Evaluation of an Occupational Injury Intervention Among Wisconsin Dairy Farmers

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ABSTRACT.

Objectives: Dairy farming injury rates are high. Previous agricultural research has shown that better information flow can speed adoption of more profitable practices. We conducted and evaluated an intervention to increase voluntary adoption of three production practices that were safer and more profitable than typical practices: barn lights, bag silos, and a mixing site for calf feed.

Methods: Print mass media, public events, university Extension, and dairy farmers already using the practices were all enlisted to disseminate information to 4,300 northeast district Wisconsin dairy farmers. Evaluation questionnaires were mailed to independent samples of farm managers before (n = 582) and after (n = 572) the 12 month long intervention.

Results: After the intervention, more managers reported getting information about barn lights from public events (12% vs. 23%) and private consultants (8% vs. 17%) and about silo bags from print media (79% vs. 87%) and private consultants (9% vs. 14%). More managers were aware of barn lights (48% vs. 72%) and the calf feed mixing site (44% vs. 56%). There was a nonsignificant tendency for more managers to report adopting barn lights (12% vs. 23%).

Conclusions: Improving information flow to operation managers about safer, more profitable production practices may be a relatively easy way to supplement conventional injury control efforts in high–hazard industries.

***Keywords**. Agriculture, Injury control, Intervention evaluation, Occupational health, Safety.*

Dairy farms have long been relatively hazardous places to work. Population–based studies of nonfatal, lost–time dairy farm injuries have shown that rates for Wisconsin (8.0 per 200,000 work hours in 1992; Gerberich et al., 1993) and the entire U.S. (6.8 in 1994; Myers, 1998) measurably exceeded rates for all types of U.S. production agriculture (4.0 in 1994; Myers, 1998) and for all U.S. private industry (2.8 in 1996; NIOSH, 1998). Studies of fatal injuries

Article was submitted for review in October 2002; approved for publication by the Journal of Agricultural Safety and Health of ASAE in April 2003.

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  ISSN 1074-7583

that included dairy farms with other production agriculture fatalities have shown that average rates for production agriculture between 1980 and 1989 (22.9 per 100,000; Myers and Hard, 1995) exceeded the average rate for production agriculture in 1998 (21.4; U.S. Department of Labor, 1999) and were far in excess of rates for all U.S. private industry for both 1980–1989 (7.0; Myers and Hard, 1995) and 1998 (4.8; U.S. Department of Labor, 1999).

Difficulties with regulation setting, enforcement, and compliance as well as the nature of the industry have all been suggested to explain why dairy and other production agriculture injury hazards persist despite traditional prevention efforts. These problems have been especially evident on smaller operations with ten or fewer employees, which employ most of the workforce. Conventional command and control regulation has been ineffective on these operations because there is little enforcement (McCurdy and Carroll, 2000; Kelsey, 1994; Murphy, 1992; U.S. Congress, 1992).

Previous research in production agriculture has shown that increasing information flow to farm managers about more profitable production practices can accelerate the awareness and adoption of improved practices (e.g., Rogers, 1995; Feder and Umali, 1993; Fliegel, 1993). Dairy farm managers and other agricultural producers have been enthusiastic adopters of new production practices that improve profits. Annual total factor productivity growth from 1948 to 1994 for U.S. agriculture was 1.94% per year, compared to 1.31% for U.S. manufacturing industries (Ahearn et al., 1998). We designed an intervention to accelerate information flow to dairy farm managers about three production practices that are safer than typical practices and that also improve profits. Our intervention used the same information channels that Wisconsin dairy farm managers had traditionally relied on to learn about production practices that improve profits (Smith, 1995; Fett and Mundy, 1990).

Methods

Design and Conceptual Model

The intervention was conducted among all dairy producers in eight geographically contiguous northeast Wisconsin counties (N = 4,300 operations) and was designed to improve information flow to dairy managers about three safer production practices: barn lights, bag silos, and a calf feed mixing site. Mail questionnaires were administered to evaluate the intervention. We were interested in whether the percentage of dairy farm managers who reported that they were aware of each practice changed after the intervention. Since the process of filling out the evaluation questionnaire also made farm managers aware of each practice, we decided to use a design that involved mailing to a different sample of dairy farmers at baseline and after one year (i.e., rolling sample cohort design) (Babbie, 1990). We drew separate, population–based, probability samples that were representative of the distribution of dairy operation sizes in Wisconsin prior to the intervention and after one year. Wisconsin is a leading dairy state that has many relatively small operations (Wisconsin Agricultural Statistics Service, 1997). We also decided to supplement the population–based samples with separate oversamples of larger dairy farms from northeast Wisconsin so our findings could better reflect dairy producers nationwide.

