

## Special Article

A CONTROLLED TRIAL OF AN EDUCATIONAL PROGRAM TO PREVENT  
LOW BACK INJURIESLAWREN H. DALTRY, DR.P.H., MAURA D. IVERSEN, B.S.P.T., S.D., MARTIN G. LARSON, S.D., ROBERT LEW, PH.D.,  
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AND MATTHEW H. LIANG, M.D., M.P.H.**ABSTRACT**

**Background** Low back injuries are common and costly, accounting for 15 to 25 percent of injuries covered by workers' compensation and 30 to 40 percent of the payments made under that program. The high costs of injury, the lack of effective treatment, and the evidence that there are behavioral risk factors have led to widespread use of employee education programs that teach safe lifting and handling. The effectiveness of those programs, however, has received little rigorous evaluation.

**Methods** We evaluated an educational program designed to prevent low back injury in a randomized, controlled trial involving about 4000 postal workers. The program, similar to that in wide use in so-called back schools, was taught by experienced physical therapists. Work units of workers and supervisors were trained in a two-session back school (three hours of training), followed by three to four reinforcement sessions over the succeeding few years. Injured subjects (from both the intervention and the control groups) were randomized a second time to receive either training or no training after their return to work.

**Results** Physical therapists trained 2534 postal workers and 134 supervisors. Over 5.5 years of follow-up, 360 workers reported low back injuries, for a rate of 21.2 injuries per 1000 worker-years of risk. The median time off from work per injury was 14 days (range, 0 to 1717); the median cost was \$204 (range, zero to \$190,380). After their return to work, 75 workers were injured again. Our comparison of the intervention and control groups found that the education program did not reduce the rate of low back injury, the median cost per injury, the time off from work per injury, the rate of related musculoskeletal injuries, or the rate of repeated injury after return to work; only the subjects' knowledge of safe behavior was increased by the training.

**Conclusions** A large-scale, randomized, controlled trial of an educational program to prevent work-associated low back injury found no long-term benefits associated with training. (N Engl J Med 1997; 337:322-8.)

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LOW back pain affects 70 to 80 percent of adults at some time.<sup>1</sup> In the United States and Canada,<sup>2-4</sup> low back injuries constitute 15 to 25 percent of the injuries covered by workers' compensation and account for 30 to 40 percent of workers' compensation payments. Most compensation claims related to back injury (87 percent) are for strains and sprains, most of which (72 percent) are due to overexertion, as in lifting and handling.<sup>4</sup> Back schools are educational programs developed by physical therapists for patients with back pain.<sup>5-7</sup> Most such programs include information on back anatomy and physiology, the mechanisms of pain, pain management, good posture, safe techniques of lifting and handling, and muscle strengthening and stretching; the training is given in small groups.<sup>8</sup> Despite the variable and inconclusive results of controlled clinical trials of training,<sup>1,8-10</sup> the high cost of back injuries, the lack of effective treatment, and evidence of the existence of behavioral risk factors have led to widespread adoption of employee education programs that teach safe lifting and handling as a form of primary prevention.<sup>1,11</sup>

The first reports of the success of back schools in reducing rates of industrial low back injury came from trials using historical controls<sup>12,13</sup> and have not been supported by more broadly based comparisons of companies with and without such programs.<sup>14</sup> Lahad et al.<sup>15</sup> identified several randomized, controlled trials of education and exercise programs in the

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workplace.<sup>16-21</sup> Programs including exercise reduced back pain and the number of sick days, but no program reduced injury rates. The generalizability of these studies was limited by the small samples and a focus on volunteers or subjects with a history of back problems. Lahad et al.<sup>15</sup> concluded that although there is some evidence that exercise prevents low back pain, the justification for other prevention strategies is insufficient. Several recent studies of back schools have found improved intermediate outcomes associated with training, such as increased knowledge, safer behavior, and fewer visits to a doctor, but no reductions in injury rates or sick leave.<sup>22-25</sup>

We developed a back school for the primary prevention of low back injury and evaluated it in a large, randomized, controlled trial in an industrial setting, which included all employees of the two facilities involved. The program's design and its effect on workers' knowledge and behavior have been described elsewhere<sup>26</sup>; the effect on rates of low back injury is described here.

