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Effect of Occupational Health and Safety Management System implementation on compliance with safety requirements in a logistics support organization

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Abstract

Previous research regarding measuring the effectiveness of safety programs has relied on reactive/lagging indicator approaches that include addressing adverse outcomes such as personnel injury. Several Occupational Health and Safety Management System (OHSMS) standards require organizations to determine an appropriate OHSMS measurement frequency but it is unknown which effectiveness indicators should be measured and the assessment frequency that is needed to realize positive change in the safety program. The purpose of this investigation was to determine the effect of leading indicator measurement on self-reported OHSMS implementation. Additionally, determine the leading indicator self-assessment frequency that leads to measurable OHSMS improvements. The current investigation was a longitudinal study design of OHSMS implementation self-assessment information compiled monthly from August 2021 – November 2022 for 15 subordinate units of a logistics support organization. Repeated measures analysis of variance and post hoc comparisons were conducted to determine which months were significantly different and to determine the length of time necessary to realize OHSMS improvement. Overall OHSMS score ranged from 71.2%–82.7%. There were significant OHSMS improvements between the first month and the final 1–2 months of monitoring. It took 8–9 months to realize significant improvements of 6%. Improvement in OHSMS compliance was observed but monthly self-assessments were too short a period to reveal significant improvement. Measuring leading indicators is useful to: assess OHSMS implementation, observe OHSMS changes, and monitor OHSMS continuous program improvement.

1. INTRODUCTION

A safe workplace environment can improve labor productivity, reduce medical costs, and reduce property damage (Brahmasrene and Smith, 2009). Among the primary benefits of administering Occupational Safety and Health (OSH) programs and safety management systems (SMSs) are to prevent workplace injuries, illnesses, and deaths and the resultant hardships that these events cause for personnel (OSHA, 2016). Historically, measuring the success of safety programs relied on reactive/lagging indicator approaches that included addressing adverse outcomes such as personnel injury or property damage. Relying on information such as lost work days due to workplace injuries and illnesses and injury severity to determine SMS effectiveness is challenging because focus on past events can prevent identification of information about complex situations in a work environment. An organization that that does not endure a substantial number of injuries or illnesses could be considered to have a well-functioning safety program if other effectiveness indicators are not measured and considered. Additionally, historically, OSH activities were primarily focused on addressing individual issues rather than an SMS that maintains and promotes workers' health and safety by

systematically incorporating individual and diverse OSH activities into an enterprise-wide system in an attempt to lower worker safety risk (Kim, 2021). In contrast to lagging indicators, leading indicators have been viewed as more favorable because focusing on input or process can be more effective in anticipating safety program changes, evaluating the functionality of the system, and identifying early signs of poor safety performance (Van Derlyke et al., 2022). Similar to other OSH principles, prevention activities such as those closely aligned with leading indicators is recommended over lagging indicators to prevent adverse outcomes. Focus on achieving goals, monitoring performance, and evaluating outcomes can lead to higher levels of OSH achievement (OSHA, 2016).

1.1 Definition of safety management systems

While safety is a broad abstract concept that can be described by a particular situation, safety management can be defined as the process to realize certain safety functions to include, in the context of safety, protecting human beings, the environment, equipment and property from unacceptable risk (Li and Guldenmund, 2018). An SMS can be defined as the collective management procedures, elements, and activities associated with ensuring positive safety performance for an organization (Li and Guldenmund, 2018). The structure of an SMS may include consolidating several safety related activities that had previously been considered discreet safety programs. Overall, an SMS is a system containing management principles and activities with the primary purpose of controlling risks and preventing accidents.

1.2 Marine corps safety management system

Specific to the U.S. Marine Corps, the purpose of the Marine Corps Safety Management System (MCSMS) is to provide a framework for managing OSH risks. The overall aim of the MCSMS is to prevent injury and ill health to Marines, Sailors, and civilian Marines, and to provide safe and healthful places to work, live, and recreate (U.S. Marine Corps, 2020a). The adoption of the MCSMS supports safe and healthful workplaces, prevents work-related injury, off-duty injury, occupational illness, and continually improves overall operational readiness. Rather than incorporating a variety of individual safety related tasks and programs as additive requirements to mission planning and completion, the MCSMS is a systematic approach that integrates principles, tasks, and requirements into mission planning and mission completion to prevent needing to apply risk reduction measures reactively after the planning phase. If accomplished correctly the MCSMS provides a framework for leaders to use in completing their missions safely, rather than just completing a safety checklist. Similar to the Plan-Do-Check-Act process used for control and continuous improvement of processes, the MCSMS provides a systematic approach to mission accomplishment that uses elements including: building a just culture; training personnel; planning, completing, and debriefing operations and activities on and off duty; assessing the effectiveness of the system; and continuous process improvement (U.S. Marine Corps, 2020a). Specifically, the MCSMS supports four pillars of: (1) Policy and Leadership, (2) Risk Management, (3) Safety Assurance, and (4) Safety Promotion and Training.

1.3 Self-assessment of safety management systems

Evaluation of safety performance allows organizations to determine if their SMS activities have the expected outcomes and enables detection and resolution of safety challenges (Karanikas, 2016; Lingard, 2017). A periodic determination of performance on selected key SMS items allows for revealing strengths and weaknesses of the system; allows for optimal management decisions in managing safety risk; influences identification and correction of deficiencies in the implementation of an SMS, and facilitates the application of measures beneficial to workers' safety (Bejinariu et al., 2017; Karanikas, 2017; Kotek & Mukhametzianova, 2014). Specifically, previous research suggests there are several factors that influence SMS outcomes to include management involvement, worker participation, education, training, and communication (Ghahramani, 2016; Mohammadfam et al., 2017). Additionally, safety audits, safety training attendance, and culture were perceived as some of the most effective leading safety indicators (Minnick & Wachter, 2019).