The intervention plan incorporated a well–known theoretical model (Rogers, 1995) and previous research findings about how and why individuals adopt agricultural technologies (e.g., Nowak and O'Keefe, 1993; Feder and Umali, 1993; Fliegel, 1993). In the model, the farm manager proceeds through three stages in a

sequential fashion: awareness to evaluation to trial and use (Rogers, 1995). Previous research has demonstrated that more farm managers (>90%) used national dairy magazines and regional agricultural newspapers than any other information source for learning about new production practices and valued the information higher than other sources (Smith, 1995; Fett and Mundy, 1990). Getting information from other farmers and from attending public events (e.g., field days and farm shows) was also common. This same research showed that farmers valued information from university Extension agent personal contacts, meetings, and bulletins as highly as print media information sources but that fewer farm managers reported using them (30% to 50%) (Fett and Mundy, 1990). As part of the intervention, we collaborated with agricultural journalists from regional and national dairy magazines and agricultural newspapers to develop and place factual articles about each production practice. Unfortunately, this meant that dairy producers throughout the U.S. and internationally were exposed to some of the intervention's components, so our design was unable to incorporate an unexposed control group of dairy producers.

Subjects

We used the Wisconsin state government's Brucellosis Ring Test list of all dairy operations in the state as a sampling frame (Wisconsin Department of Agriculture, 1997). We selected independent probability samples for the baseline (n = 282) and year 1 (n = 272) intervention evaluation of all operations in the eight northeast Wisconsin counties (N = 4,300). Since the Brucellosis Ring Test list did not include information about operation size, we turned to a second sampling frame to obtain the oversample of larger size operations. We used the state's Dairy Herd Improvement Program list of operations to select independent samples of the largest producers in the eight northeast Wisconsin counties (N = 600) using herd size as a proxy for operation size for the baseline (n = 300) and year 1 mailing (n = 300) (AgSource, 1996; Stephenson and Trechter, 1992). After drawing both samples in each year, we examined the Brucellosis Ring Test list sample for duplications of the large operations in the Dairy Herd Improvement Program sample. We removed operations that appeared on both lists from the Brucellosis Ring Test list. Second, after questionnaires were returned, we checked to ensure there were no duplicate questionnaires from the same operation prior to data entry. When duplicates were discovered, the earliest questionnaire was retained. In total, we mailed a questionnaire to 582 operations before the intervention began and to another 572 operations after one intervention year.

Intervention Components

The intervention effort incorporated social marketing principles: the audience was segmented according to the stages in the theoretical model, and materials were then developed and delivery vehicles enlisted that would be most appropriate for each segment of the target audience.

Print Mass Media

Agricultural journalists were enlisted at the half–dozen publications we judged to be regularly read by Wisconsin dairy farmers for information about new production methods (these judgments were later confirmed by results from a specific question asked on the baseline questionnaire). The journalists were equipped to write their own articles with press packets that included short–format descriptive print materials (e.g., http://bse.wisc.edu), photos, and lists of potential telephone interview contacts.

In addition, journalists at over 70 other publications, including weekly county newspapers in Wisconsin and other periodicals, also received press packet mailings. We kept track of all articles appearing in the regularly read producer publications that included coverage of the production practices that we were promoting. We used standard methods to determine column inches of coverage specific to each of our production practices for each article (Treno et al., 1996).

Public Events

Project staff, university Extension agents, and other public and private sector resource people all attended local and regional dairy farm manager meetings and conferences where they mounted exhibits, delivered presentations, and distributed short–format print materials about the practices. We kept track of the attendance at these events and of the numbers of materials distributed.

