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ORIGINAL RESEARCH

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ABSTRACT. An evaluation was conducted on the results of the Certified Safe Farm controlled intervention program on a wide range of occupational health and safety outcomes. This report focuses on the outcomes of personal protective equipment (PPE) usage among one cohort of 438 Iowa (owner-operator) farmers in the Certified Safe Farm study during a 5-year period from 2004 to 2008. Intervention farmers reported an 11% increase in regular respirator usage and a 23% increase in regular use of hearing protection relative to comparison groups. Furthermore, it was revealed that personal factors such as smoking and low self-assessment of health status are associated with lower usage of PPE. The authors provide evidence that multiple modalities of intervention are more likely to affect safe behavior changes in the owner-operator farming population compared with single modality interventions. Further, farmers reported that personal factors such as smoking history and low self-assessment of health status are associated with lower usage of PPE.

KEYWORDS. Agriculture, intervention, personal protective equipment (PPE)

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INTRODUCTION

Use of personal protective equipment (PPE) in the scheme of protection from hazardous occupational exposures for workers is a second or supplemental choice to source control. However, it often ends up as primary prevention in industries that lack resources or regulations to remove hazards. Agriculture is such an industry. A further complication of protecting agricultural workers is the fact that there is generally lax usage of PPE, especially in small family farms.[1] Reasons for this include PPE are uncomfortable to wear; PPE supply sources are not convenient; proper education on PPE usage is rare; PPE interfere with audible communication, causing the inability to accurately hear sounds of proper machine operation; and there is lack of peer and other social support.[2–4]

Several research publications have reported on results of theories of intervention to increase PPE usage, including clinical testing of hearing and respiratory function combined with personalized education,[5] social and peer support,[6,7] theory of planned behavior,[3,8] transtheoretical model,[1] and informational level education.[9] Although there was evidence that multifactor programs seemed to have a positive outcome, informational level education programs alone revealed some degree of success in achieving higher rates of PPE usage. However, most of these trials were challenged by having one or more of the following deficiencies: (1) small sample size; (2) not a representative sample; (3) self-reported results; (4) short intervention and follow-up periods; and (5) lack of a control population.

In the mid-1980s, our research group realized that although there were various theories and models of interventions for behavioral change, there was little evidence that any of them had proven long-term unbiased outcome evaluation on interventions applied to farm populations. As the exposure circumstance and cultural factors are so complex, we hypothesized that employing multiple modalities would be the more favorable method to achieve lasting change. We first tested this theory in a 5-year prospective study (early 1980s) titled the *Prevention of Respiratory Disease in Swine Workers*.[10] This was a randomized controlled study that employed multiple modes of intervention. The intervention included work environment exposure assessment and control, clinical occupational and wellness assessment, personalized education, group education, community participation and peer support socialization, and goal achievement with incentives. A rigorous evaluation was conducted over the course of the study, and outcomes over 5 years of follow-up revealed significant knowledge gain and positive health and safety behavioral and attitudinal changes noted by a significant increase in the usage of respirators and hearing protection.[11,12]

The theory, methods, experience, sociological, cultural, economic, and practical realities gained from the Prevention of Respiratory Disease in Swine Workers project led us to design a new multimodal intervention model in agriculture that we call the Iowa Integrated Model of Prevention.[2] This multimodal model was applied to our newly designed intervention, the Certified Safe Farm (CSF) Program, that was implemented and evaluated through a decade of research projects collectively totaling nearly 600 farms (1997–2003,[13] $n = 125$; 2004–2008, $n = 438$). We have been able to show a 45% decrease in medical care costs for occupational illness and injury for the intervention farms,[13] and an increased use of respiratory protection (PPE) associated with reduced incidence of the acute respiratory illness organic dust toxic syndrome (ODTS).[14] The 2004–2008 study added additional weight and further refined methods to the effectiveness of the multimodal methods of behavior change relative to the use of PPE in agricultural producers. This paper compares the 2004–2008 cohort of CSF producers with a much broader and more precisely controlled representative sample of agricultural producers, based on samples drawn in 2007 by the United States Department of Agriculture (USDS) National Agricultural Statistical Service (NASS).

