Intervention to Increase Adoption of Safer Dairy Farming Production Practices

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SYNOPSIS

Objectives. We conducted an intervention to increase adoption of three dairy farming practices shown to reduce certain traumatic and musculoskeletal injury hazards.

Methods. The intervention disseminated information to 4,300 Wisconsin dairy farm managers about three safer, more profitable production practices (barn lights, bag silos, and calf feed mixing sites) using information channels upon which these managers were known to rely. We evaluated rolling, independent, community-based samples at baseline and after each of two intervention years. We also evaluated a single sample after the intervention's second year from 1,200 Maryland dairy farm managers who were exposed only to the intervention's nationally distributed print publications, as a "partially exposed" comparison group.

Results. In before/after comparisons, Wisconsin managers reported getting more information from print media, public events, and resource people for barn lights and bag silos. Also, Wisconsin managers, in comparison with Maryland managers after the intervention's second year, reported getting more barn lights and bag silo information from public events and resource people, but not from print media. Analyses that adjusted for farm manager, farm operation, and herd variables associated the intervention with increased Wisconsin manager adoption of all three practices after the second intervention year: barn lights (odds ratio [OR] = 2.268, 95% confidence interval [CI] 1.476, 3.485), bag silos (OR=3.561, 95% CI 2.684, 4.728), and calf feeding sites (OR=2.433, 95% CI 1.059, 5.591). There were also increases in awareness of barn lights and calf feeding sites.

Conclusion. Disseminating information to managers through well-known information channels was associated with increased reports of information gathering, adoption, and awareness of safer, profit-enhancing work practices in a high-hazard industry.

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Dairy farming work is associated with fatal and nonfatal traumatic injury rates that have been higher than all crop and livestock agricultural operations combined, and with rates as much as three to six times those for all U.S. private industry.[1–6] Difficulties with regulation setting, enforcement, compliance, and the nature of the industry have all been suggested to explain why injury hazards in dairy and other agricultural work settings have resisted traditional prevention efforts.[7] Individuals at greatest risk are believed to be those working on smaller dairy operations (i.e., those with ≤10 employees), which employ most of the workforce and in which health protection and hazard prevention regulations have been least effective.[1,7,8] Promoting safer practices that are also more profitable may be a useful interim strategy in the absence of more comprehensive safety regulations.

Previous agricultural research has shown that better information flow to farm managers can speed adoption of more profitable production practices.[9–11] We conducted a two-year intervention effort that sought to (*1*) inform dairy farm managers about three production practices that were more profitable and safer than traditional work practices and (*2*) persuade the managers to adopt them. An earlier report covering the first year of our intervention documented some increases in practice awareness but not adoption.[12] We wanted to determine whether another intervention year of increased information flow to farm managers could increase the adoption rate.

METHODS

Study design and conceptual model

The intervention plan incorporated theoretical models[10] and previous research findings about how and why individuals adopt agricultural technologies.[9,11]

We administered an annual evaluation questionnaire to population-based probability samples of the treatment group before the intervention and after each of two intervention years. The questionnaire asked about awareness and adoption of three practices. Because the process of filling out the questionnaire made subjects aware of the three practices, we used rolling, independent samples to interrogate a new sample of subjects each year.[13]

The intervention emphasized information dissemination to dairy managers through all the information channels they were known to rely on for learning about production methods (e.g., print media, public events, resource people, and other farmers).[14,15] However, the same print media dairy trade publications that Wisconsin dairy managers relied on were distributed nationally. As a result, our study's group of Maryland dairy farmers must be considered a "partially exposed" comparison group.

Subjects

We used a governmental list to identify all operations in eight geographically contiguous northeastern Wisconsin counties (n=4,300) as our primary sampling frame.[16] Because Wisconsin has many relatively small operations, we supplemented our population-based samples with an oversample of the largest dairy farms, so that our findings could better reflect what could be accomplished with dairy producers nationwide.[17] We mailed evaluation questionnaires to independent probability samples each year (597 at baseline, 587 after year one, and 422 after year two). We used a list of all Maryland dairy producers to obtain our partially exposed comparison group sample.[18] We mailed evaluation questionnaires to 300 Maryland operation managers only after the second year of the intervention. Additional details on the subjects, sampling frames, and sampling procedures are available elsewhere.[12]

Intervention components

The intervention disseminated information about the three practices through those sources that Wisconsin dairy producers had previously reported using to learn about new production methods.[14,15]

Print mass media. We assisted dairy trade publication journalists in writing articles about the three practices by calling them and sending them biannual press packets that included short-format print materials,[19–21] photos, and lists of potential telephone interview contacts. We tracked articles that appeared in dairy trade publications about our three work practices in the year before and the two years during our intervention. We also used standard methods to determine annual column inches of coverage.[22]

Public events. We 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/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. We mailed short-format print materials about each practice to nine university 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. We 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.

