A Seven-Year Intervention to Diffuse Economic Innovations with Safety Benefits to Wisconsin Dairy Farmers

L. J. Chapman, C. M. Brunette, A. D. Taveira

ABSTRACT. *The purpose of this study was to conduct a targeted information dissemination campaign to persuade agricultural managers to adopt more profitable practices that reduce injury hazards compared to traditional practices. The project disseminated information to northeast Wisconsin dairy managers about three production practices that were more profitable and had safety benefits (barn lights, silage bags, and calf feed mixing sites) using information sources that these managers were known to rely on. The project prospectively evaluated rolling, independent, community-based, probability samples (a different group of operations each year) at baseline and after each of seven intervention years. The project also evaluated comparison samples from either Maryland or New York dairy operations after intervention years two through seven. In baseline versus year seven comparisons, the Wisconsin dairy managers reported getting more information about the three practices. Compared to New York managers, Wisconsin managers reported getting more information after year seven about the three practices. Among Wisconsin managers, intervention year was associated with increased adoption of all three practices. Compared to New York managers, Wisconsin managers were more likely to report adopting two of the three practices after year seven. A targeted campaign that disseminated information to managers through traditional channels was associated with increases in manager reports of getting information about, being aware of, and adopting profit-enhancing work practices with safety benefits in a high-hazard industry.*

Keywords. *Accident prevention, Agriculture, Dairy farms, Evaluation studies, Intervention studies, Musculoskeletal disorders, Occupational safety and health.*

Individual farm managers successfully adopting more profitable technological innovations have long driven improvements in agricultural productivity (Rogers, 2003). Previous research has shown that better information flow to farm managers can speed the adoption of more profitable production practices, including practices to prevent mastitis and lameness in dairy cattle (Main et al., 2012; Jansen et al., 2010; Rogers, 2003; Wejnert, 2002; Feder and Umali, 1993).

Promoting practices that are more profitable and have safety benefits may be a useful interim strategy in the absence of more comprehensive occupational safety regulation for small-business agricultural operations that are not currently subject to effective regulation

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The authors are **Larry J. Chapman,** Senior Scientist, Department of Biological Systems Engineering, and **Christopher M. Brunette,** Doctoral Candidate, Department of Industrial and Systems Engineering, University of Wisconsin, Madison, Wisconsin; **Alvaro D. Taveira,** Professor, Department of Occupational and Environmental Safety and Health, University of Wisconsin, Whitewater, Wisconsin. **Corresponding author:** Larry J. Chapman, 460 Henry Mall, University of Wisconsin, Madison, WI 53706; phone 608-262-1054; e-mail: ljchapma@wisc.edu.

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and enforcement, which includes most U.S. dairy operations (McCurdy and Carroll, 2000; Kelsey, 1994; Murphy, 1992). Annual rates of fatal and nonfatal occupational injury in dairy farming have long been higher than in production agricultural overall and have been as much as three to six times higher than average rates for all U.S. private industries (Hard et al., 2002; Myers, 1998; NIOSH, 1998; Myers and Hard, 1995; Gerberich et al., 1993).

A large body of previous work supports the effectiveness of promoting more profitable agricultural practices through targeted information dissemination campaigns and using existing social and information networks (Rogers, 2003). Other studies have evaluated the adoption of work practices in agriculture that were both safer and more profitable (Davis and Kotowski, 2007; Chapman et al., 2004). At least one previous study has successfully promoted safer work practices that were also more profitable among dairy farmers (Lundqvist, 1996). Successful interventions have tended to be those that provided persuasive, short-format information about specific, proven practices that were easy to adopt and did not interfere with efficiency (Chapman et al., 2004; Rogers, 2003; Lundqvist, 1996).

Our project was a seven-year intervention effort designed to improve information flow and increase awareness among Wisconsin dairy farm managers about three production practices that were both more profitable and safer than traditional work practices and to persuade the managers to adopt them. The practices reduced or avoided hazards leading to traumatic and musculoskeletal injury. Earlier reports published by the project staff after the first, second, and fourth years of this intervention documented some increases in practice awareness and adoption (Chapman et al., 2003, 2009a, 2011). We wanted to determine how results changed after seven intervention years for getting information about, being aware of, and adopting the three practices.

Methods

Study Design and Conceptual Model

The intervention plan incorporated a well-known theoretical model and previous research findings about how and why individuals adopt agricultural practices (Rogers, 2003; Wejnert, 2002; Feder and Umali, 1993). In the model, the farm manager proceeds through three stages in a sequential fashion: from unaware of the practice, to aware, to adopting the practice. The model presented by Rogers (2003) also specifies practice characteristics that can increase adoption (e.g., relative advantage, low complexity, etc.). Previous research has shown that targeted information dissemination campaigns can increase information flow and can, in turn, increase the speed and geographic prevalence of practice awareness and adoption. Previous research also suggests that the most efficient way to provide information flow has often been through existing social networks and other traditional information sources (Monaghan et al., 2008; Sublet and Lum, 2008; Rogers, 2003).

