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Evaluation of a Four Year Intervention to Reduce Musculoskeletal Hazards Among Berry Growers

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Abstract

Problem: Fresh market berry production workers are exposed to physical risk factors for musculoskeletal injury. *Method:* We disseminated information through trade publications and other sources to berry managers in seven U.S. states about five prevention through design practices that were both safer and more profitable than traditional methods. We administered mail evaluation questionnaires prior to the intervention and after each of four intervention years to rolling, independent U.S. samples and to comparison New Zealand berry farm manager samples after years one through three. *Results:* U.S. manager self-reports of reading trade publication information increased compared to baseline values for two of five practices and self-reported awareness increased for four of five practices. There were no increases in adoption. More U.S. than New Zealand managers reported getting information about two practices from trade publications and about four practices from public events. No U.S. versus New Zealand differences were observed in reported awareness or adoption for any practice. *Impact on Industry:* This study showed that even a modest campaign can build awareness of safer practices fairly quickly in three to four years among small agricultural firms but that increasing adoption apparently requires more time. Widespread adoption of safer practices could help keep operators in business longer as they age by reducing the workload and musculoskeletal strain associated with labor intensive crop production for them and their workforce. Adoption of practices that also improve profits, like the five practices featured in this study, could also help managers stay in business.

Keywords: Agriculture; Ergonomics; Evaluation studies; Intervention studies; Occupational health

1. Introduction

There were an estimated 18,234 operations in the United States in 2002 that each sold more than $1,000 worth of berries (e.g., strawberries, blueberries, raspberries, and blackberries; USDA, 2004). Twenty percent of these operations were located in Wisconsin, Minnesota, Michigan, Iowa, Illinois, Indiana, and Ohio. The size of the berry industry workforce is unknown. If all berry operations approximated the 1987 average farm size of 3.5 employees (USDA, 1990), there were 63,819 individuals in the 2002 national berry workforce.

Producing berries requires labor-intensive field and packing house work. Previous studies suggest that the physical musculoskeletal injury hazards of this work include: (a) lengthy periods of bent or stooped posture; (b) high hand and finger forces required during harvesting and the use of clippers or loppers during pruning; (c) lifting and carrying of loads during harvesting, chemical application or irrigation work, and the handling of boxed fruit; and (d) fast-paced, short-cycled, highly repetitive hand harvesting (Roquelaure, Dano, Dusolier, Fanello, & Penneau-Fontbonne, 2002; Mattila, Muuttomaa, & Peltonen, 2000; Parish, 1998; Steinke, 1997; Van Dien, Jansen, & Housheer, 1997; Peterson, Wolford, Timm, & Takeda, 1997; Khanizadeh, Lareau, & Buszard, 1995; Olander, 1993; Kelsey & Van Derbeck, 1977). Hand harvesting of strawberries, for example, can constitute 40% of product costs, is typically entirely stoop labor, and is often compressed into a three to six week period (Matilla et al., 2000). Other seasonal strawberry production tasks also involve stoop labor and manually-

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intensive work including setting runners, deblossoming plants, transplanting, weeding, chemical application, and irrigation (Steinke, 1997).

Berry work is also associated with reports of musculoskeletal discomfort. Self-reported Nordic musculoskeletal questionnaire data that we collected from berry operation managers exceeded the all-occupation questionnaire norms for: (a) experiencing any discomfort in the last year in the hand-wrist, upper back and hip; and (b) for being prevented from carrying out normal activities last year due to disabling pain in the lower back, shoulder, knee, and the foot-ankle (Newenhouse, Meyer, Miquelon, Brunette, & Chapman, 2002; Rosecrance, Cook, & Zimmerman, 1997; Ydreborr & Kraftling, 1986).

Other preliminary data we collected suggested that typical berry operations in Wisconsin were relatively small, with fewer than three full-time equivalent employees averaged over the year (Newenhouse et al., 2002). Managers of berry operations with less than 11 full time employees have few or no enforceable compliance requirements with federal or most state workplace safety and health rules (Kelsey, 1994).

The first concern of most farm managers is to stay in business. However, large and small farm managers are known to regularly invest in new production practices to maintain profitability (Rogers, 2003; Ahearn, Yee, Ball, & Nehring, 1998). Most farm managers also realize that they are at higher risk of injury (Thu, Donham, Yoder, & Ogilvie, 1990; Shilling & Brackbill, 1987). Although farm managers want to guard their health so they can continue to farm and to enjoy their retirement, few seem to be willing to spend for safety and health. A few growers have developed or adopted specific production practices that incorporate prevention through design because they simultaneously improved profitability and reduced physical risk factors for work-related musculoskeletal disorders (e.g., Newenhouse, Meyer, Miquelon, & Chapman, 2000, 2001a,b,c; Miquelon, Newenhouse, Meyer, & Chapman, 2001). Previous research has also established that better information flow to individual farm managers can increase the speed with which more profitable practices are adopted (Rogers, 2003; Wejnert, 2002; Fliegel & Korsching, 2001; Feder & Umali, 1993).

