NIOSH AGRICULTURAL CENTERS

ANNUAL REPORT

FISCAL YEAR 2004*

(*October 1, 2003 to September 30, 2004)

STATE

Colorado

CENTER NAME

High Plains Center for Agricultural Health and Safety

I. INTRODUCTION & EXECUTIVE SUMMARY OF THE PROGRAM

HICAHS has had a very productive first year of this three year funding cycle. Even though the starting date for this initial year was September 15, 2003, funds were not received from CDC/NIOSH until November 19, 2003. These initial funds were for the Administrative Core and only projects that did not include Human Subjects. Final release of funds for research projects involving human subjects occurred on March 3, 2004. The large number of projects involving human subjects and the need to secure IRB approval from many collaborating institutions contributed to this delay. Although the delay in funding inhibited hiring of staff and project implementation, we have been able to keep most projects on schedule. We have engaged a wide network of partners throughout Region VIII and nationally to collaborate on the research, intervention, education and outreach activities funded. New partnerships with agricultural producer organizations and workers compensation insurance carriers have been particularly exciting, with HICAHS serving to connect these groups. In addition HICAHS has played a lead role in a number of important national initiatives. We are now continuing to build and foster partnerships and look forward to an eventful second year of this project.

A. CENTER ACCOMPLISHMENTS FOR FY 2004

1. **2004 National Symposium on Agricultural Health and Safety.** HICAHS lead the organization of and hosted the first joint national conference involving the NIOSH Agricultural Centers, the National Institute for Farm Safety, and the North American Agromedicine Consortium. The 2004 National Symposium on Agricultural Health and Safety was held in Keystone, CO on June 20-24, 2004. A major theme was development of collaboration between the three participating organizations. The NIOSH Agriculture Centers used this meeting as a venue to introduce their Tractor Safety Initiative and seek input from stakeholders. Dr. John Howard, Director of NIOSH was a Keynote speaker. Another major topic of the meeting dealt with Agroterrorism.

2. **National Tractor Safety Initiative.** Drs. Reynolds, Ayers, and Liu have played key roles in the Agricultural Centers coordinated effort to develop a national Tractor Safety Initiative. Dr. Reynolds led creation of the Research section of this plan and helped to organize two sessions at the Keystone meeting – one involving the dissemination and feedback for this plan, the second involving promotion/social marketing of the plan.

Dr. Ayers organized a related technical session at this meeting. Dr. Reynolds led the development of a grant proposal to NIOSH involving collaboration of all of the NIOSH Agricultural Centers to fund the National Agricultural Tractor Safety Initiative.

3. **ROPS Design and Testing for Agricultural Vehicles.** Paul Ayers, Ph.D., P.E. Eight continuous roll field upset tests were conducted in accordance with ASAE S547, with a Deere F925 front drive mower to evaluate the rollover protective structure (ROPS) performance based on the OECD Code 6 continuous roll model. The results reveal the proposed continuous roll model does not take into account the influence of the front mower deck and can inaccurately predict continuous roll behavior. Based on these observations, the ROPS manufacturing industry has been notified to discontinue ROPS design using the existing model. Continuous roll model modification is underway to include the influence of the front deck on the continuous roll behavior.

4. **Fatalities related to injectable veterinary drugs.** In response to fatalities involving injectable veterinary drugs a special meeting was held at the 2004 National Symposium on Agricultural Health and Safety in Keystone to further understand the national scope of the problem and to plan interventions. As a first step, an article was written (English and Spanish) for Colorado Dairy News with a regional circulation of 1,000 and then picked up by the Bovine Veterinary Magazine with a national circulation. The articles provided specific guidelines to modify practice and prevent injection of veterinary drugs. The intent of the Bovine Veterinary Magazine issue was to provide veterinarians with information for training their clients.

5. Development of Novel Biomarkers for Pesticides in EPA Region VIII. We have developed analytical methods in blood, brain, and urine for atrazine and its 3 major metabolites. In vivo exposures of Sprague Dawley (SD) rats to 300 mg/kg of atrazine resulted in significantly higher globin adducts than in vitro experiments with rat whole blood suggesting that metabolism of atrazine is important for adduct formation. Mass spectrometry data indicates an approximate 107 kD addition to the beta globin chain, which may correspond to a reaction with a deprotonated diaminoatrazine metabolite of atrazine.

B. REGIONAL ACTIVITIES

1. **States Served by Center:** Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming

2. **States with Center Activity for FY 2004:** Alabama, Arkansas, California, Colorado, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah,

Washington, Washington, D.C., West Virginia, Wisconsin, Wyoming; and the countries of Canada, American Samoa, Norway, Serbia and Montenegro, and Mexico.

II. REPORT ON THE OUTREACH PROGRAM

HICAHS did not receive funding for Outreach activities in this first year, other than for the project "Regionalization " which is described below as part of the Outreach and Education Core. Funds targeted for Outreach were received for Year 02. These will be used to develop materials such as "barn door fliers" requested by Cooperative Extension and for outreach collaboration with producer organizations, for updating and maintaining the HICAHS Website and Newsletter for information dissemination.

III. CENTER PROJECT REPORT BY CORE / TYPE:

A. PROJECT TITLE

Administrative Core

B. PROJECT OFFICER(s)

Stephen J. Reynolds, Ph.D., CIH – Center Director
Environmental & Radiological Health Sciences
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Colorado State University
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stephen.reynolds@colostate.edu

Victoria Buchan, Ph.D. – Center Deputy Director

Phil Bigelow, Ph.D., CIH – Outreach/Education Core Director

Dennis Lamm, Ph.D. – Extension Education

John Rosecrance, Ph.D., PE, - Intervention/Prevention Core Director and Outreach/Education Core Director (as of 9/04)

John Tessari, Ph.D. – Research Core Director

C. PROJECT DESCRIPTION

The Specific Aims of the Administrative Core are to:

1. Provide Center Administration and Leadership.

2. Provide coordination of research, outreach, and prevention activities within the Center, with other related programs at Colorado State University, with other NIOSH Agricultural Health and Safety Centers, and with other US and international colleagues active in agricultural health and safety.
3. Utilize a strategic plan to guide the Center's development and growth.
4. Conduct evaluation (internal) of Center progress and products.
5. Provide professional education and/or training related to agricultural health and safety.

The Center is governed by the Administrative and Planning Core through an Internal Advisory Committee that is composed of the Center Director (Steve Reynolds), Center Deputy Director (Vicky Buchan), the Directors of the Prevention/Intervention (John Rosecrance), Education and Outreach (Phil Bigelow), Multidisciplinary Research Cores (John Tessari), the Director of the Master of Agriculture Program in Extension Education (Dennis Lamm), and the Administrative Assistant (Angi Buchanan). The Regional Advisory Committee represents a broad constituency including: scientists, agricultural producers, Farm Bureau, health and veterinary care providers, church, agricultural business, migrant advocates, Cooperative Extension, and government. A list of Advisory Board members is included below under Collaborators. In addition to building an infrastructure for collaborations, these advisors provide critical consultation on the needs of constituents and potential mechanisms for meeting those needs.

D. PROJECT START AND END DATES

September 15, 2003 to September 14, 2006

E. PROJECT ACTIVITIES / ACCOMPLISHMENTS

Funds for this project were released from CDC/NIOSH on November 19, 2003. Even with the delay in funding, the project is on schedule. Activities and results are described for each specific aim, relative to objectives laid out in the grant proposal.

1. The Internal Advisory Committee meets at least monthly to coordinate projects within the Center and between the Center and other organizations/programs. All of the members proposed for the External Regional Advisory Board have continued to participate. The External Regional Advisory Board met in person on June 22, 2004 at the National Symposium on Agricultural Health and Safety held in Keystone, Colorado. An external Scientific Advisory Board was proposed to be developed in Year 01 – we are continuing to pursue this as part of strategic planning with our Regional Advisory Board meeting.

2. HICAHS personnel and students have participated in seminars in various departments and Centers at CSU to foster interactions. HICAHS led the organization of and hosted the first joint national conference involving the NIOSH Agricultural Centers, the National Institute for Farm Safety, and the North American Agromedicine Consortium. The 2004 National Symposium on Agricultural Health and Safety was held in Keystone, CO on June

20-24, 2004. A major theme was development of collaboration between the three participating organizations. The NIOSH Agriculture Centers used this meeting as a venue to introduce their Tractor Safety Initiative and seek input from stakeholders. Dr. John Howard, Director of NIOSH was a Keynote speaker. Another major topic of the meeting dealt with Agroterrorism. Dr. Vicky Buchan and Dr. Reynolds secured a Conference grant to assist with this effort. V. Buchan and H. Holmquist-Johnson submitted a proceedings article to the Journal of Agromedicine at the request of Steve Kirkhorn. HICAHS products have been disseminated as requested to other NIOSH centers and other constituents.

Request for Proposals for Feasibility Projects were distributed via the External Regional Advisory Board, to Health Departments, migrant health organizations, academic institutions and other organizations in Region VIII. Two awards of $5,000 each were made. As described in the Outreach section, HICAHS has also worked specifically with the Extension Safety specialists in each state to develop additional targeted Feasibility projects. See Section IV Progress Report on Feasibility Projects and Appendices for a full report.

Drs. Reynolds, Ayers, and Liu have played key roles in the Agricultural Centers coordinated effort to develop a national Tractor Safety Initiative. Dr. Reynolds led creation of the Research section of this plan and helped to organize two sessions at the Keystone meeting – one involving the dissemination and feedback for this plan, the second involving promotion/social marketing of the plan. Dr. Ayers organized two related technical sessions at this meeting. Dr. Reynolds led the development of a grant proposal to NIOSH involving collaboration of all of the NIOSH Agricultural Centers to fund the National Agricultural Tractor Safety Initiative.

3. The major emphasis of the External Regional Advisory meeting held at Keystone in June was to revisit and update strategic planning, and to deal with a specific problem of fatalities from injectable veterinary drugs. Outreach activities to address this problem are described in the Education/Outreach section report.

4. The Center evaluation system has been updated and all personnel have been trained on completion of the overview form and logs for the tracking data base. The database is being updated and will be used for evaluating progress on projects and for preparation of reports. The Center Evaluation Plan which is utilized at HICAHS consists of maintaining the Center Program Monitoring System in an ACCESS database and personnel activity logging process. The database addresses multiple evaluation objectives. There are two data collection forms which are currently used. The Project Overview form is completed when a Center research, prevention or education project begins. The Activity Log form is completed by personnel and forwarded to the Program Assessment Resource Development (PARD) unit of HICAHS when work is completed on a project. Then the PARD staff enters the data into the database. As new personnel are hired at HICAHS they are trained on how to complete these forms. We continue to work toward improving data collection methods by making the recording of activities as convenient as possible for HICAHS personnel.

NIOSH Agricultural Center Program Objectives with corresponding HICAHS projects

Below are funded HICAHS projects listed with the NIOSH program objective which each project addresses.

NIOSH Program Objectives:

(1) Develop and conduct research related to the prevention of occupational disease and injury of agricultural workers and their families.

(2) Develop and implement model educational outreach, and intervention programs promoting agricultural health and safety for agricultural workers and their families.

(3) Develop and evaluate control technologies to prevent illness and injuries among agricultural workers and their families.

(4) Develop and implement model programs for the prevention of illness and injury among agricultural workers and their families.

(5) Evaluate agricultural injury and disease prevention and educational materials and programs implemented by the Center.

(6) Provide consultation and/or training to researchers, health and safety professionals, graduate/professional students, and agricultural extension agents and others in a position to improve the health and safety of agricultural workers.

(7) Develop linkages and communication with other governmental and non-governmental bodies involved in agricultural health and safety with special emphasis on communications with other CDC/NIOSH sponsored agricultural health and safety programs.

(8) Disseminate Center sponsored or generated information addressing agricultural health and safety, including research, outreach, intervention, prevention, and education programs and projects.

(PLEASE NOTE: This eighth NIOSH Agricultural Center Program Objective was added by the Multisite Evaluation Team and is currently provisional.)

HICAHS Projects with corresponding NIOSH Objectives

NIOSH OBJECTIVE NUMBER(S)	PROJECT TITLE
1 & 6	Development of Novel Biomarkers for Pesticides in EPA Region VIII
1 & 6	Endotoxin & Genetics in Organic Dust Lund Disease Facilities
1	Improved Methods of Obtaining Injury Information from Migrant Farmworkers
1	Evaluation of a Bacteriophage Cocktail to Reduce *Escherichia coli* 0157:H7 Shedding in Beef Cattle (Feasibility study)
1	Agricultural Injuries and Illness Among Colorado Agricultural Workers (pilot study)
2	Agricultural Curriculum Evaluation
2	Interactive Agricultural Health & Safety CD: 4-H Youth
2 & 6	Regional Education Through State Extension Agents
3 & 6	ROPS Design and Testing for Agricultural Vehicles
3 & 6	Reduction of Exposures from Dairies and Cattle Feedlots Facilities
5	In addition to the Center evaluation plan, evaluation is built into each project as appropriate.
7	Center Administrative Core
7	National Tractor Safety Initiative Lead Center
7	Lead organization and host of the 2004 National Symposium on Agricultural Health and Safety in Keystone, CO

5. A number of MS, MSW, and PhD students are working on HICAHS projects and will produce reports, theses and dissertations. Students are enrolled in programs in the College

of Veterinary Medicine and Biomedical Sciences (industrial hygienists, epidemiologist, veterinarian), College of Agricultural Sciences, College of Engineering and College of Applied Human Sciences at CSU. A graduate student at the University of Utah, Rocky Mountain Center for Occupational and Environmental Health (ERC) is also being supported on a HICAHS project. The Administrative Core has also been working to develop relationships with additional producer organizations and insurers. We are in the initial stages of collaboration on continuing education/training programs for the Colorado Corn Growers, Colorado Livestock Association and others, as well as collaborating on research and outreach dissemination.

The Administrative Core has been very successful in stimulating and coordinating interactions among Center members, and between HICAHS and regional and national partners. The 2004 National Symposium on Agricultural Health and Safety was the first time that members of the three major U.S. agricultural health and safety organizations have come together to share information and build collaborations. The coordination of this meeting, under the leadership of Dr. Buchan, with a conference committee made up of members of each organization, has been a significant accomplishment given the logistic challenges and cultural differences of the three organizations. The result of this meeting should significantly improve the efficiency of efforts to reduce the national burden of agricultural injury and illness. The NIOSH Agricultural Centers Tractor Safety Initiative represents the first major collaborative effort of all the NIOSH Agricultural Centers and is meant to address the number one cause of fatalities in U.S. agriculture. Dr. Reynolds and HICAHS were designated as the P.I. and lead Center on this national collaborative effort as the Centers sought to develop and submit a proposal to partner with multiple constituencies across the U.S.

In Year 02 the Administrative Core will continue to provide leadership and direction to the Center members and will continue to foster collaboration between HICAHS and regional and national partners. Working with the External Regional Advisory Committee on strategic planning will be a priority and a first meeting is scheduled for November 2004. We will also work closely with the Cooperative Extension Safety Specialists and Feasibility Grant awardees to ensure that their projects are successful and that findings are shared. We will continue to play a leadership role in activities such as the NIOSH Agricultural Centers Tractor Safety Initiative and the NIOSH Agricultural Centers evaluation.

F. PROJECT PRODUCTS

1. Presentations:

Chrischilles EA, Merchant J, Kuehl A, Ahrens R, Reynolds SJ, Kelly K, Thorne PS, Burmeister L. Childhood Asthma in a Rural Population. American Public Health Association Conference, San Francisco, CA Nov. 15-19, 2003.

Jones M, Thomas K, Gordon S, Reynolds SJ, Lynch C, Summary of Biological and Environmental Monitoring Results from the Agricultural Health Study-Pesticide Exposure Study. Fifth International Symposium - Future of Rural Peoples: Rural Economy, Healthy Peo Rural Communities, Saskatoon, Saskatchewan, Canada, October 19-23, 2003

2. **Publications**

   a. **Peer Reviewed Journal:**

Buchan, V. and Holmquist-Johnson, H. (in press). Summary Proceedings: 2004 National Symposium on Agricultural Health and Safety. *Journal of Agromedicine*.

Curwin BD, Hein MJ, Sanderson WT, Nishioka M, Reynolds SJ, Ward EM, Alavanja MC. Pesticide Contamination Inside Farm and Non-Farm Homes (Environmental Health Persp 2004)

Gregory A. Flamme, Ranjit Mudipalli, Stephen Reynolds, Kevin Kelly, Ann Stromquist, Craig Zwerling, Leon F. Burmeister, Shu Chen Peng, James Merchant, Prevalence of hearing impairment in a rural Midwestern cohort: Estimates from the Keokuk County Rural Health Study, 1994-1998, Ear and Hearing, 2004.

Groves WA, Reynolds SJ. Prototype Sampling System for Measuring Workplace Protection Factors for Gases and Vapors. App Occ Env Hyg 18(5)1-9, 2003

Nonnenmann MW, Donham KJ, Rautiainen RH, O'Shaughnessy PT, Burmeister LF, Reynolds SJ. Vegetable Oil Sprinkling as a Dust Reduction Method in Swine Confinement. JASH 10(1):7-15, 2004

Park HS, Reynolds SJ, Kelly KM, Stromquist AM, Burmeister LF, Zwerling C, Merchant JA. Characterization of Agricultural Tasks Performed by Youth in the Keokuk County Rural Health Study. App Occ Env Hyg. 18(6)1-12, 2003.

3. **Education / Training / Outreach**

   j. **Other:**

   Reynolds – Lecture in CSU Department of Agriculture Class A300, Issues in Agriculture – "Health and Safety in Agriculture" September 2004, 63 students.

   Lamm – CSU Department of Agriculture Class A300, Issues in Agriculture – "Health and Safety in Agriculture" September 2004, 63 students.

4. **Conferences / Meetings Sponsored:**

2004 National Symposium on Agricultural Health and Safety. First joint meeting of the National Institute for Farm Safety, the North American Agromedicine Consortium, and the NIOSH Agricultural Health and Safety Centers. Keystone, CO, June 2004. HICAHS provided organizational leadership, obtained conference grant and hosted.

Co-organizer, Fifth International Symposium, Future of Rural Peoples: Rural Economy, Healthy People, Environment, Rural Communities. Saskatoon, Saskatchewan, Canada, October 19-23, 2003

Co-organizer, Mold Remediation and Control: The National Quest for Uniformity, ACGIH Bioaerosols Committee, Orlando FL November 3-5, 2003.

5. **Other Products:**

Stanton TL, Wailes WR, Reynolds SJ, Johnson D, Davis J. The effect of algae and bacterial additions to a CAFO lagoon on the conversion from anaerobic to aerobic fermentation. CSU, Department of Animal Sciences Website, 2004

G. STATES THE PROJECT WAS ACTIVE IN

Alabama, Arkansas, California, Colorado, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Washington, Washington, D.C., West Virginia, Wisconsin, Wyoming; and the countries of Canada, American Samoa, Norway, Serbia and Montenegro, and Mexico.

III. CENTER PROJECT REPORT BY CORE / TYPE:

A. PROJECT TITLE

ROPS Design and Testing for Agricultural Vehicles

B. PROJECT OFFICER(s)

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C. PROJECT DESCRIPTION

The overall objective of this project is to investigate, develop, evaluate and disseminate information regarding rollover protective structure (ROPS) designs for agricultural vehicles in the United States to provide and ensure operator protection on vehicles not currently available. The specific objectives include:

1) Evaluation of the continuous roll prediction accuracy of the model described in the newly approved (December 2002) ASAE Standard S547 "Tip-Over Protective Structure (TOPS) Protective Structure for Front Wheel Drive Turf and Landscape Equipment". The evaluation includes:

- Field upset test verification (roll behavior and angular velocities) using Deere F 925 front drive mower
- Determination of measured and calculated critical ROPS height (CRH) for the Deere F925 front mower
- Model sensitivity analysis and parameter estimation on model factors including moment of inertia, mower deck size, ROPS and test slope deflection, center of gravity location, coefficient of elasticity of slope,

2) Determination of the required critical ROPS height (CRH) for the 17 previously examined agricultural vehicles (lawn tractors, lawnmowers, off-road utility vehicles and ATV's), utilizing the continuous roll prediction model described in ASAE S547. A comparison of the calculated (CRH) to the actual ROPS height for the available ROPS will be conducted,

3) Dissemination of information addressing ROPS design and testing will be presented to the Agricultural Vehicle Industry (including tractor, lawnmower, off-road utility vehicle and ATV). Dissemination will occur in the form of technical presentations and literature distribution at national meetings, individual site visits (vehicle and ROPS manufactures), specialty meeting (i.e., PM 52 and the OPEI EXPO). The topic areas will include general ROPS design and testing, ASAE S547 test slope construction, ASAE S547 model validation and utilization. A website presenting 1) the test slope construction details for the S547 lateral field test and 2) the OECD Code 6 continuous roll prediction model accuracy evaluation and limitations will be developed,

4) Conducting lateral field upset tests in accordance with ASAE S547 of prototype or commercially available ROPS and non-ROPS frames designed for non-traditional agricultural vehicles including lawnmowers, off-road utility vehicles and ATV's to evaluate operator protection characteristics.

D. PROJECT START AND END DATES

Start 10/1/2003
End 9/29/2004

E. PROJECT ACTIVITIES / ACCOMPLISHMENTS

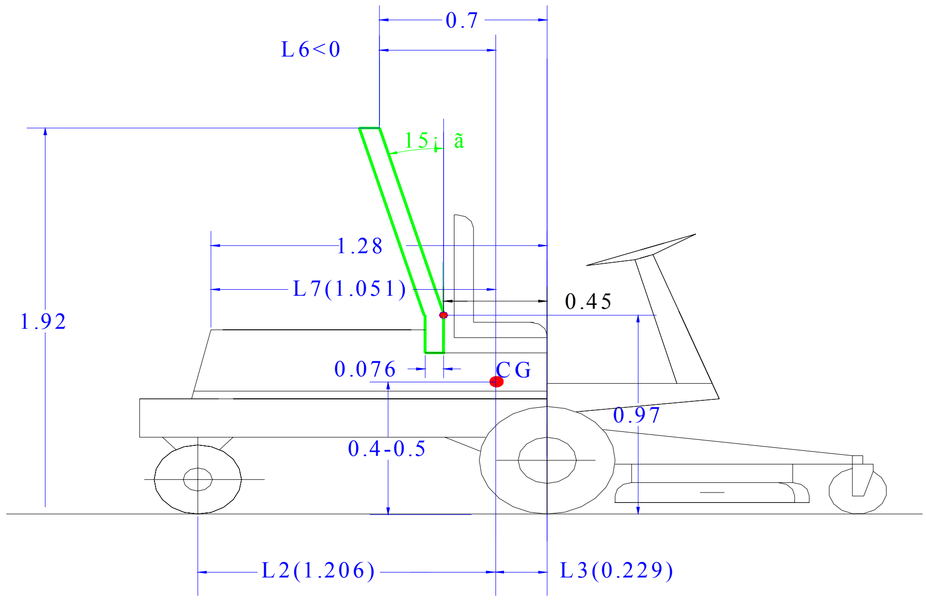
ASAE S547 Lateral Upset Test Model Evaluation, Sensitivity Analysis and Dissemination

ASAE Standard S547 "Tip-Over Protective Structure (TOPS) Protective Structure for Front Wheel Drive Turf and Landscape Equipment" was recently approved in December 2002. The S547 standard lateral upset test is designed to limit the roll angle during the side upset of a self-propelled ride-on machine. The test slope requirement is new to ROPS testing in the United States and the test slope at the University of Tennessee is the only known test slope in the U.S. to meet the Standard requirements (described below).

> The lateral upset test shall be carried out on a natural earth slope or a test ramp at least four meters long (see figure 3). The slope of the surface shall be 33degrees +5/-0. The surface shall be covered with a minimum of a 180 mm layer of material, which when measured in accordance with ASAE Recommendation R313, section 1 has a cone penetration index of A (235 + 20) or B (335 +20). (From ASAE S547)

The ASAE S547 Standard also includes a new modeling component that would allow ROPS design without actual field upset testing. The model described in the Standard is from the OECD Standard Code 6: 1998. The influence of the mower deck to determine the vehicle/slope contact points is ignored in the described model possibly producing unsafe ROPS designs. This assumption can significantly influence the model results and need to be explored prior to implementation for ROPS design.

A Deere F925 front drive mower was used in the evaluation of ASAE S547 continuous roll field testing and the OECD Code 6 model. The model inputs are described below. Note that the location of the deck is not included in the model parameters.



Inputs of F925 mower with regular ROPS

1.Height of the COG	H1=0.45m	2. Horizontal distance between the center of gravity and front axle	L3=0.229m
3.Horizontal distance between the center of gravity and rear axle	L2=1.206m	4.Height of front tire	D3=0.565m
5.Height of the rear tires	D2=0.360 m	6.Height at the point of impact	H6=1.920m
7.Horizontal distance between the center of gravity and the leading point of intersection of ROPS (minus, if it lies behind the plane of the center of gravity)	L6 =-0.471m	8.Width of ROPS	B6=0.775m
9.Height of the engine bonnet	H7=0.845m	10.Width of the engine cover	B7=0.650m
11.Horizontal distance between the center of gravity and the rear corner of the engine bonnet	L7=1.051m	12.Height of the rear-axle pivot point	H_O=0.31m
13.Rear track width	S=0.88m	14.Front tire width	B0=0.19m
15.Rear axle swing angle	D0=0.102(rad)	16.Tractor Mass	Mc=899.5kg
17.Moment of inertia About the longitudinal axis through the center of gravity	Q= 206.3(kgm^2)		

Three continuous rollover tests were conducted using the F925 front drive mower with the factory-installed ROPS using the calibrated foam pad that meets the strength requirements of the ASAE S547 Standard. A continuous roll was observed for all three tests. It should be noted that the factory-installed ROPS was not designed to meet ASAE S547 standards. An LVDT was placed on the ROPS to monitor the deflection of the ROPS top during the roll test. ROPS deflections of approximately 6.5 cm were observed which provided protection of the operator. For the factory installed ROPS, the Critical ROPS Height (CRH) is 2.14 meters, indicating the model accurately predicts a continuous roll. The Critical ROPS height (CRH) is the height that transitions from the continuous roll to non-continuous roll.

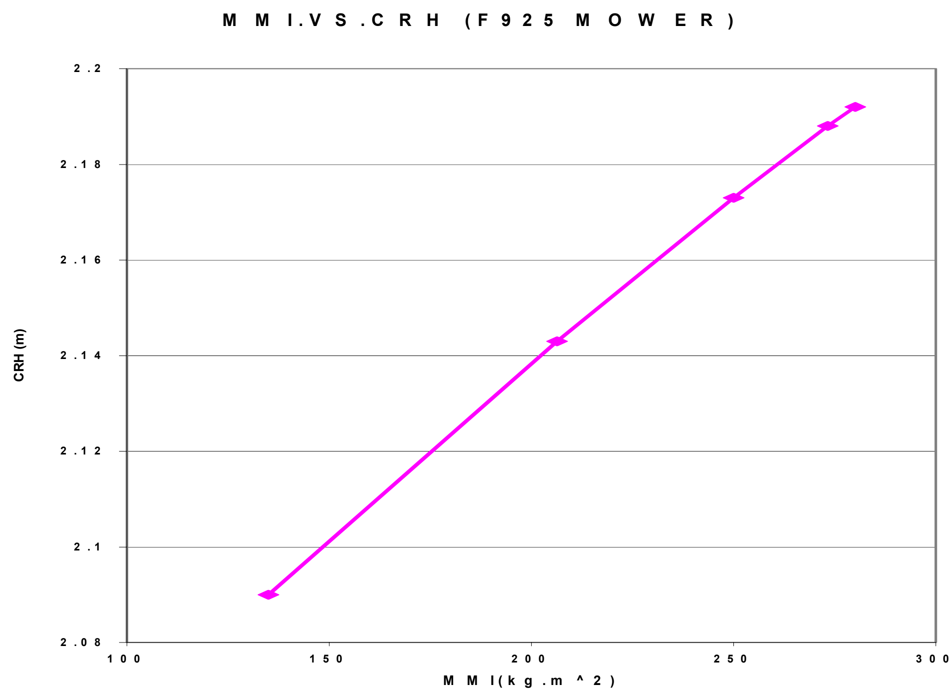
Model sensitivity analysis was conducted on mass moment of inertia and vertical height to the center of gravity. The Critical ROPS Height (CRH) for the F925 is very dependent on the vertical height to the center of gravity, which is difficult to determine. The table below indicates a CRH for the F925 ranging from 1.99 to 2.28 meters as H1 ranges from 0.4 to 0.5 m. Note the significant change in the Mass Moment of Inertia.

Regular ROPS with Deck

H1(m)	L6(m)	Q(kgm^2)	CRH(m)
0.4	-0.471	134.9	1.99
0.45	-0.471	206.3	2.14
0.5	-0.471	273.3	2.28

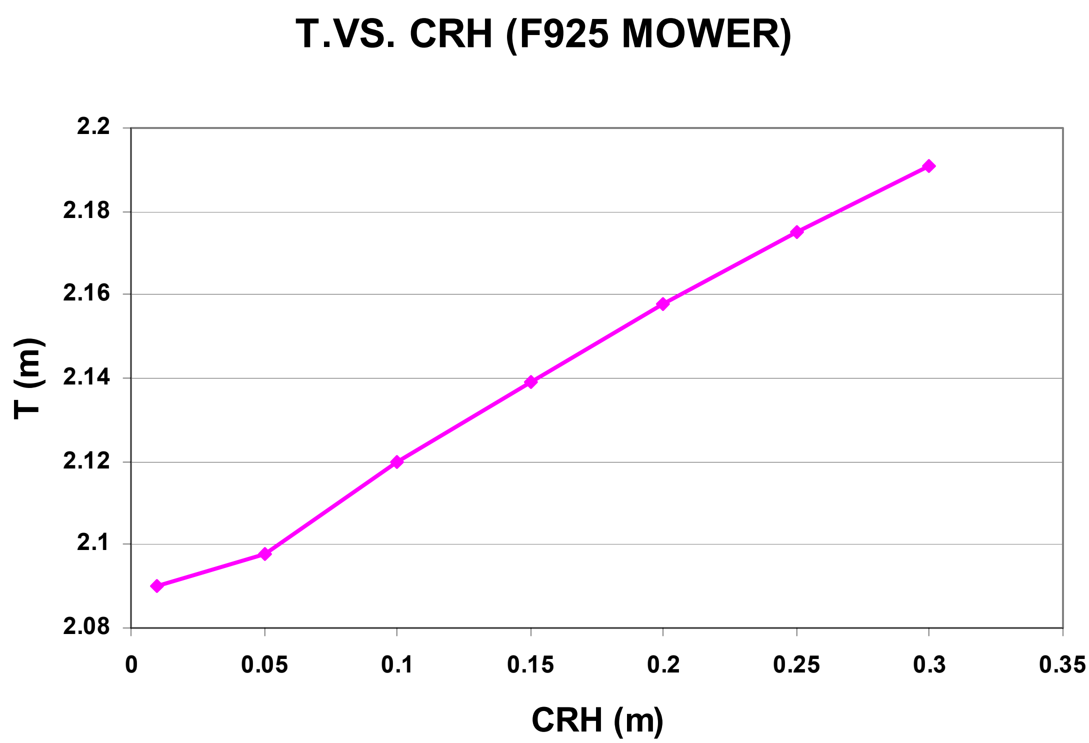
Evaluating the affect of Mass Moment of Inertia alone on the CRH yields a smaller variation.
F925

MMI(kg.m^2)	CRH(m)
134.9	2.09
206.3	2.143
250	2.173
273.3	2.188
280	2.192



The influence of the value of T (combined ROPS deflection and sinkage) does not significantly influence the CRH calculation.

T(m)	CRH(m)
0.01	2.09
0.05	2.098
0.1	2.12
0.15	2.139
0.2	2.158
0.25	2.175
0.3	2.191



ROPS extensions were constructed to increase the existing ROPS height to approximately 2.20 meters to evaluate the critical ROPS height model prediction. In addition, the ROPS was inverted to give additional ROPS contact point locations to evaluate the model. Finally, the predicted CRH is determined for the F925 without deck to evaluate the deck influence. The CRH for F925 mower can be obtained for the different ROPS locations.

Deck	ROPS Position	CRH(m)
Y	Regular	2.14
Y	Inverted	1.41
N	Regular	1.40
N	Inverted	1.80

Additional continuous roll tests were conducted with the extended ROPS in both the regular and inverted positions. Two additional tests were conducted without the deck and the ROPS in regular and inverted locations. The results are shown below.

Comparison of model to field test results.

