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The associations between occupational health and safety management system programming level and prior injury and illness rates in the U.S. dairy industry

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ABSTRACT

U.S. dairy workers suffer occupational injuries and illnesses at rates higher than the national average. Occupational health and safety management systems (OHSMS) have been proposed as a way to reduce injuries and illnesses for businesses of all types and sizes. The Occupational Safety and Health Administration (OSHA) On-Site Consultation Service provides assistance establishing an OHSMS to U.S. businesses. As part of this service, the consultants determine the level of OHSMS programming using the Safety and Health Program Assessment Worksheet (Revised OSHA Form 33). A total of 167 dairy industry records were obtained from OSHA. Forty-five of those records had both injury rate and OHSMS data. Using these records, a Spearman Rank-Order correlation was used to determine the strength and significance of the associations between prior injury rates and OSHA measured OHSMS programming level for dairy operations. Additional analyses were conducted to examine potential relationships between workforce size, injury rates, and OHSMS programming levels. There was a negative correlation between OHSMS programming level and injury rates, both for the overall OHSMS and by OHSMS component. Management Leadership was the OHSMS component most strongly associated with lower injury and illness rates. OHSMS interventions, as part of a comprehensive risk management approach for the U.S. dairy industry, may be warranted to help reduce the unacceptable number of injury and illnesses in the U.S. dairy industry. Further research is needed to determine if similar relationships between OHSMS programming and injury rates occur in other industries.

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1. Introduction

The Federal OSHA On-Site Consultation Service was established in the U.S. in 1975 to provide small businesses (generally those with fewer than 250 employees) with professional occupational health and safety (OHS) services that such businesses may not be able to otherwise afford (Occupational Safety and Health Administration [OSHA], 2001a). Services provided by OSHA consultants include compliance assistance with OHS regulations and assistance in establishing an occupational health and safety management system (OHSMS) (OSHA, 2008). An OHSMS is a series of interrelated policies, plans, and procedures that specify how an organization manages OHS issues. The American National Standard for Occupational Health and Safety Management Systems (ANSI/ASSE Z10:2102) specifies the elements of an effective OHSMS and includes requirements for management leadership, employee participation, hazard identification, hazard control, worker training, and periodic review (ANSI/ASSE, 2012). In the U.S., there is currently no national requirement for most small businesses to adopt an OHSMS, although some states have mandatory OHSMS requirements or voluntary incentive programs for adopting such a program (OSHA, 2014). OSHA consultants use the Safety and Health Assessment Worksheet (Revised OSHA Form 33) to evaluate their clients' levels of OHSMS programming and as a tool to help businesses establish an OHSMS (OSHA, 2008). Scores from the Revised OSHA Form 33 indicate the degree of implementation of multiple OHSMS attributes. Even if a business does not have a formal system in place at the time of assessment, the form is used to measure

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the de facto level of OHSMS programming and is intended to be used as a way to establish or improve a formal OHSMS. The Revised OSHA Form 33 measures 58 OHSMS attributes divided into seven OHSMS components (hazard anticipation and detection, hazard prevention and control, planning and evaluation, administration and supervision, safety and health training, management leadership, and employee participation) (OSHA, 2001b). Revised OSHA Form 33 attributes are scored on a four-item, forced-choice scale ranging from zero (attribute not present) to three (attribute fully implemented) (OSHA, 2001b). Consultants are discouraged from guessing when completing the Revised OSHA Form 33, and consultants may choose not to score attributes if they do not have enough information; in this case, the attribute is "Not Evaluated" (NE) and the attribute is not included in the overall OHSMS score (OSHA, 2008). Further, if a Revised OSHA Form 33 attribute is not applicable to a particular client, the attribute is scored "Not Applicable" (NA) and the attribute is included in the overall average score with a value of three (OSHA, 2008).

Information on client injury and illness rates is also collected by OSHA consultants for a period of up to three years prior to the consultation visit (OSHA, 2008). Two specific rates are determined for each client business. The total recordable case (TRC) rate is a measure of the total number of work-related injuries and illnesses experienced by an organization's workers. It is computed by first multiplying the total number of recordable injuries and illnesses (as required by OSHA regulations) by 200,000, which is the nominal number of hours worked by a 100 person workforce working 40 h per week and 50 weeks per year (OSHA, 2008). The product is then divided by the actual total number of hours worked by all employees at the establishment to produce the TRC rate (OSHA, 2008). Thus, the TRC rate is normalized so that the injury and illness rates of businesses can be compared with one another, regardless of differences in work schedules or workforce sizes. The second rate collected by OSHA consultants is the days away, restricted work activity, or job transfer (DART) rate (OSHA, 2008). The DART rate is computed in the same manner as the TRC rate, but only the most severe injuries and illnesses are counted that resulted in lost time or reduced work capability for the employee (OSHA, 2008).

OSHA On-Site Consultation clients with exemplary OHSMS (as evidenced by high scores on the Revised OSHA Form 33) and relatively low injury and illness rates compared to other businesses in their industry may qualify for the OSHA Safety and Health Achievement Recognition Program (SHARP) (OSHA, 2008). Businesses that achieve SHARP status receive formal recognition from OSHA as OHS leaders in their industries and they receive exemptions from programmed OSHA regulatory inspections (OSHA, 2008). Eight of the 58 Revised OSHA Form 33 attributes are considered optional 'stretch' attributes that are not normally evaluated except in the case of SHARP applicants. OSHA consultants are expected to conduct at least a partial OHSMS assessment using the Revised OSHA Form 33 for most visits, but they are only required to score all of the applicable attributes for SHARP participants (OSHA, 2008).

