AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 51:307–315 (2008)

# Evaluation of a Community-Based Effort to Reduce Blueberry Harvesting Injury

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**Background** *Harvesting of blueberries is associated with musculoskeletal injury. This study assessed the effects of several alternative designs of the harvesting rake.*
**Methods** *A community-based work team selected rake design for intervention and pilot tested potential design modifications to the blueberry harvesting rake. An "extended" handle design was selected for comparison with the traditional short-handle rake. Tested rakes were of two widths (70 and 80 tines) and four handle lengths (short handle; extended: 10, 14, or 16 in.). Workers rated each of five configurations after 4 hr of use. Evaluators tracked qualitative and quantitative indicators of the community-based approach throughout.*
**Results** *Data from 29 subjects were analyzed using two-factor analysis of variance. There was increased productivity ($P = 0.041$); greater acceptability ($P < 0.0001$); less force ($P < 0.001$); and less pain ($P < 0.0001$) with the extended handle designs. The 80 tine width was favored over the 70. Process evaluation identified problems that generally could be addressed. Outcome evaluation indicated successful achievement of all stated goals.*
**Conclusions** *The "extended" handle rake may prove effective in reducing musculoskeletal injury associated with blueberry harvesting. A community-based approach to migrant farmworker injuries can be effective, particularly if employers participate.* Am. J. Ind. Med. 51:307–315, 2008. © *2008 Wiley-Liss, Inc.*

***KEY WORDS: community based; migrant; farmworker; harvest; ergonomic; blueberry rake; musculoskeletal injury; upper extremity; back; shoulder***

## INTRODUCTION

Each year approximately 8,000 migrant and seasonal farmworkers (MSFW) participate in the harvesting of blueberries in Maine. Over a 3- to 4-week period, blueberries are "raked" from the scrubby "wild" bushes standing no higher than 16 in. off the ground using either mechanical or manual methods. The bulk of the 75 million pounds grown annually in Maine is harvested mechanically [NASS, 2007]. For economic, topographic, and philosophic reasons, a significant amount of land continues to be raked manually by a work force composed of Hispanic (45%), Native American (45%), and local Anglo (10%) workers [Maine Department of Labor, 2004].

Manual raking of wild blueberries can lead to musculoskeletal pain and injury. The process employs comb-like metal rakes with an attached collecting box. These rakes come in varying widths, and usually weigh 3.5–10 lbs. Farmworkers have traditionally used a rake with a single, short, horizontally oriented central handle (Fig. 1) that requires abduction of the wrist to engage the foliage with the rake, then adduction of the wrist while pulling directly up.

Working at a rate sometimes exceeding 30 cycles/min, the raker might pause only intermittently to empty the rake's

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Contract grant sponsor: The National Institute for Occupational Safety and Health; Contract grant numbers: R25, OH08144-02.
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Accepted 20 November 2007
DOI 10.1002/ajim.20554. Published online in Wiley InterScience (www.interscience.wiley.com)

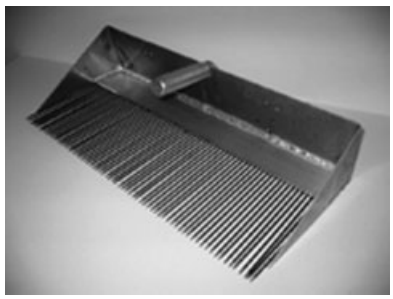

**FIGURE 1.** Traditional short-handle blueberry rake.

collecting box [Tanaka et al., 1995; Estill and Tanaka, 1998]. In recent years, some workers have modified their rakes by adding a longer handle (10–18 in.) attached on either side of the rake (Fig. 2). Using rakes with the two extended handles, workers employ shorter or longer sweeping motions, depending upon the terrain and conditions. Both raking approaches (i.e., using either the traditional or the extended handle) rely upon consistent bending at the waist and rapid, repeated, forceful motions. Evidence from a variety of sources shows that the traditional approach to blueberry raking is associated with ergonomic challenges and related worker injuries [Tanaka et al., 1994; Millard et al., 1996; Estill and Tanaka, 1998].