Deck	ROPS Height(m)	ROPS Position	No of Tests	Model Results	Test results	Prediction
N	1.92	Regular	1	No Roll	No Roll	Accurate
N	1.92	Inverted	1	No Roll	No Roll	Accurate
Y	1.92	Regular	3	Roll	Roll	Accurate
Y	1.92	Inverted	1	No Roll	Roll	Inaccurate
Y	2.20	Regular	1	No Roll	Roll	Inaccurate
Y	2.20	Inverted	1	No Roll	No Roll	Accurate

The results show that with a deck, in two test conditions, the model is predicting no continuous roll when continuous roll did occur in the field upset tests. The results of the field upset tests and related model performance demonstrate an inconsistency with the model presented in the ASAE S547 Standard. This model may not accurately predict the roll behavior of lawnmowers with front decks. Model modifications to include the influence of the front deck on the continuous roll behavior are needed prior to being used for ROPS designs. The industry is now aware of this problem and model modifications are underway. These modifications will allow ASAE S547 to be implemented by ROPS manufactures for future front drive mower ROPS designs.

The results of the tests described above have been reported to the ROPS manufacturing industry as described in the presentations and meetings described in Section F. Five presentations and three committee reports have been given. To date, no known front drive mower ROPS has been designed using the current OECD Code 6 continuous roll model.

Initial Website design has been started. The website will include 1) the test slope construction details for the S547 lateral field test and 2) the OECD Code 6 continuous roll prediction model accuracy evaluation and limitations. Also included is the modification of the continuous roll prediction model currently under development. The revised OECD Code 6 model will be available for download. Video of the ASAE S547 lateral upset test (from both the longitudinal and lateral directions) has been digitized and will be included in the web site. A description of the critical ROPS height determination will also be provided.

Critical ROPS Height Determination for 17 Vehicles

In order to evaluate the continuous roll potential for agricultural vehicles, critical ROPS height were determined for seventeen vehicles that are grouped into four categories: utility vehicles, lawn tractors, ZTR's (zero turn radius), and all-terrain vehicles (ATV's). According to ASAE S547 DEC 02, to prevent a roll over, calculation methods (using OECD Code 6 continuous roll model) can be used to determine the critical height of the ROPS needed. Since these vehicles do not have front decks, the OECD Code 6 is valid for CRH determinations. The following vehicle parameters must be determined.

Height of the Center of Gravity	H1	Horizontal distance between the center of gravity and front axle	L3
Horizontal distance between the center of gravity and rear axle	L2	Height of front tire	D3
Height of the rear tires	D2	Height at the point of impact	H6
Horizontal distance between the center of gravity and the leading point of intersection of ROPS (minus, if it lies behind the plane of the center of gravity)	L6	Width of ROPS	B6
Height of the engine bonnet	H7	Width of the engine cover	B7
Horizontal distance between the center of gravity and the rear corner of the engine bonnet	L7	Height of the rear-axle pivot point	H_O
Rear track width	S	front tire width	B0
Rear axle swing angle	D0	Tractor Mass	Mc
Moment of inertia About the longitudinal axis through the center of gravity	Q		

To determine parameter Q the formula for the moment of inertia (MMI) was found in the SAE technical paper series titled "Developments in Vehicle Center of Gravity and Inertial Parameter Estimation and Measurement." The roll MMI equation is as follows: $I_{xx} = \frac{(RH + CG) * TW}{K} * m$, where RH is the ROPS height, CG is the center of gravity, TW is the track width, m is the mass, and K is the Inertia Approximation Constant. K is found in the same paper for roll inertia for a multi-purpose vehicle. The value of K is found to be 9.4212. The moment of inertia could then be found by using the estimated or actual height of the ROPS.

The Critical ROPS Height (CRH) estimates (in meters) for 17 vehicles are shown below. These estimates can be used to predict if the vehicles will continuously roll down a 35 degree slope. CRH's range from 1.75 m to 2.69 meters, with most in the 1.75 to 1.95 m range. The four actual ROPS were in the 1.8 to 2.0 meter range. Three of the Lawn Tractors had CRH greater than 2.0 meters, indicating a tall ROPS is needed to reduce continuous roll. Of the four vehicles with ROPS, two vehicles had ROPS height less than the estimated CRH indicating continuous roll potential. Note that the actual "ROPS" listed for the Utility Vehicles are actually non-ROPS brush guards.

UTILITY VEHICLES

	Gator 4x2	Gator 6x4	Polaris 4x4	Mule 4x2	Toro Work.
H1	0.592	0.532	0.569	0.619	0.733
L3	1.14	1.3899	1.022	1.088	1.261
L2	0.626	0.6161	0.908	0.862	0.739
D3	0.5715	0.6223	0.629	0.5715	0.5334
D2	0.6223	0.5715	0.635	0.584	0.5334
H6	1.8669	1.8669	1.905	1.8288	1.8669
L6	-0.275	-0.275	-0.273	-0.275	-0.275
B6	1.524	1.524	1.524	1.375	1.524
H7	0.66	0.66	0.7874	0.686	0.648
B7	1.241	1.241	1.372	1.308	1.295
L7	1.134	0.9717	1.594	1.399	1.336
H0	0.3048	0.3048	0.318	0.286	0.254
S	1.28	1.28	1.23	1.1557	1.235
B0	0.254	0.254	0.21	0.254	0.241
D0(rad)	0	0	0	0	0
M(kg)	416.34	554.944	548.624	577.268	455.026
Q(kg)	139.09	180.869	177.204	173.337	155.079
actual R.H.	N/A	N/A	1.905	1.829	N/A
CRH calculated	1.9539	1.8406	1.890	1.886	1.798

LAWN TRACTORS

	Kubota Bx	JD X485	Murray Garden	Cub Cadet HDS
H1	0.521	0.461	0.423	0.322
L3	0.795	0.741	0.674	0.64
L2	0.627	0.656	0.57	0.62
D3	0.445	0.438	0.381	0.381
D2	0.635	0.616	0.584	0.559
H6	1.816	1.816	1.816	1.816
L6	-0.2714	-0.9826	-0.982	-0.9826
B6	0.737	0.737	0.737	0.737
H7	1	1	0.8382	0.9398
B7	0.508	0.559	0.508	0.508

L7	0.338	0.1568	0.319	0.142
H0	0.3175	0.33	0.2921	0.279
S	0.9398	0.952	0.7874	0.813
B0	0.3048	0.191	0.1651	0.191
D0(rad)	0	0	0	0
M(kg)	706.453	497.248	216.31	411.723
Q(kg)	164.691	114.411	40.478	75.962
Actual R.H.	1.816	N/A	N/A	N/A
CRH calculated	1.941	2.69	2.501	2.365

ZTR's

	Kubota ZD 21	Ferris IS 3000	Cub Cadet 3654	Toro Z-master
H1	0.373	0.502	0.37	0.437
L3	0.969	0.958	0.962	1.15
L2	0.291	0.342	0.295	0.361
D3	0.349	0.3175	0.33	0.3048
D2	0.584	0.543	0.5715	0.565
H6	1.97	1.97	1.97	1.97
L6	-0.291	-0.342	-0.295	-0.361
B6	0.889	0.889	0.889	0.889
H7	0.9398	0.71	0	1.168
B7	0.457	0.381	0	0.66
L7	0.824	0.141	0	0.437
H0	0.279	0.2667	0.2794	0.279
S	0.978	0.927	0.91	0.984
B0	0.152	0.114	0.1143	0.1524
D0(rad)	0	0	0	0
M(kg)	650.56	572.681	447.992	599.388
Q(kg)	158.23	139.295	110.269	150.686
Actual R.H.	1.97	N/A	N/A	N/A
CRH calculated	1.748	1.812	1.737	1.8098

	ATV's			
	Honda Rubicon	Yamaha Grizz.	Polaris 700	Kawasaki Prairie
H1	0.528	0.566	0.633	0.548
L3	0.616	0.615	0.655	0.6054
L2	0.654	0.668	0.64	0.69
D3	0.6096	0.6096	0.6223	0.6223
D2	0.6096	0.603	0.635	0.635
H6	1.816	1.816	1.816	1.816
L6	-0.275	-0.275	-0.275	-0.275
B6	0.737	0.737	0.737	0.737
H7	0.9144	1.016	1.143	0.9652
B7	0.3302	0.3302	0.381	0.533
L7	0.984	0.9982	1.0718	1.325
H0	0.3048	0.3048	0.3048	0.311
S	0.9271	0.9271	0.959	0.8921
B0	0.2038	0.2032	0.1905	0.1524
D0(rad)	0	0	0	0
M(kg)	287.768	286.34	355.046	269.738
Q(kg)	66.377	67.119	88.509	66.424
Actual R.H.	N/A	N/A	N/A	N/A
CRH calculated	1.777	1.798	1.876	1.747

F. PROJECT PRODUCTS

1. Presentations:

Ayers, P., X. Wang, R. Comer. 2004. Agricultural Vehicle ROPS Research. Presented at the NIOSH Ag Centers and USDA Cooperative Extension Southern Region Farm Safety Symposium 2, Nashville, TN September 20-21.

Ayers, P., X. Wang, R. Comer. 2004. Influence of Mower Deck on Front Drive Mower Rollover Characteristics Presented at the Agricultural Equipment Technology Conference, Louisville KY, ASAE PM-52 Turf and Landscape Equipment Committee meeting February 10.

Ayers, P., X. Wang, R. Comer. 2003. ASAE S547 roll behavior prediction validation for mowers without decks. Presented at the 2003 Outdoor Power and Equipment Institute (OPEI), Louisville KY, ASAE PM-52 Turf and Landscape Equipment Committee meeting October 20.

Ayers, P., X. Wang, R. Comer, B. Marsh. 2004. Lateral Upset Tests to Evaluate Tip-Over Protective Structure (TOPS) Performance. Presented at the 2004 National Symposium of Agricultural Health and Safety (and National Institute for Farm Safety), Keystone Resort, Colorado June 20-24.

Ayers, P., X. Wang, R. Comer, B. Marsh. 2004. Modification of ASAE S547 Continuous Roll Model to include Mower Deck. Presented at the 2004 ASAE/CSAE ANNUAL INTERNATIONAL MEETING Ottawa, ON, Canada August 1-4.

2. Publications

d. Other Publications:

Liu, J., P. Ayers., S. Reynolds. 2004. Feasibility Study to Mount Cost effective ROPS (CROPS) on Older Tractors. Research report submitted to James Harris, NIOSH Division of Safety Research, Morgantown, WV.

4. Education / Training / Outreach

e. Other:

NIFS Tractor and Machinery Issues Committee report on ROPS Updates. 2004 National Symposium of Agricultural Health and Safety, Keystone Resort Colorado June 20-24.

PM 23/2/2 ROPS committee report on ASAE S547 field upset test evaluation. Agricultural Equipment Technology Conference, Louisville KY. February 9.

PM 23/2/2 ROPS Committee report on Mower ROPS testing. 2004 ASAE/CSAE ANNUAL INTERNATIONAL MEETING Ottawa, ON, Canada August 1-4.

4. Conferences / Meetings Sponsored:

Session Coordinator - Engineering Controls Research for Tractor Safety (8 presentations) at the 2004 National Symposium of Agricultural Health and Safety, Keystone Resort Colorado June 20-24.

G. STATES THE PROJECT WAS ACTIVE IN

Tennessee, Kentucky, Georgia and Colorado.

III. CENTER PROJECT REPORT BY CORE / TYPE:

A. PROJECT TITLE

Reduction of Exposures from Dairies and Cattle Feedlots

B. PROJECT OFFICER(s)

Stephen J. Reynolds, Ph.D., CIH – PI
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Dr. Tim Stanton	Colorado State University	Co-Investigator
Brad Lester	Colorado State University	Co-Investigator/ PhD Candidate

C. PROJECT DESCRIPTION

Colorado's dairy industry makes a significant contribution to the state's agricultural economy. In 2001, Colorado ranked 18th in the nation with approximately 80,000 cows (mostly Holstein) on 500 dairy farms which produced approximately 1.97 billion pounds of milk annually. Workers on dairies and feedlots are exposed to excessive levels of airborne hydrogen sulfide, ammonia, other gases, and aerosols including bacterial endotoxins. A novel intervention, using an assemblage of algae to create aerobic conditions in manure holds promise for reducing exposure to these gases and aerosols. The algae system will be introduced into manure lagoons at two local dairies, and occupational exposure analysis will be performed to measure reduction in exposures. A unique aspect of this study is the evaluation of the Cyranose 320 electronic nose as a qualitative and quantitative sampling device, and the comparison of the Cyranose to a scentometer and gas chromatography methods for odor assessment. This project will build on and expand current work in collaboration with the CSU Center for Animal Agriculture and Community Enhancement, local dairy producers, and the producer of the algae intervention. The goals of this project are to: 1) develop community-based partnerships to implement this project and disseminate results; 2) implement an algae manure intervention and evaluate its effectiveness in reducing emissions and occupational exposures of workers to particulates, bioaerosols, and gases from dairies and eventually feedlots, 3) evaluate the utility of the Cyranose 320 electronic nose (a simple direct reading tool for field use) for detection, identification, and quantification of gaseous emissions from diaries and feedlots as an alternative to a scentometer and gas chromatography methods, and 4) disseminate information on intervention technology, costs, and results in coordination with producers, agribusinesses, regulators, and communities via HICAHS outreach core and Cooperative Extension. This project addresses key NIOSH agriculture initiative objectives of developing, evaluating, and disseminating cost-effective interventions to reduce occupational exposure in the livestock production industry.

D. PROJECT START AND END DATES

September 15, 2003 to September 14, 2006

E. PROJECT ACTIVITIES / ACCOMPLISHMENTS

Funds for this project were released from CDC/NIOSH on November 19, 2003. Even with the delay in funding, the project is on schedule. Staff have been hired. Brad Lester will use this project for his PhD dissertation. Marcus Cusannelli has been working on calibration and adaptation of the electronic nose and will use this for his M.S. thesis (expected Spring 2005). All equipment has been purchased and acquired. Staff underwent training on the operation and calibration of all instruments including the Cyranose 320, Jerome 631-X Hydrogen Sulfide Analyzer, Drager Pac III Ammonia Analyzer, and the Davis Instruments Weather Station. Two dairies have been recruited and the algal intervention is in place at one. We are still in the process of recruiting and confirming additional dairies. Sampling and laboratory protocols have been developed and pilot tested.

Initial IRB approval was granted on November 13, 2003. Following completion of all documents including questionnaires in Spanish, final IRB approval was granted on March 24, 2004. Several scouting trips have been completed to La Luna Dairy, Wellington, CO and to DUO Dairy, Loveland, CO to discuss plans with owners Jon Slutsky and Mike Dickenson. Scouting trips were used to determine sample collection device placement, weather station placement, and to take preliminary samples (pilot testing). The Cyranose 320 has been calibrated for manure from two of three dairies. It was also calibrated against several other compounds including hydrogen sulfide, ammonia, acetone, and butanol at varying concentrations and mixtures.

Fourteen (14) participants have been recruited from La Luna Dairy (Wellington, CO) out of twenty-four (24) total workers. The participants range in age from 18 to 55+ years. All of the participants are Hispanic. Seventy-one percent (71%) are male (10 out of 14). One male worker has been removed from the study after losing his job for undisclosed reasons. Preliminary data show that the highest respirable particulate (4.9 mg/m^3) levels are found near the manure lagoon (site range 0.7 – 4.9mg/m^3). The highest inhalable particulate levels (3.8 mg/m^3) were found in the calf area (site range 0.2 – 3.8 mg/m^3). The highest total particulate levels (3.3mg/m^3) were found in the milking parlor (site range BDL – 3.3 mg/m^3). Hydrogen sulfide and ammonia levels measured near the lagoon ranged from 0 – 670 parts per billion and 0 to 10 parts per million, respectively. Data collection continues.

A control dairy (non-algae) in Weld County has been acquired. Participant consent will be granted and data collection will begin this month.

F. PROJECT PRODUCTS

1. Presentations:

Cusanelli M, Reynolds SJ, Lester B. Odor characterization using the Cyrano 320 electronic nose. ASAE S1000 Committee Meeting, Colorado State University, Ft. Collins, CO, September 24, 2003.

Cusanelli M, Reynolds SJ, Lester B, Buchan R, Stanton T. Calibration of the Cyranose 320 (Electronic Nose) for Characterization of Odor from Dairy and Livestock Operations. Poster. 2004 National Symposium on Agricultural Health and Safety, June 20-24, 2004, Keystone, CO

Reynolds, HICAHS Overview and Opportunities for Collaboration, Colorado Livestock Association Board of Directors Meeting, July 16, 2004, Greeley, CO

Roman-Muniz I, Van Metre D, Garry F, Reynolds SJ, Wailes W, Keefe T. Dairy Worker Safety Education: Current Status and Future Needs in the Colorado Dairy Industry. 2004 National Symposium on Agricultural Health and Safety, June 22, 2004, Keystone, CO

2. Publications

b. Trade Journals:

"Exercise Caution When Inoculating Livestock" Colorado Dairy News, September/October 2004, Helen Schledowitz.

Interview (Reynolds, Schledowitz) and text for article "**Invest in manure safety** Use this checklist to learn how to keep employees safe when working around manure." By Shirley Roenfeldt, Managing Editor, Dairy Herd Management

"Teach Clients Proper Inoculations Procedures" in Bovine Veterinary Magazine. Fall 2004. Reformatted from Colorado Dairy News, September/October 2004, Helen Schledewitz.

3. Education / Training / Outreach

f. Other:

MS Student – Noa Roman Muniz, Thesis - *Worker Safety Training and Future Needs of the Colorado Dairy Industry.* Summer 2004. Reynolds – Thesis Committee.

5. **Other Products:**

   An SOP for operation of the Cyranose 320 for agricultural applications has been developed and is currently being refined.

G. STATES THE PROJECT WAS ACTIVE IN

Colorado, Nebraska, Kansas, Wisconsin, California, Ohio, New York

III. CENTER PROJECT REPORT BY CORE / TYPE:

A. PROJECT TITLE

Agricultural Health and Safety Curriculum Evaluation

B. PROJECT OFFICER(s): R. Seiz, P.I.; V. Buchan, Co-P.I.; & T. Keefe

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C. PROJECT DESCRIPTION

The purpose of this project is to evaluate an innovative computer-based [CD] agriculture health and safety curriculum being taught to youth aged 15 to 17 enrolled in rural Colorado and Wyoming high school agriculture classes. Farmers and ranchers are among the highest risk groups for occupational injuries and illnesses. The agriculture industry annually employs about 667,000 young workers. In addition, many more young people are conducting agricultural work for their farming/ranching parents and/or are exposed in varying degrees to one of the most hazardous occupational environments in the United States. Credible knowledge about the environmental and occupational hazards encountered on America's farms and ranches is critical to the safety and health of these youth.

The technology-driven curriculum was based upon the developmental stage of the target youth and a needs assessment of agricultural educators in Colorado and Wyoming. It provides information on hazard and safety issues involved in the use of tractors, ATV's, and garden machinery; the handling of horses, livestock, agricultural chemical and volatile organic compounds; being around stored grain, organic dusts, electrical conduits and power lines; and emergency rescue. This 5-year study was undertaken to evaluate changes in student's knowledge, attitudes and safety behavior due to the inclusion of the curriculum into existing school curricula and to tack changes in incidences of agriculture-related injuries and illnesses. The study utilizes repeat measures and semi-structured family interviews with random-assignment to study and standard curriculum groups. The development of the multiple instruments and interview schedule used in the study were completed earlier in the project's history.

D. PROJECT START AND END DATES:

10/15/01 – 9/30/06

E. PROJECT ACTIVITIES / ACCOMPLISHMENTS

Between October 1, 2003 and September 30, 2004 the collection of quantitative and qualitative data in Colorado was completed in accord with the project's timeline. The final post-posttest instrument measuring the retention of prevention knowledge was administered and collected, and the final administration of the self-reporting instrument of the incidences of agricultural injury and illness was accomplished and collected. In addition, of the 32 families in the study group who agreed to participate in the interview process, 29 participating students (response rate of 91%) and 28 parents (response rate of 88%) completed the interview process. Of the 19 families in the control group who agreed to participate in the interview process, 15 parents (response rate of 79%) participated in the interview process. In Wyoming, quantitative data on the incidences of agricultural injury and illness continued to be collected in accord with the project's timeline. At the same time, statistical and thematic analysis of collected data continued.

F. PROJECT PRODUCTS

1. **Presentations:**

   Buchan, V., Seiz, B. (2004). Initial findings [in the form of a thematic schemata] of the family interviews performed in Colorado were presented at the *2004 National Symposium on Agricultural Health and Safety*, June 20-24, 2004, Keystone, Colorado.

G. STATES THE PROJECT WAS ACTIVE IN:

Colorado and Wyoming

III. CENTER PROJECT REPORT BY CORE / TYPE:

A. PROJECT TITLE: Interactive Agricultural Health and Safety CD: 4-H Youth

B. PROJECT OFFICER(s):

V. Buchan, P.I.; R. Seiz and J. Liu Co-PIs.
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C. PROJECT DESCRIPTION

Today there are many youth living and working on farms and ranches. Because agriculture is one of the most dangerous occupational environments in the U.S., statistics show there are increased injuries and fatalities each year to these youth. There is an urgent need to decrease this phenomenon. The objectives of this project are to: 1) Develop an interactive CD for delivery of agricultural health and safety information to youths in 4-H and 2) Evaluate and revise the prototype CDs using both formative and process evaluation methods.

D. PROJECT START AND END DATES: 10/15 /03 – 9/30/06

E. PROJECT ACTIVITIES / ACCOMPLISHMENTS

We have completed the first year of the three year project that targets 4-H youth in grades 3-5. Development of the project is by a collaborative team including the P.I. V. Buchan, and Co-PI's R. Seiz and J. Liu. The team also includes 4-H youth, 4-H leaders and cooperative extension agents and the Director of 4-H at CSU. To date, the research team has worked the Director of 4-H and 3 Cooperative Extension agents to select potential topics for the CD. Then, with the assistance of two Cooperative Extension agents in Fort Morgan, CO., a "concept team" was developed made up of youth and their parents who are all currently living on ranches and farms in eastern Colorado. This concept team assisted the researchers in choosing the topics and developing scenarios that would help to introduce the five safety topics to the youth. The topics include: tractor safety, ATV safety, livestock handling, grain handling & storage and chemical safety. A prototype CD has been developed by Dr. Liu based upon the concept team suggestions. The prototype contains an introduction, video clips, quizzes and a scoring system to engage the youth. We are now ready to undertake formative evaluation of the CD in two different Colorado counties under the direction of two Cooperative Extension agents. Based upon the evaluation feedback from parents, 4-H leaders and the agents, revisions will be made to the CD, additional components will be added and in year II we plan a more rigorous evaluation of the CD in 3 additional regional states.

F. PROJECT PRODUCTS

1. Presentations:

Buchan, V., Seiz, B., Vice, B. (March, 2004). Concept Team, Fort Morgan, CO., Cooperative Extension Office

Buchan, V., Seiz, B., Vice, B. (Nov., 2003). Director of 4-H and Cooperative Extension Safety Specialists, Colorado State University

3. Education / Training / Outreach

e. CD-ROMs or other Computer-Based Training Programs:

1 prototype Agricultural Health and Safety CD for 4-H Youth.

5. Other Products:

Formative evaluation questionnaire

G. STATES THE PROJECT WAS ACTIVE IN:

Colorado

III. CENTER PROJECT REPORT BY CORE / TYPE:

A. PROJECT TITLE

Regional Education Through State Extension Safety Agents

B. PROJECT OFFICER(s)

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C. PROJECT DESCRIPTION

The goal of this project is to determine the feasibility of regionalizing HICAHS and its resources to improve agricultural health and safety education throughout PHS Region VIII. This is being accomplished by utilizing the existing structure of cooperative extension services and other agricultural stakeholders within each state. The following are the specific aims (objectives) to achieve the stated goal of this project.

1. Provide financial support for Region VIII Extension Farm Safety Specialists to enhance agricultural health and safety education in each state.

2. Deliver agricultural health and safety education programs throughout Region VIII that meet the unique agricultural safety and health needs for the stakeholders in each geographic region.

3. Facilitate open effective communication between HICAHS and the participating Extension Safety Specialists in each state of Region VIII.

4. Facilitate collaboration between HICAHS and Extension Safety Specialists in each state by providing opportunities to meet, present projects/materials, and to share experiences and products developed.

5. Evaluate HICAHS developed educational materials throughout Region VIII utilizing HICAHS program monitoring tools.

6. Evaluate Region VIII extension safety programs by individual State objectives utilizing HICAHS program monitoring tools.

7. Disseminate HICAHS developed health and safety materials in agriculture where appropriate throughout Region VIII.

8. Provide access to agricultural health and safety expertise from among HICAHS personnel to State Extension Safety Specialists in Region VIII, and other NIOSH sponsored agricultural centers as appropriate.

D. PROJECT START AND END DATES

October 1, 2003 to September 30, 2004.

E. PROJECT ACTIVITIES / ACCOMPLISHMENTS

The original principle investigator (Phil Bigelow, PhD) of this project left Colorado State University for a research position in Canada. Dr. Bigelow and Professor Stephen Reynolds (P.I. of the HICAHS) asked Dr. John Rosecrance (also in the Department of Environmental and Radiological Health Sciences) to assume full responsibility of this regionalization project at the end of Year 1 and in Years 2 and 3. Dr. Rosecrance has previous research experience in both agricultural and construction occupational health and safety and fit well into the role of P.I. for this project.

To adequately address the personnel needs of this regionalization project, we hired a part-time Health and Safety Research Associate to work with Region VIII State Extension Specialists and other agricultural stakeholders. The Research Associate has an MS degree in industrial hygiene, has five years experience in health and safety program management, and has personal and professional experience in agricultural work. The research associate provides agriculture health and safety expertise to stakeholders throughout Region VIII.

HICAHS provided funds for State Extension Specialists from PHS Region VIII to attend an educational meeting, at Colorado State University, to discuss each State Extension Specialist needs and assist with proposal writing for HICAHS grant funds. The meeting provided an opportunity for state Extension Specialists to interact with each other as well as with research scientists at HICAHS. All 6 states in Region VIII have received funds from the HICAHS Regionalization Initiative for their education / outreach projects. All Extension Specialists have made significant progress on their respective outreach projects.
These projects include the following topics:

ATV Safety – Utah
Manure Pit Safety – South Dakota
Bio-Ag Terrorism – Wyoming
Hearing Conservation for Youths – Montana
Youth Farm Safety Colorado
Tractor and Farm Machinery Safety for Youths – North Dakota

The Research Associate actively worked with Extension Specialists in the region and one completed project was the development of a Hearing Protection program for the Montana State Extension. In addition, the Research Associate provided education materials and an exhibition booth for the Colorado State Extension Specialist. During the preliminary meeting in March, HICAHS facilitated a meeting for the Region VIII Extension Specialists to exchange ideas and materials. The North Dakota State Extension Specialist will be providing plans for the Colorado State Extension Specialist to build an education diorama for Farm Safety Camps.

The Research Associate met with the Wyoming, Montana, and Colorado State Extension Specialists in Casper Wyoming to discuss their specific needs and how HICAHS can be an integral part of their operation. Existing HICAHS educational materials, videos on farm safety, were also reviewed and discussed at this meeting. The Research Associate will be providing health and safety expertise on a number of projects that the Extension Specialists are planning (these are in addition to the HICAHS supported projects)

The investigators and the Research Associate have been active in outreach activities that were requested by Extension Specialists in Region VIII. As an example, HICAHS provided a presentation on Combine and Farm Machinery Safety to the Department of Agriculture Biotech

Compliance Inspectors. The Inspectors represented over 30 states, one from Canada, and one from Puerto Rico. A key outcome of this project has been fostering interaction and collaboration among the Extension Specialists in EPA Region VIII.

F. PROJECT PRODUCTS

1. Presentations:

Schledewitz, H. (March, 2004). Combine and Farm Machinery Safety presentation to Department of Biotech Compliance Inspectors, Department of Agriculture, Fort Collins, CO.

2. Publications

c. Trade Journals:

"Exercise Caution When Inoculating Livestock" Colorado Dairy News, September/October 2004, Helen Schledowitz.

"Teach Clients Proper Inoculations Procedures" in Bovine Veterinary Magazine. Fall 2004. Reformatted from Colorado Dairy News, September/October 2004, Helen Schledewitz.

5. Education / Training / Outreach

f. Other:

Interview (Reynolds, Schledowitz) and text for article "**Invest in manure safety** Use this checklist to learn how to keep employees safe when working around manure." By Shirley Roenfeldt, Managing Editor, Dairy Herd Management

G. STATES THE PROJECT WAS ACTIVE IN

Colorado, Wyoming, North Dakota, South Dakota, Utah, Montana

III. CENTER PROJECT REPORT BY CORE / TYPE:

A. PROJECT TITLE:

Development of Novel Biomarkers for Pesticides in PHS Region VIII

B. PRINCIPAL INVESTIGATOR:

John D. Tessari, PhD
Associate Professor
Department of Environmental & Radiological
Health Sciences
College of Veterinary Medicine & Biomedical Sciences

C. PROJECT DESCRIPTION:

The proposed research is intended to develop critically needed tools to develop novel biomarkers of exposure and address the following issues: (1) What is the relationship of biomarker concentrations with the intensity and duration of exposure in the receptor population? (2) What time domains of exposure are confidently assessed by specific biomarkers of the parent chemical, metabolites, or adducts. We intend that the results of this research could be used for future risk assessment model-building frameworks following standard methods that rely on current US EPA applications of mode of action for assigning the shape of the dose response curves and dosimetry (i.e. PBPK models)to support low-dose and interspecies extrapolation.
Specific Aims-

Aim 1: We will develop analytical methods for biomarkers of exposure (using rodent hair and blood samples) to determine specific bound protein adducts of atrazine, and chlorpyrifos and their major metabolites to hemoglobin.

Aim 2: We will develop analytical methods for biomarkers of exposure (using rodent and human samples) to determine free residues of atrazine, chlorpyrifos and their metabolites in blood, brain, hair, saliva, and urine.

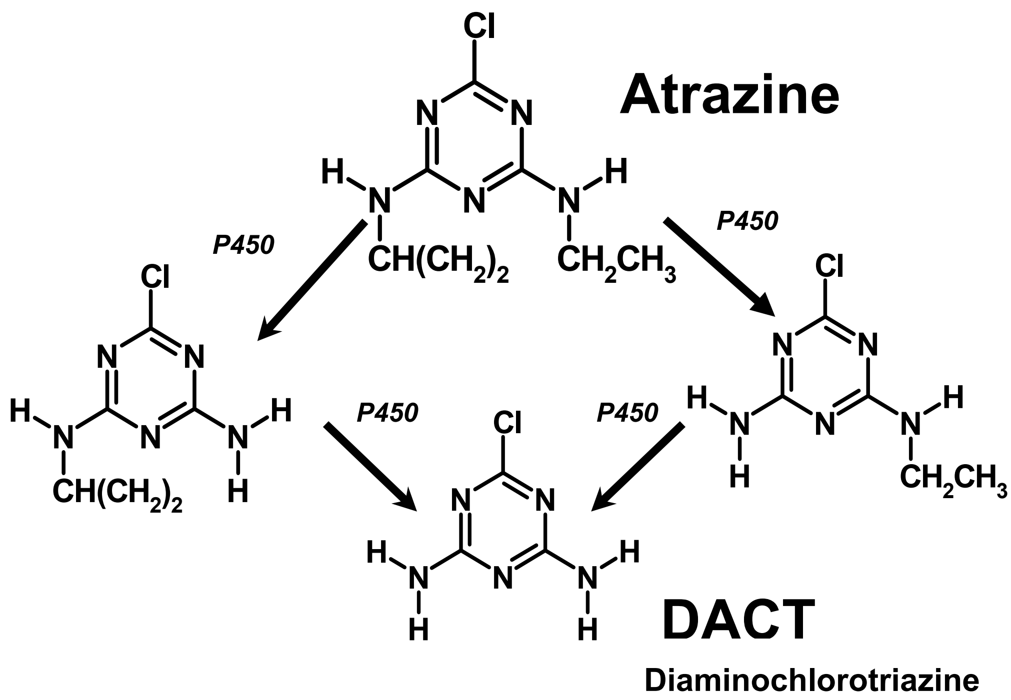
Aim 3: We will identify and characterize biomarkers of exposure to atrazine and chlorpyrifos by utilizing in-vivo techniques and laboratory studies in rodents.

D. PROJECT START AND END DATES:

Project Start Date: 09/01/03
Project End Date: 08/31/06

E. PROJECT ACTIVITIES/ACCOMPLISHMENTS:

Our research focuses on the metabolism of atrazine as shown below.



During this time period there were no significant issues with conducting the proposed research or the quality control/assurance associated with the work. There were no changes in the scope or objectives.