Until recently, OSHA consultants input client injury and illness rates and Revised OSHA Form 33 scores into the Web Integrated Management Information System (WebIMIS) database (OSHA, 1995). These data were used to generate norms and to inform policy decisions (OSHA, 2008). The generated norms that are most relevant to the OSHA consultation process are the average industry OHSMS performance data and the average industry injury and illness data (OSHA, 2008). Average industry data are queried in WebIMIS using North American Industry Classification System (NAICS) codes to produce Industry Comparative Reports (ICRs) and Employer Comparative Reports (ECRs) (OSHA, 1995). The ICR and ECR reports are tools that OSHA consultants use to research industry OHSMS and injury and illness performance of similar businesses, and to benchmark their clients' performance in these areas (OSHA, 2008). The ICR and ECR reports include average, overall Revised OSHA Form 33 scores by industry and average scores for each OHSMS component and individual attribute (OSHA, 1995). The reports also include average Days Away, Restricted and Transferred (DART) and Total Recordable Case (TRC) rates as input by OSHA consultants from clients' Log of Work-Related Injuries and Illnesses (OSHA Form 300) forms (OSHA, 1995). When determining if potential SHARP participants have lower injury and illnesses rates than the national average, Bureau of Labor Statistics (BLS) rates are used by OSHA consultants because the rates can be directly compared for the year (or years) relevant to the SHARP applicant's candidacy (OSHA, 2008). As of 2014, OSHA consultants now input client data into the new OSHA Information System (OIS) database, but they still use ICR and ECR reports generated in WebIMIS (OSHA, 2013a).

Workers in the U.S. dairy industry suffer occupational injuries and illnesses at rates higher than the national average (U.S. Bureau of Labor Statistics, 2012). Despite historically meager regulatory enforcement of OHS on dairies, OSHA officials have recently enacted two Local Emphasis Programs (LEPs) in Wisconsin and New York State (OSHA, 2012a, 2013b). Through these LEPs, OSHA regulators have established a process of programmed regulatory inspections of dairies in the affected states (OSHA, 2012a, 2013b). Given this recent increase in regulatory attention, it may be helpful to consider ways that dairy producers can reduce their regulatory liability as well as their injury and illness rates. OSHA regulators believe that OHSMS are an effective means for businesses to prevent injuries, illnesses, and fatalities, and OSHA compliance officers use OHSMS as evidence of employers' good faith in providing a safe work environment (OSHA, 2009). There is also evidence that voluntary OHSMS interventions in the U.S. can improve an organization's OHS performance (Bunn et al., 2001; LaMontagne et al., 2004). In the most comprehensive review of OHSMS interventions to-date, the authors found that most of the studies included in the review showed positive changes resulting from OHSMS interventions, but that there were insufficient data in the published literature to recommend any such interventions (Robson et al., 2007). No previous studies were found that have specifically evaluated OHSMS interventions in agriculture. However, dairies were found to be one of the top adopters of mandatory OHSMS components as compared to other industries in the Australian agricultural sector (Lower et al., 2011). The International Labour Organization has also included OHSMS guidelines in their most recent *Code of Practice on Safety and Health in Agriculture* (International Labour Organization, 2010). In the U.S. dairy industry, farm management practices have been shown to influence milk quality and production, but human resource management on dairy farms has not been well studied (Hagevoort et al., 2013). In a 2013 paper presented at the Western Dairy Management Conference, researchers called for a systematic approach to OHS management and the integration of OHSMS with other dairy systems, citing benefits that included reduced injuries and improved productivity and quality (Reynolds et al., 2013). OHSMS and integrated systems are highly flexible and can be tailored to all sizes and types of businesses. The current increased attention from OSHA regulators, the potential OHS and regulatory benefits of OHSMS, and the flexibility and feasibility of OHSMS indicate that OHSMS interventions may be beneficial for the dairy industry.

No studies evaluating the relationship between Revised OSHA Form 33 scores and injury and illness rates were found during a literature search. However, Akbar-Khanzadeh and Wagner (2001) compared the OSHA Form 33 scores of 107 Ohio OSHA consultation clients from a variety of industries to the number of OSHA violations observed in the client businesses and found a negative corre-

lation between the number of OSHA violations and the level of OHSMS programming. It is postulated that a similar relationship between Revised OSHA Form 33 scores and injury and illness rate may also exist. Akbar-Khanzadeh and Wagner (2001) also reported a positive correlation between the number of employees and Revised OSHA Form 33 scores, and no apparent relationship between the number of employees and the number of OSHA violations. The authors speculated that as the number of employees increased so did an organization's OHS capabilities, which would lead to improved Revised OSHA Form 33 scores while keeping the ratio of OSHA violations to the number of workers stable (Akbar-Khanzadeh and Wagner, 2001). In contrast, Douphrate et al. (2009) analyzed worker's compensation insurance claims from Colorado agriculture producers and found that smaller dairy farms (those with fewer than 10 employees) were more strongly associated with livestock handling injuries than farms with more than 10 workers. Therefore, a negative association between the number of dairy workers on a farm and farm injury and illness rates is hypothesized.

Akbar-Khanzadeh and Wagner (2001) suggested that fewer OSHA violations could indicate a decreased risk of injuries and illnesses, but they cited the lack of injury and illness data as a major limitation in their study. The authors used binary logistic regression to determine the strength and significance of the correlations in their study because the OHSMS scores and number of violations were not normally distributed (Akbar-Khanzadeh and Wagner, 2001). They divided the number of violations into two groups: a low and high group, split roughly in the middle to produce approximately equal group sizes for the types of violations they were analyzing (Akbar-Khanzadeh and Wagner, 2001). Thus, their reported correlation coefficients were actually a measure of the strength of the relationship between Revised OSHA Form 33 scores from businesses with a relatively low number of violations, compared to ones with relatively high number of violations. The high- and low-violation comparison groups were separated by an arbitrary midpoint, except in the case of the "regulatory violations" category, which resulted in two groups for that violation type of no violations (low) and some violations (high) (Akbar-Khanzadeh and Wagner, 2001).