Resource People

University of Wisconsin–Extension agriculture and agribusiness agents were provided with short–format print materials about the practices to distribute during their farm visits and group programs. The intervention also enlisted and provided materials to USDA milk inspectors who visited dairy farms periodically. We involved relevant individuals from the commercial sector by providing them with materials and by encouraging them to pass information on to dairy farmers about the production practices our project was promoting in ways they felt were appropriate. These resource people included veterinarians, farm consultants, and the farm equipment and supply dealers who sold and installed barn lighting fixtures, silo bags and bagging equipment, and calf care facilities and equipment.

Farmer–to–Farmer Resource People

We facilitated farmer–to–farmer exchanges of information by recruiting a small group of pilot farm managers around the state who were already using the practices. After gaining permission, we encouraged farm managers and agricultural journalists who were interested in particular production practices to contact and visit these pilot farmers. We also assisted pilot farmers with travel expenses so they would be more likely to attend conferences and workshops and enlisted some pilot farmers as presenters and exhibitors at public events.

Production Practices

The intervention was designed to encourage dairy farmers to consider adopting three production practices that can improve both safety and profits over typical practices.

Barn Lights

Supplemental high–intensity lighting of dairy livestock housing during October to March that simulates summer day lengths and light intensities has been demonstrated to increase cow milk yields and heifer growth by 5% to 15% and can be accomplished with 1– to 2–year payback periods on most operations (Dahl et al., 2000; Peters, 1994). Cow barns are generally poorly lighted (Chastain and Hiatt, 1998). Better lighted cow barns are likely to improve work quality and output while reducing the risks of employee/animal injuries and slips and falls on the same level in the barn, as well as injuries resulting from vehicle collisions with barn structures (Josefsson et al., 1999a; Bhattacharya, 1998). For example, follow–up studies after falls on the same level in other occupations have shown that poor illumination can increase risks of injury two to three times over that in well lighted conditions (Davies et al., 2001).

Bag Silos

Silage storage in long tubular plastic bags on the ground compares favorably, in terms of capital and operating costs and silage quality, to both traditional tower silos and to newer bunker silos. Payback periods can be as short as one year or less depending on how extensive and how recently investments were made in other practices (Josefsson et al., 1999b; Roenfeldt, 1998; Rotz, 1996; Holmes, 1995a, 1995b). Storing silage in bags largely eliminates the dangers of silo gas and falls during climbing associated with tower silos (Josefsson et al., 2001). Bag silos can also reduce or eliminate hazards associated with bunker silos, including the risks of tractor rollover associated with loading, suffocations associated with silage face collapse, and falls from elevation (Josefsson et al., 2001).

Calf Feed Mixing Site

Constructing 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 (Josefsson et al., 1999c). Payback periods on the investment range from 1 to 5 years depending on operation size. For example, operations with 300 or more cows raised about 30 calves at a time, and their payback period was less than one year. Operations with 150 cows raised about 15 calves on average at any one time, and their payback period was about 2 years. Typical Wisconsin operations had 60 cows in 1998, raised about 6 calves at a time, and their payback period was between 3 and 4 years. An on–site feed preparation area can also reduce the risks of back and other musculoskeletal injury attributable to lifting, carrying, and other manual materials–handling performed by calf care employees because materials are available much closer to calf housing sites. Exposures to inclement weather conditions (e.g., intense heat or cold windy weather; walking through mud, rain, ice, or snow) are also decreased because time to feed calves is less (Josefsson et al., 1999c). Farm managers who did not raise calves or who raised them in the cow barn were excluded from the awareness and adoption portion of the analysis since they would have no conceivable use for a calf feed mixing site.

Evaluation Questionnaire Administration and Procedure

We developed and administered a mail questionnaire based on standardized recommendations (Dillman, 1991, 1978). The questionnaire included standard items about demographics, milking herd size, and other dairy operation characteristics adapted from formats used by federal and state agricultural statistics agency instruments (Wisconsin Agricultural Statistics Service, 1997). The questionnaire also asked about intervention process measures (such as having read agricultural newspapers and magazine articles about the practices, and having seen information about the practices at public events) and, in total, required about 10 to 20 minutes to complete. The baseline questionnaire item about where farmers had seen information about the practices asked about “ever” hearing, while the year 1 questionnaire item asked about hearing “in the 12 months.” The cover page requested that the questionnaire be filled out by the farm operator or the person who made the most management decisions about how the dairy farm ran. The cover letters emphasized the social utility of the survey, the importance of each respondent completing the survey, and the privacy protections for returned questionnaires. A series of follow–up mailings to nonrespondents, including a reminder postcard 8 to 14 days later and repeated remailings of the questionnaire and cover letters at 24 and again at 35 days later, were conducted for nonrespondents (Dillman, 1991, 1978). In the baseline