AIM1 Hemoglobin Adducts: Hemoglobin consists of approximately 3.8% heme and 96.2% globin, with a molecular weight of 64.4504. There are two α globin chains containing 141 amino acid residues, and two β chains containing 146 amino acids.

Globin was extracted from human and rodent blood. Red blood cells were separated from plasma following centrifugation of blood and lysed with cold distilled water. Heme was removed from the globin with acidification and the globin was precipitated with ethyl acetate and the pellet dried. Purified globin was then dissolved in MΩ water at a concentration of 25 mM for separation and purification.

In vivo exposures of Sprague Dawley(SD) rats to 300 mg/kg of atrazine resulted in significantly higher globin adducts than in vitro experiments with rat whole blood suggesting that metabolism of atrazine is important for adduct formation. Mass spectrometry data indicates an approximate 107 kD addition to the beta globin chain, which may correspond to a reaction with a deprotonated diaminoatrazine metabolite of atrazine. We are using globin isolated from SD rats

exposed to atrazine to investigate the nature of the covalent binding of metabolized atrazine to the beta chain of globin.
We have attempted to purify globin and separate the α- chains from the β- chains using polyacrylamide gel electrophoresis. We could not resolve the α-chains from the β-chains using this method although we found a clear band at approximately 16,000Da. No other bands were detected.
High performance liquid chromatography of rat globin is being investigated as a means to separate the alpha and beta chains in about 30 minutes. Collected fractions will be analyzed with MALDI-TOF-MS to confirm the identity and purity of the globin chain fractions. The beta chains will be digested with trypsin and the digest analyzed with MALDI-TOF-MS to identify possible differences in mass due to the addition of a covalent triazine adduct in atrazine exposed rats compared to controls.

AIM 2: We have developed analytical methods in blood, brain, and urine for atrazine and its 3 major metabolites.
Blood: A Hewlett Packard 5890 series II plus gas chromatograph equipped with a Model 5972 mass selective detector (MSD) in selected ion monitoring (SIM) mode to identify atrazine and N-dealkylated derivatized products has been developed. Identification and quantification of these compounds was achieved by monitoring retention times and detection of characteristic target and qualifying ions in their respective mass spectra. This analytical method allows for individual quantitative analysis of parent compound and chlorinated metabolites to 100 ng/ml in plasma isolated from whole blood.

Brain: An analytical method for the determination of parent compound (atrazine) and its 3 major metabolites in rodent brain has been developed. Brain samples are extracted using polymeric mixed mode cation exchange solid-phase extraction followed by chemical derivatization and gas chromatography/mass spectrometry as described in the analytical method developed for blood. Estimated method detection limits range from 1.0 ng/mg for DACT to 0.04 ng/mg for atrazine and other metabolites.

Urine: Atrazine and its chlorinated metabolites are eliminated in the urine. DACT is the major chlorinated metabolite eliminated in the urine, 24 hours after a single dose of the parent compound. We have developed and analytical method using 1.0 ml of urine polymeric mixed mode cation exchange solid-phase extraction followed by chemical derivatization and gas chromatography/mass spectrometry. Estimated method detection limits range from 1.0 ng/g to 5.0 ng/g. Method quantitation limits were established at 10 ng/g.

We will begin to develop/modify existing analytical methods for chlorpyrifos.

F. PROJECT PRODUCTS

1. Presentations:

Tessari, J. (June, 2004) National Symposium on Agricultural Health and Safety, Keystone Resort, Colorado, Analytical Determination of Atrazine and its chlorinated Metabolites in Urine. June 20-24.

Tessari, J. (April, 2004) Undergraduate Research and Creativity Showcase, April 21, 2004, Colorado State University, Development of Analytical Methods for the Determination of Triazine Herbicides.

2. Publication:

d. Other Publications:

Tessari, J. Submitted a research proposal to the National Children's Center Marshfield, WI The title of the proposal was: "A Pilot Study of Pesticide Exposures in Youth Migrant Field Workers: Multiresidue Screening"

3. Education/Training/Outreach

f. Other:

EH446 Environmental Toxicology: A class in the undergraduate program at CSU Seminar in Environmental and Radiological Health Sciences, presented 10/4/04

G. STATES THE PROJECT WAS ACTIVE IN

Colorado

III. CENTER PROJECT REPORT BY CORE / TYPE:

A. PROJECT TITLE

Endotoxin and Genetics in Organic Dust Lung Disease

B. PROJECT OFFICER(s)

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Dr. Dean Lillquist	University of Utah-ERC	Co-Investigator
Dr. David Schwartz	Duke University	Co-Investigator
Dr. John Tessari	Colorado State University	Co-Investigator

C. PROJECT DESCRIPTION

More than 1,000,000 U.S. farm workers are at risk for occupational lung disease related to organic dust exposures. It is clear that Gram-negative bacterial endotoxin plays an important role, however key aspects of exposures and genetic susceptibility remain unknown. This project, building on current HICAHS research, will use a novel Recombinant Factor C (rFC) endotoxin assay in concert with mass spectrometry (MS) chemical methods to explore the role of endotoxin exposure and genetic factors in lung disease among corn dust workers. The specific aims of this project are to 1) characterize worker exposure to endotoxin-containing corn dust aerosols; 2) evaluate respiratory outcomes including symptoms, cross shift changes in pulmonary function, (PFT) and cellular/immune markers (cytokines); 3) survey genetic markers related to lung disease and endotoxin etiology (TLR4 gene mutations, and polymorphisms of IL1-RN, and TNF-alpha); 4) explore whether endotoxin assay or GC/MS is best predictor of biomarkers; 5) explore whether cellular/immune responses and PFT differ among those with different genetic status.

A unique aspect of this project is the ability to study endotoxin exposure, respiratory outcomes and genetic factors in a concerted multidisciplinary approach. This project involves close collaboration with the University of Utah ERC, Duke University, University of Saskatchewan (Institute of Agricultural, Rural, and Environmental Health), and NIOSH.

D. PROJECT START AND END DATES

September 15, 2003 to September 14, 2006

E. PROJECT ACTIVITIES / ACCOMPLISHMENTS

Funds for this project were released from CDC/NIOSH on March 3, 2004 after the final IRB approval was received from the University of Utah. Even with the significant delay in funding, the project is on schedule. Staff have been hired and trained. Angelica Maria Serrano Martinez, M.D. is a physician studying epidemiology at CSU. She works on this as a Graduate Research Assistant. John Mehaffy, M.S. is an industrial hygienist with experience in agriculture and in performing endotoxin assays. He is a Research Associate II. Kurt Church is a MS student at the University of Utah, working under the direction of Dr. Lillquist. IRB approval at CSU was obtained on 11/17/03, IRB approvals from Duke University, University of Saskatchewan, NIOSH and the University of Utah were all obtained by 2/17/04. All instruments and protocols were pilot tested and approved by the IRBs. These included: Advertisement for recruiting, recruiting letter and response postcard, questionnaires for owners/operators concerning farm and grain handling facilities, pre-shift participant questionnaire, post-shift questionnaire, individual results letter; nasal lavage and cytokine preparation, pulmonary function testing, blood drawing for DNA, dust sampling. Sample handling and shipping, QA, and safety are part of each protocol. A spirometer was acquired from within CSU and was upgraded and calibrated by the manufacturer. Training of staff and pilot testing was coordinated with University of Utah and colleagues at the University of Saskatchewan. Plans for recruiting in Utah are still under development, since the LDS Church was not able to enlist the aid of its farm managers. Recruiting in Colorado has been conducted with the assistance of the Colorado Corn Growers Association, Pinnacol Assurance, Colorado Livestock Association, and the Colorado Grain and Feed Handlers Association. More than 50 participants have been recruited in Colorado to date. Currently data has been collected for 7 participants. All are males, five are Hispanic. Personal dust exposures measured with IOM samplers have ranged from a low of 0.59 mg/m^3 up to 75.98 mg/m^3 for one worker using a front end loader to move grain. Blood samples for DNA and nasal lavage samples for cytokines have been received at Duke and NIOSH respectively. Dr. Koehncke is assisting with reviewing pulmonary function results. Scheduling and data collection are proceeding well.

As a result of interactions with producer organizations on this project the HICAHS outreach core is also now working with the Associations and with Pinnacol Assurance on a number of collaborative projects. Recruiting through the LDS Church has met with some resistance and we are exploring other partners such as the Utah Corn Growers and Grain Handlers Associations.

F. PROJECT PRODUCTS

1. Presentations:

Reynolds SJ, Ragan J, Thate R, Tessari J, Nakatsu J, Tillery M, Larsson L, Lewis D, Chen L. Evaluation of Recombinant Factor C Endotoxin Assay using Agricultural Dusts. Fifth International Symposium, Future of Rural Peoples: Rural Economy, Healthy People, Environment, Rural Communities, Saskatoon, Sasktachewan, Canada, October 19, 2003

O'Shaughnessy P, Lo WY, Nonnenmann M, Reynolds SJ. DIFFERENCES IN AEROSOL SAMPLER COLLECTION CHARACTERISTICS WHEN SAMPLING THREE DUST TYPES. American Association for Aerosol Research Oct. 20-23, 2003

Reynolds, HICAHS Overview and Opportunities for Collaboration, Colorado Livestock Association Board of Directors Meeting, July 16, 2004, Greeley, CO

Reynolds SJ, Mehaffy J, Ragan J, Thate R, Tessari J, Lewis D, Milton D, Alwis U, Larsson L, Chen L. Evaluation and Optimization of a new rFC Endotoxin Assay for Agricultural Dusts. 2004 National Symposium on Agricultural Health and Safety, June 22, 2004, Keystone, CO

2. Publications

a. Peer Reviewed Journal:

Kirychuck SP, Senthilselvan A, Dosman JA, Jurio V, Feddes JJR, Willson P, Classen H, Reynolds SJ, Guenter W, Hurst TS. Respiratory Symptoms and Lung Function in Poultry Confinement Workers in Western Canada. Can Respir J, Oct; 10 (7): 375-380, 2003
Groves WA, Reynolds SJ. Prototype Sampling System for Measuring Workplace Protection Factors for Gases and Vapors. App Occ Env Hyg 18(5)1-9, 2003

Reynolds SJ, Mehaffy J, Ragan JV, Tessari J, Keefe T, Milton D, Alwis U, Larsson L, Chen L. Evaluation and Optimization of a new rFC Endotoxin Assay using Agricultural Dusts. AJIM (submitted 2004) Reynolds, Dosman, Koehncke editors special edition.

d. Other Publications:

Merchant JA, Thorne PS, Reynolds SJ. Animal Exposures. In: Textbook of Clinical Occupational and Environmental Medicine, 2nd Edition. Rosenstock L, Cullen MR, Brodkin CA, Redlich C (Eds) Elsevier Inc., in press.

Reynolds, Dosman, Koehncke - Editors special edition of AJIM on Exposure to Endotoxin and the Lung.

6. Education / Training / Outreach

a. Training Seminars:

Reynolds, Endotoxin and Organic Dust Lung Disease, Seminar Department of Environmental and Radiological Health Sciences, Colorado State University, October 11, 2004.

f. Other:

Telephone consultation to prospective homeowner concerned about organic dust exposures and asthmatic child in Idaho.

4. Conferences / Meetings Sponsored:

Co-organizer, Fifth International Symposium, Future of Rural Peoples: Rural Economy, Healthy People, Environment, Rural Communities. Saskatoon, Saskatchewan, Canada, October 19-23, 2003

Lead Organizer, Joint meeting of National Institute for Farm Safety, North American Agromedicine Consortium, and NIOSH Agricultural Health and Safety Centers. Keystone, CO, June 2004

Reynolds Organized and Chaired Pre-Conference Session: Exposure to Endotoxin and the Lung

Reynolds SJ -Co-Organizer and presenter, 3rd International Videoconference – Remediation of Books and Manuscripts, AIHA, ACGIH, US EPA, OSHA, NIOSH. American Industrial Hygiene Association - International Affairs Committee. Multiple international sites including CSU. Oct. 16, 2003.

G. STATES THE PROJECT WAS ACTIVE IN

Colorado, Utah, North Carolina, West Virginia, Saskatoon Saskatchewan, Idaho

III. CENTER PROJECT REPORT BY CORE / TYPE:

G. PROJECT TITLE

Improving Injury Information from Migrant Farmworkers

H. PROJECT OFFICER(s)

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Ed Hendrikson, M.D.
Salud Clinics

I. PROJECT DESCRIPTION

Migrant agricultural farm workers experience increased injury and pesticide exposure compared to other farm workers. They are also less likely to report hazardous conditions or receive medical care when injured due to cultural and economic reasons. Because of these problems, culturally sensitive research adapted to this underserved population is needed which includes exposures, risk factors for injuries/illness and to gain more accurate information regarding the true rates of occupational injury/illness. The goal of this project is to improve collection methods of migrant farm workers work history including occupational hazards as well as occupational and motor vehicle related injuries. Studies are being conducted with Colorado migrant farm workers and non-migrating farm workers in Guanajato, MX to obtain in depth information about their cultural, social and health beliefs. Theories of disease, injury and health beliefs influence how people respond to interview questions and differences between migrant farm workers in Colorado and native Mexican farm workers will provide important information in understanding the best way to collect this data.

Specific Aim 1: To conduct ethnographic studies of migrant farmworkers in Colorado and resident farmworkers in Guanajuato, México to uncover similarities and differences in theories of disease, injury, injury etiology, and prevention so that such information can be used to adapt interview techniques to ensure items are both culturally appropriate but also address the underlying socio-cultural factors. Guanajuato is selected because a majority of migrant farmworkers in Colorado originate from this state, thus differences in health and injury beliefs have important implications in designing programs whose goals are to improve the health and safety of this underserved population.

Specific Aim 2: To adapt an existing icon-calendar interview method based on information from ethnographic studies to obtain more detailed histories of acute occupational risks and injury experiences, as well as related socio-cultural factors, in Hispanic migrant farmworkers. Additional areas of enquiry will include motor vehicle travel, acute pesticide exposures and effects, injury risks at home, safety risk perception, and other factors influencing the adoption of protective behaviors.

Specific Aim 3: To conduct a cross sectional survey of 150 migrant farmworkers in Colorado and in Guanajuato, México using the modified icon-calendar technique to assess potential occupational exposures, injury risks, occupational diseases and injuries.

Specific Aim 4: To disseminate the research findings so that they may be incorporated in existing prevention and occupational health surveillance programs. This work will focus on partnering with the Center Education and Outreach Core, the Colorado Injury Control Research Center, and the Salud Family Health Centers as they have existing prevention programs in both

Colorado and in Guanajuato that address migrant farmworker health needs.

J. PROJECT START AND END DATES

9/15/03-8/31/06

E. PROJECT ACTIVITIES / ACCOMPLISHMENTS

Ethnographic interviews were conducted among 10 migrant farm workers in Colorado and 5 farm workers in Guanajuato Mexico. All interviews were conducted in Spanish and tape recorded. The interviews were transcribed and translated into English. Currently, the transcribed interviews are being analyzed to identify injury areas which need to be included in the upcoming detailed interviews. We are discussing the relative merits of using the Icon-Life Events calendar or a more qualitative approach similar to the one used in the ethnographic interviews. Based on the initial work, it seems to be more important to pursue the ethnographic approach than the Icon-Life Events calendar approach.

F. PROJECT PRODUCTS

2. Publications

a. Peer Reviewed Journal

Soledad Vela-Acosta, Martha, M.D., M.S., Ph.D., Chapman, Phillip, Ph.D., Bigelow, Philip L., Ph.D., C.I.H., Kennedy, Catherine, Ph.D., Buchan, Roy M., P.H., C.I.H. MEASURING SUCCESS IN A PESTICIDE RISK REDUCTION PROGRAM AMONG MIGRANT FARMWORKERS IN COLORADO (See full article attached as Appendix B)

3. Education/Training/Outreach

f. Other

Pre/posttests used for evaluation of Pesticide Risk Reduction Program in Colorado.

G. STATES THE PROJECT WAS ACTIVE IN

Colorado and Guanajuato Mexico.

IV. PROGRESS REPORT ON FEASIBILITY PROJECTS (AS APPROPRIATE)

Limited funds for Feasibility Projects were awarded only for this first year. Request for Proposals for Feasibility Projects were distributed via the External Regional Advisory Board, to Health Departments, migrant health organizations, academic institutions and other organizations in Region VIII. Only one external application was received, possibly because of the small amount of dollars involved. It is also possible that lack of familiarity with the grants process played a role. The need to work intimately with the Extension Safety Specialists in each state to develop suitable proposals underscored this observation. Two awards of $5,000 each were made, one to Dr. Larry Goodridge at the University of Wyoming and one to Dr. John Rosecrance. The decision to fund Dr. Rosecrance was made since we had insufficient time to seek additional external applications for this funding period and because his project involved key collaboration with Pinnacol Assurance that could provide the basis for a number of important future HICAHS projects. Full reports for these Feasibility Projects are presented below.

A. PROJECT TITLE

Evaluation of a Bacteriophage Cocktail to Reduce *Escherichia coli* O157:H7 Shedding in Beef Cattle.

B. PRINCIPAL INVESTIGATOR

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C. PROJECT OBJECTIVE

The objective of this research is to study the *in vitro* effectiveness of a bacteriophage cocktail in reducing and/or eliminating *E. coli* O157:H7 from rumen, duodenal, and fecal samples.

D. PROJECT OVERVIEW

The recognition of *Escherichia coli* O157:H7 as a distinct serotype of pathogenic *E. coli* occurred in 1983 following a report by Riley *et al.* (1983), of two outbreaks of a distinctive gastrointestinal illness characterized by severe abdominal pain, watery diarrhea, bloody diarrhea, and little or no fever. Since 1983, a great deal of research as been accomplished, and has led to many different methods for rapid detection and control of *E. coli* O157:H7 in the beef cattle slaughter environment.

In addition to meat processing facilities, it seems that another logical area to control the spread of *E. coli* O157:H7 would be in the live animal, prior to slaughter. On the farm, effective control of *E. coli* O157:H7 requires reducing the frequency and intensity of fecal shedding of this pathogen by cattle, in addition to targeting environmental sources of the organism. To that end, many research groups have focused on the control of *E. coli* O157:H7 in cattle. Several interventions have been proposed as strategies to reduce fecal shedding of *E. coli* O157:H7. These interventions include the use of probiotic cultures that produce antimicrobial substances capable of destroying the pathogenic cells, and the use of vaccines to vaccinate cattle against *E. coli* O157:H7 (Laegreid 2004, VanDonkersgoed 2004). However, problems have been observed with both methods.

Bacteriophage (phage) therapy is the application of bacteriophages (bacterial viruses) to bacterial infections in living animals with the goal of reducing bacterial load. Phages can be delivered topically, orally, directly into body tissues, or systemically. In this treatment, the natural ability of phages to kill infected bacteria is exploited to reduce the amounts of bacteria present in the animal.

Several researchers have tried to control fecal shedding of *E. coli* using combinations of between one and seven different phages. For example, Waddell *et al.* (2000) successfully used O157 specific bacteriophages as a means of reducing the duration of *E. coli* O157:H7 fecal shedding in calves. However, in most cases, bacterial resistant mutants to the phages rapidly appeared. This resistance is probably due to bacterial mutations in the surface receptors that the phages must use to attach to the bacterial surface. In an elegant study, Tanji *et al.* (2004) showed that when two different phages that utilized different receptors on the bacterial surface were employed in a phage cocktail, the appearance of phage resistant *E. coli* O157 cells was significantly delayed. Therefore, the aim of this proposal is to develop an effective phage cocktail to reduce *E. coli* O157:H7 in cattle, and to test the efficacy of the phage method in an *in vitro* model that simulates the cattle gastrointestinal tract (GIT).

E. PRELIMINARY RESULTS

We have developed a phage cocktail that addresses the bacterial resistance problems seen with the other studies. The development of the cocktail is based on a rational design – that is, the phages in the cocktail were chosen based on their ability to eliminate multiple strains of *E. coli* O157:H7, as well as the fact that the phages all utilize multiple (and different) bacterial cell receptors. Our cocktail is comprised of 60 different phages, meaning that, in order for bacterial resistance to occur, the bacteria would have to develop mutations in all of the cell surface receptors that the phages use. Preliminary studies and the work by Tanji *et al.* (2004), show this to be unlikely.

We are currently investigating the ability of the cocktail to eliminate several *E. coli* O157:H7 strains with the use of an anaerobic digester that simulates the GIT environment of cattle, and mimics *in vivo* digest. In this work, we obtained rumen, duodenal and fecal samples from two cannulated cattle housed at the University of Wyoming beef unit. The samples were clarified by filtration through cheese cloth, and the clarified samples were placed into anaerobic jars and incubated overnight in a Daisy Anikom Anaerobic digestor, under conditions that mimicked the digestion of the cattle GIT. We evaluated four different samples: Each sample consisted of 1 liter of fluid. The samples were rumen fluid, duodenal fluid (at normal pH), duodenal fluid (pH adjusted to 7.5), and fecal fluid (The fecal sample was prepared by filtering solid fecal material with 0.1 M sodium phosphate (pH 7.5). Each sample had a control. *E. coli* O157:H7 strain 933 W was transformed with a plasmid that contained a red fluorescent protein and an ampicillin resistance gene. Approximately 10^4 CFU/ml of strain 933 W was inoculated into each anaerobic jar, followed by addition of 50 µl/ml of ampicillin, and 100 ml of 10X nutrient broth. The jars were mixed well, flushed with CO2 (to produce an anaerobic environment), and placed into the anaerobic digestor for 3 hours to allow the *E. coli* O157:H7 cells to acclimate to the environment. Following the acclimation process, all of the jars were sampled to determine the initial *E. coli* O157 concentration, and the test samples were inoculated with 250 mls of the bacteriophage cocktail (10^9 PFU/ml). Two hundred and fifty milliliters of 0.1 M sodium phosphate buffer (pH 7.5) was added to the control samples, so that the volume was the same as the phage treated samples. The jars were flushed with CO2 and returned to the anaerobic digestor. Samples were withdrawn at 2, 4, 8, 12, 24, and 48 hours, and tested for the presence of *E. coli* O157:H7 933 W by plating on TSA agar containing 50 µl/ml of ampicillin, and counting the red colonies (the ampicillin and red color that developed in the *E. coli* 933 W cells allowed us to easily distinguish these cells from any other bacteria that may have grown on the ampicillin plates). The results indicated that the phage cocktail was extremely effective at eliminating the *E. coli* O157:H7 933 W cells from the rumen and fecal samples. For example, in both the rumen and fecal samples, the phage cocktail completely eliminated the *E. coli* O157:H7 cells within 2 hours (Figure 1 and Figure 2). The *E. coli* O157:H7 cells persisted in the control jars for at least 48 hours (we stopped sampling at 48 h). We did not observe the formation of any resistant *E. coli* O157:H7 bacteria during 48 hours of sampling. We could not evaluate the cocktail in the duodenal samples, since the ampicillin plates were overgrown with *Proteus*

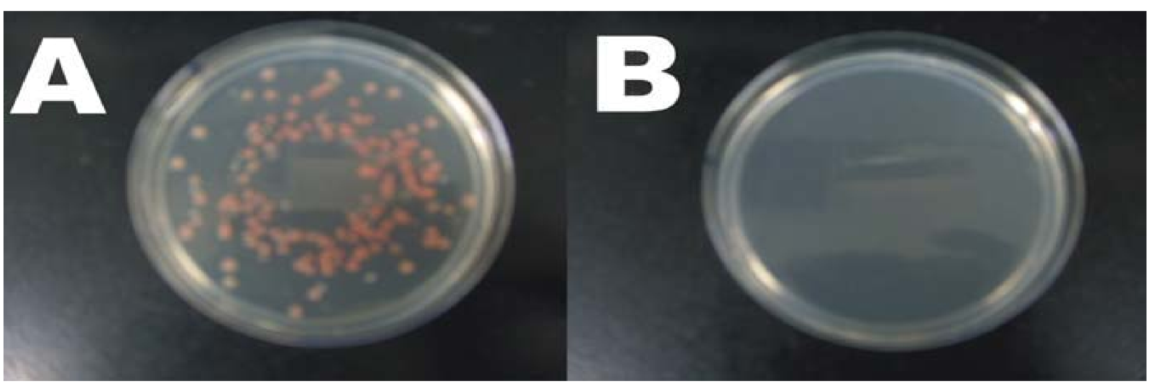

Figure 1. Plate count results for the rumen treated and control samples. Panel A: rumen control sample at 2 hours; Panel B: rumen treated sample at 2

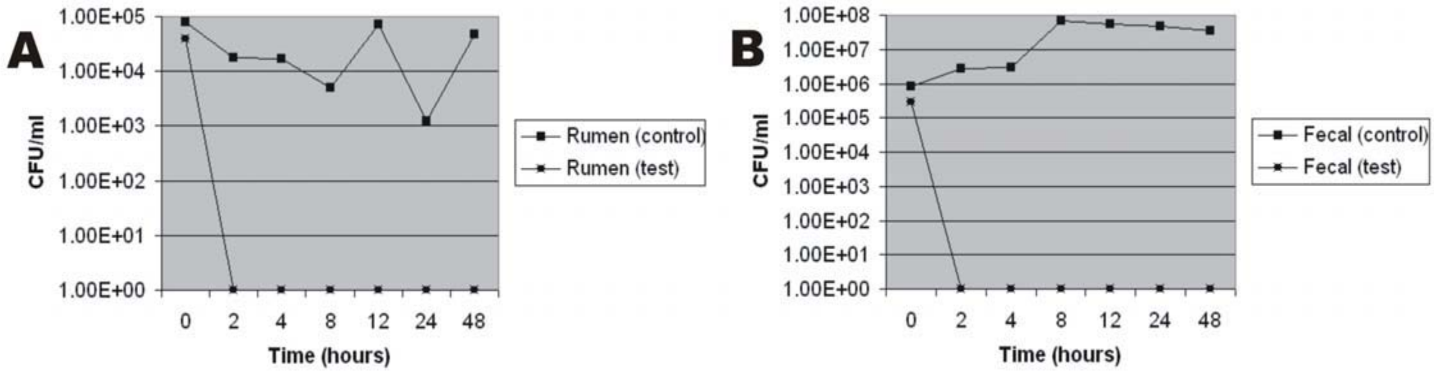

Figure 2. Graphs indicating the results of the rumen and fecal sample *E. coli* O157:H7 reduction study. Panel A: Graph showing the reduction of *E. coli* O157:H7 933 W in the rumen sample over a period of 48 hours. The bacteriophage cocktail completely eliminated 10^4 CFU/ml of E. coli O157:H7 933 W in the rumen test sample within 2 hours. In contrast, the *E. coli* O157:H7 bacteria persisted in the rumen control sample for at least 48 hours. Panel B: Graph showing the reduction of *E. coli* O157:H7 933 W in the fecal sample over a period of 48 hours. The bacteriophage cocktail completely eliminated 10^5 CFU/ml of *E. coli* O157:H7 933 W in the fecal test sample within 2 hours. In contrast, the *E. coli* O157:H7 bacteria persisted in the fecal control sample for at least 48 hours.

The results of the preliminary studies indicate that the phage cocktail that we have developed is capable of eliminating 10^4 CFU/ml of *E. coli* O157:H7 in rumen contents within 2 hours, and eliminating 10^5 CFU/ml of *E. coli* O157:H7 in fecal contents within 2 hours. These results bode well for future research in cattle, since *E. coli* O157:H7 is known to be transient in the rumen, and to colonize the terminal ilieum. Therefore, specifically targeting the phage cocktail simultaneously to the rumen and the lower GIT should result in the phages coming in contact with the largest number of *E. coli* O157:H7 cells present in the GIT. Also, the fact that the phage cocktail can eliminate 10^5 CFU/ml of *E. coli* is a great result, since this is the highest level of *E. coli* O157:H7 shedding that has been observed in cattle (Omisakin *et al.* 2003). The results of this research have been used as preliminary data in a research proposal submitted to the National Cattlemen's Beef Association (NCBA), to evaluate the developed phage cocktail in live cattle.

F. REFERENCES

Laegreid, W. 2004. Probiotic Developments. 57^{th} Reciprocal Meat Conference. University of Kentucky, June 20 -23, 2004.

Omisakin, F., MacRae, M., Ogden, I. D., and N. J. Strachan. 2003. Concentration and prevalence of *Escherichia coli* O157 in cattle feces at slaughter. *Appl. Environ. Microbiol.* **69:**2444-7.

Riley, L.W., R.S. Remis, S.D. Helgerson, H.B. McGhee, J.G. Wells, B.R. Davis, R.J. Herbert, E. S. Olcott, L.M. Johnson, N.T. Hargett, P.A. Blake, and M.L. Cohen. 1983. Hemorrhagic colitis associated with a rare *Escherichia coli* serotype. *N. Engl. J. Med*. **308:**681-685.

Tanji, Y., Shimada, T., Yoichi, M., Miyanaga, K., Hori, K., and H. Unno. Toward rational control of *Escherichia coli* O157:H7 by a phage cocktail. *Appl Microbiol Biotechnol*. 270-4.

VanDonkersgoed. J. 2002. Current Research and Development for Vaccination against *E. coli O157:H7*. 57th Reciprocal Meat Conference. University of Kentucky, June 20 -23, 2004.

Waddell, T., Mazzocco, A., Johnson, R.P., Pacan, J., Campbell, S., Perets, S., MacKinnon, A., Holtslander, J., Pope, B., and C. Gyles. 2000. Control of *Escherichia coli* O157:H7 infection of claves by bacteriophages, in: 4th International Symposium and Workshop on Shiga toxin (verocytotoxin) producing *Escherichia coli* infections, Kyoto, Japan.

A. PROJECT TITLE

Agricultural Injuries and Illnesses Among Colorado Agricultural Workers

B. PROJECT OFFICER(s)

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C. PROJECT DESCRIPTION

The purpose of this pilot study was to determine the most prevalent occupational injuries, the attributed causes, and the associated medical costs among agricultural workers in Colorado. This pilot project utilized the database of Colorado's largest workers compensation carrier of agricultural policies (insuring approximately 75% of all agricultural enterprises in Colorado).Of all eight agricultural occupations analyzed (diary farmers, field crop farmers, cattle raisers, grain millers, bean sorters, hay/grain feed dealers, cattle dealers, and grain elevator operators), contusions and sprain/strains combined accounted over half of all types of injures. "Environmental" causes (such as electric shock or falls on ice or snow) resulted in the majority of occupational injuries among dairy farm workers, field crop workers, cattle/livestock raisers and cattle dealers. Strain caused by overexertion resulted in the majority of occupational injuries among grain millers, bean sorters/handlers, hay grain/feed dealers and grain elevator operators. Sprains/strains were the most expensive injury type among most agricultural groups. In terms of injury cause, falls and slips were the most expensive among most agricultural groups studied. In all but one occupational class code, the economic burden, as a percent of period payroll, of injuries increased with agriculture businesses that had smaller period payrolls. Thus, the economic burden was greatest for agricultural businesses and farmers that had the smallest payrolls. Additional work is needed to determine the effectiveness of specific interventions in reducing the frequency, severity and costs of the agricultural injuries identified. This pilot study has assisted in the development of a foundation to efficiently target effective health and safety interventions in agricultural operations.

V. REPORT ON SPECIFIC IMPROVEMENTS IN AGRICULTURAL SAFETY AND HEALTH THAT RESULTED FROM CENTER ACTIVITIES (RESEARCH TO PRACTICE).

Administrative Core, Outreach, and Reduction of Exposures from Dairies and Cattle Feedlots

"Invest in manure safety: Use this checklist to learn how to keep employees safe when working around manure." By Shirley Roenfeldt, Managing Editor, Dairy Herd Management provides background and specific recommendations for confined space entry on dairies. Also includes contact information for NIOSH Ag Centers nationwide to serve as resources.

In response to fatalities involving injectable veterinary drugs, an article was written for Colorado Dairy News with a regional circulation of 1,000 and then picked up by the Bovine Veterinary Magazine with a national circulation. The articles provided specific guidelines to modify practice and prevent injection of veterinary drugs. The intent of the Bovine Veterinary Magazine issue was to provide veterinarians with information for training their clients.