Detection of these problems led to the development of an ergonomic intervention recommended by the National Institute for Occupational Safety and Health (NIOSH) and disseminated in its Simple Solutions publication [Baron et al., 2001]. Observations of blueberry raking in recent seasons showed no evidence of the wheeled rake pushed with a long handle that was proposed as an intervention. Discussions with both farm owners and farmworkers revealed that adoption of the proposed ergonomic intervention did not succeed because of grower concerns regarding damage to the plants. Thus, this effort may have failed due to insufficient community participation in the identification of an acceptable mode of intervention.

Recognition of the need for a community-based approach [Israel et al., 1998; Arcury, 2000; Lavery et al., 2005] to occupational injury in Maine's blueberry industry underlies the Community Collaboration for Farmworker Health and Safety (CCFHS) project. This collaborative effort between local health practitioners, the Maine Migrant Health Program (MMHP), and the Northeast Center for Agricultural Health (NEC) decided, in 2003, to address occupational health issues in the blueberry industry. The stated goals of this effort were:

(1) Assemble a team of farmworkers, employers, health professionals, and other stakeholders who share the common goal of reducing occupational injury and illness.
(2) Guide the team in establishing injury/illness priorities and identifying prominent risk factors for occupational injury and illness.
(3) Design and test interventions intended to reduce illness/injury under the guidance of the community team. Evaluate the impact of each intervention upon migrant worker injury and illness.
(4) Assess the results of these evaluations with the community team and assist community organizations to disseminate and institutionalize those interventions found to be effective.

The community-based approach described here depends upon a work team (WT) composed of both Hispanic and Native American farmworkers, and representatives from several of the blueberry producers in the ''downeast'' region of Maine. The organization of this team and its efforts in determining priorities for intervention are described in a previous paper [Hawkes et al., 2007]. Briefly, the team relied upon its first-hand knowledge of work processes, epidemiologic data gathered by NEC, ergonomic consultation, and important input from community interviews and focus groups, to designate the reduction of musculoskeletal pain and injury as a priority and rake design as a mode of intervention. The purpose of this report is to describe the approach used to select a specific intervention, the findings from an evaluation of this intervention and the assessment of this community-based approach as method for addressing occupational problems affecting migrant farmworkers.

**FIGURE 2.** Modified blueberry rake with long or extended handles.

## METHODS

### Candidate Rake Designs

Early in the course of its monthly meetings, the Maine WT selected rake design as its preferred mode of intervention for the problem of back, shoulder, and upper extremity musculoskeletal pain and injury. The team considered several rake design factors: handle length, extension height, diameter, and tilt, along with the number of tines (i.e., rake width). A consulting ergonomist met with the WT on several

occasions to more clearly define the specific risk factors likely to be associated with raking injury.

Recognizing that individual farmworkers had tried a wide variety of rake modifications in recent years, the team solicited members of both the Hispanic and Native American worker communities to share their various designs. Photographs or actual rakes were reviewed and assessed at WT meetings. In a series of brainstorming sessions, farmworkers proposed potential rake design changes based upon their experience and raking preferences. An artist was hired to work with the team to produce accurate drawings of candidate designs. From these drawings, the team selected three basic designs for comparison with the traditional short-handled rake. These included: (a) the design with the two longer handle extensions described above; (b) a traditional short-handled rake with a side grip to stabilize the box while raking; and (c) a rake with a semi-circular, steering wheel-like grip that enabled the worker to hold the rake with one or two hands in a variety of positions (Fig. 3).

## Testing of Candidate Designs

The team conducted a pilot study employing 12 rake designs during the 2005 harvest. In total, four head widths (60, 70, 80, and 90 tines) were included, as well as three handle designs (steering wheel, side grip, and extended handles). Over the course of a 12-day rotation trial, rakers were systematically assigned each of the 12 variations (three handle designs times four widths). At the end of each workday, each raker was interviewed with standardized English/Spanish questionnaire regarding their experience with the particular rake assigned that day. Information collected included self-reported muscle or joint pain, its location, and the farmworkers' description of the postures associated with the discomfort. Rakers also provided information about the functional problems and/or benefits encountered with each specific rake design. Finally, the number of standard boxes of blueberries harvested using each specific test rake was documented. After completion of the 12-day trial, workers were asked in an exit interview to select their preferred rake design.