An SMS is developed such that management periodically reviews measurement data to determine the effectiveness of the SMS. However, SMS standards (BS ISO, 2018; ANSI/ASSP, 2019) require that organizations determine the measurement frequency of leading and lagging indicators. Suggested measurements include leading performance indicators such as training compliance and effectiveness of controls and lagging indicators such as number of injuries and illnesses. When developing and implementing an SMS, one useful data point is the completion and implementation of the individual SMS elements, such as administrative plans development. However, there is no published literature to suggest the assessment frequency of SMS element development/implementation when an SMS is in its infancy. That is, should SMS development/implementation be assessed annually, quarterly, or monthly? Further, during management review of SMS assessment data, SMS guidance authors recommend that,

"Reviews should present results…to focus top management on the Occupational Health and Safety Management System (OHSMS) elements most in need of their attention." (ASSP, 2019).

An additional advantage of routinely determining safety performance is reduction of mishaps, defined as an unplanned or unexpected event or series of events that results in damage to property or illness/injury to personnel (U.S. Marine Corps, 2020a). One study found that an increase in the number of audits led to significantly reduced recordable incident rates (Brahmasrene and Smith, 2009). In another study, investigators found safety management scores were associated with lost time injury rates (Mearns et al., 2003). A similar study indicated that measuring audit outcomes with a scoring process enables management to compare status and evaluate progress (Esposito, 2009). Thus, safety audits are a critical component of effective safety management. An example of a tool designed to support evaluations of an organization's SMS in the USMC is the MCSMS requirements tracker. The purpose of this tool is to improve understanding of the SMS by tracking and reporting SMS implementation status to the next higher headquarters (HHQ) until ultimately being reported to the Assistant Commandant via the Commandant of the Marine Corps (CMC) Safety Division (U.S. Marine Corps, 2020b).

This MCSMS requirements tracker as a self-evaluation tool allows for determining compliance with the SMS requirements based on a set of qualitative and quantitative questions (items) that cover select aspects of OSH elements applicable to a properly functioning SMS. Each item is qualitatively or quantitatively assessed by the respective Ground Safety Officer (GSO)/Ground Safety Manager (GSM) due to their role in ensuring a functional SMS that protects the health and safety of workers. Examples of general topic areas addressed by the MCSMS requirements tracker tool include: measures of safety climate/culture; traffic safety; training status; creation of a safety policy; and mishap reporting. The tracker allowed for creation of a scoring process that included establishment of color-coded thresholds of good (green), marginal (yellow) or poor (red). This color-coding allowed for comparisons of program status and evaluations of progress.

Several studies have investigated the effectiveness of an OHSMS particularly in determining if an OHSMS effectively reduces lagging indicators such as mishaps. However, research is limited in determining the effective assessment frequency of an OHSMS to ensure continuous improvement. The purpose of the current investigation was to determine the effect of self-reported SMS implementation on compliance with MCSMS requirements. Additionally, it was sought to determine the appropriate monitoring frequency in order to measure changes in compliance with SMS requirements. Finally, researchers sought to measure level of association between number of "Completed," "In-Progress," "Not-Started," and "Overall Score." Identifying key factors that affect SMS implementation enables organizations to enhance their safety management and to optimize the allocation of organizational resources.

2. METHODOLOGY

The current investigation was conducted for 3rd Marine Logistics Group (3d MLG) predominately located at Okinawa Japan. 3d MLG is a Major Subordinate Command that serves as a logistics support organization for the U.S. Marine Corps. The primary functional areas/activities for 3d MLG include: supply, maintenance, transportation, general engineering, health services, and other functions such as legal, food, disbursing, postal, billeting, religious, mortuary, morale, and recreation services. During the investigation time-frame, 3d MLG was composed of 15 subordinate organizations. Each organization maintained their own SMS and provided SMS support for their respective organization population ranging from 118-880 personnel. The GSO or GSM of each organization conducted monthly self-assessments of their SMS. Training for each GSO/GSM included a 14-day Ground Safety for Marines course and a 5-day Ground Mishap Investigation Course. Each self-assessment was used to measure implementation with the same 26 SMS areas with the intent of gauging overall compliance with safety element requirements and determining SMS improvement over time. Qualitative and quantitative items from the "MCSMS Checklist & Tracker" tool was assessed and included, but were not limited to, the SMS leading indicators found in Table 1.

Table 1. Leading Indicators Measured by the MCSMS Checklist & Tracker

Administrative/Planning (% Complete)	**Training (% Complete)**	**Safety and Health Surveys (% Performed)**	**Employee Involvement**
Safety Policy Statement/ Document Developed	Safety Officer Trained	Safety Climate Survey	Safety Council Meeting
Safety Officer/Ground Safety Manager Assigned	Private Motor Vehicle Training (drivers under 26 years of age)	Personal Protective Equipment Survey/Assessment	
Pre-Mishap Plan Developed	Motorcycle Training	Industrial Hygiene Survey(s)	
Safety Budget Established	Supervisor/Leader Safety Training	Safety Assessment	
Hazard Abatement Log Developed	Risk Management Training	Hearing Conservation Compliance Report	
Number of Motorcycle Riders Identified	Hazard Communication Training		
Local Hazards Briefs Developed	Last Operational Pauses/Back in The Saddle/101 Critical Days of Summer Training		
Job Hazard Analyses Completed			
RMI-SIR Accounts Established			
Joint Risk Assessment Tool (JRAT) account			

Each leading indicator was assessed as: "Completed", "In-Progress" or "Not Started" (Table 2). Criteria for items classified as "Not Started" included: training completion less than 80%, Safety Policy Statements and Pre-Mishap Plans not existent, and Personal Protective Equipment (PPE) surveys not started. Criteria for items classified as "In-Progress" included training completion greater than 80% but less than 90%, Safety Policy Statements and Pre-Mishap Plans started/in-draft form but not published, and PPE surveys started but not fully complete. Criteria for items classified as "Completed" included: training completion greater than 90%, Safety Policy Statements

and Pre-Mishap Plans published, and PPE surveys completed for all items. Answers to each assessment item were scored where yes or "completed" items equaled 1 point and "In-Progress" or "Not Started" areas equaled zero points. Additionally, an "Overall Score" serving as a compliance percentage was calculated according to total number of items "Completed" divided by the total of 26 assessed items (e.g., number completed/26). Last, data were converted to nominal variables (1, 2, or 3, Table 2) and the number of each leading indicator category were counted to determine significant differences between each category according to calendar month of assessment. Each organization's self-reported assessment was conducted monthly. HHQs safety personnel validated the results of each organization's submission to ensure consistency and accuracy and to reduce subjectivity. HHQs safety personnel also validated the reported information during annual HHQ safety assist visits and annual HHQ safety inspections.