Subjects

Our project used non-overlapping samples (i.e., an entirely different group of individuals each year) in order to better represent awareness and adoption in the entire target population at each point in time compared to overlapped samples (i.e., the same group of individuals year after year). The intervention treatment group was the managers who made day-to-day decisions on all dairy operations in eight geographically contiguous

northeastern Wisconsin counties (n = 4,300 in 1997). Our project used a governmental list of all dairy operations in the state as our primary sampling frame for simple probability samples each year of about 300 operations that excluded operations previously mailed to (Wisconsin, 2005). Because Wisconsin has many relatively small operations and because the industry was rapidly consolidating, we supplemented our population-based samples in the evaluation each year with separate oversamples of larger dairy farms in the eight counties from the Wisconsin Dairy Herd Improvement Program's lists (AgSource, 2005). Our project staff drew independent samples of 100 to 300 of the largest operations in the eight counties from the membership lists each year and then combined and reconciled the two samples so there were no duplications and no repeats from previous years' mailings. Project staff mailed evaluation questionnaires to rolling, independent probability samples (a different group each year) of 597 managers in northeast Wisconsin at baseline (before the intervention commenced) and then to 352 to 587 managers per year over the next seven years.

Beginning at the end of the second intervention year, our project used a list of all Maryland dairy producers to obtain comparison group samples (Maryland, 2001). After four years (i.e., intervention years two through five), we had exhausted our list of Maryland dairy producers because Maryland had many fewer operations than Wisconsin. We then (years six and seven) began using a sampling frame of all New York state dairy operations for comparison group operations (New York, 2005). Project staff mailed evaluation questionnaires to comparison group samples of 300 to 472 after the second through seventh year of the intervention. Dairy operations in both Maryland and New York were geographically distant yet resembled those in Wisconsin over the study period in the distribution of operation sizes and in the distributions of cow milking and housing system types.

Production Practices

Our project staff consulted with university Extension dairy specialists and the published literature to identify promising work practices. We studied what we judged to be the dairy work practices (e.g., tools, equipment, and facilities) that had the greatest potential to improve both safety and work efficiency simultaneously. Our project used existing evaluations and conducted some work of our own to identify, quantify, and compare the hazards and costs of the most promising practices compared to the conventional practices (e.g., Josefsson et al., 1999a, 1999b, 1999c, 2001). Project staff prioritized practices that were both reasonable in cost and made important improvements in work efficiency so that the practices would be attractive and practical for even the most small-scale operations. Our staff decided to focus on three less common yet typical sources of traumatic and musculoskeletal injury hazards. In choosing the practices, we also prioritized other criteria we deemed desirable, such as whether the safer practices were relatively new to the industry (i.e., not already widely known) and whether the concept of the practice was easy to describe in our outreach materials and methods. We also considered the extent to which the safer practices reduced important work hazards to which high proportions of the workforce were exposed. The three production practices that the intervention promoted were barn lights, silage bags, and calf feed mixing sites.

Barn lights. Many dairy animals spend most of the year inside poorly lighted cow barns (Chastain and Hiatt, 1994). From October through March, scheduled supplemental lighting of dairy livestock housing that simulates summer day lengths and light intensities has been demonstrated to biologically increase milk yields and heifer growth by 5% to

15%. For most operations, the return on investment for adopting barn lights is one to two years (Dahl et al., 2000; Peters, 1994). Supplemental lighting can improve safety because poor lighting and low visibility are generally known to increase the risk of slips and falls on the same level in injury research, and lighting was likely to reduce falls in the dairy barn, animal contact injuries, and vehicle collisions with barn structures (Josefsson et al., 1999a, 2001; Davies et al., 2001; Bhatttacharya, 1998).

Silage bags. Winter feed for cows has traditionally been stored in tower silos. Silage storage in long, tubular plastic bags on the ground compares favorably to both traditional tower silos and to newer bunker silos in terms of capital investment, operating costs, and silage quality. Payback periods can be one year or less, depending on how extensive and how recently investments were made in bunkers or towers (Josefsson et al., 1999b). Storing silage in bags also largely eliminates the dangers of silo gas and of falls from climbing tower silos, as well as machinery entanglement hazards from tower silo unloaders. Furthermore, silage bags reduce or eliminate hazards associated with bunker silos, including tractor rollover during loading, suffocations due to silage face collapse, and falls from elevation (Josefsson et al., 2001).

Calf feed mixing sites. Dairy herd calves have traditionally been housed in hutches or other structures at some distance from the cow barn because this reduces infectious disease incidence and otherwise significantly enhances calf survival and growth. A mixing and storage facility for liquid and solid calf feed that is immediately adjacent to the calf housing area can measurably reduce feeding time and labor requirements with payback periods of one to five years, depending on operation size (Josefsson et al., 1999c). A calf feed mixing site is also likely to lower the risks of back and other musculoskeletal injuries by reducing lifting, carrying, and other manual materials handling because feed is available in much closer proximity to calf housing sites and because employee time exposed to these musculoskeletal hazards is reduced (Josefsson et al., 1999c).

