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The Pennsylvania Central Region Farm Safety Pilot Project: Part II—Baseline Data Associations between Approach-to-Safety and Hazard Conditions

D. Landsittel, D. Hard, D. Murphy, N. E. Kiernan

Abstract

This article analyzes baseline data associations between farmers' approach-to-safety and hazard conditions on their farms. Identifying which aspects of approach-to-safety are significantly associated with actual hazard conditions will help researchers design and implement more effective educational interventions. Baseline data on 216 different farms in the Pennsylvania Central Region Farm Safety Pilot Project (PCRFSPP) were collected through the use of a self-administered survey questionnaire of the farmers' approach-to-safety and a hazard audit (by a trained auditor) of participating farms. Factor analysis was used to determine construct validity of the questionnaire. To measure the reliability of the survey, Cronbach's alpha was calculated for each component in the questionnaire. After adjusting for significant demographics (farm size, income, and hired labor) in a linear regression, greater concern by farm operators for absence of safety features was significantly associated with less hazardous conditions. These results provide useful guidelines for designing and implementing agricultural safety interventions by identifying which factors are significantly related to hazard conditions.

Keywords. Hazard conditions, Approach-to-safety, Demographics, Reliability.

The Pennsylvania Central Region Farm Safety Pilot Project (PACRFSPP) is an agricultural safety and health project that tests three interventions designed to reduce hazards and risks of farm work. The three interventions represent distinct operational approaches to farm safety and health education and farm risk reduction. Agricultural safety research so far has not revealed which, if any, aspects or components of a farmer's approach-to-safety are associated with differences in hazards on farms. Nor is there a good understanding of how demographic variables affect associations between a farmer's approach-to-safety and farm hazard conditions. The purpose of this analysis is to describe baseline data associations which address these points.

For this project, data from 216 different farms and farm operators in four counties were collected (three intervention counties and one county as a control) before and after the introduction of safety interventions. This study analyzes the baseline data collected before the implementation of the interventions. Future

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analyses will describe the post-intervention results. Due to the size of the project, identification of the interventions, details about the project's background and rationale, operational procedures, development of instruments, educational objectives, and preliminary descriptive results from analysis of baseline data are described in a separate article (see Murphy et al., 1998). This article focuses on possible associations between components of farmers' approach-to-safety and actual hazard conditions, and how these associations may be influenced by demographic variables. Understanding associations between approaches-to-safety and actual hazard conditions is a critical step in producing effective farm safety interventions.

Methods

Data Collection

The survey, which measures a farmer's approach-to-safety, is composed of four separate components: beliefs about safety issues, concern for absence of safety features and protective devices, importance of safety practices, and knowledge of hazards and risks (see Murphy et al., 1998). Beliefs about safety issues are assessed by asking the farm operator to state their viewpoint, using a seven-point Likert scale from strongly disagree to strongly agree, with respect to 10 different statements about safety issues. These statements include the following: (1) accidents are generally unpredictable events that are going to happen to people regardless of safety education; (2) avoiding accidents is largely a matter of common sense; (3) a really good place to learn about safety is at farmer workshops and seminars; (4) farmers generally have enough money to fix safety hazards; (5) accidents are mostly predictable events that are preventable by applying good safety management techniques and principles; (6) avoiding accidents does not require training to know how to deal with hazards; (7) a really good place to learn about safety is on-the-job; (8) avoiding accidents is largely a matter of practical experience; (9) farmers usually do not have time to correct safety hazards; and (10) avoiding accidents requires training to recognize hazards. The total score for this component attempts to characterize the farm operators' overall beliefs about safety issues.

Concern for absence of safety features and protective devices is addressed by asking the farm operators to rate the extent of their concern, using a six-point Likert scale ranging from not much to extreme, for a number of different safety features and protective devices. A wide range of features and devices pertaining to tractors (such as rollover protective structure), machinery (such as a driveline shaft shield for a PTO-powered machine or wagon), buildings and structures (such as a multi-class fire extinguisher in a regularly used farm building), and emergencies (such as written emergency reporting guidelines posted near a phone) are listed. The total score for this component attempts to characterize the farm operators' overall concern for absence of safety features and protective devices.