## METHODS

### Population

The study population consisted of approximately 4000 U.S. postal workers at two mail-processing facilities. Before the study, low back injury occurred at a rate of 2.4 percent per year and accounted for 17 percent of workers' compensation injuries and 35 percent of workers' compensation payments, figures similar to national averages. The workers studied included mail handlers (and some maintenance workers), who do heavy lifting — such as handling 16-to-32-kg (35-to-70-lb) bags — and clerks, who do light work, such as manual or mechanized mail sorting. In the study population, 70 percent of low back injuries in the five years before the study began were related to lifting and handling.

### Intervention

The intervention, described in detail elsewhere,<sup>26</sup> included all elements of typical employee-education programs on low back safety<sup>5,6,27</sup> but was adapted to a Postal Service setting (Table 1) and was designed with extra features according to health-education principles.<sup>28</sup> Workers and supervisors, in groups of 10 to 12, were taught principles of back safety, correct lifting and handling, posture, exercises, and pain management; the instructors were physical therapists. The therapists examined each work station with workers and supervisors and suggested physical and procedural modifications, such as the adjustment of shelf heights, the use of lumbar supports on chairs, the installation of rollers on chairs, and changes in the pacing of mechanized operations. Workers and line supervisors discussed ways to facilitate implementation. Protective equipment, such as lifting belts, was not part of the program. Subjects were trained in work-unit groups in order to allow workers and supervisors to establish and reinforce norms of proper lifting and handling and to reduce the likelihood that the workers given training would interact with and influence the control group. The therapists provided additional reinforcement training six months after the first sessions and yearly thereafter.

Because the Postal Service considered the program to be an employee-safety initiative, attendance at training sessions was mandatory, on paid company time, for workers and supervisors in the intervention group. Protocols for data collection and safeguards for the protection of the workers' privacy and rights were negotiated with union representatives and approved by our hospital's Committee to Protect Human Subjects from Research Risks.

**TABLE 1. ELEMENTS OF THE PROGRAM TO PREVENT BACK INJURY.**

|   |
|---|
| Teaching staff  |
| Physical therapists   |
| Classroom methods   |
| Two 90-minute sessions  |
| 12 workers and supervisors per class  |
| Lecture   |
| Discussion  |
| Film and slides   |
| Pamphlets   |
| Demonstration and practice  |
| Program content   |
| Safe lifting and handling   |
| Posture while sitting, standing, and lying down   |
| Pain management   |
| Stretching and strengthening exercises  |
| Group discussion of barriers to implementation  |
| On-site work-station ergonomic analysis   |
| Reinforcement   |
| Physical therapists observe work stations, followed by review with supervisor, workers, or both                             |
| Supervisors trained to provide reinforcement to workers, with in-person or videotape review of supervisor's skills annually |
| Pamphlets, paycheck stuffers (1 or 2 a year)  |

### Design

The study was a randomized, controlled trial lasting 5.5 years. The unit of analysis was the work unit: an administrative grouping of employees, usually on the same shift, working under a common general supervisor in a shared work environment. We arranged 34 work units into 17 pairs, matched on the basis of craft (clerk or mail handler [the latter category included a small number of maintenance workers]) and job characteristics (machine or manual work), and we randomly assigned 1 unit of each pair to receive training and the other to serve as a control group. All the workers (including controls) received the standard Postal Service training in back-injury prevention (a film shown at the orientation of new employees) as well as periodic safety talks given at their supervisors' discretion. Control workers transferring into intervention-group units were also trained, to reduce any diminution of the intervention's effect. Data on exposure to risk and injury were not collected for a matched pair of units until training began in the intervention-group unit.

If a worker had a back injury, we calculated the number of calendar days between the injury and the subject's return to work. The individual worker was the unit of analysis for the assessment of the effect of pre-injury training on time off from work. Decisions about return to work were made independently of the study. When they returned to work, injured subjects (from both the intervention group and the control group) were randomly assigned to participate or not in the ongoing back-education classroom sessions and were stratified according to the original status of their work unit (intervention group or control group). Injured subjects from control units received training, on their return to work, in primary-prevention sessions with a neighboring intervention-group unit, but they continued working in their own original work units. This secondary randomization allowed us to assess, in a two-by-two factorial design, the differential effect of classroom training (intervention-group training vs. secondary training of controls) on time until further injury for individual workers.

### Measured Variables and Data Management

The data collected from computerized Postal Service records included the subject's craft category (clerk or mail handler [including maintenance workers]), sex, age, duration of employ-

ment, work unit, shift, and hours worked (as estimated quarterly for each work unit). The occurrence of a back injury, its cause, and its cost were determined on the basis of workers' compensation claims and Postal Service accident reports; either data source was sufficient to identify a case, but 89 percent of the injuries were identified from both sources. Diagnoses (acute low back pain, with or without radiculopathy; chronic low back pain; and disk or inflammatory disease) were taken from the workers' compensation claim forms filled out by the workers' physicians. Data on individual injured workers were cross-checked by hand.