We investigated whether an intervention that improved information flow to berry managers in seven U.S. states could increase their awareness and adoption of five production practices likely to improve profits that would, at the same time, reduce exposures to musculoskeletal injury hazards.

2. Method

2.1. Treatment group participants

The sampling frame we used for both the U.S. state's year 0 baseline sample and for the year 1 sample after the first year of the intervention contained 850 operation names and addresses from four states. Since governmental agricultural statistics agency lists of berry growers were not available to us, we developed our sampling frame based on less precise but easily available private sources. We initially compiled and reconciled lists of likely berry producers using information from membership lists for growers in Wisconsin, Minnesota, Iowa, and Michigan that we obtained from national and regional fruit and vegetable grower organizations as well as the subscriber list from a regional print publication.

After the second year of the intervention, we increased the size and scope of the sampling frame we used by including an additional 415 likely berry growers from three additional bordering states: Illinois (140), Indiana (61), and Ohio (214). We reasoned that growers in these three states were probably already exposed to the print media portion of our intervention because they were likely to read many of the same nationally-distributed trade publications. We also learned in the first intervention year that some growers in the three states traveled to attend our public events in Wisconsin, Michigan, Minnesota, and Iowa.

We were interested in what percentage of growers reported they were aware of each practice before and after each of the four years of our intervention. Because the process of filling out the questionnaire also made growers aware of the practices, we decided to use a rolling sample cohort design (Babbie, 1990). This design minimized questionnaire-caused awareness because we mailed to a different sample of growers each year until we had mailed to all 1,265 operations in the sampling frame. We mailed questionnaires to probability samples, without replacement, of 168 operations at baseline and then to 168, 303, 311, and 307 after intervention years 1−4.

2.2. Comparison group participants

We also wanted to identify a comparison group of berry growers who were not targeted by the intervention's components. We reasoned that New Zealand berry growers were appropriate comparisons because: (a) most were also small growers, (b) they used similar production practices and so could benefit from the same safer, more efficient practices, and (c) they were unlikely to be exposed to the public events and resource people in the seven U.S. states that we were using to deliver the intervention (although they might be exposed to our intervention's print media or Internet components). We used a list of berry growers maintained by three New Zealand berry grower associations. We did not mail questionnaires to any New Zealand berry growers during our baseline year (prior to the intervention). We did mail to independent probability samples of 106, 107, and 87 New Zealand operations after intervention years 1–3 (but not after year 4).

2.3. Intervention theoretical basis

The intervention plan incorporated well-known theoretical models and previous experiential research findings about how and why individuals adopt agricultural technologies (e.g., Rogers, 2003; Fliegel & Korsching, 2001). For example, one model postulates that farm managers proceed through various stages in a sequential fashion from (a) awareness to (b) information gathering and consideration, to (c) adoption of the innovation (Rogers, 2003). Theory also suggests that informational communications move through multiple channels and

actors before they reach the manager (Rogers, 2003) and so our intervention's materials and methods were designed accordingly, as described below.

2.4. Intervention components

Previous research showed that agricultural producers said they most often learned about new production methods from (in order) other farmers, print media such as trade publications, public events like conferences and workshops, and directly from one to one contacts with resource people like university Extension agents (Lasley, Padgitt, & Hanson, 2001; Fett & Mundy, 1990). Our intervention's components were based on this research and included:

- *Other Growers:* We facilitated grower to grower exchanges by recruiting pilot berry farmers who were already using the practices to cooperate with the intervention. We had a dozen pilot farms, 10 in WI and one each in IA and MN. We encouraged growers and agricultural journalists who were interested in particular production practices to contact and visit the pilot farmers. We also trained and assisted some pilot farmers with travel expenses so they could serve as presenters and exhibitors at conferences and workshops for berry growers.
- *Print Mass Media:* Agricultural journalists were enlisted at the half-dozen trade publications we judged to be those most regularly read by berry growers in the seven U.S. states for information about new production methods (i.e., berry and fruit grower magazines, newsletters, and seed catalogues). We helped to equip journalists at these publications to write their own articles with press packets (e.g., a press release, one-page tip sheets on each work practice, photos, story ideas, and lists of potential telephone interview contacts). We kept track of all articles that appeared in producer publications that mentioned the five production practices we were promoting. We used standard methods to determine column inches of coverage specific to our production practices for each article (Treno et al., 1996).
- *Public Events:* To assist our small project staff, we enlisted resource people (e.g., university Extension) and growers already using the production practices to attend local and regional grower meetings, conferences, and workshops. They set up and staffed exhibits, delivered presentations, and distributed one-page tip sheets about each practice or a summary handout describing all of the practices. Our materials were available at one or more growers' meeting or conference in each state in the first intervention year, and at three or more in each state by the fourth year.
- *Resource People:* We sent mailings of one-page tip sheets about each practice biannually to university Extension horticulture agents, staff at state and regional grower organizations, and to other advisors for them to distribute during their farm visits and group programs. We also made regular phone calls to offer our materials in formats suitable to their needs and to learn about how to improve our efforts in the next year. Some examples of the materials included business cards and postcards that illustrated the better practices and lightweight, single-use poster displays for field days.
- *Radio*: We recorded 11 short radio interviews about the work practices that were aired on farm radio shows in Wisconsin. Three other interviews were aired regionwide (Newenhouse, 2002; Newehouse, 2003).
- *Internet:* We maintained a website where noncopyrighted materials about each practice were freely available (http://bse.wisc.edu/hfhp/). We announced the website via postcards that we sent to resource people and included our website listing on business cards, letterhead, exhibits, and all our printed materials.

2.5. Production practices

We identified what we judged to be the best prevention through design work practices (i.e., tools and equipment that most improved safety and work efficiency). We prioritized practices that were both reasonable in cost and that made important improvements in work efficiency so they would be attractive and practical for most small scale growers. In choosing practices, we also considered other desirable criteria such as whether they were relatively new to the industry (i.e., not already widely known), whether the concept of the practice was easy to describe in our outreach materials, and the extent to which the safer practices reduced important work hazards that high proportions of the workforce were exposed to (Rogers, 2003). The five production practices that the intervention promoted were (Fig. 1):

- *Hoophouses* are plastic covered, unheated structures similar to greenhouses. They provide a controlled environment as well as economic advantages through yield increases, harvest season extension, and better crop quality (Byczynski, 2003; Lamont, 2003). Hoophouses reduce pesticide needs and also protect workers from wind, cold, and the sun's ultraviolet rays. They allow growers to create more convenient harvest systems, such as raised beds, that reduce musculoskeletal physical risk factors. A medium-sized hoophouse costs about $8–10,000 and can pay for itself in one or two seasons on an average-sized berry operation (Pritts, 1999; Newenhouse et al., 2000).
- *Prone carts* are gasoline-powered, tracked platforms that carry workers in the prone position over the crop row to plant, weed, harvest, or otherwise tend the plants. Prone carts can reduce crawling, bending, and stooping and ease typical labor-intensive tasks like transplanting, weeding, thinning, pruning, tying, staking, and harvesting. Research suggests the prone position is less fatiguing and more efficient compared to the stooping, squatting, or seated position because the worker's head and body are supported (Meyer & Radwin, 2007; Meyer, 2004; Mattila et al., 2000). Prone carts have a foot-pedal controlled power source to inch along crop rows. A motorized prone cart can pay back its cost (i.e., $6,000–8,000) in two to three seasons on an average-sized operation (Newenhouse et al., 2001a).
- *Portable field stools* allow workers to avoid the repeated stooping or squatting required to pick crops at or above the

Fig. 1. Photos of all five production practices (clockwise from top left) hoophouse, field stool, prone cart, long handled hoe, and narrow aisle platform truck.

soil level. The stool is worn like a belt, does not interfere with movements, allows workers to change work postures often, and is inexpensive (<$25) (Miquelon et al., 2001; Matilla et al., 2000).

- *Narrow aisle platform trucks* help move boxes of produce around, especially in and out of coolers, and allow workers to roll many boxes at once, rather than carrying them by hand. These trucks reduce the amount of time spent hand lifting and carrying, time spent in awkward positions, and reduce gripping time and effort compared to containers with poorly-designed or nonexistent handles. The narrow aisle platform truck can be pushed by hand from either end and swivels easily around tight corners. This type of hand truck costs about $160–$275 and can pay for itself in two seasons on an average-sized operation (Newenhouse et al., 2001b).
- *Long-handled diamond hoes* are sharp on all four sides of a diamond-shaped blade and have a six foot long handle with a "T" shaped handle on the end. Many berry growers use hoeing crews to remove at least a portion of their weeds, because not all weeds are killed by herbicides or tractor-pulled cultivators. With this type of hoe, workers can stand upright and glide the hoe back and forth instead of using the bent-forward, chopping motion commonly used with other hoes. Workers can change their posture often, for example by pushing or pulling, and use the hoe with one hand or the other (or both) on the "T" handle. The long-handled hoe requires less effort to use compared to other hoes, the work is done faster, and they are inexpensive at around $40 each (Newenhouse et al., 2001c).