Table 2. Leading Indicator Implementation Scoring Methodology

Status	Status Score	Status Criteria	Nominal Variable Score	Compliance %
Completed or Yes	1	Administrative plans published Training completion > 90% Surveys completed	1	Total completed or yes/total # of assessed items (26)
In Progress	0	Administrative plans drafted Training completion 80%-90% Surveys started but not completed	2	
Not Started	0	Administrative plans non existent Training completion < 80% Surveys not started	3	

The longitudinal study design focused on self-assessments of 15 organizations that conducted repeated monthly self-assessments of their SMS during the 16-month period from August 2021 to November 2022. The self-assessment tool had been used prior to Aug 2021 but the beginning of the current time-frame coincided with substantial format changes of the data collection tool. For the monthly self-assessment analysis, the values reported for Aug 2021 served as a reference for later comparison with self-assessment analysis during future months. Descriptive statistics were performed to include: range, percentage, mean, median, and standard deviation (SD) and were used to describe SMS status during the Aug 2021-Nov 2022 time-frame. Because monthly self-assessment data did not meet the parametric assumptions associated with Repeated Measures Analysis of Variance (ANOVA), a Friedman's Repeated Measures ANOVA was conducted to determine if there were significant differences between the median number of "Completed," "In-Progress," "Not-Started," and "Overall Score" according to month.

Analyses were conducted for monthly self-assessment results to determine the optimal self-assessment frequency. In order to determine the approximate length of time to observe significant SMS improvement, post hoc comparisons were conducted to determine specifically which calendar months were significantly different than others. In an effort to reduce unnecessary pair-wise comparisons, SMS self-assessment results were compared with the final two months (Oct 2022 and Nov 2022) of the time-frame.

Correlation analysis was also conducted to determine level of association between "Completed," "In-Progress," "Not-Started," and "Overall Score." Because data did not meet the parametric assumptions associated with Pearson's Correlation, Spearman's Correlation test was conducted to determine the strength of association. Statistical tests were performed using JASP (Version 0.16.4; JASP Team, 2022). The significance threshold was set to $p = 0.05$.

3. RESULTS

3.1. Monthly self-assessment

Descriptive statistics for monthly self-assessment results are reported in Table 3. The initial Aug 2021 SMS self-assessment median compliance percentage was 76.9%, median number of safety items "Completed" was 20, median number of safety items "In-Progress" was 4, and median number of "Not Started" safety items was 0. While all monthly assessment results were compared to the final two months, the initial Aug 2021 assessment also served as a reference for later comparison during future months. Continuous improvement in SMS implementation was observed overall when comparing data at the beginning and end of the Aug 2021–Nov 2022 time-frame; however, not every successive month revealed improved compliance with MCSMS requirements.

As shown in Table 3, "Overall Score" ranged from 71.2% (occurring Jan 2022) to a high of 82.7% (occurring during several months of Apr 2022, May 2022, Oct 2022, and Nov 2022). Median number of SMS elements reported as "completed" ranged from 18.5 (occurring Jan 22) to a high of 21.5. Similar to "Overall Score," this improvement in "completed" elements occurred during the months of Apr 2022, May 2022, Oct 2022, and Nov 2022. The change in "Overall Score" is also visually depicted as a percentage in Figure 1. "In-Progress" elements ranged from 2-5 with the most occurring Jan 2022 and the fewest occurring Apr, Aug, Sep, and Nov 2022. SMS elements classified as "Not Started" ranged from 0-2 with the fewest "Not Started" elements occurring Aug 2021 and Dec 2021 and the most elements being reported Jan, Feb, Jun, Aug, Sep, and Nov 2022.

Table 3. Descriptive Statistics for Monthly Self-Assessment Results

		Median	Mean	Standard Deviation	Minimum	Maximum
Nov 2022	**Not Started (n)**	2.00	2.64	2.56	0.00	10.00
	In Progress (n)	2.00	2.86	2.11	1.00	7.00
	Complete (n)	21.50	20.50	3.74	10.00	25.00
	Overall Score (%)	82.69	78.85	14.37	38.46	96.15
Oct 2022	**Not Started (n)**	1.50	2.00	1.88	0.00	6.00
	In Progress (n)	3.00	2.71	1.77	0.00	6.00
	Complete (n)	21.50	21.21	2.69	15.00	25.00
	Overall Score (%)	82.69	81.59	10.36	57.69	96.15
Sep 2022	**Not Started (n)**	2.00	2.29	1.49	0.00	5.00
	In Progress (n)	2.00	2.64	1.82	1.00	7.00
	Complete (n)	21.00	20.79	2.58	16.00	24.00
	Overall Score (%)	80.77	79.95	9.91	61.54	92.31
Aug 2022	**Not Started (n)**	2.00	2.29	1.73	0.00	6.00
	In Progress (n)	2.00	3.07	2.24	0.00	7.00
	Complete (n)	21.00	20.64	3.34	15.00	25.00
	Overall Score (%)	80.77	79.40	12.86	57.69	96.15
Jul 2022	**Not Started (n)**	1.00	2.64	2.74	0.00	8.00
	In Progress (n)	3.00	3.29	1.49	1.00	5.00

