Memorandum

Date: February 6, 2002

From: Michael J. Galvin, Jr., Ph.D., Lead Program Activity
Office of Extramural Programs, NIOSH, D30

Subject: Final Report Submitted for Entry into NTIS for Grant 1 R01 CC514357-01.

To: William D. Bennett
Data Systems Team, Information Resources Branch, EID, NIOSH, P03/C18

The attached final report has been received from the principal investigator on the subject NIOSH grant. If this document is forwarded to the National Technical Information Service, please let us know when a document number is known so that we can inform anyone who inquires about this final report.

Any publications that are included with this report are highlighted on the list below.

Attachment
cc: Sherri Diana, EID, P03/C13

List of Publications

Meyer RH, Newenhouse A, Miquelon M, Chapman LJ: Tip Sheets on Specialized Harvest Cart. Rolling Dibble Marker, Mesh Bags, Standard Containers, Narrow Pallet System, Packing Sheld Layout. In Baron S, Estill C, Steege A, Lalich N. (Eds): Simple Solutions: Ergonomics for Farm Workers. NIOSH Publication No. 2001-111. Cincinnati, OH: NIOSH 2001

Chapman L, Karsh B, Meuers J, Newenhouse A, Meyer R, Miles J, Janowitz I: Chapter 12 Ergonomics and Musculoskeletal Injuries in Agriculture. In D Pedersen & S Reynolds (Eds.): Cooperative Agricultural Safety and Health. Dincinnati OH: Amreican Conference of Governmental Industrial Hygienists (in press 2001c)

Chapman LJ, Taveira AD, Newenhouse AC, Meyer RH, Joesfsson KG: Causal factors in production agriculture injuries: working children and yuth versus adults. In S. Kumar (ed.) Advances in Occupational Ergonomics and Safety. Washington DC: IOS Press 1998:73-76

Title:	Childhood Agricultural Safety and Health Intervention
Investigator:	Larry Chapman, Ph.D.
Affiliation:	University of Wisconsin
City & State:	Madison, WI
Telephone:	(608) 262-7408
Award Number:	1 R01 CC514357-01
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Abstract:
We assessed the work performed by children, adolescents, and adults on Wisconsin dairy and fresh market vegetable farms. We also continued and evaluated two ongoing interventions to protect children, adolescents, and adults from musculoskeletal and traumatic injury associated with paid and unpaid work on dairy and fresh market vegetable farms. We built on previous work that suggested that:

- children and adolescents in traditional agriculture suffered largely the same types of injuries as adults since there were few differences in the rankings and proportionate weights of injury causal factors between youth and adults (Chapman et al., 1998)
- adult farm managers determined which production practices and equipment were used on an operation and, thereby, what hazards child, adolescent, and adult workers were exposed to (Rogers, 1995), and
- interventions that encouraged the adult farm manager to modify production practices and equipment in ways that improved both production efficiency and safety at the same time were more likely to be successfully adopted by the largest number of adult farm managers (e.g. Nowak and Okeefe, 1993).

Publications

Meyer RH, Newenhouse A, Miquelon M, Chapman LJ: Tip Sheets on Specialized Harvest Cart. Rolling Dibble Marker, Mesh Bags, Standard Containers, Narrow Pallet System, Packing Sheld Layout. In Baron S, Estill C, Steege A, Lalich N. (Eds): Simple Solutions: Ergonomics for Farm Workers. NIOSH Publication No. 2001-111. Cincinnati, OH: NIOSH 2001

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Final Performance Report of the Wisconsin Childhood Agricultural Safety and Health Intervention

US NIOSH Grant Award R01 CCR 514 357
October 1, 1997-September 30, 2000

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July 25, 2001

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ABSTRACT AND SUMMARY STATEMENT

We assessed the work performed by children, adolescents, and adults on Wisconsin dairy and fresh market vegetable farms. We also continued and evaluated two ongoing interventions to protect children, adolescents, and adults from musculoskeletal and traumatic injury associated with paid and unpaid work on dairy and fresh market vegetable farms. We built on previous work that suggested that:

- children and adolescents in traditional agriculture suffered largely the same types of injuries as adults since there were few differences in the rankings and proportionate weights of injury causal factors between youth and adults (Chapman et al., 1998),
- adult farm managers determined which production practices and equipment were used on an operation and, thereby, what hazards child, adolescent, and adult workers were exposed to (Rogers, 1995), and
- interventions that encouraged the adult farm manager to modify production practices and equipment in ways that improved both production efficiency and safety at the same time were more likely to be successfully adopted by the largest number of adult farm managers (e.g. Nowak and Okeefe, 1993).

As described in our original application, we accomplished the following specific aims:

• 1. *Learn from a pilot group of dairy producers and fresh market vegetable growers more about the work that children and adolescents typically perform and what hazards they face.* We confirmed that adolescents and, to a lesser degree children, largely performed the same range and scope of work as adults employed in dairy and fresh market vegetable production.

• 2. *Learn more about what this pilot group of producers and growers has already done to improve safety and health among working children and adolescents, especially modifications (including changes in management practices and equipment) that maintain or improve profitability.* We learned about many production practices and equipment that a few dairy and fresh market vegetable producers already had in place with potential to reduce hazard exposures while improving or sustaining work efficiency.

• 3. *Evaluate these modifications and others we identify or develop with quantitative/qualitative methods to better document the type and degree of advantages to profits and safety.* We studied a number of these production practices and equipment items in the field with small scale, ad hoc research efforts and were able to quantify the order of magnitude of any improvements in hazard exposure or production efficiency. We spent a great deal of time with growers and dairy farmers and were able to produce some research results but not the quantity of evidence that we originally intended and planned to complete. We encountered difficulties setting up and accomplishing scientifically-controlled comparisons using skilled personnel from dairy and fresh market vegetable operations. We also encountered difficulties controlling for "extraneous" variables including weather and weather differences within local areas, normal crop quality and maturation variability within fields, personal characteristics of operators and their changing situations, etc.. However, we believe we successfully accomplished our original aim and acquired enough data and field experience with the production methods and labor aids we promoted to reasonably justify their value as injury hazard-reducing modifications that sustained or improved production efficiency.

• 4. *Share the results with other state dairy producers and vegetable growers in a public information communication campaign and evaluate the campaign among a carefully defined, large sample selected to be representative of operations statewide.* The results of this work were successful and demonstrated that, for each intervention:

- a) new promotional materials were developed and additional resource people were enlisted and trained,
- b) work with pilot farms continued and pilot farms continued to provide demonstration sites to promote the interventions,
- c) we continued to provide our materials and present at public events including farmer field days, conferences, and other meetings,
- d) our work with agricultural journalists was successful at resulting in numerous articles about the production practices and labor aids we were promoting that appeared in specialty publications intended for dairy producers and growers,

- e) our questionnaire results demonstrated that growers and dairy farmers saw, read, or heard about the production practices and labor aids we were promoting at public events, in production print publications, and in other venues we aided,
- f) the questionnaire results showed that vegetable grower awareness, adoption and perceptions increased across the three intervention years for only a few of the production practices and labor aids we promoted (perhaps due to our difficulties in maintaining comparability between operations in our 98-99 and 00-01 sampling frames),
- g) the questionnaire results showed that dairy producer awareness, adoption and perceptions increased measurably between the baseline and fourth intervention year for all but one production practice, although the increases were often marked by early rises and later stabilization instead of steady sequential increases (perhaps due, in part, to larger economic forces/low milk prices depressing investment).

Specific Aim #1. Learn from a pilot group of dairy producers and fresh market vegetable growers more about the work that children and adolescents typically perform and what hazards they face

Overview of Accomplishments: Our originally-stated aim was to study child and adolescent work in dairy and fresh market vegetable production. The results of this work indicated that adolescents, and to some degree children, performed, by and large, the same range and scope of work as adults. The results also showed that adolescents, and to a lesser degree children, by and large performed all the tasks for which our intervention was promoting production practices or labor aids to improve fresh market vegetable work (carts and labor aids for hand harvest and weeding, mesh bags and hands-free washer for washing and packing, standard containers for loading and unloading) and dairy work (barn lighting for general barn work, bag silos instead of tower silo feeding, and various labor aids for calf feeding).

FRESH MARKET VEGETABLE WORK BY CHILDREN AND ADOLESCENTS

Work Exposures: In 1998, we administered a questionnaire to over 100 Wisconsin fresh market vegetable operations with children or adolescents in their workforce (see TABLE 1 below). The results of the questionnaire showed that, on typical fresh market vegetable operations with child or adolescent workers (Chapman et al., 2001a):

- children and adolescents accomplished, by and large, the same range and scope of work as adults, so the same prevention interventions can benefit children, adults and adolescents,
- 12-14 yr. olds were working an average of 26 hours per week in season doing one-quarter of all weeding accomplished on their operations and almost one-fifth of hand harvest, wash and pack, and load and unload work (for detail on other age groups see Chapman et al., 2001a),
- children and adolescents were exposed to work with hazards that the production methods and labor aids in this intervention project sought to mitigate (i.e. sit down cart for hand harvest & weeding, mesh bag and hands-free washer for washing and packing, standard containers for load and unload).

TABLE 1. WISCONSIN CHILD AND ADOLESCENT EXPOSURES TO FRESH MARKET VEGETABLE WORK

	weeding	hand harvest	wash and pack	load and unload	tractor operation	total
all ages from 5-18 yr:						
percent of all hrs worked on farm	14%	8%	14%	20%	22%	
hrs worked in a typical week	6	7	3	3	4	23
total hrs worked all last yr	58	86	29	26	41	240
age 12-14 only:						
percent of all hrs worked on farm	26%	17%	16%	18%	8%	
hrs worked in a typical week	8	12	2	2	2	26
total hrs worked all last yr	109	182	34	23	15	363

Musculoskeletal Discomfort: Many of the tasks involved in labor-intensive fresh market vegetable work are known to be very demanding for the musculoskeletal system (Chapman et al., 2001c). Growing vegetables for the fresh market typically involves planting, transplanting, weeding, harvesting, and product handling activities that are inefficient, require high levels of physical effort, and place heavy demands on the musculoskeletal system. Many of the tasks, because they must be accomplished at or near soil level, have been shown to involve high energy expenditures, highly repetitive movements, difficult work postures, fast work paces, and heavy spinal loading during lifting and carrying (Miles, 1996; Conlan et al., 1995; Cavaletto

et al., 1994). No research is available that reports on work exposures or rates of diagnosed musculoskeletal disorders in fresh market vegetable working populations.