mailing prior to the intervention, respondents were told that a drawing would be held and that one of every three respondents 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 mailing after the intervention, the cover letter offered all those returning reasonably complete questionnaires an incentive of ten first–class postage stamps, then worth $3.20. The protocol was approved by the University of Wisconsin–Madison College of Agricultural and Life Sciences human subjects committee.

Data Analysis and Hypotheses

The individual dairy operation was the unit of analysis. Reasonably complete questionnaires were coded and entered into a database. All questionnaire responses were then rechecked and compared with the original entries to provide data quality control. The operation–size representative sample and the larger–sized operation oversample were combined for analyses. Student's t test was used to compare numerical values, and Pearson's chi square tests were used to compare percentages (SPSS, 1996). In those instances where Levene's test for equality of variances was significant, the p–value reported for the associated t–test was for the test where equal variances were not assumed. In all other cases, the p–value of the t–test refers to the test where equal variances were assumed. The evaluation investigated two hypotheses to determine whether dairy farm managers in northeast Wisconsin:

1. Were more likely to recall receiving information about the production practices from information sources we collaborated with after the intervention.
2. Were more likely to be aware of and to adopt the production practices after the intervention.

Hypothesis testing was first performed on whether adoption or awareness levels were significantly increased after the intervention for each of the three practices. Alpha was set at $p < 0.05$ family–wise within each production practice area for two–tailed chi square tests. After these six comparisons, the rest of the statistical comparisons were performed as post hoc tests without any correction for multiple comparisons.

Results

Intervention Delivery

Eighteen articles about the three production practices were placed in national dairy magazines and regional agricultural newspapers during the intervention year. Nine articles were published about barn lights (222 total column inches), five on bag silos (75 column inches), and four on the calf feed mixing site (18 column inches). No articles had been published in the year prior to our intervention in any of the magazines or newspapers about the three production practices, except for one 30 column inch article about barn lighting. Information about all three practices was provided at nine public events in northeast Wisconsin as well as two in south central Wisconsin (in or near Madison) that producers in northeast Wisconsin were known to attend in large numbers (i.e., World Dairy Exposition, University of Wisconsin Farm Short Course). University Extension dairy and livestock agents in the eight northeast Wisconsin counties reported conveying information during the intervention year through individual or group programs to farm managers about barn lights (350 farm managers), silo bags (350), and the calf feed mixing site (100).

Questionnaire Responses and Demographics

Questionnaire response rates for the baseline (72%) and year 1 groups (74%) were not statistically different. The response rate for the DHI group large farm sample was 216/300 or 72% at baseline and 211/300 or 70% after one intervention year. The response rate for the BRT general farm sample was 204/282 or 72% at baseline and 215/272 or 79% after one intervention year. There were no significant differences between the baseline and year 1 groups for personal demographic or operation economic variables or for the risk perception or information use items (table 1). The average herd sizes for the baseline (n = 102.3 cows) and year 1 groups (n = 116.6 cows) in this study were higher than Wisconsin's 1998 statewide average (63.0), and higher than those of five of the other nine most important dairy states (California 472.6, New Mexico 390.0, Washington 203.1, Texas 124.4, New York 80.7, Michigan 80.0, Minnesota 61.6, Pennsylvania 59.1, and Ohio 51.8).

Manager Exposure to Information

All farm managers who reported that they had seen, heard, or read about each production practice were asked where they had found their information (table 2). After the intervention, more managers reported hearing about barn lights at a public event (12% vs. 23%) or from a private farm consultant (8% vs. 17%). There were also increases after the intervention in managers reading about silo bags in print media (79% vs. 87%) and hearing about them from a private consultant (9% vs. 14%), as well as a decrease in hearing about them from other farmers (66% vs. 53%).

Table 1. Sample demographics and characteristics.