Two-factor analysis of variance (ANOVA) and the *F*-test were used to analyze continuous response variables (e.g., productivity); the $\chi^2$ test was used to analyze categorical response variables (e.g., pain, yes/no).

## Evaluation of the Extended Handle Rake Intervention

Based upon the findings of these pilot tests, the project focus was narrowed to a comparison between the extended handle modification and the traditional, short center handle blueberry rakes. Responding to the productivity findings and farmworker and/or employer preferences, the WT selected only the 70 and 80 tine widths for this subsequent, formal evaluation. (Employers on the WT advised that 90-tine rake usage tends to result in greater fruit damage and therefore would be unacceptable to most farm owners.)

A two-factor experimental design fixed rake head width at two levels (70 and 80 tines) and rake handle type at four levels (center handle and 10, 14, and 16 in. extensions) for a total of eight test rake configurations or ''treatments.'' Due to the generally disruptive nature of the intervention, coupled with some farmworkers' long-term unavailability, expected worker tolerance limits and potential negative impact on production levels, only four of the eight treatments were intended for each subject (i.e., in ''incomplete blocks''). The subsequent removal of several worker subjects from the study, due to a truncated harvest season and radical between-farm differences in worker motivation/productivity, necessitated departures from the strict implementation of the two-factor, experimental design as originally conceived. Therefore, the eight treatment rakes were assigned with incomplete blocks of size five, instead of balanced, incomplete blocks of size four as primarily intended. Participating farmworkers committed to use of the specifically assigned rake during each morning of the testing period. These workers were not permitted to exchange rakes with one another, nor to put aside the assigned test rake (i.e., in order to resume working with their own rake) during this morning test period unless they experienced pain that differed (e.g., in kind, duration, or intensity) from what they typically experienced

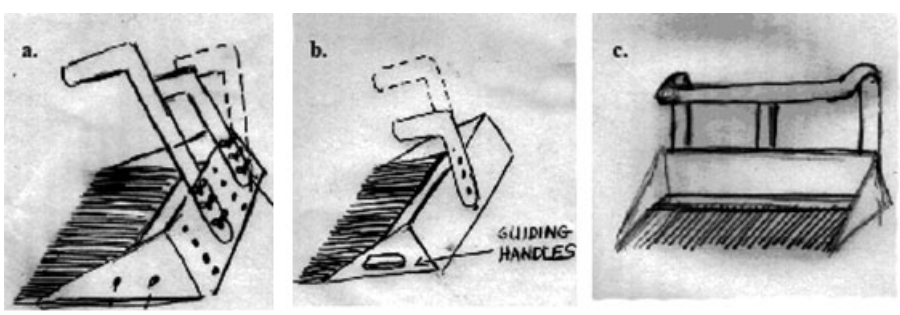


**FIGURE 3.** Alternative blueberry rake designs (**a**) handle extensions; (**b**) side grip; (**c**) steering wheel.

while using their own rake. If ''unusual pain'' was encountered, subjects were asked to describe the differences as clearly as possible to project interviewers. Rakes were assigned each morning, at approximately 8:00 a.m., and then retrieved at noon when interviews were administered.

Prior to the test period, each subject completed at least 3 days of work with their usual equipment in order to acclimate to raking. This prerequisite was intended to minimize variation in the subjects' responses over the test period attributable to opening season ''warm up.'' The six, consecutive day test period progressed as follows: on day one, farmworkers used their own rake (to establish a ''baseline''); on days two through six, each subject was randomly assigned one of the eight test rake designs, with no repeated assignment. This resulted in each subject working with his or her own rake, followed by five different test rakes, over the 6-day period.

''Productivity'' was defined as the self-reported number of standard blueberry boxes raked during an 8-hr period, and calculated for each of the rakes used during the 6-day test period. (Eight-hour productivity was extrapolated from the self-reported number of boxes harvested during the hours of actual rake usage.) In addition, farmworkers rated each of the test rakes used with respect to general liking on a five-point scale (1 = excellent, 2 = good, 3 = fair, 4 = poor, 5 = very poor). Workers also subjectively rated the force required with each, assigned test rake, relative to their own rake, on a three-point scale (1 = less, 2 = same, 3 = more), and whether or not they experienced pain (1 = yes, 2 = no) with a given test rake.