A few studies of self-reported musculoskeletal discomfort have been published that used a common reporting instrument, the Nordic questionnaire (Kuorinka et al., 1978) (see TABLE 2). For example, adults working in fresh market vegetable production have reported a one year period prevalence for discomfort well above the all industry norms for low back pain (49-66% vs. 40% all industry norms), wrist and hand pain (34-36% vs. 13% norms), neck pain (37-46% vs. 25% norms) and shoulder pain (37-64% vs. 25% norms) (Hildebrandt, 1995; Palmer, 1996; Chapman et al, 2001c). Musculoskeletal discomfort for adult fresh market vegetable workers was often found to be markedly higher than those for most other commodity types within production agriculture work and compared to normative data from all industries (TABLE 2).

We collected data from a small pilot sample (n=12) of adolescents (15-18 yrs) working in fresh market vegetable production in Wisconsin that showed high discomfort rates in the lower back, neck, and foot (see TABLE 2). The one year period prevalence rates reported in our study for foot-ankle pain across all ages (21%) and low back pain for 15-18 year olds (50%) were both somewhat high, about one standard deviation above all occupation questionnaire norms for adults (Gustafsson et al., 1994). However, only adolescent reports of musculoskeletal discomfort in the foot approached or exceeded levels reported in other studies of adult fresh market vegetable workers, (perhaps because the youth in our study worked an average of just 23 hours in a typical week) (Chapman et al., 2001a).

TABLE 2. REPORTS OF MUSCULOSKELETAL DISCOMFORT IN FRESH MARKET VEGETABLE WORK

	Dutch adult fresh veg workers (n=167)	British adult tomato greenhouse workers (n=56)	WI adult fresh veg growers (n=93)	WI 15-18 yr fresh veg. workers (n=12)	quest. norms mean ± SD (n=9,000)
lower back (% yes)	49	61**	70**	50	40 ± 10
shoulder	45**	64**	41**	8	25 ± 10
neck	45**	46**	37**	33*	25 ± 5
hand-wrist	19	34**	37**	8	12.5 ± 7.5
upper back	-	-	34**	8	10 ± 5
knee	15	18	29	25	25 ± 5
foot	-	-	28**	33**	15 ± 5
elbow	19*	11	23**	0	10 ± 5
hip	-	-	21*	0	10 ± 5

** = greater than 2.25 and * = greater than 1.5 standard deviations above the normal mean for 29 occupations
question wording: "have you at any time in the last 12 months had trouble (such as pain, discomfort, numbness) in"
Sources: Palmer, 1996; Hildebrandt, 1995; Chapman et al., 2001; for questionnaire norms- Gustafsson et al., 1994.

Very little research on musculoskeletal disorders in young workers is available. Reports of back pain have received the most attention. This research indicates that back pain in children and adolescents may be a common problem that is infrequently reported to physicians. The largest study to date (n=29,400) determined one year period prevalence rates for low back pain in the Danish general population were 22% for 15 year olds and 38% for 17 year olds (Leboeuf and Kyvik, 1998). A study of 1200 US school children determined that the one year period prevalence rate for low back pain was 22% for 11-17 year olds (Olsen et al., 1992). In a study of 1200 Finnish children and adolescents, 18% of the 14 to 16 year olds reported any experience with low back pain last year (Taimela et al., 1997). In our study, 24% of 15-18 year olds doing dairy work and 50% of 15-18 year olds doing fresh market vegetable work reported experiencing low back discomfort last year, rates as high or somewhat higher than have been found in these other general population studies (Chapman et al., 2001a&b).

The relevance of reports of "any discomfort in the last year" to clinically-diagnosable musculoskeletal injury or disease is debatable. To a greater degree than a report of any discomfort, a report of disabling discomfort is likely to interfere with work in the near term and may be a more reliable precursor of serious disorders in the long term. We asked a second question about whether discomfort ever precluded work or other normal daily activities (Chapman et al., 2001a&b). Among our child and adolescent fresh vegetable workers, disabling pain in the lower back was reported by 22% (2 of 9) 9-11 year olds and 25% (3 of 12) 15-18 year olds. In a study from Finland, 18% of general population 14 and 16 year olds reported low back pain severe enough to interfere with normal activities last year (Taimela et al., 1997). A study of 10 to 13 year olds in Finland suggested that disabling pain in the last year was more common in the lower limbs (31%) than in the lower back (21%) or the neck-shoulder (13%) (Kujala et al., 1992). Very few other studies have examined child or adolescent musculoskeletal discomfort in body parts other than the low back. For our 9-11 year old and 15-18 year old fresh market vegetable workers, this suggests that our study subjects experienced a one year period prevalence of disabling discomfort as high or perhaps higher than has been found in some general population studies of children and adolescents.

DAIRY WORK BY CHILDREN AND ADOLESCENTS

Work Exposures: In 1998, we administered a questionnaire to 197 Wisconsin dairy operations with children or adolescents in their workforce (see TABLE 3 below). The questionnaire results showed that on typical dairy operations with child or adolescent workers (Chapman et al., 2001b):

- children and adolescents accomplished, by and large, the same range and scope of work as adults, so the same prevention interventions can benefit children, adults and adolescents,
- 12-14 yr. olds were working an average of 17 hours per week year round, doing one-third of all calf feeding accomplished on their operations and almost one-sixth of milking and tower silo feeding work (for detail on other age groups see Chapman et al., 2001b),
- children and adolescents were exposed to work with hazards that the production methods and labor aids in this intervention project sought to mitigate (i.e. barn lighting for general barn work, bag silos for tower silo feeding, and various labor aids for calf feeding),
- for calf feeding and care, most children and adolescents completed the full range of tasks including distributing milk or grain to each calf (91%), bottle feeding new calves (83%), adding bedding to calf housing (79%), mixing up water and milk replacer formula for liquid feed (78%), cleaning pails after feeding (70%), and cleaning pens (53%). Only the task of treating sick calves (22%) was done by less than half of the respondents.
- for tower silo feeding of cows, most children and adolescents operated the silo controls to unload feed (89%) but relatively few climbed the silo to open doors (7%) or entered the silo to repair unloader machinery (16%).

TABLE 3. WISCONSIN CHILD AND ADOLESCENT EXPOSURES TO DAIRY WORK

	milking	tower silo feeding	feeding calves	tractor operation	total
all ages from 6-18 yr:					
percent of all farm hrs	18%	23%	39%	13%	
hrs worked in a typical week	8	4	4	4	19
total hrs worked all last yr	233	110	124	103	570
age 12-14 only:					
percent of all farm hrs	16%	15%	32%	13%	
hrs worked in a typical week	7	3	3	4	17
total hrs worked all last yr	196	58	97	109	60

Musculoskeletal Discomfort: A few studies of dairy work musculoskeletal discomfort have been published using a common reporting instrument, the Nordic questionnaire (Kuorinka et al., 1978) (see TABLE 4 below). For example, adult males from Sweden and Wisconsin working on dairy operations have reported a one year period prevalence for discomfort well above the all industry norms for low back pain (49-55% vs. 40% all industry norms), knee pain (39-41% vs. 25% norms), and hand-wrist pain (18-23% vs. 12.5% norms) (Gustafsson et al., 1994; Chapman et al, 2001c).

We collected data from a small pilot sample (n=136) of children and adolescents working on Wisconsin dairy operations (see TABLE 4). Aside from slight elevations in the foot for 15-18 year olds and 6-18 year olds and in the upper back for 16 year olds, none of our child or adolescent reports of musculoskeletal discomfort approached or exceeded levels considered to be all industry norms. None of our child or adolescent reports of musculoskeletal discomfort approached levels reported in the other studies of adult dairy workers (perhaps because the youth in our study worked an average of just 19 hours in a typical week) (Chapman et al., 2001b).

Very little research on musculoskeletal disorders in young workers is available. Reports of back pain have received the most attention. This research indicates that back pain in children and adolescents may be a common problem that is infrequently reported to physicians. The largest study to date (n=29,400) determined one year period prevalence rates for low back pain in the Danish general population were 22% for 15 year olds and 38% for 17 year olds (Leboeuf and Kyvik, 1998). A study of 1200 US school children determined that the one year period prevalence rate for low back pain was 22% for 11-17 year olds (Olsen et al., 1992). In a study of 1200 Finnish children and adolescents, 18% of the 14 to 16 year olds reported any experience with low back pain last year (Taimela et al., 1997). In our study, 24% of 15-18 year olds doing dairy work reported experiencing low back discomfort last year, rates as high or somewhat higher than have been found in these other general population studies (Chapman et al., 2001a&b).

TABLE 4. REPORTS OF MUSCULOSKELETAL DISCOMFORT IN DAIRY WORK

	Sweden adult male dairy workers (n=2081)	WI adult dairy workers (n=621)	WI 15-18 yr dairy workers (n=38)	WI 6-18 yr dairy workers (n=136)	quest. norms mean ± SD (n=9,000)
lower back (% yes)	55*	49	24	19	40 ± 10
shoulder	37*	32	16	7	25 ± 10
neck	25	26	18	11	25 ± 5
hand-wrist	18	23*	13	8	12.5 ± 7.5
upper back			16*	10	10 ± 5
knee	41**	39**	11	9	25 ± 5
foot	-		16	16	15 ± 5
elbow	18*	15	0	0	10 ± 5
hip	-		3	2	10 ± 5

** = greater than 2.25 and * = greater than 1.5 standard deviations above the normal mean for 29 occupations
Question wording: "have you at any time in the last 12 months had trouble (such as pain, discomfort, numbness) in"
Sources: Chapman et al., 2001b; for Sweden and questionnaire norms- Gustafsson et al., 1994.

The relevance of reports of "any discomfort in the last year" to clinically-diagnosable musculoskeletal injury or disease is debatable. To a greater degree than a report of any discomfort, a report of disabling discomfort is likely to interfere with work in the near term and may be a more reliable precursor of serious disorders in the long term. We asked a second question about whether discomfort ever precluded work or other normal daily activities (Chapman et al., 2001a&b). Disabling pain in any body part was infrequent among our child and adolescent dairy farm workers (3-7%).