Table 3. Descriptive Statistics for Monthly Self-Assessment Results

		Median	Mean	Standard Deviation	Minimum	Maximum
	Complete (n)	20.50	20.07	3.58	13.00	24.00
	Overall Score (%)	78.85	77.20	13.78	50.00	92.31
Jun 2022	**Not Started (n)**	2.00	2.69	3.17	0.00	11.00
	In Progress (n)	3.00	3.39	1.39	1.00	6.00
	Complete (n)	21.00	19.92	3.45	12.00	24.00
	Overall Score (%)	80.77	76.63	13.27	46.15	92.31
May 2022	**Not Started (n)**	1.00	1.42	1.31	0.00	5.00
	In Progress (n)	3.00	3.25	2.56	0.00	9.00
	Complete (n)	21.50	21.33	2.84	16.00	25.00
	Overall Score (%)	82.69	82.05	10.92	61.54	96.15
Apr 2022	**Not Started (n)**	1.50	1.75	1.29	0.00	5.00
	In Progress (n)	2.00	3.17	2.62	0.00	8.00
	Complete (n)	21.50	21.08	2.47	17.00	24.00
	Overall Score (%)	82.69	81.09	9.49	65.39	92.31
Mar 2022	**Not Started (n)**	1.50	2.33	2.02	0.00	7.00
	In Progress (n)	3.00	3.42	2.61	0.00	8.00
	Complete (n)	20.50	20.25	2.70	16.00	24.00
	Overall Score (%)	78.85	77.89	10.39	61.54	92.31
Feb 2022	**Not Started (n)**	2.00	2.08	1.17	1.00	4.00
	In Progress (n)	4.00	4.33	1.88	0.00	7.00
	Complete (n)	19.50	19.58	2.50	16.00	24.00
	Overall Score (%)	75.00	75.32	9.63	61.54	92.31
Jan 2022	**Not Started (n)**	2.00	2.50	2.07	0.00	7.00
	In Progress (n)	5.00	4.17	2.17	0.00	7.00
	Complete (n)	18.50	19.33	2.81	14.00	24.00
	Overall Score (%)	71.15	74.36	10.80	53.85	92.31
Dec 2021	**Not Started (n)**	0.00	1.33	2.15	0.00	6.00
	In Progress (n)	4.00	4.83	2.37	1.00	10.00
	Complete (n)	20.00	19.83	3.38	14.00	25.00
	Overall Score (%)	76.92	76.28	13.00	53.85	96.15
Nov 2021	**Not Started (n)**	1.00	1.42	2.07	0.00	7.00
	In Progress (n)	4.00	3.83	1.47	1.00	6.00
	Complete (n)	21.00	20.75	2.67	16.00	25.00
	Overall Score (%)	80.77	79.81	10.26	61.54	96.15
Oct 2021	**Not Started (n)**	1.00	1.75	1.29	0.00	4.00
	In Progress (n)	4.00	3.83	1.80	1.00	8.00
	Complete (n)	20.00	20.42	2.54	16.00	25.00
	Overall Score (%)	76.92	78.53	9.77	61.54	96.15
Sep 2021	**Not Started (n)**	1.50	1.92	1.62	0.00	6.00
	In Progress (n)	4.00	4.25	1.71	1.00	8.00
	Complete (n)	19.50	19.83	2.26	17.00	24.00
	Overall Score (%)	75.00	76.28	8.65	65.39	92.31

Table 3. Descriptive Statistics for Monthly Self-Assessment Results

	Median	Mean	Standard Deviation	Minimum	Maximum
Aug 2021 Not Started (n)	0.00	1.08	1.62	0.00	5.00
In Progress (n)	4.00	5.33	3.34	2.00	12.00
Complete (n)	20.00	19.58	3.15	14.00	24.00
Overall Score (%)	76.92	75.32	12.10	53.85	92.31

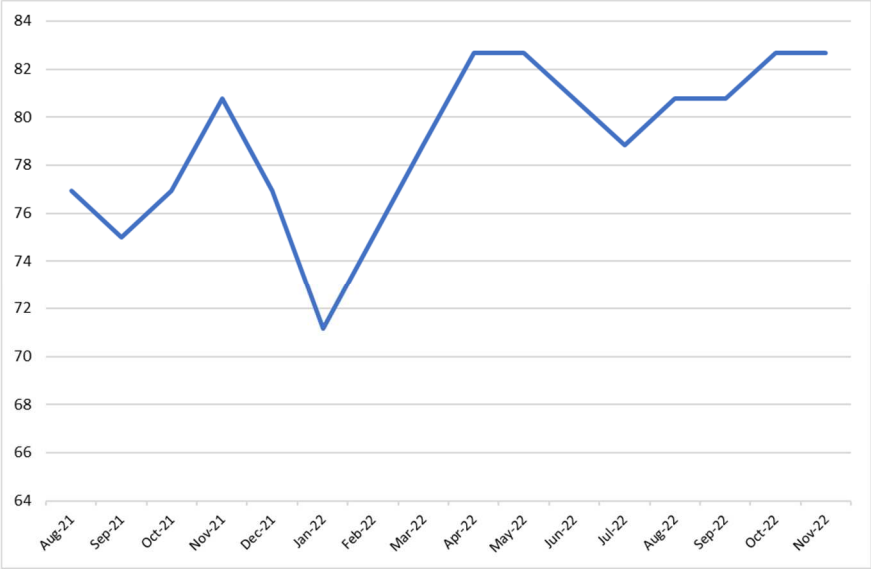

Figure 1. Monthly Change in Overall Percentage Score Aug 2021 – Nov 2022

There were significant differences between number "Complete" (p=0.003), "In-Progress" (p<0.001), and "Overall Score" (p=0.003) according to month as shown in Table 4. There was not a significant difference between number of "Not-Started" (p=0.326).

Table 4. Friedman's Repeated Measures ANOVA for Monthly SMS Self-Assessment Results

SMS Safety Item Status	Chi-Squared	df	*P**
Complete	34.467	14	**0.003**
In-Progress	42.399	14	**< .001**
Not-Started	16.885	14	0.326
Overall Percentage	34.467	14	**0.003**

*p in bold is statistically significant result at an alpha level of 0.05

Post hoc analysis of monthly reported SMS self-assessment results was compared to the final two months of Oct and Nov 2022. As shown in Table 5, post hoc tests revealed significant differences (improvements) in "Overall Score" and for number of "complete" SMS elements for Oct 2022 when compared to Aug 2021 (p=0.014), Sep 2021 (p=0.008), Dec 2021 (p=0.011), Jan 2022 (p=0.002), and Feb 2022 (p=0.003). There was a slight reduction in overall scores in Nov 2022 and, as a result, scores were only significantly different (improved) when compared to Jan 2022 (p=0.037) and Feb 2022 (p=0.048).

