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Journal of Agromedicine

ISSN: 1059-924X (Print) 1545-0813 (Online) Journal homepage: https://www.tandfonline.com/loi/wagr20

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To cite this article: Kelley J. Donham, Shannon M. Meppelink, Kevin M. Kelly & Diane S. Rohlman (2019) Health Indicators of a Cohort of Midwest Farmers: Health Outcomes of Participants in the Certified Safe Farm Program, Journal of Agromedicine, 24:3, 228-238, DOI: 10.1080/1059924X.2019.1591316

To link to this article: https://doi.org/10.1080/1059924X.2019.1591316

Accepted author version posted online: 08 Mar 2019.
Published online: 26 Mar 2019.

JOURNAL OF AGROMEDICINE
2019, VOL. 24, NO. 3, 228–238
https://doi.org/10.1080/1059924X.2019.1591316

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Health Indicators of a Cohort of Midwest Farmers: Health Outcomes of Participants in the Certified Safe Farm Program

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ABSTRACT

Occupational illness, injury, and fatality rates for those working in production agriculture are higher than in any other industry. A potential risk factor contributing to occupational injuries across all industries is acute or chronic co-morbidity (e.g., obesity, high blood pressure, high cholesterol), and related health issues that increase the risk for an occupational injury or illness. These chronic health conditions have been associated not only with increased risk for injuries, but also higher health-care costs, and greater absenteeism. Certified Safe Farm (CSF) is a comprehensive intervention program aimed to reduce occupational health and safety hazards and to promote general health among farmers. Prior publications have described CSF program efforts to reduce hazardous exposures, disabling injuries, organic dust toxic syndrome, occupational health-care costs, and to increase positive occupational health behaviors. This paper reports on the general health indicators of a cohort of 438 Iowa farm owner/operators enrolled in the CSF program. Overall, this study found that the farming population in Iowa has higher body mass index (BMI), but lower total cholesterol, low-density lipoprotein (LDL), and lower prevalence of hypertension compared to the general population. There was evidence that the combination of high blood pressure, cholesterol, and BMI were related to increased injury rates. Poor self-reported health status was also related to increased injuries but was not related to clinical health indicators. The CSF intervention led to improvements on health outcomes, particularly among those in the 35 to 49 age group. Little research has focused on the individual's general health status as a predictor of risk of occupational injury. This study suggests the need for additional research and interventions integrating occupational safety and health prevention along with health promotion.

KEYWORDS
Agriculture; occupational injuries; farmer health status

Introduction

Health indicators, such as blood pressure or obesity, among the general US population, have been collected by public health agencies and non-governmental organizations for many years.[1,2] However, very little surveillance of basic health indicators have been reflective of agricultural populations, which in the United States have occupational illness, injury, and fatality rates higher than any other industry.[3] Although the absolute number of fatalities in agriculture has declined over the years, the injury and fatality rates have not declined to an appreciable extent. Data from the U.S. Department of Labor indicates that in 2015 the non-fatal injury rate for agricultural workers was 20% higher (4.8 injuries per 100 workers) than for workers in all other industries (3.8 injuries per 100 workers[4]). Furthermore, in 2015 the fatality rate for agriculture (19.2 per 100,000 workers) was nearly six times higher than rates in other industries. Each day, approximately 100 agricultural workers suffer a lost time injury (an Occupational Safety and Health or OSHA recordable incident, in which an employee is not able to return to work or is assigned restricted work on the day or shift following the incident). Also, around 400 agricultural workers per year lose their lives following acute traumatic injuries.[4]

Findings across various industries indicate that chronic health conditions and poor health status contribute to occupational injuries.[5–8] Studies utilizing U.S. norms have found that obesity is linked to cardiovascular disease, high blood pressure (hypertension), and high cholesterol levels, which

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in turn are associated with workers productivity, retention, and occupational injury risk.[5,6,9–12] In addition, physical inactivity and obesity among a German cohort were associated with increased risk of occupational injuries.[7] Chronic conditions (e.g., diabetes, arthritis, back problems, heart disease, depression, and asthma) were also associated with increased work-related injuries.[6,8] However, these indicators have not been examined among agricultural workers.