	Baseline (n = 421)	Year 1 (n = 426)	p
Sample group size	582	572	
Returned questionnaires	421 (72%)	426 (74%)	
Age	45.1 ±11.0	45.8 ±10.6	0.354
Male farm managers	394 (96%)	407 (96%)	0.546
Years in dairy farming	29.4 ±12.6	30.5 ±12.2	0.205
Years managing this dairy	19.0 ±11.3	20.1 ±11.5	0.166
Education[a]	4.0 ±1.6	4.1 ±1.6	0.753
Herd size	102.3 ±97.0[d]	116.6 ±124.1[d]	0.064
Gross value of sales last year[b]	3.9 ±1.5	4.0 ±1.5	0.651
% sales from milk	85.3 ±12.0	85.6 ±12.3	0.703
% assets owned free	61.6 ±28.0	60.9 ±27.1	0.721
Rating of own farm's safety[c]	4.0 ±0.6	4.0 ±0.6	0.163

[a] Education: 1 = grade school, 2 = some high school, 3 = high school grad, 4 = some vocational school, 5 = UW farm short course, 6 = some college work, 7 = 2–year associate degree, 8 = 4–year college degree, 9 = some graduate school, and 10 = graduate degree.

[b] Gross sales: 1 = <$50,000; 2 = $50,000 to 99,999; 3 = $100,000 to 199,999; 4 = $200,000 to 299,999; 5 = $300,000 to 499,999; 6 = $500,000 to 699,999; 7 = $700,000 to 899,999; and 8 = ≥$900,000.

[c] Rating: 1 = very unsafe, 2 = unsafe, 3 = neither safe nor unsafe, 4 = safe, and 5 = very safe.

[d] Unequal variances according to Levene's test, so p value reported is for t–test where equal variances were not assumed.

Table 2. Aware farm manager's reports of where they had seen, read, or heard about each practice[a] (in %)

	Barn Lights			Silo Bags			Calf Feed Mixing Site		
	Baseline (*n*=202)	Year 1 (*n*=303)	p	Baseline (*n*=396)	Year 1 (*n*=407)	p	Baseline (*n*=156)	Year 1 (*n*=204)	p
Print media	78	79	0.930	79	87	0.001	73	68	0.310
Public event	12	23	0.001	38	38	0.931	19	19	0.885
Resource people:									
Other farmer	24	30	0.156	66	53	0.000	42	32	0.077
Extension agent	18	24	0.085	15	19	0.258	9	13	0.235
Veterinarian	14	13	0.753	—	10		—	8	
Electricity supplier	9	10	0.583	—	—		—	—	
Private consultant	8	17	0.003	9	14	0.025	4	7	0.271
Equipment dealer	6	9	0.126	17	22	0.091	3	5	0.405
Radio/TV	—	6		—	8		—	2	
Milk inspector	—	1		—	—		—	—	
Other	4	3	0.630	5	5	0.715	5	6	0.531

[a] Baseline questionnaire wording = "ever"; year 1 questionnaire wording = "in the last 12 months."

Table 3. Dairy farmer reports of awareness, adoption, and perceptions for the three practices.

	Barn Lights			Silo Bags			Calf Feed Mixing Site[a]		
All Respondents	Baseline (*n*=418)	Year 1 (*n*=417)	p	Baseline (*n*=417)	Year 1 (*n*=423)	p	Baseline (*n*=287)	Year 1 (*n*=282)	p
Unaware	216 (52%)	116 (28%)	0.000	21 (5%)	15 (4%)	0.296	160 (56%)	123 (44%)	0.004
Aware	152 (36%)	204 (49%)		225 (54%)	226 (53%)		108 (37%)	131 (46%)	
Adopted	50 (12%)	97 (23%)	0.076	171 (41%)	182 (43%)	0.639	19 (7%)	28 (10%)	0.517
Total	418 (100%)	417 (100%)		417 (100%)	423 (100%)		287 (100%)	282 (100%)	

[a] Results for the calf feed mixing site do not include farm managers who reported that they did not raise any calves or that they raised calves in the cow barn.

Awareness and Adoption

After the intervention, the percentage of farm managers who reported being unaware of barn lights (52% vs. 28%) and the calf feed mixing site (56% vs. 44%) both decreased (table 3). Reported adoption of barn lights (12% vs. 23%), silo bags (41% vs. 43%), and the calf feed mixing site (7% vs. 10%) did not increase significantly, although barn lights came closest ($p < 0.076$).