In a study from Finland, 18% of general population 14 and 16 year olds reported low back pain severe enough to interfere with normal activities last year (Taimela et al., 1997). A study of 10 to 13 year olds in Finland suggested that disabling pain in the last year was more common in the lower limbs (31%) than in the lower back (21%) or the neck-shoulder (13%) (Kujala et al., 1992). Very few other studies have examined child or adolescent musculoskeletal discomfort in body parts other than the low back.

Specific Aim #2. Learn more about what this pilot group of producers and growers has already done to improve safety and health among working children and adolescents, especially modifications (including changes in management practices and equipment) that maintain or improve profitability

Overview of Accomplishments: Our originally-stated aim was to select and begin to study, via field research, one production method innovation in dairy and another in fresh market vegetable production to add to the intervention. We completed the selections and the field research. For dairy, we decided to study and promote two calf feeding labor aids (calf bottle holders and moving feed and supplies by wagon). For fresh market vegetable, we decided to study and promote: a) a nonmotorized sitting cart for field weeding and harvesting, b) a half pallet system for loading and unloading boxed produce, and c) an improved packing shed layout for washing and packing produce.

Fresh Market Vegetable Production Practices and Labor Aids: We developed a nonmotorized field cart that supported individuals in a seated posture as they worked over the crop row and that eased the demands of harvesting produce and weeding by hand. We identified commercially available devices for a half pallet system to ease the strain of materials handling with boxed produce. We studied grower best practices and ergonomics principles to develop recommendations for how to improve the layout of work stations and work flow in the packing shed.

TABLE 5. NEW PRODUCTION PRACTICES AND LABOR AIDS PROMOTED EACH INTERVENTION YEAR

intervention year	production methods and labor aids	total methods & aids being promoted
99 (year 1 Mar 98- Feb 99)	standard containers, mesh bags	2
00 (year 2 Mar 99- Feb 00)*	all of above plus half pallet, sitting cart, packing shed	5
01 (year 3 Mar 00- Feb 01)	all of above plus hands-free washer, dibble drum	7
02 (year 4 Mar 01- Feb 02)	all of above plus laying prone harvest cart, portable field stool	9

* = CASHR-funded years

Dairy Production Practices and Labor Aids We identified two production method innovations in calf care (beyond those we were already promoting) that were highly likely to improve work efficiency and working conditions and hazard exposures. The calf feeding labor aids appear to have payback periods of one year or less:

- bottle holders on pens that allow workers to avoid the task of holding bottles for newborn calves.
- wagons for carrying pails of grain and liquid feed to the calf hutches or housing area.

TABLE 6. NEW PRODUCTION PRACTICES AND LABOR AIDS PROMOTED EACH INTERVENTION YEAR

intervention year	new production methods and labor aids	total methods & aids being promoted
98 (year 1 Mar 97- Feb 98)	barn lights, bag silos, calf feed mixing site	3
99 (year 2 Mar 98- Feb 99)*	all of above	3
00 (year 3 Mar 99- Feb 00)*	all of above plus calf wagons, calf milk bottle holders	5
01 (year 4 Mar 00- Feb 01)	all of above	5
02 (year 5 Mar 01- Feb 02)	all of above plus calf grain bottles, stall barn milking stool	7

* = CASHR-funded years

Specific Aim #3. Evaluate these modifications and others we identify or develop with quantitative and/or qualitative methods to better document the type and degree of advantages to profits and safety

Overview of Accomplishments: Our originally stated aim was to evaluate the production practices and labor aids that we selected for promotion to farmers. We completed this work and were satisfied that each modification provided safety and profit advantages. The final research products we completed were adequate for our purposes but less extensive (smaller numbers of operators and trials) than we had anticipated. We felt that field trials of the production methods and labor aids comparing our modifications with traditional methods should be accomplished with skilled operators in actual settings. However, conducting high quality, well controlled research on operating farms proved to be considerably more complicated than we anticipated, even with our experienced research team and careful planning. Furthermore, we learned that the truest test of a production method's advantages required days to weeks of research measurements for each operator instead of the hours long trials we were capable of. On actual farms, there were sometimes great differences between fields or herd segments or operators or work methods or other factors that greatly complicated our attempts at matched comparisons and sometimes overwhelmed any influences that might have been attributable to the production practices and labor aids. Difficulty predicting external variables such as weather, seasonal cycles of calving and crop and weed growth, and occasionally loss of operator cooperation due to unforeseen circumstances sometimes intervened and prevented us from capturing the quality and quantity of data we would have liked to acquire. Nonetheless, we acquired enough data and field experience with the production methods and labor aids we promoted to reasonably justify their value as injury hazard-reducing modifications that sustained or improved production efficiency.

FRESH MARKET VEGETABLE PRODUCTION PRACTICES AND LABOR AIDS

Sitting Cart: For vegetable production, the nonmotorized sitting cart underwent testing with five vegetable employees. Their ideas and comments were incorporated into ideas for redesign. Some of the resulting modifications included:

- deleting the steering mechanism since stable front wheels were easier to manage in rough fields and since most workers picked up the front end of the cart to turn it rather than steered it,
- developing a three-wheeled version of the cart since that reduced the weight and was easier to maneuver when workers picked up the front end of the cart to turn it,
- attempts were made to incorporate a removable but rigid (instead of spring-loaded) sternum pad to lean the upper body and chest against while sitting and leaning forward since growers said that they tended to exert their back muscles to prevent the spring-loaded pad from drooping too far but that they tended to relax when leaning on a rigid support. We also experimented with making the placement locations of the rigid sternum pad adjustable so that individuals with short and long trunks (male and female adults, children and adolescents) could find a comfortable leaning forward position. In the final version, we eliminated the sternum pad on advice from growers since they preferred to lean their torso or forearms on their thighs instead.

The preliminary results from one operator were promising and showed improvements in labor efficiency and posture with the cart versus crawling (TABLE 7).

TABLE 7. SITTING CART LABOR EFFICIENCY AND POSTURE

	crawling on hands and knees n=3	sitting in cart n=8	percent change
time to harvest a crate of spinach (min)	7.8	4.6	- 41%
percent time in most acceptable (#1) postures (%)	49	60	+ 22%
percent time in less acceptable (#2) postures (%)	49	38	- 29%

note: n=no. of trials w/ single operator. Cart did not have sternum pad. Posture evaluated with the OWAS posture analysis system at 6 observations/min from 23 total minutes of harvest work w/o the cart and 37 min with the cart.

Half Pallet Materials Handling System: We also completed and analyzed field trials on the half pallet system for loading and unloading boxed produce (TABLE 8). Reductions in time workers spent under load were impressive (66%) as were reductions in the time required to complete the task of loading a cooler (66%).

TABLE 8. HALF PALLET SYSTEM LABOR EFFICIENCY AND HAZARD EXPOSURES

	without pallets & hand truck	with pallets & hand truck	percent change
total number of boxes	232	232	
box weight (in lbs)	7.0	7.0	
distance to cooler (in feet)	45	45	
time to cooler per box (in sec)	4.31	1.45	- 66%
carrying distance per box (in ft)	11.25	2.8	- 75%
one-way trip to cooler time (in sec)	17.3	23.3	+ 35%
number of trips to fill cooler	58	14.5	- 75%
total time under load (in sec)	1001	337	- 66%
total distance under load (in ft)	2610	652.5	- 75%

Source: Chapman et al., 1998.

DAIRY PRODUCTION PRACTICES AND LABOR AIDS

For the dairy production methods, we investigated two labor aids for use during the feeding of dairy calves: holders for bottle feeding and the various wagons for transporting (instead of carrying) pails of feed to the hutches or housing area.

Calf Bottle Holder: The bottle holder essentially eliminated the 2-3 minutes per calf that employees needed to spend holding a bottle for the calf during the days before it began to drink from a pail (TABLE 9). Without bottle holders, calf head heights can mean that tall workers need to stoop and short workers (e.g. children) have to hold the bottles above elbow heights. Bottle holding involves avoidable static loads on the upper extremities. With bottle holders, these musculoskeletal risk factors are avoided and labor efficiency improves dramatically since it takes just seconds to drop a bottle into a holder.

TABLE 9. LABOR SAVINGS USING BOTTLE HOLDERS

	60 calves raised per yr	120 calves raised per yr	240 calves raised per yr	480 calves raised per yr
average number of calves bottle-fed daily	1.25	2.5	5	10
annual labor savings (at $15 per hr)	$150	$300	$600	$1200
cost of bottle holders (assuming 1 yr life span)	$8	$16	$32	$60
net savings	$142	$284	$568	$1140

* = number of calves fed milk in bottles from birth up to 1 week of age averaged over the year.

Wagon For Hauling Calf Feed: On many dairy operations, liquid calf feed (e.g. milk replacer) is hand carried by workers in two 5-7 gallon buckets from the milk house (or other location where milk replacer is obtained) to the calf hutches or other calf housing area (e.g. calf barn, calf greenhouse). This distance varies widely between different dairy farms but may be tens of yards or even hundreds of yards. A typical full bucket of liquid feed can weigh as much as 20 lbs and hauling two buckets may involve a relatively

substantial physical energy expenditure for an adult and more for a younger worker or smaller-statured worker. When you carry milk, feed and supplies for 15 pre-weaned calves by hand, you make 10 round trips a day between the milkhouse and hutch area. Assuming a distance of 50 yards from milkhouse to hutch area, this means carrying loads in buckets for a total of 10-15 minutes each day. Hauling two buckets of liquid feed at a time by hand is less efficient than hauling six or eight or ten buckets at once on a cart or wagon. In our example, using a simple cart can cut the number of trips and the total travel time in half and save more than an hour each week. Provided there is a surfaced path to support the cart wheels, wagons for transporting calf feeding materials are an inexpensive and easy-to-implement way to improve labor efficiency and to reduce exposures to musculoskeletal risk factors.

Specific Aim #4. Share the results with other state dairy producers and vegetable growers in a public information communication campaign and evaluate the campaign among a carefully defined, large sample selected to be representative of operations statewide

Overview of Accomplishments: Our originally-stated aim was to continue our ongoing vegetable and dairy interventions to adult farm managers for one (vegetable) and two (dairy) additional years and to continue our process and outcome evaluation procedures for both efforts. Both interventions were successfully continued and evaluated. The evaluation results showed that;

1) our information dissemination efforts were reaching the vegetable and dairy producers,
2) the questionnaire results showed that vegetable grower awareness, adoption and perceptions increased across the three intervention years for only a few of the production practices and labor aids we promoted (perhaps due to our difficulties in maintaining comparability between operations in our 98-99 and 00-01 sampling frames),
3) the questionnaire results showed that dairy producer awareness, adoption and perceptions increased measurably between the baseline and fourth intervention year for all but one production practice, although the increases were often marked by early rises and later stabilization instead of steady sequential increases (perhaps due, in part, to larger economic forces/low milk prices depressing investment).