There was little other research found that evaluated the OSHA Form 33 or used OSHA Form 33 data. Weems and Smitherman (1998) reported the results of reliability and validity testing of a previous version of the OSHA Form 33 and concluded that OHSMS components and attributes on the form were valid measures of OHSMS programming level. The authors then reported the results of a follow-up predictability study in which they concluded that performance of a newer version of the OSHA Form 33 was predictive of reduced injuries and illnesses (Weems and Smitherman, 2000). This follow-up study included a representative sample of small, high-hazard industries from each state (Weems and Smitherman, 2000). Based on these findings, the OSHA Form 33 was revised again in 2001 to the 58 item version that is in use today (OSHA, 2001b).

The primary hypothesis for this project was that OHSMS programming level would be negatively correlated with injury and illness rates for commercial dairies. That is, as the OHSMS programming level increased there would be a reduction in the injury and illness rates. It was also hypothesized that workforce size on dairy farms would be correlated with increased OHSMS programming and decreased injury and illness rates. The objective of this research was to determine if OHSMS programming is associated with lower injury rates for dairy workers, and if so, what components and attributes of an OHSMS are more likely to help prevent injuries and illness in the U.S. dairy industry.

2. Methods

2.1. Data

An authorized OSHA representative from the Office of Information Technology Solutions provided OSHA consultation data for the dairy cattle and milk production industry (NAICS 112120) between 2003 and 2013, including Revised OSHA Form 33 scores and injury/illness rates from WebIMIS. Injury and illness data were limited to TRC and DART rates; additional information about the number, type, and severity of the injuries and illnesses was not available. The consultation records also included the state in which the dairies were located and the number of workers employed by each dairy. A nondescript OSHA reference number was used to pair the demographic, OHSMS, and rate data for a particular dairy. The OSHA representative provided no information that would enable the identification of a specific dairy whose information was included in the data. A consultant code was also included with the data, which could be used to determine if the same consultant entered OHSMS and injury/illness data into WebIMIS for all of the dairy consultations in a particular state. All study procedures were approved by the Research Integrity and Compliance Review Office (RICRO) at Colorado State University and all data received from OSHA were managed according to the WebIMIS Rules of Behavior (Colorado State University, 2014; OSHA, 2005).

An OSHA ICR for NAICS 112120 was produced that indicated there were 220 potential Revised OSHA Form 33 records in WebIMIS for dairies. Lenth's Power Applet was used to make a conservative estimate of the power of a test of correlation between OHSMS programming level and injury/illness rates assuming a R^2 of 0.1 for the 220 Revised OSHA Form 33 sample size indicated in the ICR (Lenth, 2009). The estimated power was greater than 99 percent. Another power estimate was made using only a third of the ICR-indicated sample size ($n = 75$, 34%) and the power was estimated to be 80 percent assuming the same correlation. This second power estimate was conducted to account for the possibility that a large portion of the indicated ICR sample size may not be useable (e.g., if many records had OHSMS data but not injury and illness rates, or vice versa). The conservative correlation estimate that was used to estimate statistical power was similar to many of the associations reported by Akbar-Khanzadeh and Wagner (2001) between Revised OSHA Form 33 scores and serious OSHA violations. The final number of dairy industry consultation records received from OSHA was 167, which was fewer than expected based on the industry ICR.

2.2. Analysis

Spearman's Rank-Order Correlation test was used to assess the strength of association between average, overall Revised OSHA Form 33 scores for each dairy and their paired, average TRC and DART rates. The TRC and DART rates of each record were averaged over the three years prior to the consultation visit. No data on changes to the injury and illness rates following the consultation visit were available. Correlation was also tested between TRC/DART rates and the average OHSMS Form 33 scores for each of the seven OHSMS components. The non-parametric Spearman alternative to linear correlation was used because the assumptions for linear correlation were not supported. Specifically, the injury rates and Revised OSHA Form 33 scores were not normally distributed, the potential relationships were not all convincingly linear, and there were some significant outliers that could not be omitted from the analysis. The assumption of linearity was assessed using a Lack of Fit test and the assumption of normality

was tested using a Shapiro–Wilk test. Diagnostic plots were also visually inspected in conjunction with the statistical tests to support or reject the assumptions for linear correlation. This approach allowed the relationship between OHSMS programming level and injury and illness rates to be assessed without dividing the observations into high and low rate categories when considering the overall Revised OSHA Form 33 scores and the scores by OHSMS component.

To evaluate the strength of association between Revised OSHA Form 33 scores with higher completion percentages and dairy worker injury/illness rates, Spearman's Rank-Order Correlation testing was repeated using a sub-set of the OHSMS observations consisting of only those observations where 50 percent or more attributes had been scored on the Revised OSHA Form 33. The higher completion rate Revised OSHA Form 33 analysis was conducted for the overall OHSMS programming level and by each OHSMS component.

Spearman correlation testing was also conducted to assess the relationship between the number of workers at a dairy and the level of OHSMS programming. The correlation tests were completed for two samples, the first consisting of the observations that were included in the previous analyses by virtue of having paired OHSMS and rate data. In addition, the larger sample of observations that had OHSMS scores, but did not necessarily have paired injury and illness rate data, were also evaluated because average TRC and DART rates were not necessary to evaluate the relationship between workforce size and OHSMS level. Spearman's Rank-Order Correlation test was again used to evaluate the strength of association between the number of dairy employees and worker injury and illness rates.

Descriptive analysis included examining the number and geographic distribution of dairies and dairy workers who received OHSMS assistance, as compared to the number and distribution of commercial dairies nationally using the most recent U.S. census of agriculture data (National Agricultural Statistics Service [NASS], 2012a). In addition, the number of different consultants who provided services for the dairy industry and the numeric completion percentage of Revised OSHA Form 33 attributes was determined. The proportion of scored Revised OSHA Form 33 attributes was computed for each OHSMS component to determine which OHSMS components were being assessed less frequently by OSHA consultants.

Data analysis for this project was conducted using SAS software, Version 9.2 of the SAS System for Windows. Copyright, SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.