Production practices

We studied what we judged to be the work practices (e.g., tools, equipment, and facilities) 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 operations. 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) and whether the concept of the practice was easy to describe in our outreach materials. 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:

1. *Barn lights.* Many dairy animals spend most of the year inside poorly lighted cow barns.[23] 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 cow milk yields and heifer growth by 5% to 15%. For most operations, the return on investment is one to two years.[24,25] Supplemental lighting improves safety because it is likely to reduce the risk of slips and falls on the same level in the barn, animal contact injuries, and vehicle collisions with barn structures.[19,26,27]
2. *Bag silos.* Winter feed for cows has traditionally been stored in tower silos. Silage storage in long, tubular plastic bags on the ground compares favorably (in terms of capital investment, operating costs, and silage quality) to both traditional tower silos and to newer bunker silos. Payback periods can be one year or less, depending on how extensive and how recently investments were made in bunkers or towers.[20] Storing silage in bags also largely eliminates the dangers of silo gas and falls from climbing tower silos. Furthermore, bag silos reduce or eliminate hazards associated with bunker silos, including tractor rollover during loading, silage face collapse suffocations, and falls from elevation.[28]
3. *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 diseases 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. 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 much closer to calf housing sites and because employee time exposed to these musculoskeletal hazards is reduced.[22]

Evaluation questionnaire administration and procedure

We developed and administered a mail questionnaire based on standardized recommendations, which required about 20 minutes to complete.[29,30] 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 the form, and privacy protections. We conducted a series of follow-up mailings to nonrespondents, including a reminder postcard eight to 14 days later, and repeated mailings of the questionnaire and cover letter approximately 24 days later and again 35 days after the original mailing.

We also used incentives. In the baseline mailing prior to the intervention, the cover letter explained that a drawing would be held and one of every three individuals who returned complete questionnaires would receive a choice of a selection of personal protective equipment items valued at $10–$12 (e.g., sun hat, hearing protectors, and boots). In the mailing after the first and second intervention years, all respondents were promised and received 10 first-class postage stamps. The protocol was approved by the University of Wisconsin-Madison College of Agricultural and Life Sciences Human Subjects Committee.

Data analyses and hypotheses

Reasonably complete questionnaires were coded and entered into a database. All questionnaires were manually checked to verify the accuracy of data entry. In the analysis of the calf feed sites data, operations that reported not raising calves were excluded. Our evaluation tested two hypotheses:

1. *Did managers report getting more information?* We used univariate statistics to investigate whether Wisconsin farm managers' reports of information changed during the course of the study (baseline data were compared with data collected after intervention year two) and whether reports of information differed between Wisconsin and Maryland managers (data from the second intervention year in Wisconsin were compared with the Maryland data from that year). Pearson's Chi-square test was used to compare percentages.[31] The significance level was set at $p \leq 0.05$. No adjustments were made for multiple statistical comparisons.
2. *Did managers report more adoption and awareness?* To assess the main research question, we used logistic regression[32] to generate a total of six equations: one for adoption and one for awareness 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 and second intervention years were compared with the baseline, pre-intervention year while controlling for manager age, education, and gender; operation milking herd size; manager years of experience in dairy farming; gross sales; and manager reports of the percentage of their operation that was owned debt-free. Operations that reported having adopted one of the three production practices in the baseline questionnaire prior to our intervention were excluded from the analysis for that work practice. The significance level was set at $p \leq 0.05$. To investigate for differences between Wisconsin and Maryland manager awareness and adoption, we also used univariate Pearson's Chi-square tests to compare data from the second intervention year in Wisconsin with Maryland.