Work we accomplished under our CASHR funding to continue the information dissemination interventions included (but was not limited to) the following:

- new promotional materials were developed and new and existing materials were distributed via print media, public events, the Internet and a variety of other venues,
- the dairy intervention was broadened from Northeast Wisconsin to the entire state and the fresh market vegetable intervention was broadened from Wisconsin to a four state area (WI, MI, MN, IA).
- additional community-based resource people and farmer educators were enlisted and trained,
- new pilot farms were recruited and enlisted -- along with existing pilot farms they provided demonstration sites to promote the interventions and they provided farm managers who had already adopted who were willing to talk with "next generation"farm manager adopters,
- we continued to provide our materials and present at public events across broad geographic areas including farmer field days, conferences and other meetings, (when possible, pilot farmers were presenters),
- our work with agricultural journalists expanded regionally and was successful at resulting in articles about the production practices and labor aids we were promoting that appeared in specialty publications intended for dairy producers and growers,

We also successfully continued our intervention evaluation work:

- our questionnaire results demonstrated that growers and dairy farmers saw, read, or heard about the production practices and labor aids we were promoting at public events, in farmer print publications, and elsewhere.
- our questionnaire results demonstrated that awareness, adoption, and perceptions were improving for many if not most of the production practices and labor aids.

INDUSTRY, WORKFORCE SIZE AND SUBJECTS FOR THE INTERVENTIONS

Fresh Market Vegetable: Good quality data was not available at the state or national level on the actual total numbers of fresh market vegetable operations (nor on the size of the workforce or the health and hazard problems that they faced). This was especially true for small scale vegetable growers where the demand for statistical information has been less strong and, consequently, where funding has been less available for state and national surveys. Compared to other agricultural commodity groups, relatively little was known about

fresh market vegetable growers because this information has not been a priority for governmental agricultural statistics agencies (e.g. USDA Agricultural Statistics Service).

As a result, we began working to develop a list of fresh market vegetable operations in 1997. Since then we have assembled and used rolling samples of different operations each year to repeatedly interrogate a sampling frame of names and mailing addresses for fresh market vegetable operations initially in Wisconsin and then throughout the four state region (WI, MN, MI, IA). According to our own estimates based on figures from state and industry experts, there were approximately 30,000 fresh market vegetable operations in the US with a workforce of 105,000 (including 28,000 child and adolescent workers) in 2000 (TABLE 10). About 18% of the nation's operations were in our study states: Wisconsin, Minnesota, Michigan and Iowa. Our estimates for the numbers of child and adolescent workers were based on assumptions (utilizing Wisconsin census data on families) that all farms were "family farms", that 64% of fresh market vegetable operations nationwide have any child or adolescent workers, that each of these has an average of 1.5 children or adolescents who work, and that all children and adolescents in these farm families worked on the farm. For additional detail see Chapman et al., 2001b.

TABLE 10. FRESH MARKET VEGETABLE OPERATIONS AND WORKFORCE SIZE ESTIMATES

	Wis	MN	MI	IA	WI,MN,MI,IA Total	US
operations	1,500	1,500	1,600	900	5,500	30,000
total workforce @ 3.5/farm*	5,250	5,250	5,600	3,150	19,250	105,000
children and adolescents**	1,440	1,440	1,536	864	5,280	28,800

* 3.5 workers per operation is the average workforce size for all US farms re USDA, 1990.
** assuming all farms are family run and 64% of all families have an average of 1.5 children and/or adolescents and that they all work.

The procedures we used to acquire lists of growers for the evaluation deserve to be described in greater detail due to their unusual circumstances. At the beginning of the project, we were faced with a dilemna. We wanted to quickly begin our intervention but we also needed to obtain a baseline from a grower sample before we could start to disseminate information. We especially wanted to survey a large baseline grower group to determine their levels of awareness and adoption of our production practices for comparison with results from future years. The core of our dilemna was that there was no comprehensive list of fresh market growers in Wisconsin.

In the three months prior to the start of our first intervention year, we worked to develop as large a list as we possibly could using existing lists available from grower organization membership lists, lists of farmer's markets vendors from around the state, and grower lists maintained by organic certification organizations and by university Extension. The list we ended up with included 452 growers. Since our vegetable grower project was initially funded for a single intervention year, we randomly selected one half of the addresses for the baseline mailing (i.e. "98" in TABLE 11, 16, & 17) and used the other half to evaluate the first intervention year in a mailing twelve months later (i.e. "99" in TABLE 11, 16, & 17).

We were then awarded funding under the NIOSH Childhood Agricultural Safety and Health Research initiative to continue our fresh market vegetable grower intervention for an additional year. As a result, we needed to develop a new list of Wisconsin growers for "'00" since we had mailed to all the operations on our 98-99 list. We elected to use a rolling sample approach to growers (mailing questionnaires to different growers each year) because we realized that the questionnaire itself made growers aware of production practices we were promoting and would detract from our ability to determine whether our intervention was reaching growers. To develop the new Wisconsin list, we returned to all the sources we had used for the first Wisconsin list (i.e. grower organization membership lists, lists of farmer's markets vendors from around the state, and grower lists maintained by organic certification organizations and by university Extension) in a search for any grower operations we had not already mailed a questionnaire to

in either 98 or 99. This effort produced almost no new Wisconsin operations. In a new approach, we tried asking a handful of grower publications (e.g. American Vegetable Grower, Great Lakes Vegetable Grower, Growing for Market) for their subscriber lists. This produced a fairly sizable list of operation names we had not yet mailed to in Wisconsin. However, we were concerned that this new list (which we relied on to acquire the data for the "00" and "01" years in TABLE 11, 16 & 17) was made up of different types of growers than we used for the 98 & 99 list.

As can be seen in TABLE 11 below, questionnaire response rates were fairly good and reasonably consistent across the four years (i.e. 60% or 146 of 243 were returned in 98; 65% or 135/208 in 99; 71% or 153/216 in 00; 74% or 209/284 in 01) (TABLE 11). Not all the returned questionnaires could be coded. Some were incomplete or failed to meet other necessary criteria for inclusion (i.e., at least $500 in fresh market vegetables sales last year and was returned by an individual who affired that he or she made the day to day decisions about the operation). Overwhelming, the most common reason for a returned questionnaire not being coded was that the grower failed to sell $500 or more in fresh market vegetables last year. The percent of returned questionnaire that were coded varied from year to year and dropped off rather steeply for the 00 and 01 lists (i.e. 71% or 103 of 146 were coded in 98; 59% or 79/135 in 99; 35% or 54/153 in 00; 33% or 69/209 in 01). This added support to our suspicions that the 00 & 01 lists contained a lower proportion of fresh market vegetable growers than our 98 & 99 lists had.

TABLE 11. WISCONSIN FRESH MARKET VEGETABLE GROWERS W/ NO MORE THAN 25 FMV ACRES

	98	99	00	01
initial mailing sent to Wis sample of:	243	208	216	284
number of Wis questionnaires returned:	146	135	153	209
number of Wis questionnaires coded:*	103	79	54	69
number with ≤ 25 FMV acres:**	83	56	36	56
total acres of FMV grown last yr	4.7±5.3	5.2±5.3	5.9±5.7	5.0±5.8
total gross value of farm sales last yr***	2.7±1.6	2.9±1.5	2.3±1.5	2.1±1.5
% of total farm sales from FMV	65±39	67±35	56±41	54±38
% total household income from FMV	30±30	40±36	18±25	19±24
% of operations w/ any organic acres	35	26	14	4
operator/manager age	46±11	46±11	50±12	50±12
operator/manager education****	6.3±2.2	6.7±1.9	5.5±2.3	6.1±2.3
operator yrs of experience in FMV	11±10	10±8	12±11	14±14

note: FMV = fresh market vegetables
* only coded if respondents said they grew FMV last year and sold more than $500 worth, affirmed that they were the individual who made most of the day to day decisions, and provided questionnaire responses were reasonably complete.
** respondents said they grew no more than 25 acreas of FMV last yr and selling more than $500 worth of FMV last yr.
*** gross value of sales coded as: 1 = < $5,000, 2 = $5-15k, 3 = $15-25k, 4 = $25-50k, 5 = $50-100k, 6 = $100-200k, 7 = $200-400k, 8 = > $400k.
**** yrs of education coded as: 1 = grade school, 2 = some high school, 3 = high school grad, 4 = high school plus vo/tech, 5 = some college, 6 = 2yr assoc. degree, 7 = 4 yr college degree, 8 = some graduate school, 9 = graduate degree.

Grower demographics for the 98-99 list differed the most from the 00-01 list for:

- % of operations with any organic certified fresh market vegetable acres (35%, 26% vs. 14%, 4%),
- % of household income from fresh market vegetable sales (30%, 40% vs. 18%, 19%),
- % of total farm sales from fresh market vegetables (65%, 67% vs. 56%, 54%),
- gross value of sales last year (2.7, 2.9 vs. 2.3, 2.1), and
- manager age (46, 46 vs. 50, 50).

To sum up, due to the nature of the methods we used to compile our grower lists, we suspect that the 98-99 list may have been made up of the most visible and most accessible fresh market growers in the state, especially small organic growers serving the Madison and Milwaukee metropolitan areas in the Southern

portion of the state. Since they were easiest for us to locate, we believe that they were also the segment of growers that was best connected to other information networks (i.e. easier than most growers to disseminate information to about prodution methods and also, more likely than most growers to already be aware of the lastest information about new production methods). These systematic biases may be responsible for the unexplained drop in many outcome measures between 98-99 values and 00-01 values. For our planned publications, we plan to develop and use statistical methods to "'adjust"our grower samples for 98-01 so that they are more comparable across those variables that are now most different (e.g. % of household income from fresh market vegetable sales, % with any organic acres).