The importance of safety practices is addressed by asking farm operators to rate the importance, using a six-point Likert scale ranging from not much to extreme, of various practices. These practices pertain to tractors (such as turning a tractor's headlights on during public road travel in the day time), machinery (such as walking around an unshielded operating PTO driveline shaft instead of stepping over it), and buildings and structures (such as having the inside of barns free of debris). The total score for this component attempts to characterize the farm operators' overall opinion about the importance of safety practices. Page limitations prevent including with this

article approach-to-safety questions or a
of these are available upon request from t

Knowledge of hazards and risks is add
their agreement with various statements
again focus on tractors (such as opera
common sense than knowledge of haz
entrapment by a PTO shaft nearly alw
structures (such as Class A fire extinguis
for most farm fires), and emergencies (su
in a farm accident is to check out the
before going for emergency services h
attempts to characterize the farm operato

The survey questionnaire also gather
data include the following: size of farm,
per week of farm work, average time
working on the farm, number of hired la
twelve months, gross income, and off-
were re-coded for analysis purposes.

Hazard conditions of farms were ass
all 216 farms participating in the stu
identify and describe different conditio
audited item. Hazard indicators rang
inspected in the audit included feature
PTO machines (such as driveline shaft s
oils, grease, etc.), silo unloading rooms/
box covers), two-story bank barns (su
pesticide storage (such as decontaminat
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storage (such as restricted access), and en
emergency reporting instructions).

Statistical Analysis

To determine general results about t
to-safety and hazard conditions on th
hazard conditions was calculated. Asso
from different components of farmers' a
following algorithm was utilized to calcu

The hazard indicator, as described in
1 and 5 assigned to each item covered
optimal level and a score of 5 represented
preassigned a numerical value referred to
importance of that item. For instance, ro
hazard factor of 10 and the other items
less important in assessing farm hazar
3 and 5.

The total hazard score for tractors w
average of hazard indicators (weighted
tractor total hazard score was divided b
the results back to a number between 1 (
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tion results. Due to the size of the project, etails about the project's background and evelopment of instruments, educational results from analysis of baseline data are irphy et al., 1998). This article focuses on its of farmers' approach-to-safety and actual iations may be influenced by demographic between approaches-to-safety and actual ducing effective farm safety interventions.

thods

r's approach-to-safety, is composed of four fety issues, concern for absence of safety ince of safety practices, and knowledge of 98). Beliefs about safety issues are assessed viewpoint, using a seven-point Likert scale e, with respect to 10 different statements include the following: (1) accidents are ing to happen to people regardless of safety ely a matter of common sense; (3) a really rmer workshops and seminars; (4) farmers safety hazards; (5) accidents are mostly e by applying good safety management ccidents does not require training to know d place to learn about safety is on-the-job; of practical experience; (9) farmers usually rds; and (10) avoiding accidents requires al score for this component attempts to liefs about safety issues.

es and protective devices is addressed by it of their concern, using a six-point Likert , for a number of different safety features features and devices pertaining to tractors chinery (such as a driveline shaft shield for dings and structures (such as a multi-class uilding), and emergencies (such as written ar a phone) are listed. The total score for the farm operators' overall concern for vices.

ddressed by asking farm operators to rate cale ranging from not much to extreme, of n to tractors (such as turning a tractor's the day time), machinery (such as walking eline shaft instead of stepping over it), and ie inside of barns free of debris). The total icterize the farm operators' overall opinion age limitations prevent including with this article approach-to-safety questions or a listing of hazard conditions audited. A copy of these are available upon request from the authors.

Knowledge of hazards and risks is addressed by asking the farmers the strength of their agreement with various statements about hazards and risks. These statements again focus on tractors (such as operating tractors safely has more to do with common sense than knowledge of hazards and safety rules), machinery (such as entrapment by a PTO shaft nearly always results in a fatal injury), buildings and structures (such as Class A fire extinguishers are the best type of extinguisher to have for most farm fires), and emergencies (such as in remote locations the best response in a farm accident is to check out the scene and consider first aid for the victim before going for emergency services help). The total score for this component attempts to characterize the farm operators' knowledge of hazards and risks.

The survey questionnaire also gathers data on demographic information. These data include the following: size of farm, gender, age, education level, average hours per week of farm work, average time working off the farm, number of children working on the farm, number of hired labor working on the farm, injuries in the past twelve months, gross income, and off-farm income. Some of the above variables were re-coded for analysis purposes.