Data were analyzed using two-factor ANOVA and a 5% significance level in the *F*-test for differences. Post hoc, pair wise comparisons were made using the Tukey–Kramer adjustment. The rating, force, and pain responses were treated as interval-scaled measures in order to utilize ANOVA.

Because of the above-noted reduction in the number of available subjects, the data were analyzed in the context of a completely randomized design rather than an incomplete block design. This simplification of the analysis, in addition to making more efficient use of the reduced sample size (n), also proved much more conservative; that is, greater between-treatment differences were required in order to show statistical significance at the designated alpha level. In short, this analytic approach imposed more stringent demands on finding and reporting significant differences between various test rake configurations.

## Evaluation of the Community-Based Approach

As noted above, a potential strength of the basic design of this project is its reliance upon the coalition and the community in which the project was based. This community-based process was systematically evaluated throughout the course of the project. The project evaluation team was not directly involved in the WT or field trial aspects of this effort. Rather, they monitored evidence of WT and coalition effectiveness. Monitoring included: frequency of WT meetings; attendance at meetings by various groups; occasional direct observation of team meetings; monthly review of meeting notes; and tracking of adherence to the project timeline. The evaluators also sought other indicators of commitment to the effort by various WT members. Project evaluators attempted to contact all members of the WT and key staff of the collaborating organizations for extended telephone interviews annually to assess participants' perceptions regarding the inclusiveness and effectiveness of the community-based approach. These findings were analyzed and results presented annually to coalition members and WT members at the project's joint annual meeting. Identified problem areas were addressed at the annual meeting and on occasion subsequent meetings were held to resolve these issues.

Outcome evaluation assessed whether the project achieved its four goals as stated above.

## Dissemination

Prior to the final harvest season of the project, the WT decided to disseminate this extended handle intervention to workers based at a number of camps through the region, including camps and employers who had not previously participated in this study. Rake manufacturers were contracted to build handle kits prior to the season. Rakers were advised regarding the findings of the previous rake assessments at various gatherings and social events held at the beginning of the blueberry harvest. The project hired ''handle installers'' to visit camps in the early days of the harvest with drills and handle kits to facilitate the retrofitting of handles for all interested workers. Finally an education video was planned to emphasize the importance of a morning warm up period, the advisability of extended rake handles, appropriate ergonomic postures and a variety of other potential problems including heat and sun exposure (the WT's second highest priority problem), insect bites, and heat hazards.

This project was approved and monitored by the Mary Imogene Bassett Hospital Institutional Review Board. Subjects in this project were provided information on the project in either English or Spanish. All subjects subsequently consented verbally and in all but three instances were willing to provide signed consent. This approach was approved by the IRB.

# RESULTS

## Pilot Trial

The 2005 trial of 12 candidate rake designs (three handle types and four head widths as previously noted)

involved 3 farms and 42 workers. Available data were limited by workers' unwillingness in some cases to use certain rake designs for the entire day, most notably those designs that featured the steering wheel handle, which proved to be uniformly disliked by the rakers.

### Problems with the rake

Worker responses with regard to problems and muscle or joint pain were recorded only for subjects who used an assigned rake design for at least four continuous hours. Neither worker reported muscle or joint pain nor non-specific ''general'' problems related to rake head width. However, the proportion of reported general problems did differ with respect to handle type: 42% of those who used rakes with the extended handle (n = 64) reported having a general problem, compared to 73% who used the steering wheel handle (n = 48) and 66% who used the side-lip handle (n = 50; $\chi^2 = 12.3$, $P = 0.0021$). From a comparatively small subsample of 13 workers who named a single ''best'' rake, all such rakes were of the extended handle type. Eight of these ''best''-ranked, extended handle rakes (62%) were 70-tine width, three were 80-tine width (23%), and two were 90-tine width (15%). The 60-tine width received no nomination for ''best'' rake. Among 12 rakes rated as least liked, 10 of these (83%) were the steering wheel handle type, and the remaining 2 (17%) were side-lip handle type. Restricting attention to rakes with extended handles and tine head widths other than 60, 11 of 18 (61%) using the 70-tine variety reported pain, compared to 6 of 10 (60%) using the 80-tine and 6 of 15 (40%) using the 90-tine. Back pain predominated for the 70 and 80-tine rakes and leg pain was slightly more common for the 90-tine rakes. For the entire group, back pain was considerably more common and the workers related this to bending motions.