2.6. Questionnaire and procedure

We developed a mail questionnaire based on standardized recommendations that required about 20 minutes to complete (Dillman, 2000). The cover page requested that the questionnaire be filled out by the farm operator or the person who made most of the management decisions about how the operation ran. As an incentive to encourage responses, the accompanying cover letters stated that individuals who completed and returned the questionnaire would receive 10 first class U.S. (or New Zealand) postage stamps. The cover letters also emphasized the social utility of the survey, the importance of each respondent completing the survey, and the privacy protections for returned questionnaires (Dillman, 2000). We also included three first class stamps as an incentive in the initial mailing. A series of follow-up mailings was made to nonrespondents, including a reminder postcard after one to two weeks, a repeat mailing of the questionnaire and cover letter after four weeks, and a second reminder postcard six weeks after the initial mailing. The protocol was approved by the University of Wisconsin-Madison College of Agricultural and Life Sciences' human subjects committee. The questionnaire is available from the authors.

2.7. Hypotheses and data analysis

The individual operation was the unit of analysis. Reasonably complete questionnaires were coded and entered into a database. We excluded operations that produced less than $500 worth

of berries last year. All of the questionnaires were manually checked to verify the accuracy of data entry.

Primary questions. We used logistic regression to evaluate two aspects of the primary research question "did managers report more awareness and adoption?"

1. whether our intervention increased awareness ("have you seen, read or heard about…") or adoption ("do you use ….") for each of the five production practices. We pooled the seven U.S. state manager data collected at baseline and after each of four years in the multivariate analyses.
2. whether our intervention increased awareness or adoption of any of the five production practices among the seven U.S. state growers compared to New Zealand comparison growers (data collected over three intervention years in the United States were pooled and compared to data from New Zealand from the same time period in multivariate analyses).

Secondary questions. We used univariate statistics to investigate two aspects of the question "did managers report getting more information?"

3. whether the U.S. state managers' reports of where they saw, read, or heard about each production practice changed over the course of the study to favor the print media, public events, and other venues used by our intervention (baseline data from the U.S. states were compared to data from the U.S. states after the fourth intervention year) and,
4. whether reports of where they saw, read, or heard about the production practices differed between the U.S. states and New Zealand managers (data collected after the third intervention year in the seven U.S. states were compared to data from New Zealand for the same year).

In the univariate statistics, Student's T test was used to compare numerical values and Pearson's Chi Square test was used to compare percentages (SPSS, 1996). The significance level was set at $p<0.05$. When Levene's test for equality of variances was significant, the p-value reported for the t-test was for the test where equal variances were not assumed. No adjustments were made for multiple statistical comparisons.

Stata version 8.0 was used for the logistic regression analyses (StataCorp, 2003). For the logistic regression analyses of practice awareness and adoption among the seven U.S. state managers alone, we attempted to construct 10 different equations with our data (one for adoption and one for awareness for each of the five practices). In each equation, intervention year was modeled as a categorical variable where the three intervention years (or four for hoophouses) were compared to the baseline, pre-intervention year. Also, each equation adjusted for manager age, education, and years of experience as well as operation gross sales and acres. Operations that reported having adopted a work practice in the baseline questionnaire prior to our intervention were excluded from the analysis for that work practice (i.e., 15 U.S. hoe adopters, there were no adopters in the baseline year for any of the other practices). The significance level was set at $p \leq 0.10$ and odds ratios and confidence intervals were calculated. We took a similar approach to comparing awareness and adoption of the five practices between the U.S. states and New Zealand for the three comparable years of data.

3. Results

3.1. Questionnaire responses and sample demographics

Overall, the return rates for the questionnaires shown in Table 1 ranged from 57% to 70% for the U.S. state growers over the five years and were 76% to 77% for the New Zealand growers. Each year, over 25% of the U.S. state questionnaires that were returned were from individuals who reported that they had never grown berries, no longer grew berries, no longer were operation managers, or failed to grow a commercial berry crop that year worth at least $500. These questionnaires were not retained for further analysis. Analyses of the eligible, reasonably complete questionnaires showed that manager age and operation size were similar, although there were significant differences between the U.S. state sample at baseline and after the fourth intervention year for two variables: manager years in berry farming and gross sales last year. Similarly, there were significant differences between the seven U.S. states and the New Zealand samples evaluated after the third intervention year for the variables manager education, percent of farm sales from berries, percent of farm income from berries, percent certified organic, and percent growing fresh market vegetables, although manager age, years in berry farming, gross sales, and fruit bearing acres were similar (see Table 1).