Cardiovascular disease (CVD) impacts a large percentage of adults in the United States (35% of men and women over the age of 20).[13–16] Risk factors for CVD include high cholesterol and hypertension. Prolonged hypertension, a risk factor for CVD, has been shown to be elevated among "blue collar" or hourly workers.[14] When adjusted for age, 21% of U.S. workers meet the criteria for metabolic syndrome.[17–19] Older and obese workers have the highest prevalence of metabolic syndrome at 43% and 32%, respectively.[16] Metabolic syndrome disproportionately affects rural populations. In the U.S. National Health and Nutrition Examination Survey, 40% of a cohort of rural residents had metabolic syndrome, compared to 33% of urban residents.[17]

Previous findings have indicated that although studies have examined the impact of physical risk factors (e.g., working with livestock or machinery, heavy lifting) and work environment factors (e.g., long work hours, short deadlines, perceived stress) on occupational injury in agriculture,[20–24] no studies have examined the impact of health status on risk of injury. Furthermore, no U.S. data are available describing the general health matrices (e.g., blood pressure, cholesterol, etc.) of farmers that may affect their overall health status and impact their risk of occupational injuries and illnesses.

In 1996 an integrated, multiple factorial prevention program for farmers was designed and implemented by Iowa's Center for Agricultural Safety and Health, University of Iowa. This program is called the Certified Safe Farm (CSF). The CSF program is a multimodal program that combines and integrates health promotion along with farm occupational safety and health. The overarching goals of CSF are improvement of overall health, wellness, reduced occupational illnesses and injuries, improved productivity, and retention of workers. The program includes safety audits, technical support in removing hazards, occupational and general health screening and education, and health coaching to address general health and occupational illnesses and injuries. This program is still in place today in North Carolina, and similar versions in New York and Wisconsin. More recently a broader recognition (e.g., NIOSH) of the linkage of general health and occupational health has now given support to the original concept of the CSF and its possible application in production agriculture. In 2011, The National Institute for Occupational Safety and Health (NIOSH) developed the Total Worker Health (TWH) initiative, which advocates for programs that include both mitigation of physical injury risk factors and also promotes health and wellbeing.[22]

Program

Details of the CSF program and results of occupational health and safety outcomes have been reported previously.[25–35] This paper reports on baseline health indicators and changes following participation in the CSF program of a cohort of Iowa Farmers. The CSF program was linked to the AgriSafe Network of Agricultural Occupational Health Clinics that were located in 22 locations throughout Iowa at rural hospitals or county health departments, with providers who have been trained in a 40-h core course in Agricultural Medicine.[34] Not included in this study are results from a similar CSF program – the AgriSafe program in North Carolina.

There were three primary aims of this research. The first aim was to prepare a profile of health indicators of a representative cohort of Iowa farmers. The second aim was to examine possible relationships of adverse health indicators to injury outcomes among this cohort. The third aim was to determine if the CSF intervention was associated with improvement in health indicators (e.g., BMI, blood pressure levels, heart rate, and cholesterol levels) by comparing results from a baseline clinical examination to a second clinical examination following the intervention (separated by a 24- to 35-month interval).

Methods

Data collection

Data were collected as part of a 5-year prospective stratified–random cohort study of 438 Iowa owner-operator farmers.[27,28] The mean age was 54.6 years at the start of the study, and all participants were male. The farmers lived in 38 counties in Iowa (of the total 99 counties in Iowa) within close proximity to 10 AgriSafe[36] agricultural occupational health and safety clinics. Inclusion criteria included meeting the USDA farmer definition (i.e., having at least $1000 in sales of agricultural products per year), being a principal farm operator, farming at least 20 h/week, and living in the targeted counties. This list was stratified according to age and gender of the farmer and type and size of farming operations to create a cohort representative of the demographic characteristics of Iowa farmers and farms as a whole. This list was then sent to the Farm Bureau of Iowa, who sent out mailers to recruit participants. Further details of the selection process and makeup of the cohort are described in an earlier publication.[28]

The AgriSafe Clinics provided specialized preventative clinical health examinations for farmers and agricultural workers. Clinic health providers were certified by examination to provide agricultural health screenings through completion of the 40-h Agricultural Medicine Core Course taught at the University of Iowa. (Note that although the Iowa providers only attended the Core Course in Iowa, this core course is also taught at the University of Nebraska, the University of Texas, the North Carolina Agromedicine Institute, Deakin University in Australia, Swedish University of Agricultural Sciences, and the Vermont Farm Health and Safety Coalition.)[36,37]