Similarly, post hoc tests revealed significant differences (improvements) in number of "In-Progress" SMS elements for Oct 2022 when compared to Aug 2021 (p=0.006), Sep 2021 (p=0.030), Nov 2021 (p=0.026), Dec 2021 (p=0.003), Jan 2022 (p=0.015), and Feb 2022 (p=0.012). Similar to Oct 2022, when compared to Nov 2022, self-assessment results regarding the number of "In-Progress" SMS elements were significantly different (improved) when compared to Aug 2021 (p=0.004), Sep 2021 (p=0.023), Nov 2021

(p=0.020), Dec 2021 (p=0.002), Jan 2022 (p=0.011), and Feb 2022 (p=0.009). "Overall Score" improved nearly 6% from Aug 2021 to Nov 2022. An increase of 1.5 "Completed" SMS elements and a 2-item reduction in "In-Progress" elements was observed during the same time frame.

Table 5. Conover's Post Hoc Comparisons for Monthly SMS Self-Assessment Results

Months		**Overall Score**		**Complete**		**In-Progress**	
		T-Stat	***p***	**T-Stat**	***p***	**T-Stat**	***p***
Nov 2022	**Oct 2022**	1.040	0.300	1.040	0.300	0.110	0.912
	Sep 2022	0.796	0.427	0.796	0.427	0.684	0.495
	Aug 2022	0.774	0.440	0.774	0.440	0.419	0.676
	Jul 2022	0.354	0.724	0.354	0.724	1.015	0.312
	Jun 2022	0.310	0.757	0.310	0.757	1.236	0.219
	May 2022	0.022	0.982	0.022	0.982	1.192	0.235
	Apr 2022	0.066	0.947	0.066	0.947	0.662	0.509
	Mar 2022	0.531	0.596	0.531	0.596	1.324	0.188
	Feb 2022	1.991	**0.048**	1.991	**0.048**	2.648	**0.009**
	Jan 2022	2.101	**0.037**	2.101	**0.037**	2.560	**0.011**
	Dec 2021	1.548	0.124	1.548	0.124	3.111	**0.002**
	Nov 2021	0.420	0.675	0.420	0.675	2.361	**0.020**
	Oct 2021	0.708	0.480	0.708	0.480	1.809	0.072
	Sep 2021	1.637	0.104	1.637	0.104	2.295	**0.023**
	Aug 2021	1.460	0.146	1.460	0.146	2.891	**0.004**
Oct 2022	**Sep 2022**	0.243	0.808	0.243	0.808	0.794	0.428
	Aug 2022	0.265	0.791	0.265	0.791	0.309	0.758
	Jul 2022	0.686	0.494	0.686	0.494	0.905	0.367
	Jun 2022	0.730	0.467	0.730	0.467	1.125	0.262
	May 2022	1.062	0.290	1.062	0.290	1.081	0.281
	Apr 2022	0.973	0.332	0.973	0.332	0.552	0.582
	Mar 2022	1.570	0.118	1.570	0.118	1.214	0.227
	Feb 2022	3.030	**0.003**	3.030	**0.003**	2.538	**0.012**
	Jan 2022	3.141	**0.002**	3.141	**0.002**	2.449	**0.015**
	Dec 2021	2.588	**0.011**	2.588	**0.011**	3.001	**0.003**
	Nov 2021	1.460	0.146	1.460	0.146	2.251	**0.026**
	Oct 2021	1.747	0.083	1.747	0.083	1.699	0.091
	Sep 2021	2.676	**0.008**	2.676	**0.008**	2.185	**0.030**
	Aug 2021	2.499	**0.014**	2.499	**0.014**	2.780	**0.006**

p in bold is statistically significant result at an alpha level of 0.05

T-Stat=t-statistic

As shown in Table 6, the SMS element most commonly reported as non-compliant was completion of job hazard analysis which was reported as "Complete" only 71 times (34.8%) out of a total of 204 observations. This was followed by establishment of a pre-mishap plan which was "Complete" 110 times (53.9%) and safety officer/manager training "Complete" 122 times (59.8%). Similarly, the most common SMS elements reported as "in-progress" were safety officer/manager training at 39.7%, development of a pre-mishap plan at 37.3%, and job hazard analysis at 31.9%. The most commonly reported "Not Started" SMS elements included pre-mishap plan establishment at 33.3%.