3. Results

3.1. Sample characteristics

One-hundred sixty-seven (167) OSHA consultation records were provided by OSHA for the dairy cattle and milk production industry (NAICS 112120). Forty-five of 167 (27 percent) had both Revised OSHA Form 33 scores and TRC and DART rates that could be paired. The OSHA records for each observation also included the state where the dairy was located, the number of workers employed by the dairy, and a consultant code. Only one of the 167 records had two sets of Revised OSHA Form 33 scores, indicating a potential follow-up visit to reevaluate the client's OHSMS. However, their scores were identical so only one set was included in the analysis. This indicates that the dairy records included in this study represented the initial OHSMS evaluation for each dairy, and that none had a follow-up assessment that would have measured changes in the Revised OSHA Form 33 scores resulting from the provided consultation services. The OSHA records were created between 2003 and 2013. A summary of the major study variables is provided in Table 1.

All of the 167 dairy consultation records were from five U.S. states. A vast majority of the dairy consultation records were for California dairy farms ($n = 150$, 90 percent). The other states with dairy consultation records were Wisconsin ($n = 13$, eight percent), Oregon ($n = 2$, one percent), Michigan ($n = 1$, 0.5 percent), and New York ($n = 1$, 0.5 percent). These states represent four OSHA regions, specifically OSHA Regions 2, 5, 9, and 10. Among the 45 dairy records that had both Revised OSHA Form 33 scores and injury and illness rates, only California ($n = 40$, 89 percent), Wisconsin ($n = 4$, nine percent), and Oregon ($n = 1$, two percent) were represented.

Four of the five states with dairy consultation records are among the top 10 in U.S. milk production, and the top two milk producing states are represented (California and Wisconsin) (NASS, 2014). The distribution of dairy consultation records by state and U.S. milk production is illustrated in Fig. 1.

The number of dairy workers employed by the 167 dairies with OSHA consultation records was 2862. The mean number of workers per dairy was 17. Only 26 of 167 dairies (16 percent) had fewer than 10 workers. Of the 45 dairy consultation records with paired injury/illness rates and Revised OSHA Form 33 scores, the mean number of workers per dairy was 23 and the total number of workers represented was 1023. The number of dairy workers covered by OSHA consultation visits by state is also provided in Fig. 1.

The 167 OSHA consultation records for dairy farms were input into WebIMIS by only 25 consultants. Sixteen of those 25 (64 percent) conducted the 150 dairy consultation visits in California. Five of the 25 (20 percent) conducted the 13 consultation visits in Wisconsin. The remaining four consultants conducted the four consultations in Oregon, Michigan, and New York.

The mean numeric completion rate (the number of attributes not scored NE divided by the total number of attributes) for all of the Revised OSHA Form 33 records was 46 percent, ranging from a low of 26 percent to a high of 83 percent. The mean response rate per Revised OSHA Form 33 attribute was 46 percent, ranging from two to 100 percent. When the eight optional stretch attributes were not considered, the mean numeric response rate per attribute was 49 percent with the same range. The mean response rate per stretch attribute was 27 percent, ranging from four to 84 percent. The numeric response rates to Revised OSHA Form 33 attributes by overall Revised OSHA Form 33 and OHSMS component are presented in Table 2.

Table 1
Summary of dairy industry data from 45 OSHA On-Site consultation service records with revised OSHA Form 33 scores and TRC & DART rates.

Variable	Median	Mean (SD)	Min–Max
Number of employees	23	22.7 (11.0)	3–55
TRC Rate	7.3	7.7 (5.3)	0–19.2
DART Rate	4.7	5.0 (4.1)	0–18.6
Revised OSHA Form 33 Scores[a]			
Overall	1.8	1.7 (0.4)	0.4–2.1
Hazard anticipation and protection	1.8	1.6 (0.4)	0.3–2.0
Hazard prevention and control	1.8	1.7 (0.4)	0.6–2.3
Planning and evaluation	2.0	1.6 (0.6)	0–2.0
Administration and supervision	2.0	1.8 (0.4)	0–2.5
Safety and health training	2.0	1.7 (0.5)	0–2.7
Management leadership	2.0	1.6 (0.7)	0–2.3
Employee participation	2.0	1.7 (0.4)	0–2.0

OSHA – U.S. Occupational Safety and Health Administration.
TRC – Total Recordable Case Rate.
DART – Days, Away, Restricted, or Transferred Rate.
[a] Possible Scores for Revised OSHA Form 33 Attributes Range from 0 (attribute not present) to 3 (attribute fully implemented).