Hazard conditions of farms were assessed through conducting a hazard audit of all 216 farms participating in the study. Hazard indicators were established to identify and describe different conditions associated with protective devices for an audited item. Hazard indicators ranged from 1 (optimal) to 5 (worst). Items inspected in the audit included features of tractors (such as rollover protection), PTO machines (such as driveline shaft shield), farm shops (such as storage of fuels, oils, grease, etc.), silo unloading rooms/areas (such as electrical fuse/circuit breaker box covers), two-story bank barns (such as hay/feed drop opening - ladder), pesticide storage (such as decontamination equipment/supplies), bottom unloading grain bins (such as grain suffocation warning signs/decals), manure handling and storage (such as restricted access), and emergency procedures (directions to farm and emergency reporting instructions).

Statistical Analysis

To determine general results about the associations between farmers' approach-to-safety and hazard conditions on the farm, an overall estimate of each farm's hazard conditions was calculated. Associations between this value and total scores from different components of farmers' approach-to-safety were then analyzed. The following algorithm was utilized to calculate an overall hazard score for each farm.

The hazard indicator, as described in the previous section, was a score, between 1 and 5 assigned to each item covered in the audit. A score of 1 represented the optimal level and a score of 5 represented the worst level. Each item in the audit was preassigned a numerical value referred to as the hazard factor, which represented the importance of that item. For instance, rollover protection for tractors was assigned a hazard factor of 10 and the other items concerning tractors, which are considered less important in assessing farm hazards, were assigned hazard factors between 3 and 5.

The total hazard score for tractors was then calculated by taking the weighted average of hazard indicators (weighted by the appropriate hazard factors). The tractor total hazard score was divided by the sum of the hazard indicators to scale the results back to a number between 1 (optimal) and 5 (worst). This algorithm was repeated for each tractor on the farm (up to the 3 most often used). In order to assess the exposure of the operator to these hazards, these values were then weighted by the appropriate number of days used. The result, the overall hazard score for tractors, was a value again ranging between 1 and 5. These steps were repeated for the PTO machinery and buildings and structures covered in the audit. The overall scores for each of these three areas were then averaged together to get the overall hazard score for the entire farm. This value, which represents the overall level of hazardous conditions on the farm, ranged between 1 and 5.

The survey questionnaire consisted of four (pre-specified) main areas: (1) beliefs about safety issues; (2) concern for safety features; (3) importance of safety practices; and (4) knowledge of hazards and risks. To determine the optimal construct for analysis purposes, principal component analysis, a type of factor analysis, was run on all questions in the survey. Principal components were also calculated for each of the four main areas of the survey and for sections (specific to tractors, machinery, and buildings) of each component. Pair-wise correlations of appropriate items were examined to investigate the structure of the data set.

As a measure of reliability, Cronbach's alpha was calculated for farmers' approach-to-safety, for each component, and for sections (specific to tractors, machinery, and buildings) of each component. Results of the principal component and reliability analysis were considered to determine the optimal constructs to be retained in the analysis. Responses to the Likert scales were treated as continuous scores and summed to compute total scores for a given factor. These scores were then categorized based on their frequency distributions.

Since the distribution of overall hazard scores was approximately normal, linear regression analysis was used to identify and assess significant associations with hazard conditions. Significant demographic variables were first identified through a forward selection process (Hosmer and Lemeshow, 1989), using 0.25 and 0.10 as the entrance and exit criteria, respectively. After adjusting for these demographics, associations between the hazard conditions and the cumulative scores representing the overall farmers' approach-to-safety were investigated. The final regression model was then examined to quantify these associations and the model fit.

Results

Overall Hazard Score

The distribution of overall hazard scores was normal with a mean of 2.33 and a standard deviation of 0.53. Approximately 10% of the farms had an overall hazard score greater than 3 and approximately 25% less than 2. The overall hazard ranged from 1.27 to 3.92. The distribution of overall hazards was approximately symmetric with a median of 2.27.