METHODS

Intervention

The details of the intervention methods were reported previously.[13] The intervention consisted of four primary components (which consolidate the multimodal components developed under the Prevention of Respiratory Disease in Swine Workers Project): (1) a clinical wellness and occupational health screening (health goals were set with follow-up checks) conducted twice during the study period by a trained agricultural health nurse; (2) an on-farm safety and health exposure and risk audit conducted twice during the study period by a CSF-trained auditor; (3) an educational process, both in a group and an individual format, including group educational meetings, one-on-one review of health screening results, personalized occupational health and injury risk review, personalized PPE demonstration, selection and fit testing, and consultation for on-farm PPE including convenient, accessible storage; and (4) incentives to encourage safe and healthy behavioral practices (i.e., $150 if they achieved a minimum score of 85% on the risk audit) after completion of each round of data collection.

Intervention Group

This controlled intervention study was conducted in the service areas of 10 AgriSafe Network providers (www.agrisafe.org) covering 38 counties in Iowa between 2004 and 2008 (Figure 1). Recruitment of the intervention group was completed through a combination of mailed invitations and convenience sampling conducted locally by AgriSafe clinic staff. The sample was stratified geographically by the locations of the AgriSafe clinics that were responsible for the clinical portion of the study. Three introductory mailings were sent out by the Iowa Farm Bureau to its members. Two additional mailings were conducted by NASS (Table 1). In addition to these mailings, recruitment was augmented by local AgriSafe clinic staff through personal contacts at meetings, fairs, referrals, and previous study participants.

Eligibility criteria for this study included (1) principal farm operator (and/or spouse); (2) lived in targeted project counties; and (3) farmed at least 20 hours/week on average. A total of 438 participants were recruited to the study, and 36 were lost to follow-up in the second round of data collection.

FIGURE 1. Project locations/AgriSafe clinics (color figure available online).

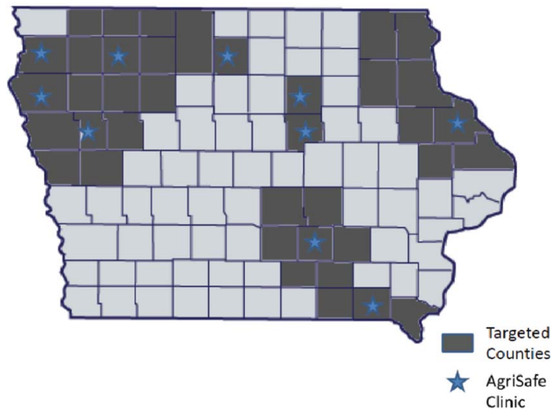


TABLE 1. Recruitment Methods

Method (number)	Number enrolled
Mailing 1 ($n = 60$)	7
Mailing 2 ($n = 1057$)	18
Mailing 3 ($n = 1100$)	22
Mailing 4 ($n = 6448$)	212
Mailing 5 ($n = 2577$)	58
Self-recruitment	73
Other	48

In the mailings conducted by the Farm Bureau, prospective subjects were instructed to contact the CSF project coordinator by phone or e-mail for additional details regarding enrollment. In the mailings conducted by NASS, prospective subjects were instructed to return an enclosed, self-addressed postcard to NASS if they were interested in more details or participation. These postcards were forwarded to the CSF project coordinator who contacted the farmers to discuss participation. Those interested in enrolling in the program were mailed an informed consent document, and they were considered enrolled when the project coordinator received the signed informed consent document (institutional review board [IRB] nos. 200608755 and 200309064).

Comparison Group

A comparison group was included to analyze outcomes of the intervention group relative to those who did not receive the intervention.

In 2007, NASS staff conducted a survey in the 10 project locations and all contiguous counties ($n = 51$), aiming at a sample that was geographically and demographically (based on age, sex, acres farmed, and swine production) comparable to the CSF intervention cohort (Table 2). The comparison group survey was returned to NASS, and a research data set without personal identifiers was provided by NASS to project staff. The criteria for this population included (1) lived in a targeted contiguous county to project locations; (2) age 18 years and above; and (3) current farmer (USDA definition of having annual sales of agricultural products of at least $1000). The comparison group consisted of 411 Iowa farmers.