VI. COLLABORATION

Agricultural Media organizations:
Ragan Adams, Publisher Colorado Dairy News (Article on needle sticks)
Shirley Roenfeldt, Managing Editor, Dairy Herd Management (article on manure safety)
Geni Wren, Editor, Bovine Veterinarian Magazine, Lenexa, KS (article on needle sticks)

Agricultural producer organizations:
Colorado Corn Growers Association
Colorado Livestock Association
Colorado Grain and Feed Handlers
Colorado Homestead Ranchers
Colorado Potato Growers
Colorado Wine Growers Association
The National Pork Board
Routt Country Woolens
Utah Grain and Feed Handlers Association
Church of Latter Day Saints, Salt Lake City, Utah
Jon Slutsky, La Luna Dairy, Wellington, CO

Agricultural Service/manufacturing
AgLand Incorporated
Gary Mills, Deere and Company
Monsanto Corporation
Pioneer Hy-bred International
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Bill Hetzler, Nebraska DOL, FACE (Micotil needle sticks issue)
Scott Philips, MD, CO Poison Control Center (Micotil issue)

APPENDIX

I. TOTAL CENTER BUDGET FOR FY 2004

1. **Total NIOSH Expenditures: $672,861**

2. **In-Kind Contributions: $50,000 Salary and fringe, $13,104 indirect $8,000 Agricultural Experiment Station**

3. **Other Outside Funding: $15,000 Colorado Dairy Industry, $15,000 CDC Conference Grant.**

II. CENTER PROJECTS / ACTIVITIES FOR FY 2004

1. **Ongoing Projects: 8**

2. **Projects Completed: 0**

3. **New Projects: 1** (Website)

4. **Feasibility Projects:**

   a. Evaluation of a Bacteriophage Cocktail to Reduce *Escherichia coli* 0157:H7 Shedding in Beef Cattle.

   b. Agricultural Injuries and Illnesses Among Colorado Agricultural Workers

III. CENTER INVESTIGATORS

1. **Scientific Investigators: 17**

2. **Program Support Staff: 5**

IV. CENTER PRODUCTS

1. **Presentations:**

   a. Childhood Asthma in a Rural Population
   b. Summary of Biological and Environmental Monitoring Results from the Agricultural Health Study-Pesticide Exposure Study.
   c. Agricultural Vehicle ROPS Research
   d. Influence of Mower Deck on Front Drive Mower Rollover Characteristics

e. ASAE S547 roll behavior prediction validation for mowers without decks
f. Lateral Upset Tests to Evaluate Tip-Over Protective Structure (TOPS) Performance
g. Modification of ASAE S547 Continuous Roll Model to include Mower Deck
h. PM 23/2/2 ROPS Committee report on Mower ROPS testing
i. Odor characterization using the Cyrano 320 electronic nose
j. Calibration of the Cyranose 320 (Electronic Nose) for Characterization of Odor from Dairy and Livestock Operations
k. HICAHS Overview and Opportunities for Collaboration
l. Dairy Workers Safety Education: Current Status and Future Needs in the Colorado Dairy Industry
m. Initial findings [in form of a thematic schemata] of the family interviews performed in Colorado
n. Concept Team
o. Director of 4-H and Cooperative Extension Safety Specialists
p. Evaluation of a Recombinant Factor C Endotoxin Assay using Agricultural Dusts
q. Differences in Aerosol Sampler Collection Characteristics when Sampling Three Dust Types
r. Evaluation and Optimization of a new rFC Endotoxin Assay for Agricultural Dusts

2. Publications

a. Peer Reviewed Journal: 9

b. Trade Journals: 3

c. Fact Sheets / Brochures / Technical Publications: 1

d. Other Publications: 4

3. Education / Training / Outreach

a. Training Seminars: 2

b. Short Courses: 0

c. Hazard Surveys / Consultations: 2

d. Academic Training: 6 students sponsored, 1 graduated

f. **CD-ROMs or other Computer Based Training Programs: 1**

g. Other:

i. Lecture in CSU Department of Agriculture Class A300, Issues in Agriculture – "Health and Safety in Agriculture"
ii. NIFS Tractor and Machinery Issues Committee report on ROPS Updates

iii. PM 23/2/2 ROPS committee report on ASAE S547 field upset test evaluation
iv. Thesis – *Worker Safety Training and Future Needs of the Colorado Dairy Industry*
v. Formative evaluation questionnaire
vi. Telephone consultation to prospective homeowner concerned about organic dust exposures and asthmatic child in Idaho
vii. Pre-posttests used for evaluation of Pesticide Risk Reduction Program in Colorado

4. **Conferences / Meetings Sponsored:**
   a. 2004 National Symposium on Agricultural Health and Safety
   b. Fifth International Symposium, Future of Rural Peoples: Rural Economy, Healthy People, Environment, Rural Communities
   c. Mold Remediation and Control: The National Quest for Uniformity
   d. Pre-Conference Session: Exposure to Endotoxin and the Lung

5. **Other Products:**
   a. The effect of algae and bacterial additions to a CAFO lagoon on the conversion from anaerobic to aerobic fermentation. CSU, Department of Animal Sciences Website
   b. An SOP for operation of the Cyranose 320 for agricultural applications has been developed and is currently being refined

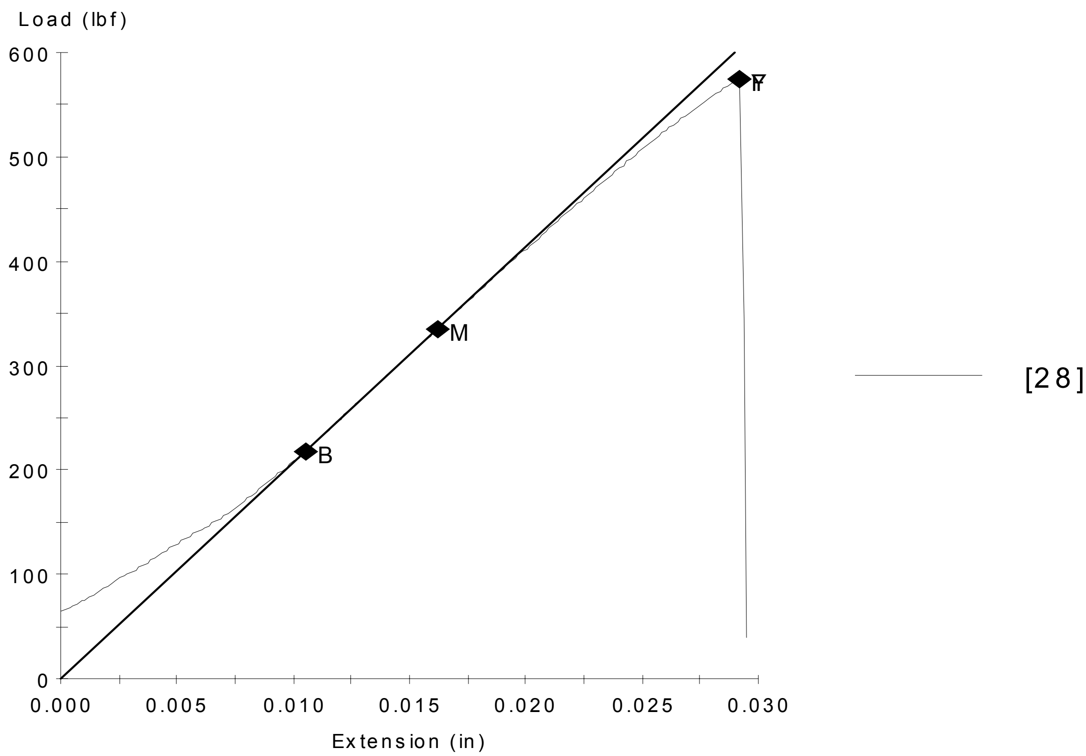
V. ADMINISTRATIVE REPORT

Dr. Phil Bigelow served as Director of the Outreach/Education Core and PI on the Research Project Improved Methods of Obtaining Injury Information from Migrant Farmworkers until August 2004 when he left CSU to take a position in Toronto, Ontario, Canada. At that time John Rosecrance, Ph.D., PE, - assumed the role of Core Director for Outreach/Education. Dr. Rosecrance has been extremely productive in building new relationships and collaborations. Dr. Lorann Stallones, Co-PI on the Migrant Workers project assumed the role of PI. Dr. Bigelow will continue to contribute to that project.

There have been no other changes in personnel during this first year of funding.

Appendix A - ROPS Design and Testing for Agricultural Vehicles

Shear Test Results



Shear Test Observed Data and Calculated Results

Sample Type	Sample #	Short Side (in.)	Long Side (in.)	Area (in^2)	Peak Force (lb)	Shear Stress (psi)	
Ren 132	1	0.28	0.3	0.065973446	451.021	3418.201028	
Ren 132	7	0.285	0.295	0.066032351	382.761	2898.283921	
Ren 132	8	0.28	0.3	0.065973446	413.778	3135.943526	
Ren 132	9	0.285	0.295	0.066032351	424.626	3215.28763	
Ren 132	10	0.285	0.295	0.066032351	355.175	2689.401459	
					mean	3071.423513	std de

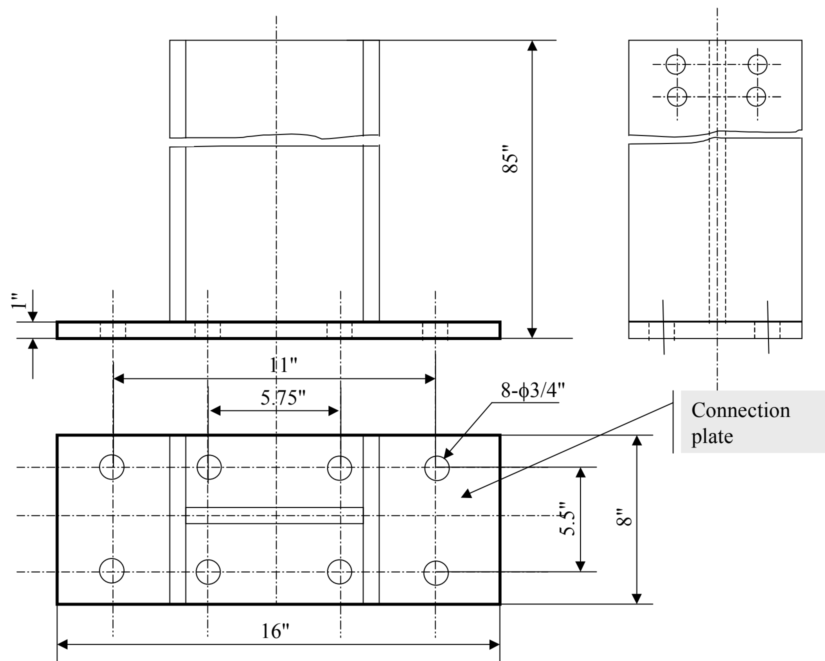
Sample Type	Sample #	Short Side (in.)	Long Side (in.)	Area (in^2)	Peak Force (lb)	Shear Stress (psi)	
Devcon	2	0.285	0.295	0.066032351	468.128	3544.686777	
Devcon	3	0.285	0.295	0.066032351	595.165	4506.616792	
Devcon	4	0.28	0.3	0.065973446	389.484	2951.823993	
Devcon	5	0.28	0.305	0.067073003	542.411	4043.437557	
Devcon	11	0.285	0.297	0.066480028	578.465	4350.667572	
Devcon	12	0.286	0.294	0.066039419	520.951	3944.242746	
Devcon	13	0.287	0.303	0.06829901	559.108	4093.090094	
Devcon	14	0.282	0.307	0.067995061	524.202	3854.70647	
Devcon	15	0.294	0.296	0.06834849	575.581	4210.634368	
Devcon	16	0.28	0.3	0.065973446	419.709	3180.893429	
					mean	3868.07998	std de

Shear Test Observed Data and Calculated Results Continued

Sample Type	Sample #	Short Side (in.)	Long Side (in.)	Area (in^2)	Peak Force (lb)	Shear Stress (psi)
Ren 3215-3	a	0.285	0.305	0.0683	556.412	4075.040331
Ren 3215-3	b	0.285	0.295	0.0660	571.612	4328.272392
Ren 3215-3	c	0.282	0.304	0.0673	515.266	3826.38722
Ren 3215-3	d	0.286	0.297	0.0667	467.636	3504.818863
Ren 3215-3	e	0.285	0.3	0.0672	589.871	4392.088208
Ren 3215-3	f	0.275	0.31	0.0670	514.369	3841.14341
Ren 3215-3	g	0.283	0.303	0.0673	548.213	4070.056039
Ren 3215-3	h	0.294	0.297	0.0686	582.467	4246.66173
Ren 3215-3	i	0.286	0.294	0.0660	580.931	4398.365456
Ren 3215-3	j	0.286	0.296	0.0665	556.904	4187.961842
Ren 3215-3	k	0.285	0.295	0.0660	608.306	4606.12105
Ren 3215-3	l	0.29	0.295	0.0672	571.551	4253.193074

Ren 3215-3	m	0.282	0.302	0.0669	568.45	4249.289719	
Ren 3215-3	n	0.285	0.294	0.0658	479.144	3640.440914	
Ren 3215-3	o	0.268	0.315	0.0663	604.546	4558.942631	
Ren 3215-3	p	0.282	0.298	0.0660	527.664	3997.350368	
Ren 3215-3	q	0.276	0.307	0.0665	551.613	4144.452421	
Ren 3215-3	r	0.277	0.301	0.0655	575.142	4391.460104	
					mean	4150.66921	std dev

Connection Dimension of Axle Housing Test I-Beam



Axle House Test I-Beam

APPENDIX B

MEASURING SUCCESS IN A PESTICIDE RISK REDUCTION PROGRAM AMONG MIGRANT FARMWORKERS IN COLORADO

Martha Soledad Vela-Acosta, M.D., M.S., Ph.D., Phillip Chapman, Ph.D., Philip L. Bigelow, Ph.D., C.I.H., Catherine Kennedy Ph.D., and Roy M. Buchan, Dr. P.H., C.I.H.,

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Running title: Pesticide risk reduction program in Colorado

ABSTRACT

Background The High Plains Intermountain Center for Agricultural Health and Safety bilingual pesticide risk reduction program, which complied with the Worker Protection Standard for migrant farmworkers was evaluated
Methods A pretest/posttest comparison of farmworkers (n = 152) assigned to either the experimental or control group was used. Independent variables included demographics, agricultural experience, and health locus of control. Dependent variables were pesticide knowledge, safety risk perception (SRP), and safety-behavior outcomes.
Results The bilingual pesticide program effectively increased farmworker's pesticide knowledge (p = 0.0001), SRP (p = 0.0001) and two (out of four) behavior outcomes. Workers with external health locus of control were less likely to adopt safety behaviors (p = 0.0001).
Conclusions The cognitive decision-making process whereby farmworkers' readiness to change and permanently adopt safety behaviors was supported by the pesticide program. Our results support the need for long-term sustained bilingual, intervention programs that demonstrate effectiveness using with an integrative methodology.

Key Words: Migrant, Farmworkers, Pesticides, Safety, Risk, Perception, Behavior, Health, Locus, WPS

INTRODUCTION

The farmworker population in the U.S. has been reported to consist of largely young, undocumented, Hispanics with a median education of six years, only one out of ten farmworkers could read English, and one quarter (26%) of that labor force was replaced every two years (U.S. Department of Labor, 2000). This agricultural workforce faces a high risk for the toxic effects of pesticide exposures and extreme field working conditions (McCauley et al., 2002; Salazar et al., 2004). Farmworkers are exposed to pesticides through agricultural tasks, and their families are exposed through pathways that include agricultural take-home and drift into housing adjacent to agricultural fields (Quandt et al., 2004; Thompson et al., 2003; McCauley et al., 2001). The adverse health effects due to pesticide exposure include neurobehavioral and endocrine dysfunction, genotoxicity, cancer, and respiratory disease (Reeves and Schafer, 2003; Garry, 2004; Zeljezic and Garaj-Vrhovac, 2004; Knopper and Lean, 2004; Regidor et al., 2004; Lee, et al., 2004).

Recognizing the potential for multiple disease outcomes due to pesticides, the Worker Protection Standard (WPS) was enacted in 1995 aimed to reduce the risk of pesticide exposure (EPA, 2003). The U. S. General Accounting Agency (2000) has made specific recommendations to improve WPS enforcement and compliance, in addition to assure for language appropriateness regardless of working site or worker status (Arcury et al., 1999). It has been stated that WPS training increases pesticide knowledge among farmworkers, and the extent to which this knowledge is put into practice has not been reported (McCauley, 2004). WPS programs need to be tailored to farmworkers' health beliefs to effectively communicate pesticide risks to farmworkers (Quant et al., 2004). Farmworker perceived pesticide risk has been correlated with pesticide information and adoption of safety-related behaviors, especially for those having information about pesticide safety among farmworkers, who have demonstrated higher pesticide perceived control scores (Arcury et al., 2002).

Behavioral-based safety or "Safety Culture" acknowledges that cognitive competence leads workers to adopt behaviors based on their perception of risk (Garcia et al., 2004). The Health Locus of Control (HLC) model predicts that those individuals taking responsibility for their own health adopt healthy habits (Wallston and Wallston, 1981; Kist-Kline and Lipnickey, 1989). There are three subscales in the HLC model. The HLC-Internal subscale identifies individuals who believe they can influence their own health through their own actions, and predicts that individuals will readily adopt new health-related behaviors (Ansbaugh et al., 1994). The HLC-Powerful Others (HLC-Powerful) subscale pertains to individuals who believe their health is in the hands of doctors and nurses and others. The HLC-Chance subscale identifies individuals who believe that health is primarily an effect of luck or fate. Inclusion of the three HLC subscales can elucidate the effect of farmworkers' health beliefs on the effectiveness of safety risk reduction programs.

The Transtheoretical model (TTM) proposed by Prochaska and DiClemente (1983) offers a comprehensive tool to measure progress towards the adoption of health behaviors. Individuals attempting to adopt a new health behavior may progress though six stages: Precontemplation, Contemplation, Preparation, Action, Maintenance, and Termination (Prochaska et al., 1993).

Effective health promotion programs cause individuals to move from less active stages towards the permanent adoption of a healthy behavior (Finfgeld et al., 2003). The TTM has not been used to evaluate pesticide risk behaviors (Goldman et al, 2004). The effect on the behavioral-based safety as outcome for this pesticide program can be explained by the cognitive decision-making process of the TTM (Herrick et al., 1997; Prochaska et al., 2004).

The High Plains Intermountain Center for Agricultural Health and Safety (HI-CAHS) is a National Institute for Occupational Health (NIOSH) agricultural center serving the Rocky Mountain region. In response to the enactment of the WPS, HI-CAHS initiated a pesticide risk reduction program (hereafter called pesticide program) developed in a bilingual format to reach migrant and seasonal farmworkers (hereafter called farmworkers, EPA, 2003; HI-CAHS, 1996). The evaluation of the pesticide program included pesticide knowledge, SRP, HLC, and safety behaviors, before and after participation in the pesticide program. Behavioral safety outcomes evaluated the association of farmworker's readiness to change with pesticide knowledge, SRP and HLC. This study builds on a larger study (n = 1407) that included safety walk-through surveys on farmworker housing (camps), central locations, and field work locations with the significant addition of statistical comparison of measure of impact due to the pesticide program (Vela Acosta et al., 2002).

MATERIALS AND METHODS

During the 1998 growing season four agricultural employers receiving HI-CAHS services and managing seven agricultural fields in Adams and Weld Counties of Colorado agreed to take part in this study. Adult farmworkers (≥ 18 years of age) working in those fields more than 32 hours per week were invited to participate. Farmworkers (n = 152) from each field were assigned as a unit to either the experimental (n = 77) or the control group (n = 75), because farmworkers from a field lived and worked together, and were likely to communicate extensively.

A 60 minute pesticide program provided training about sources of pesticides, pesticide absorption and toxicity, general chemical safety first aid, and emergency responses. An EPA approved Worker Protections Standard (WPS) flipchart was used interactively, and farmworkers were asked to respond to real or simulated case scenarios. The first language for all participants was Spanish; therefore, all instruction was given in Spanish. A worker verification card (supplied by EPA) was given to farmworkers who completed the pesticide program.

Information was collected on farmworkers' demographic characteristics, including previous agricultural experience, migration patterns and job concerns. A pretest was administered to all participants prior to the pesticide program. Within two weeks of the pretest the experimental group received the pesticide program, and approximately one week later a posttest was administered to all participants. After the posttest, the control group was also given the pesticide program. Both tests included four identical components to evaluate the effectiveness of the pesticide program: pesticide knowledge, SRP, HLC, and TTM of behavior outcomes (Selected sample questions are presented in Table I). The pesticide knowledge component contained 20 questions about pesticide sources, absorption, toxicity, first aid, and safety; it was adapted from the Ameri-Corps safety training evaluation project in WPS studies (Deeny, personal communication). The SRP component, with 13 questions, was based on the Safety Culture Survey developed by Safety Performance Solutions using a five-point Likert scale with the lowest score indicating the highest degree of SRP (Geller et al., 1996).

Participants' perceived control of their own health component was measured using the Health Locus of Control Scale (HLC)-form A (Wallston et al., 1978). All three sub-scales were included: HLC-Internal, HLC-Powerful, and HLC-Chance. Each scale had 18 items in a 5-point Likert format that had responses ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Normative means for healthy adults have been established for each subscale: HLC-Internal = 25.6; HLC-Powerful = 19.2; and HLC-Chance = 16.2 (Wallston et al., 1978).

The Transtheoretical Model (TTM) component included 20 questions for four safety behaviors: (1) wearing long sleeve shirts, (2) wearing long pants, (3) washing hands (when water was available) before eating or using the portable toilet, and (4) separating clothes before washing them after working in the field. Participants were staged across the recommended five stages of behavioral change according to Prochaska et al. (1992): Termination stage, for behaviors were reported for more than 5 years; Maintenance stage, for behaviors reported for more than 6 months; Action stage, for behaviors reported from 0 to 6 months; Contemplation stage, when planning to adopt within a month, and Precontemplation stage, if no change was planned.

All tests were translated from English into Spanish and back into English by independent translators to ensure translation accuracy. Test questions were pilot tested with a group of farmworkers (n = 5) not participating in this study to provide feedback about language appropriateness and the group interview process. Pre and posttests were read aloud to experimental and control groups, and if necessary, individual assistance in recording answers was provided. Participants received a small financial compensation for their time and cooperation. The Human Research Committee at Colorado State University approved the study's protocol and instruments.

SAS Institute (SAS, 2003) was used for data management and data analysis. Demographic responses and pretest scores were compared by group using two sample t-tests for continuous responses and chi square tests for categorical responses. Posttest scores for pesticide knowledge, SRP, and HLC components were compared by group using analysis of covariance (ANCOVA) with each corresponding pretest score as the primary covariate. Additional covariates included gender, plus three covariates constructed from seven highly correlated literacy and experience variables. Five literacy variables included number of years of school completed and reading and writing abilities in English and Spanish. Principal components analysis was used to reduce these five variables to two principal component scores, Liter1 and Liter2, which explained 84% of the variation. Two experience variables, age and years of agricultural work experience, were reduced to one principal component score, Life1, which explained 80% of the variation. Locus1 and Locus2 were created using principal component analysis of the HLC components and explained 83% of the variation. ANCOVA models were simplified using backward selection of covariates until all remaining covariates were significant ($P < 0.05$). Adjusted posttest means (lsmeans) were compared by group using the final models. Unadjusted means were also compared using t-tests.

The effect of the pesticide program on the four behavior outcomes was evaluated using logistic regression. Given the small cell size for the pre and post-test stages of change, the scale was collapsed from five stages to four by combining the first two stages (Precontemplation, and Contemplation) into one stage called “Preactive”. Using the resulting four stages of change scale, a subject’s readiness to change was identified as having improved (moved to a higher stage), or not. Readiness to change for each behavior outcome was compared by group using logistic regression with covariates: pesticide knowledge, SRP, Life1, Locus1, and Locus2, pretest stage of safety behavior, gender, pesticide symptoms, and being told when pesticides are applied (told-pesticide). Models were simplified using backward selection. Odds ratios were compared by group using the final models.

RESULTS

The pretest was administered to 227 participants, of whom 152 were present to complete the posttest and were included in the analysis (34% lost to follow up). Selected demographic characteristics for farmworkers in the experimental (n = 77) and in the control (n = 75) groups are presented in Table II. The entire study population was Hispanic, primarily from Mexico, and almost half of the participants (45%) were from the Mexican state of Guanajuato. Sixty-five farmworkers (57%) reported that they had worked in agriculture in states other than Colorado. The five states that were reported most frequently were Florida (23%), California (21%), Arizona (15%), New Mexico (12%), and Texas (10%,). Two-thirds of the farmworkers (66%) planned to return to the U.S. to work seasonally. The experimental group was older than the control group (p = 0.002, Table II). Farmworkers who reported consuming alcohol (64%), averaged 6.5 drinks/wk (1 drink = 12 oz beer, 6 oz wine, or 1oz distilled liquor), with a range from 1 to 48 drinks/wk. Job activities were primarily harvesting (88%) and weeding (81%), and 25% reported pesticide related activities such as mixing, loading, applying, flagging, and managing pesticide containers. Nine percent of the study participants (experimental = 6, control = 7) reported experiencing symptoms of pesticide exposure during the previous 2 years, but only 5 farmworkers sought medical attention.

Previous WPS training was reported by 42 farmworkers, 20% of these stated that instruction was provided in English, 20% had not understood the training, and 30% indicated that no time was allocated for questions. Those farmworkers with previous WPS training demonstrated better pesticide knowledge and SRP pretest scores than those without WPS training (p = 0.0001), that difference was undetectable after the current training session. Female farmworkers and those reporting the U.S. as their home country had significantly better SRP pretest (unadjusted) scores (p = 0.0001, and p = 0.0003 respectively).

There was no difference between the experimental and control groups in the pretest pesticide knowledge or SRP scores (Table III). Unadjusted mean scores for the posttest pesticide knowledge in the experimental group were significantly higher than the control group (Table III, p = 0.0001). The posttest SRP unadjusted mean scores for the experimental group were significantly lower than the control group, indicating an enhanced safety risk perception as a result of the training (Table III, p = 0.0001). The adjusted means for pesticide knowledge and SRP components demonstrated significant improvement for the experimental group (Table IV, p = 0.0001). Gender, age, and agricultural experience (Life1) were not significant for the final models. For the final model of the SRP component, HLC remained significant as principle component covariates (Locus1, Locus2) and for each HLC subscale in the model as covariates.

The HLC subscale unadjusted scores for the experimental and control groups are presented in Table III. About 12% of all participants demonstrated an internal orientation, i.e. scores higher than 25.6 for HLC-Internal, and lower than 19.2 for HLC-Powerful and 16.2 for HLC-Chance. The experimental group had lower HLC-Internal pretest scores than the control group (p = 0.02). In addition, it was found that older farmworkers, those with less education and those who reported working in agriculture all year, were more likely to have a strong external orientation. There was no statistically significant effect any on the HLC subscales due to the pesticide program. The slopes in the regression models indicated that a farmworker who had a higher score for HLC-Internal would, on average, demonstrate improvement in pesticide knowledge (p = 0.01) and SRP (p = 0.001).

Readiness to change was significant for farmworkers who were already actives in behavior outcomes (Table V). A farmworker's pretest SRP increased the odds of readiness to change for washing hands in the field and for separating clothes before washing them (Table V). Locus1 increased the odds of adopting the behavior of separating clothes before washing them and wearing long pants. Farmworkers who were in Termination stage for washing hands in the field had better scores for SRP than those who were in Action (p = 0.04), and Preactive stages (p = 0.01).

Responses to the open ended questions about main concerns of the farmworkers included, salary (33%), housing (23%), worker safety (18%), and immigration (16%). Other concerns raised included family, loneliness, unemployment, health services, transportation, cancer, and discrimination.

DISCUSSION

The pesticide program evaluation utilized a behavioral-safety approach identifying factors that influence farmworkers rationale to adopt safety-related behaviors: knowledge, safety risk perception, and Health Locus of Control. Our findings were consistent with previously published research in that information alone did not support participants' behavioral outcomes (Geller et al, 1996). Participants' readiness to change was influenced by their perception of safety risk (Dejoy et al, 2004). Decreasing their tolerance for risk supported the change in behavior (Geller, 1996). The individuals' sense of control over his/her own situation was significant towards adoption of a new behavior (Prochaska, 2004; Simoni and Ng, 2002).

This study demonstrated that the pesticide program improved farmworkers pesticide safety knowledge and enhanced their perception of pesticide-related risks. The use of the TTM contributed to the assessment of the effect of this pesticide program on the improvement of farmworkers behavior outcomes. Targeted behavior outcomes such as washing hands and separating clothes, where cultural determinants may not be as critical such as wearing long pants and long sleeve shirt were good indicators of the program. Some behaviors recommended in the WPS, such as wearing long pants and long sleeve shirts were readily adopted by farmworkers.

The present study elucidates the interaction of factors interplaying in safety-related behaviors that result from WPS training. The SRP scores were significantly different for farmworkers at Termination stages compared to those in Preactive and Action stages, low SRP scores were also correlated with an increased likelihood of adoption of safety behaviors as indicated by readiness to change. Thus the findings of the study provide support for the hypothesis that pesticide safety training increases knowledge, modifies safety risk perception and is associated with cognitive decision-making supporting the adoption of safer work practices.

Our results agreed with those reported in an earlier study where information about pesticide application was related to perceived pesticide risk, which in turn led to adoption of safety-related behaviors for farmworkers in North Carolina (Arcury et al., 2002). Arcury's study differed in that no training was given and the instruments used to measure SRP consisted of 5 simple questions, while in this study, the measure of safety risk perception (SRP) was based on a comprehensive approach taking in consideration farmworkers risk perception for their work environment and their control over their risks (Geller, 1996).

The Health Locus of Control and TTM helped to explain the pesticide program effect beyond the traditional language barriers and health beliefs factors influencing this population (McCauley et al., 2002). The pesticide program (one time intervention) did not change the HLC subscales (mean scores). Programs that have been demonstrated to have an effect upon HLC are reported to last four to six months (Kist-Kline and Lipnickey, 1989; McLean and Pietroni, 1990; Kennedy et al., 1999; Lefcourt, 1984). As predicted by theories of health-related behavior change (Wallston and Wallston, 1978), those participants who had high internal locus of control were more likely to improve their safety risk perception and to adopt safety behaviors. However, the majority of study population had low internal and high external Health Locus of Control, and it was for this population that the training seemed to be least effective. Our findings clearly indicate that research on training methods designed to influence persons with a high external locus of control is needed.

Over 50% of these farmworkers consumed alcohol and 30% reported smoking cigarettes, these percentages were higher than those reported by others (McCurdy, et al 2003). High tobacco and alcohol consumption could be expected to be compatible with the low HLC-Internal scores present in our sample (Kist-Kline and Lipnickey, 1989; Wallston, et al., 1978). Mental health programs and drug and alcohol counseling for farmworkers have been recommended by Slesinger (1992) given there is a lack of studies looking at possible interaction smoking and drinking with pesticide exposure.

Understanding the beliefs, values, and concerns of a population is one of the first and most important steps in assessing its health needs (Green, 1990). Findings of this present study were in agreement with the profile of the Mexican-American population found by other researchers (Kennedy et al., 1999; Bundek et al., 1993). The HLC-Powerful orientation of the farmworkers in this study probably reflected a tendency to rely upon family, friends, and or medical professionals with respect to the treatment of illness and disease. This high HLC-Powerful score may be a reflection of the farmworkers' social network (Kennedy et al., 1999; Bundek et al., 1993; Molina and Aguirre-Molina, 1994).

Health disparities for an informal workforce such as farmworkers were voiced in this study: housing, immigration, and salary were the main concerns and these were similar to other reports (U.S. Department of Labor, 2000; Magana and Hovey, 2003). Loneliness was reported as a prevalent stressor among this worker population, which comprised mainly of 'solo' workers and that may have contributed to jeopardizing their health via alcohol consumption (McLaurin, 2000).

CONCLUSION

The evaluation of this bilingual and bicultural pesticide risk reduction program provided evidence that the attitudes, beliefs, and knowledge (HLC, SRP, and pesticide knowledge) of a farmworker influenced his/her safety-related behavior outcomes. The Transtheoretical Model was instrumental for measuring the safety-related behaviors in a work environment. The combination of HLC and the Transtheoretical Model used in this research, disclosed information about the predicting factors for adoption of safety behaviors. Sustained programs that support the principles taught in WPS are required to effectively decrease pesticide risk for farmworkers (Vela Acosta et al., 2002; Konradsen et al., 2003; DeJoy et al, 2004).

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Table I. Selected questions from pre/posttests used for evaluation of Pesticide Risk Reduction Program in Colorado.

Knowledge Component. Responses recorded as yes, no, or I do not know.
1. After pesticides have been applied they can be found only on the leaves of the plants. 2. It is dangerous to use pesticide containers even after rinsing them with hot water and soap. 3. Pesticides can enter my body as I am breathing. 4. If a co-worker passed out in an enclosed space where there are pesticides, one should rescue him/her and give mouth to mouth breathing. 5. My boss should provide transportation to see a doctor if I become sick due to pesticide exposure while working. 6. I should always separate my field work clothes from those of my family when doing laundry.
Safety Risk Perception Component. Responses: Likert Scale (strongly agree = 1, strongly disagree = 5)
1. I think my boss is well informed about how to protect workers from pesticides. 2. I want to know about the risks of being exposed to pesticides. 3. My boss is more concerned about work than about the health of the workers. 4. When I know that pesticides have been applied to the field, I do not go to work in the field. 5. If I inform my boss that something is wrong in the fields, for example, that there is no water, he promptly corrects the problem and shows interest on my comments. 6. I am willing to inform my co-workers not to enter a field where pesticides have been applied.