Discussion

Did Manager Reports of Where They Got Information Change?

The intervention was successful at disseminating information through the print media and public event sources that dairy managers have traditionally relied on to learn about production practices. Many dairy periodicals and agricultural newspapers ran articles about the three production practices during the intervention year. University Extension agents and various other resource people presented and distributed information about the three practices at public events. Dairy managers

reported that private farm consultants were powerful information sources about both barn lights and bag silos. Since many dairy managers pay for advice from private farm consultants, it is not surprising that larger percentages of farm managers reported hearing about the practices from them. A number of farm consultants contacted our project staff about the practices during the intervention year.

Did Awareness or Adoption Change?

Perhaps the most important goal of the intervention was to increase adoption of the safer practices. This evaluation can provide only limited evidence to show that any gains in the adoption and awareness of these three safer practices can be attributed solely to our intervention. To some degree, the gains may be attributable to pre–existing, on–going trends in the industry and that this study, which lacked any unexposed control group, cannot account for. The barn lights innovation was the most successful. After 12 months, barn lights adoption nearly doubled (12% vs. 23%), albeit nonsignificantly, and the percentage of managers who were unaware of barn lights was reduced by nearly one–half (52% vs. 28%). Dairy operations of all types and sizes could benefit from long day barn lighting, so most of the target audience was susceptible to the innovation. Once the complexities of financing and initial installation have been mastered, the innovation is easy to operate, quick to pay back, and production profit increases are relatively high. Adoption barriers presented by a lack of experienced, local electrical installers and lighting equipment dealers will likely tend to diminish as more dairy producers adopt the innovation and as installers and dealers gain experience. Barn lighting clearly improves working conditions, although its ability to reduce specific types of injuries, aside from falls on the same level, is less well substantiated (Davies et al., 2001; Bhattacharya, 1998). According to the theoretical model we used (Rogers, 1995), after some proportion of individuals become aware and others begin adopting, innovations reach a take–off stage in which they rapidly recruit more adopters before leveling off again in an S–curve. More than one cooperating university Extension agent commented on the high levels of interest among dairy farmers during the intervention year. The doubling of adoption levels suggests that barn lighting may have been moving into its take–off stage, at least in northeast Wisconsin.

Very few farm managers were unaware of silo bags before or after the intervention (5% vs. 4%), and adoption percentages were virtually unchanged as well (41% vs. 43%). Information about silo bags had, apparently, been readily available to most managers prior to the intervention, and the new information that our intervention made available persuaded few to adopt. Silo bags may represent, for northeast Wisconsin dairy farmers, a mature or late–stage innovation. According to the theoretical model, as awareness fully permeates the target audience, the steeply increasing S–curve flattens out, and the length of time between awareness and adoption becomes longer, as the remaining proportion of more conservative, less innovative enterprise managers are slowly enlisted to adopt (Rogers, 1995; Green, 1997). Compared to barn lights or the calf feed mixing site, many dairy producers have relatively larger and longer term investments in conventional silage storage methods (e.g., tower or bunker structures and the associated feed distribution systems), and taking advantage of the remaining useful life of these investments may have also contributed to slower adoption. Continuing the intervention for additional years may be the best way to increase silo bag adoption.

After the intervention, the number of dairy managers who reported being unaware of the calf feeding site practice decreased significantly (56% vs. 44%). As noted

previously, the payback period for the calf feed mixing site depends heavily on how many calves are being raised at any time. Only those operations with over 300 cows, raising about 30 calves at a time, could expect to pay back their investment in one year or less (like barn lights or silo bags for producers of all sizes). This may explain the nonsignificant adoption increase, since our baseline and year 1 intervention groups averaged 102 and 117 milk cows, respectively, and so were raising only 10 or so calves at any one time, and their payback period was in the range of 2.5 to 3 years. Furthermore, returns on the calves themselves are delayed two years until they are full grown dairy herd replacements. Calf feeding and related work is also routinely assigned to unpaid family workers (farm spouses, children, and older adults), so profitability aspects of calf care may receive less scrutiny from farm managers. Continued promotion of this practice appears to have some merit, however, because this labor–intensive work can be relieved, and those individuals doing it may be able to influence managers once they learn more about improved practices.