3.2. Did managers report getting more information?

Compared to their baseline, after the fourth year of the intervention significantly more of the U.S. state managers reported getting information from print media about two of the five practices: hoophouses (70% vs. 97%; $p \leq 0.000$) and prone carts (17% vs. 72%; $p \leq 0.040$).

After the third year of the intervention, significantly more U.S. than New Zealand growers reported getting information from print media about two practices: hoophouses (90% vs. 50%; $p \leq 0.000$), and diamond hoes (82% vs. 50%; $p \leq 0.023$). In addition, more U.S. than New Zealand growers also said they got information from public events about four of the five practices: hoophouses (35% vs. 8%; $p \leq 0.009$), diamond hoes (32% vs. 0%; $p \leq 0.048$), portable stools (33% vs. 0%; $p \leq 0.056$), and prone carts (37% vs. 0%; $p \leq 0.016$).

3.3. Did managers report more awareness and adoption?

The multivariate logistic regression results in Table 2 simultaneously controlled for manager age, education, years of experience, operation gross sales, and operation acres.

3.3.1. Seven U.S. states

These results showed that, for U.S. managers, the intervention was associated with significant improvements in the odds of being aware of four practices: hoophouses (Odds Ratio = 1.2,

Table 1
Demographics of seven US States and New Zealand comparison group

	Group	Year 0	Year 1	Year 2	Year 3[e]	Year 4[d]
Number mailed	US	168	168	303	311	307
	NZ	-	106	107	87	-
Number received	US	95	115	211	193	180
	NZ	-	82	82	66	-
Return rate	US	57%	68%	70%	62%	69%
	NZ	-	77%	77%	76%	-
Eligible responses	US	64	87	142	117	95
	NZ	-	63	62	45	-
Age	US	54±12	56±12	57±13	57±12	56±11
	NZ	-	52±10	53±11	54±12	-
Education (1-9)[a]	US	5.2±2.2	5.8±2.2	5.7±2.2	5.9±2.2	5.8±2.2
	NZ	-	4.2±2.0	4.4±2.3	4.2±2.0***	-
Gender (% male)	US	94%	86%	85%	88%	88%
	NZ	-	84%	86%	88%	-
Years in berry farming	US	19±14	18±11	20±14	23±13	23±15*
	NZ	-	19±10	19±10	20±9	-
Fruit-bearing acres[b]	US	3.0	3.0	3.0	2.8	3.0
	NZ	-	7.4	4.9	5.6	-
Gross sales last year[c]	US	3.2±2.4	3.0±2.0	3.5±2.3	3.4±2.2	4.2±2.4*
	NZ	-	4.3±2.1	3.7±2.0	4.0±2.2	-
Berries of farm sales (%)	US	46.4±42.6	39.4±36.5	33.2±37.3	35.3±39.5	35.1±38.4
	NZ	-	68.4±31.7	63.6±35.1	61.0±35.9***	-
Berries farm income (%)	US	20.0±26.7	16.1±25.1	13.6±24.1	14.5±23.3	20.3±27.9
	NZ	-	48.9±33.3	44.0±35.3	41.8±31.9***	
Certified organic (% yes)	US	4.7%	3.4%	2.1%	5.2%	6.3
	NZ	-	0.0%	4.8%	2.3%	-
Grow fresh vegetable (%)	US	43.8%	56.3%	57.0%	64.9%	55.3%
	NZ	-	30.2%	37.1%	26.8%***	-

a. education scale US: 1=grade school, 2=some high school, 3=high school grad, 4=high school plus vo/tech, 5=some college, 6=2 yr associate degree, 7=4 yr college degree, 8=some graduate school, 9= graduate degree. New Zealand: 1=primary school, 2=some secondary school, 3=school certificate (11-12 yrs), 4=university entrance (13 yrs), 5=some tertiary ed (Tech Inst./Univ), 6=University diploma(<2 yr) or Technical Institute Degree, 7=University degree(BS/B), 8=some post-graduate study, 9=post-graduate degree (MSc/PhD).
b. median for number of fruit-bearing acres, all others mean.
c. gross sales scale: 1=<$5,000, 2=$5–15 k, 3=$15-25 k, 4=$25–50 k, 5=$50–100 k, 6=$100–200 k, 7=$200–400 k, 8=>$400 k.
d. p values for statistical tests comparing the seven US states year 0 (if available) or year 1 to year 4 (Student's T test for numeric variables, Chi square for percents).
e. p values for statistical tests comparing seven US states year 3 to New Zealand year 3.
*p<.05. **p<.01. ***p<.001.