Table I (continued)

Health Locus of Control Component Responses: Likert Scale (strongly agree = 1, strongly disagree = 5)
1. When I get sick, it is what I do that determines how quickly I get better. 2. I am in control of my health. 3. Seeing the doctor regularly is the best way to avoid getting sick. 4. My family has much to do with my becoming sick or healthy. 5. No matter what I do, if I am going to get sick, I am going to get sick. 6. Good health is just a matter of good luck.
Transtheoretical Model Component (one behavior) Response: varies
1. After working in the field do you separate your work clothes from your nonwork/family's clothes? Always, If not always, when? Frequently, Sometimes, Rarely, Never 2. If you do not separate your work clothes from your nonwork/family's clothes after working in the fields, have you thought about doing so during the next 6 months? Yes, continue with following question. No, skip to question #___ 3. Have you thought about separating your work clothes from your nonwork/family's clothes after working in the fields during the upcoming month? Yes, continue with following question. No, skip to question #___ 4. How long have you been separating your work clothes from your nonwork/family's clothes after working in the fields? 1 to 6 months More than 6 months More than 5 years

Table II. Demographic characteristics of farmworkers participating in the Pesticide Risk Reduction Program in Colorado

		Experimental Group		Control Group	
Characteristic	subgroup	n	%	n	%
Gender	Male	63	81.8	65	86.7
	Female	14	18.2	10	13.3
Age	18-20	7	9.1	22	29.3
	21-30	33	42.9	30	40.0
	31-40	18	23.4	11	14.7
	41-50	8	10.4	7	9.3
	51-60	10	13.0	2	2.7
	mean (yrs)[a]	33.3		27.6	
Education	mean (yrs)	5.4		5.6	
Read Spanish	None	3	3.9	6	8.0
	Little	24	31.2	23	30.7
	Well	25	32.5	23	30.7
	Very Well	25	32.5	25	33.3
Write Spanish	None	3	3.9	6	8.0
	Little	24	31.2	21	28.0
	Well	25	32.5	27	36.0
	Very Well	25	32.5	21	28.0
	None	50	64.9	59	78.7

Read English	Little	17	22.1	14	18.7
	Well	7	9.1	1	1.3
	Very Well	3	3.9	1	1.3
Write English	None	55	71.4	63	84.0
	Little	14	18.2	11	14.7
	Well	5	6.5	0	0.0
	Very Well	3	3.9	1	1.3
Nation of Origin	Mexico	71	93.4	69	94.5
	USA	5	6.6	4	5.5
Home Country	Mexico	62	81.6	69	92.0
	USA	14	18.4	6	8.0
Prior agricultural work in Mexico		43	55.8	57	76.0
Previous WPS Training		22	28.6	20	26.7
Tobacco Use	use cigarettes	29	37.7	24	32.0
	mean cigarettes/day	7.1		4.6	
	mean yrs of use	8.0		7.1	
	use chewing tobacco	65	85.5	62	82.7
Alcohol Use	Yes	42	54.5	41	54.7
	mean drinks/wk	7.0		6.0	

[a]p=0.002

TABLE III Unadjusted mean scores for Pesticide Knowledge, Safety Risk Perception (SRP) [1] and Health Locus of Control (HLC) among Farmworkers participating in the Pesticide Risk Reduction Program, Colorado.

		Experimental n = 77	Control n = 75	
Component	Test	Mean (SE)	Mean (SE)	p-value
Pesticide Knowledge Max = 20	Pre	13.6(0.2)	13.5 (0.3)	0.9
	Post	16.0(0.2)[b]	13.9(0.2)	0.0001
SRP[a] Max = 5	Pre	2.5(0.05)	2.5 (0.05)	0.9
	Post	2.3(0.04)[c]	2.4(0.04)	0.0001
HLC-Internal Healthy Adult=25.6	Pre	22.7 (0.4)	24.0(0.4)	0.02
	Post	22.5(0.3)	23.5(0.3)	0.1
HLC-Powerful Healthy Adult=19.2	Pre	26.4(0.4)	26.0(0.4)	0.5
	Post	26.5(0.3)	26.4(0.3)	0.9
HLC-Chance Healthy Adult=16.2	Pre	22.0 (0.6)	21.9(0.6)	0.2
	Post	22.1(0.5)	22.2(0.5)	0.9

[a]Maximum of five points, with a score of 1 indicating the strongest safety risk perception

[b] p=0.00002 Mean difference between pretest and posttest for experimental group

[c] p=0.007 Mean difference between pretest and posttest for experimental group

TABLE IV. Stepwise backward multiple linear regression analysis of the pesticide knowledge, safety risk perception (SRP), and Health Locus of Control (HLC)

Pesticide Knowledge R^2=0.28, p=0.00001; lsmeans[a]: exp = 15.5, control = 13.2, p=0.0001			
Covariates	Parameter est.	Std. error	p-value
Pretest knowledge score	0.2	0.07	0.006
Experimental group indicator	2.3	0.4	0.00001
Pretest SRP	-0.6	0.3	0.03
Home Country (Mexico)	1.3	0.5	0.02
SRP R^2=0.60, p=0.0001; lsmeans[a]: exp = 2.2, control = 2.5, p = 0.0001			
Pretest SRP	0.34	0.04	0.0001
Experimental group indicator	-0.36	0.06	0.00001
Told Pesticides in Field	-0.2	0.07	0.006
Locus1	-0.03	0.005	0.00001
Locus2	-0.02	0.009	0.04
HLC-Internal R^2 = 0.23, p = 0.0001; lsmeans[a]: exp = 22.7, control = 23.1, p = 0.5			
Experimental group indicator	-0.45	0.6	0.5
Pretest Score HLC-Internal	0.47	0.09	0.00001
Pretest Score HLC-Chance	0.18	0.06	0.006
HLC Powerful R^2 = 0.25, p = 0.0001; lsmeans[a] = exp = 26.5, control = 26.3, p = 0.6			
Experimental group indicator	0.22	0.4	0.6
Pretest Score HLC-Powerful	0.46	0.07	0.00001
Life1	-0.01	0.004	0.01
HLC-Chance R^2 = 0.27, p = 0.0001; lsmeans[a]: exp = 21.8, control = 22.4, p = 0.4			
Experimental group indicator	-0.59	0.7	0.4
Pretest Score HLC-Chance	0.53	0.07	0.00001

[a]Posttest adjusted mean scores for experimental (exp) and control groups.

Table V Logistic Regression Models and Odds Ratio[a] for Readiness to Change (TTM) for each behavior outcome among farmworkers participating in the Pesticide Program.

Independent Variables	Odds Ratio	95% Confidence Intervals	p-value
Wearing Long Sleeve Shirt			
Experimental group indicator	0.3	0.10-0.92	0.03
Life1	0.98	0.96-0.99	0.01
Wearing Long Pants			
Maintenance Stage	480	19.9-900	0.0001
Locus1	0.77	0.6-0.9	0.04
Washing Hands in the Field			
Pretest SRP	3.84	1.3-10.9	0.01
Separating Clothes Before Washing Them			
Exp. Group Indicator	1.02	0.02-15.9	0.04
Action Stage	50.9	10.6-243.4	0.00001
Locus1	1.3	1.0-1.5	0.003

[a]Odd ratio: Adjusted odds ratio obtained from multivariate analyses adjusted for all variables in the model.

APPENDIX C

A Progress Report on the HICAHS Feasibility Project

Agricultural Injuries and Illnesses Among Colorado Agricultural Workers

PROJECT INVESTIGATORS

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REGIONAL COMMUNITY PARTNERS INVOLVED IN PROJECT

Pinnacol Assurance – Colorado Workers Compensation
Colorado Cattlemen's Association
Colorado Livestock Association
Colorado Corn Growers Association
Colorado Grain and Feed Association

PURPOSE

The purpose of this report is to provide an account of the progress that has been made in regards to the feasibility project entitled "Agricultural Injuries and Illnesses Among Colorado Agricultural Workers."

INTRODUCTION

Agriculture is among the most hazardous of occupations in which injuries are important contributors to mortality and morbidity (McCurdy and Carroll, 2000). Unfortunately, there have been relatively few effective intervention / prevention strategies that reduce musculoskeletal injuries among agricultural workers. The lack of effective interventions is likely related to the mismatch between existing recommended agricultural interventions and the variety of agricultural tasks throughout the U.S. For example, the NIOSH publication "Simple Solutions: Ergonomics for Farm Workers" (2001) provides an array of effective interventions for agricultural tasks performed in the Western U.S. but none are related to the primary agricultural tasks performed in Colorado and surrounding states. The specificity of intervention development must be based on the types of injuries and the attributed causes of these disorders in specific agricultural populations. The purpose of this epidemiologic study is to determine the most prevalent occupational injuries, the attributed causes, and the associated medical costs among agricultural workers in Colorado.

Injuries involving the musculoskeletal system cause life-long pain and disability, human suffering, afflict millions and cost the US economy billions of dollars (NIAMS 2000). The costs of agricultural musculoskeletal injuries are rising, and these costs place financial hardships on the companies that conduct business in the agriculture industry. Financial success is increasingly difficult in the agriculture industry, and agriculture related injuries contribute to this economic challenge. There are substantial data on the prevalence of various work-related musculoskeletal disorders among manufacturing workers (NIOSH 1997). However, information about the causes and nature of musculoskeletal disorders among agricultural workers is not well established. One approach for targeting primary prevention strategies (i.e., ergonomic interventions) is to use workers' compensation claim data to obtain a better understanding of the types, causes, and nature of occupational injuries and illnesses.

The prevalence of musculoskeletal disorders among farm workers is second only to skin disorders (NSC 2000). Information on cattle and dairy farmers in the U.S. is scarce. Studies conducted in Scandinavia reported that over 80% of dairy farmers complain of musculoskeletal disorders in a 12 month period (Gustafsson et al. 1994; Stal et al. 1996). These results contrast with the lower 12 month period prevalence reported in manufacturing industries (Bureau of Labor Statistics 2002).

Based on the few studies available and on the physical nature of agricultural operations, it is apparent that farm workers suffer from acute and chronic injuries involving the musculoskeletal system such as low back injury, shoulder injuries, and lower limb injuries. Effective intervention strategies should be developed based on empirical evidence and targeted to specific agricultural sectors and tasks. Interventions targeted to prevent injuries should be preceded by a systematic analysis of the nature and causes of these disorders.

SPECIFIC AIMS OF STUDY

The specific aims of the study include the following:

1. To identify the specific types and causes of occupational injuries in cattle, dairy, and grain and feed operations in Colorado.

2. To identify the economic costs (medical and indemnity) associated with injuries among cattle, dairy, and grain and feed workers.

3. To determine the economic burden of farm injuries expressed as a percent of farm payroll for cattle, dairy, and grain and feed operations.

METHODOLOGY

After gaining approval from the Colorado State University Human Subjects Committee, injury data was obtained in a secured fashion from Pinnacol Assurance, Denver, Colorado. The data was then analyzed using the Brio Explorer database software package.

Pinnacol Assurance is the largest carrier of agricultural policies in the state of Colorado insuring approximately 75% of all agricultural enterprises; therefore the Pinnacol database is representative of the Colorado agriculture industry.

Pinnacol Assurance provided the investigators access to their complete workers' compensation database for the analysis of claims data in the agricultural sector. Specific industry occupations are classified by NCCI coding. NCCI (National Council on Compensation Insurance) class codes are numerical codes used by the workers compensation insurance industry to classify occupations and their job responsibilities. The database is derived from first report of injury forms, medical cost data, medical reports, and company profiles. The database consists of information on worker date of birth, employment status (full-time versus part-time), date hired, weekly wage, occupation, days worked per week, length of days away from work due to injury, accident or injury location, time of injury, cause of injury, nature of injury, and body part injured, payroll of worker's employer, total cost of injury, cost of indemnity, cost of medical, and additional information.

Because workers compensation annual policies have varying 12 month intervals (i.e. June to May or November to October), only data involving completed policy years were included. In addition, only closed injury claims were included in this study. Therefore, for the purposes of this study, all closed injury claims between the closed-policy years of 2000-2004 were analyzed.

Preliminary data investigations involved performing descriptive statistical analyses. A total of 3,995 injury claims were obtained from the following agriculture occupations:

Occupation	NCCI Code	O*NET Code
Dairy Farms	0036	45-2092.02
Field Crops-Including Drivers	0037	45-2091.00
Cattle/Livestock Raising	0083	45-2093.00
Grain Milling	2014	45-2091.00
Bean Sorting/Handling	8102	45-2041.00
Hay Grain/Feed Dealers	8215	45-4011.11
Cattle Dealers	8288	13-1021.00
Grain Elevator Operators	8304	53-7011.00

The following job descriptions are found at the Occupational Information Network (better known as O*NET) website. O*NET is a comprehensive database of worker attributes and job characteristics. Currently, O*NET is the replacement for the *Dictionary of Occupational Titles* (DOT) Manual.

Dairy Farms

Apply pesticides, herbicides, and fertilizer to crops and livestock; plant, maintain, and harvest food crops; and tend livestock and poultry. Repair farm buildings and fences.
Duties may include: operating milking machines and other dairy processing equipment; supervising seasonal help; irrigating crops; and hauling livestock products to market.

Field Crops-Including Drivers
Operate and control farm equipment to till soil and to plant, cultivate, and harvest crops. May perform tasks, such as crop baling or hay bucking. May operate stationary equipment to perform post-harvest tasks, such as husking, shelling, threshing, and ginning.

Cattle/Livestock Raising
Farmworkers, Farm and Ranch Animals - Attend to live farm, ranch, or aquacultural animals that may include cattle, sheep, swine, goats, horses and other equines, poultry, finfish, shellfish, and bees. Attend to animals produced for animal products, such as meat, fur, skins, feathers, eggs, milk, and honey. Duties may include feeding, watering, herding, grazing, castrating, branding, de-beaking, weighing, catching, and loading animals. May maintain records on animals; examine animals to detect diseases and injuries; assist in birth deliveries; and administer medications, vaccinations, or insecticides as appropriate. May clean and maintain animal housing areas.

Grain Milling
Drive and control farm
equipment to till soil and to plant, cultivate, and harvest crops. May perform tasks, such as crop baling or hay bucking. May operate stationary equipment to perform post-harvest tasks, such as husking, shelling, threshing, and ginning.

Bean Sorting/Handling
Grade, sort, or classify unprocessed food and other agricultural products by size, weight, color, or condition.

Hay Grain/Feed Dealers
Sell agricultural products and services, such as animal feeds, farm and garden equipment, and dairy, poultry, and veterinarian supplies.

Cattle Dealers
Purchase farm products either for further processing or resale.

Grain Elevator Operators
Control or tend conveyors or conveyor systems that move materials or products to and from stockpiles, processing stations, departments, or vehicles. May control speed and routing of materials or products. Descriptive statistical analyses were performed concerning the injured claimants, as well as business policy holders. Injury cost analyses were broken down based on cause of injury, type of injury, and body part injured. Dollar costs of injuries included both medical and indemnity costs combined. Medical costs include all medical interventional costs associated with the treatment of the injured worker. Indemnification costs include all costs associated with supplementation of wages that were lost when the worker was unable to work as a result of his/her injury.

PRELIMINARY DATA RESULTS
The following tables provide preliminary general demographic statistics of all injury claims analyzed to date:

Table 1. Preliminary Data of Total Claims, Total Policies and Policy Holder Payrolls

	Total Claims	Total Policies	Avg Period Payroll	Period Payroll Range
Dairy Farms	480	80	$554,349	$30 - $2,279,305
Field Crops-Including Drivers	281	57	$77,077	$2,878 - $380,000
Cattle/Livestock Raising	1,182	407	$316,528	$450 - $2,665,127
Grain Milling	446	30	$313,134	$13,681 - $779,493
Bean Sorting/Handling	263	20	$394,839	$2,812 - $970,221
Hay Grain/Feed Dealers	265	42	$379,110	$5,887 - $832,642
Cattle Dealers	776	88	$723,974	$10 - $2,014,303
Grain Elevator Operators	302	25	$196,329	$2,316 - $562,043

Table 2. Preliminary Demographic Data of Claimants

	Avg Age	Age Range	Avg Work Dur. (mths)	Work Dur. Range	Male (%)	Female (%)
Dairy Farms	34.5	18-67	28.8	0-282	424 (88.3)	56 (11.7)
Field Crops-Including Drivers	39.4	19-74	47.9	0-491	258 (91.8)	239 (8.2)
Cattle/Livestock Raising	38.5	18-77	37.1	0-491	1,028 (87.1)	153 (12.9)
Grain Milling	38.9	18-77	45.4	0-479	403 (90.4)	43 (9.6)
Bean Sorting/Handling	38.9	18-80	51.9	0-480	194 (73.8)	69 (26.2)
Hay Grain/Feed Dealers	40.4	18-70	42.3	0-338	243(91.7)	21 (8.3)
Cattle Dealers	38.7	18-78	37.2	0-371	710 (91.7)	65 (8.3)
Grain Elevator Operators	39.2	18-73	41.7	0-350	267(88.4)	35 (11.6)

To address the specific aims of the study, statistical analyses were conducted to determine the prevailing occupational injury causes, injury types, and body parts affected in the different agricultural occupations identified. In addition, the economic costs of these different injuries have also been determined.

Although the Pinnacol database does not have accurate estimates of the number of employees at each insured enterprise, the database does have a complete accounting of the cost of payroll for each agricultural enterprise. Thus, the economic burden of injuries is expressed as a percentage of the farm period payroll. The period payroll is the annual payroll of the policy holder during which the injury took place. The following figures display the statistical analyses performed to date.

<u>Specific Aim 1A: Nature of Occupational Injuries</u>

Fig. 1 DAIRY FARMS INJURIES (NCCI 0036) (n=480)

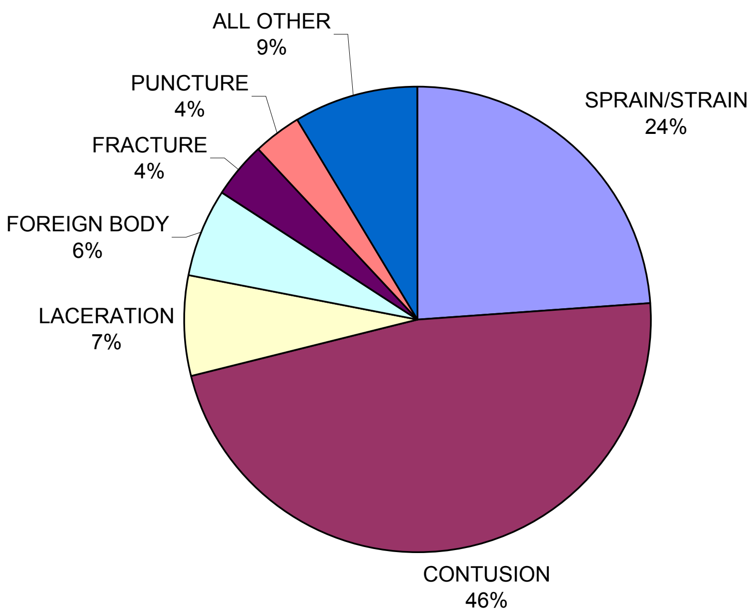
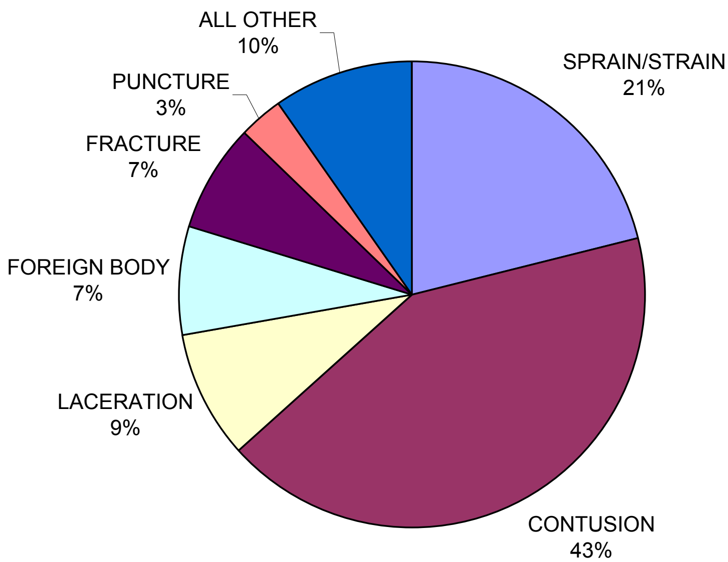


Fig. 2 FIELD CROPS-INCLUDING DRIVERS INJURIES (NCCI 0037) (n = 281)



Specific Aim 1A: Nature of Occupational Injuries cont.

Fig. 3 CATTLE/LIVESTOCK RAISERS INJURIES (NCCI 0083) (n = 1182)

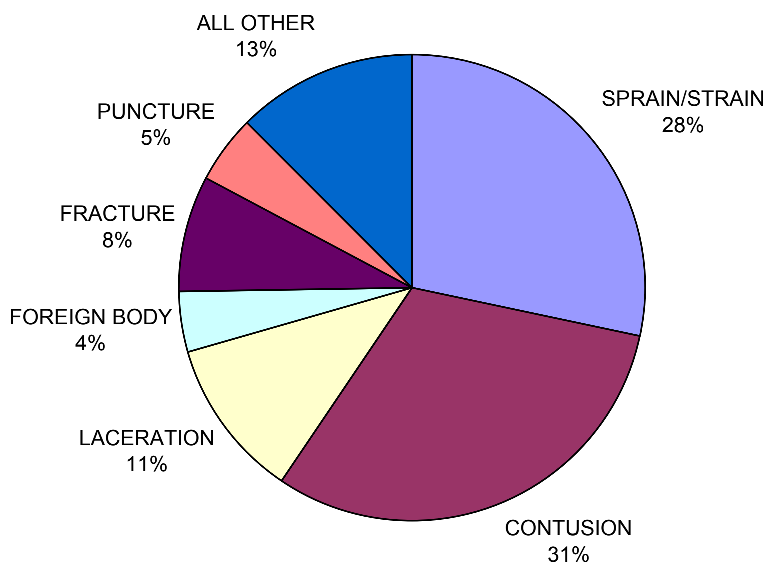
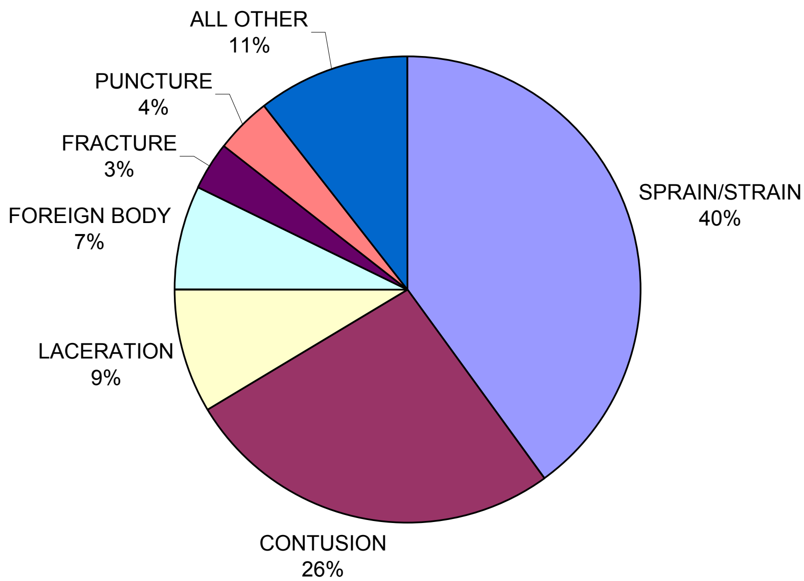


Fig. 4 GRAIN MILLING INJURIES (NCCI 2014) (n = 446)



Specific Aim 1A: Nature of Occupational Injuries cont.

Fig. 5 BEAN SORTING/HANDLING INJURIES (NCCI 8102) (n = 263)

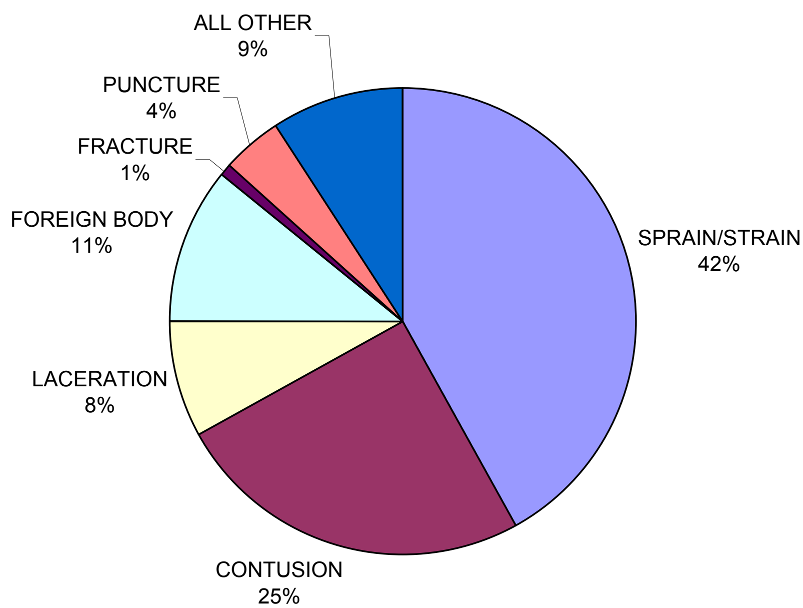
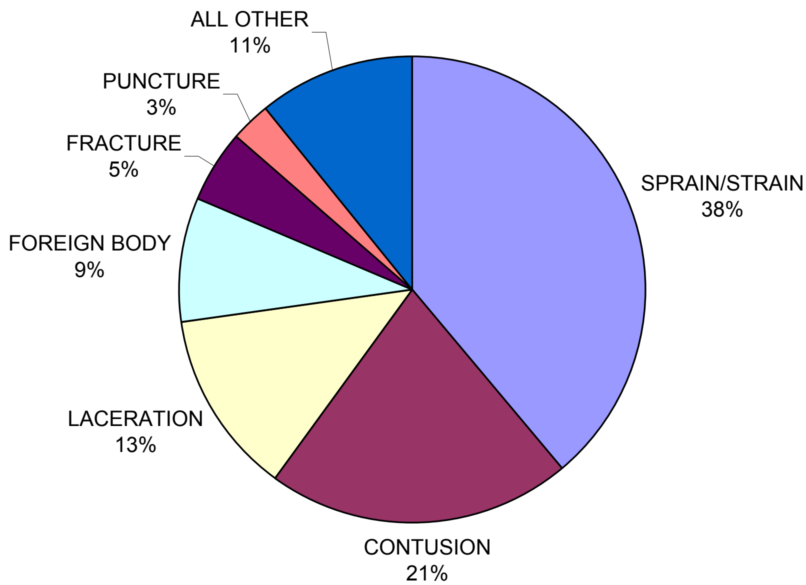


Fig. 6 HAY GRAIN/FEED DEALERS INJURIES (NCCI 8215) (n = 265)



Specific Aim 1A: Nature of Occupational Injuries cont.

Fig. 7 CATTLE DEALERS INJURIES (NCCI 8288) (n = 776)

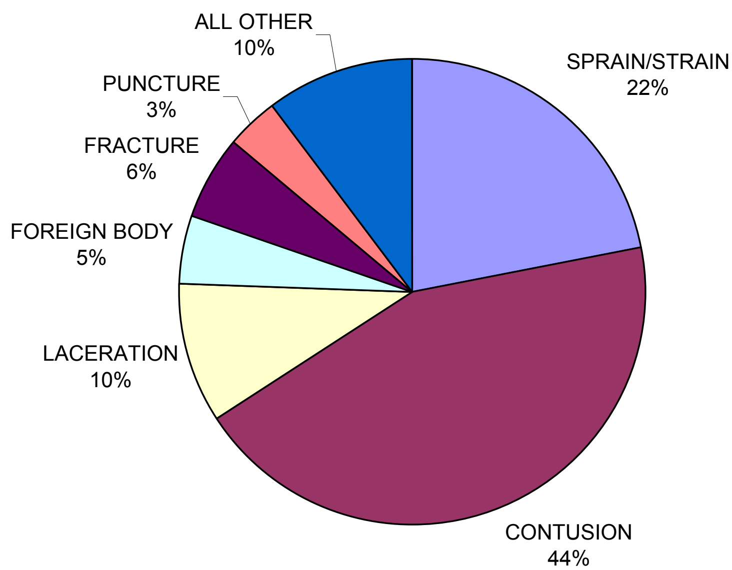
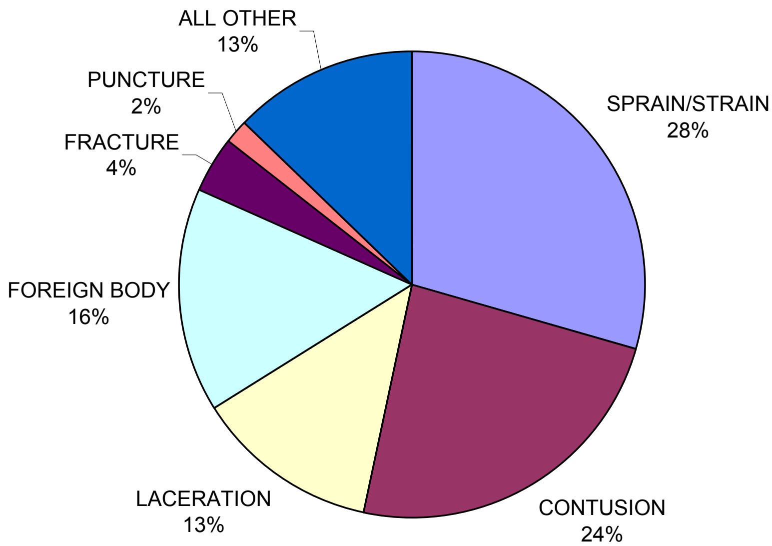


Fig. 8 GRAIN ELEVATOR OPERATORS INJURIES (NCCI 8304) (n = 302)



Specific Aim 1B: Causes of Occupational Injuries

Fig. 9 DAIRY FARMS INJURY CAUSES (NCCI 0036) (n = 480)

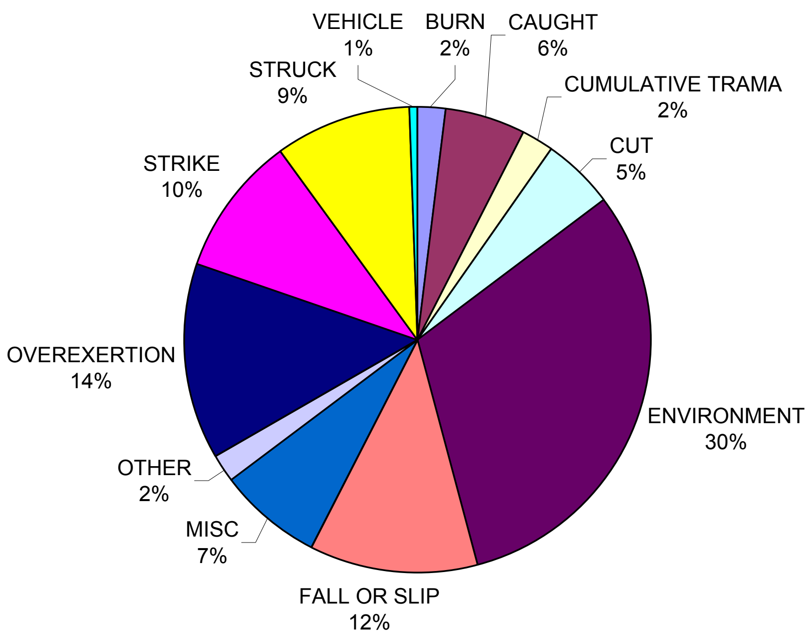
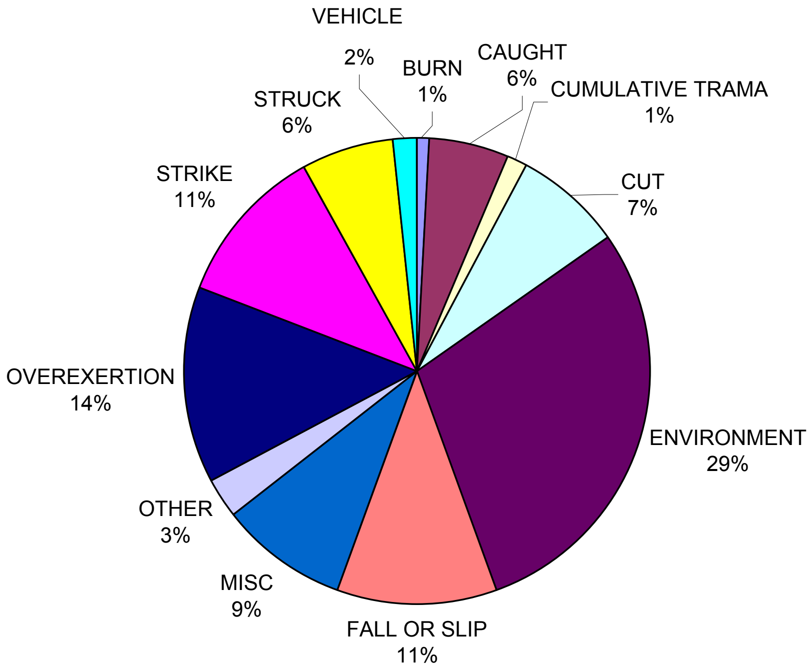


Fig. 10 FIELD CROPS-INCLUDING DRIVERS INJURY CAUSES (NCCI 0037) (n = 281)



Specific Aim 1B: Causes of Occupational Injuries cont.

