0872
									Multinomial (+)	0.6	2.5	0.1141
High alcohol use	4.1	3.5	−0.7	0.0468	1.8	2.6	0.8	0.0071	Multinomial (−)	1.7	1.6	0.2124
									Multinomial (+)	0.7	1.0	0.3295
High stress	2.7	2.2	−0.5	0.1059	2.4	1.4	−1.0	0.0005	Cumulative	1.1	0.0	0.8351
Biometric screening risk												
High blood pressure	3.8	2.4	−1.3	0.0077	0.7	1.6	0.9	0.0090	Multinomial (−)	2.8	4.2	0.0399
									Multinomial (+)	0.9	0.1	0.7004
High cholesterol	9.4	11.6	2.1	0.0044	10.6	11.5	0.9	0.1964	Multinomial (−)	0.8	0.6	0.4361
									Multinomial (+)	1.4	1.4	0.2415
High blood glucose	3.6	4.6	1.0	0.0193	3.0	2.5	−0.5	0.0719	Multinomial (−)	1.7	0.8	0.3841
									Multinomial (+)	3.4	3.8	0.0502

	Average Value 2006	Average Value 2007	Average Value Δ	P	Average Value 2006	Average Value 2007	Average Value Δ	P	Δ b/w Treatment‡	t	P
Biometric screening value											
BP systolic	124.4	124.2	−0.2	0.5340	124.6	126.0	1.4	0.0003	−1.6	−4.9	<.0001
BP diastolic	80.5	77.9	−2.6	<.0001	79.8	78.4	−1.4	0.0017	−1.2	−2.9	0.0040
Cholesterol	194.8	195.3	0.4	0.5744	196.3	197.9	1.5	0.2270	−1.1	−1.0	0.3440
Blood glucose	94.2	97.3	3.0	<.0001	95.0	94.5	−0.5	0.3538	3.6	5.8	<.0001

*The sample for biometric measures is a subset of the overall health risk sample. The biometric sample size is n = 1564 (intervention), n = 417 (control).
†Multinomial models used "no change in risk" as the reference category, whereas cumulative models used "increased risk" as the reference group. Odds ratios represent the odds of intervention compared to control.
‡"Δ b/w Treatments" was calculated as Intervention-Control.

treatment group had higher odds of decreasing tobacco use over time (OR = 1.8, $P = 0.0872$), and although these findings were directional, they did not achieve significance. Counter to expectations, high blood glucose prevalence increased more in the treatment group compared to the control group (approaching significance with an OR = 3.4, $P = 0.0502$), and actual blood glucose levels increased significantly for treatment subjects ($P < 0.0001$) (Table 3).

Examining the Effects of Gender and Missing Data

After stratifying the data by gender, we found that the subject's gender did not greatly influence changes on certain weight-related risk factors (Data not shown). We also controlled for the effects of attrition and missing data using the two techniques previously mentioned: non-response weighting and mean based imputation. In general, our prior findings were unaffected by missing data. Although there were some minor differences in the within-treatment group analysis, all of the DID results were substantiated when missing data were considered in the analyses (Tables 4 and 5).

Discussion

As part of a large-scale longitudinal study sponsored by the NHLBI, several universities and research centers around the US are studying whether relatively low-cost environmental and social-ecological interventions introduced at the workplace can bring about changes in overweight and obesity rates among workers, and reduce health risks associated with several chronic diseases. Our research team, partnered with the Health Services staff at Dow, designed, implemented, and evaluated evidence-based environmental interventions that complement individually focused health promotion programs. More information on the overall design of this project and detailed descriptions of

TABLE 4
Non-Response Weight: Outcomes for Hypotheses by Intervention and Control With Propensity Scores