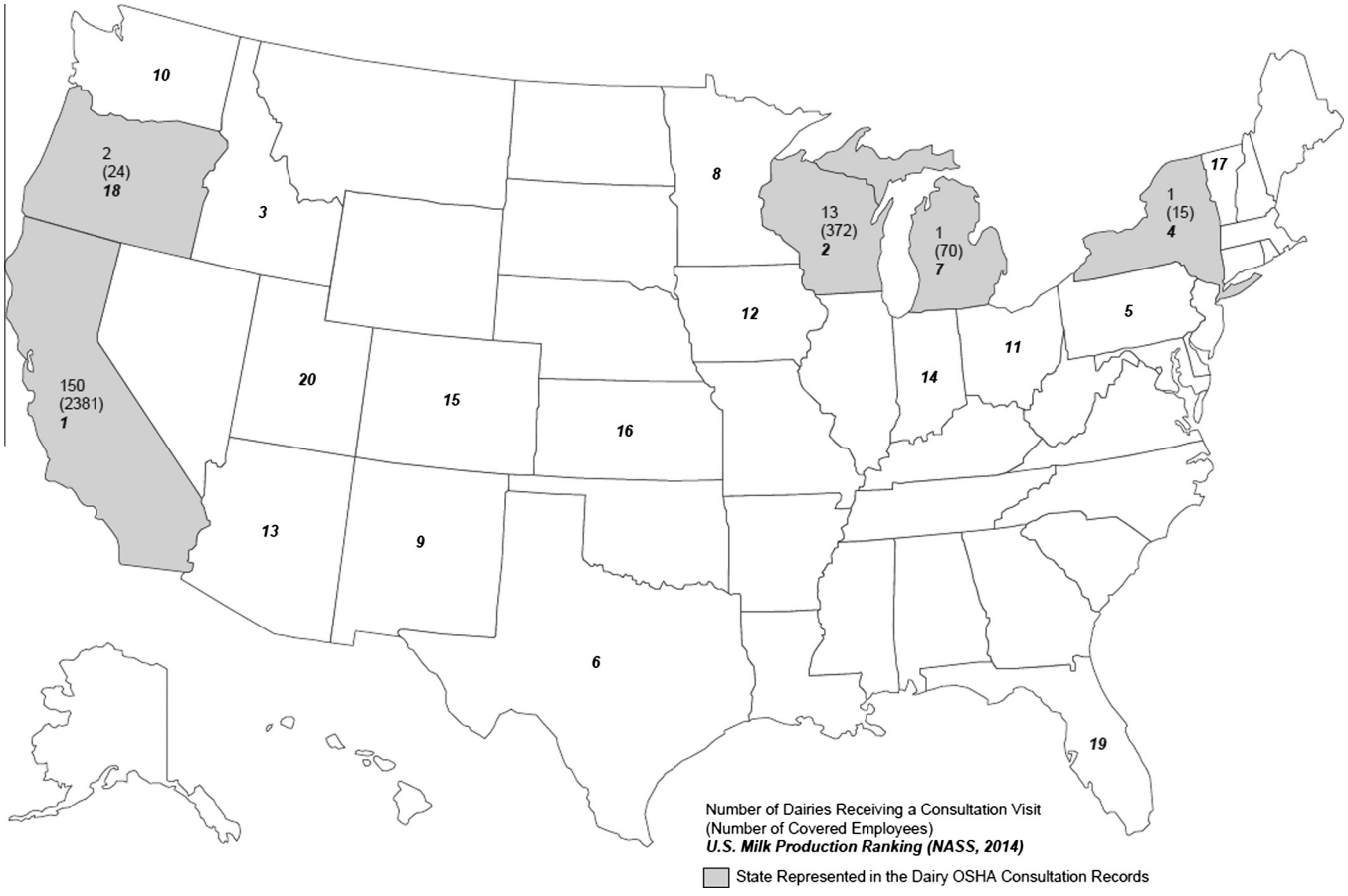

Fig. 1. Ranking of the Top 20 Milk producing states in the U.S. and the Number of OSHA dairy consultations and covered dairy workers.

Table 2
Consultation numeric response rate for revised OSHA Form 33 and Each OHSMS component.

OHSMS component	Total no. attributes	Mean no. scored attributes	Overall numeric response rate (%)
Overall Revised OSHA Form 33	58	26.7	46
Hazard anticipation and detection	10	4.7	47
Hazard prevention and control	9	4.4	48
Planning and evaluation	6	3.2	54
Administration and supervision	8	4.4	56
Safety and health training	6	3.6	59
Management leadership	10	1.3	13
Employee participation	9	4.2	47

OSHA – U.S. Occupational Health Administration.
OHSMS – Occupational Health and Safety Management System.

3.2. Measures of association

No statistically significant association was found between overall OHSMS programming level and TRC or DART rates. However, a significant association was found between both TRC and DART rates and the Hazard Prevention and Control and Management Leadership OHSMS components. The results of the Spearman's Rank-Order Correlation analysis for OHSMS programming level and injury/illness rates for the 45 paired dairy records are provided in Table 3.

Thirty-eight of 45 paired dairy industry records (84 percent) had Revised OSHA Form 33 entries where fewer than half of the 58 attributes were assigned a numeric score. Seven of 45 (16 percent) paired observations were included in a secondary correlation analysis because they included Revised OSHA Form 33 records where at least half or more of the attributes ($\geqslant 29$) were assigned a numeric score. When the smaller subset of more complete Revised OSHA Form 33 records were analyzed, a moderate association was found between overall OHSMS programming and injury and illness rates. Moderate to strong associations were also found between each of the seven OHSMS components and TRC/DART rates. All but the Planning and Evaluation and Employee Participation OHSMS components had statistically significant associations. The results of this secondary analysis are included in Table 4.

Nonparametric correlation analysis between the number of workers and injury/illness rates was conducted for the paired ($n = 45$) and unpaired ($n = 46$) OSHA consultation records with injury data. The number of dairy workers was not significantly associated with the injury and illness rates when examining either sample. Moderate positive associations were found between the

Table 3
Spearman correlation coefficients for the strength of association between injury & illness rates and OHSMS programming level ($n = 45$).

OHSMS element	TRC	DART
Overall	−0.17	−0.12
Hazard anticipation and detection	−0.15	−0.13
Hazard prevention and control	−0.30*	−0.33*
Planning and evaluation	0.13	0.22
Administration and supervision	−0.06	−0.08
Safety and health training	−0.19	−0.14
Management leadership	−0.36*	−0.35*
Employee participation	−0.10	−0.15

OHSMS – Occupational Health and Safety Management System.
TRC – Total Recordable Case Rate.
DART – Days, Away, Restricted, or Transferred Rate.
* Correlation was significant ($P < 0.05$).

Table 4
Spearman correlation coefficients for the strength of association between injury & illness rates and OHSMS programming level revised OSHA Form 33 completion rates $\geqslant$50% ($n = 7$).