Fig. 11 CATTLE/LIVESTOCK RAISING INJURY CAUSES (NCCI 0083) (n = 1182)

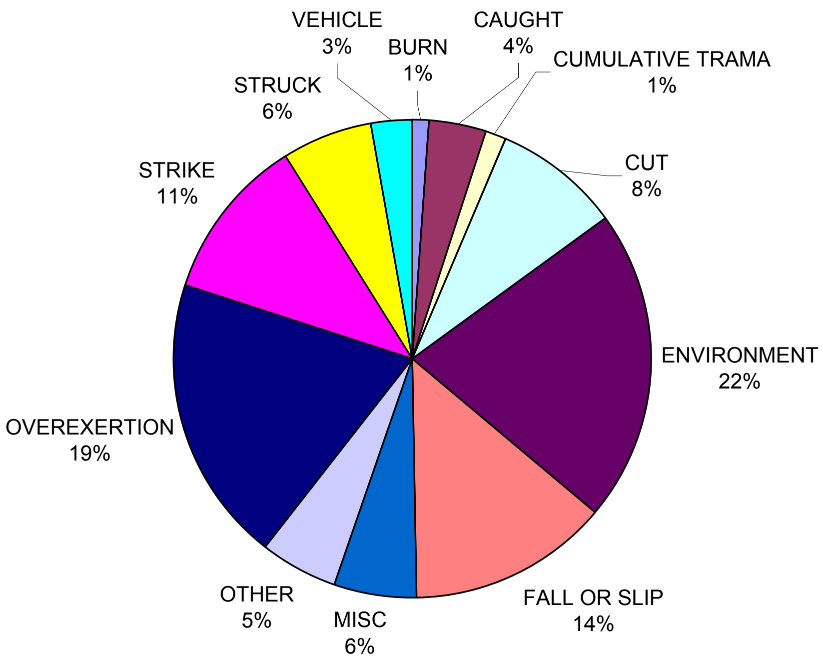
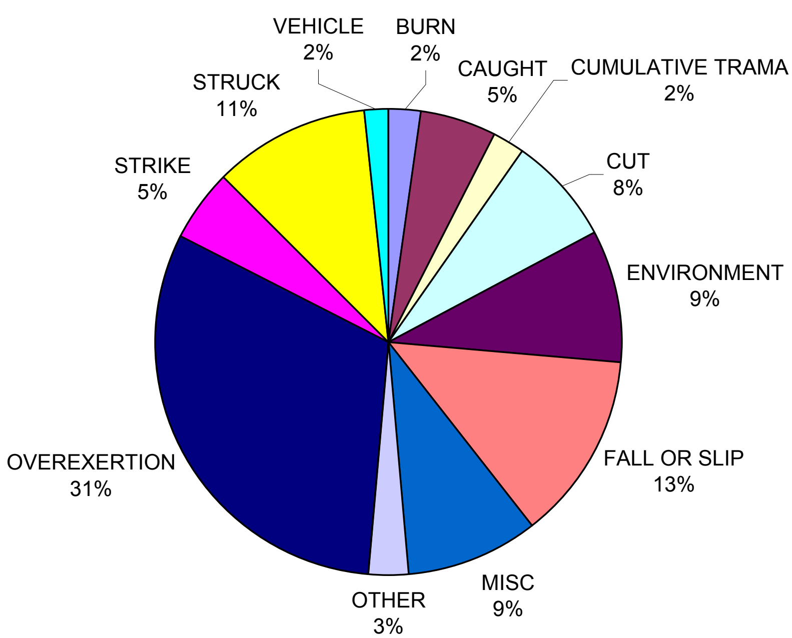


Fig. 12 GRAIN MILLING INJURY CAUSES (NCCI 2014) (n = 446)



Specific Aim 1B: Causes of Occupational Injuries cont.

Fig. 13 BEAN SORTING/HANDLING INJURY CAUSES (NCCI 8102) (n = 263)

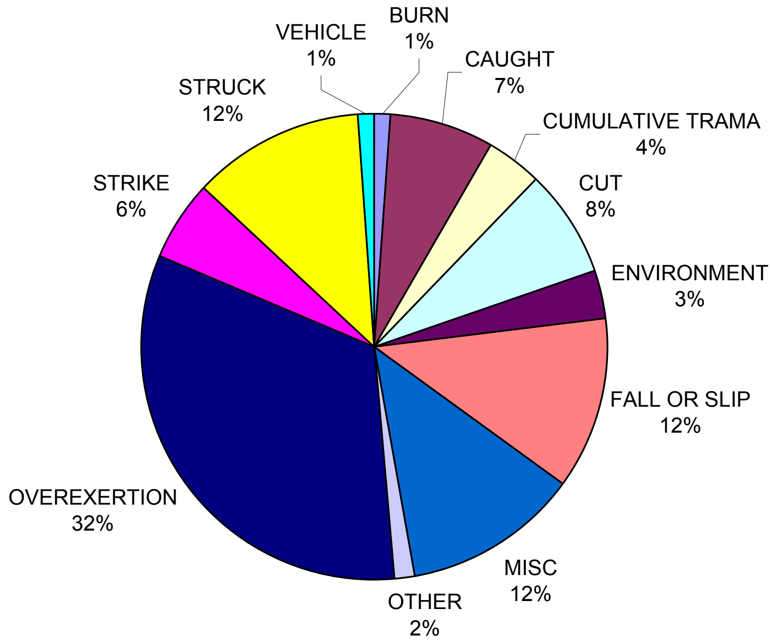
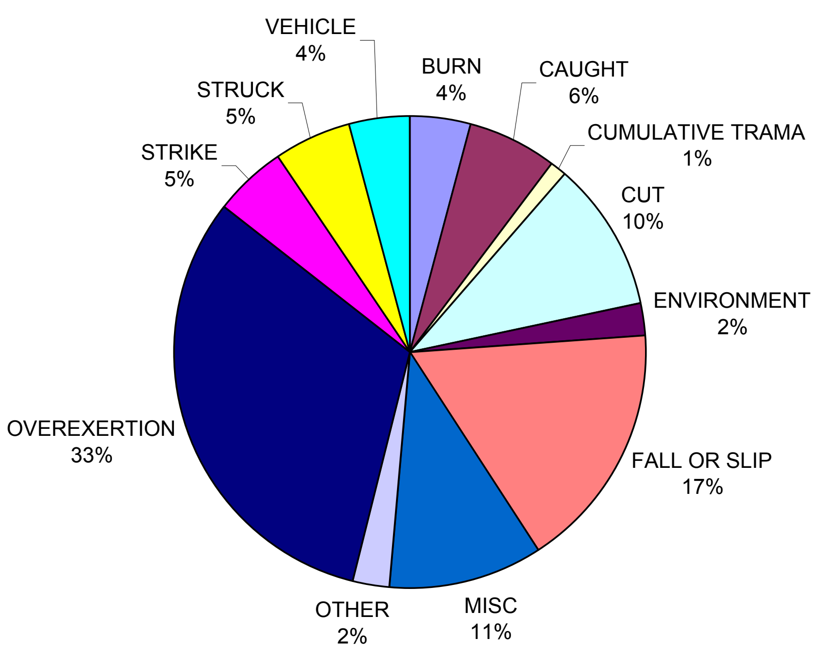


Fig. 14 HAY GRAIN/FEED DEALERS INJURY CAUSES (NCCI 8215) (n = 265)



Specific Aim 1B: Causes of Occupational Injuries cont.

Fig. 15 CATTLE DEALERS INJURY CAUSES (NCCI 8288) (n = 776)

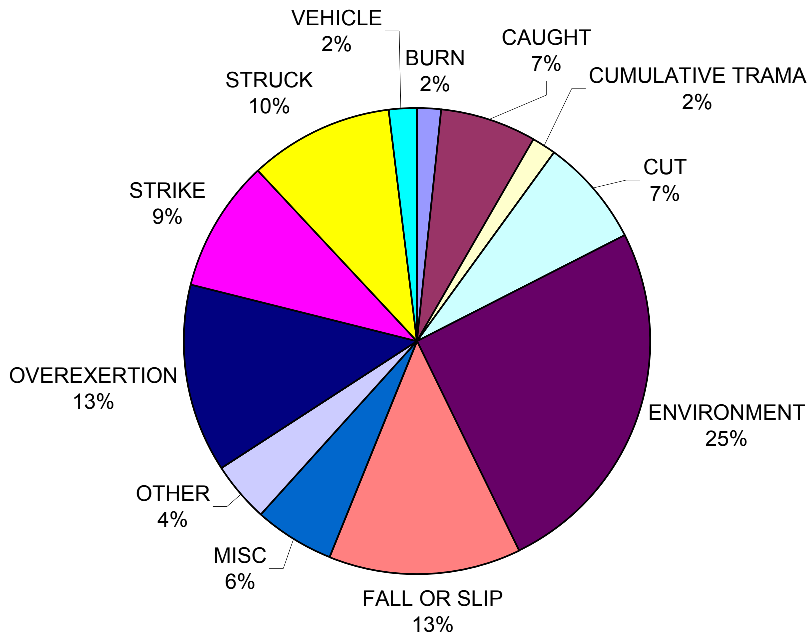
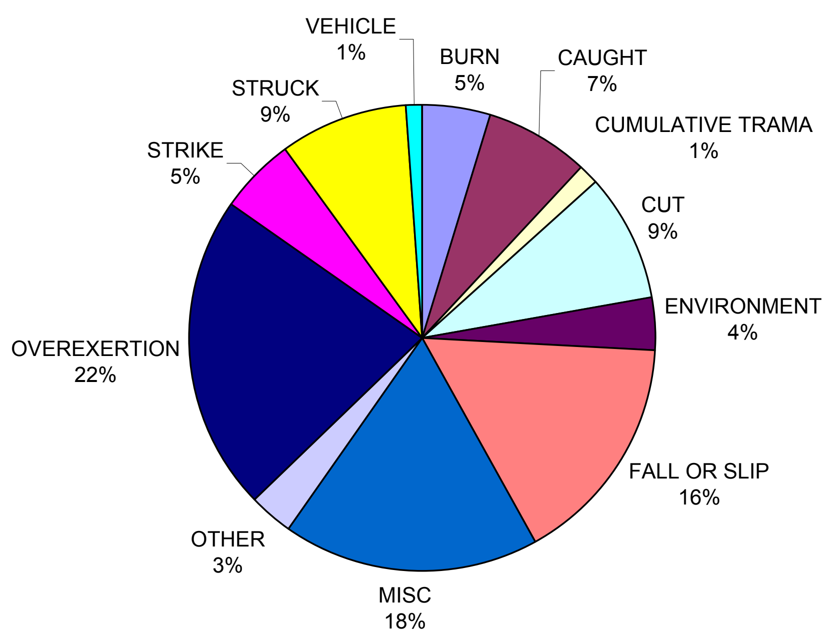


Fig. 16 GRAIN ELEVATOR OPERATORS INJURY CAUSES (NCCI 8304) (n = 302)



Specific Aim 1C: Occupational Injury by Body Part

Fig. 17 DIARY FARMS INJURED BODY PART (NCCI 0036) (n = 480)

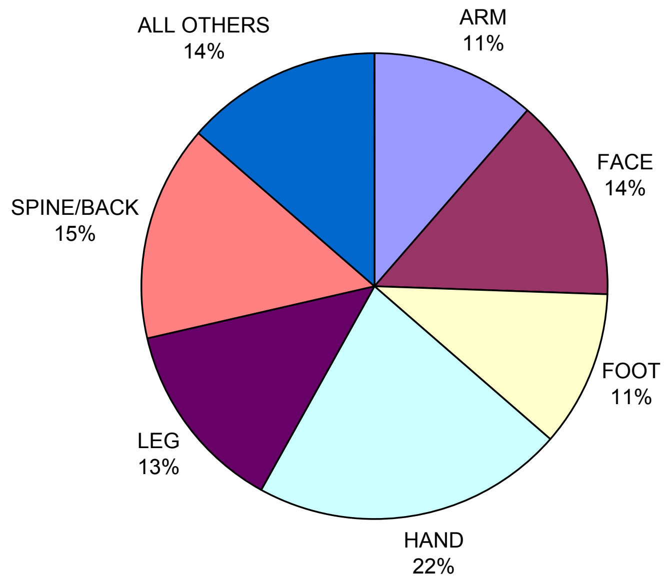
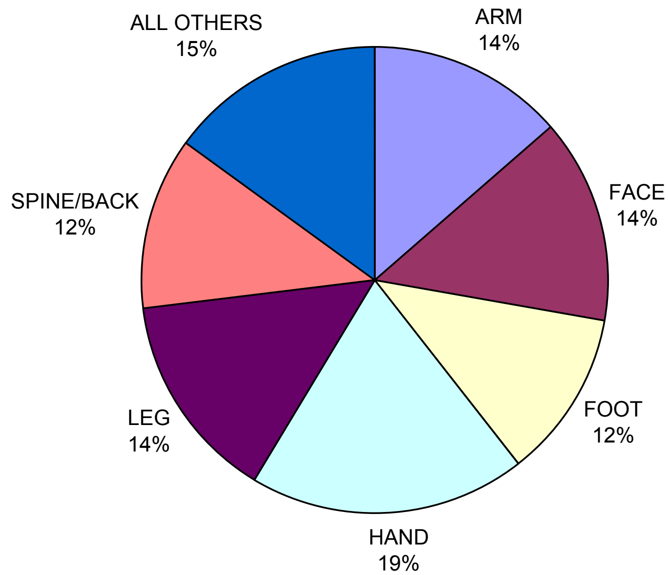


Fig. 18 FIELD CROPS-INCLUDING DRIVERS INJURED BODY PART (NCCI 0037)
(n = 281)



Specific Aim 1C: Occupational Injury by Body Part cont.

Fig. 19 CATTLE/LIVESTOCK RAISING INJURED BODY PART (NCCI 0083) (n = 1182)

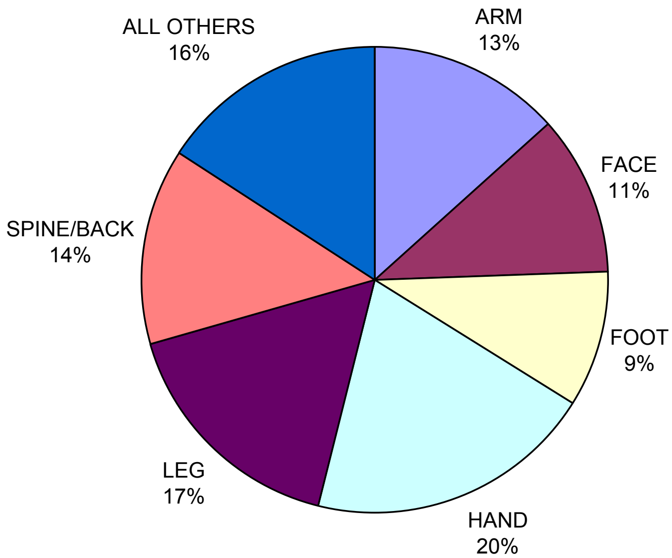
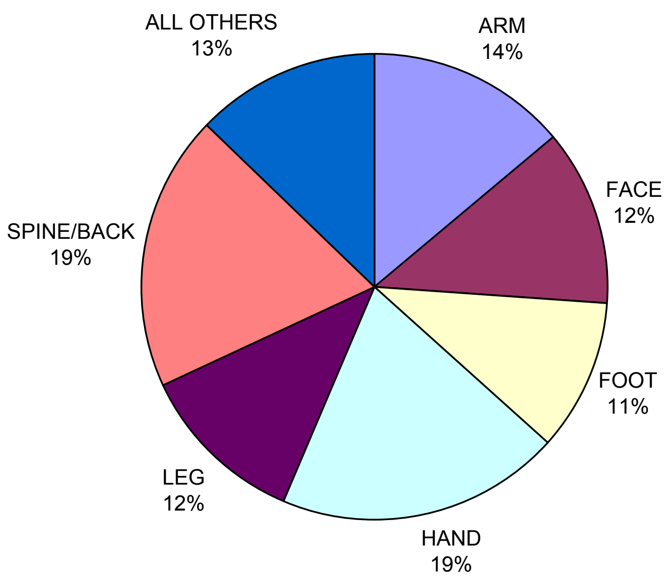


Fig. 20 GRAIN MILLING INJURED BODY PART (NCCI 2014) (n = 446)



Specific Aim 1C: Occupational Injury by Body Part cont.

Fig. 21 BEAN SORTING/HANDLING INJURED BODY PART (NCCI 8102) (n = 263)

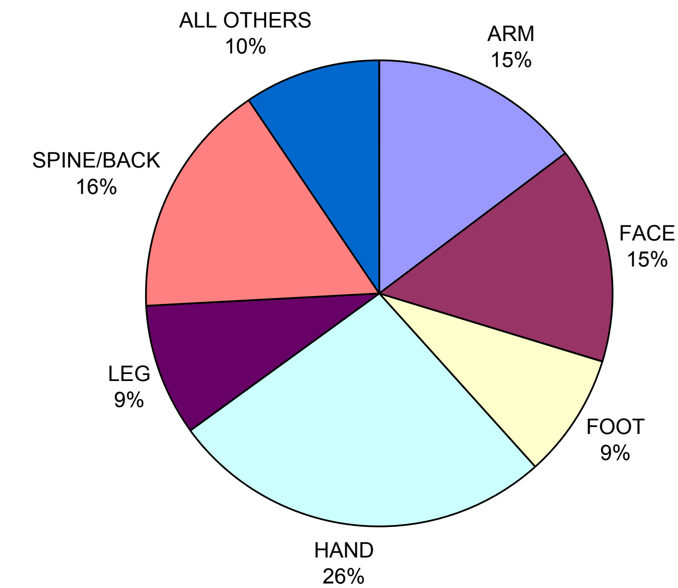
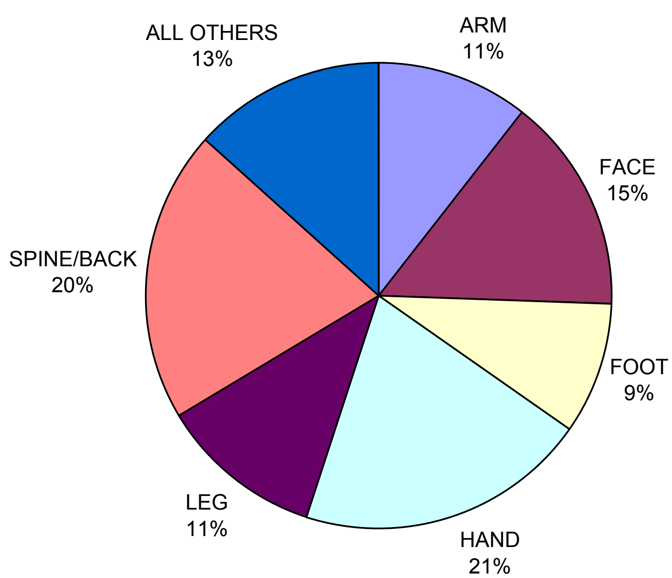


Fig. 22 HAY GRAIN/FEED DEALERS INJURED BODY PART (NCCI 8215) (n = 265)



Specific Aim 1C: Occupational Injury by Body Part cont.

Fig. 23 CATTLE DEALERS INJURED BODY PART (NCCI 8288) (n = 776)

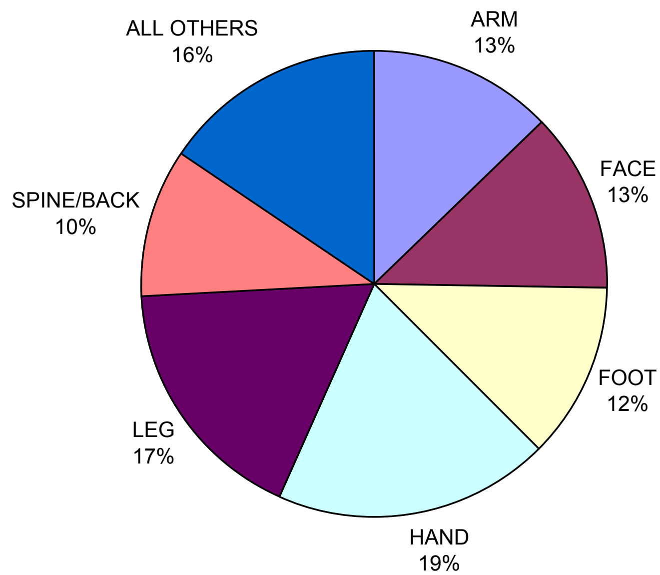
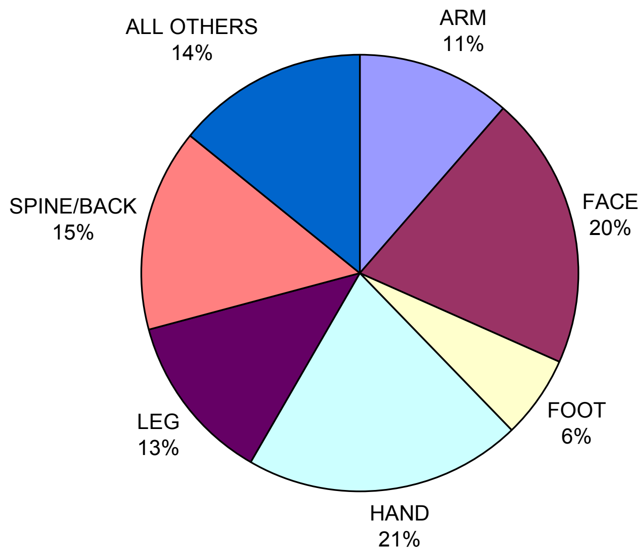


Fig. 24 GRAIN ELEVATOR OPERATORS INJURED BODY PART (NCCI 8304) (n = 302)



Specific Aim 2: Average Economic Costs of Injuries by Cause (Medical + Indemnity)

Fig. 25 DAIRY FARMS (NCCI 0036)

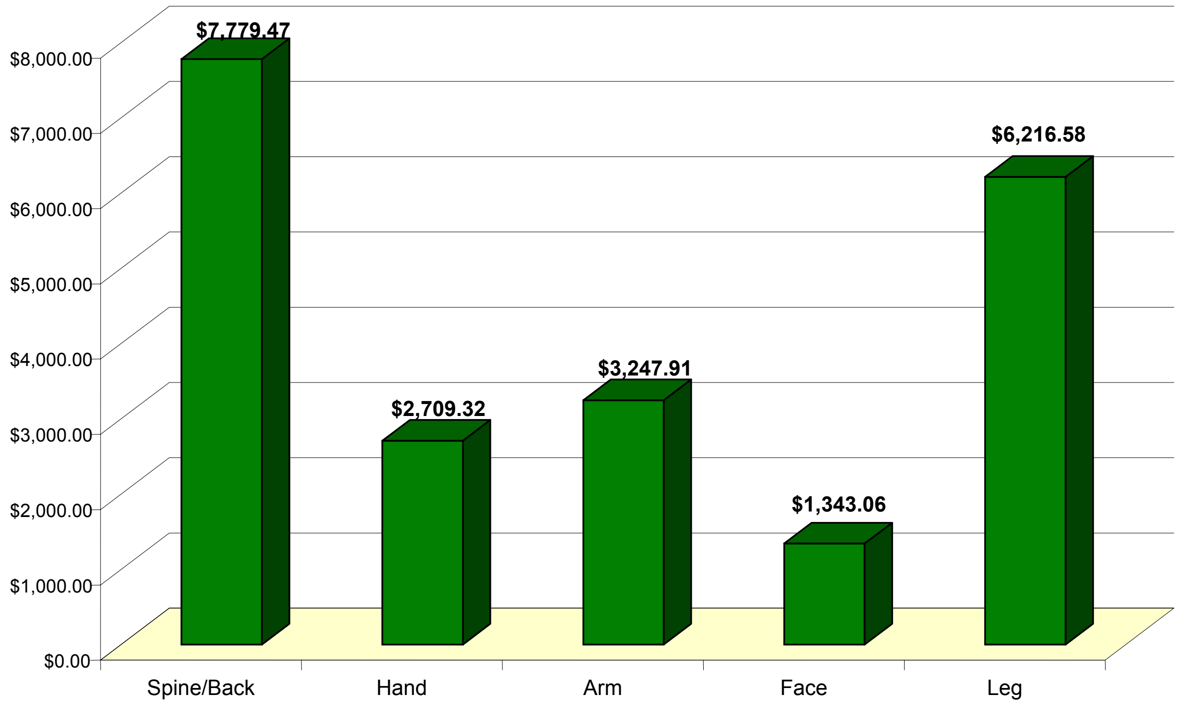
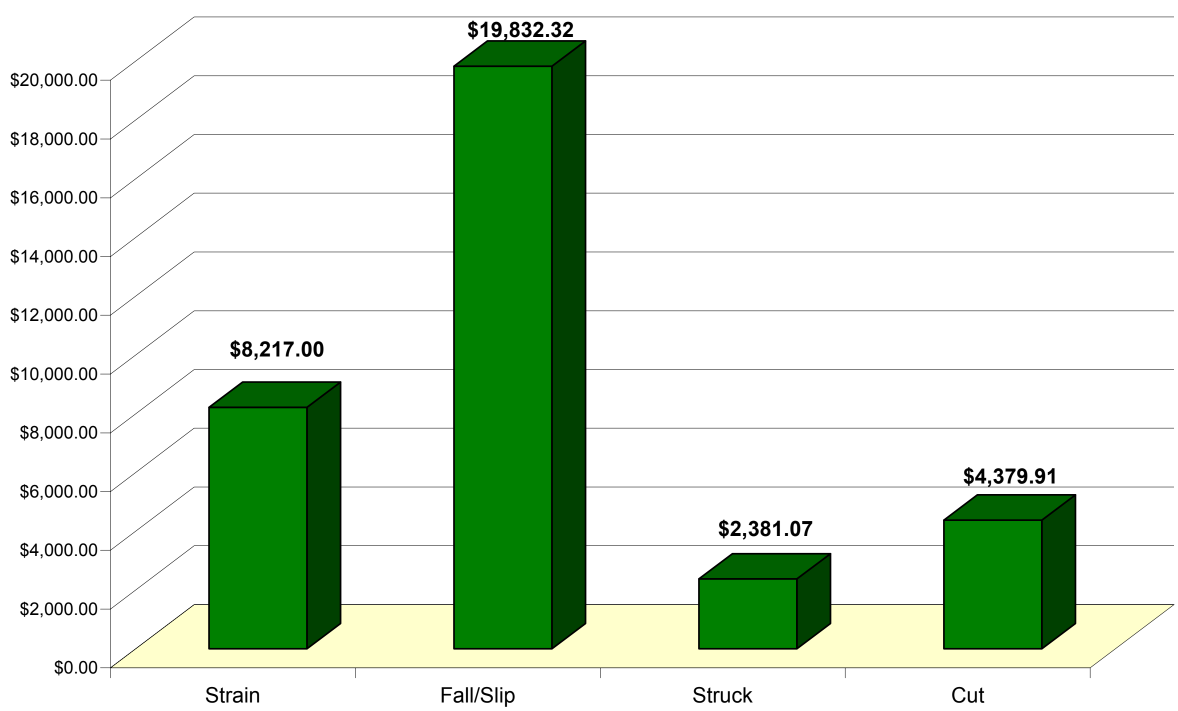


Fig. 26 FIELD CROPS-INCLUDING DRIVERS (NCCI 0037)



Specific Aim 2: Average Economic Costs of Injuries by Cause (Medical + Indemnity) cont.

Fig. 27 CATTLE/LIVESTOCK RAISING (NCCI 0083)

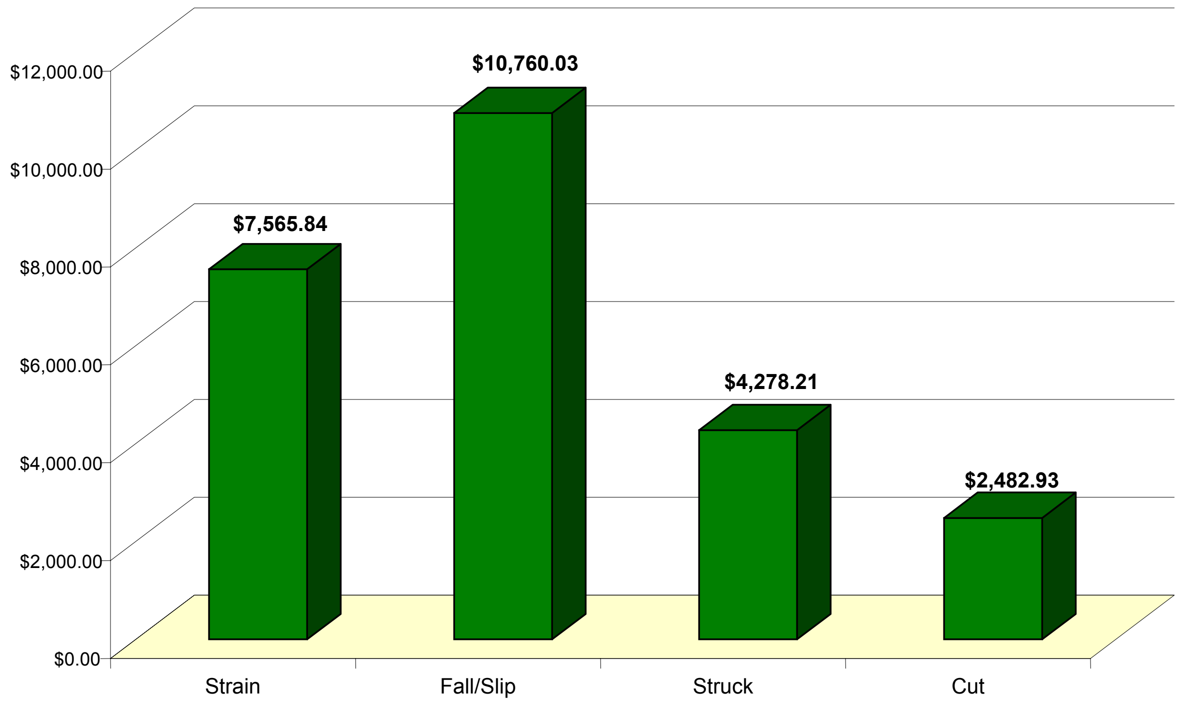
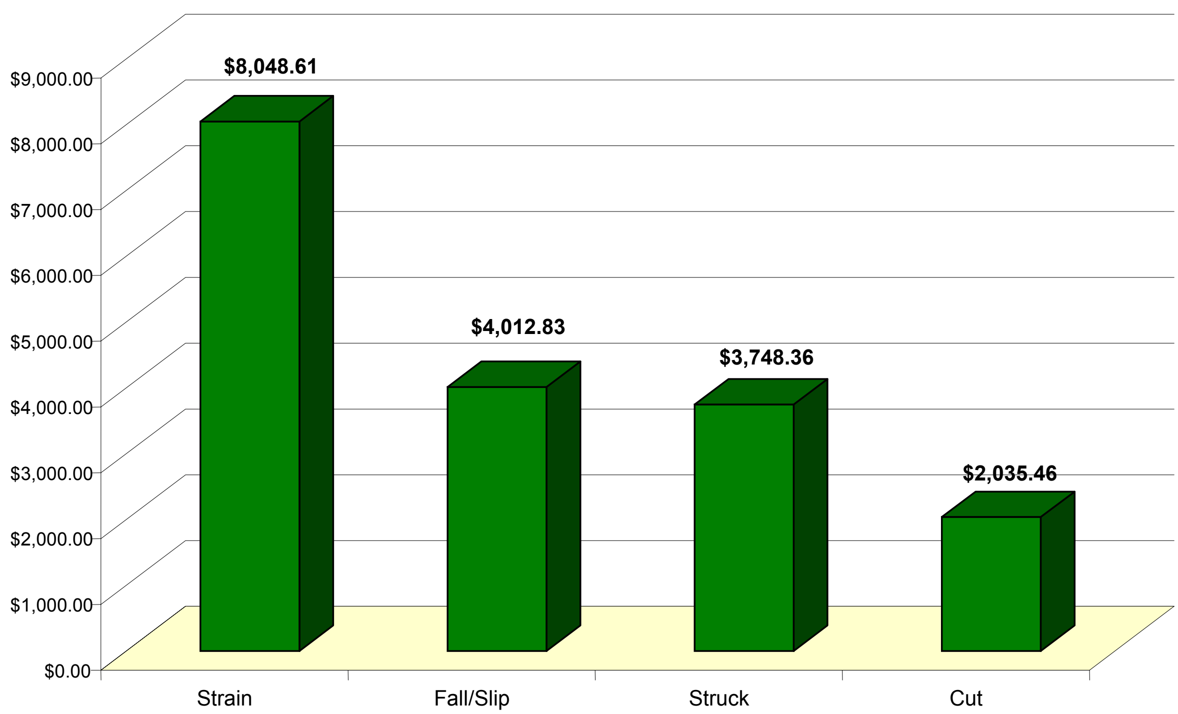


Fig. 28 GRAIN MILLING (NCCI 2014)



Specific Aim 2: Average Economic Costs of Injuries by Cause(Medical + Indemnity) cont.