A baseline survey was sent to participants, which included items addressing occupational history, personal protective equipment (PPE) use, self-reported occupational injuries, number of acres farmed, and types of crops and livestock raised. Following the survey, the intervention included a baseline clinical health examination and occupational health screening that were conducted during a visit at a local AgriSafe clinic. Clinical data collected included height, weight, BMI, blood pressure, resting heart rate, vision, hearing testing, cholesterol levels, pulmonary function, skin cancer screening, and musculoskeletal examination. In addition to the clinical health screening, additional information was collected about the participants' farming practices, including details of types of livestock and crops produced, chemicals applied, medications taken, and PPE use. Following the health screening, the AgriSafe nurse provided health coaching to all participants, which included working with individual participants to set personal health goals (e.g., weight loss, reduce cholesterol). Also, they provided education to the farmer addressing health and wellness topics based on their personal health screening results and on their type of farming operation. Additional coaching by the nurse included phone calls at 6-month intervals to those who had adverse health indicators based on the clinical examination, to follow-up on progress toward their health goals. Also, the nurse encouraged these participants to attend educational sessions that included occupational respiratory health, PPE selection and use, diet, weight, and hypertension management.

Individuals with adverse markers (high blood pressure, high LDL, or total cholesterol, high BMI, high resting heart rate) were asked to come back for a follow-up clinical visit. Referrals to a physician were made if health indicators (either at baseline or follow-up) so warranted. Farm safety audits using a standard CSF safety audit checklist were conducted at participants' farms by a trained auditor. The farm auditor also provided education concerning safety hazards identified on the participant's farm and facilitated the farmer to achieve correction of those hazards. Scores were assigned to each farm based on the audits, with 100 as the highest possible score. An overall score of 85 was required as a passing grade for the farm to become a "Certified Safe Farm." Farms that failed were allowed to make improvements to subsequently raise their score and pass a follow-up audit. Participants that completed the health component and received a passing farm safety score received a monetary incentive of $200. (This incentive was a surrogate for potential insurance discount incentive currently in development).

Data analysis

Data were analyzed using the FREQ procedure in SAS to compute chi-square tests to determine if associations existed between the adverse wellness health risk factors and injuries. Included in the health indicators investigated were BMI, blood pressure, cholesterol, and heart rate. We did not collect sufficient data to determine the prevalence of metabolic syndrome; however, we did look at the combination of high blood pressure, high total cholesterol, and high BMI, which may be correlated to metabolic syndrome and, we therefore empirically refer to as risk factors for metabolic syndrome in the analyses. (Data on abdominal adiposity and blood glucose, which are included in the American Heart Association's definition of metabolic syndrome, were not collected).

These health matrices were analyzed for possible associations to other known risk factors and farming practices included in the self-reported health survey. These risk factors included mental stress status, self-reported general health status, number of acres farmed, pesticide use, welding status, use of power tools, and use of PPE and sunscreen. For the self-reported stress status question, respondents were asked to rate their overall stress level during the past year (i.e., very low, low, medium, high, and very high). The self-reported health status questionnaire included questions that asked the respondents to rate their health "as compared to others their age" (i.e., poor, fair, good, very good, excellent) as reported in a previous CSF publication.[30] To make the responses dichotomous, health status responses were divided into two groups: the first were those who responded "poor, fair, and good" and the second was those who responded "very good and excellent." A similar process was used for the stress status variable. The first group including participants who responded stress status of "high or very high," and the second group included participants who responded "very low, low, and medium." PPE use was also dichotomized (always/sometimes and sometimes/never).

To determine whether there were health improvements between the first and second clinical health visits, paired t-tests were calculated using SAS software to analyze any differences in the initial screenings and the follow-up screening 2–3 years after the intervention was initiated. The rationale for the timeframe for follow-up was based on the estimate that at least 2 years would be required to show a change in health indicators with the intervention. The same clinical variables used to calculate chi-square for relationships to injury were calculated with t-tests between the first and second round clinical health visits. First clinical health visit variables were also used to calculate t-tests to determine whether there was a difference between those who came back for a second clinical health visit and those who did not. Ninety-five percent confidence intervals (CI) were considered to be statistically significant for all calculations.