Intervention Information Dissemination Components

The project staff reviewed previous research about which information sources Wisconsin dairy managers used and trusted (Smith, 1995; Fett and Mundy, 1990). In our baseline questionnaire, administered prior to the intervention, our staff asked Wisconsin dairy managers what information sources they used to get information about more profitable practices and how much they trusted them (Chapman et al., 2009b). Based on these findings, we planned the intervention emphasizing the most used and trusted sources.

Print mass media. Over the seven-year intervention period, we assisted dairy trade publication journalists in writing their own articles about the three practices that our project promoted by sending them biannual press packets that included short-format print materials (e.g., http://bse.wisc.edu/hfhp/tipsheetpage.htm), photos, and lists of potential telephone interview contacts. Project staff tracked articles about our three work practices that appeared in print media (regional agricultural newspapers and national dairy trade publications) in the year before and during the seven years of our intervention. Project staff also used standard methods to determine annual column inches of coverage (Treno et al., 1996).

Public events. Project staff provided materials and other assistance about the three practices to university Extension agents and other public and private sector resource people who were mounting exhibits, staffing booths, delivering presentations, or otherwise disseminating information at local and regional field days, farm shows and expositions, and other events traditionally attended by dairy farmers. We tracked attendance at events

that promoted our practices and followed up by phone at events where our project staff was not present to find out how our materials were received.

Resource people. Project staff mailed short-format print materials about each practice to the region's nine university dairy and livestock extension agents, four farm equipment dealers, 46 dairy veterinarians, six farm electrical suppliers, and to farm consultants for them to distribute during their farm visits and group programs.

Farmer-to-farmer exchange. Project staff recruited six dairy farm managers in northeastern Wisconsin who were already using the practices to cooperate with the intervention. We encouraged other farm managers and agricultural journalists to contact and visit them.

Internet-based outreach. Beginning in the third year of the intervention, project staff maintained a website where non-copyrighted 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 at public events, and all our printed materials.

Evaluation Questionnaire Administration and Procedure

Project staff developed and administered a mail questionnaire based on standardized recommendations that required about 20 minutes to complete (Dillman, 2000, 2006; Salant and Dillman, 1994). The cover page requested that the questionnaire be filled out by the farm operator or the person who made the most dairy farm management decisions. The accompanying cover letter emphasized the social utility of the questionnaire, the importance of each respondent completing it, and privacy protections. Our project also conducted a series of follow-up mailings to nonrespondents, including a reminder postcard 8 to 14 days later and repeated mailings of the questionnaire and cover letter at about 24 days and again at 35 days afterward. In the baseline mailing administered prior to the intervention, the cover letter told subjects that a drawing would be held and one of every three individuals who returned complete questionnaires would receive their choice of a selection of personal protective equipment items valued at $10 to $12 (e.g., sun hat, hearing protectors, boots). In the seven annual mailings after the first through the seventh intervention years, all respondents were promised and received ten first-class postage stamps as an incentive. The protocol was approved by the University of Wisconsin-Madison College of Agricultural and Life Sciences human subjects committee.

Data Analysis and Hypotheses

Reasonably complete questionnaires were coded and entered into a database. Our project defined a reasonably complete questionnaire as one in which the overwhelming majority of the question items were completed in a satisfactory fashion, taking into account the skip patterns that required certain respondents to leave some questions blank and taking into account that some respondents may have declined to respond to specific questions, such as gross income last year, information about personal health, etc. All questionnaires were also manually checked to verify the accuracy of data entry. Our evaluation tested two hypotheses: (1) did managers report getting more information? and (2) did managers report more awareness and adoption? The significance level was set at $p \leq 0.05$ for all tests.

Did managers report getting more information? We used univariate statistics to investigate (1) whether Wisconsin farm managers' reports of information changed during the course of the study (baseline data were compared with data collected after interven-

tion year seven) and (2) whether reports of information differed between Wisconsin and New York managers (data from the seventh intervention year in Wisconsin were compared with the New York data from that year). Pearson's chi-square test (two-sided) was used to compare percentages and Student's t-test (two-tailed) was used to compare numerical values after Levene's test for equality of variances (SPSS, 1996). No adjustments were made for multiple statistical comparisons.