Dairy: According to the National Agricultural Statistics Service, there were 105,000 dairy operations in the US in 2000 with a workforce of over 367,000 (see TABLE 12). Wisconsin had 21,000 dairy farms or about 20% of the nation's total and over 73,000 workers (USDA, 2001). Based on federal Census data from Wisconsin state agencies, we estimated the numbers of children and adolescents in the Wisconsin dairy workforce was 20,160 by assuming that all farms were "family" farms, that 64% of all families have any children or adolescents living at home, that each of these families has an average of 1.5 children or adolescents, and that all children or adolescents in these farm families work on the farm. Wisconsin's distribution of herd sizes resembles the nation's, aside from a somewhat larger proportion of herds of 50-99 cows and somewhat lower proportion of herds with more than 499 cows. Our intervention targeted all Wisconsin dairy farms. Each year our intervention evaluation effort mailed questionnaires to rolling samples of dairy operations in the Wisconsin counties with the most dairy operations. Our sampling frame made use of operation lists maintained by the Wisconsin Department of Agriculture, Trade and Consumer Protection and the state's dairy herd improvement organization. For additional detail see Chapman et al., 2001e.

TABLE 12. DAIRY OPERATIONS, WORKFORCE SIZE AND MILK COWS, 1999-2000

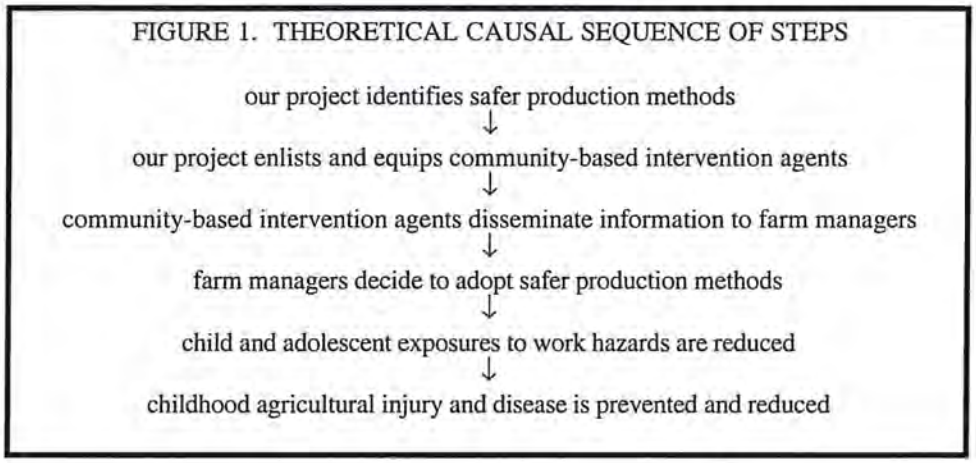
	Wis	US	Wis as % of US
operations	21,000	105,000	20%
total workforce @ 3.5/farm*	73,500	367,500	20%
children and adolescents**	20,160	100,800	20%
milk cows	1,365,000	9,156,000	15%
distribution of operation herd size			
< 50 cows	50%	51%	98%
50-99 cows	38%	30%	127%
100-199 cows	9%	12%	75%
200-499 cows	3%	5%	60%
> 499 cows	0.4%	2%	21%
	100%	100%	

* 3.5 workers per operation is the average workforce size for all US farms re USDA, 1990.
** assuming all farms are family run and 64% of all families have an average of 1.5 children and/or adolescents and that they all work. sources: operations-WASS,2001, milk cows-WASS, 2000, herd size-USDA,2000.

DESIGN AND PROCEDURES FOR THE VEGETABLE AND DAIRY INTERVENTIONS

This project conducted and evaluated interventions in the dairy and fresh market vegetable industries intended to prevent or reduce traumatic and musculoskeletal agricultural injuries among children, adolescents, and adults. In previous work, we had learned that children and adolescents who work in agricultural production in "traditional agriculture" areas were subject, by and large, to the same hazards and suffered the same types and rates of traumatic injuries and musculoskeletal problems as adult workers (Chapman et al., 1998; 2001a; 2001b). As in other industries, the work methods and equipment used on each operation largely determined what hazards the workforce was exposed to and the operation manager largely determined what work methods and equipment were used. As a result, our interventions improved information flow to these operation managers to persuade them to adopt certain production methods and labor aids that improved safety and maintained or improved profitability. On operations where these safer methods and labor aids were put in place, we reasoned that child and adolescent workers would be exposed to fewer and less severe hazards. As more dairy and fresh market vegetable operations adopted safer practices that reduced hazards, injuries and diseases among child and adolescent workers would be reduced (see FIGURE 1 below).

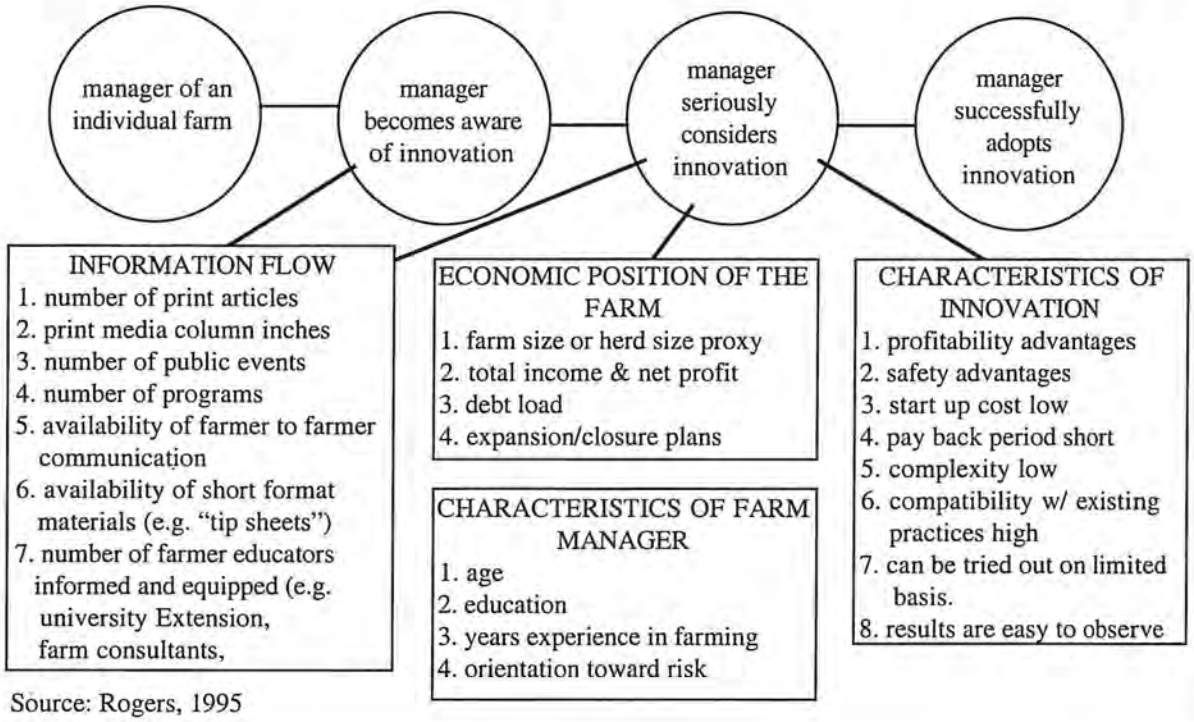
FIGURE 1. THEORETICAL CAUSAL SEQUENCE OF STEPS



There was a theoretical model and extensive research information available about how farmers adopt new production methods that improve profits and productivity. Our interventions incorporated this widely-recognized theoretical model known as adoption-innovation diffusion theory. The theory has been subjected to extensive research among agricultural producers and in other industries over the last forty years (Rogers, 1995; Nowak & O'Keefe, 1995) (FIGURE 2).

The model postulated that the adoption process by individual enterprises follows a series of stages that the enterprise manager proceeds through in a sequential fashion (Rogers, 1995). The model's output and final stage is farmer adoption. Prior to adoption, operation managers typically move through two other stages: 1) they become aware that a particular production practice improvement exists, and 2) they consider and evaluate the advantages and disadvantages of the production practice with regard to their own operation. The model's inputs include four components: information flow, individual farm economic factors, personal characteristics of the farm manager, and characteristics of the production practice innovation (FIGURE 2). These components interact to determine whether and how quickly an individual farm manager adopts a new production method. Information flow to the farm manager is crucial because it: 1) determines whether he/she becomes aware of a production method, and 2) in combination with operation and manager variables and the characteristics of the production method, it determines whether the production method will survive the consideration process and be adopted by the farm manager (e.g. Wadsworth, 1995). Our intervention selected production practices with favorable characteristics and improved the information flow to farm managers.

FIGURE 2. THEORETICAL MODEL FOR FARMER ADOPTION OF PRODUCTION METHODS & LABOR AIDS



Source: Rogers, 1995

Specifically, we modified components within the system for the farm manager learning about new production methods by: 1) selecting production practice innovations with favorable characteristics (i.e. profitability, safety advantages, start up cost low, see characteristics of innovation box in FIGURE 2), and 2) utilizing a wide variety of community-based media, organizations, and human resources that farmers already typically used to improve information flow about specific production practices (see information flow box in FIGURE 2). According to previous research on social marketing to general populations and research on farmer information use, the most effective interventions are those that design different communication efforts around the same problem or practice in order to link into the various information networks that individuals use (Nowak & O'Keefe, 1995).

Fresh Market Vegetable: Research showed that many fresh market vegetable growers attended grower meetings sponsored by producer organizations (56%) and made individual contacts with other growers (82%) and they rated this information as highly useful (3.6) (TABLE 13). They also relied on producer magazines or newsletters (31-42%) or university Extension (36%) but rated this information as slightly less useful (2.6-3.4). Organic vegetable growers tended to get their information from different sources than conventional growers. We disseminated information to both organic and conventional grower groups by including print media, public events, etc. that each was likely to consult.

TABLE 13. SOURCES WIS VEGETABLE GROWERS USE TO LEARN ABOUT NEW PRODUCTION METHODS

	used last yr (% yes)	ranked usefulness (1-4 scale)
other farmers	82	3.6
conferences	56	3.6
producer newsletters and magazines:	-	-
Growing for Market	42	3.4
Great Lakes Vegetable Grower	22	2.9
American Vegetable Grower	31	2.6
university Extension	36	3.2
equipment dealers and suppliers	23	2.8
agricultural newspapers	23	3.1
farmers' market manager	16	2.5

Question wording: "Which sources did you use last yr to learn about new equipment or procedures to improve your operation and how useful were they ?" 1 = not useful, 4 = very useful).
Source: Chapman et al., 2001d.