Study Strengths and Limitations

Strengths of the study included sample size and statistical power. A large number of individual enterprises (N = 4,300) and a large total workforce (N = 15,000 at 3.5 employees per operation; USDA, 1990) were involved in the intervention. Previous occupational intervention research studies have usually been limited to a single workplace, or a few workplaces, and to workforces of less than 1000 (Westgaard and Winkel, 1997; Zwerling et al., 1997; Goldenhar and Schulte, 1994). Another strength was the study's inclusion of quantitative intervention process measures to determine whether and how well intervention efforts were reaching the target audience, often a weak point in previous research (Westgaard and Winkel, 1997). The study also had a strong theoretical base, another feature often lacking in other occupational health interventions (Goldenhar and Schulte, 1994).

The study suffered from a number of limitations. We used a non–experimental design that lacked random assignment to the intervention group (since all dairy producers in northeast Wisconsin received the intervention), although independent, probability–based population samples were employed in the evaluation. The study also lacked a true control group that was not exposed to the intervention. The national and international reach of the dairy print publications we used in the intervention made it difficult to locate truly unexposed controls. Because our study lacked random assignment to treatment and a true control group, we cannot unequivocally attribute all or any of these improvements to the intervention, since secular trends may have contributed to or may entirely explain the changes (Zwerling et al., 1997; Goldenhar and Schulte, 1994). Our study may also have suffered a reporting bias that favored aware and adopting managers because they may have been more likely than unaware managers to return their questionnaires. Finally, for some of our comparisons, the study lacked the statistical power to discern differences. For example, for a comparison of two sample percentages, our study had sufficient power to demonstrate a statistically significant difference 90% of the time at the 0.05 level of significance when the outcome was 10% at baseline and upwards of 20% after one intervention year when each group size was above 220. For the comparisons between adopters before and after, the groups were too small to reach this size.

Our intervention evaluation measured changes in self–reported awareness and adoption of production practices that would reduce hazards. We made no attempt to verify self–reported data. We did not investigate for any corresponding changes in rates of nonfatal or fatal injuries associated with the traditional, more hazardous

methods of production that we sought to replace. In part, this was due to the well known limitations of existing injury surveillance systems for production agriculture (Purschwitz, 1992; Myers, 1990) and, in part, to the need for much larger subject populations than our study used to attain the statistical power that would be needed to find differences for the specific types of injuries our practices could have prevented. Ideally, future research should be conducted on much larger multi–state or national populations to enable investigations of injury outcomes.

Our research was also limited because we did not explore why certain producers adopted specific production practices and why others did not. This study investigated producers' perceptions of relative safety and profit advantages, but it did not explore other farmers' perceptions of each practice (e.g., complexity, divisibility for trial, etc.; Rogers, 1995). Future research should consider more extensive study of how farmers perceive each production practice. Future research should also continue to study populations over a number of years because other research has shown that the diffusion of technology can be a gradual process over many years (Rogers, 1995).

In this study, Wisconsin dairy producers appeared to be voluntarily responding to an intervention that coupled safety and profitability. Safer production methods were gradually but steadily replacing traditional methods, and dairy operation managers were becoming aware of safer, more profitable methods at an even faster pace. Among aware managers who had not adopted, many agreed that some of the new practices were safer and more profitable than typical practices. In a high–hazard, high–injury occupation where no good command and control regulatory strategy is currently available, these results should be encouraging.

Acknowledgements

Editorial assistance was rendered by Paula Volpiansky. Research assistance was provided by university Extension faculty including Tom Anderson, Matt Glewen, Scott Gunderson, Scott Hendrickson, Brian Holmes, Jeff Key, Zen Miller, Irvin Possin, Mark Purschwitz, Douglas Reinemann, Ronald Schuler, Terry Smith, Doug Sutter, and Laura Wind–Norton. Part of this work was supported through an Agricultural Safety Promotion Systems cooperative agreement from the U.S. Centers for Disease Control and Prevention's National Institute for Occupational Safety and Health (Federal Grant Identification Number U05/CCU506065–01). The contents of this report are solely the responsibility of the authors and do not necessarily represent the official views of the National Institute for Occupational Safety and Health.

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