### Statistical Analysis

In the main hypothesis test we used extended log-linear models<sup>29</sup> to compare rates of low back injury in the intervention and control groups. Only a worker's first injury was counted. In secondary analyses, we examined the intervention's effect on the rates of other musculoskeletal injuries (not low back) related to lifting and handling. Time off per injury and time until further injury were modeled with life-table analyses.<sup>30</sup> Given the highly skewed distributions, we compared the costs of injuries with Wilcoxon rank-sum statistics. Our main analysis was based on the assignment of work units to be trained, regardless of the actual percentage of workers trained, but we also modeled workers' actual exposure to the education program. We regard an intention-to-treat analysis as the appropriate one for assessing a policy of training all workers.

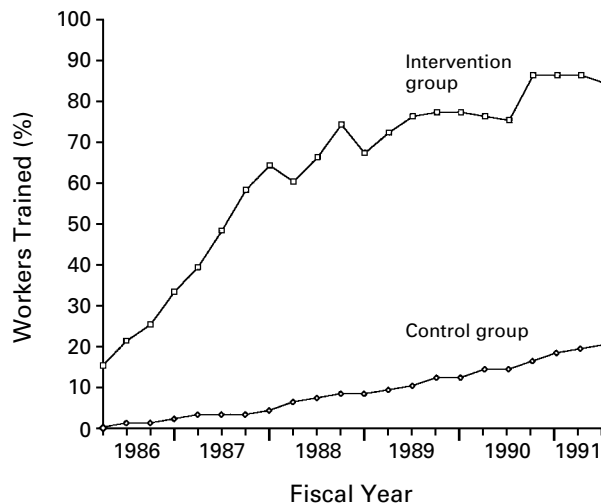
We estimated that we would need data on 390 injuries to have an 80 percent power to detect a 25 percent reduction in injury rates ( $\alpha = 0.05$ ).<sup>31</sup> If there were 5000 workers in the study and a base injury rate of 17 per 1000 worker-years (1 worker-year consisting of 2000 hours of work), 390 injuries would accrue in 5 years. This sample size and estimated injury rate would also give the study an 80 percent power to detect a 25 percent reduction in days off from work per injury and in time until further injury, as assessed with survival-analysis techniques.

## RESULTS

### Program Implementation

Over a period of five years (from September 1985 to September 1990), 12 staff physical therapists and 2 senior therapists trained 2534 workers and 134 supervisors in primary prevention. After the end of training, we continued to track injuries and their costs for six months. During the study period, there were 8886 reinforcement contacts (personal, video, and written) from the physical therapists (3.5 per worker), plus an undocumented amount of reinforcement by line supervisors. Training sessions were scheduled so as not to interfere with the work units' productivity; periodic catch-up sessions maintained each unit's training level.

In the last three years of the study, we maintained an average of 71 percent of workers trained (range, 66 to 86 percent) in intervention-group work units (Fig. 1); transfers gradually contaminated the control-group units (20 percent of control-group workers had received training by the end of the study). The average proportion of trained subjects, during all 5.5 years of the study, was 61 percent in intervention-group units and 8 percent in control-group units. Worker turnover prevents any simple characterization of the study groups, but a cross-section of the population in the fourth quarter of fiscal 1990



**Figure 1.** Percentage of Postal Service Workers Trained, According to Study Group.

Data points are for the midpoint of each quarter of the fiscal year.

showed the two study groups to be similar in age, sex, craft category, and duration of employment (Table 2). A survey conducted at the study's midpoint<sup>26</sup> found significant increases in knowledge of safe behavior among workers in the intervention group, as compared with the control group, but no significant improvements in actual behavior, as reported by the subjects, or significant reductions in the proportion of workers with tired backs.

### Rates of Primary Low Back Injury

Among the subjects, 360 had low back injuries in 16,960 worker-years of exposure to risk (21.2 injuries per 1000 worker-years of exposure), a rate similar to that seen in national data and historical data from the site. Most of the injuries (93 percent) were characterized by acute low back pain (or strain), and 85 percent were due to lifting and handling (Table 3). Of the injuries, 58 percent caused the loss of at least one workday beyond the day of injury itself.