Dairy: Other research showed that dairy farmers differed from fresh market vegetable growers in the sources that they typically turned to for information about new production methods. Dairy producers most often sought information about new production methods from certain specialty publications (i.e. 90%) and many also took advantage of contacts with local university Extension agents (30%) (TABLE 14). Information from agricultural newspapers, producer magazines and from Extension agents was rated the most highly (3.2-3.4 on a 1-4 scale of usefulness). Other research established that the farmers who influenced other farmers to adopt an innovation were more likely to attend Extension-sponsored public events and field days than all farmers (Dillman et al., 1989). Since Fett and Mundy's 1990 survey (depicted in TABLE 14), other developments have influenced dairy farmer learning about new production methods (especially information availability via the Internet) and our intervention effort also made use of these new sources (e.g. list serves and our project websites for farmers <http://bse.wisc.edu/hfhp>). As recommended by previous research on social marketing and the diffusion of innovations, we used different communication efforts around the same problem or practice in order to link into these various information networks that farm managers already relied on (e.g. Rogers, 1995; Nowak and OKeefe, 1993).

TABLE 14. SOURCES WIS DAIRY FARMERS USE TO LEARN ABOUT NEW PRODUCTION METHODS

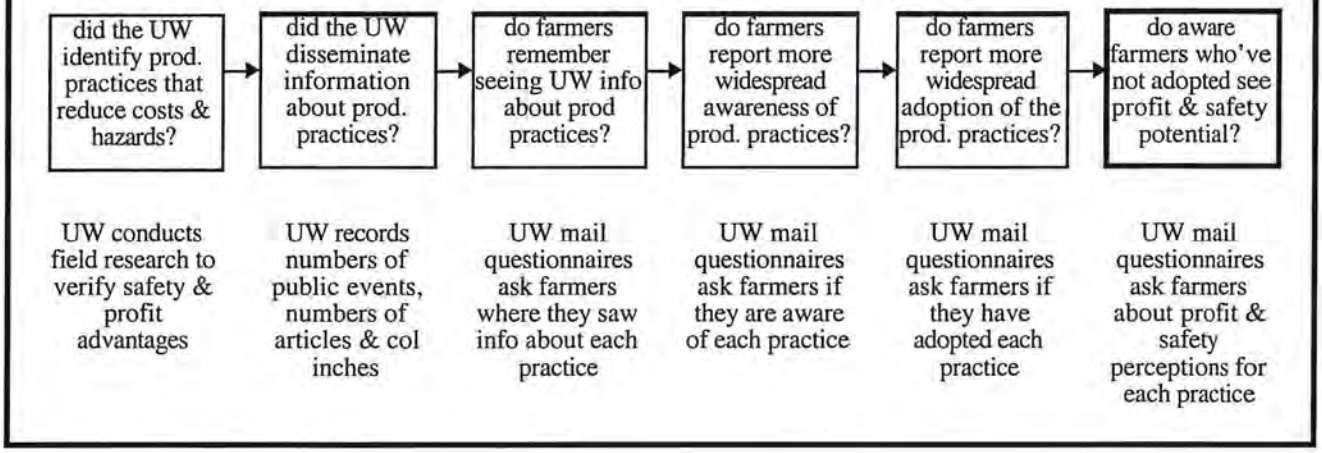
	used last yr (% yes)	ranked usefulness (1-4 scale)
agricultural newspapers	90	3.4
producer newsletters and magazines:	90	3.3
other farmers	82	2.9
radio	60	2.8
television	52	2.2
conferences	35	3.1
university Extension	30	3.2

Source: Fett and Mundy, 1990

SEQUENTIAL EVALUATION OF INTERVENTION STEPS IN THEORY-BASED EVALUATION

To evaluate the two interventions, we used techniques advocated by theory-based intervention evaluation research (Birckmayer et al., 2000; Weiss, 1998). This approach can help clarify the assumptions on which an intervention is based; what activities were being conducted, what effects the activities were intended to produce, what responses were expected, etc. up to the final outcomes of adoption (and improved perceptions in nonadopters). Proponents of theory-based evaluation (e.g. Weiss, 1998) advocate specifying a causal sequence of steps to the final outcome and then collecting data at as many points as possible in this sequence to test the program's assumptions. Figure 3 depicts a number of the assumptions we based our interventions on, from identifying innovative production methods and labor aids to improving information flow to farm managers to awareness, adoption, and perceptions of nonadopters. Figure 3 also shows the specific outcomes that we evaluated below each step.

FIGURE 3. THEORETICAL CAUSAL SEQUENCE OF INTERVENTION STEPS AND OUTCOMES EVALUATED



FRESH MARKET VEGETABLE INTERVENTION RESULTS

Funding History: The baseline and the first intervention years for our fresh market vegetable project were funded by a NIOSH Community Partners for Healthy Farming Cooperative Agreement. After that, support for the second intervention year was provided during the last 18 months of this NIOSH Childhood Agricultural Safety and Health Research R-01 award. Support for intervention years 3 and 4 is being provided by a NIOSH Implementation of the National Occupational Research Agenda R-01 award (TABLE 15). Each intervention year included the administration of a mail questionnaire to a sample of growers. Questionnaire administration was timed to occur at the close of the "off-season"(March), that part of the seasonal cycle just before the planning and soil preparation activities for another year began. As a result, each intervention year began in March and ended 12 months later in February, followed by questionnaire administration. During the months of April through September, questionnaire data was coded, checked, analyzed, and written up. During the growing season (April 15-October 15), field research was conducted to study new production methods and labor aids. The information dissemination intervention to growers continued year round.

TABLE 15. NIOSH FUNDING HISTORY FOR THE FRESH MARKET VEGETABLE INTERVENTION

intervention year	NIOSH program title	award dates	award ID#
98 (baseline Mar 97- Feb 98)	Community Partners for Healthy Farming	10/96-9/99	U06/CCU 512 940
99 (year 1 Mar 98- Feb 99)	Community Partners for Healthy Farming		
00 (year 2 Mar 99- Feb 00)*	Childhood Ag Health and Safety Research	10/97-9/00	R01 OH1 4357
01 (year 3 Mar 00- Feb 01)	Implementation of the Nat Occ Res Agenda	10/99-9/02	R01 OH0 3953
02 (year 4 Mar 01- Feb 02)	Implementation of the Nat Occ Res Agenda		

* = CASHR funded year

Process Evaluation Results: We evaluated a number of intervention information dissemination sources that contributed to increasing information flow to the managers of fresh market vegetable operations. The results for these process measures are presented in the table below (TABLE 16) and include total column inches of print media coverage in grower periodicals and agricultural newspapers and the total number of public events conducted where information about innovations was disseminated (i.e. grower conferences and workshops). For example, there were 114 column inches of press coverage about mesh bags in 1999, 3 inches in 2000, and 14 inches in 2001. Similarly, mesh bags were promoted at 5 public events in 1998 (before the intervention formally began) and at 8, 18, and 22 events in 1999, 2000, and 2001 respectively (TABLE 16). Annual mail questionnaires asked a representative, rolling, probability sample of growers (n=168) whether they had seen, read, or heard about each production practice in print media or at public events in the last year (TABLE 16). For example, 37% of growers reported seeing, reading, or hearing about mesh bags in grower publications in the baseline year (1998) before the intervention began and 59%, 62%, and 58% reported seeing, reading or hearing about mesh bags in grower publications in the three intervention years (1999, 2000, 2001). We concluded that our print media intervention effort for mesh bags was effective because it raised and maintained the percentages of growers who reported getting information about mesh bags from print media. Similarly, 34% of growers reported learning about mesh bags at public events during the baseline year and 50%, 28% and 23% in the three intervention years. The fall off from 50% to 28% and 23% in reports of getting information about mesh bags at public events may be an artifact attributable to our switch from evaluating only Wisconsin growers in 1998 & 1999 and then broadening the intervention so that evaluation results in 2000 and 2001 cover growers in all four states.

TABLE 16. PROCESS MEASURES OF INTERVENTION INFORMATION REACHING VEGETABLE GROWERS

	print media (col inches last yr)				public events (number last yr)				grower reports (% saw print media)				grower reports (% saw public event)			
	98	99	00*	01	98	99	00*	01	98	99	00*	01	98	99	00*	01
mesh bag	0	114	3	14	5	8	18	22	37%	59%	62%	58%	34%	50%	28%	23%
stan container	0	10	8	44	5	8	18	22	45%	53%	62%	68%	33%	49%	22%	25%
half pallet		0	3	38		0	18	22		39%	48%	63%		48%	18%	26%
sitting cart		0	38	105		0	18	22		46%	72%	73%		63%	22%	32%
packing shed		0	18	19		0	18	22		56%	47%	76%		62%	22%	30%

* = CASHR-funded year

note: data for 98 &99 are for Wisconsin growers only, data for 00 & 01 are for growers from WI, IA, MN & MI. First entry in table is baseline year (i.e. 98 for mesh bag & standard containers, 99 for all others).

Process evaluation data for most of the other production practices showed similar trends (i.e. standard containers, half pallet, sitting cart). After the baseline year, larger percentages of farmers reported getting information about the practices from print media and affirmative reports from

equivalent or larger percentages of growers then continued during each subsequent intervention year. Similarly, grower reports of encountering information about the other production practices at public events often showed trends similar to that for mesh bags. Specifically, compared to data from 1999, the percentages of growers fell off dramatically in 2000 and 2001. As noted above, 1999 data was collected from only Wisconsin growers but 2000 and 2001 data included growers from WI, MN, MI, and IA. One possible explanation may come from the fact that the print media we utilized were distributed to all four states (indeed nationally). As a result, growers in all four states were as likely to receive this information as those only in Wisconsin. For public events however, we may have attained good coverage of events attended by Wisconsin growers in 1999, the first intervention year but our public event coverage in 2000 and 2001 was less successful at reaching the growers in all four states.