### Productivity

Productivity observations were based upon a minimum of 4 hr of raking and, as previously noted, extrapolated to give calculated 8-hr totals. Once more, restricting attention to 70, 80, and 90 tines, extended handle rakes, the 70-tine rake (n = 18) showed some indication, though not statistically significant, of higher 8-hr productivity (50.2 boxes) compared to both the 80-tine (21.4 boxes, n = 10) and 90-tine rakes (22.6 boxes, n = 16).

### Preferences

Due to early departures from the region, exit interviews were completed on only 24 of the 42 workers. Preferences for the various designs are noted on Figure 4. Further consolidation of these results based on tine-width shows a decided preference for the 70-tine rake (garnering 50% of the votes), with the 80- and 90-tine rakes tied (at 21% apiece), and the 60-tine rake being the least worker-preferred (8%). Based on handle type, the rakes with extended (''long'') handles prove the overwhelming favorite (with 83% of the votes), followed by the decided minority who preferred the side-grip (17%). Votes favorable to the steering wheel handle are conspicuously absent. These findings reinforce the results reported above, with worker preference clearly advocating the usage of rakes with 70-, 80-, or 90-tine head widths and an extended handle. Subsequent discussion with employers removed the 90-tine option as it was viewed as unacceptable to most growers.

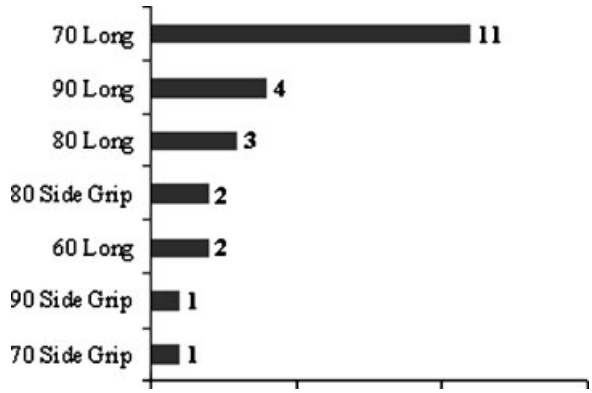


**FIGURE 4.** Preferred blueberry rake size and design.

Workers' suggestions for further design improvements were not unexpected and often not entirely realistic due to cost (e.g., make it larger and lighter). They consistently requested rakes with longer handles, larger holding boxes, and of lighter weight. Additionally, there were concerns regarding the mode (i.e., angled vs. not angled) and location of handle attachment and size of handle grips. However, these additional concerns were deemed secondary to rake handle type and head width.

## Evaluation Trial

During the 2006 blueberry harvest season, 29 Hispanic workers participated in the evaluation of eight test rakes whose selection was based on findings from the preceding Pilot Trial. These eight test rakes were composed from two design factors: head-width at two levels (70- and 80-tine), and handle type at four levels (one short center handle, or two handles extended 10, 14, or 16 in.).

### Productivity

The 80-tine rakes were marginally more productive than the 70-tine rakes, 105.1 boxes versus 91.9 boxes per 8 hr, respectively ($P = 0.07$). Productivity was significantly higher ($P = 0.04$) with the extended handle rakes than the

traditional short handle rakes (Fig. 5). Although, for the effect of rake type, none of the post hoc, pair wise comparison was significant at the 0.05 level, it is both numerically and graphically evident that rakes employing two extended handles, particularly the 10 and 14 in. extensions, are more productive than the traditional, single-handled type.

Also, in the absence of a statistically significant interaction between the two design factors ($P = 0.56$), we note that the effects of tine-width and handle type on farmworker productivity operate independently of one another. The effect of tine-width is evident in the vertical separation between the two lines in Figure 5. The effect of handle-type is shown by parallelism between the two lines with respect to the line segments joining successive handle designations as denoted along the horizontal axis.

The two-factor interaction was also absent from all subsequent analyses of the remaining response variables.