Table 6. Frequencies of SMS Self-Assessment Results

Safety Program Elements	Complete	Percent	In-Progress	Percent	Not Started	Percent
1. Date Commanding Officer (CO) Assumed Command	202	99.02	0	0.00	2	0.98
2. Date Safety Officer/Ground Safety Manager Assigned	196	96.08	7	3.43	1	0.49
3. Date Safety Officer Trained	122	59.80	81	39.71	1	0.49
4. Date of Safety Climate Survey	139	68.14	44	21.57	21	10.29
5. Safety Policy Statement/Document complete?	187	91.67	12	5.88	5	2.45
6. Established Pre-Mishap Plan - complete?	110	53.92	76	37.26	18	8.82
7. Personal Protective Equipment Survey/Assessment - complete?	142	69.61	35	17.16	27	13.24
8. Safety Budget complete?	146	71.57	41	20.01	17	8.33
9. Date of Last Command Safety Council	146	71.57	24	11.77	34	16.67
10. Date of last Force Preservation Council	179	87.75	9	4.41	16	7.84
11. Industrial Hygiene Survey(s) - (completed/current/on hand) complete?	140	68.63	51	25.00	13	6.37
12. New Join Safety/Local Hazards Briefs - Complete?	195	95.97	7	3.43	2	0.98
13. Date of Last Operational Pauses/Back In The Saddle (BITS) / 101 Critical Days of Summer (CDS) training	200	98.04	3	1.47	1	0.49
14. RMI-SIR Accounts Established - Completed?	191	93.63	12	5.88	1	0.49
15. Hazard Abatement Log Established - Complete?	189	92.65	13	6.37	2	0.98
16. Joint Risk Assessment Tool (JRAT) account established?	197	96.57	7	3.43	0	0.00
17. Unit SMS Self-Assessment completed?	133	65.20	33	16.18	38	18.63
18. Date of HHQ Conducted Command Safety Assessment?	158	77.45	23	11.28	23	11.28
19. Percentage Private Motor Vehicle (PMV) drivers under 26 completing Alive @ 25: numerator/denominator or just %	159	77.94	26	12.75	19	9.31
20. Identified Number of Motorcycle Riders: Exact Number	184	90.20	14	6.86	6	2.94
21. Percentage Motorcycle Training - % completed and current	143	70.10	43	21.08	18	8.82
22. Supervisor/Leader Safety Training - % Completed	169	82.84	19	9.31	16	7.84
23. Risk Management Training - % Completed	175	85.78	21	10.29	8	3.92
24. Hazard Communication (HAZCOM) Training - % Completed	131	64.22	37	18.14	36	17.65
25. Completed Job Hazard Analysis - % Completed	71	34.80	65	31.86	68	33.33
26. Hearing Conservation Compliance Report - % Complete	148	72.55	31	15.20	25	12.26

Note: 204 total observations

Besides the indicator "Date Commanding Officer (CO) Assumed Command" which served as a trigger for the CO to establish a safety policy, the SMS elements most commonly reported as "complete" were completion of the "Back in the Saddle" and "101 Critical Days of Summer" safety stand-down at 98%, establishment of a Joint Risk Assessment Tool account at 96.6%, and assignment of a GSO or GSM at 96.1%. The percentage of SMS indicators classified as "complete" are visually displayed in Figure 2.

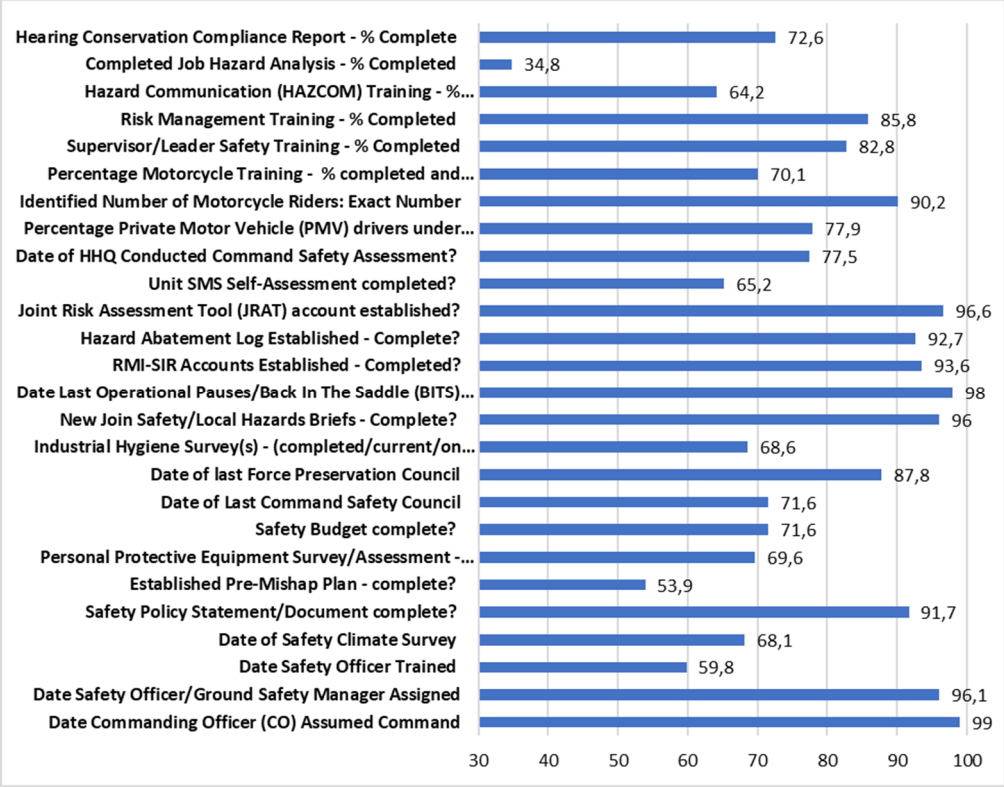

Figure 2. Percentage of SMS Indicators Classified as Complete

3.2. Sample associations

All MCSMS implementation correlation results are shown in Table 7.

Table 7. Spearman correlation coefficients for strength of association between MCSMS implementation metrics

		Spearman's rho	*p*
Number Not Started	**- Number In Progress**	0.059	0.404
Number Not Started	**- Number Complete**	-0.617	**< .001**
Number Not Started	**- Overall Score**	-0.617	**< .001**
Number In Progress	**- Number Complete**	-0.771	**< .001**
Number In Progress	**- Overall Score**	-0.771	**< .001**
Number Complete	**- Overall Score**	1.000	**< .001**

p in bold is statistically significant result at an alpha level of 0.05

Correlation analysis between number "Completed," "In-Progress," "Not Started," and "Overall Score" revealed predominantly statistically significant negative associations. There was a strong negative correlation between number "Complete" and number "In-Progress" ($r = -0.771$, $p < 0.001$), "Overall Score" and number "In-Progress" ($r = -0.771$, $p<0.001$), number "Complete" and number "Not Started" ($r = -0.617$, $p<0.001$), and "Overall Score" and number "Not Started" ($r = -0.617$, $p<0.001$). There was a strong positive correlation between number "Complete" and "Overall Score" ($r=1$, $p<0.001$).