RESULTS

Evidence that the intervention was delivered

The barn lights practice received the most extensive print coverage, followed by bag silos. Two articles totaling 30 column inches of coverage appeared in dairy print media about barn lights in the baseline year before the start of our intervention. During the two intervention years, seven (totaling 222 column inches) and then nine (164 column inches) barn lights articles were published. Similarly, one article (2 column inches) at baseline and then four articles (101 column inches) and one article (23 column inches) about bag silos appeared. There were no articles during the baseline year about calf feed mixing sites followed by two articles (33 column inches) after the first intervention year and one article (7 column inches) after the second intervention year. Our intervention also made information available to farm managers about all three practices through 13 public events in Wisconsin (at farm shows, expositions, and field days) in the first year of the intervention and 10 public events in the second year.

Questionnaire responses and sample demographics

The mean questionnaire return rate of Wisconsin dairy managers was 72% (vs. 53% of Maryland managers). Wisconsin manager samples at baseline were comparable to samples after year two for age and assets owned debt-free, but not for education, gender, years as a dairy farmer, herd size, or gross sales (Table 1). Similarly, there were significant differences between Wisconsin and Maryland dairy farmer samples evaluated after the second year of the intervention for education, herd size, gross sales, and the percentage of assets owned debt-free.

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 had obtained this information. Compared with their baseline, after the second intervention year significantly more Wisconsin dairy farmers reported getting information about barn lights from print media (80% vs. 90%, $p<0.002$), public events (12% vs. 38%, $p<0.0005$), other farmers (24% vs. 39%, $p<0.001$), equipment dealers (6% vs. 20%, $p<0.0005$), farm consultants (8% vs. 18%, $p<0.003$), and electrical suppliers (9% vs. 24%, $p<0.0005$). They also reported getting more information about bag silos from print media (79% vs. 88%, $p<0.0005$), public events (38% vs. 52%, $p<0.0005$), equipment dealers (17% vs. 35%, $p<0.0005$), and farm consultants (9% vs. 18%, $p<0.001$). There were no significant differences for getting calf feed mixing site information.

After the second intervention year, there were no differences between Wisconsin and Maryland farmers for reports of getting print media information about any of the three practices. Significantly more Wisconsin farmers than Maryland farmers said they received barn lights information at public events (38% vs. 10%, $p<0.0001$), or from university extension agents (19% vs. 3%, $p<0.001$), farm consultants (18% vs. 6%, $p<0.016$), and electrical suppliers (24% vs. 2%, $p<0.0001$). For bag silos, more Wisconsin than Maryland farmers reported getting information at public events (52% vs. 23%, $p<0.0001$) and from university extension agents (12% vs. 5%, $p<0.042$). For the calf feed mixing sites, more Wisconsin than Maryland farmers reported getting information from other farmers (42% vs. 19%, $p<0.004$).

Adoption and awareness

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

Adoption. Among the Wisconsin farmers, the intervention was associated with increased adoption of all three practices after the second intervention year: barn lights (odds ratio [OR] = 2.268, 95% confidence interval [CI] = 1.476, 3.485), bag silos (OR=3.561, 95% CI 2.684, 4.728), and calf feed mixing sites (OR=2.433, 95% CI 1.059, 5.591) (Table 2, Figures 1–3). When other variables were held constant, higher operation gross sales were also associated with adoption for all three work practices. For bag silos, manager age and the farm's debt status were also associated with adoption.

Compared with Maryland farmers, Wisconsin

Table 1. Wisconsin and Maryland dairy operation evaluation samples

Characteristic	*Group*	*Baseline*	*Year 1*	*Year 2*[a]
Number of questionnaires mailed	WI	597	587	422
	MD	NA	NA	300
Number of questionnaires received	WI	427	428	306
	MD	NA	NA	158
Return rate (percent)	WI	72	73	73
	MD	NA	NA	53
Number of eligible responses	WI	420	423	305
	MD	NA	NA	116
Manager age (in years)	WI	45 ± 11	46 ± 11	46 ± 10
	MD	NA	NA	47 ± 12
Manager education (1–9)[b]	WI	4.0 ± 1.6	4.1 ± 1.6	4.3 ± 1.8[c]
	MD	NA	NA	3.8 ± 2.2[d]
Gender (percent male)	WI	95.6	96.4	90.3[c]
	MD	NA	NA	93.1
Number of manager years in dairy farming	WI	29 ± 13	30 ± 12	31 ± 12[c]
	MD	NA	NA	33 ± 13
Herd size	WI	102 ± 97	117 ± 124	127 ± 203[c]
	MD	NA	NA	87 ± 76[c]
Gross sales last year[e]	WI	3.9 ± 1.5	4.0 ± 1.5	4.2 ± 1.6[c]
	MD	NA	NA	3.6 ± 1.5[f]
Assets owned debt-free (percent)	WI	62 ± 28	61 ± 27	64 ± 26
	MD	NA	NA	75 ± 25[f]
Anyone injured last year (percent yes)	WI	9.0	9.0	11.5
	MD	NA	NA	11.5

[a]*P*-values for WI line are WI Year 0 (baseline) vs. WI Year 2. *P*-values for MD line are for MD Year 2 vs. WI Year 2. Calculations used Chi-square for percent and Student's t-test for numerical values.