Data Collection

An occupational health survey questionnaire was developed for comparison of the intervention and comparison populations. Both groups received identical surveys. The survey instrument included questions on basic demographic information such as age, number of acres farmed, and type of livestock raised. Health and safety data collected included information on general health and wellness indicators, injury and illness history over the past 12 months, and PPE usage in various work settings and work processes (i.e., "When exposed to loud noises on the farm [such as working with hogs, driving tractors or combines, or drying grain] how often do you use hearing protection [ear muffs or plugs]?" "When exposed to dusty activities [such as grain or silo dust, moving or processing livestock, power washing, or disinfecting] on the farm, how often do you use respiratory protection [disposable mask or cartridge mask]?"). Respondents were asked to rate their answers using a scale of (1) Always, (2) Sometimes, or (3) Never.

The occupational health survey was sent to intervention farmers in three mailings (if a farmer responded to the first mailing, they were excluded from the subsequent mailings), obtaining responses from 355 persons (81% response rate), which included responses from 15 couples in the study (340 unique farm responses). The questionnaire was sent to intervention farmers from December 2007 to March 2008 after they had completed the intervention. The survey responses are unique, with each participant responding only one time. The comparison

TABLE 2. Demographics of Intervention Group, Comparison Group, and General Iowa (IA) Farmers

Chracteristics	Intervention[a]	Comparison	IA (2007)
Total	355	411	92,856
Sex			
Male	328 (92%)	378 (92%)	84,404 (91%)
Female	27 (8%)	29 (8%)	8452 (9%)
Age			
<35	11 (3%)	18 (4%)	6278 (7%)
35–49	72 (20%)	95 (23%)	
50–64	149 (42%)	163 (40%)	
65+	122 (34%)	133 (32%)	25,996 (28%)
Farm work per week[b]			
<40	135 (38%)	234 (57%)	
40 or more	220 (62%)	177 (43%)	
Acres**			
<500	167 (47%)	255 (62%)	73,579 (79%)
500 or more	173 (49%)	141 (34%)	19,277 (21%)
Swine farm			
Yes	82 (23%)	98 (24%)	8758 (9%)
No	261 (73%)	278 (78%)	84098 (91%)

[a]Intervention responses were 355/438.
[b]Differences between intervention and comparison group, $p < .0001$.

group did not receive the intervention, and only a baseline survey was conducted from January 2007 to March 2007.

Data Analysis

The data set used in this report was from the occupational health survey instrument sent to intervention and comparison farmers during 2007 and 2008. Results were evaluated from intervention farmers post intervention relative to the comparison farmers who received no intervention. This data set focuses specifically on questions regarding PPE use. The data were analyzed using descriptive statistics, chi-square tests for identifying differences between the intervention and comparison groups, and stepwise logistic regression. SAS statistical software was used for analysis (version 9.1, 2007; SAS Institute, Cary, NC).

RESULTS

The CSF intervention farmers showed a difference in usage of respiratory protection relative to the comparison group. Eighty-nine percent of the CSF intervention farmers used PPE regularly compared with 78% of the comparison group, a difference of about 11% ($p < .0001$). Furthermore, the number of CSF intervention farmers who never wore respirators was half that of the comparison group (11% vs. 22%, respectively; $p < .0001$). Figure 2 shows these highly statistically significant results.

Swine producers, in general, reported an increased use of respirators (92%) compared with those who did not raise swine (81%). Only 8.5% of swine producers reported never using respirators, compared with 19% of non-swine-producing farmers. Figure 3 shows this result, which is highly statistically significant ($p < .0011$). Even within the comparison group, the swine producers were more likely to wear respirators, suggesting that there is an influence of production type on respirator use (see Figure 4; $p < .0015$).

In addition to respirator use, we investigated the use of hearing protection in the CSF intervention relative to the comparison group.

FIGURE 2. Respirator use of intervention group relative to comparison group.

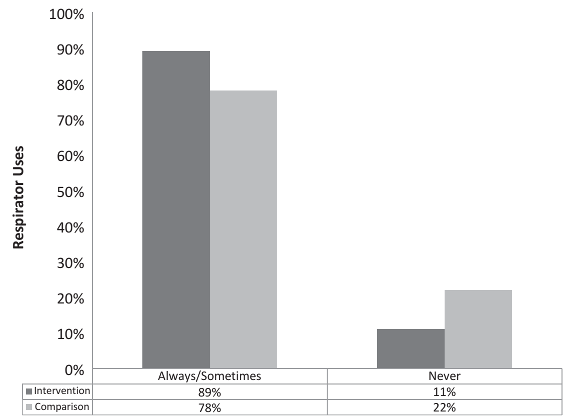


FIGURE 3. Respirator use by swine production.