95% Confidence Interval=0.98–1.38, $p \leq 0.086$), prone carts (OR=1.2, CI=1.01–1.14, $p \leq 0.039$), portable stools (OR=1.3, CI=1.07–1.70, $p \leq 0.012$), and long-handled diamond hoes (OR=1.2, CI=0.91–2.85, $p \leq 0.053$). We were unable to construct comparable adoption equations for four of the five tools due to lack of adopters (e.g., 2–10). For the one adoption equation that we did generate (for the long-handled hoe), there was no significant improvement in the odds of adopting. Table 2 also shows that higher manager education was significantly associated with greater awareness for three of the five practices (all but the prone cart and truck). Higher operation gross sales, a proxy for operation size, was significantly associated with greater awareness of four of the five practices (all but long handled diamond hoes) and with adoption of one (hoes).

Fig. 2 shows the gradual increase in managers reporting they were aware of each practice. For hoophouses, a total of 42% of U.S. managers reported being aware of hoophouses (although none had adopted them) in the baseline year prior to our intervention. After the fourth year of the intervention, significantly more managers said they were aware of hoophouses (65%). Similarly, awareness of prone carts (37% vs. 56%), field stools (21% vs. 30%), and long handled diamond hoes (40% vs. 48%) all increased significantly from before the intervention to after the fourth intervention year. Adoption of hoophouses increased from 0% in the baseline year to 1% after the fourth intervention year, but the change was not significant ($p \leq 0.503$) (not shown in Fig. 2). Adoption of two of the four other practices also increased, but not significantly (field stool 0% vs. 2%, $p \leq 0.356$; narrow platform truck 0% vs. 3% $p \leq 0.129$). There was no adoption of the prone cart (0% vs. 0%) and adoption of the hoe decreased (17% vs. 12% $p \leq 0.113$).

3.4. Seven U.S. states versus New Zealand

We also used multivariate analyses to compare awareness and adoption between New Zealand and seven U.S. state managers for the first three intervention years. We were able to construct logistic regression equations for only the prone cart and long-handled hoe awareness and only for long-handled hoe adoption (due to lack of adopters, missing values, or failures to satisfy the likelihood ratio test). However, there were no significant differences in the odds of being aware or adopting for any of the equations. After year 2, hoe awareness in New Zealand was higher than in the United States but there was a much greater

Table 2
Logistic Regression Results For Seven US State Manager-Reported Awareness of the Five Practices

Practice and Variable	Odds Ratio	95% Confidence Interval
Hoophouse		
Years intervention	1.162	0.979–1.379+
Manager age	0.976	0.954–0.998*
Manager female	1.015	0.522–1.973
Manager education	1.147	1.038–1.267**
Gross sales	1.281	1.138–1.441***
Years making decisions	0.997	0.973–1.021
Total acres	0.986	0.975–0.996**
Prone cart		
Years intervention	1.193	1.009–1.411*
Manager age	0.983	0.961–1.005
Manager female	1.051	0.540–2.044
Manager education	1.030	0.934–1.137
Gross sales	1.131	1.018–1.257*
Years making decisions	1.131	1.018–1.257*
Total acres	0.992	0.983–1.002+
Portable stool		
Years intervention	1.344	1.068–1.692**
Manager age	0.991	0.996–1.016
Manager female	0.915	0.433–1.934
Manager education	1.106	0.989–1.238+
Gross sales	1.115	0.993–1.254+
Years making decisions	0.995	0.969–1.023
Total acres	0.996	0.988–1.004
Narrow aisle platform truck		
Years intervention	0.922	0.714–1.190
Manager age	0.991	0.964–1.019
Manager female	0.633	0.247–1.620
Manager education	1.107	0.942–1.216
Gross sales	1.284	1.127–1.464***
Years making decisions	0.979	0.948–1.010
Total acres	0.995	0.986–1.004
Long-handled diamond hoe		
Years intervention	1.230	0.911–2.852*
Manager age	1.003	0.981–1.026
Manager female	0.691	0.352–−1.358
Manager education	1.175	1.061–1.300**
Gross sales	1.022	0.925–1.130
Years making decisions	0.981	0.957–1.005
Total acres	1.000	0.999–1.000

+p<.10. *p<.05. **p<.01. ***p<.001.

rate of change in the United States during years 3 and 4 that led to U.S. hoe awareness surpassing that in New Zealand by the end of year 4.