[b]Education scale: 1 = grade school, 2 = some high school, 3 = high school graduate, 4 = high school plus vocational/technical school, 5 = some college, 6 = two-year associate degree, 7 = four-year college degree, 8 = some graduate school, 9 = graduate degree

[c]$p\leq0.05$

[d]$p\leq0.01$

[e]Gross sales scale: 1 = <$5,000; 2 = $5,000–$15,000; 3 = $15,001–$25,000; 4 = $25,001–$50,000; 5 = $50,001–$100,000; 6 = $100,001–$200,000; 7 = $200,001–$400,000; 8 = >$400,000

[f]$p\leq0.001$

WI = Wisconsin

MD = Maryland

NA = not available because a Maryland sample was not evaluated at baseline or after the first intervention year farmer reports of adoption after the second year of the intervention were higher for bag silos (44% vs. 34%, $p<0.053$).

Awareness. The intervention was associated with increased awareness among the Wisconsin farmers for two of the three practices after the second intervention year: barn lights (OR=2.272, 95% CI 1.860, 2.777) and calf feed mixing sites (OR=1.518, 95% CI 1.273, 1.810), but not bag silos (OR=1.697, 95% CI 0.965, 2.982) (Table 3, Figures 1–3). When other variables were held constant, higher operation gross sales and higher manager education were associated with increased awareness of the calf feed mixing sites. Higher operation gross sales, higher manager education, younger manager age, and being male were associated with increased awareness of barn lights.

Table 2. Logistic regression analysis estimating with northeast Wisconsin dairy farmer adoption of barn lights, bag silos, and calf feed mixing sites

Practice and variable	*Odds ratio*	*95% CI*
Barn lights		
Intervention year 1	5.100[a]	2.200, 11.822
Intervention year 2	2.268[a]	1.476, 3.485
Manager age	0.974	0.931, 1.019
Manager gender	2.342	0.824, 6.662
Operation gross sales	1.305[b]	1.055, 1.614
Percentage of assets owned debt-free	0.991[c]	0.981, 1.001
Number of manager years in dairy farming	1.002	0.962, 1.043
Manager education	0.976	0.850, 1.120
Operation herd size	1.000	0.999, 1.002
Bag silos		
Intervention year 1	1.685[c]	0.898, 3.162
Intervention year 2	3.561[a]	2.684, 4.728
Manager age	0.961[b]	0.928, 0.996
Manager gender	1.354	0.592, 3.099
Operation gross sales	1.268[d]	1.071, 1.501
Percentage of assets owned debt-free	0.991[b]	0.983, 0.999
Number of manager years in dairy farming	1.023	0.990, 1.058
Manager education	0.997	0.887, 1.121
Operation herd size	0.999[c]	0.997, 1.000
Calf feed mixing sites		
Intervention year 1	5.720[b]	1.138, 28.763
Intervention year 2	2.433[b]	1.059, 5.591
Manager age	0.973	0.879, 1.076
Manager gender	0.000	0.000, 0.000
Operation gross sales	2.079[a]	1.453, 2.977
Percentage of assets owned debt-free	0.992	0.969, 1.015
Number of manager years in dairy farming	1.024	0.933, 1.125
Manager education	0.946	0.714, 1.253
Operation herd size	1.000	0.998, 1.002

[a]$p \leq 0.001$
[b]$p \leq 0.05$
[c]$p \leq 0.10$
[d]$p \leq 0.01$
CI = confidence interval

Figure 1. Northeast Wisconsin manager-reported awareness and adoption of barn lights