OHSMS element	TRC	DART
Overall	−0.79*	−0.79*
Hazard anticipation and detection	−0.79*	−0.79*
Hazard prevention and control	−0.84*	−0.84*
Planning and evaluation	−0.65	−0.65
Administration and supervision	−0.76*	−0.76*
Safety and health training	−0.90*	−0.90*
Management leadership	−0.91*	−0.91*
Employee participation	−0.55	−0.55

OSHA – U.S. Occupational Safety and Health Administration.
OHSMS – Occupational Health and Safety Management System.
TRC – Total Recordable Case Rate.
DART – Days, Away, Restricted, or Transferred Rate.
* Correlation was significant ($P < 0.05$).

Table 5
Spearman correlation coefficients for the strength of association between the number of employees on a dairy, OHSMS programming level, and injury & illness rates.

Sample	Correlations for workforce size	
	ρ[a]	P-value
TRC Rate, *Paired* ($n = 45$)	−0.18	0.25
DART Rate, *Paired* ($n = 45$)	−0.17	0.26
TRC Rate, *Unpaired* ($n = 46$)	0.12	0.43
DART Rate, *Unpaired* ($n = 46$)	0.06	0.66
Revised OSHA Form 33 Scores, *Paired* ($n = 45$)	0.28	0.07
Revised OSHA Form 33 Scores, *Unpaired* ($n = 166$)	0.29	<0.001

OSHA – U.S. Occupational Safety and Health Administration.
OHSMS – Occupational Health and Safety Management System.
TRC – Total Recordable Case Rate.
DART – Days, Away, Restricted, or Transferred Rate.
[a] Spearman's rank-order correlation coefficient.

number of dairy workers and overall Revised OSHA Form 33 scores when both the paired ($n = 45$) and unpaired ($n = 166$) records with Revised OSHA Form 33 scores were included. Only the larger unpaired sample was statistically significant at the $\alpha = 0.05$ level. The results of the correlation analysis for the number of dairy workers are provided in Table 5.

4. Discussion

The injury and illness rates observed for dairies in this study were higher than the national average rate of non-fatal injuries and illnesses in the milk production industry over the same time period. Between 2003 and 2013, the national average injury rate for the U.S. dairy industry was 5.8, ranging from a low of 3.9 in 2010 to a high of 7.3 in 2006 (BLS, 2015). By comparison, the mean TRC rate observed in this study was 7.7 with a range of 0 to 19.6. This suggests that companies seeking OSHA consultation assistance may have done so in part due to the high number of workplace injuries that their workers had experienced. Alternatively, the higher rates may reflect assistance in proper recordkeeping provided by the consultant. Unfortunately, the data used in this study were provided over a range of years and individual dates of service were not available to compare variances in sample population rates as compared to national trends. However, formal OSHA OHSMS assessment procedures and dairy industry production were relatively consistent during the study period. The study period occurred between OSHA adopting a new version of the Form 33 in 2001, and OSHA adopting a new information management system in 2014. In addition, national milk production increased in every year of the study period except for 2009, when total milk production was slightly less than 2008 (NASS, 2014).

The level of OHSMS programming, as measured by the Revised OSHA Form 33, was associated with lower injury and illness rates for dairy workers. The strength of association and the number of statistically significant associations for each OHSMS component increased considerably when only those forms were included where 50 percent or more Revised OSHA Form 33 attributes were assigned a numeric score. These findings suggest that when more attributes are scored by a consultant, there is a clearer association between Revised OSHA Form 33 scores and injury rates. However, there are many reasons why a consultant may not be able to assess many of the OHSMS attributes on the Revised OSHA Form 33. OSHA consultants have a number of important responsibilities when providing services to small business clients. Aside from OHSMS assistance and recordkeeping from the OSHA Form 300 log, consultants need to inspect facilities and interview workers and management to identify hazards and assess compliance with OSHA regulations (OSHA, 2008). In addition, many visits may not be comprehensive in nature and may only warrant scoring those components of the Revised OSHA Form 33 relevant to the scope of consultation. Consultants also conduct a limited number of visits to each establishment, and key personnel for assessing particular attributes may not always be present during these visits. Except for SHARP participants, who often have long-term relationships with OSHA consultants that develop over a number of years, there may often be insufficient time to uncover all of the necessary indicators to assess a particular attribute. Despite these challenges, the Revised OSHA Form 33 attribute scores and comments can provide valuable feedback to an organization about OHSMS performance and what changes may lead to improvements. In a recent study, 97 percent of respondents to a survey of OSHA consultation clients in Colorado reported that the Revised OSHA Form 33 was accurate and that the results were helpful for improving their organization's OHSMS (Autenrieth et al., 2015). Detailed comments and suggestions on low scoring attributes were considered particularly helpful for making workplace improvements, according to respondents (Autenrieth et al., 2015). Given the value of Revised OSHA Form 33 to clients and the apparent associations between OHSMS programming and reduced injury and illnesses, prioritizing the completion of the Revised OSHA Form 33 and including comments and suggestions for improvement may be beneficial for consultation visits in the U.S. dairy industry.

There was a significant, positive association between the number of workers employed by a dairy and level of OHSMS programming, but there was no significant association between the number of dairy workers and a farm's injury and illness rates. These findings are similar to those reported by Akbar-Khanzadeh and Wagner (2001), who suggested that the greater number of employ-

ees serve to keep the rate of regulatory violations stable while improving the overall OHSMS. In contrast, the lack of association between the number of workers and injury rates are contrary to those reported by Douphrate et al. (2009) who found an association between smaller organizations and increased livestock handling injuries. Means testing results also indicated that injury and illness rates were not significantly different between small and large dairy organizations. However, the dairy records in this project were from relatively large, commercial operations with an approximate range of 250–5500 milking cows assuming 80–100 cows per worker (Douphrate et al., 2013). Therefore, there may not have been sufficient representation of smaller dairies to elucidate potential differences between the injury rates of dairies with different workforce sizes.