3.5. Evidence that the intervention was delivered

For each of the five work practices, the number of articles and their total column inches as they appeared in berry grower trade publications are listed in Table 3. Over the four years that the intervention promoted them, 25 articles appeared about hoophouses, amounting to 569 total column inches of coverage. The other four work practices were promoted for three years. Of them, the motorized prone cart received the most coverage (10 articles totaling 169 column inches) followed by the long-handled diamond hoe (5 articles totaling 129 column inches) and the field stool (6 articles totaling 113 column inches). Table 3 also shows the number of berry grower public events (grower meetings,

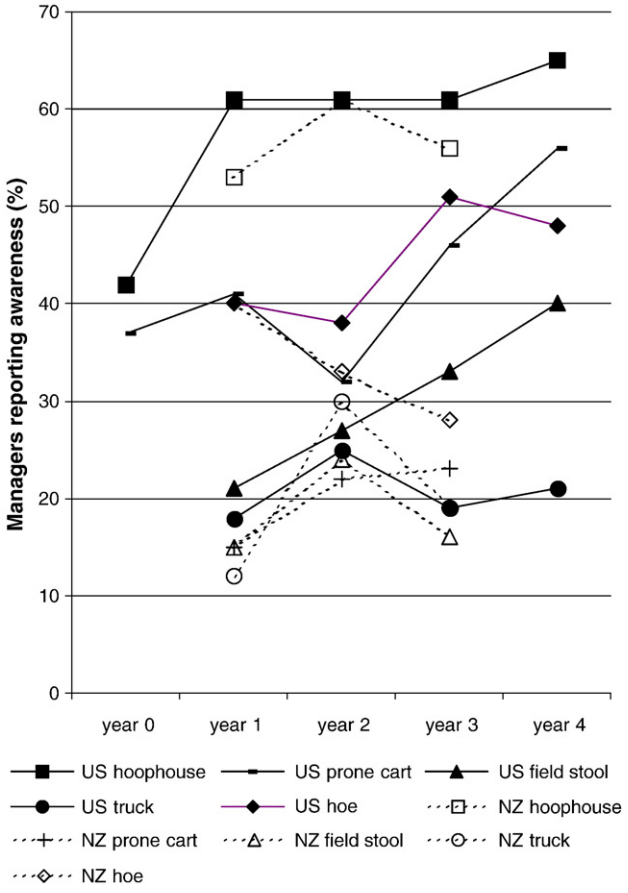

Fig. 2. Seven US state and New Zealand manager-reported awareness of five practices.

conferences and workshops) where we distributed information about the five practices to U.S. managers. In the first intervention year, we promoted hoophouses alone at 28 public events in four

Table 3
Trade publication and public event coverage of the five practices in the seven US States

Practice/Variable	Year 0	Year 1	Year 2	Year 3	Year 4	Total
Hoophouses						
Number of articles	-	3	8	5	9	25
Total column inches	-	73	135	114	247	569
Number of public events	-	28	31	39	28	126
Prone cart						
Number of articles	-	-	4	4	2	10
Total column inches	-	-	77	74	18	169
Number of public events	-	-	31	39	28	98
Field stool						
Number of articles	-	-	3	2	1	6
Total column inches	-	-	41	67	5	113
Number of public events	-	-	31	39	28	98
Narrow aisle platform truck						
Number of articles	-	-	2	1	0	3
Total column inches	-	-	60	36	0	96
Number of public events	-	-	31	39	28	98
Long-handled diamond hoe						
Number of articles	-	-	3	1	1	5
Total column inches	-	-	76	35	19	129
Number of public events	-	-	31	39	28	98

states. In the second, third, and fourth intervention years, we promoted all five practices at 31, 39, and 28 public events.

4. Discussion

4.1. Did managers report getting more information?

For at least two practices, our results indicated that they did. U.S. managers reported more encounters with print media information about hoophouses and prone carts after the intervention. Print media trade publications were information sources that our intervention effort fed. More print media articles were published about hoophouses than any other practice during the intervention. Prone carts were second. These results suggest that, for these two practices, the print media component succeeded in reaching the seven U.S. state manager target audience and that practices with more articles and column inches were more likely to be seen and remembered by managers.

In addition, in questionnaire comparisons between the United States and New Zealand after the third intervention year, U.S. managers reported getting significantly more print media information than the New Zealand growers about hoophouses and diamond hoes. Furthermore, the managers also reported getting more public event information about hoophouses, diamond hoes, prone carts, and field stools than NZ growers. These findings suggest that our intervention's materials were more effective at reaching our intended target group than our comparison group for both print media and public events.

4.2. Did managers report more awareness and adoption?

Our results suggest that we succeeded, at least in part. Within the United States, our evaluation was able to demonstrate an increase in awareness after the intervention for four of the five practices. On the other hand, our intervention failed at persuading U.S. managers to adopt any of the practices.