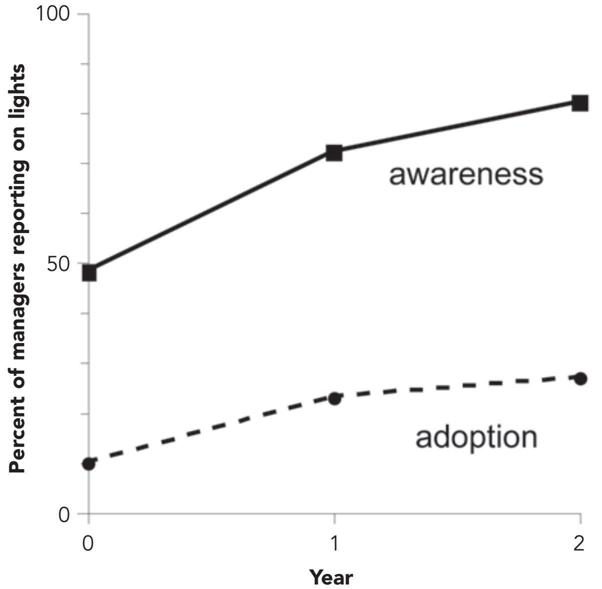


Figure 2. Northeast Wisconsin manager-reported awareness and adoption of bag silos

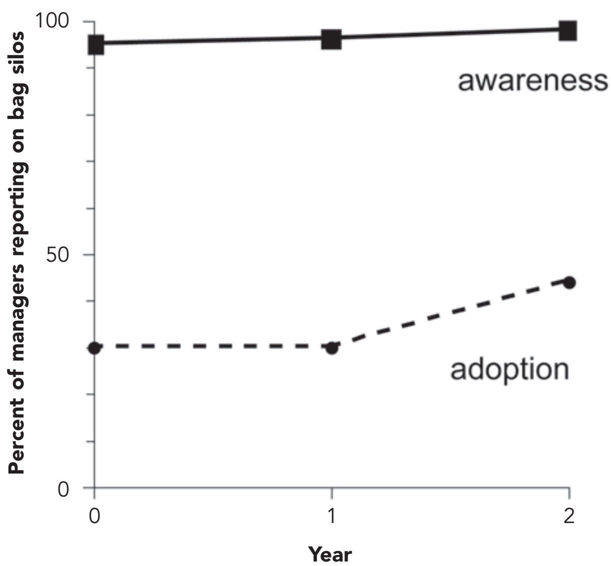
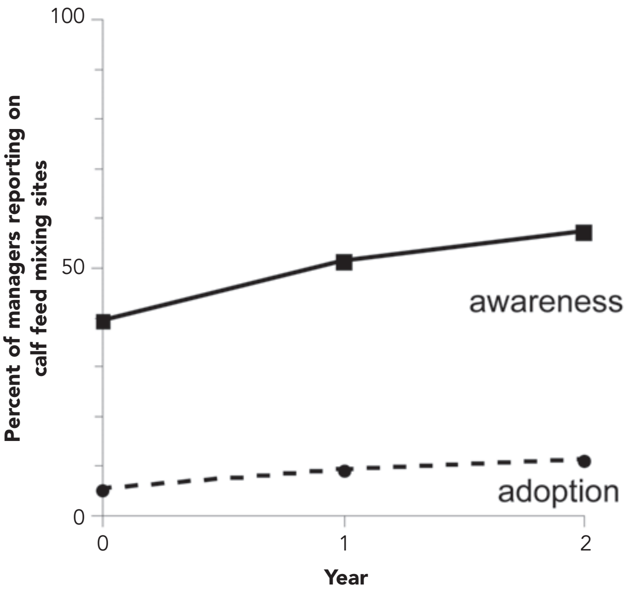


Figure 3. Northeast Wisconsin manager-reported awareness and adoption of calf feed mixing sites



Compared with the Maryland farmers, significantly fewer Wisconsin farmers were unaware of barn lights (19% vs. 41%, $p<0.0001$) and calf feed mixing sites (42% vs. 61%, $p<0.001$) after the intervention's second year.

DISCUSSION

Baseline reports compared with results collected after the second intervention year provided evidence that Wisconsin farmers did get significantly more information about both barn lights and bag silos from print media, public events, equipment dealers, and farm consultants. For barn lights, they also received more information from other farmers and electrical suppliers. These findings suggested that our intervention used information channels effectively to reach farmers. The predominance of print media confirmed earlier research regarding which sources of production practice information were most often used by Wisconsin dairy farmers.[13,14] 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.