4. DISCUSSION

One of the purposes of the current investigation was to determine the effect of self-reported SMS implementation on compliance with MCSMS requirements. In all cases, SMS improvements were noted from beginning to end of the time-frame, however, there were not significant improvements for all metrics. In some cases, SMS compliance worsened after the Aug 2021 reference but ultimately improved to the highest levels by Oct 2022 and Nov 2022. Specifically, despite Aug 2021 serving as the first month monitored with the current format self-assessment, the lowest SMS compliance scores were not reported for the month of Aug 2021. The reason for the extended time to realize significant changes was likely due to each organization having a relatively established SMS at the beginning of the study. Having an established SMS at the beginning of the research time-frame and having low numbers of "Not Started" may have also been the reason for not observing significant differences. This also suggests that most SMS elements had been implemented and that it can take longer than a month to start and become compliant with some safety requirements. Results of the current study is consistent with a study by Ghahramani & Salminen (2019) that found organizations using OHSMSs had better OSH activity rates, including elements such as policy, planning, implementation/operation, checking, and management review. Specifically, implementation of OHSMS principles had a positive effect on occupational injury reduction, improving safety climate, and OSH practices in certified companies compared to organizations that did not use an OHSMS (Ghahramani & Salminen, 2019). Mohammadfam et al. (2017) also found organizations that implemented an OHSMS similar to activities of the current study and consisting of policy, planning, implementation and operation, checking, and management review activities had better performance than organizations that had not implemented an OHSMS. Results of the current investigation conflict with findings from a study where OHSMS evaluation and effectiveness in the Republic of Korea Navy was investigated (Lee et al. 2023). Results from this Korea Navy study found OHSMS-applied workplaces did not show a statistically higher level of OSH effort and performance as a result of OHSMS implementation (Lee et al. 2023). The conditions of OHSMS application in the Korean Navy study were slightly different from the results of the current study in that the former study compared applied and unapplied OHSMS organizations while the current study compared performance for several organizations that were using an OHSMS model (Lee, et al. 2023).

Varying levels of SMS implementation across the time period may have been due to gaps and turnover in the GSO/GSM position, new management with varying levels of focus on SMS elements, and new personnel joining the organization thus contributing to safety training deficiencies. The GSO/GSM typically serves in the safety position for a year and SMS improvement/progress slows or SMS status worsens after the program transitions to a new GSO/GSM, thus each SMS is consistently in a state of continuous improvement as new GSOs/GSMs learn their new role. A total of six GSOs and GSMs turned over responsibility of their organization's SMS since beginning self-assessments Aug 2021 which may explain some of the variability throughout the investigation time-frame. Specifically, from Dec 2021–Jan 2022 there was a 5.8% decrease in overall score and from Oct-Nov 2021 there was a 3.8% decrease. These were the largest reductions over a single month period and coincided with six organizations turning over GSO and GSM positions during the Jan 2022 time-frame and three GSO and GSM positions turning over during the Nov 2021 time-frame. The results of the current study were similar to what was found during a Korean Navy investigation that found only 1.9% of workers had more than 2 years of OHSMS experience and only 17.3% of personnel responsible for directly implementing the OHSMS had more than 2 years of experience (Lee et al. 2023). The transient nature of a career in the military makes it challenging for personnel to gain stable experience and maintain safety expertise.

Also, three new organizations that had not previously conducted self-assessments were added Jul 2022. This was the first month that these organizations conducted self-assessments and, as a result, had a worse SMS overall score by over 21% compared to the other organizations with SMSs established and assessed for a longer duration. Upon a detailed review of monthly overall score, this was also reflected in a decrease in median compliance to 78.8% compared to the median overall score being >80% for the

preceding three months of Apr–Jun 2022 for all other organizations. This likely explains the sudden reduction in scores beginning Jul 2022. However, beginning Aug 2022 through the remainder of the study period, overall score improved across all organizations.

It was possible for overall score to stagnate while small improvements were being made by shifting not-started SMS elements to in-progress. These small improvements may not be reflected in overall score on a month-to-month basis but may have been reflected in a quarterly reporting periodicity. However, without maintaining a monthly reporting requirement, it is possible that the GSO/GSM could lose focus on maintaining or continuously improving the SMS. Monthly monitoring allows each organization's HHQ to closely monitor SMSs and provide mentorship and assistance when negative trends become apparent.

One of the objectives of this investigation was to determine the appropriate monitoring frequency in order to measure changes in compliance with SMS requirements. The current investigation revealed monthly self-assessments and reporting were too short a period to realize a statistically significant improvement from one month to the next. Significant differences in number in-progress, number complete, and overall score suggests that assessing compliance with MCSMS requirements on a monthly or quarterly basis may lead to a trajectory of improvement over time. However, results showed the necessary time-frame for improving SMS performance was longer than a monthly and quarterly measurement periodicity. Specifically, based on the data assessed in this investigation, it took 8–9 months or up to 3 quarters, to begin observing significant improvement in SMS performance. These results were similar to an investigation by Karanikas (2017), who suggested that content analysis of documented data for such information as safety audits, meetings, and safety investigations could be sampled initially and annually to assess implementation of safety management activities and monitor indicators linked to individual SMS processes. Still, the primary purpose of requiring monthly status updates with the MCSMS requirements tracker tool was to improve the GSO's and GSM's understanding of the SMS, and assist performance simply by ensuring GSOs/GSMs maintain focus on consistently improving the SMS. An additional outcome from recurring self-assessments included determining level of compliance with SMS requirements to facilitate actions for continuous improvement. Reducing self-assessment frequency to semi-annually or annually to coincide when changes are expected to be observed could have the unintended consequence of reducing each organization's focus on continuous SMS improvement. It is also possible that it would take longer to realize improvement due to a lack of attention on the program and that the small improvements found during this investigation were only observed because SMS compliance was assessed monthly.