Did managers report more awareness and adoption? To assess the main research question, our study used logistic regression to generate a total of six equations: one for awareness and one for adoption of each of the three production practices with the northeastern Wisconsin data. In each equation, the intervention year was modeled as a categorical variable whereby the first through seventh intervention years were compared with the baseline, pre-intervention year while controlling for seven variables: manager age, education, and gender, operation milking herd size, manager years of experience in dairy farming, gross sales, and manager reports of the percent of their operation that was owned debt-free. Operations that reported having adopted any one of the three production practices in the baseline questionnaire prior to our intervention were excluded from the analysis for that work practice. The logistic regressions for barn lights excluded operations that failed to report using timers for their barn lights or that provided fewer than six hours of darkness each day because this meant that the managers had not adopted what the practice actually required. The calf feeding site regression and univariate analyses excluded operations that reported not raising calves or raising calves only in the cow barn. The significance level was set at $p \leq 0.05$. To investigate for differences between Wisconsin and New York managers in awareness and adoption, we also used univariate Pearson's chi-square tests to compare data from the seventh intervention year in Wisconsin with that from New York.

Results

Evidence that the Intervention was Delivered

Barn lights. Over the seven-year intervention, a total of 39 articles (1177 total column inches of content) describing barn lights appeared in regional agricultural newspapers and national dairy trade publications that were available to Wisconsin managers. In the baseline year prior to the start of our intervention, two articles appeared (30 column inches). Over the seven years, our intervention made information available at 75 public events for dairy farmers, including farm shows, field days, expositions, and university Extension programs.

Silage bags. Over the seven years, a total of 25 articles (791 column inches) relevant to silage bags appeared in regional and national print publications. One article appeared in the baseline year prior to our intervention. Our project made silage bag information available at 75 public events.

Calf feed mixing sites. Over the seven years, a total of six articles (78 column inches) relevant to calf feed mixing sites appeared in regional and national print publications. No articles appeared in the baseline year prior to our intervention. Our project made calf feed mixing sites information available at 46 public events.

Questionnaire Responses and Sample Demographics

The questionnaire return rate of Wisconsin dairy managers ranged from 68% to 79% (versus 38% to 58% for the Maryland and New York managers) (table 1). Wisconsin

Table 1. Wisconsin and Maryland-New York dairy operation evaluation samples.

		Year								p
	Group[a]	0	1	2	3	4	5	6	7	Value[b]
Questionnaires mailed	WI	597	587	422	394	352	354	361	380	
	MD/NY	-	-	299	240	200	202	450	472	
Number returned (% of mailed)	WI	427 (72%)	428 (73%)	306 (73%)	295 (75%)	278 (79%)	264 (76%)	245 (70%)	244 (68%)	
	MD/NY	-	-	115 (38%)	114 (48%)	115 (58%)	115 (57%)	262 (58%)	239 (51%)	
Number eligible (% of mailed)	WI	411 (69%)	415 (71%)	300 (71%)	292 (74%)	267 (76%)	257 (73%)	245 (70%)	225 (62%)	
	MD/NY	-	-	115 (38%)	112 (47%)	112 (56%)	111 (55%)	261 (58%)	222 (47%)	
Manager age (years)	WI	45.1 ±11.0	45.8 ±10.6	45.9 ±9.9	45.9 ±10.1	47.5 ±10.7	46.9 ±11.3	47.2 ±11.1	46.3 ±10.5	0.170
	MD/NY	-	-	46.9 ±12.0	47.2 ±12.6	47.3 ±12.8	48.6 ±12.1	49.7 ±12.3	48.8 ±11.8	0.021[e]
Manager education (1 to 9)[g]	WI	4.0 ±1.6	4.1 ±1.6	4.5 ±1.8	3.9 ±1.6	3.9 ±1.7	3.9 ±1.7	3.9 ±1.5	4.3 ±1.8	0.037[e]
	MD/NY	-	-	3.81 ±2.2	3.5 ±2.3	3.1 ±2.0	4.0 ±2.3	4.5 ±2.5	4.5 ±2.4	0.500
Number of male managers	WI	394 (96%)	407 (96%)	270 (91%)	261 (89%)	242 (92%)	225 (88%)	208 (89%)	190 (87%)	0.001[c]
	MD/NY	-	-	108) (93%)	102 (90%)	100 (91%)	300 (91%)	204 (90%)	193 (91%)	0.197
Manager years in dairy	WI	28.6 ±11.9	30.0 ±11.8	30.5 ±11.7	29.3 ±11.2	31.3 ±12.4	30.4 ±13.2	30.5 ±12.4	30.2 ±11.7	0.979
	MD/NY	-	-	32.4 ±12.6	31.4 ±13.5	32.9 ±13.5	31.5 ±15.0	31.6 ±14.1	31.8 ±13.5	0.062[f]
Number of cows in herd	WI	102.3 ±97	116.6 ±124	126.9 ±203	101.5 ±182	99.1 ±159	90.7 ±144	93.9 ±145	162.2 ±274	0.002[d]
	MD/NY	-	-	87.5 ±75	97.6 ±103	86.0 ±66	107.0 ±130	111.5 ±163	113.6 ±170	0.028[e]
Gross sales last year (1 to 8)[h]	WI	3.9 ±1.5	4.0 ±1.5	4.2 ±1.6	3.5 ±1.6	3.3 ±1.6	3.5 ±1.6	3.2 ±1.5	4.3 ±2.0	0.029[e]
	MD/NY	-	-	3.6 ±1.5	3.7 ±1.7	3.3 ±1.7	3.8 ±1.9	3.4 ±1.8	3.5 ±1.8	0.001[c]
Number injured with medical attention last year[i]	WI	37 (9%)	38 (9%)	35 (12%)	18 (6%)	19 (7%)	27 (11%)	17 (7%)	28 (13%)	0.099[f]
	MD/NY	-	-	6 (5%)	9 (8%)	9 (8%)	27 (8%)	21 (9%)	23 (11%)	0.424