	Intervention (n = 1464)				Control (n = 323)				Intervention vs Control			
	% At High Risk 2006	% At High Risk 2007	% At High Risk Δ	*P*	% At High Risk 2006	% At High Risk 2007	% At High Risk Δ	*P*	Logistic Regression Model†	Odds Ratio	χ^2	*P*
Biometric screening risk												
Obese	35.1	35.7	0.6	0.3607	37.5	38.0	0.5	0.6676	Multinomial (−)	1.5	4.0	0.0466
									Multinomial (+)	1.6	5.3	0.0216
Overweight	38.8	40.3	1.5	0.1116	42.0	41.9	−0.1	0.9534	Multinomial (−)	1.0	0.0	0.9924
									Multinomial (+)	1.2	1.9	0.1636
High blood pressure	3.9	2.3	−1.6	0.0064	0.9	1.4	0.5	0.5239	Multinomial (−)	3.6	21.0	<.0001
									Multinomial (+)	1.0	0.0	0.9751
High cholesterol	9.1	11.7	2.5	0.0030	9.1	10.7	1.6	0.3451	Multinomial (−)	1.1	0.2	0.6803
									Multinomial (+)	1.2	2.2	0.1370
High blood glucose	3.7	4.6	0.8	0.0950	2.6	2.3	−0.3	0.6246	Multinomial (−)	1.3	0.6	0.4299
									Multinomial (+)	4.0	15.3	<.0001

	Average Value 2006	Average Value 2007	Average Value Δ	*P*	Average Value 2006	Average Value 2007	Average Value Δ	*P*	Δ b/w Treatment‡	*t*	*P*
Biometric screening value											
Weight	194.2	194.0	−0.2	0.5914	196.5	198.3	1.7	0.0005	−1.9	−4.1	<.0001
BMI	28.8	28.9	0.1	0.0134	28.9	29.3	0.4	<.0001	−0.3	−4.1	<.0001
BP systolic	124.2	124.1	−0.1	0.8215	124.6	127.6	3.0	0.0002	−3.1	−4.7	<.0001
BP diastolic	80.8	78.0	−2.8	<.0001	79.9	78.6	−1.3	0.0065	−1.5	−3.5	0.0005
Cholesterol	194.7	195.5	0.8	0.2646	194.2	196.6	2.4	0.0823	−1.6	−1.3	0.1897
Blood glucose	94.5	97.4	2.8	<.0001	95.2	94.8	−0.3	0.6127	3.1	5.0	<.0001

*Multinomial models used "no change in risk" as the reference category, whereas cumulative models used "increased risk" as the reference group. Odds ratios represent the odds of intervention compared to control.
†"Δ b/w Treatments" was calculated as Intervention-Control.
There were no missing values for health risk variables; therefore, the model outcomes are the same as those in Tables 2 and 3.

the interventions introduced at Dow and other study sites can be found in previous articles.[59,63–66]

In this paper, we report our first year results from the interventions implemented at Dow. These are interim results since our intervention is intended to last 2 years. Although future papers will report on longer-term outcomes, we felt it was important to present our first year findings as a midpoint analysis of program impact. A similar approach, whereby interim and longer term results were reported in multiple publications, was used for a series of studies focused on Johnson & Johnson's landmark Live for Life health promotion programs (New Brunswick, NJ), which were first introduced by the company in the late 1970s.[67–72] First year findings were published for Johnson & Johnson, followed by studies reporting multi-year results.[30]

Our analysis was focused on the central hypothesis for this study. The hypothesis concerns changes in overweight and obesity prevalence for all employees exposed to environmental intervention at treatment sites, regardless of the intensity level of the intervention, compared to employees at control sites receiving the standard individually-oriented programs. For employees at the treatment sites, the null hypothesis was that the change in outcomes would be the same as for employees at the control sites. Secondary sets of hypotheses concerned reductions in weight-related risk factors when comparing treatment and control subjects.

After 1 year of exposure to environmental interventions, we found no statistically significant reductions in the prevalence of overweight and obesity among treatment subjects, compared to controls. In fact, we found an increase in the prevalence of obesity among treatment subjects. We did, however, find that control subjects gained weight after 1 year while treatment subjects maintained their weight. This produced a very modest (1.5 pound) but statistically

TABLE 5
Mean Based Imputation: Outcomes for Hypotheses by Intervention and Control With Propensity Scores

	Intervention (*n* = 1464)				Control (*n* = 323)				Intervention vs Control			
	% At High Risk 2006	% At High Risk 2007	% At High Risk Δ	*P*	% At High Risk 2006	% At High Risk 2007	% At High Risk Δ	*P*	Logistic Regression Model*	Odds Ratio	χ^2	*P*
Biometric screening risk												
Obese	34.4	35.0	0.6	0.3134	34.7	35.0	0.2	0.8143	Multinomial (−)	1.5	3.01	0.0830
									Multinomial (+)	1.7	6.63	0.0100
Overweight	38.8	40.5	1.7	0.0593	40.5	40.0	−0.5	0.7795	Multinomial (−)	1.0	0.02	0.8789
									Multinomial (+)	1.3	2.96	0.0852
High blood pressure	4.0	2.4	−1.5	0.0070	0.9	1.6	0.7	0.3515	Multinomial (−)	4.0	23.23	<.0001
									Multinomial (+)	1.0	0.01	0.9114
High cholesterol	9.4	11.6	2.1	0.0108	10.6	11.5	0.9	0.5539	Multinomial (−)	1.1	0.62	0.4316
									Multinomial (+)	1.4	4.74	0.0294
High blood glucose	3.6	4.6	1.0	0.0365	3.0	2.5	−0.5	0.4095	Multinomial (−)	1.1	0.12	0.7254
									Multinomial (+)	4.9	18.24	<.0001