## Force required

Farmworkers were asked to subjectively rate the force required to harvest blueberries with each of their assigned test rakes compared to their usual rake (1 = less, 2 = same, 3 = more). A highly significant effect due to handle type was noted with respect to the mean comparative force rating ($P < 0.0001$, See Table I).

Pair wise comparisons with respect to handle type show a marginal decrease in comparative rated force between the traditional, short handle rake, and the 10-in. extended handle rake ($P = 0.07$), and highly significant reduction between the short handle rake and either the 14 in. extensions ($P = 0.0005$) or the 16 in. extensions ($P = 0.0002$).

## Reported pain

Farmworkers reported whether they experienced musculoskeletal pain (yes = 1, no = 2) with each of the test rakes assigned to them. Tine width showed no effect with respect to reported pain. However, another highly significant effect attributable to handle type was noted ($P < 0.0001$): Workers using rakes with extended handles reported less pain than those using rakes with one center handle (Table I). In pair wise comparisons, each of the extended handle rakes was significantly different from the traditional center handle rake (traditional vs. 10 in. extensions: $P = 0.03$; vs. 14 in.: $P < 0.0001$; vs. 16 in.: $P = 0.006$), but not from each other.

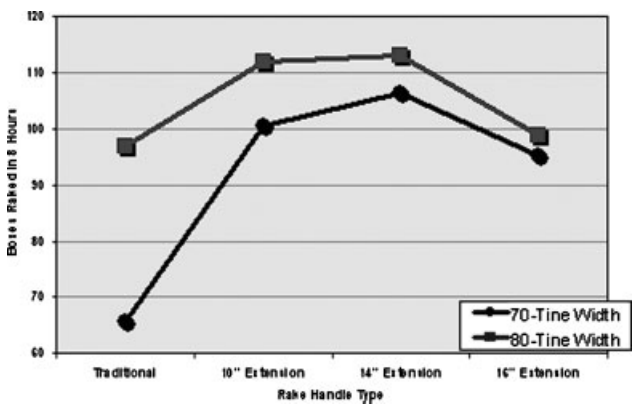


**FIGURE 5.** Blueberry rakers' self-reported 8 hr productivity.

**TABLE I.** Effects of Blueberry Rake Design on Measured Endpoints

| Factor | Rake | Mean | *P*-value (*F*-test) |
|---|---|---|---|
| Effect upon force required | | | |
| Tine width | 70 | 2.32 (a) | |
| | 80 | 2.26 (a) | 0.6789 |
| Handle type | Traditional | 2.78 (a) | |
| | 10 in. | 2.32 (b) | |
| | 14 in. | 2.04 (b) | |
| | 16 in. | 2.01 (b) | <0.0001 |
| Effect upon pain experienced | | | |
| Tine width | 70 | 1.72 (a) | |
| | 80 | 1.75 (a) | 0.6789 |
| Handle length | Traditional | 1.45 (a) | |
| | 10 in. | 1.74 (b) | |
| | 14 in. | 1.94 (b) | |
| | 16 in. | 1.79 (b) | <0.0001 |
| Effects on acceptability to workers | | | |
| Tine width | 70 | 3.06 (a) | |
| | 80 | 2.46 (b) | 0.0003 |
| Handle length | Traditional | 3.77 (a) | |
| | 10 in. | 2.57 (b) | |
| | 14 in. | 2.24 (b) | |
| | 16 in. | 2.46 (b) | <0.0001 |

Mean values for a given factor adjoined by different letters of the alphabet are significantly different from each another in post hoc, pair wise comparisons.

## Rake acceptability

Rake width was a highly significant determinant of acceptability to workers (on a scale of 1 = excellent, 2 = good, 3 = fair, 4 = poor, 5 = very poor; i.e., the lower the mean score, the more acceptable the factor level). The 80-tine rakes scored, on average, 2.46 versus 3.06 for 70-tine rakes ($P = 0.0003$). Likewise, handle length was also a highly significant factor with respect to worker acceptability ($P = 0.0001$, see Table I). Rakes with extended handles were strongly preferred to the traditional, short center handle rakes. In pair wise comparisons, each of the extended handle rakes is significantly more acceptable than the traditional, short center handle rake (traditional vs. 10 in. extensions: $P < 0.0001$; vs. 14 in.: $P < 0.0001$; vs. 16 in.: $P < 0.0001$), but not from each other.