Results

Health data were collected from 438 participants. However, for detailed analysis of health matrices compared to other risk variables, 301 (69%) participants were included, as they were the principal farm operator and had completed the survey, clinical health screening, and intervention. A subset of the intervention population (118 or 39%) was asked to come back for a follow-up clinical health screening 2 to 3 years following the baseline, based on health indicators higher than the normal or recommended range on the baseline screening. Compared to all participants, this group was older (p-value = 0.0496), weighed more (p-value = 0.0096), had a higher BMI (p-value = 0.0145), had higher diastolic blood pressure (p-value = 0.0020), higher total cholesterol levels (p-value ≤ .0001) and higher LDL levels (p-value = 0.0080).

The following data provide a health summary of the overall 438 participants screened. Regarding BMI, 47% had values between 25 and 29.9 (considered overweight by CDC), and 32.7% were had values over 30 (considered obese by CDC), for a total of 79.7% either overweight or obese (Table 1). The farmers' collective BMIs were higher by 9.4% for either overweight or obese compared to the respective national averages for men, which are 41% and 29.5%, respectively (Table 3).

Regarding blood pressure, 63.1% of the farmers (national average is 30%) had blood pressures considered to be pre-hypertensive (120–139 mm Hg). However, the farmers were lower (15.9% compared to the national average 33.2%) for stage 1 hypertension (140–159 mm Hg) or stage 2 hypertension (>160 mm Hg).

Regarding total cholesterol, 44.3% of the farmers had levels higher than desirable (>200), but this was lower than the national average (47.8%) (Table 2).

Table 1. CSF clinical variables.

Variable	n	Yes	%	Definition
Injuries	301	29	9.6%	Injury in past 12 months?
>25 BMI	297	140	47.0%	overweight, BMI > 25
>30 BMI	297	97	32.7%	obese, BMI > 30
>35 BMI	297	23	7.7%	severely obese, BMI > 35
Hypertensive Stages 1&2	301	48	15.9%	Hypertensive, systolic > 140, diastolic >90
Pre-Hypertensive & HPT	301	190	63.1%	Pre-Hypertensive, systolic >120, diastolic > 80
High BP+CHL	264	84	31.8%	High BP & CHL
High CHL	264	117	44.3%	Cholesterol >199 or LDL >129
CHL >200	264	102	38.6%	CHL over 200
BMI+BP+CHL	262	8	3.1%	High BP, CHL & BMI

BMI = Body Mass Index
HPT = Hypertensive
BP = Blood Pressure
CHL = Cholesterol

Table 2. National averages 2004.

Overweight >25% BMI	%
CSF	80.1
National Average	66.0
Men 20+ (National)	70.5
Obesity >30% BMI	
CSF	32.7
National Average	31.4
Men 20+ (National)	29.5
Pre-Hypertension & Hypertension	
CSF	63.1
Hypertension Stages 1&2	
CSF	15.9
National Average	33.6
Men 20+ (National)	33.2
Cholesterol	
Cholesterol >199 or LDL >129	44.3
CSF CHL>199	38.6
National Average	48.4
Men 20+ (National)	47.8
Cardiovascular Disease	
National Average 2004	37.1
Men 20+ (National) 2004	37.5
National Average 2010	35.3
Men 20+ (National) 2010	36.7

BMI = Body Mass Index
CSF = Certified Safe Farm participants (the study group)
CHL = Total Cholesterol

(Note in Table 2 that the CSF data are compared to 2004 national norms, which is close in timeframe to when data were collected in this study).

No statistically significant associations were found between BMI, high cholesterol, high blood pressure, or self-reported stress level relative to self-reported injury. However, a statistically significant association was found with the combined variables related to metabolic syndrome (high blood pressure, high cholesterol, and high BMI) with increased injuries (odds ratio 5.5, 95% CI, 1.2–24.5). There was also an association between high self-reported health status and lower self-reported injuries (OR 2.5, 95% CI, 1.2–5.6).

To further study the possible relationship of self-reported health status to other clinical variables, chi-square values were calculated between self-reported health status and BMI, hypertension, and high cholesterol. However, no statistically significant associations were found.