[a] WI = Wisconsin, MD = Maryland, and NY = New York.

[b] The p-values for WI are WI year 0 versus WI year 7. The p-values for MD/NY are MD/NY year 7 versus WI year 7. Calculations used chi-square (two-sided) for percent and Student's t-test (two-tailed) for numerical values.

[c] $p \leq 0.001$.

[d] $p \leq 0.01$.

[e] $p \leq 0.05$.

[f] $p \leq 0.10$.

[g] 1 = grade school, 2 = some high school, 3 = high school grad, 4 = high school plus vocational-technical school, 5 = some college, 6 = two-year associate degree, 7 = four-year college degree, 8 = some graduate school, and 9 = graduate degree.

[h] 1 = <$5K, 2 = $5K to $15K, 3 = $15K to $25K, 4 = $25K to $50K, 5 = $50K to $100K, 6 = $100K to $200K, 7 = $200K to 400K, and 8 = >$400K.

[i] Refers to the number of operations reporting injuries that required medical attention.

manager samples at baseline were comparable to samples after year seven for manager age, manager years as a dairy farmer, and number of injuries on the operation last year requiring medical attention, but not for manager education, percentage of managers who were female, herd size, or gross sales last year, all of which increased (table 1). Wisconsin managers were comparable to New York managers after year seven for manager education, percentage of managers who were male, manager years as a dairy farmer, and number of injuries on the operation last year that required medical attention, but not for manager age (higher in New York) or for herd size or gross sales last year (higher in northeast Wisconsin).

Getting More Information

Those dairy farmers who reported that they had seen, heard, or read about each practice in the last year were asked where they obtained this information. Each year, respondents were given a checklist of information sources they could select. Compared with the baseline, after the seventh intervention year significantly more Wisconsin dairy managers reported getting information about silage bags from print media (79% at baseline vs. 88% after year seven, $p < 0.012$), public events (38% vs. 48%, $p < 0.018$), and equipment dealers (17% vs. 29%, $p < 0.001$). Wisconsin managers reported getting more information about barn lights from print media (79% vs. 90%, $p < 0.004$), public events (12% vs. 47 %, $p < 0.001$), equipment dealers, (6% vs. 28%, $p < 0.001$), other farmers (24% vs. 51%, $p < 0.001$), extension agents (18% vs. 31%, $p < 0.002$), farm consultants (8% vs. 23%, $p < 0.001$), and electrical suppliers (9% vs. 32%, $p < 0.001$). Wisconsin managers reported getting more information about calf feed sites from print media (76% vs. 84%, $p < 0.029$).

After the seventh intervention year, more Wisconsin than New York dairy managers reported getting information from public events about barn lights (47% vs. 28%, $p < 0.001$), silage bags (48% vs. 31%, $p < 0.001$), and calf feed mixing sites (27% vs. 13%, $p < 0.014$). Wisconsin managers also reported getting more information than New York managers about silage bags from private consultants (14% vs. 6%, $p < 0.009$) and the internet (5% vs. 1%, $p < 0.023$) and about barn lights from consultants (23% vs. 11%, $p < 0.004$), extension agents (31% vs. 20%, $p < 0.017$), and electrical suppliers (32% vs. 10%, $p < 0.001$).

Did Managers Report More Awareness and Adoption?

The multivariate logistic regression analyses simultaneously controlled for seven variables: manager age, gender, education, and years of dairy farm experience, as well as operation gross sales, herd size, and percent of operation owned debt-free.

Awareness. The intervention was associated with increased awareness among the Wisconsin farmers for two of the three practices after the seventh intervention year: barn lights (odds ratio [OR] = 1.338, confidence interval [CI] 1.270-1.409, $p < 0.001$) and calf feeding sites (OR = 1.140, CI 1.093-1.190, $p < 0.001$) (table 2, figs. 1 through 3). When other variables were held constant, higher gross sales was associated with awareness of all three practices. Younger manager ages and more manager education were associated with awareness of barn lights and calf feeding sites. Smaller percentages of assets owned debt-free were associated with barn lights and silage bag awareness. Smaller herd sizes were also associated with silage bag awareness. Compared with the New York dairy managers, significantly more Wisconsin managers were aware of barn lights after the intervention's seventh year (87% vs. 68%, $p < 0.001$).