Outcome Evaluation Results: The annual mail questionnaires were also our source of outcome data on grower awareness and adoption of the production practices and labor aids (TABLE 17). For example, grower reports of mesh bag awareness rose from 50% in the year prior to our intervention to 62% in 1999. However, awareness levels then fell to 39% in 2000 and rose to 57% in 2001. In part, the year 2000 awareness decrease may be related to the decline in our print media coverage for mesh bags from 114 column inches in 1999 to 3 inches in 2000 and then 14 inches in 2001 (see TABLE 16). Grower reports of adopting mesh bags increased strongly after the first year of the intervention (from 15% at baseline in 1998 to 27% in 1999). Once again, however, the percent of growers reporting adoption of mesh bags then fell back to 21% in 2000 and 13% in 2001. Here again, the clear break between 1998-1999 and the 2000-2001 experiences is puzzling, as is the large fall off in 2001.

TABLE 17. AWARENESS, ADOPTION AND PERCEPTIONS OF VEGETABLE GROWING PRACTICES

	awareness (% yes have heard of)				adoption (% yes used last yr)				perception** (is more profitable)				perception** (is safer)			
	98	99	00*	01	98	99	00*	01	98	99	00*	01	98	99	00*	01
mesh bag	50	62	39	57	15	27	21	13	2.9	3.9	4.0	3.9	4.0	3.8	3.9	3.7
stan. cont.	80	78	69	78	48	70	56	49	3.6	3.8	3.6	4.0	3.6	3.6	3.5	3.9
half pallet		48	28	41		10	10	13		3.7	3.8	4.6		4.1	4.5	4.5
sitting cart		49	44	55		20	6	10		3.5	3.9	3.7		4.0	3.9	4.0
packing shed		50	30	41		59	60	32		1.7	2.4	3.0		4.2	4.0	4.3

* = CASHR-funded year.
** = perceptions of aware nonadopters only (i.e. candidate pool for next generation of adopters) on a 1-5 scale (5=highest).
note: data are for Wisconsin growers only, for respondents growing no more than 25 acreas of FMV last yr and selling at least $500 worth of FMV last yr. First entry in table is baseline year (i.e. 98 for mesh bag & standard containers, 99 for all others).

Outcome evaluation results for the other production practices were mixed. Standard container awareness between 1998-2001 declined somewhat (80%-78%-69%-78%) while adoption rose and then declined fairly strongly (48%-70%-56%-49%). The half pallet and sitting cart production practices as well as the packing shed were not introduced until 2000 so the 1999 data constituted their baseline year (i.e. data collected prior to any information dissemination efforts by us). At baseline, about half of all growers were aware of the the half pallet and packing shed production practices but awareness then declined sharply in 2000 and failed to even catch up to baseline levels in 2001 after two full intervention years (e.g. half pallet 48%-28%-41%, packing shed 50%-30%-41%). The sitting cart began at about the same level at baseline, declined less after one intervention year, and then recovered completely and exceeded the baseline in 2001 (i.e. 49%-44%-55%).

One possible explanation for these results is that there may have been systematic biases between the grower list we used for 98-99 compared to the list we used for 00-01. As stated earlier, assembling our sampling frame of growers was difficult and needed to be done twice (i.e. once for 98 &99, then again for 00 & 01). Each list may have been representative of different segments of Wisconsin growers. The 1998-1999 Wisconsin grower list may have represented a geographic cluster of both better connected and more well-informed growers than the operations on the 2000-2001 grower list. The growers in our 98 and 99 samples may have been overall more progressive, better informed and more likely to be early adopters in part since these growers were better connected and easier for us to identify and include in our sampling frame than the growers we identified in 2000 and 2001.

As can be seen from table 11, 35% of the farms in 98 reported any organic acres. In 00 and 01, the percentage of farms with any organic acreage drops to a low in 2001 of 4% of our sample. Some of the production practices we promoted were especially useful for organic growers and the tasks they perform. For example, the seated cart can also function as a seated work platform for pulling weeds -- a task conventional growers avoid since they can rely on chemical control methods rather than hand pulling.

Another possible contributor to the "drops" in 2000 and 2001 may have been the relatively low print media column inches of coverage for the practices in these two years (except for the sitting cart) (see TABLE 16). As stated earlier, in future publications we plan to develop and use statistical methods to ""adjust"our grower samples for 98-01 so that they are more comparable across those variables that are now most different (e.g. % of household income from fresh market vegetable sales, % with any organic acres).

Farm managers who were aware of each practice but had not yet adopted were also asked how they perceived, on a 1-5 scale (5 being highest advantage), any profit or safety advantages for the practice versus conventional methods (in an attempt to capture the state of mind of the potential "next generation" of adopters). Each year, as more farm managers adopt a new production practice, they drop out of this "next generation" group. As a result, the managers who remain are, more and more each year, those who resist adoption. Just maintaining the profit or safety perception scores at some value from year to year in this group is a considerable accomplishment. Any improvement in perception scores among this "next generation" group can be considered an exceptional achievement of our information dissemination effort. For example, average grower perception of mesh bag profitability (i.e. the amount of vegetables that can be washed in an hour) was 2.9 prior to our intervention in 1998. In other words, at baseline in 1998, the average grower felt that working with mesh bags allowed no more vegetables to be washed in an hour than working without them (i.e. 1= much less, 3= no difference, and 5= much more). Grower-reported perceptions of mesh bag profit then increased to 3.9 in 1999 and remained close to that figure at 4.0 in 2000 and 3.9 in 2001 suggesting that our intervention was associated with an early improvement in farmer perceptions of mesh bag profitability that then stabilized. Average grower perceptions of mesh bag safety (i.e. effect on physical strain and fatigue compared to not using them) were 4.0 in the baseline year meaning that the average grower felt there was somewhat less physical strain and fatigue when using mesh bags than when not. Grower reports of mesh bag safety perceptions then slipped to 3.8 in 1999 and were 3.9 and 3.7 in 2000 and 2001. Since there was a slight decrease or no change overall, our intervention was not associated with improving grower perceptions of mesh bag safety over the course of the intervention.

DAIRY INTERVENTION RESULTS

Funding History: The baseline and the first intervention year for our dairy project were funded by a NIOSH Agricultural Safety Promotion Systems Cooperative Agreement. Support for the 2nd and 3rd intervention years was provided by this NIOSH Childhood Agricultural Safety and Health Research R-01 award. Support for intervention years 4 and 5 is being provided by a NIOSH Implementation of the National Occupational Research Agenda R-01 award (TABLE 18). Each intervention year has included the administration of a mail questionnaire to a different sample of dairy farmers (i.e. rolling sample). Questionnaire administration was timed to occur at the end of the slower months of the year (March), before forage harvest planting activities for the new cropping season began. As a result, each intervention year began in March and ended 12 months later in February, followed by questionnaire administration. During the months of April through September, questionnaire data was coded, checked, analyzed and written up. Throughout the year, field research was conducted to study new production methods. The information dissemination intervention to dairy farmers continued year round.

TABLE 18. NIOSH FUNDING HISTORY FOR THE DAIRY INTERVENTION

intervention year	NIOSH program title	award dates	award ID#
97 (baseline Mar 96- Feb 97)	Ag Safety Promotion Systems Coop Agreement	10/94-9/98	U05/CCU 506 065
98 (year 1 Mar 97- Feb 98)	Ag Safety Promotion Systems Coop Agreement		
99 (year 2 Mar 98- Feb 99)*	Childhood Ag Health and Safety Research	10/97-9/00	R01 OH1 4357
00 (year 3 Mar 99- Feb 00)*	Childhood Ag Health and Safety Research		
01 (year 4 Mar 00- Feb 01)	Implementation of the Nat Occ Res Agenda	10/99-9/02	R01 OH0 3953
02 (year 5 Mar 01- Feb 02)	Implementation of the Nat Occ Res Agenda		

* = CASHR funded years

Process Evaluation Results: We have evaluated four intervention years that were intended to increase information flow to Wisconsin dairy managers. Our intervention efforts began covering the entire state in 2000. The data in the tables below cover only dairy managers in the seven county region in Wisconsin's North East university Extension district, the seven county region where we began the intervention in 1997 and where we have the longest data series (see TABLE 19 & 20). The process measures that we present here included column inches of print media coverage and the total number of public events each year where information about the production practices and labor aids was promoted (i.e. barn lights, silo bags, mixing site, bottle holders). For example, there were 30 column inches of print media coverage of barn lights in the baseline year prior to the start of our intervention (1997). During the four intervention years of 1998, 1999, 2000, and 2001 there were respectively 222, 164, 180 and 134 inches of print media coverage of barn lights (TABLE 19). Our intervention increased information flow to farm managers through demonstrations, presentations and providing short format print material about the production practices and labor aids at public events attended by Wisconsin dairy farmers like farm shows and field days. Between 1998 and 2001 there were 13, 10, 9, and 16 public events where information about barn lights was made available.

TABLE 19. PROCESS MEASURES OF INTERVENTION INFORMATION REACHING NE WI DAIRY FARMERS

	print media (col inches last yr)					public events (number last yr)					farmers reports (% saw print media)					farmer reports (% saw public event)				
	97	98	99*	00*	01	97	98	99*	00*	01	97	98	99*	00*	01	97	98	99*	00*	01
barn lights	30	222	164	180	134	0	13	10	9	16	79	82	90	87	82	12	25	38	43	43
silo bags	0	101	23	186	34	0	13	10	9	16	79	89	90	84	81	38	39	52	47	44
mixing site	0	33	7	9	36	0	13	10	9	16	76	72	79	82	78	20	20	29	30	28
bottle holder			0	0	0			10	9	16			82	77	89			34	39	36

* = CASHR funded years.
note: first table entry is baseline yr (i.e. 97 for barn lights, silo bags & mixing site) except 99 is baseline for bottle holder.

Annual mail questionnaires asked a representative rolling probability sample of North East district Wisconsin farmers whether they had seen, read, or heard about each production practice in the last year and where they had. For example, 79% of dairy farmers reported seeing, reading, or hearing about barn lights in print media during the baseline year before our intervention began (1997). In 1998, that figure rose to 82% and was 90%, 87% and 82% for 1999, 2000, and 2001. In other words, our intervention was associated with a slight increase in the percent of dairy farmers who reported getting information about barn lighting from print media that was most apparent in 1999 and 2000 (even though 1998 was the year of our greatest number of print media column inches about barn lights in print media). In the 1997 baseline year, 12% of dairy farmers reported getting information about barn lights at a public event. During the intervention years of 1998-2001, 25%, 38%, 43%, and 43% of dairy farmers reported getting information about barn lights from public events. In other words, our intervention was associated with fairly strong, incrementally increasing farmer reports of getting information about barn lights at public events.