Health improvements were noted between the first and second round clinical health visits. There were significant improvements in cholesterol, LDL, and heart rate values comparing the first clinical health visit to the second clinical health visit. The median values for total cholesterol dropped 8 points (total cholesterol, $p < .0001$ and LDL, $p < 0.0148$). Heart rate values dropped four points ($p = 0.0094$). There was no change from visit 1 to 2 for weight, BMI or blood pressure.

Health improvements were further studied by analyzing improvements by age categories (the group was dichotomized into four age groups, <35, 35–49, 50–64, and >64). The 35 to 49-year-old age group showed the most improvements out of the four age brackets, with statistically significant improvements in three variables; lower BMI (p-value < 0.01), lower diastolic blood pressure (p-value = 0.01), and lower cholesterol levels (p-value = 0.04). The 50 to 64-year-old group showed a statistically significant improvement in cholesterol levels (p-value < 0.01). The 65+ year-old group showed a statistically significant improvement in systolic blood pressure (p-value = 0.04). The < 35-year-old age group had no statistically significant health improvements (Table 3–4, Figure 1).

Discussion

Prior to the current study, few studies have been reported on the general health status of farm owner–operators in the United States. Also, few programs have been reported that focus on health promotion of principal farm operators. There is a program offered by a health-care network in East

Table 3. Paired t-test, paired participants.

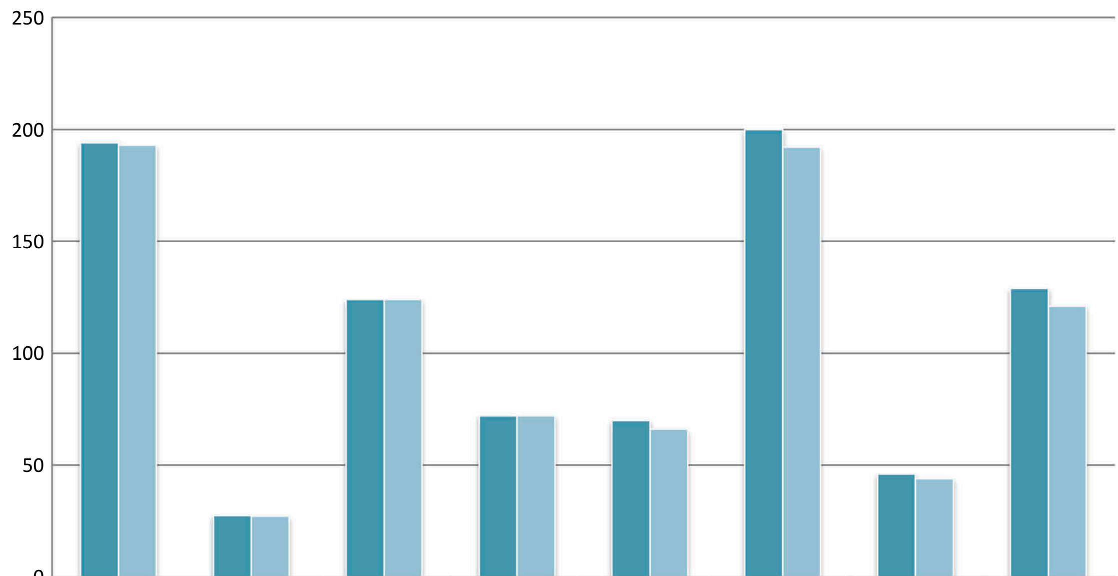
Parameter	n	Clinic Visit 1 mean	Clinic Visit 1 std	Clinic Visit 2 mean	Clinic Visit 2 std	Change	std	t	p
Age	113	54.9	11.7	56.4	11.80	−1.49	NA	NA	NA
Weight	97	196	31.84	195	32.98	−2.30	14.60	−1.55	0.12
BMI	95	27.87	4.38	27.67	4.11	−.22	1.26	−1.68	.10
Systolic	118	128	16.23	126	13.49	2.02	13.94	1.57	.12
Diastolic	118	74	10.86	74	9.90	.13	10.58	.13	.90
Apical Pulse	99	70	7.32	67	9.48	2.50	9.37	2.65	**.0094**
Cholesterol	71	201	39.46	189	40.20	18.24	35.11	4.38	**<.0001**
HDL	66	48	11.44	46	14.18	.11	6.26	.14	.89
LDL	65	125	34.54	120	33.69	11.77	28.79	3.30	**.0016**

BMI = Body Mass Index
HDL = High-Density Cholesterol
LDL = Low-Density Cholesterol

Table 4. Paired t-test by age group, paired participants.