Reliability and Factor Analysis

A Cronbach's alpha of 0.86 was computed for the entire questionnaire. This value seems to indicate good overall reliability, but is partially a result of the large number of items (74) in the survey (Cortina, 1993). Results of reliability analysis for each component of the questionnaire are summarized in the following paragraphs. Beliefs about safety issues had the lowest reliability with alpha equal to 0.46. In addition, several beliefs which were expected to correlate very highly did not. For instance, item 1: accidents are generally unpredictable events that are going to happen to people regardless of safety education, and item 5: accidents are mostly predictable events that are preventable by applying good safety management techniques and principles, were expected to correlate very negatively, but had a correlation of 0.36.

All other pair-wise correlations, usi
coefficient, were below 0.3 in absolute v
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(without using a rotation). Cronbach's a
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(0.76), and concern variables related o
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concern for absence of safety features. T
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All other pair-wise correlations, using Spearman's non-parametric correlation coefficient, were below 0.3 in absolute value.

Principal component analysis identified four factors in the beliefs about safety issues component. Variables with a loading greater than 0.5 were included in the given factor (Fishbein and Ajzen, 1975). These factors were interpreted as representing experience (items 7 and 8), resources (items 4, 5, and 9), knowledge (items 2, 3, and 10), and unpredictability (items 1 and 6). The factors, however, accounted for only 56% of the variability in the data. Final communality estimates ranged between 0.41 and 0.65, indicating that the original variables were not well accounted for by the factors. Results of the pair-wise correlations and principal components in the factor analysis indicate that the items used in the measurement do not reliably characterize the farm operators' beliefs about safety issues. Thus, this component (beliefs about safety issues) was not included in further analyses.

Principal component analysis was run on all items dealing with concern for safety features. Four factors were identified using the criteria of an eigenvalue greater than one. All items in this component, however, had a high loading on the first factor (without using a rotation). Cronbach's alpha was equal to 0.90 for all variables in this component. A relatively large value for alpha was also calculated for the concern variables related only to tractors (0.83), concern variables related only to machinery (0.76), and concern variables related only to buildings and structures (0.79). The results seem to indicate that all these items reliably characterize the farm operator's concern for absence of safety features. The total of each farm operator's scores in this component of the survey was, therefore, used to measure their concern for safety.

Principal component analysis revealed four underlying factors, with an eigenvalue greater than one, from the items on importance of safety practices. All items again had a high loading on the first factor. Chronbach's alpha was equal to 0.83 for all variables in this component. A relatively large value for alpha was also calculated for the importance variables related only to tractors (0.73), importance variables related only to machinery (0.70), and concern variables related only to buildings and structures (0.73). The results seem to indicate that all these items reliably characterize the importance of safety practices for these farm operators. The total of each farm operator's scores in this component of the survey was therefore used to measure the importance of safety practices for each farm operator.

Principal component analysis was conducted on the knowledge component questions. From 34 items in this component, 12 principal components, which were not interpretable, were retained. When run separately for each area of the farm (tractors, machinery, and buildings), factor analysis again failed to identify any interpretable underlying factors. Cronbach's alpha was slightly lower for this component (0.72), as compared to concern for safety and importance of practices. For the items specific to tractors, and items specific to buildings, the reliability was similar to the reliability of the entire component (alpha equaled 0.63 and 0.64, respectively). The items specific to machinery, however, had very poor reliability (alpha equaled 0.04).

Considering the results of reliability and factor analysis, a single cumulative measure was calculated for concern about safety and importance of safety practices. Due to the lack of identifiable factors in the knowledge of hazards and risks component, a single measure was also calculated to characterize knowledge. These cumulative measures were calculated by summing scores of each item and then categorizing the continuous scores based on frequency distributions.

Regression Analysis

Before testing associations between farm operators' approach-to-safety, as measured by concern for safety, importance of practices, and knowledge of hazards and risks, important demographic variables were analyzed by using the procedure for linear regression (REG) in SAS (SAS, 1990). Table 1 lists results from univariate linear regression analysis of the demographic information collected in the survey questionnaire. Frequency distributions and regression runs with different covariate forms were examined to determine the scale of continuous variables.

A negative model slope indicates a negative association existed between the given variable and hazard conditions. A larger farm, working full-time on the farm, having hired labor, and a higher income were all associated with less hazardous farms. The remaining demographic variables, older age, having at least some college education, working off the farm, having child labor, and earning off-farm income were all associated with more hazardous farms. Age of farm operator ($p = 0.634$) and presence of child labor ($p = 0.872$) were dropped from further analysis due to lack of statistical significance. Education level ($p = 0.151$) also met the criteria for entrance into the model.