Table 2. Logistic regression analyses for adoption and awareness of three practices by northeast Wisconsin dairy farmers (OR = odds ratio; CI = confidence interval).

	Barn Lights		Silage Bags		Calf Feed Mixing Sites	
Variable	OR	95% CI	OR	95% CI	OR	95% CI
Adoption						
Intervention years	10.775[a]	4.769-24.347	2.346[a]	1.873-2.939	1.788[b]	1.080-2.960
Manager age	0.957[a]	0.923-0.992	0.980[b]	0.961-1.000	1.008	0.959-1.059
Manager gender	0.651	0.292-1.450	1.240	0.813-1.891	0.743	0.244-2.268
Manager years in dairy farming	1.036[b]	1.002-1.071	1.005	0.987-1.024	0.992	0.949-1.038
Manager education	1.177[b]	1.046-1.324	0.984	0.914-1.060	1.028	0.879-1.203
Operation gross sales	2.019[a]	1.687-2.417	1.217[a]	1.101-1.344	1.800[a]	1.471-2.203
% of operation assets debt-free	0.990[b]	0.982-0.998	0.989[a]	0.984-0.994	0.989[c]	0.976-1.001
Operation herd size	0.997[d]	0.995-0.999	0.999	0.999-1.000	1.000	0.999-1.002
Awareness						
Intervention years	1.338[a]	1.270-1.409	1.114	0.996-1.248	1.140[a]	1.093-1.190
Manager age	0.965[a]	0.948-0.982	0.965	0.931-1.001	0.973[a]	0.958-0.988
Manager gender	0.724[c]	0.470-1.503	2.045	0.617-6.777	0.751	0.520-1.084
Manager years in dairy farming	1.009	0.994-1.025	1.127	0.994-1.061	1.016[b]	1.001-1.030
Manager education	1.205[a]	1.121-1.294	1.139	0.960-1.350	1.117[a]	1.054-1.185
Operation gross sales	1.303[a]	1.187-1.430	1.594[a]	1.272-1.997	1.350[a]	1.235-1.475
% of operation assets debt-free	0.995[b]	0.991-0.999	0.985[d]	0.975-0.966	0.997	0.993-1.001
Operation herd size	0.999[c]	0.998-1.000	0.997[a]	0.996-0.999	1.000	0.999-1.001

[a] $p \leq 0.001$.
[b] $p \leq 0.05$.
[c] $p \leq 0.10$.
[d] $p \leq 0.01$.

Adoption. Among the Wisconsin dairy managers, the intervention was associated with increased adoption of all three practices after the seventh intervention year: barn lights (OR = 10.775, 95% CI 4.769-24.347, $p < 0.001$), silage bags (OR = 2.346, CI 1.873-2.939, $p < 0.001$), and calf feeding sites (OR = 1.788, CI 1.080-2.960, $p < 0.024$) (table 2, figs. 1 through 3). When other variables were held constant, higher gross sales were also associated with adoption of all three work practices. For barn lights, younger manager ages, more manager years of dairy farming experience, more manager education, smaller percentages of assets owned debt-free, and smaller herd sizes were also associated with adoption. For silage bags, younger manager ages, and smaller percentages of assets owned debt-free were associated with adoption. Compared with New York farmers, Wisconsin farmer reports of adoption after the seventh year of the intervention were higher for barn lights (30% vs. 16%, $p < 0.029$) and silage bags (53% vs. 39%, $p < 0.005$).

Discussion

Did Managers Report Getting More Information?

Baseline reports compared with results collected after the seventh intervention year provided evidence that Wisconsin farmers reported getting significantly more information about all three practices from print media and about both barn lights and silage bags from public events and equipment dealers. For barn lights, they also received more information from other farmers, extension agents, farm consultants, and electrical suppliers. These findings suggest that our intervention used information channels effectively to reach farmers. The predominance of print media and public events confirmed earlier research regarding which sources of production practice information were most often used by

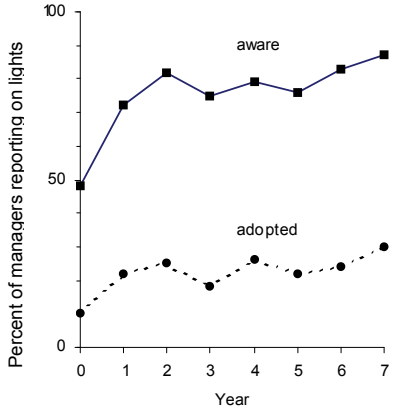

Figure 1. Barn lights awareness and adoption reported by northeast Wisconsin managers.