Age<35		Clinic Visit 1		Clinic Visit 2					
Parameter	n	mean	std	mean	std	Change	std	t	p
Age	5	31.2	1.92	32.6	2.19	1.40	0.55	5.72	0.005
Weight	5	170	16.07	171	16.34	1.40	2.19	1.43	0.23
BMI	5	22.60	0.99	22.79	1.23	0.19	0.30	1.45	0.22
Systolic	5	115	7.60	111	8.07	−3.40	5.98	−1.27	0.27
Diastolic	5	69	8.67	63	1.79	−6.00	8.00	−1.68	0.17
Heart Rate	5	65	0.89	70	15.01	4.80	15.27	0.70	0.52
Cholesterol	2	180	27.26	178	47.62	2.50	24.75	0.14	0.91
HDL	2	54	15.92	53	13.08	−6.00	1.41	−6.00	0.11
LDL	2	113	20.73	111	31.05	2.50	27.58	0.13	0.92
35–49									
Age	36	43.9	3.49	45.76	3.75	1.58	0.60	15.74	<.0001
Weight	30	195	28.77	203	34.02	7.40	22.53	1.80	0.08
BMI	29	27.30	3.99	27.95	3.58	0.56	1.02	2.97	**0.006**
Systolic	36	118	8.22	120	8.63	2.92	10.04	1.74	0.09
Diastolic	36	70	6.78	73	9.02	3.22	7.47	2.59	**0.01**
Heart Rate	29	69	6.16	67	5.36	−2.45	6.66	−1.98	0.06
Cholesterol	21	203	33.77	192	36.05	−13.14	26.63	−2.26	**0.04**
HDL	18	46	8.50	47	13.18	−0.22	5.61	−0.17	0.87
LDL	17	126	35.19	124	32.76	−6.29	17.00	−1.53	0.15
50–64									
Age	47	57.5	5.04	59.3	4.77	1.47	0.62	16.22	<.0001
Weight	39	207	31.94	202	32.49	0.31	9.17	0.21	0.84
BMI	39	29.43	4.27	28.85	4.37	0.17	1.42	0.76	0.45
Systolic	50	129	14.57	127	13.47	−2.12	11.69	−1.28	0.21
Diastolic	50	75	12.59	74	11.01	−0.76	12.67	−0.42	0.67
Heart Rate	41	71	7.92	67	11.65	−3.41	11.24	−1.95	0.06
Cholesterol	36	203	42.58	191	29.93	−22.19	35.79	−3.72	**0.0007**
HDL	35	49	19.88	45	12.97	−3.51	19.87	−1.05	0.30
LDL	34	123	35.11	120	29.25	−9.50	37.33	−1.48	0.15
65+									
Age	27	71.6	5.09	73.1	4.98	1.41	0.57	12.78	<.0001
Weight	23	177	27.92	174	23.37	−0.78	7.87	−0.48	0.64
BMI	22	25.89	3.89	25.62	3.23	−0.16	1.32	−0.56	0.58
Systolic	27	143	18.39	133	15.50	−8.15	20.06	−2.11	**0.04**
Diastolic	27	77	10.8	74	8.72	−2.33	9.38	−1.29	0.21
Heart Rate	24	70	8.18	66	8.22	−2.50	6.85	−1.79	0.09
Cholesterol	13	196	41.98	192	42.62	−26.92	54.11	−1.79	0.10
HDL	12	47	8.40	51	14.65	−0.42	11.93	−0.12	0.91
LDL	13	130	40.92	122	35.09	−20.92	43.57	−1.73	0.11

BMI = Body Mass Index
Systolic = Systolic blood pressure
Diastolic = Diastolic blood pressure
HDL = High-density lipoprotein
LDL = Low-density lipoprotein



	Weight	BMI	Systolic	Diastolic	Apical	CHL	HDL	LDL
Visit 1	194	27.47	124	72	70	200	46	129
Visit 2	193	27.12	124	72	66	192	44	121

Figure 1. Paired clinical medians.
BMI = Body Mass IndexSystolic = Systolic blood pressureDiastolic = Diastolic blood pressureApical = Apical pulse or heart rateCHL = CholesterolHDL = High-density lipoproteinLDL = Low-Density lipoprotein

Central Wisconsin (Rural Health Initiative[31]) that provides general health screening for farmers, similar to the health promotion component of the CSF. However, no data were found on the outcomes of this program.