### Primary Prevention of Low Back Injury

As recorded quarterly, each work unit in the study had a slowly changing mix of trained and untrained mail handlers and clerks. We estimated the effect of the intervention on the rates of primary injury with log-linear models, examining the influence of craft, season, fiscal year, and proportion of trained workers in the work unit for each quarter. Only the craft category had a statistically significant effect on outcome; mail handlers had a higher injury rate than clerks (rate ratio, 1.24; 95 percent confidence interval, 1.01 to 1.53). The variation in outcome according to fiscal year was nearly significant (chi-square = 8.96, 5 df;  $P = 0.11$ ). Intervention-group units had

**TABLE 2.** CHARACTERISTICS OF INTERVENTION-GROUP AND CONTROL-GROUP WORK UNITS AS OF THE FOURTH QUARTER OF FISCAL 1990.

| CHARACTERISTIC                                  | INTERVENTION    | CONTROL         |
|---|-----------------|-----------------|
| No. of workers                                  | 1703            | 1894            |
| Mean ( $\pm$ SD) age — yr                       | 43.0 $\pm$ 12.0 | 42.0 $\pm$ 12.5 |
| Average ( $\pm$ SD) duration of employment — yr | 6.2 $\pm$ 4.0   | 5.1 $\pm$ 3.8   |
| Male sex — %                                    | 75              | 74              |
| Clerks — %*                                     | 60              | 65              |

\*The workers who were not clerks were mail handlers or maintenance workers.

**TABLE 3.** CHARACTERISTICS OF 360 WORKERS WITH LOW BACK INJURIES.

| CHARACTERISTIC  | VALUE       |
|---|-------------|
| Male sex — %  | 66          |
| Clerks — %*   | 58          |
| Age — yr  |             |
| Median  | 33          |
| Range   | 18–73       |
| Duration of employment — mo   |             |
| Median  | 33          |
| Range   | 1–378       |
| History of back injury in past 3 yr — %                               | 6           |
| Acute low back pain, with or without radiculopathy — %                | 93          |
| Chronic low back pain — %   | 3           |
| Disk or inflammatory disease — %                                      | 4           |
| Lifting-and-handling-related injury — %                               | 85          |
| Lost $\geq$ 1 workday after injury — %                                | 58          |
| No. of calendar days until return to work for those losing work time† |             |
| 25% back at work  | $\leq$ 8    |
| 50% back at work  | $\leq$ 14   |
| 75% back at work  | $\leq$ 40   |
| 100% back at work   | $\leq$ 1717 |

\*The workers who were not clerks were mail handlers or maintenance workers.

†Numbers of days shown are for quartiles of workers returning after losing work time due to back injury. Data on 10 workers were censored because the study ended before they returned to work.

a higher rate of injury than control-group units (rate ratio, 1.11; 95 percent confidence interval, 0.90 to 1.37), but the difference was not significant. Similarly, trained workers had a higher rate of injury than untrained workers (rate ratio, 1.12; 95 percent confidence interval, 0.49 to 2.55), but the difference was not significant. The intervention's effect remained nonsignificant, even when we controlled for craft category and year. The comparison of trained and untrained workers within the study groups, ac-

ording to craft category (Table 4), showed that trained workers had lower rates of injury in three of the four comparisons, and that untrained workers in intervention-group units had a higher rate of injury than untrained workers in control-group units.

There were 177 lifting-and-handling injuries that caused lost workdays (10.4 such injuries per 1000 worker-years). These are the most consequential of the injuries that might be influenced by an intervention to change behavior. Mail handlers had higher rates of this type of injury than did clerks (rate ratio, 1.34; 95 percent confidence interval, 0.99 to 3.61). In a pattern consistent with historical data, there were significant seasonal variations in the rate of these injuries (chi-square = 15.02, 2 df;  $P < 0.001$ ); the rate was almost twice as high in spring and summer as in fall and winter. Although the rate of major lifting-and-handling injuries was higher in intervention-group units than in control-group units (rate ratio, 1.29; 95 percent confidence interval, 0.96 to 1.73), the difference was not significant, even when we controlled for craft category and season. Trained and untrained workers had similar rates of this type of injury (rate ratio, 0.97; 95 percent confidence interval, 0.74 to 1.30).