Fig. 29 BEAN SORTING/HANDLING (NCCI 8102)

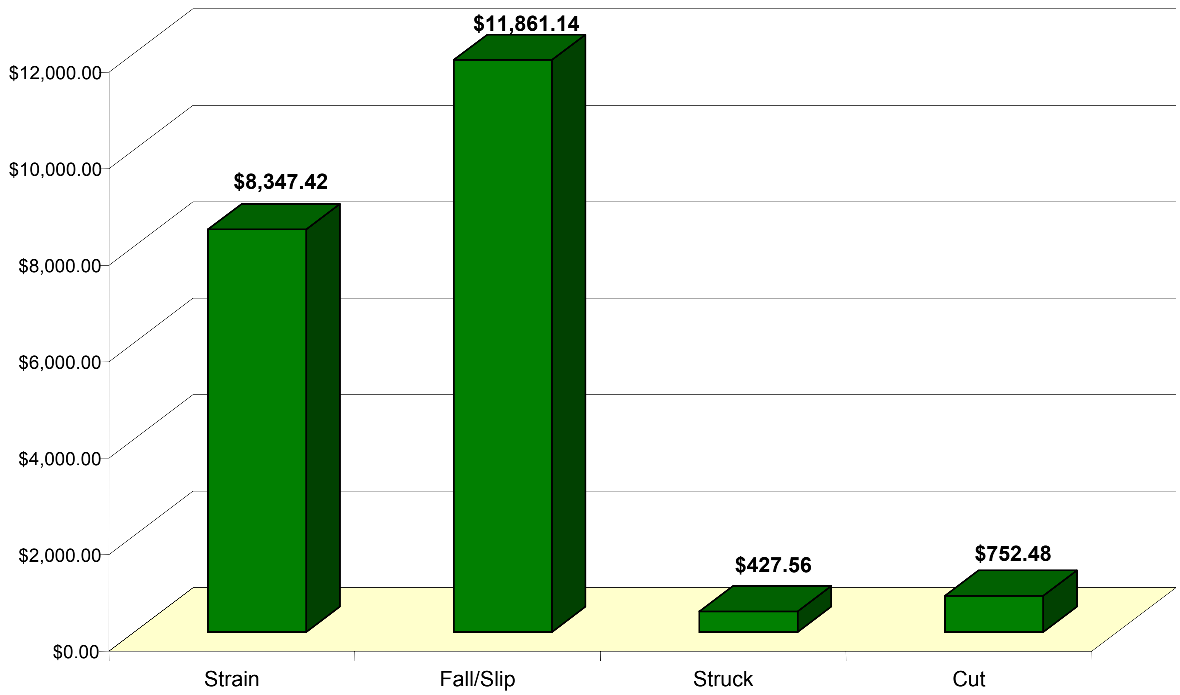
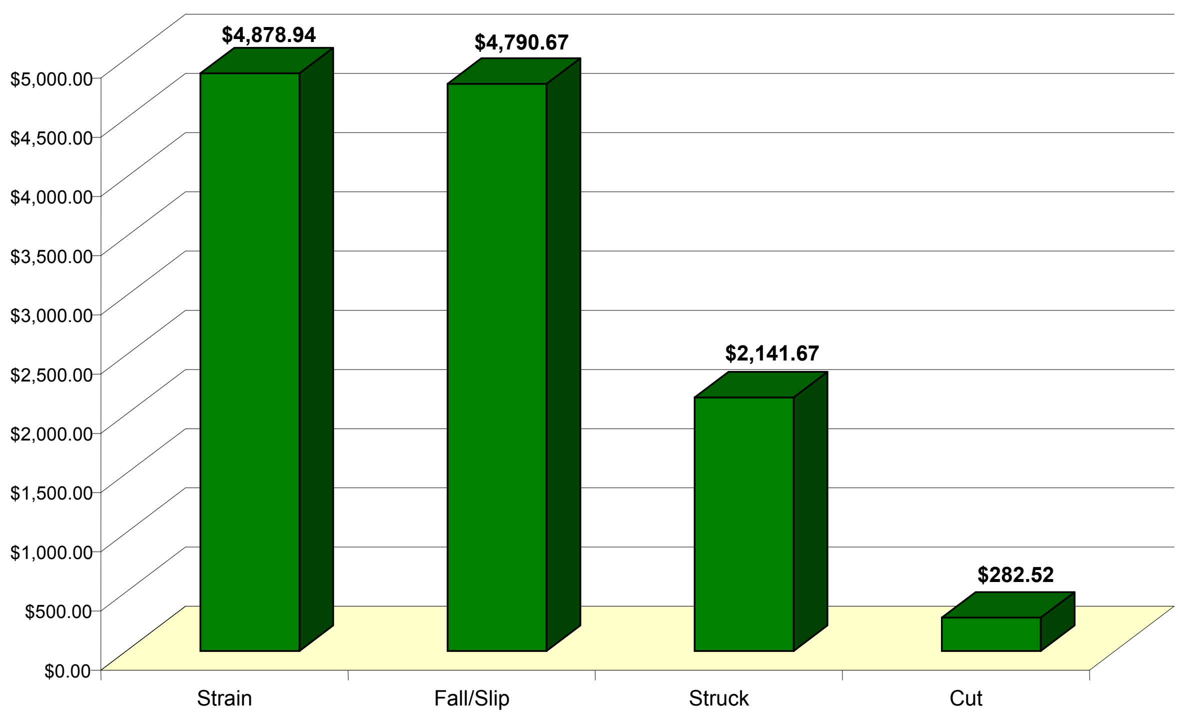


Fig. 30 HAY GRAIN/FEED DEALERS (NCCI 8215)



Specific Aim 2: Average Economic Costs of Injuries by Cause (Medical + Indemnity) cont.

Fig. 31 CATTLE DEALERS (NCCI 8288)

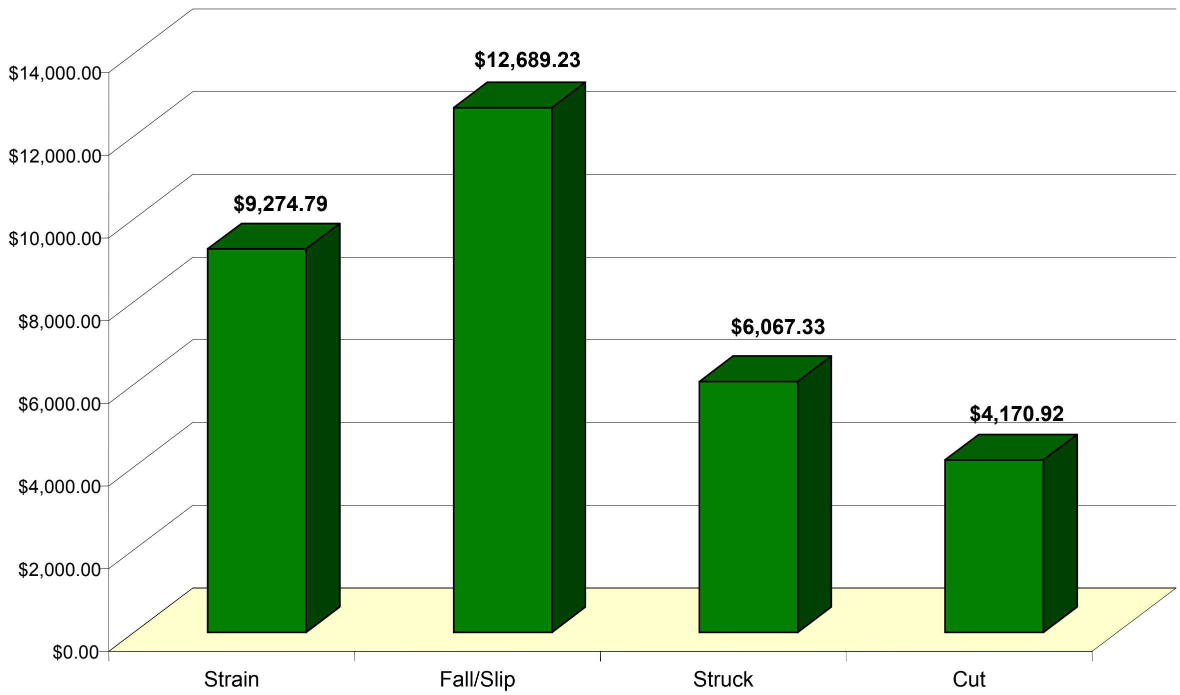
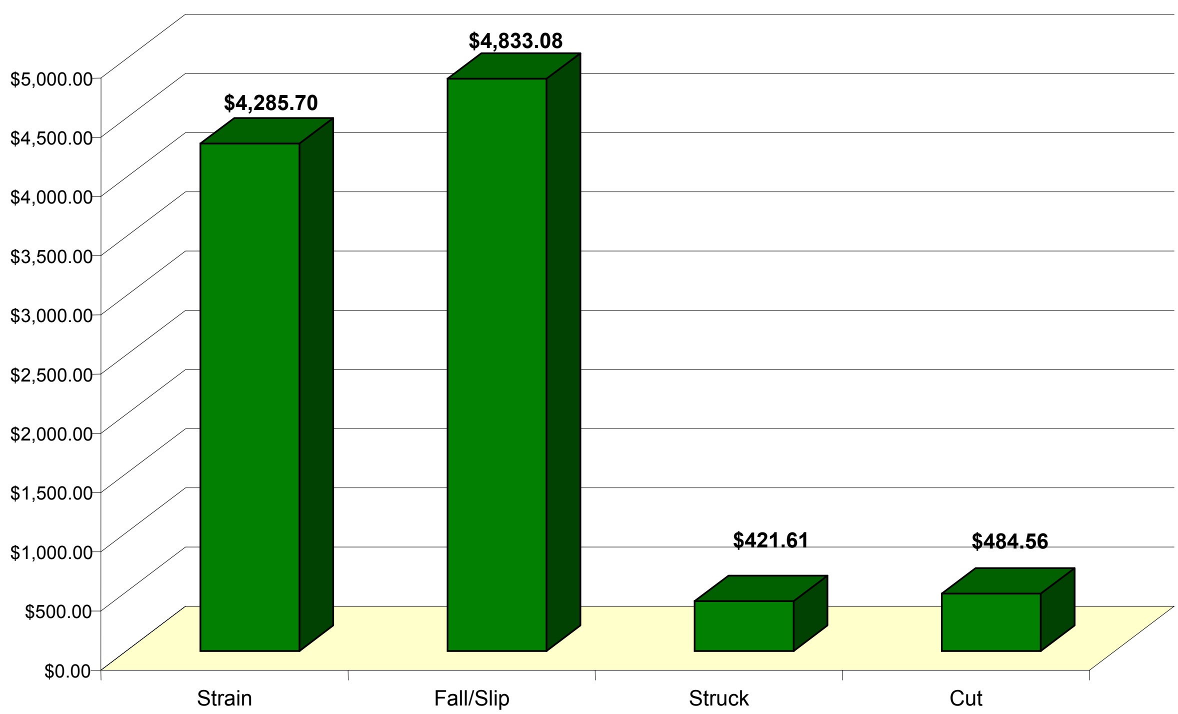


Fig. 32 GRAIN ELEVATOR OPERATORS (NCCI 8304)



Specific Aim 2: Average Economic Costs of Injuries by Nature (Medical + Indemnity) cont.

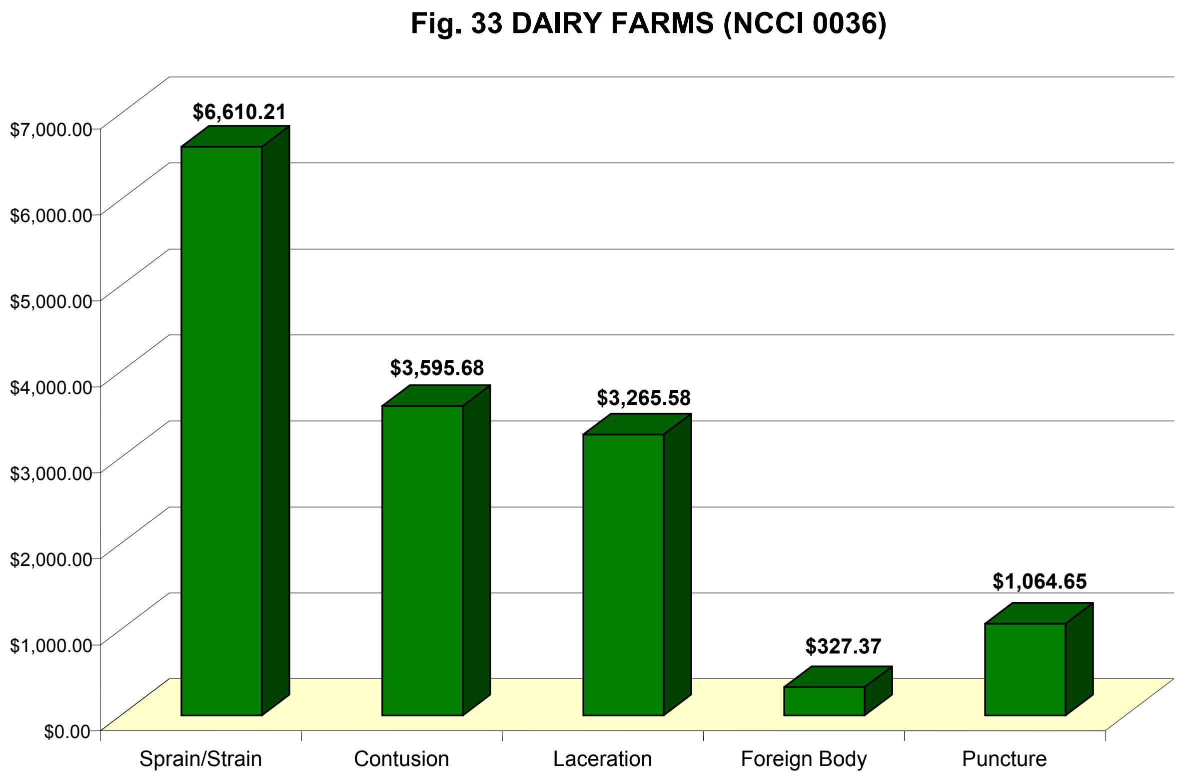
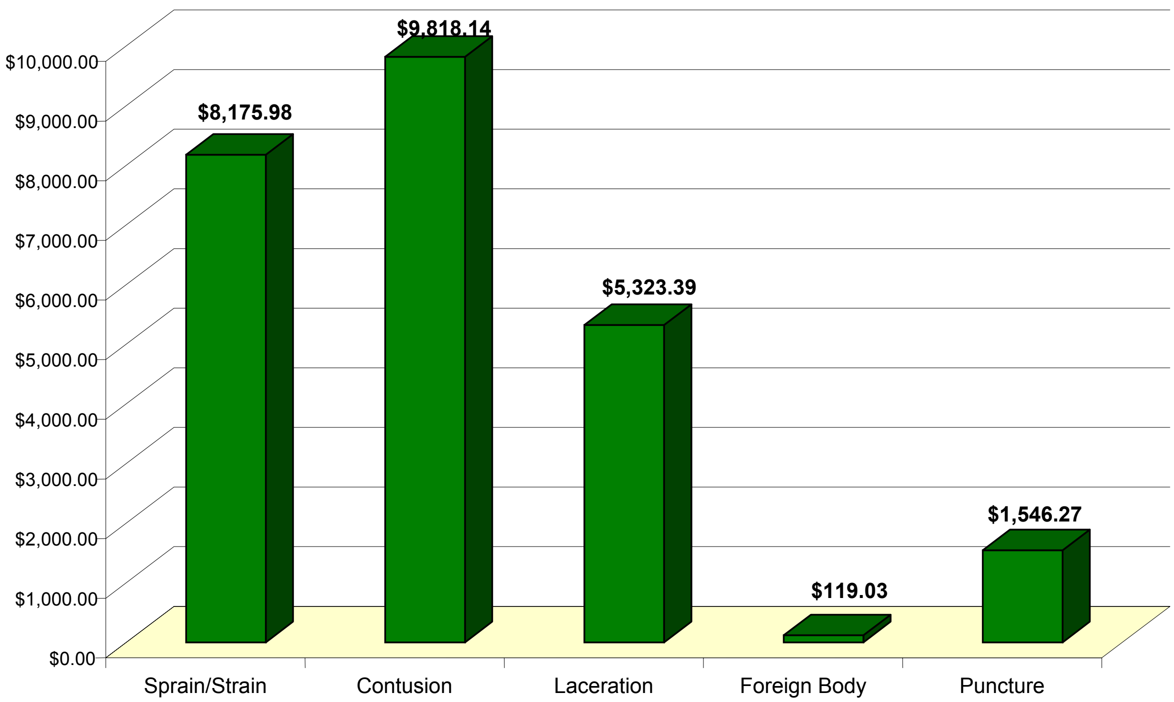


Fig. 34 FIELD CROPS-INCLUDING DRIVERS (NCCI 0037)



Specific Aim 2: Average Economic Costs of Injuries by Nature (Medical + Indemnity) cont.

Fig. 35 CATTLE/LIVESTOCK RAISERS (NCCI 0083)

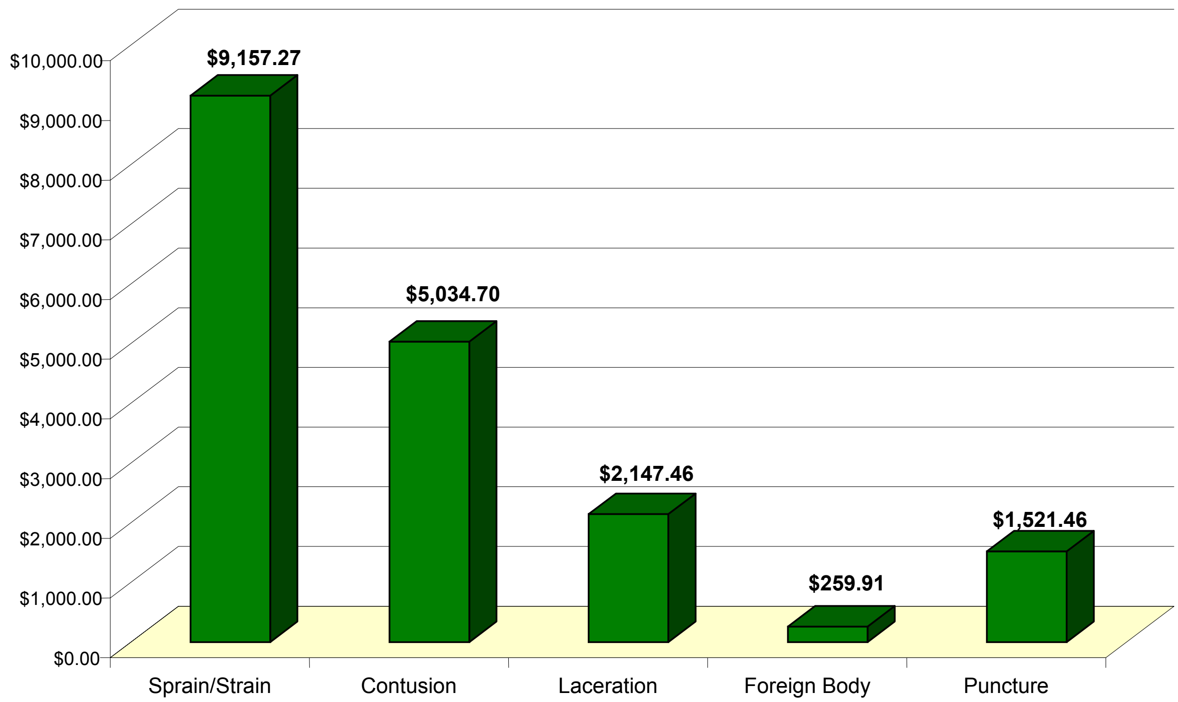
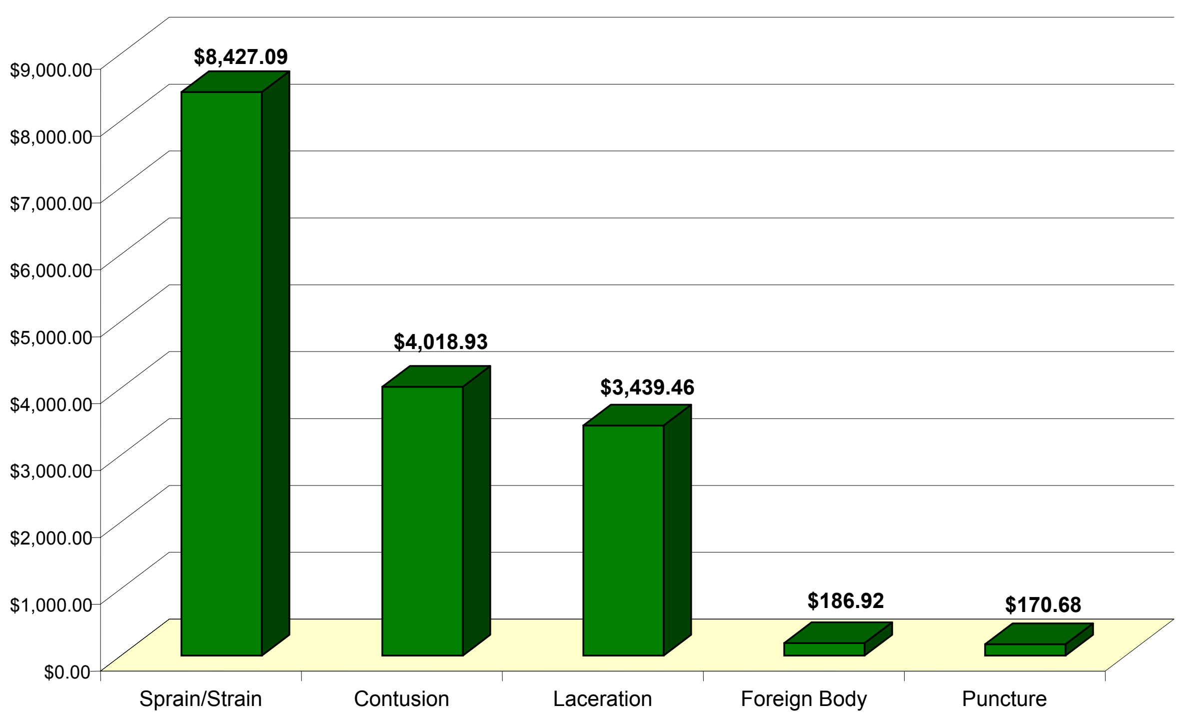


Fig. 36 GRAIN MILLING (NCCI 2014)



Specific Aim 2: Average Economic Costs of Injuries by Nature (Medical + Indemnity) cont.

Fig. 37 BEAN SORTING/HANDLING (NCCI 8102)

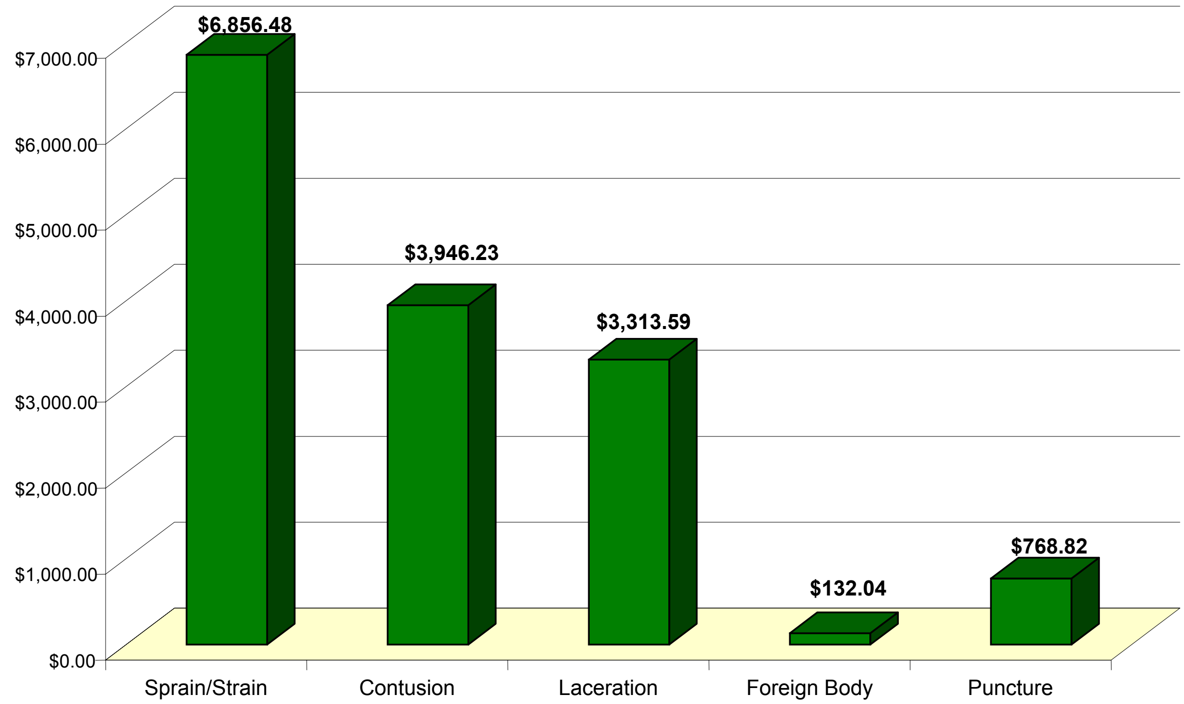
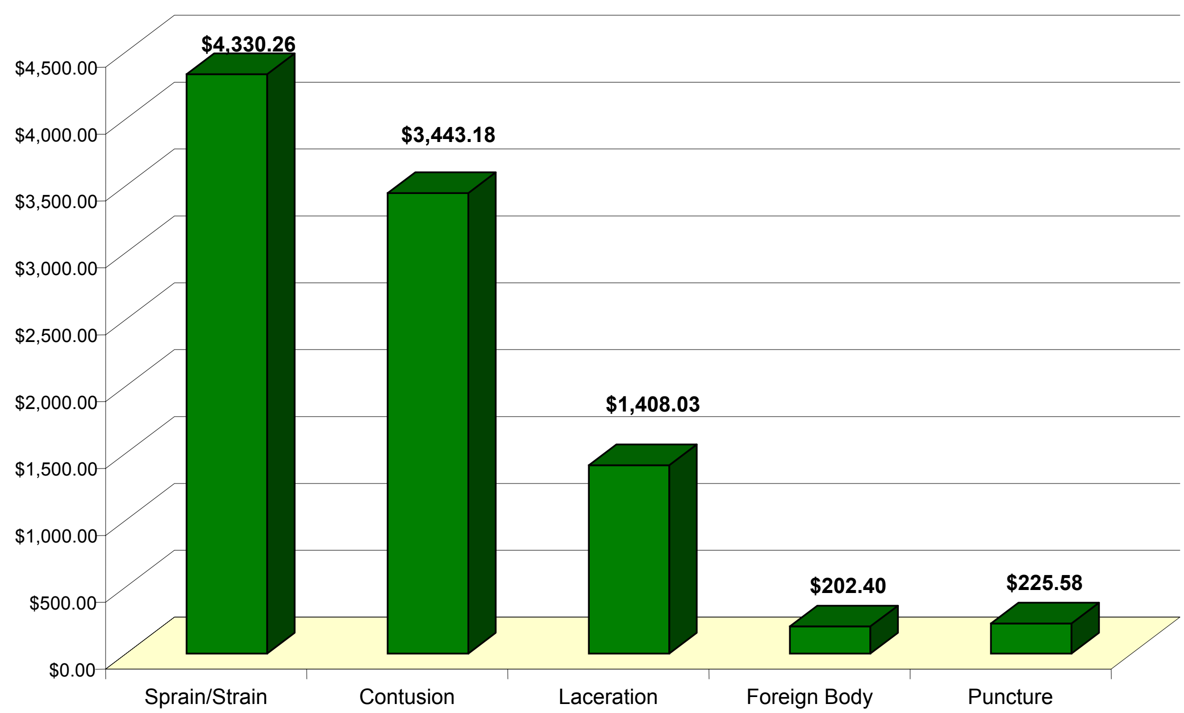
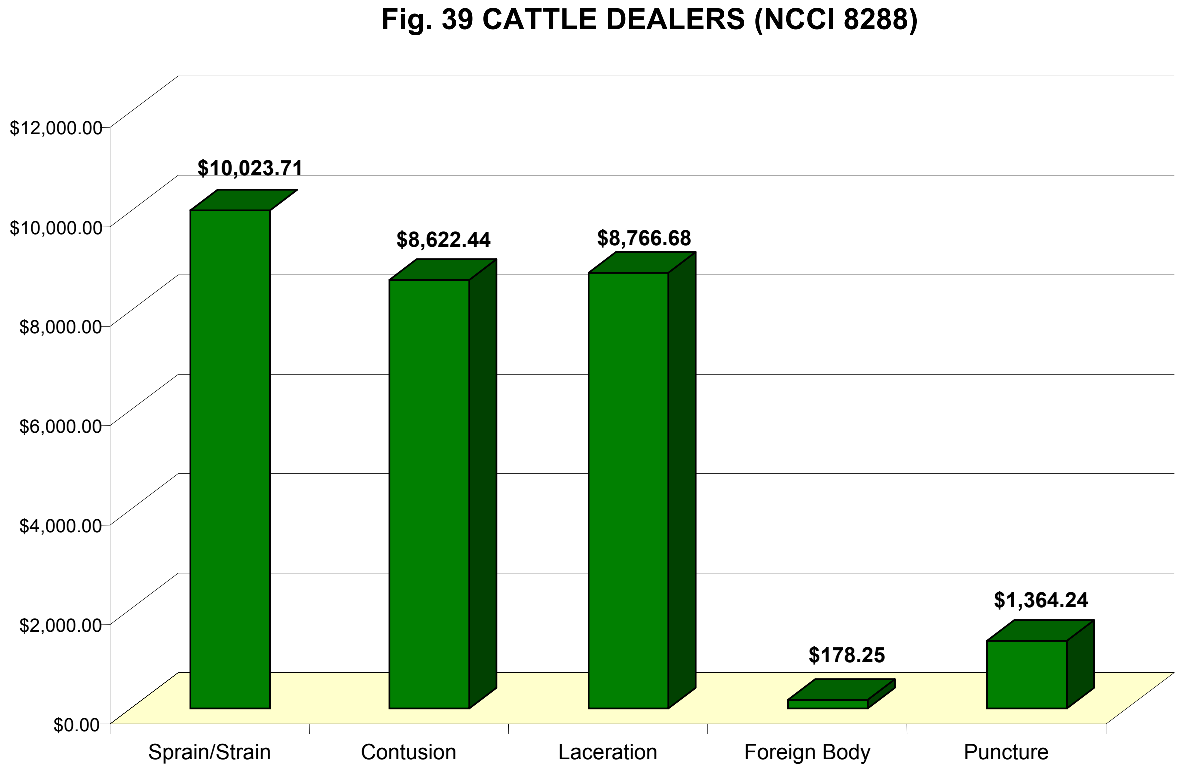
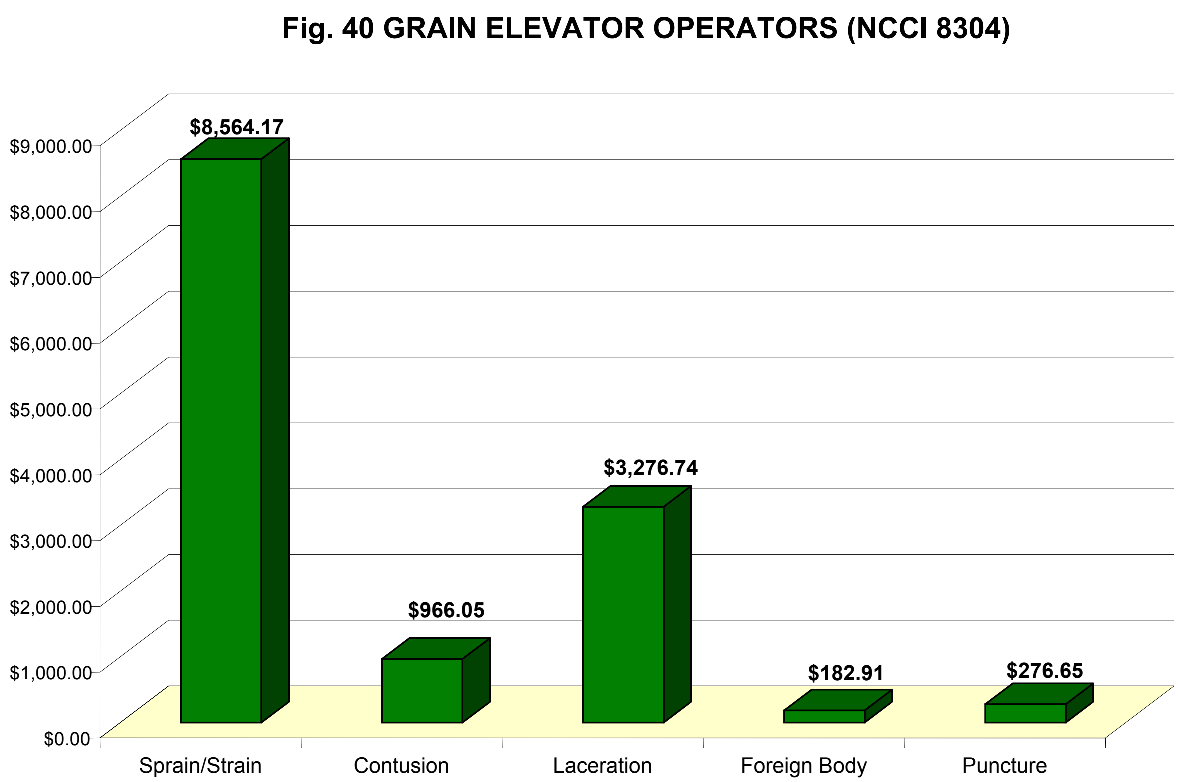


Fig. 38 HAY GRAIN/FEED DEALERS (NCCI 8215)



Specific Aim 2: Average Economic Costs of Injuries by Nature (Medical + Indemnity) cont.