In Australia, Brumby et al.[38] has reported higher obesity, diabetes, and cardiovascular disease in farmers compared to Australian norms. In response to this finding, Brumby and co-workers[38,39] initiated the Healthy Farm Families Program, which focuses on health promotion factors in farmers. They found psychological stress in farmers was a risk factor for metabolic syndrome, and that an exercise intervention was related to a reduction in BMI.[38]

Regarding subjective findings in the current study, we found agreement in two prior publications from the CSF study, which have shown that individuals with low self-reported health status are 2.5 times more likely to experience an injury relative to those reporting good or excellent health status.[27,28] However in the current study, we found no association between self-reported health status and objective adverse clinical health variables of cholesterol, BMI, and hypertension. This suggests that these health indicators are silent relative to an individual's self-perceived health status. A workable hypothesis that might explain this dichotomy is that social/mental health may play a role in self-perceived health status, as well as increased risk for injuries. Research to investigate this hypothesis are warranted.

Prior studies[32] have shown that U.S. farmers appear to have a reduced risk of fatalities from heart attack, stroke, and cancer, relative to the general population.[32] Blair and colleagues have shown mortality to these conditions to be only about 60% of that when compared to the general population.[32] However, our study has shown that health indicators of Iowa farm owner–operators are only slightly better than the general population (higher BMI, but lowered cholesterol and blood pressure). Although there is little general information on the relationship of health indicators found in this study that may explain this situation, others have suggested factors that may reduce risks of the observed lower risk of cardiovascular and malignancy events, including healthier diets, increased exercise, and decreased smoking and alcohol consumption. Also, the healthy worker effect has been proposed as influencing these observations.[32]

It is possible that U.S. national norms for BMI is not an accurate health metric for the U.S. farm population. Although frequently used as a biological marker and risk factor for cardiovascular disease, BMI can be misrepresentative as a measure of obesity. BMI numbers are not necessarily comparable between age (older individuals tend to have more body fat than younger people at the same BMI). Also, BMI can be misleading when measuring individuals with a high proportion of lean muscle mass, such as athletes or others who regularly engage in strenuous work, such as farmers.[13] As has been discussed in studies of lung capacity of farmers,[29] the development of a different set of (farmer-specific) pulmonary function metrics may be advantageous for clinicians working with the agricultural community (farmers generally have higher pulmonary function values than comparison populations). Likewise, perhaps a specific farmer BMI standard would be helpful for health recommendations, as it is not apparent from our data that high BMI is related to other health or injury risks (hypertension and high cholesterol were lower in the study population compared to the national averages). This evidence suggests that this study cohort could possibly have better overall health than the general population in spite of higher BMI's. (Note that this study cohort consisted of white Midwestern farmers [mainly of Northern European descent] and cannot be generalized to all farmers or farm workers). Further studies would be needed to validate this hypothesis.

Although we found a significant association between our stated risk factors for metabolic syndrome (combined high blood pressure, cholesterol, and BMI) and higher injury prevalence, this finding was based on a relatively small sample size. No other significant associations when analyzed individually between clinical risk factors (BMI, blood pressure, heart rate, or cholesterol) and injuries were found. To understand this relationship and test its validity, a larger population would need to be assessed.

Cholesterol, resting heart rate, and LDL levels were all significantly lowered between the first and second clinical health visits for individuals asked to come back for further monitoring, demonstrating the impact of the intervention on health. Several explanations may explain this change: 1) education received at the clinical exams may have been sufficient to change the habits or lifestyles of the individuals, 2) the health-care providers were trained to share the individuals' clinical results and discuss short and long-term implications of the findings, 3) the provider worked with the individual to devise health and wellness goals, and continued follow-up phone calls for coaching and to determine compliance with directives to achieve those goals, and 4) the combined effect of all aspects of the CSF (on farm safety audit, group health and safety education, and monetary incentive) was necessary to create the health outcomes. Also, following the first clinical health screening, if clinical evidence indicated individuals were referred to their primary care physicians, they may have obtained prescriptions for cholesterol-lowering drugs (e.g. statins).