**Other Musculoskeletal Injuries**

We used accident-report data to examine the effect of the program on lifting-and-handling injuries to other major muscle groups (neck, abdomen, chest, hip, shoulder, trunk, and thigh) that would presumably be protected, like the back, by changes in behavior. Since the intervention focused on injury to the back, we expected the data on other injuries to be less susceptible to reporting bias and Hawthorne effects (responses to administrative concern over working conditions rather than the intervention itself).

There were 359 accident reports of musculoskeletal injuries not involving the back that were due to lifting and handling and related unsafe practices (21.2 such injuries per 1000 worker-years). The rate of these injuries was 15.4 per 1000 worker-years for control-group clerks, 19.8 per 1000 for intervention-group clerks, 28.0 per 1000 for control-group mail handlers, and 27.2 per 1000 for intervention-group mail handlers. Mail handlers had a higher rate of such injuries than clerks (rate ratio, 1.58; 95 percent confidence interval, 1.24 to 2.02), but there was no significant difference between the intervention group and the control group (rate ratio, 1.15; 95 confidence interval, 0.93 to 1.41), even when we controlled for craft category.

**Time off from Work**

There was little difference in the proportions of total injuries that resulted in lost workdays in the intervention group (61 percent) and the control group

**TABLE 4.** FITTED RATES OF PRIMARY LOW BACK INJURIES AMONG BOSTON POSTAL WORKERS, ACCORDING TO CRAFT CATEGORY, WORK-UNIT ASSIGNMENT TO THE INTERVENTION OR CONTROL GROUP, AND ACTUAL TRAINING STATUS.\*

| CATEGORY OF WORKERS | MAIL HANDLERS                        |                          |                | CLERKS              |                          |                |
|---------------------|--------------------------------------|--------------------------|----------------|---------------------|--------------------------|----------------|
|                     | CONTROL-GROUP UNITS                  | INTERVENTION-GROUP UNITS | COMBINED UNITS | CONTROL-GROUP UNITS | INTERVENTION-GROUP UNITS | COMBINED UNITS |
|                     | rate of injury per 1000 worker-years |                          |                |                     |                          |                |
| Untrained workers   | 21.6                                 | 27.4                     | 23.4           | 19.4                | 23.2                     | 20.4           |
| Trained workers     | 27.2                                 | 25.0                     | 25.4           | 16.4                | 18.0                     | 17.8           |
| All workers         | 22.2                                 | 25.8                     | 24.2           | 19.2                | 20.0                     | 19.5           |

\*The overall crude rate was 21.2 injuries per 1000 worker-years of exposure. The individual rates shown have been fitted to proportional exposure time. A small number of maintenance workers are included in the group of mail handlers.

(56 percent). The only factor significantly associated with the loss of workdays was a history of a workers' compensation claim for a non-back injury in the previous three years (rate ratio, for those with such a history as compared with those without, 3.4; 95 percent confidence interval, 1.28 to 9.03). For the 210 workers with lost workdays, the median time off from work was 14 days (range, 1 to 1717). Survival-analysis (log-rank) models of time elapsed until return to work showed no significant effect associated with assignment to an intervention-group unit or with training before the injury. Only the cause of injury reliably predicted time off from work; the median number of days off was 13 for lifting-related injuries and 18 for injuries not related to lifting (chi-square = 3.99,  $P = 0.046$ ).

#### Cost

The median total cost per back injury, as accrued through the end of the study, was \$204 (range, zero to \$190,380). The median cost was \$103 in the control group (range, zero to \$190,380), and \$309 in the intervention group (range, zero to \$122,145). Workers with a history (before the study) of low back injury had higher median total costs than did workers without such a history (\$1,300 vs. \$192;  $P = 0.005$ ), higher median medical costs (\$150 vs. zero,  $P = 0.03$ ), and higher median personnel-replacement costs (\$965 vs. zero,  $P = 0.004$ ). No other variable, including study group or training status, was significantly associated with cost.

#### Training after Injury

We evaluated whether participation in an ongoing primary-prevention program, after returning to work following a low back injury, prevented further injuries. There were 183 primary injuries among intervention-group workers; 90 of these injured workers

were assigned to training and 93 to no training on their return to work. Of the 90 assigned to training, 62 percent actually received training; of the 93 assigned to no training, 26 percent in fact received subsequent training. The 26 percent training rate in this secondary control group reflects subjects' participation in their units' ongoing primary-prevention sessions.

There were also 177 primary injuries among control-group workers; 84 were assigned to training and 93 to no training on their return to work. Of the 84 assigned to training, 69 percent actually received it; of the 93 designated controls, 5 percent in fact received subsequent training. The median time from return to work until the start of training, for all injured subjects, was five months, because subjects had to wait for the scheduled classes on their shifts.