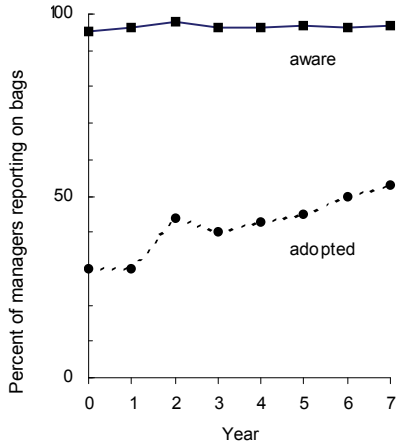

Figure 2. Silage bags awareness and adoption reported by northeast Wisconsin managers.

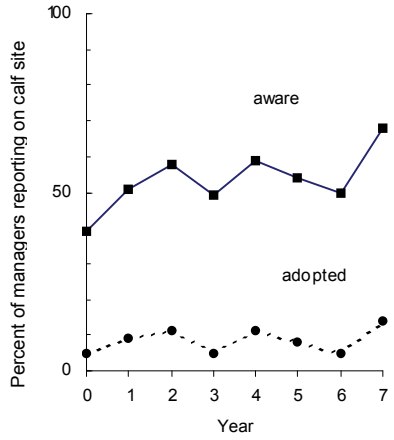

Figure 3. Calf feed sites awareness and adoption reports by northeast Wisconsin managers.

Wisconsin dairy farmers during the period of time under study (Chapman et al., 2009b; Smith, 1995; Fett and Mundy, 1990). However, to our knowledge, previous research has not used nor demonstrated that farm consultants or electrical suppliers can act as sources of new production method information.

The reports from Wisconsin dairy managers about getting information from university Extension decreased over the seven-year intervention for two of the three practices (barn lights: 24% vs. 31%; silage bags: 19% vs. 12%; calf feeding sites: 13% vs. 9%). On the other hand, previous research has shown that users of information provided by university Extension often failed to attribute it correctly because the role of agents and specialists in information disseminated through public events, print media, and other sources often goes unrecognized (Hoag, 2005; Kalambokidis, 2004; ECOP, 2002). In our experience, working with university Extension agents and specialists was useful and often vital to our efforts to disseminate information about the three practices. University Extension personnel were involved in organizing and presenting at most of the dairy manager public events over the seven years. Extension was also often the bridge to information dissemination through dairy print publications and through other farmers and resource people. Previous research has noted that university Extension "has its greatest impact in the early stages of dissemination of a new technology. As more farmers become aware of the new technology, the impact of extension diminishes" (Anderson and Feder, 2004, p. 42).

We considered the New York and Maryland dairy farmers a partially exposed comparison group because we suspected that they were as likely as Wisconsin dairy farmers to read the same nationally distributed print media where "our" articles about the three practices appeared. The questionnaire data provided evidence to support this idea in that there was no difference in the percentage of Wisconsin compared to New York dairy farmers who reported getting information from print media about each of the three practices after the seventh year of the intervention. However, more Wisconsin than New York farmers reported getting information from public events about all three practices and getting information from private consultants about barn lights and silage bags. This suggests that New York dairy farmers were indeed exposed to the print media component of our intervention but not to the more geographically specific public events or private consultant intervention components that our project may have inspired for all three practices (as well as information from Extension agents and electrical suppliers about barn lights).

Did Managers Report More Awareness and Adoption?

The most important goal of our intervention was to increase adoption of the three more economic practices with safety benefits. Within the Wisconsin treatment group, logistic regression analyses confirmed that intervention year was associated with increased adoption of all three practices and with increased awareness of two of the three practices (barn lights and calf feed sites). This suggests that our intervention was successful. Prior to our intervention, silage bag awareness was already widespread in Wisconsin (i.e., 95% in the baseline year), so our intervention had little room to improve this outcome. Despite this high silage bag awareness prior to the intervention, adoption increased from 30% at baseline to 53% after year seven.

The demographic variable association that was most consistently significant was between higher Wisconsin operation gross sales and increased adoption and awareness of all three practices. Because gross sales can be considered a proxy for operation size, this finding was also consistent with previous research on agricultural innovations (Rogers, 2003; Wejnert, 2002; Feder and Umali, 1993). Similarly, our study also found significant

associations that were in keeping with previous studies of agricultural innovations, with younger Wisconsin managers being more likely to adopt barn lights and silage bags and be aware of barn lights and calf feed mixing sites, and with managers with more education being more likely to adopt barn lights and to be aware of barn lights and the calf feed mixing sites (e.g., Rogers, 2003).

We believe that these associations between higher gross sales (and other variables) and increased adoption and awareness were interesting but less important than our findings about the value of conducting an information dissemination effort for seven years. Compared to our report after the fourth year of this intervention (Chapman et al., 2011), three additional years greatly improved the odds ratio for barn lights adoption (5.576 vs. 10.775) while nearly sustaining the odds of silage bag adoption (2.939 vs. 2.346), although calf feed site adoption was lower (2.151 vs. 1.788). Awareness odds declined somewhat between years four and seven for both barn lights (2.383 vs. 1.388) and calf feed site awareness (1.598 vs. 1.140). We found that awareness improvements occurred earlier than adoption increases, as our theoretical framework predicted and consistent with previous research.