Resting heart rate values and blood pressure did drop significantly following the intervention. This could have been a result of education, coaching, and prescribed goals provided by the CSF health-care provider, which included dietary and exercise recommendations. Or, based on referrals to physicians, these lowered values may have resulted from prescribed heart medications (e.g., beta-blockers). Or, as mentioned above, the effect could have been a result of the combination of all components of the CSF Program. In addition, the resting heart rate may have changed because participants were more comfortable or less anxious for the second clinical health screening.

It is interesting to note that the improvements in health outcomes varied among age groups. Most improvements were seen in the younger (35 to 49-year-old) age group, who lowered their BMI, blood pressure, and total cholesterol from the first to second clinical visits. However, the older groups improved in only one category each (50–60 years, only cholesterol, and those greater than 60, only blood pressure). Younger people may be more motivated and more physically able to comply with interventions that may include exercise and dietary changes. This observation needs further investigation to determine if this holds up, and if there are different interventions that may be more effective for different age groups of farmers.

While this study was strengthened by the overall range of data collected, there may have been more improvements made than those observed, as second round data were not collected on those with normal or marginally high health indicators. Further, there were no clinical health data available on our comparison (non-intervention) population. Therefore, the change in health indicators from baseline to second clinical visit following intervention depended on each individual being their own control.

There was a conscientious effort in the study design to obtain a study population that was a random representative sample of the Iowa Farm population. As the Farm Bureau sent out the recruitment letters, we received a relatively high response rate (our prior experience told us that visible cooperation with a well-known farm organization increased participation). However, not all farmers in Iowa are Farm Bureau members (80% of Iowa farmers belong to Farm Bureau). There is a possibility that this study was not a complete random and representative sample, because of selection bias, and this is a limitation of this study.[39]

Finally, as previously mentioned, this study included several modalities of intervention. The end results may have been a result of a composite effect of this multimodal program (onsite safety inspection and consultation, clinical occupational health and wellness examination, health, wellness coaching, and safety education, intervention group interaction, and incentives to achieve stated goals). It is beyond the scope of this study to parse out the effect of the various factors of the program.

Conclusions

Overall, this study indicates that clinical data suggest that the farming population is a little more "healthy" than the general population. They have higher BMIs, but lower total cholesterol, LDL, and lower prevalence of hypertension. However, in previous studies (mentioned above) the data indicate farmers die much less frequently of the major causes of death than the general population (cardiovascular disease, stroke, cancer). Adverse clinical health indicators seem incompatible with the observed lowered mortality rate. Lower smoking, alcohol, better diet, and exercise may explain the difference.

There was some evidence that the combination of high blood pressure, cholesterol, and BMI were related to increased injury rates. Also, poor self-reported health status was related to increased injuries but was not related to clinical health indicators.

There were significant improvements following the intervention as measured between clinical examinations both within the group as a whole, as well as within age groups, suggesting that the intervention was successful in its goals. Overall, there was an improvement in total cholesterol, LDL, heart rate, and blood pressure. The younger group (35–49 years) had the most health indicator improvement, followed by one improvement each in the older groups (total cholesterol in the 50–64-year-old age group, and lowered blood pressure in the 65+ age group).

A substantial number of prior studies have been conducted examining farmer risk factors associated with specific occupational injury hazards or illnesses (such as machinery injuries, needle sticks, falls, hearing loss, etc.).[40] However, very little research has focused on the individual's general health status as a predictor or risk of occupational injury. Even less research focuses on cardiovascular health or chronic disease and its impact on an occupational injury. This study suggests the need for more clinical health research in agricultural and rural communities relative to the risk of occupational injuries. This study also highlights health issues facing the agricultural community and the need for interventions integrating occupational safety and health prevention along with health promotion.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This research as supported by funding to the University of Iowa from the Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health (Training Grant No. T42OH008491 to the Heartland Center for Occupational Safety and Health and Cooperative Agreement No. U19OH008858 to the Healthier Workforce Center of the Midwest), NIOSH grants U06/CCU72119, UIO/OH008110, U07/0H07548), Iowa Wellmark Foundation, Pioneer Hi-Bred International, Monsanto Corp, Iowa Pork Council, and Iowa's Center for Agricultural Safety and Health.

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