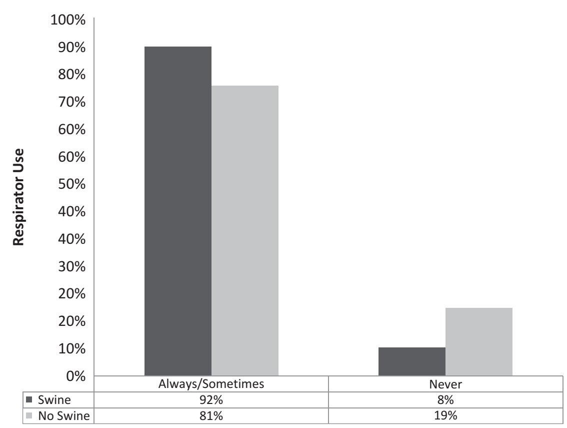


FIGURE 4. Comparison population respirator use by swine production.

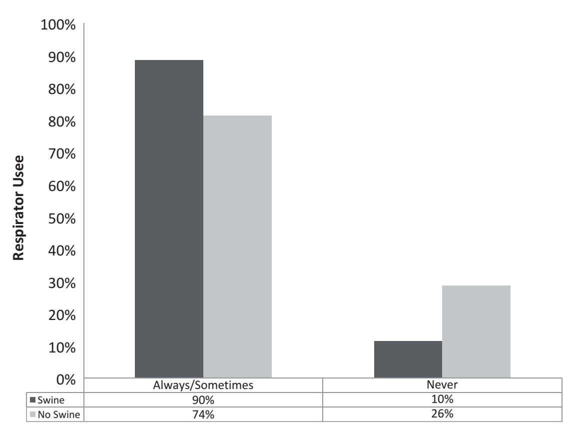


FIGURE 5. Hearing protection use of intervention group relative to comparison group.

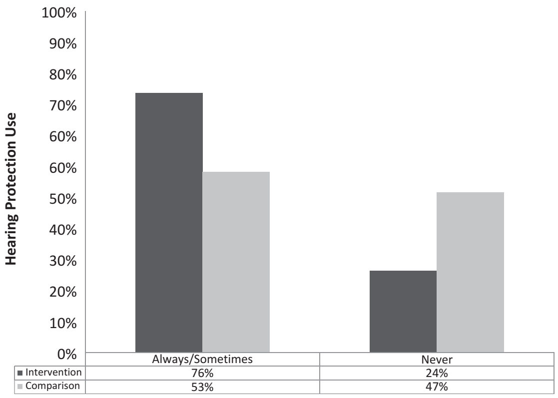


FIGURE 6. Hearing protection use by respirator use.

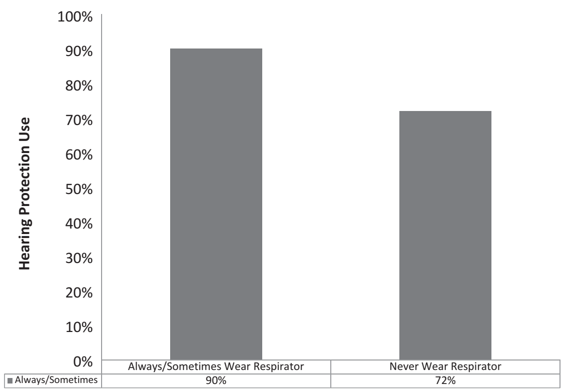


Figure 5 shows a statistically significant 23% higher usage of hearing protection in the CSF intervention group compared with the comparison group (p < .0001).

We also investigated other variables associated with use or nonuse of PPE. A significant discovery included the finding that if people wore respirators, they were also more likely to wear hearing protection. Figure 6 shows that those who wore respirators were about 18% more likely to also wear hearing protection (p < .0001).

Another factor that influenced PPE usage was smoking status. Current smokers and ex-smokers were less likely to use hearing protection than nonsmokers (see Figure 7; p < .002). This was most pronounced in comparison of current smokers to never smokers (24% difference).