Specific Aim 2: Average Economic Costs of Injuries by Body Part (Medical + Indemnity)

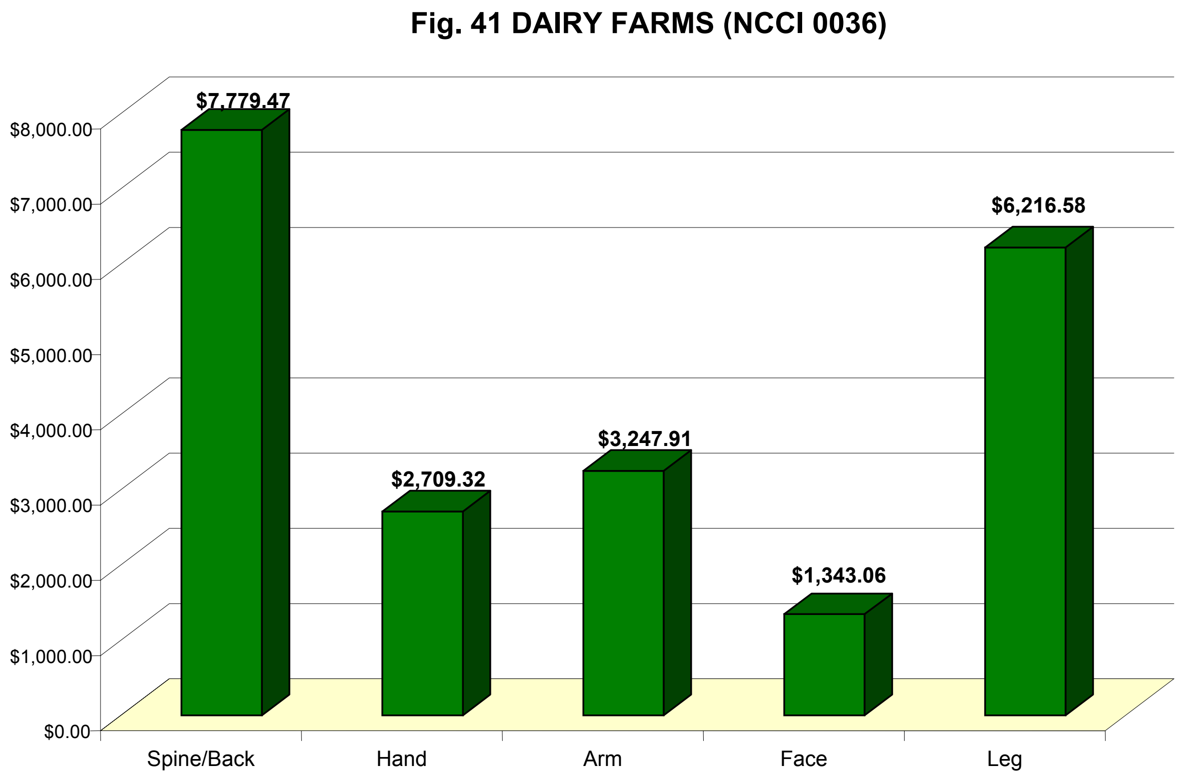
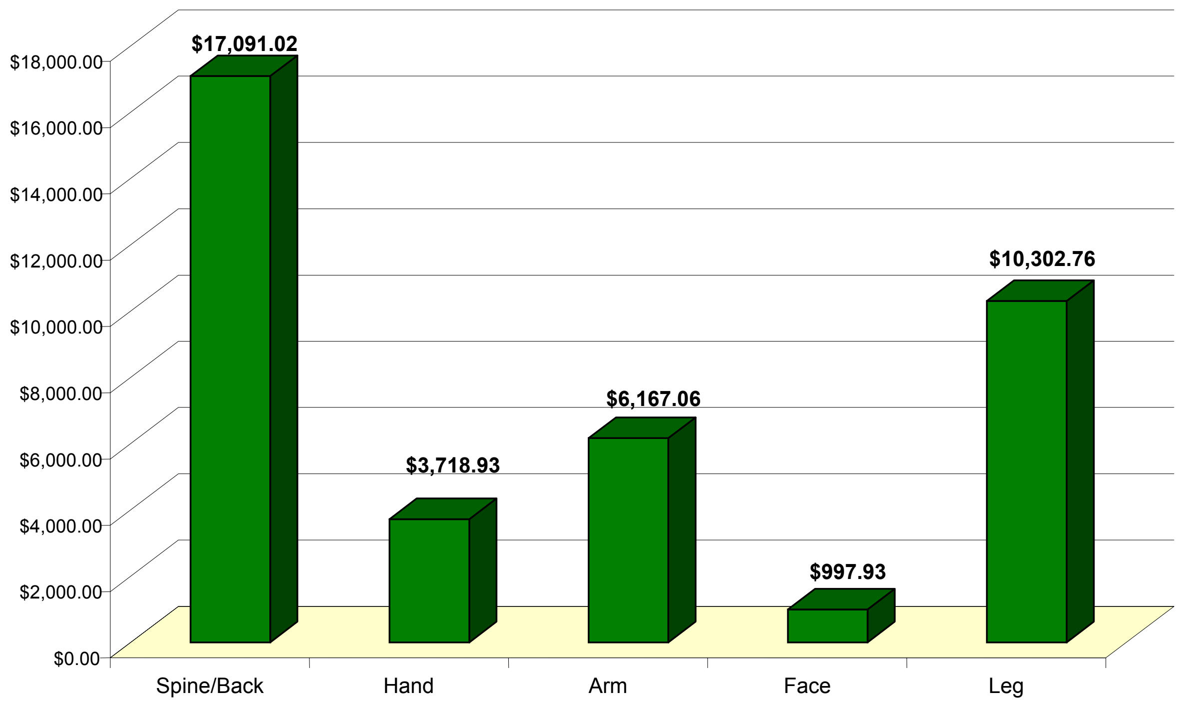


Fig. 42 FIELD CROPS-INCLUDING DRIVERS (NCCI 0037)



Specific Aim 2: Average Economic Costs of Injuries by Body Part (Med + Indemnity) cont.

Fig. 43 CATTLE/LIVESTOCK RAISERS (NCCI 0083)

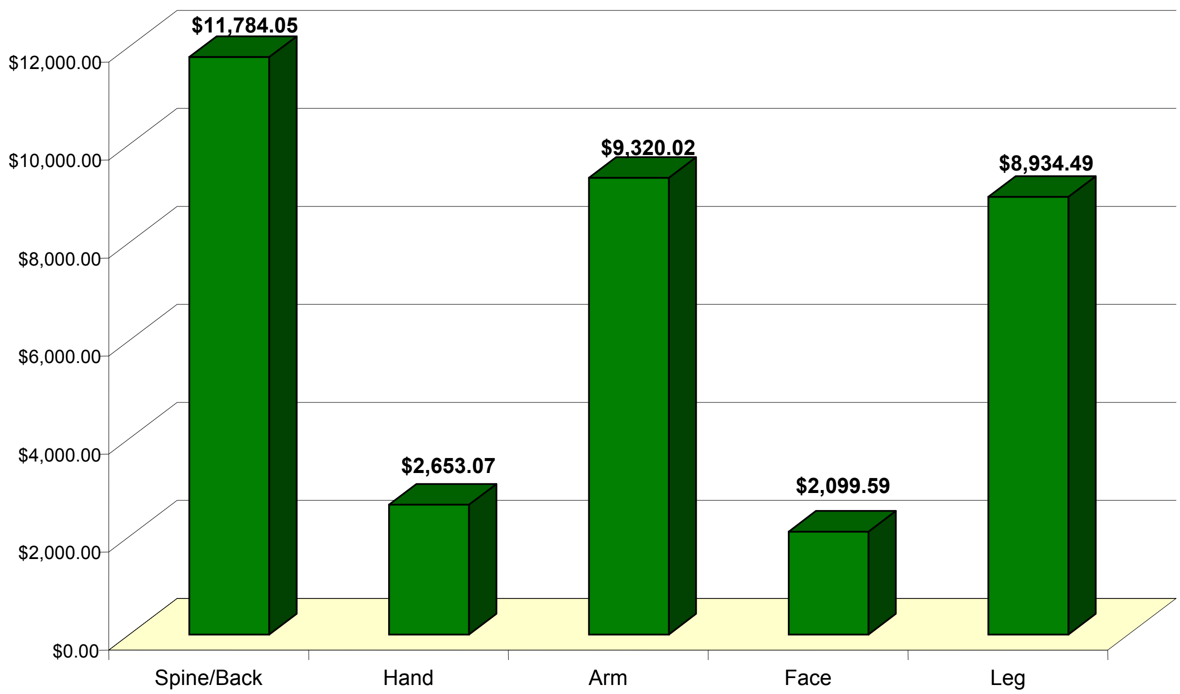
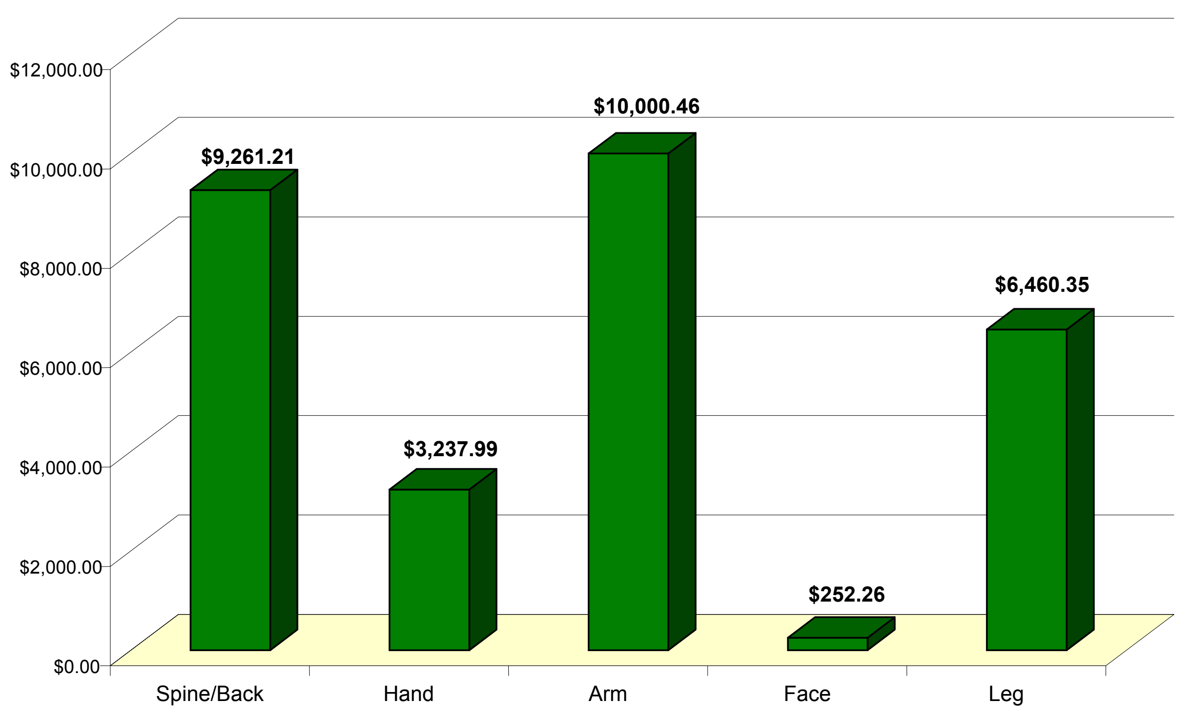


Fig. 44 GRAIN MILLING (NCCI 2014)



Specific Aim 2: Average Economic Costs of Injuries by Body Part (Med + Indemnity) cont.

Fig. 45 BEAN SORTING/HANDLING (NCCI 8102)

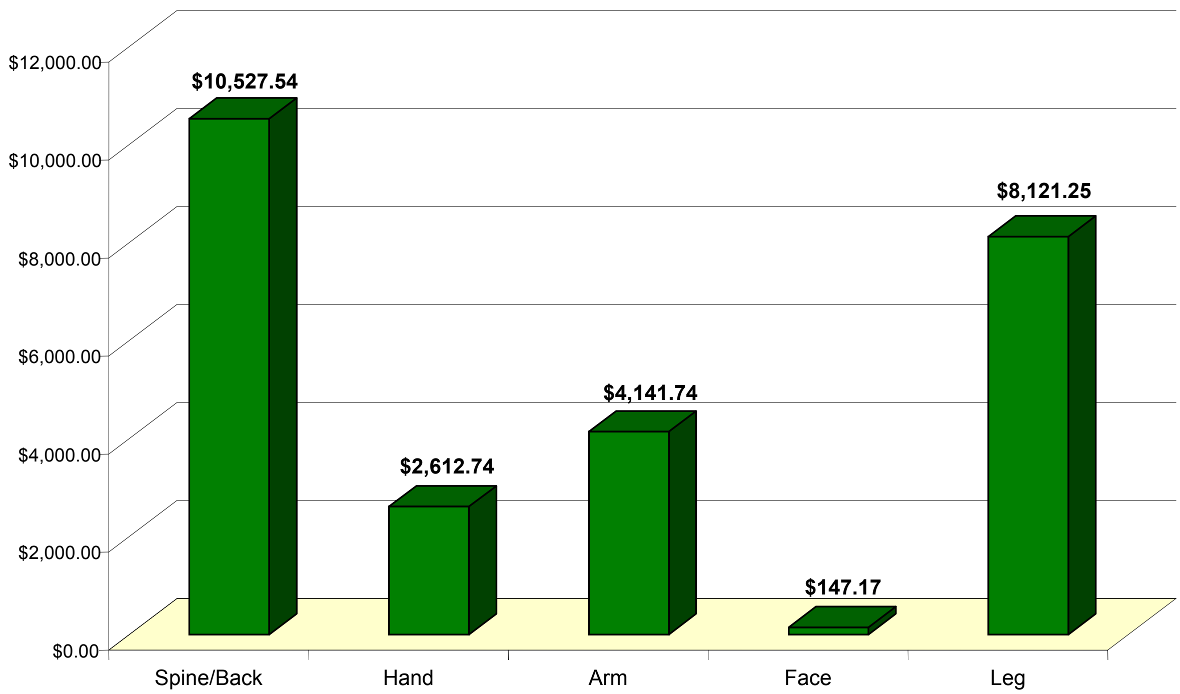
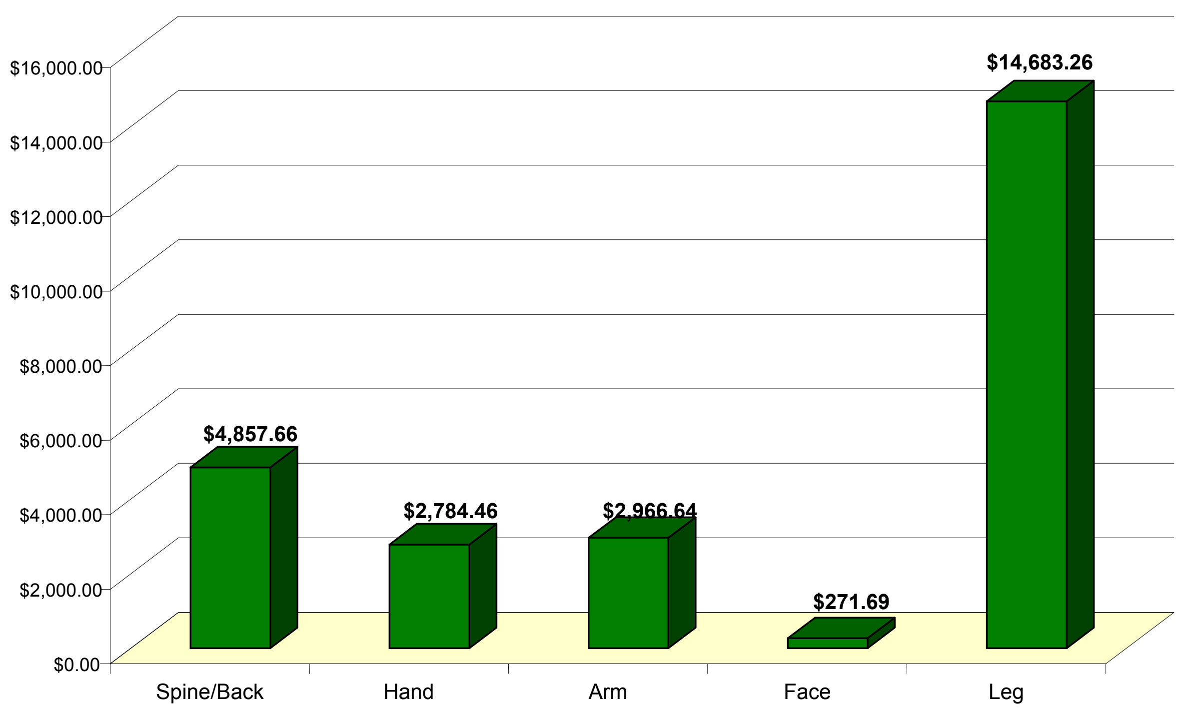


Fig. 46 HAY GRAIN/FEED DEALERS (NCCI 8215)



Specific Aim 2: Average Economic Costs of Injuries by Body Part (Med + Indemnity) cont.

Fig. 47 CATTLE DEALERS (NCCI 8288)

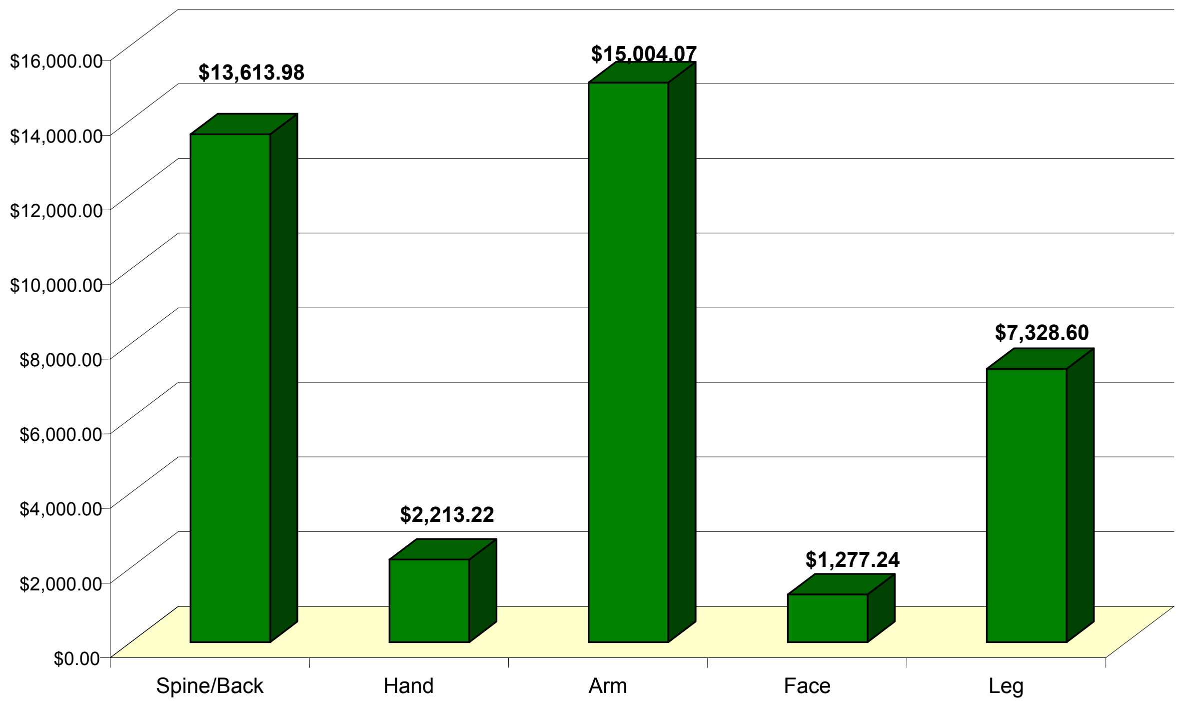
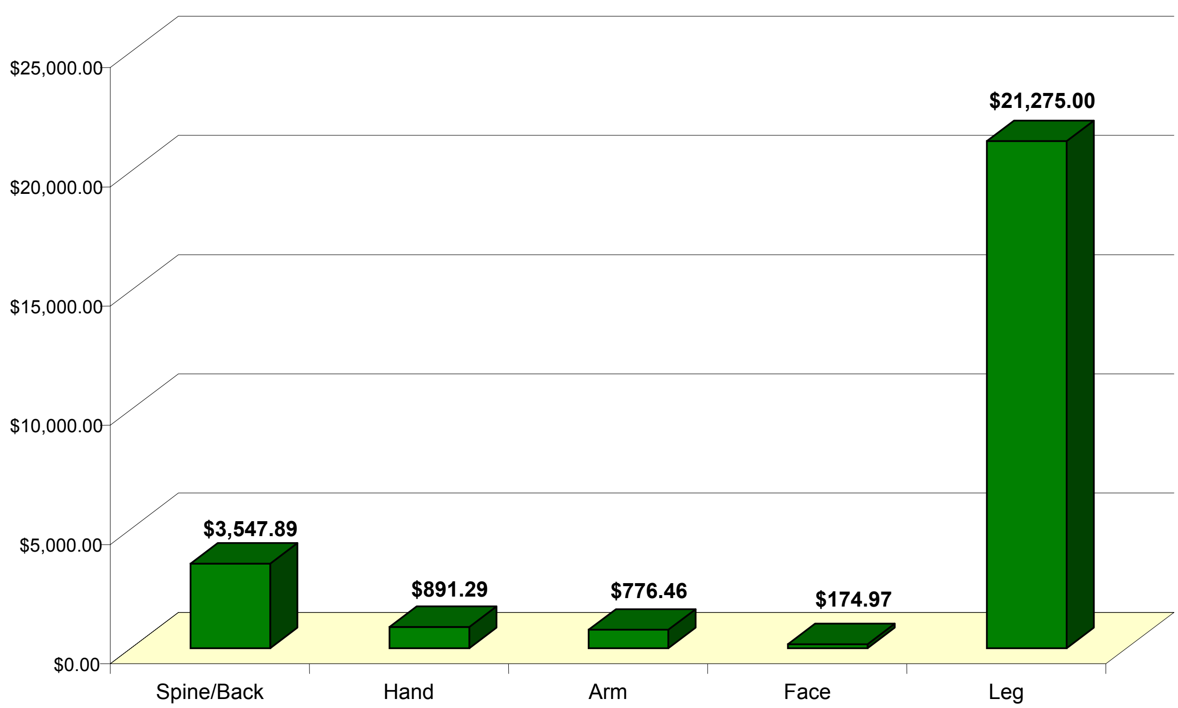


Fig. 48 GRAIN ELEVATOR OPERATORS (NCCI 8304)



Specific Aim 3: Economic Burden of Injuries

Table 3. Economic Burden of Injuries as Percentage of Payroll

Class Code	Period Payroll Range	Economic Burden (% of Payroll)
Diary Farms (0036)	Less than $759,768	0.97
	$759,769 - $1,519,536	0.63
	Greater than $1,519,537	0.14
Field Crops-Incl Drivers (0037)	Less than $126,666	1.75
	$126,667 - $253,333	3.57
	Greater than $253,334	0.94
Cattle/Livestock Raising (0083)	Less than $888,400	1.85
	$888,401 - $1,776,800	0.26
	Greater than $1,776,801	0.14
Grain Milling (2014)	Less than $266,666	0.95
	$266,667 - $533,333	0.42
	Greater than $533,334	0.55
Bean Sorting/Handling (8102)	Less than $323,333	0.81
	$323,334 - $646,666	0.19
	Greater than $646,667	0.23
Hay Grain/Feed Dealers (8215)	Less than $277,547	1.55
	$277,548 - $555,095	0.75
	Greater than $555,096	0.49
Cattle Dealers (8288)	Less than $671,434	1.25
	$671,435 - $1,342,869	0.49
	Greater than $1,342,870	0.30
Grain Elevator Operators (8304)	Less than $187,348	1.04
	$187,349 - $374,695	0.50
	Greater than $374,696	0.07

EXECUTIVE SUMMARY

Nature of Injuries

Upon analysis of the eight agriculture codes, contusions were the leading type of occupational injuries among dairy workers, field crop workers, cattle/livestock raisers, and cattle dealers. Sprain/strains were the leading type of injury among grain millers, bean sorters/handlers, hay grain/feed dealers and grain elevator operators. Dairy farm workers had the highest percentage (46%) of contusions and bean sorters/handlers had the highest percentage (42%) of sprains/strains. In all eight occupations analyzed, contusions and sprain/strains combined accounted over half of all injures. Grain elevator operators had the highest percentage of foreign body injuries (10%). Hay grain/feed dealers and grain elevator operators each had the highest percentage of laceration injuries (13%).

Causes of Injuries

An investigation into the causes of occupational injuries among agriculture workers was performed. Upon analysis, "environmental" causes resulted in the majority of occupational injuries among dairy farm workers, field crop workers, cattle/livestock raisers and cattle dealers. Environmental causes included injuries that resulted from coming in contact with cold objects or substances, collapsing materials (slides of earth), electric shock and falls on ice or snow. Strain caused by overexertion was the leading cause of occupational injury among grain millers, bean sorters/handlers, hay grain/feed dealers and grain elevator operators. Dairy farm workers had the highest percentage (30%) of injuries caused by environmental sources and hay grain/feed dealers had the highest percentage (33%) of injuries caused by overexertion (strain). Fall/slip injuries accounted for a minimum of 11% of injuries in all occupational categories, with hay grain/feed dealers having the highest percentage of 17%. No occupational category analyzed did cumulative trauma injuries account for more than 4% of injuries, with bean sorting having the highest percentage (4%).

It is interesting to note that those occupations (dairy workers, field crop workers, cattle/livestock raisers, and cattle dealers) with the highest percentages of contusions also had the highest percentages of injuries caused by environmental factors. In addition, those with the highest percentage of sprains/strains (grain millers, bean sorters/handlers, hay grain/feed dealers and grain elevator operators) also had the highest percentages of injuries caused by overexertion.

Injured Body Part

An analysis was performed to investigate the most common body regions where occupational injuries took place among agriculture workers. In all but one occupation analyzed, the majority of occupational injuries was classified in the "All Other" domain. The majority of injuries among grain elevator operators took place on the hand. Injuries to the hand and spine/back were the second and third leading body areas for injury respectively among dairy farm workers, field crop workers, cattle/livestock raisers, grain millers, bean sorters/handlers, hay grain/feed dealers and cattle dealers. The face and spine/back were the second and third leading areas of injury respectively among grain elevator operators.

Costs of Injuries

In accordance with Specific Aim 2, economic cost analyses were performed. Sprains/strains were the most expensive injury among all agriculture workers analyzed except for field crop workers. The average cost (medical + indemnity) for a sprain/strain injury ranged from $4,330 to $10,023. In the majority of workers (six of the eight occupations analyzed), contusions were the second most expensive injury, with the average cost ranging from $966 to $9,818.

Fall/slip was the most expensive cause of injury among field crop workers, cattle/livestock raisers, bean sorters/handlers, cattle dealers and grain elevator operators. The average cost of an injury caused by a fall/slip ranged from $4,013 to $19,832. Overexertion (strain) injuries were the most expensive injures among dairy workers, grain millers and hay grain/feed dealers. Overexertion injury costs ranged from $4,286 to $9,275. The least expensive causes of injuries were cuts and struck injuries.

Injuries to the spine/back were the most expensive among dairy workers, field crop workers, cattle/livestock raisers and bean sorters/handlers. These injuries ranged from $3,547 to $17,091. Leg injuries ranged from $6,217 to $21,275 and arm injuries ranged from $776 to $15,004. Injuries to the face were the least expensive among all workers investigated with average costs ranging from $147 to $2,100.

Economic Burden

In all but one occupational class code (Field Crops-Including Drivers), the economic burden (% of period payroll) of injuries increased with those agriculture businesses that had smaller period payrolls. In other words, the economic burden was greater with businesses that had smaller payrolls. This potentially could be interpreted that smaller agricultural operations could have higher economic burdens due to their occupational injuries (if these operations did not have workers compensation insurance).

One must keep in mind that the workers compensation company bears the responsibility of paying for the medical and indemnity costs of injuries for the policy holders. Some businesses do not carry workers compensation insurance and they budget for and pay for their own occupational injury insurance (better known as “self-insured”). The data generated from this study will serve these companies by demonstrating their true economic burden as a result of occupational injuries. Historical injury costs help determine the policy premiums for those who do purchase workers compensation insurance. The data generated from this study will serve these companies by demonstrating how their future operational costs (insurance premiums) will be calculated. In the long run, the assimilation of health and safety interventions may be more effective if the agriculture operation owners have a better appreciation of the economic burden due to occupational injuries.

FUTURE WORK

The purpose of this report is to provide an account of the progress that has been made in regards to this research project. More data analysis will be conducted to gain a more specific insight into the demographics of the injured worker and the individual agriculture operation enterprise. More detailed analyses will be conducted to determine the economic ramifications of occupational injuries in the agriculture sector.

After completion of this project, the data generated will be presented to four agricultural associations that include the Colorado Cattlemen's Association, Colorado Livestock Association, Colorado Corn Growers Association, and Colorado Grain and Feed Association under the guidance of Pinnacol Assurance.

The knowledge gained from work on this project will generate additional hypotheses that lead to new insights, and novel methods that contribute to effective prevention strategies for all occupational musculoskeletal injuries. The results of this study will target Colorado agriculture sectors that are in need of ergonomic strategies to reduce or eliminate job related injuries. Future research studies will be conducted based on the results of this investigation to determine the effectiveness of specific ergonomic interventions in reducing the frequency, severity and costs of agriculture injuries. This study can also be used as a format to investigate injuries in other Colorado industry sectors.

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