Of all the injured subjects, 75 (21 percent) had at least one further injury. The median time between return to work and another injury was 4 three-month quarters (range, 0 to 21). Time until further injury was analyzed with Cox regression models,<sup>30</sup> with the quarter as the time unit. The likelihood of repeated injury was higher if the worker had lost more workdays because of the initial injury (rate ratio for  $\geq 15$  days vs. 1 to 14 days vs. none, 1.05; 95 percent confidence interval, 1.01 to 1.09); if the worker had a more serious initial injury, defined as a disk problem, inflammatory disease, or chronic low back pain as compared with acute low back pain alone (rate ratio, 1.62; 95 percent confidence interval, 1.05 to 2.51); or if the worker was a man (rate ratio, 1.66; 95 percent confidence interval, 0.98 to 2.83). Age, craft category, duration of employment, and a history of a low back injury before the start of the study had no effect on the likelihood of repeated injury. When we controlled for the seriousness of the initial injury, the time off from work resulting from

the initial injury, and sex, we found that the study-group assignment, assignment to training or no training after injury, or whether the subject was actually trained had no significant effect on the likelihood of repeated injury. However, the power of our analysis to detect a treatment effect was reduced to 30 percent because of the low rates of actual training among workers assigned to training and contamination of the control group by the inclusion of workers who actually received training.

## DISCUSSION

Employers, eager to reduce the illness, lost work, and cost associated with low back injuries, have adopted back-education programs without clear evidence of their effectiveness. The results of our large, randomized trial indicate that back schools are not by themselves an effective intervention for the primary prevention of industrial low back injury. We found that workers' being in a unit assigned to training or actually being trained had no significant effect on rates of primary low back injury, on time off from work, on costs associated with injury, or on time elapsed until a further injury.

The failure to detect any effect of a program may be due to inadequate sample size, inadequate implementation of the program, or a fundamental lack of efficacy of the program. Our analysis had adequate power (78 percent) to detect meaningful differences between groups, but contrary to our expectations, injury rates were higher in the intervention group than among controls. It is unlikely that our intervention caused injuries; the techniques of lifting and handling that were recommended, which are biomechanically correct in theory and taught in a large number of back schools, have been shown to be capable of reducing the number and severity of back symptoms.<sup>5,7</sup>

Our data suggest that the elevated rate of claims in our study may be due to an increased acceptability of reporting injuries among the intervention-group units (Table 4). In three of four comparisons of trained and untrained workers (in groups defined by craft category and study-group assignment), trained workers had lower injury rates than untrained workers, which suggests that training was effective. Moreover, untrained workers in intervention-group units had higher injury rates than untrained workers in control-group units, which suggests a reporting bias. Finally, the number of reports of lifting-and-handling injuries involving muscle groups other than the back were also higher in the intervention-group units (data not shown).

The education program successfully imparted knowledge and skills related to safe lifting and handling, but despite this training and, for most intervention-group workers, its regular reinforcement, the increased practice of desirable behavior did not

take place. This failure to change behavior reflects complex factors such as the workers' level of job satisfaction and negative perceptions of what supervisors and coworkers were doing to improve back safety.<sup>26</sup> Our program included substantial efforts to maintain and reinforce the practice of learned behavior. If such reinforcement is in fact ineffective, it represents a key weakness in educational programs directed at individual workers and small groups at the work site. Larger economic and social factors, and management-labor issues, may ultimately determine the success or failure of such programs.

The failure of our program to reduce the number of repeated injuries may be due in part to the incomplete and delayed training of returning workers, which significantly reduced the power of the analysis to detect differences between groups. Programs that focus on educating injured workers before their return to work<sup>32</sup> and programs emphasizing exercise for workers after their return<sup>15</sup> may be more effective than our approach. In this trial, we could not study the effect of offering training to freshly injured workers to speed their recovery, because workers resisted participation in such programs while workers' compensation claims were pending.

We believe that by dealing realistically with the challenges of training a changing work force in a large industry, our program has provided a fair test of the ability of back-education programs to limit injuries. Our results are consistent with the findings of the few other randomized, controlled studies of back schools, which have generally found no significant effect of the schools on injury rates, despite some evidence of better pain management and reductions in the number of sick days.<sup>7</sup> Back-education programs may still have a place in reducing back injury and disability, but they appear to be ineffective when undertaken alone.

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