Several considerations are important when reviewing the results in table 1. Significant results in a regression equation do not necessarily imply causation, rather only an association with hazard conditions. A significant association with the outcome could result from an association with another covariate which is associated with the outcome. To adjust for this possibility we used forward selection of appropriate multiple regression models to obtain a final model. Four of the variables, farm hours worked, off-farm hours, farm income, and off-farm income, were never included in the same model to avoid multicollinearity (Myers, 1990). Table 2 lists the results of the final demographic model. The final demographic model had the highest R^2, adjusted R^2, and the lowest mean square error of the models considered.

Table 2 indicates that larger farms, and farms with hired labor are associated with lower hazard conditions. Operators working off the farm are associated with a greater hazard, as measured by the previously described audit. Hours worked off the farm is likely a surrogate measure for income, which was also significantly associated with hazard conditions. Off farm hours was included in the model, rather than income, based on the R^2 value of the regression model, and statistical significance.

Table 1. Linear regression of demographic variables

Demographic Variable	Scale	Model Slope	P-Value
Size of farm	Continuous in log (acres)	−0.321	0.001
Age	Continuous in years	0.001	0.634
Education	Dichotomous, baseline: no college	0.109	0.151
Hours/week on farm	Dichotomous, baseline: ≤ 40 hours	−0.251	0.006
Hours/week off farm	Dichotomous, baseline: no work off-farm	0.508	0.001
Child labor	Dichotomous, baseline: no child labor	0.012	0.872
Hired labor	Dichotomous, baseline: no hired labor	−0.244	0.001
Farm income	Dichotomous, baseline: < $50,000/year	−0.349	0.001
Off-farm income	Dichotomous, baseline: < $10,000/year	0.131	0.071

Table 2. Final regression model of demographic variables

Demographic Variable	Scale	Model Slope	P-Value
Size of farm	Continuous in log(acres)	−0.162	0.003
Hours/week off farm	Dichotomous, baseline: no work off-farm	0.423	0.001
Hired labor	Dichotomous, baseline: no hired labor	−0.164	0.017

Table 3. Linear regression model

Survey Component	Categories
Concern for safety	Low concern Medium conce High concern
Importance of practices	Poor practices Average practic Safe practices
Knowledge of hazards	Poor knowledg Average knowl Good knowled

Table 3 lists the results of adding cu importance of practices, and knowledge model described in table 2. All cumulati ordinal categories based on their freque analysis runs.

Table 3 indicates that, after adjusti scores on the farm operators' approach- farm conditions. Neither knowledge o significant after adjusting for concern for off-farm hours, and concern for safety w model. Note, however, that R^2 was only poor fitting model.

Discussion a

This article illustrates that different c safety, which include concern for abse practices, and knowledge of hazards and farm conditions. The association betwee still highly significant after adjusting f important findings with respect to e association between increased concern a hazard conditions by increasing the far protective devices. Some caution should since a significant association does not n

Another contribution of this article is which are significantly associated with Specifically, farm size, off-farm workin identified as a subset of demographic v with farm hazard levels. Information o data which should be accounted for be hazards. These associations may be, but a

The reliability and factor analysis c indicate that the concern for safety importance of safety practices sections overall measure of those particular aspe hazards and risks component did not (alpha approximately equal to 0). In a

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of demographic variables

	Model Slope	P-Value
cres)	−0.321	0.001
	0.001	0.634
ne: no college	0.109	0.151
ne: ≤ 40 hours	−0.251	0.006
ne: no work off-farm	0.508	0.001
ne: no child labor	0.012	0.872
ne: no hired labor	−0.244	0.001
ne: < $50,000/year	−0.349	0.001
ne: < $10,000/year	0.131	0.071

lel of demographic variables

	Model Slope	P-Value
es)	−0.162	0.003
e: no work off-farm	0.423	0.001
e: no hired labor	−0.164	0.017

Table 3. Linear regression model of survey questionnaire components

Survey Component	Categories	Model Slope	P-Value
Concern for safety	Low concern	1.00	—
	Medium concern	−0.237	0.003
	High concern	−0.273	0.001
Importance of practices	Poor practices	1.00	—
	Average practices	−0.144	0.068
	Safe practices	−0.210	0.013
Knowledge of hazards	Poor knowledge	1.00	—
	Average knowledge	−0.073	0.416
	Good knowledge	−0.129	0.077

Table 3 lists the results of adding cumulative measures of concern for safety, importance of practices, and knowledge of hazards, (in a univariate fashion) to the model described in table 2. All cumulative scores from the survey were coded into ordinal categories based on their frequency distributions and preliminary regression analysis runs.