FIGURE 7. Hearing protection use by smoking status.

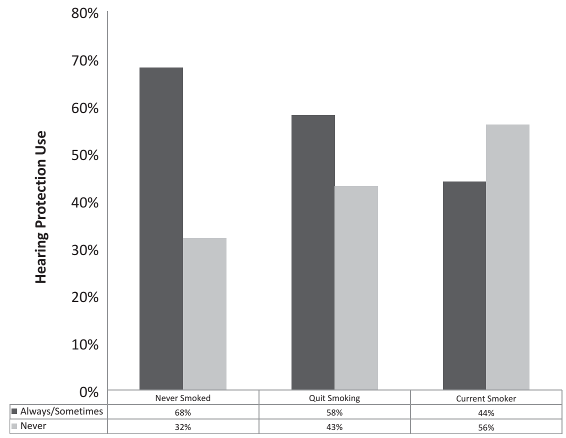
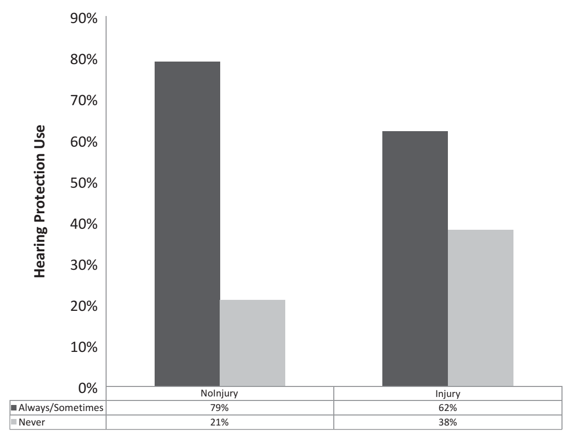


FIGURE 8. Hearing protection use by injury status.



Interestingly, smoking status was not associated with respirator usage.

We also found that there was a significant increase in hearing protection use in those that appeared to be more injury free. Those who were injury free during the previous 12 months were much more likely to wear hearing protection compared with those who reported injuries in the prior 12 months (p < .0145). Figure 8 shows this difference. This difference was not seen with respirator usage.

Finally, we found a significant association between a high self-reported heath status and wearing hearing protection, but not respiratory protection. This association was highly significant (p < .0003).

TABLE 3. Multivariate Model of Use of Respiratory Protection

Odds ratio estimate	
Effect	Point estimate (95% confidence interval)
Participation in the intervention protocol	2.256 (1.414–3.598)
Raise swine	2.333 (1.262–4.314)
Reported farm operation as highly stressful	1.878 (1.001–3.526)
Reported farm operation as low stress	1.927 (1.128–3.292)
Work 40 hours or more on farming operation	2.005 (1.266–3.176)

Note. Candidate variables not selected in the stepwise logistic modeling included subject age, no history of smoking, current smoker, injury in last 12 months, and pain prevented normal work in the past 30 days.

TABLE 4. Multivariate Model of Use of Hearing Protection

Odds ratio estimate	
Effect	Point estimate (95% confidence interval)
Participation in the Intervention Protocol	2.812 (1.984–3.986)
Age	0.707 (0.574–0.871)
Current smoker	0.459 (0.215–0.980)
Work 40 hours or more on farming operation	1.756 (1.248–2.470)

Note. Candidate variables not selected in the stepwise logistic modeling included raising swine, no history of smoking, reported farm operation as low stress, reported farm operation as highly stressful, injury in last 12 months, and pain prevented normal work in the past 30 days.

Multivariate Analysis

Stepwise logistic regression (SAS Proc Logistic) was used to explore factors that might be associated with healthy behaviors (i.e., use of personal protective equipment). When the probability of "always or sometimes" is modeled (Table 3), factors such as participation in the intervention, swine production, working on a farming operation that was regarded as high or low stress, and farming 40 or more hours per week were associated with use of respiratory protection. Protective factors associated with use of hearing protection (Always or Sometimes; Table 4) included participation in the intervention and farming 40 or more hours per week, whereas age and current smoking were identified as risk factors.