For silo bags, the results were roughly similar for print media since farmer reports of getting information increased over the 1997 baseline in 1998 and 1999 but then began to gradually decrease in 2000 and 2001 (nearly in parallel with decreases in print media column inches). Farmer reports of encountering silo bag information at public events increased somewhat over the intervention years (38% at baseline followed by 39%-47%-44%). Data for the calf feed mixing site and calf feeding bottle holder exhibited roughly similar trends of a discernable increase that leveled off and slightly declined in the last intervention year (but not to as low as baseline values).

Outcome Evaluation Results: The annual mail questionnaires were the source for data on the final outcomes of our dairy intervention (i.e. farmer awareness, adoption, and perceptions) (TABLE 20). For example, 48% of farmers reported awareness of barn lights in the baseline year prior to our intervention (1997). Levels of barn lights awareness then increased to 72% in 1998 and were reported to be 82%, 75% and 78% in 1999-2001. Farmer reports of adopting barn lights increased from 21% in the baseline year prior to our intervention to 31%, 34%, 23% and 31% in 1998-2001. We were pleased to see barn lights adoption increase from 21% at baseline to 31% in the first intervention year. However, there has been little upward movement since then and we are unclear about the reasons for the apparent drop in reported adoption to 23% in 2000. One possible explanation is that farmers are now better informed and mmore farmers are now able to make the distinction between simply acquiring new barn lights and the more complex practice of long day barn lighting which involves placing enough fixtures to get intense light to all barn areas, connecting lights to a timer, and carefully following an annual schedule. The information disseminated by our intervention may have broadened dairy farmer awareness of the actual costs and complexity of adopting this practice, as well as the rewards so that after an initial rise in adoption, the remaining operations are taking a wait and see attitude.

TABLE 20. AWARENESS, ADOPTION & PERCEPTIONS OF DAIRY FARMING PRACTICES, NE WI 1997-2001

	awareness (% yes have heard of)					adoption (% yes used last yr)					perception** (is more profitable)					perception** (is safer)				
	97	98	99*	00*	01	97	98	99*	00*	01	97	98	99*	00*	01	97	98	99*	00*	01
barn lights	48	72	82	75	78	21	31	31	23	31	3.7	4.0	4.0	3.9	3.9	3.9	3.8	3.9	3.8	3.6
silo bags	95	96	98	95	96	32	31	45	42	45	2.8	3.0	3.1	3.1	2.9	4.0	4.0	4.1	4.1	3.9
mixing site	39	51	58	47	54	13	16	19	11	17	3.4	3.4	3.4	3.2	3.3	3.7	3.8	3.8	3.8	3.7
bottle holder			71	71	71			39	31	28			3.6	3.4	3.8			3.8	3.8	3.7

* = CASHR funded years for Wisconsin Northeast district farmers only.
** = perceptions of aware, nonadopters only (i.e. candidate pool for next generation of adopters) on a 1-5 scale (5 highest). First entry in table for each production practice is baseline year. note: silo bag perceptions are compared to tower silos.

Silo bags were unusual since awareness was remarkably high to begin with (95%) and stayed as high. Silo bag adoption remained essentially unchanged from its baseline year (1997) to the first intervention year (1998), that is 32%-31%. Then adoption climbed during the next year and remained high (45%-42%-45%). Results for awareness of the calf feed mixing site started low at 39% in the baseline year and then increased during the first intervention year and held relatively steady for another three years (51%-50%-47%-54%). Adoption of the mixing site was more variable with a 13% baseline followed by 16%-19%-11%-17%. Results for awareness of the calf feeding bottle holder started out at 71% in the baseline year and then stayed at 71% for the next two years. Calf feeding bottle holder adoption was unusual in that 39% of dairy farmers reported having adopted in the baseline year but then the percentages fell off during the next two intervention years (31%-28%).

Farm managers who were aware of each practice but had not yet adopted were also asked how they perceived, on a 1-5 scale (5 =much more), any profit or safety advantages for the practice versus conventional methods (in an attempt to capture the state of mind of the potential "next generation" of adopters). Each year, as more farm managers adopt a new production practice, they drop out of this "next generation" group. As a result, the managers who remain aware but who have not yet adopted are, more and more each year, those who resist adoption. Just maintaining the profit or safety perception scores at some value from year to year in this group is a considerable accomplishment. Any improvement in perception scores among this "next generation" group can be considered an exceptional achievement of our information dissemination effort. For example, average dairy farmer perception of barn light profitability compared to conventional lighting (i.e. 1= much less, 3= no difference, 5= much more) was 3.7 in the 1997 baseline year prior to our intervention. In the four subsequent intervention years of 1998-2001, barn lighting profitability perceptions were 4.0, 4.0, 3.9, and 3.9 demonstrating a marginal to slight increase that was largely maintained. Average dairy farmer perceptions of barn light safety were 3.9 in the baseline year and 3.8, 3.9, 3.8, and 3.6 across the four intervention years (1998-2001) and exhibited essentially no difference aside from the decrease in 2001.

For profit and safety perceptions of the silo bags, the calf feed mixing site and the bottle holders, the data trends were largely similar to barn lighting with some slight or no increase from the baseline to the first intervention year that was maintained in the following years aside from a slight decrease in the final year.

CONCLUSION

Production practices that are both more efficient and safer are especially interesting for high hazard industries such as production agriculture, where no effective workplace safety rules or enforcement exist for tens of thousands of small to mid-sized operations. When production practices which are marginally more efficient and relatively easy to adopt become available, many if not most firm managers will eventually adopt them, given adequate information flow and sufficient time. We investigated whether better information flow could increase the speed of adoption and the extent of a practice's eventual spread throughout two large populations of farm managers. Each practice provided some efficiency advantages along with strong safety and health benefits.

The work we present in this report is innovative and advances the field for at least four reasons. First, interventions of this sort constitute efforts to translate research findings into standard practices throughout an industry. Interventions seeking to accomplish goals of this magnitude are rare in the occupational safety and health research literature. Second, we have conducted a treatment focused on child and adolescent injuries that targets parents and other adults farm managers, who can thereby help modify workplace hazards. Interventions that have taken this approach are uncommon in the existing research literature but hold great promise, especially compared to traditional approaches to childhood agricultural injury. Third, we conducted interventions that were innovative in the type of information dissemination they accomplished. We attempted to convey research findings to an audience of farm managers using media, events and other sources that the farm managers were already known to rely on for information about new production practices and labor aids. This was also unusual for an injury intervention project, particularly in agriculture. Finally, coupling safety and profit in the production practices that we promoted was innovative. Farm managers are oriented toward improving their operation's productivity and reducing costs. Safety interventions in agriculture and other industries have typically not incorporated this dual focus.

Both interventions are continuing and we plan to gather and analyze additional process and outcome evaluation data in future years. The findings about our interventions have been (or are being) written up and submitted to peer review publications. Our field work research results suggest that the production practices and labor aids we are promoting in these two interventions are viable strategies for reducing exposures to workplace hazards and thereby capable of preventing at least some of the occupational injury and disease suffered by adult, child, and adolescent workers. Some of the production practices we have reported on here are already on their way to being widely accepted practices in many if not most workplaces (i.e. silo bags and barn lighting in dairy; standard containers, mesh bags, and half pallet systems in fresh market vegetable production). Furthermore, the increases in adoption rates for the production practices and labor aids (coupled with the process outcomes verifying that farmers saw the sources where we improved information flow) show that these interventions, funded by the NIOSH Childhood Agricultural Safety and Health Research initiative, are likely to have already made some difference in the control of dairy and fresh market vegetable workplace hazards and, potentially, reductions in adult, child, and adolescent injuries.

LIST OF PUBLICATIONS AND PLANNED PUBLICATIONS

Oral Presentations:

Chapman LJ, Taveira AD, Newenhouse AC, Meyer RH, Josefsson KG. Causal factors in production agriculture injuries: working children and youth versus adults (abstract and oral presentation). Presented at the 13th Annual International Occupational Ergonomics and Safety Conference. Ann Arbor, MI: June 11-14, 1998.

Meyer RH, Newenhouse A, Chapman LJ. Healthy profits and healthy farmers: four agricultural ergonomics case studies from Wisconsin's fresh market vegetable industry. (oral presentation) delivered to a NIOSH workshop on Ergonomics in Agriculture held in Cincinnati OH, July 7, 1998 (in press 1999).

Chapman LJ, Taveira AD, Josefsson KG, Newenhouse AC, Meyer RH, Hard DL. "An evaluation of a social marketing intervention to reduce injuries on Wisconsin dairy farms" (abstract and oral presentation) delivered at the 4th International Symposium "*Rural Health and Safety in a Changing World*" in Saskatoon, Canada, held October 18-22, 1998.

Chapman LJ, Newenhouse AC, Meyer RH, Josefsson KG, Schmitz K, Hornemann C. "Coupling child and adolescent worker safety with operation profits among Wisconsin dairy producers and fresh market vegetable growers" (abstract and oral presentation) delivered at the 4th International Symposium "*Rural Health and Safety in a Changing World*" in Saskatoon, Canada, held October 18-22, 1998.

Chapman LJ, Josefsson KG, Meyer RH, Newenhouse AC, Karsh B, Miquelon M. Dairy and fresh market vegetable production work by Wisconsin children and adolescents. (abstract and oral presentation) Presented at the NIOSH conference "Agricultural Safety and Health in a New Century" on April 28-30, 2000 in Cooperstown NY.

Chapman LJ, Josefsson KG, Meyer RH, Newenhouse AC, Karsh B, Miquelon M. Intervention research to reduce injuries on dairy, berry, and fresh market vegetable farms. (abstract and oral presentation) Presented at the NIOSH conference "Agricultural Safety and Health in a New Century" on April 28-30, 2000 in Cooperstown NY.

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Chapman LJ, Karsh B, Taveira A, Josefsson KG, Hard DL. Effects of a two year, profit-improving, occupational injury intervention among Wisconsin dairy farmers. Madison WI: University of Wisconsin Biological Systems Engineering Department, 2001 (in preparation).

Chapman LJ, Newenhouse AC, Meyer RH, Taveira AD, Karsh B, Ehlers J, Palermo T. An evaluation of a one year intervention to reduce musculoskeletal hazards in fresh market vegetable growers. *Scandinavian Journal of Work, Environment and Health* (to be submitted for peer review 7/30/01).

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