Table 3 indicates that, after adjusting for significant demographics, increased scores on the farm operators' approach-to-safety are associated with less hazardous farm conditions. Neither knowledge of hazards or importance of practices was significant after adjusting for concern for safety. Size of farm, presence of hired labor, off-farm hours, and concern for safety were therefore selected as the final regression model. Note, however, that R^2 was only equal to 0.27 in the final model, indicating a poor fitting model.

Discussion and Conclusions

This article illustrates that different components of farm operators' approach-to-safety, which include concern for absence of safety features, importance of safety practices, and knowledge of hazards and risks, are all associated with less hazardous farm conditions. The association between concern for safety and hazard conditions is still highly significant after adjusting for demographic variables. These results are important findings with respect to educational interventions. The significant association between increased concern and lower hazard implies that one can affect hazard conditions by increasing the farm operators' concern for safety features and protective devices. Some caution should be exercised in making this interpretation since a significant association does not necessarily imply causation.

Another contribution of this article is the identification of demographic variables which are significantly associated with increased or decreased hazard conditions. Specifically, farm size, off-farm working hours, and presence of hired labor were identified as a subset of demographic variables which are most strongly associated with farm hazard levels. Information on these variables thus provides researchers data which should be accounted for before analyzing other associations with farm hazards. These associations may be, but are not necessarily causal in nature.

The reliability and factor analysis completed in earlier sections of this article indicate that the concern for safety features and protective devices, and the importance of safety practices sections of the questionnaire can provide a reliable overall measure of those particular aspects of approach-to-safety. The knowledge of hazards and risks component did not provide a reliable measure for machinery (alpha approximately equal to 0). In a more detailed analysis one could use, for instance, the tractor section of this component to study associations with hazards specific to tractors. One could then use cumulative scores, which were more reliable, for tractors and buildings and exclude this component for machinery. In an effort to simplify the analysis, and its interpretation, such an approach was not taken for this article.

The reader should take caution in interpreting the final regression model. The final model (and all other models mentioned in the analysis) does not fit the data as well as one would like. The data used for this article were baseline data from a pilot project using a questionnaire which has not been standardized. The results are extremely useful for guiding researchers in variable selection and assessing farm operators' approach-to-safety in the study of farm safety, but should not be considered a definitive study on the subject.

In summary, this article presents an analysis of a survey questionnaire which effectively captures several aspects of farmers' approach-to-safety. Characterizing these views is a critical part of implementing educational farm safety interventions. We also quantified each farm's hazard conditions by calculating an overall hazard score. Findings from regression analysis indicate that better approaches-to-safety are associated with reduced farm hazards. Researchers should use these results to help determine how to measure different aspects of approach-to-safety, and which demographic variables to control for in an analysis of such data.

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Injury Risk Facto
Agricultural Wo

S. G. Pratt,

Abs

Agriculture has consistently ranked am
and rate of death from workplace injur
investigations of occupational agricultural
State Fatality Assessment and Control F
presence of multiple injury risk factors for
factors were unrecognized or unaddressed
available at the worksite, and the use of e
to the worker's exposure to injury risk. T
variety of prevention strategies, includi
controls.

Keywords. Occupational fatalities, Fatal

Agriculture has consistently been
frequency of death) most hazardo
past 50 years (Burke, 1987; Mur
tasks using a variety of equipment.
environmental conditions, with weather,
substantial economic and time pressures
Runyan, 1993; Murphy, 1992). In addi
(Aherin et al., 1992; Hair, 1991; Knap
influences on the injury risks to which far

Heinrich's theory of the "accident sequ
attributed to a series of antecedent oc
recognition that multiple factors, immed
with a single injury event (DeReame
determining the primary or most obviou
Russell, 1994; Tritch, 1992). Heinrich's
unsafe acts of individuals has since b
Hammer, 1989). However, his original co
sequence will prevent the injury cont
intervention strategies today. Current

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