DISCUSSION

The evidence base for our Iowa Integrated Model of Prevention had its beginnings with our research in the early 1980s. Before that time, it was difficult to point to any previously published, evidence-based intervention theories with positive findings to model our approach. Thus, our design is a hybrid model and included elements of several theories, including the Health Belief Model[2] and the theory of planned behavior.[3,8] However, the effectiveness of multimodal approaches has now been shown in three separate studies, over the course of more than a decade, since the original design of this study. McCullagh and Robertson[15] reported on the use of the Pender Health model in an intervention they developed to increase the use of hearing protection among farmers. The Pender Health model involves the use of several factors in development and implementation including cognitive and attitudinal factors, addressing barriers, realizing benefits, self-efficacy, and interpersonal factors including modeling and support.[16] Employer factors identified for a successful PPE program most importantly include management supplying PPE that is proven effective, fits correctly, and does not interfere with the work requirements.[17] El Dib and colleagues[18] published an article in the *Cochran Database of Systematic Reviews* that included a meta-analysis of PPE interventions; they found evidence that programs that included multiple-factor interventions and "tailored" education were effective in increasing PPE usage. Gates and Jones[19] as well as Jenkins and colleagues[20] also deployed multiple-factor interventions with positive results.

Regarding our current study compared with others in the literature, there were several combined research criteria that resulted in an uncommonly robust study in the field. This study used the extensive multimodal methods of the CSF and a controlled intervention design, covering multiple years of follow-up. DeRoo and Rautiainen[21] conducted an in-depth study of many farm health and safety interventions. They evaluated these studies relative to the ideal requirements of a controlled clinical trial. They found overall that those interventions applying multiple modalities were most successful, and of those studies, only a few would fit the criteria for a randomized controlled study. The CSF was one of those studies. The weight of evidence from the CSF intervention, and from several other recently published studies, indicates that multiple modalities of evidence-based theories and programs will likely have greater impact than single modality interventions.

Additional research methods employed in our current study included several techniques to help achieve a good participation rate. We collaborated with organizations that have high recognition by farmers (Farm Bureau, USDA, and local AgriSafe clinics) to mail study invitations on their letterhead. Even so, we still did not attain a high participation rate (438 from approximately 10,000 invitations). However, the demographic comparisons were very similar between the intervention group, the comparison group, and data for the state as a whole. The differences included that the intervention and comparison groups were slightly older and farmed more acres than the general farm population. Also, the intervention group farmed slightly more acres and worked longer hours than the comparison group.

The low participation rate could have introduced some selection bias. However, based on recent research, low participation rates are what appear to be the norm.[13] Furthermore, the fact that the study population demographics are very similar to the general farm population for the state suggests that these results are generalizable. An additional limitation of this study includes reliance on self-reported data. It is possible that some or all of the difference observed in respirator and hearing protection usage may be due to the "Hawthorne" effect, which states that interaction with people over a period of time may cause them to respond in ways beyond what the intervention alone may have done. However, we did have auditors visit the farms for the standard CSF audit. Evidence of personal protection usage is a part of that process. Evidence means PPE equipment on hand and evidence of usage. Therefore, we have an additional check beyond the questionnaire. A further limitation was the use of only three response categories: Always, Sometimes, and Never. Future studies should include survey techniques such as multiple questions concerning the same concept to verify the accuracy of self-reports as well as broader range response categories to allow for greater precision in analyzing responses.

Conclusions

Usage of PPE can be increased and multimodal model interventions seem effective in helping to create behavior change that lasts over long time periods (5-year observational period). The intervention appears to have a greater effect on the difference in use of hearing protection (23% difference) compared with an 11% difference in respirator use—an observation supported by multivariate analysis. Swine producers are more likely to use respirators compared with other farmers. Further, it appears that general personality type is associated with PPE use. For example, we found that nonsmokers, those already using one type of PPE, those with less occupational injury history, and those with a high perception of health status are all more likely to wear PPE. Wearing hearing protection is more significantly associated with these latter variables compared with wearing respirators.

These findings lead to further research questions. We found that certain behaviors are associated with the likelihood of PPE usage (e.g., risk taking, smokers, if they use one type of PPE they use another, self-assessed health status, and injury prevalence). Future studies should include methods to study these factors individually or in combination. Participation and program success may be partly associated with innate behavioral factors. Additional studies along the lines of personality associated with injury and wellness among the agricultural population appears warranted.

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