In previous research, agricultural manager failures to adopt apparently advantageous practices have been ascribed to a variety of factors such as the persistence of perceived risk and uncertainty among potential adopters despite improved information flow, unfavorable practice attributes such as poor return on investment, and the lack of sufficient time for information and persuasion to work (Rogers, 2003; Fliegel & Korsching, 2001). Managers of agricultural operations have been shown to be especially risk aversive compared to managers in other industries (Rogers, 2003; Fliegel & Korsching, 2001; Feder & Umali, 1993). The payback periods or return on investment for the five practices may have been too low for managers to bother with compared to competing investments (e.g., planting higher and longer yielding berry varieties).

Research on other types of communication interventions has noted the relative speed and ease with which relatively widespread improvements in awareness can be accomplished, but how rates of adoption can be much slower (Vaughan & Rogers, 2000). Previous research has also provided considerable evidence that increasing the adoption of new practices among thousands of operations can require more than three or four years of an information dissemination intervention, particularly among managers of agricultural operations (Rogers, 2003; Fliegel & Korsching, 2001; Karshenas & Stoneman, 1995). In agriculture's classic example, improved hybrid seed corn among Iowa farmers, virtually complete adoption by all eligible farmers required more than a generation (20 years; Fliegel & Korsching, 2001). There is also the possibility that our evaluation failed to detect small but real increases in adoption due to inadequate statistical power because our annual evaluation study sample sizes were simply too small to detect them.

Consistent with previously published work, in our study greater manager education and higher gross sales (i.e., larger operation size) were associated with more awareness (Rogers, 2003; Fliegel & Korsching, 2001). In the U.S. sample, we found that higher manager education was significantly associated with greater awareness for three of the five practices (all but the prone cart and truck). Higher operation gross sales, a proxy for operation size, were also significantly associated with greater awareness of four of the five practices (all but long handled diamond hoes) and with adoption of one (hoes).

4.3. Study limitations and strengths

Our study was not a randomized controlled trial. The constraints of conducting and evaluating an intervention in a real world agricultural industry sector of thousands of operations with unrestricted information flow precluded random assignment to treatment and control groups or ex ante control over demographic variables. Our study was also unable to provide a true control group because our comparison group of New Zealand berry producers may have been able to access some of our intervention's materials about the five work practices through contact with internationally-available berry producer trade publications or through the Internet-based resources we provided. Our study was also not a comprehensive community-based trial because no sampling frame was available to us that could, with confidence, claim to include all U.S. berry producing operations. Furthermore, because evidence that associates an intervention with outcomes cannot constitute proof of causation of those outcomes, we acknowledge that secular trends may have contributed to or may entirely explain those significant changes we did find.

Our sampling frame for berry operations in the seven U.S. states suffered from poor specificity. We believe that our relatively low levels of eligible responses (i.e., 31%–51% of questionnaires mailed), among the U.S. operations managers, despite our relatively high return rates (i.e., 57%–70% of questionnaires mailed), were attributable, in part, to our berry operation lists containing high proportions of "hobby farm" sized operations that did not produce $500 or more worth of berries per year and, in part, to the normal but high level of churning or turnover in berry operations producing a commercially-marketable crop each year. Although we included New Zealand growers as a comparison, we were unable to take full advantage of them in the statistical sense because of the lack of a baseline from them or a year 4 sample, as well as small

samples sizes, small adopter numbers, and lack of full comparability on the controlled variables.

We were surprised by the high baseline levels of hoophouse awareness and adoption in New Zealand. During the course of our study we learned that hoophouses have long been used in berry production in New Zealand and Europe (Lieten, 2001). This meant that our interest in using New Zealand operations as a comparison group for U.S. growers to gauge the effect of our intervention was precluded for hoophouses by circumstances that existed before our intervention began.

One strength was our study's emphasis on intervention process measures to determine whether and how well our intervention efforts were reaching the target audience, often a weak point in previous research (Goldenhar & Schulte, 1994). Our study also incorporated a theoretical model, a feature often lacking in other occupational health interventions (Robson, Shannon, Goldenhar, & Hale, 2001; Goldenhar & Schulte 1994). The degree of difficulty associated with acquiring information about new practices constitutes an access cost to managers and can be a barrier to adoption (Mokyr, 2002). Another strength was that our intervention minimized information access costs about the five practices by relying on the information channels that berry managers already used and trusted (i.e., farmer to farmer exchanges, trade publications, public events, etc.; Lasley et al., 2001; Fett & Mundy, 1990).

5. Summary

Our intervention was associated with increased manager reports of becoming aware of four of five practices and of receiving information about them from particular sources. However, there were no changes in manager reports of adopting any of the practices. Findings from a comparison group corroborated the changes seen across the four years within the treatment group.

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