In summary, an 80-tine rake with handle extensions of any tested length (10, 14, or 16 in.) showed evidence of higher

productivity and more favorable worker acceptance. Rakes utilizing handle extensions of any length also presented strong, consistent evidence of less reported pain, as well as comparatively less reported force exerted relative to the worker's usual rake. These effects, especially those attributable to handle length, are more pronounced with respect to worker acceptance and musculoskeletal impact than to reported, 8 hr productivity.

## Evaluation of the Community-Based Design

### *Process evaluation*

During the first year of the project, the WT met on a monthly basis. Later the group mutually agreed to meet as needed (minimum was quarterly), while conducting more business via phone between meetings. The WT was consistently on schedule or ahead of schedule for the project's stated timeline. WT participation was assessed by both the numbers of regular attendees and also by other indicators of particular commitment to this community-based effort. Participation was an ongoing challenge for the WT. Regular representation by more than two employers was uncommon. Typically three to five rakers were present at team meetings, though representation of Hispanic workers was consistently minimal. Despite this it was notable that among those who did attend were Native American workers who might drive for several hours in the off-season to get to the meetings. Commitment by some of the employers was demonstrated by the donation of several thousand dollars worth of rakes to the project and also by willingness to commit specific fields and worker time to the rake tests described above.

The evaluation team also collected qualitative data in 28 annual interviews over the 3-year evaluation process. Eight of these involved WT members, four were with community agencies, ten with MMHP staff and six with NEC staff. Among the key benefits identified were: heightened awareness of raking injuries among both the workers and employers; improved communication between employers and workers and a very positive response in the migrant community to this effort. An unexpected benefit was the development of a much more collaborative relationship between MMHP and a number of the region's key growers. Criticisms generally related to the timing of the team meetings, the failure to include key individuals and groups in the WT and the relatively slow pace at the beginning of the process. Despite these, a high level of satisfaction with the overall process was evident among all groups.

### *Outcome evaluation*

The results described to this point document achievement of three of the project's four stated goals. The fourth related to effective dissemination of the intervention and sustainability of the project. Project staff made ten camp visits over the course of the harvest to review the results of the project and offer to install longer handles on workers' rakes. Prior to the season, manufacturers built handle kits and 120 of these were sold and installed for workers at $20 apiece. The major rake manufacturer now features extended handles on his website and catalogue. A number of employers participated (actively or passively) in this dissemination effort. This included employers and camps that were geographically remote and had not been participants in the community-based effort. It is expected that with continued dissemination efforts in the next season, a majority of the rakes in the Maine blueberry barrens will have extended handles. The proposed educational video is still in production and thus was not available for the 2007 season.

## DISCUSSION

Community-based approaches to public health interventions are increasingly used, because at the same time the community is being targeted, it can help provide resources and serve as an agent of change in the public health effort [McLeroy et al., 2003]. One of the advantages of the community-based approach used in this project was the ability to access the experience of knowledgeable individuals in the selection of potentially effective alternatives to the traditional blueberry rake. Early in the data collection efforts, members of the WT played key roles in interacting with the larger worker community [Hawkes et al., 2007] to designate priority issues for intervention. Subsequently, team members helped to plan the intervention testing and most recently they assisted in the dissemination of the understanding gained in this project. The partnering of a research-oriented group with a community health group to support this community team considerably enhanced the overall effort.

Though not unique, this project is unusual among community-based efforts for at least two reasons. The first reason is the inclusion of both migrant farmworkers and employers on the WT. This feature added linguistic and social challenges to the functioning of the team, but these challenges were outweighed by the advantages of having individuals who look at the work issues from both points of view. Previous ergonomic interventions suggested for blueberry harvesting have failed because of limited community participation and opposition from employers that was apparently not anticipated [Baron et al., 2001]. The structure of the community WT also greatly enhanced access to workers, corresponding access to work sites, and the process of planning the trials. One employer on the team even contributed a number of the rakes that were modified for the testing.