4.1. Limitations

The OSHA consultation data used in this study were not collected for research purposes. Instead, the data were collected and stored for internal evaluation purposes and to generate industry norms (OSHA, 2008). As such, the data may not be representative of all injuries and illnesses suffered by dairy workers (e.g., minor injuries that were not recordable would not likely be included), nor of the entire scope of OHSMS programming in place at these organizations. There were fewer ($n = 167$) than expected ($n = 220$) OSHA consultation records for the dairy industry with either OHSMS or injury data. This could be because older records included in the estimate were no longer available or that some of the records did not have any relevant data. There is also the possibility that data in these records were miscoded at entry. To address this limitation, all OSHA data were searched for invalid entries (e.g., any value for State other than two letter U.S. state codes or any Revised OSHA Form 33 attribute score other than 0, 1, 2, 3, NA, or NE). Further, injury/illness and OHSMS programming data were paired independently using two different identifier codes to ensure proper matching for correlational analysis.

The OSHA consultation records for the dairy industry included in this study represented only five U.S. states, and 90 percent of the records were from California dairies. Although California is the leading dairy producing state in the U.S. (by total milk weight), 15 of the top 20 dairy producing states have no representation in this analysis (NASS, 2014). However, the five states that are included in this study account for 45 percent of all hired dairy farm workers in the U.S. (NASS, 2012a). Another potential disparity in the representation of dairies is that commercial dairies in California are required to comply with Section 3203 of the California OSHA regulations by establishing and maintaining an OHSMS (California Department of Industrial Relations, 1991).The California OHSMS regulations may explain why the vast majority of OSHA consultations resulting in Revised OSHA Form 33 scores are from California. It is also reasonable to suspect that OHSMS programming levels may be higher on California dairies than on dairies in other states because of these regulatory requirements. To evaluate this potential difference, a Wilcoxon signed-rank test was completed comparing the mean, overall Revised OSHA Form 33 scores from California records ($n = 149$) and those from other states ($n = 17$). There was no statistically significant difference between the mean OHSMS programming levels of the two groups.

Although the total number of employees represented in this data set was small, the average workforce size was large relative to U.S. dairy industry averages. There were an estimated 64,098 farms with milk cows in the U.S. in 2012, and 60,484 of those farms (94 percent) had fewer than 500 milk cows according to the most recent U.S. census data (NASS, 2012a). However, there were only 27,744 farms with hired labor classified as dairies in NAICS, and of those, 10,215 dairies (37 percent) had 500 or more milk cows (NASS, 2012a). In 2013, Douphrate et al. reported a 1:80–100 worker-to-cow ratio for large dairy operations. Two-thirds of the milk produced in the U.S. in 2011 came from farms with greater than 500 cows in 2012 (NASS, 2012b). While many small farms with at least some dairy cows may not be represented here, the results of this project should be relevant for large herd, commercial dairies that house the most dairy cows, produce the most milk, and employ a large proportion of U.S. dairy workers.

A relatively small number of consultants performed the site visits for dairies whose data were included in this study. While this may offer some degree of confidence in the lack of inter-rater differences, as suggested by Akbar-Khanzadeh and Wagner (2001), it may also indicate some uncertainty in the Revised OSHA Form 33 scores due to individual biases. For instance, if a single consultant tended to always score high on the form and that consultant was the one conducting most of the dairy visits for that state, it stands to reason that the dairies for that state may have higher than expected overall Revised OSHA Form 33 scores. The nature or magnitude of these potential scorer effects cannot be estimated or controlled for in the current analysis. While this is an important potential limitation, all OSHA consultants do receive the same rigorous training that includes strategies for minimizing low or high scoring errors (OSHA, 2012b).

Of the 167 total dairy industry consultation records, only 45 records had both Revised OSHA Form 33 scores and injury/illness rates that could be paired for an individual organization. It was not clear why so many records had OHSMS programming data but lacked injury data for comparison. One likely explanation is that virtually all OSHA consultation site visits require the completion of at least part of the Revised OSHA Form 33 but fewer require recordkeeping assistance. Still, a review of a client company's injury and illness logs is supposed to be a routine part of the consultation process (OSHA, 2008). With such a low proportion of records (27 percent) having paired injury data, an additional analysis was performed to determine if those with injury and illness rates were representative of those without. Thus, a Wilcoxon sign-ranked test between the mean, overall Revised OSHA Form 33 scores of dairy records with paired injury rates ($n = 45$) and without paired injury rates ($n = 122$) was conducted. The results of this test indicated that the average level of OHSMS programming was indeed significantly higher in the group with paired injury data (P-value < 0.01). This finding suggests that the dairies included in our correlation analysis may have done a better job of systematically addressing OHS than those that were not included. Thus, the reported associations may not be as applicable to those dairies with lower levels of OHSMS programming. In addition, dairies that received OSHA consultation visits may differ from those that did not receive services. Dairy farm managers who sought out consultation services indicated some level of awareness and concern for worker safety and may have had higher levels of OHS performance than those who did not contact OSHA. Alternatively, those dairy managers who contacted OSHA may have been doing so in response to an incident or OHS compliance visit and may therefore have had worse OHS performance. Furthermore, the measures of association presented here lack a temporal relationship because client OHSMS are assessed during a consultation visit and the injury rates included in this study only included those incidents that occurred in the time leading up to the consultation visit. Additional injury and illness data and Revised OSHA Form 33 scores for a period following the initial visit would be necessary to draw conclusions about the effects of the OSHA consultation visit as an OHSMS intervention.