As noted previously, we considered Maryland farmers a partially exposed comparison group because we suspected that they were as likely as Wisconsin farmers to read many of the same nationally distributed dairy trade publications and other print media in which articles about the three practices, assisted by our intervention, appeared. The questionnaire data provided evidence to support this idea in that the percentage of Wisconsin vs. Maryland dairy farmers who reported getting information from print media about each of the three practices after the second year of the intervention was not significantly different. However, more Wisconsin than Maryland farmers reported getting both barn lights and bag silo information from public events and university extension agents (and, for barn lights alone, from other farmers, farm consultants, and electrical

Table 3. Logistic regression analysis estimating association with northeast Wisconsin dairy farmer awareness for barn lights, bag silos, and calf feed mixing sites

Practice and variable	*Odds ratio*	*95% CI*
Barn lights		
Intervention year 1	2.682[a]	1.960, 3.669
Intervention year 2	2.272[a]	1.860, 2.777
Manager age	0.974[b]	0.950, 0.999
Manager gender	0.515[b]	0.265, 1.000
Operation gross sales	1.197[c]	1.058, 1.355
Percentage of assets owned debt-free	0.997	0.992, 1.003
Number of manager years in dairy farming	1.005	0.981, 1.029
Manager education	1.155[c]	1.051, 1.268
Operation herd size	0.999	0.998, 1.001
Bag silos		
Intervention year 1	1.200	0.579, 2.490
Intervention year 2	1.697[d]	0.965, 2.982
Manager age	1.006	0.947, 1.067
Manager gender	1.588	0.207, 12.167
Operation gross sales	1.260	0.945, 1.679
Percentage of assets owned debt-free	0.985[b]	0.971, 1.000
Number of manager years in dairy farming	1.014	0.959, 1.074
Manager education	1.108	0.874, 1.405
Operation herd size	0.998[d]	0.996, 1.000
Calf feed mixing sites		
Intervention year 1	1.664[a]	1.222, 2.267
Intervention year 2	1.518[a]	1.273, 1.810
Manager age	0.980	0.956, 1.004
Manager gender	0.757	0.396, 1.446
Operation gross sales	1.255[a]	1.102, 1.428
Percentage of assets owned debt-free	0.996	0.991, 1.001
Number of manager years in dairy farming	1.006	0.983, 1.030
Manager education	1.141[c]	1.049, 1.242
Operation herd size	1.000	0.998, 1.002

[a]$p\leq0.001$
[b]$p\leq0.05$
[c]$p\leq0.01$
[d]$p\leq0.10$
CI = confidence interval

suppliers). This suggests that Maryland dairy farmers were indeed exposed to the print media component of our intervention, but not to the public events, university extension agents, and other geographically specific intervention components delivered in Wisconsin.

The most important goal of our intervention was to increase adoption of the three safer practices. Within the Wisconsin treatment group, logistic regression analyses confirmed that each 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 mixing sites). This suggests that our intervention was successful. Bag silo awareness was already widespread in Wisconsin according to the baseline data collected prior to our intervention (e.g., 95% in the baseline year), so our intervention had little room for improvement.

Further evidence of the intervention's success was provided by the univariate comparisons with the Maryland group for just the second year of the intervention. Wisconsin managers reported significantly more silage bag adoption, more barn lights awareness, and more calf feed mixing site awareness than Maryland managers.

There were also significant associations between younger Wisconsin managers and increased awareness of barn lights as well as increased adoption of bag silos that were consistent with previous research on agricultural innovations. Similarly, we found significant associations between higher manager education and increased awareness (for barn lights and calf feed mixing sites) for which there were precedents in other agricultural innovation research. The association that was most consistently significant was between higher operation gross sales and increased adoption and awareness (both were significant for all three practices except awareness of bag silos). Because gross sales can be considered to be a proxy for operation size, this finding was also consistent with previous research on agricultural innovations.[9–11]

We believe these associations between higher gross sales (and other variables) and increased adoption and awareness are interesting but, perhaps, less important than our findings about the value of each additional intervention year.