Second, the extensive evaluation (both testing of intervention and of the project's community-based design)

described above is also unusual for a community-based project. In the past a relatively limited number of these projects have undergone such evaluation [Nilsen, 2004; Viswanathan et al., 2004]. This paper describes the detailed evaluations of project outputs and outcomes as well as a careful look at the community-based nature of this project. Indeed, one of the primary contributors to the success of this effort was the ability to recognize and modify specific practices and behaviors in order to ensure the long-term strength of the collaborative relationships essential to the project.

The basic premise of the WT's intervention selection is that by modifying the traditional blueberry rake, harvest work can be done with less ergonomic stress and therefore less discomfort to the workers. This is not a novel concept [Baron et al., 2001]. It has been common practice for blueberry harvesters to ''customize'' their rakes in any of a number of ways. Among these various modifications have been attachment of handle extensions to either side of the raking box. This approach offers the theoretical advantages of less spine flexion and replacing the rapidly alternating, forceful radial and ulnar deviations at the wrist associated with use of the traditional, short-handled rake for harvesting [Tanaka et al., 1994; Estill and Tanaka, 1998]. However, the extended handle rake does still require moderate bending and requires more forceful shoulder motions associated with sweeping the rake through the blueberry plants. Thus, the superiority of this modification over numerous other alternatives, or over the traditional, short-handle rake, was uncertain. The evaluation trial described above strongly suggests that the modification employing extended handles is superior to the traditional rake in terms of less reported pain, less comparative force required, general worker preference, and increased productivity. The last of the key findings listed here is especially important, because neither employers nor farmworkers are likely to show much interest in any intervention that reduces productivity.

There are weaknesses in the testing described above. The sampling of farmworkers did not provide a cohort representative of all blueberry workers because it focused exclusively upon Hispanic workers. Many Native Americans also rake blueberries, but for most of them the event is more of a traditional social gathering, with part-time days and a much more leisurely pace to the raking. The results described above relate to a segment of the farmworkers for which the pace of work is quite demanding. Formal documentation of improved ergonomics is not described in these results. Workers' subjective impressions of force are reported since there were no empirical measures of forces developed for use in these studies. The attrition of subjects noted in the exit interviews represents a problem commonly encountered in studies of farmworkers. There is no reason to believe that the early departure of some subjects introduced a bias into the exit data, but this possibility cannot be entirely ruled out. Finally, there is no evidence of decreased medical visits for musculoskeletal problems associated with blueberry raking. Given the relatively small magnitude of, and the critical time constraints imposed upon this study, sufficient documentation of this type of outcome was not feasible. Yet it seems quite likely that the reductions in comparative force and work-associated pain reported by farmworkers when they used the extended handle rakes will translate into less discomfort and disability and less need for medical care over the long term.

Weaknesses were also uncovered in the course of our evaluation of the community-based process. Perhaps the most glaring early issue was the failure to include a local rake manufacturer and local Anglo rakers in the WT. The former was invited to join in subsequent years and contributed substantially thereafter. The latter never were included because the process was proceeding well and the impact upon group dynamics was uncertain. One or two members of the WT believed that their opinions were not always respected. The timing of meetings was felt to be challenging for workers in particular, though it was acknowledged that during the season, no time was actually very good. The most significant issue noted was the persistent low participation by Hispanic workers despite a variety of efforts to enlist more members.

Despite these numerous issues, participants believed that this process did work and the various evaluations would suggest that they are correct. This appears to have been a meaningful effort for the worker community. Less anticipated were the positive experience noted by the employers and the improved relationships between the growers and the migrant health program.

This model may prove to be useful in a number of situations where farmworkers experience musculoskeletal and other injuries related to the pace, ergonomic challenges, and general environmental conditions of their work. Changing in the design of tools can be an effective mode of intervention, particularly since it does not rely upon the more difficult challenge of changing human behaviors. In these situations, the workers and their employers can bring considerable expertise to the process and are usually the best judges of the suitability of various proposed interventions. However, they often lack the organizational stimulus, intervention and evaluation expertise and funding that an interested investigator or better, a coalition, can bring to the process. Combining these components resulted in a very productive undertaking in this project and should be considered in other opportunities to address farmworker occupational health challenges.

## ACKNOWLEDGMENTS

Supported by the National Institute for Occupational Safety and Health grant # 5R25OH008144—Community

Collaboration for Farmworker Health and Safety (Environmental Justice).

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