The mean, numeric completion rate for the Revised OSHA Form 33 attributes was less than 50 percent in both the records with paired injuries and illnesses data ($n = 45$) and in all of the records with OHSMS data ($n = 166$). Even when the stretch attributes were

excluded, the numeric completion remained quite low. This suggests that the Revised OSHA Form 33 scores in this study may not reflect the entire OHSMS of the client dairies. Furthermore, only seven records included Revised OSHA Form 33 records where 50 percent or more of the attributes were given a numeric score. As a result of the lower than expected number of records that could be included in the correlational analysis, the study statistics were underpowered. A priori power analysis found that a sample size of 75 would be necessary to assure 80 percent statistical power, assuming a low level of correlation ($r^2 = 0.1$). In this study, the effect of underpowered statistics is conservative, because lower levels of correlation would not have been statistically significant as compared to larger expected samples sizes. As a result, only those relationships with higher degrees of covariance in this study were statistically significant. It was not possible to collect additional OHSMS and injury data from dairy farms to ensure adequate statistical power for weak correlations. Future prospective study designs should ensure sufficient sample sizes to detect statistically significant relationships, even at the correlations as low as those provided in Table 3, and those reported in a previous study examining relationships between OSHA Form 33 scores and the number of safety and health violations (Akbar-Khanzadeh and Wagner, 2001).

Management Leadership was the OHSMS component with the lowest numeric completion rate, by far, on the Revised OSHA Form 33 (13 percent). Management leadership is often cited as one of the critical determinants of OHSMS success, and the component is tied for the largest number of attributes on the Revised OSHA Form 33 (10 of 58 attributes) (OSHA, 2001b). Given that the correlation results of this study indicated that higher scores in the Management Leadership component were more strongly associated with lower injury and illness rates than any other OHSMS component, the low numeric response rate was concerning. It may have been that the attributes in this component took longer to evaluate, and thus the attributes were not evaluated as often as those in other OHSMS components. This conforms to the requirements that consultants should avoid guessing and score only those attributes for which they have sufficient information (OSHA, 2008). In addition, Management Leadership on dairy farms may be particularly difficult for consultants to evaluate because of several factors. Workforce and environmental characteristics, including language barriers; shift length and times; work pacing; and geographical distribution of workers and work areas present potential challenges for consultants interviewing and observing workers to assess the Management Leadership component.

The use of Revised OSHA Form 33 data itself is another important limitation of this study. Most of the research that used Revised OSHA Form 33 data, or evaluated the use of Revised OSHA Form 33, utilized previous versions of the instrument (Akbar-Khanzadeh and Wagner, 2001; Weems and Smitherman, 1998, 2000). This is the first study known to incorporate the use of OHSMS programming data from the current version of the Revised OSHA Form 33. As such, questions remain regarding the reliability, validity, repeatability, and predictability of the Revised OSHA Form 33 for scientific research and how the scores relate to OHS and business outcomes in dairy and in other industries. However, the associations found between Revised OSHA Form 33 scores and injury rates in this study and the findings in previous research suggest, in general, that OSHA Form 33 results may be associated with higher levels of OHS performance.

The potential limitations of using TRC and DART rates also warrant some discussion. Dairy management may over- or under-report worker injuries on the OSHA Form 300 because of misunderstanding or misusing recording requirements. In a 1995 study, researchers concluded that relatively low injury and illness rates observed in small businesses were due to underreporting of injuries (Oleinick et al., 1995). More recently, Leigh et al. (2014) estimated that the undercount of occupational injuries and illnesses in U.S. animal production agriculture was greater than 80 percent, and that over half of the undercounting may be due to intentional and unintentional underreporting by the employer. However, OSHA consultants are trained to look for mistakes on the OSHA Form 300 logs of clients and provide assistance in proper recordkeeping (OSHA, 2012b). Thus, recordkeeping errors may have been less likely in this study. Another concern is that small fluctuations in the actual number of incidents can have a large effect on the TRC and DART rates because of the relatively small workforce sizes observed in this study. Therefore, the range of injury and illness rates observed may be larger than what might be expected in larger industries and workforces. Thus, comparisons between the effect sizes observed in this study and those of other industries with substantially greater workforce sizes may not be appropriate.

There is considerable uncertainty in these results due the limitations described in this section. The observational nature of this study and the constraints of the data limit the control of experimental variables. Because this study was correlational, another important limitation is the possibility that some other unaccounted variable(s) may explain some or all of the observed relationships. For example, dairies with more effective stockmanship training might have lower rates of injuries and illnesses (Sorge et al., 2014) and might also score higher on the Revised OSHA Form 33 because of their improved training. In this example, stockmanship may account for some of the observed relationship between injury rates and OHSMS programming. One way to assess whether these findings are valid, and not due to some unknown additional variables, is to apply the same study methodology to a second dataset to see if similar associations are observed. In a follow-up study, the authors will apply the same research protocol to OSHA consultation records from a second industry to determine if similar associations exist despite differences between the geographical, organizational, and occupational injury and illness risk characteristics between the two industries.

5. Conclusions

There was a low to moderate, negative correlation between OHSMS programming level and dairy farm injury and illness rates. Higher levels of OHSMS programing in the Hazard Anticipation and Detection and Management Leadership OHSMS components were significantly associated with reduced injury and illness rates. When the Revised OSHA Form 33 was at least half-completed, the overall OHSMS and all by-component associations were strong and statistically significant. The Management Leadership OHSMS component had the strongest association with lower TRC and DART rates, despite being the component with the lowest completion rate. Larger dairy farm workforces were associated with higher OHSMS programming levels, but there was no significant association between workforce size and injury/illness rates. Substantial limitations in this study and the OSHA dataset prohibit any inferential conclusions about the effectiveness of OHSMS assistance provided by the OSHA On-Site Consultation Program. However, this research highlights some of the benefits and challenges associated with OHSMS research using U.S. government data and details one approach to investigate the link between occupational injuries and OHSMS programming in a high-hazard industry. Limited research on the Revised OSHA Form 33 is publicly available, but these and other findings suggest that the Revised OSHA Form 33 is useful in evaluating OHS aspects of small businesses and that the OHS aspects being measured by the form may influence occupational injuries and illnesses; a relationship that may be most evident when more attributes are assessed. More research is needed

to determine if these associations persist in different experimental applications. Overall, this research indicates that higher levels of OHSMS programming may help commercial dairies reduce worker injuries and illnesses. The OSHA On-Site Consultation Service can provide such assistance to help U.S. dairy operations improve their OHSMS.

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