After the intervention, the reports from our dairy farm manager sample suggested that safer barn lighting was likely to be in use on about one in four northeastern Wisconsin dairy farms, and safer bag silos were likely to be in use on about four of nine northeastern Wisconsin dairy farms. We made repeated, but ultimately unsuccessful, attempts to support our adoption findings by requesting Wisconsin sales records from the relevant manufacturers. More widespread use of safer production practices is likely to be associated with reduced numbers of exposures and exposures of shorter duration to injury hazards that could contribute to reductions in specific types of injuries.[20,28]

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.[28] Conceivably, if all Wisconsin farmers using tower silos or other methods of silage storage replaced them by adopting bag silos, few or no future deaths or other 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 and animals in dairy barns could be reduced. Currently, the surveillance of both fatal and nonfatal injuries in the dairy industry and all of production agriculture in the U.S. is much less comprehensive and accurate than in other industries.[1,33] Improvements in agricultural injury surveillance, including better recording of nonfatal injuries and greater detail about causal factors that contribute to nonfatal and fatal injuries, 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 measures of injury reduction).[34,35] However, our study did incorporate other attributes, including a theoretical model, community-based probability samples, long-term follow-up, and relatively large-sized intervention and evaluation subject groups. Because our subjects were not randomly assigned to treatment, our evidence was associational rather than causal, 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.

Previous research clearly indicates that awareness is a necessary but not sufficient condition for adoption, and has often found that it can take years to get from awareness to adoption of a practice.[9–11] Future research should investigate the length of the time lag between awareness and adoption associated with particular production practices and the barriers and enabling factors that predict it.

CONCLUSION

Nationwide, there were 78,000 dairy operations in the U.S. in 2005[36] and most were exempted by federal budget riders from enforcement of governmental occupational safety regulations.[1,7,8] 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 with information dissemination interventions that emphasize the greater profitability of safer work practices may be a viable interim supplement to more comprehensive occupational safety regulation and enforcement in the dairy industry.

The authors thank Aashish Mehta, who provided statistical assistance.

Part of this work was supported through grants from the National Institute for Occupational Safety and Health (NIOSH) (federal grant identification numbers U05CCU506065, R01CCR514357, and R01OHO3953). The contents of this article are solely the responsibility of the authors and do not necessarily represent the official views of NIOSH.