After the seventh year of the intervention, the reports from our dairy farm manager sample suggested that barn lighting was likely to be in use on about three in ten northeastern Wisconsin dairy farms, and safer silage bags were likely to be in use on about half. More widespread use of economic production practices with safety benefits is likely to be associated with reduced numbers of exposures to injury hazards and with exposures of shorter duration compared to traditional practices, which may contribute to reductions in specific types of injuries (Josefsson et al., 2001). Between 1992 and 2003, there were a total of 16 Wisconsin farmer deaths (and an undetermined number of nonfatal injuries) attributed to falls, suffocations, and silo unloader machinery injuries associated with tower silos (Skjolaas et al., 2005; Josefsson et al., 2001). Conceivably, if all Wisconsin farmers using tower silos or other methods of silage storage replaced them silo bags, few or no future deaths or injuries would be attributable to these tower silos hazards. Similarly, if all Wisconsin farmers adopted barn lights, then some of the fatal and nonfatal injuries due to falls on the same level and collisions with barn structures or animals in dairy barns where poor lighting was a contributing factor could be reduced. Currently, the surveillance of both fatal and nonfatal injuries in the dairy industry (and for all of production agriculture in the U.S.) is much less comprehensive, accurate, and precise than in other industries (Hard et al., 2002; McCurdy and Carroll, 2000). Improvements in agricultural injury surveillance, including better recording of nonfatal injuries and greater detail about sources of injury and other causal factors, may soon allow research to link interventions like ours with specific measures of injury reduction.

Strengths and Limitations

Our research lacked some of the attributes that are desired for optimal workplace intervention evaluation research (e.g., random assignment to treatment groups, control comparison groups confidently isolated from all treatment aspects, verification of self-reported data, and links with objective, statistically powerful measures of injury reduction that could be associated with specific intervention components) (Rautiainen et al., 2008; Robson et al., 2001). However, our study incorporated other desirable attributes, including a theoretical model, community-based probability samples, prospective design, baseline data, long-term follow-up, control comparison groups, and relatively large-sized samples for the intervention and comparison subject groups. Because our subjects were

not randomly assigned to treatment, our evidence was not causal but associational, and so the gains we observed in practice adoption and awareness may be attributable, wholly or in part, to ongoing industry trends or other influences rather than our intervention. More research to follow these gains in Wisconsin and to compare them with results from other samples of dairy farmers who were better isolated from the intervention could better separate any effect of time from the effect of the intervention.

Another limitation was our study's reliance on unconfirmed self-reports by dairy managers. Our project staff made repeated, but ultimately unsuccessful, attempts to confirm these self-reports of practice adoption by requesting Wisconsin sales totals by county from the relevant manufacturers (e.g., regional suppliers of silage bags and barn lighting systems).

One strength of this study was our good fortune in finding funding that allowed us to extend the usual project time limits. Our project was able to supplement its initial three-year award with other funding in later years. Had this not been possible, our project would not have been able to follow the effects of the intervention for over seven years. Funding agencies should consider making allowances for long-term follow-up when projects conduct and evaluate efforts to diffuse innovations among large groups.

Previous research clearly indicates that awareness is a necessary but not sufficient condition for adoption and has often found a time lag between awareness and adoption of a practice that can amount to many years (Rogers, 2003; Wejnert, 2002; Feder and Umali, 1993). Future research should investigate the length of and reasons for this time lag between awareness and adoption associated with particular production practices and the barriers and enabling factors that help predict it.

Nationwide, there were 62,500 dairy operations in the U.S. in 2011 (USDA, 2012), and most were exempted by federal budget riders from enforcement of governmental occupational safety regulations (McCurdy and Carroll, 2000; Murphy, 1992; Kelsey, 1994). Difficulties with regulation setting, enforcement, compliance, and the nature of the industry have all been suggested to explain why injury hazards in dairy production and other agricultural work settings have resisted traditional prevention efforts (Murphy, 1992). For example, over 90% of U.S. farms are not subject to OSHA reporting requirements and regulatory enforcement because they have fewer than eleven employees (Davis and Kotowski, 2007; McCurdy and Carroll, 2000; Kelsey, 1994). Dairy farm managers may be placed at a disadvantage due to unsafe conditions and injuries that interfere with production. Our research suggests that promoting safer work through information dissemination interventions that emphasize more economic work practices with safety benefits may be a viable interim supplement to more comprehensive occupational safety regulation and enforcement in the dairy industry.

Conclusion

We conducted and evaluated an information dissemination intervention effort to persuade agricultural managers to adopt more profitable practices that reduced injury hazards compared to traditional practices. Our intervention successfully disseminated information to managers through traditional channels and was associated with increases in manager reports of getting information about, being aware of, and adopting profit-enhancing work practices with safety benefits in a high-hazard industry.

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