	Average Value 2006	Average Value 2007	Average Value Δ	*P*	Average Value 2006	Average Value 2007	Average Value Δ	*P*	Δ b/w Treatment†	*t*	*P*
Biometric screening value											
Weight	193.6	193.6	−0.1	0.7403	191.8	193.2	1.4	0.0008	−1.5	−3.40	0.0007
BMI	28.7	28.8	0.1	0.0056	28.4	28.7	0.3	<.0001	−0.2	−3.44	0.0006
BP systolic	124.4	124.2	−0.2	0.5393	124.7	126.0	1.4	0.0573	−1.6	−2.50	0.0126
BP diastolic	80.5	77.9	−2.6	<.0001	79.8	78.4	−1.4	0.0012	−1.2	−2.93	0.0035
Cholesterol	194.9	195.3	0.4	0.5461	196.3	197.9	1.5	0.2270	−1.1	−0.92	0.3573
Blood glucose	94.2	97.3	3.0	<.0001	95.0	94.5	−0.5	0.3538	3.6	5.89	<.0001

*Multinomial models used "no change in risk" as the reference category, whereas cumulative models used "increased risk" as the reference group. Odds ratios represent the odds of intervention compared to control.
†"Δ b/w Treatments" was calculated as Intervention-Control.
There were no missing values for health risk variables; therefore, the model outcomes are the same as those in Tables 2 and 3.

significant difference in weight gain when comparing treatment and control subjects against baseline. From a clinical perspective, and at an individual level, a 1.5 pound difference in weight is not very meaningful. However, from a population standpoint it may be meaningful, especially if weight reduction, or the lack of weight gain, can be achieved for large groups of people and sustained over several years, and if the trend in weight gain can be attenuated.

The finding that treatment subjects maintained their weight, as measured in pounds, but their rates of overweight and obesity increased, though not more so than for control subjects, was counterintuitive until further analysis was conducted (not shown). We found that almost all employees (93%) at the treatment sites did not change their BMI categories even though some on average, lost weight. In contrast, two-thirds of treatment subjects who gained weight moved from a lower to a higher risk weight category.

As for secondary outcomes, we observed some positive changes in several risk factors. Workers at the treatment sites were significantly more likely to reduce their blood pressure compared to control site workers, and there was a trend toward decreased tobacco use. However, contrary to expectations, blood glucose levels for treatment subjects increased significantly compared to control group subjects.

We did not observe any major differences in risk reduction for males compared to females. In addition, when controlling for missing data at follow-up using two different methods, our initial results were corroborated.

Overall, our analysis revealed a modest effect on population health risks when environmental interventions are introduced at the worksite. In terms of overweight and obesity, these effects were achieved because treatment subjects maintained their original weight while control subjects gained weight even after 1 year.

However, results are tentative and will need to be revisited after more years of data become available. Other positive intervention effects were noted for blood pressure reductions among treatment subjects, but, unexpectedly, blood glucose levels increased for treatment subjects more so than for control subjects.

Limitations

A limitation of this study is that 12 sites participated in the study, although data for several thousands of workers at those sites were analyzed. Environmental interventions are intended to affect all workers at each site in a similar fashion, and so some may argue that the unit of analysis should be the site and not the worker. To address this limitation, we studied the effects of the intervention on all employees at the study sites and adjusted for differences in employee characteristics, as well as their placement at treatment and control sites, using a DID design with propensity score weighting. Ideally, many thousands of sites exposed to an environmental intervention would be compared to many thousands of other not exposed. But such a design would be costly and hard to implement in a real-world setting. A strength of the study was that nine treatment sites were randomly assigned to either moderate or intense conditions and the effects of engaging senior leadership in environmental interventions at intense sites will be examined more closely in future analyses.