REFERENCES

1. McCurdy SA, Carroll DJ. Agricultural injury. Am J Ind Med 2000;38: 463-80.
2. Department of Labor, Bureau of Labor Statistics (US). 1998 census of fatal occupational injuries. Washington: Department of Labor, Bureau of Labor Statistics; 1999.
3. Myers JR. Injuries among farm workers in the United States—1994. DHHS/NIOSH Publication No. 98-153. Cincinnati: National Institute for Occupational Safety and Health (US); 1998.
4. Myers JR, Hard DL. Work-related fatalities in the agricultural production and services sectors, 1980–1989. Am J Ind Med 1995;27:51-63.
5. Surveillance for nonfatal occupational injuries treated in hospital emergency departments—United States, 1996. MMWR Morb Mortal Wkly Rep 1998;47(15):302-6.
6. Gerberich SG, Gibson RW, Gunderson PD, French LR, Martin F, True JA, et al. Regional Rural Injury Study (RRIS): a five state population based effort funded by the Centers for Disease Control, 1989–1992. St. Paul (MN): University of Minnesota School of Public Health; 1993.
7. Murphy D. Safety and health for production agriculture. St. Joseph (MI): American Society of Agricultural and Biological Engineers; 1992.
8. Kelsey TW. The agrarian myth and policy responses to farm safety. Am J Public Health 1994;84:1171-7.
9. Wejnert B. Integrating models of diffusion of innovations: a conceptual framework. Annu Rev Sociol 2002;28:297-326.
10. Rogers EM. Diffusion of innovations. 5th ed. New York: Free Press; 2003.
11. Feder G, Umali DL. The adoption of agricultural innovations: a review. Technol Forecast Soc Change 1993;43:215-39.
12. Chapman LJ, Taveira AD, Josefsson KG, Hard D. Evaluation of an occupational injury intervention among Wisconsin dairy farmers. J Agric Saf Health 2003;9:197-209.
13. Babbie E. Survey research methods. 2nd ed. Belmont (CA): Wadsworth Publishing; 1990.
14. Fett J, Mundy P. Disseminating annual crop practice recommendations via supplements in weekly agricultural newspapers. Presented at the Agricultural Communicators in Education annual convention; 1990 Jul 15–18; Minneapolis.
15. Smith T. Wisconsin dairy industry needs assessment. Madison (WI): University of Wisconsin Center for Dairy Profitability; 1995.
16. Wisconsin Department of Agriculture, Trade, and Consumer Protection. Brucellosis ring test list. Madison (WI): Wisconsin Department of Agriculture, Trade, and Consumer Protection; 1997.
17. AgSource Cooperative Service. List of dairy herd improvement program members. Madison (WI): AgSource Cooperative Service; 1996.
18. State of Maryland Department of Agriculture. Brucellosis ring test list. Baltimore: State of Maryland Department of Agriculture; 1998–1999.
19. Josefsson G, Miquelon M, Chapman L. Work efficiency tip sheet: long-day lighting in dairy barns. Madison (WI): University of Wisconsin Biological Systems Engineering Department; 2000. Also available from: URL: http://bse.wisc.edu/hfhp/tipsheet.htm [cited 2009 Feb 5].
20. Josefsson G, Miquelon M, Chapman L. Work efficiency tip sheet: use silage bags. Madison (WI): University of Wisconsin Biological Systems Engineering Department; 2000. Also available from: URL: http://bse.wisc.edu/hfhp/tipsheet.htm [cited 2009 Feb 5].
21. Josefsson KG, Miquelon M, Chapman LJ. Work efficiency tip sheet on liquid feed mixing facilities for dairy calves. Madison (WI): University of Wisconsin Biological Systems Engineering Department; 1999. Also available from: URL: http://bse.wisc.edu/hfhp/tipsheet.htm [cited 2009 Feb 5].
22. Treno AJ, Breed L, Holder HD, Roeper P, Thomas BA, Gruenewald PJ. Evaluation of media advocacy efforts within a community trial to reduce alcohol-involved injury. Eval Rev 1996;20:404-23.
23. Chastain JP, Hiatt RS. On-site investigation of indoor lighting systems for dairy facilities. Paper presented at the 1994 Annual International Meeting of the American Society of Agricultural and Biological Engineers; 1994 Dec 13–17; Atlanta.
24. Dahl GE, Buchanan BA, Tucker HA. Photoperiodic effects on dairy cattle: a review. J Dairy Sci 2000;83:885-93.
25. Peters RR. Photoperiod and management of dairy cows: a practical review. In: Bucklin R, editor. Dairy systems for the 21st century. Proceedings of the Third International Dairy Housing Conference. St. Joseph (MI): American Society of Agricultural and Biological Engineers; 1994. p. 662-6.
26. Davies JC, Kemp GJ, Stevens G, Frostick SP, Manning DP. Bifocal/varifocal spectacles, lighting and missed-step accidents. Saf Sci 2001;38:211-26.
27. Bhattacharya A. Ergonomics of task performance on slippery surfaces. Final report on project R01 OH030079. Cincinnati: National Institute for Occupational Safety and Health (US); 1998.
28. Josefsson KG, Chapman LJ, Taveira AD, Holmes BJ, Hard D. A hazard analysis of three silage storage methods for dairy cattle. HERA 2001;7:1895-907.
29. Dillman DA. Mail and Internet surveys: the tailored design method. 2nd ed. New York: Wiley & Sons; 1999.
30. Dillman DA. The design and administration of mail surveys. Annu Rev Sociol 1991;17;225-49.
31. SPSS. Statistical package for the social sciences. New York: McGraw Hill; 1996.
32. Menard SW. Applied logistic regression analysis. Thousand Oaks (CA): Sage Publications; 2001.
33. Hard DL, Myers JR, Gerberich SG. Traumatic injuries in agriculture. J Agric Saf Health 2002;8:51-65.
34. Rautianen RH, Lehtola MM, Day LM, Schonstein E, Suutarinen J, Salminen S, et al. Interventions for preventing injuries in the agricultural industry. Cochrane DB Syst Rev 2008;1. DOI:10.1002/14651858.CD006398.pub2.
35. Robson LS, Shannon HS, Goldenhar LM, Hale AR. Guide to evaluating the effectiveness of strategies for preventing work injuries. DHHS/NIOSH Publication No. 2001-119. Cincinnati: National Institute for Occupational Safety and Health (US); 2001.
36. Wisconsin Agricultural Statistics Service. 2006 Wisconsin agricultural statistics. Washington: Department of Agriculture (US), National Agricultural Statistics Service; 2006. Also available from: URL: http://www.nass.usda.gov/Statistics_by_State/Wisconsin/Publications/Annual_Statistical_Bulletin/as06web.pdf [cited 2008 Nov 14].

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