Another objective of the study was to measure level of association between number of completed, in-progress, not-started, and the overall score. Significant differences (improvements) were found during similar months for overall score, complete, and in-progress when assessed monthly. Correlation results revealed a strong statistically significant negative correlation between number complete/overall score and number in-progress and between complete/overall score and number not started. There was also a strong positive correlation between number complete and overall score. Overall score was not a metric formally adopted by the USMC when reporting the results of these self-assessments during the time-period of this study; however, these results suggest that a summary metric such as overall score may be used alone as a surrogate to determine overall status of SMS implementation rather than focusing on several other measures. This metric could also be paired with the establishment of overall score targets to include an overall goal and monthly, quarterly, semi-annual, or annual percent improvement targets at the individual organization level. Implementing these goals and percent improvement targets could encourage organizations to strive for continuous SMS improvement. These results are similar to a study that investigated the utility of using a safety hazard and management assessment questionnaire as a tool for safety self-improvement (Moore et al. 2022). Leading and lagging indicators were found to be interrelated and measurement of both could be used to improve safety efforts and organizational self-improvement efforts (Moore et al. 2022).

Regarding individual elements of the MCSMS requirements tracker, job-hazard analysis completion, creation of a pre-mishap plan, and GSO/GSM training were the most frequently reported non-compliant areas. There are several potential explanations for the GSO/GSM training non-compliance. Considering 40.2% of the observations indicated incomplete GSO/GSM training but 96.1% of the observations indicated GSOs/GSMs were appointed, it is possible that this is indicative of a high turnover rate. During the study time-frame, the Ground Safety for Marines course was offered quarterly while the Ground Mishap Investigation Course was offered approximately twice per year. The infrequent occurrence of the mishap investigation course coupled with high personnel turnover suggests the GSO/GSM position turns over before being able to complete required training. This finding was similar to the results of an investigation of an OHSMS implementation study for the Korean Navy which found frequent personnel turnover with an average OHSMS expert working period of 1.56 years (Lee et al., 2023). Conflicting operational commitments of the GSO/GSM that interfere with taking a two-week safety course was common feedback received by HHQ safety personnel. Frequent reporting of incomplete job hazard analyses and pre-mishap plans suggests additional training needs to be conducted to emphasize these aspects of an MCSMS.

Leading indicators are intended to be a method for senior managers and safety practitioners to monitor changes in elements of an SMS during periods of transformation that could have the potential to modify risk levels before suffering from an injury or property damage. A critical aspect of the potential effectiveness of leading indicators is associated with the ability of the indicator to capture gaps in the SMS (Van Derlyke et al., 2022). Self-assessments are designed to evaluate safety performance by senior leaders and designated staff in charge of OHSMSs. The self-assessment identified completed/compliant SMS areas to be maintained as well as SMS areas that were in-progress of being implemented and SMS aspects not started/implemented yet. These in-progress and not started SMS areas are an indication of organizational culture, system weaknesses and areas for improvement to prevent organizational failure and ensure organizational success. Identifying key factors that affect SMS implementation enables organizations to enhance their safety management and optimizes the allocation of organizational resources. The self-evaluation and rating for each component requires long-term commitment to determine future actions needed to be undertaken in order to minimize safety risks and ensure continuous SMS improvement.

4.1 Limitations

There were several limitations associated with the current investigation. Because the MCSMS self-assessment was an intervention initially implemented in Aug 2021, comparative data were not available pre-intervention implementation. In addition, the data for this study were collected over a short 16-month period between 2021 and 2022 which may have limited the observation of statistically significant changes in MCSMS status. Another important limitation involves the use of the MCSMS requirements tracker results as a method of self-assessment which were collected by 3d MLG safety personnel for non-research purposes related to their normal work duties. As a result, the items in the requirements tracker were not validated as a survey tool. However, the tracker was used for all organizations USMC-wide to measure MCSMS implementation. Future investigation should include measuring changes in self-assessment results as the MCSMS requirements tracker is updated over time. Despite these limitations, the current study comprises a contribution to the literature and professional practice and introduces a technique that can be used and extended by safety practitioners and organizational leadership to evaluate SMS implementation and identify areas for improvement. Future study should distinguish between indicators that may be quickly accomplished or may take less effort to address (e.g., "number of motorcycle riders identified" or "safety officer assigned") from indicators that take longer to accomplish or require more effort. Future research is needed to explore motivation to improve SMSs and to determine the SMS elements that best align safety management activities and safety performance. Additionally, because the SMS requirements tracker format changed substantially, effective Dec 2022, a future evaluation with the present investigation's research design would assist in measuring changes in self-assessment format.

5. CONCLUSIONS

The purpose of the current investigation was to determine the effect of self-reported SMS implementation on compliance with MCSMS requirements. This study revealed several changes can occur in an organization's SMS over-time that may lead to reductions in SMS performance. Some of the most common discrepancies of the SMSs monitored in the current study included not having a pre-mishap plan, job-hazard analyses not being completed, and GSOs/GSMs not completing required training. Incomplete pre-mishap plans and job-hazard analyses are serious concerns for OSH leaders and practitioners since these leading indicators could result in unmitigated safety hazards and increase the severity of mishaps. The connection between lack of OSH manager training and continuity in staffing the position is a serious concern that needs to be addressed for all organizations to ensure future continuous improvement. This could include establishing minimum levels of competency for OSH personnel responsible for implementing the SMS such as strengthening professional education and hiring skilled personnel. This could also include reorganizing the SMS to ensure tasks are given to personnel with relatively low job change rates so they can build SMS skills.

Observing significant improvements in SMS performance monitoring after 8-9 months of monthly monitoring is an important finding for OSH leaders and practitioners. These findings could lead to the conclusion that monthly monitoring is a waste of resources and unnecessary but perhaps this frequency of monitoring is critical to ensuring small SMS challenges are identified early before larger challenges are revealed, ultimately ensuring a focus on continuous improvement.

The strong correlation between number of completed SMS items and overall score could be a useful summary metric alone or as a surrogate to determine overall status of SMS implementation rather than focusing on several other individual measures. Overall score was not a metric formally adopted by the USMC when reporting the results of these self-assessments; however, using a summary metric could be a useful measure to quickly assess SMS implementation of an organization, compare SMS status across multiple organizations, report SMS compliance to management in an easily understood way, and observe organizational SMS changes over time.

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