Another limitation is that behavioral risk data were self-reported using an HRA. However, a strength of the study is that biometric data were professionally collected using standard clinical protocols developed by Dow's Health Services. Unfortunately, at one control study site, blood pressure measurements at baseline were taken using non-approved protocols, and therefore the validity and reliability of those measures were questionable, and those baseline data were removed from the database.

Another limitation relates to the ease or difficulty of implementing environmental interventions at the study sites, and the fidelity of those interventions across sites. For example, instituting a uniform vending machine policy was very challenging because it required coordination with vendors to ensure that machines were stocked with healthy food items, healthy items were labeled correctly, and promotional pricing was in place. Because of limited parking options, it was cost-prohibitive to establish parking areas more than 500 feet from the worksite. Due to safety hazards, the use of walking paths was limited because company policy required wearing heavy personal protective equipment by employees when outdoors, and hot weather precluded extensive outdoor exercise. In the course of our research, we collected many process measures related to treatment fidelity and will report our findings on these in future papers.

Although there were barriers to implementing certain environmental interventions at Dow worksites, many programs were put in place in just 1 year and they operated effectively. All treatment sites implemented worksite walking paths, provided shower facilities, offered healthy food choices in vending machines or cafeterias, introduced new on-line weight management programs, and offered substantially more health education materials and programs. Many worksites also received increased local leadership support and attention as well as support from corporate headquarters. As noted, many of the interventions were slow to begin, and full implementation did not start until the second intervention year of the study; thus, the modest gains observed after only 1 year are to be expected.

Conclusions

This research provides preliminary evidence that environmental interventions may produce a positive impact on biometric and behavioral risk factors, albeit small, when added to individual interventions, after the first year of implementation. Future research will examine longer-term outcomes, differential effects of being at moderate or intense site locations, and program effects on health care utilization, absenteeism, and presenteeism. At the conclusion of the study, we will examine the cost-benefit of offering environmental interventions at the worksite which, in general, are less expensive than individually-oriented health promotion programs.

A general observation is that it probably takes longer to introduce environmental interventions that exert a positive health impact than individual interventions. It is likely that introducing changes to the environment by, for example, altering vending machine contracts, introducing new cafeteria menus, posting signs, updating company policies, engaging leadership, setting health goals, and revising recognition programs may be more cumbersome and administratively burdensome compared to providing individual coaching and counseling programs. Layers of approval are needed to design new programs and management buy-in has to be negotiated before programs are accepted and implemented. Thus, newly introduced environmental programs may need additional time to achieve their desired effect. Nonetheless, the modest effects shown here after only 1 year are reassuring, and further research will determine whether these changes are maintained and enhanced over a longer time period.

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Appendix

APPENDIX
Operational Definitions for Health Risks

	Definitions
Health risk	
Poor nutrition	4 or more fast food meals per week OR 2 or more sweetened beverages per day OR 3 or fewer fruit and vegetable servings per day
Poor physical activity	Does not engage in moderate or strenuous activity at least once per week
Tobacco use	Currently using tobacco
High alcohol use	Men—3 or more drinks per day OR 15+ drinks per week Women—2 or more drinks per day OR 8+ drinks per week
High stress	Reported being in high stress over the past four wk and having poor ability to deal with stress
Biometric risk	
Obese	BMI greater than or equal to 30
Overweight	BMI between 25 and 29.9
High blood pressure	Blood pressure 160/100 or higher (systolic/diastolic)
High cholesterol	Total cholesterol 240 mg/dL or higher
High blood glucose	Blood glucose 126 mg/dL or higher
Control variables*	
Age	years of age at time of 2006 survey
Gender	Male or female
Ethnicity	American Indian/Alaska Native, Asian, Black/African American, Hispanic/Latino, and Caucasian
Exempt status	Exempt, non-exempt, unknown
Work status	Officials and Managers, Professionals, & Sales; Technicians, Office and Clerical, & Craft Workers (skilled); Operatives (semi-skilled), Laborers (unskilled), & Service Workers
Education	Not Indicated, Less than Bachelor Degree, Bachelor Degree, Masters or Doctorate
Disease severity	Based on the CCI: 0 comorbidities; 1 comorbidities; 2 comorbidities; 3 comorbidities; 4 comorbidities; 5 or more comorbidities; Unknown

*Control variables may have been reclassified in some analyses due to quasi-separation of data points.