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SCIRT, The Construction Industry Health and Safety Leaders – paper

Story: Health and Safety

Theme: Programme Management

A final year paper prepared by University of Canterbury students examining the positive effects of SCIRT on the New Zealand construction industry's health and safety performance.

This document has been provided as an example of a tool that might be useful for other organisations undertaking complex disaster recovery or infrastructure rebuild programmes.

For more information about this document, visit www.scirtlearninglegacy.org.nz

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SCIRT, The Construction Industry Health and Safety Leaders

E. R. Gualter and T. L. Wilkins

Final Year Projects, 2015
Dept. of Civil and Natural Resources Engineering
University of Canterbury
Project Supervisor: Dr. E. Scheepbouwer

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ABSTRACT

In the last five years the New Zealand construction industry has taken steps to improve its health and safety performance in an attempt to meet the standard set by the likes of Australia and the United Kingdom. The Government formed the Business Leaders' Health and Safety Forum to encourage the chief executives and managing directors of New Zealand companies to take ownership of workplace health and safety. In the wake of the 2011 Canterbury earthquakes, the Stronger Christchurch Infrastructure Rebuild Team (SCIRT) was formed. The alliance has had a strong safety focus throughout its duration. This study investigated the positive effects that SCIRT has had on the health and safety performance within the New Zealand construction industry. SCIRT intentionally created a business model where innovations from each contractor were shared. This contributed to the learning legacy of the project, which will ultimately benefit the health and safety performance of the New Zealand construction industry. SCIRT's health and safety performance has been proven to exceed that of the set New Zealand benchmark published in the Benchmarking Report by the Business Leaders' Health and Safety Forum. The strongest factor influencing this was the number of reported lead indicators, also exceeding that of the New Zealand benchmark. Key performance indicators that influenced the workload of contractors were used to encourage a proactive health and safety culture, hence motivating this success. Investigations into using key performance indicators more frequently in other forms of contracting is the next logical research step.

1. INTRODUCTION

1.1. Background

Figure 1 shows that in the late 1990's New Zealand's workplace fatalities were similar to that of Australia and the United States. However, unlike these countries New Zealand has not made the same improvements over the last twenty years.

Figure 1. Work Related Fatalities per 100,000 Workers (Gunby, 2011).

New Zealand's workplace injury rate is about twice that of Australia and almost six times that of the United Kingdom (Business Leaders' Health and Safety Forum, 2015b).

The New Zealand Government is now committed to improving the health and safety performance of the construction sector. They formed the Business Leaders' Health and Safety Forum in 2010, which now has over 200 members from New Zealand companies, influencing hundreds of thousands of employees and contractors (Business Leaders' Health and Safety Forum, 2015b). The Forum is globally unique in their efforts to leverage the influence of senior leaders to lift health and safety performance.

The Stronger Christchurch Infrastructure Rebuild Team (SCIRT) was formed in the wake of the Canterbury earthquakes in 2010 and 2011. SCIRT is a unique alliance as it is a disaster response, responsible for rebuilding the city's publicly owned horizontal infrastructure. The parties that entered the alliance were the client organisations; Canterbury Earthquake Recovery Authority, Christchurch City Council and New

Zealand Transport Agency (NZTA) joined by civil engineering construction companies City Care, Downer, Fletcher Construction, Fulton Hogan and McConnell Dowell (SCIRT, 2014).

The five principal contractors were ranked and allocated work based on the key performance indicators (KPI) and key result areas (KRA); safety, value, our team, customer satisfaction and environment (SCIRT, n.d.). Companies were also encouraged to share ideas and innovations through the jointly agreed performance indicators, so that one company's good idea could be implemented throughout the alliance.

1.2. Aims and Objectives

The purpose of this project was to identify the effect that the SCIRT alliance has had on the New Zealand construction industry's health and safety performance and to determine if and how these effects can be replicated in other alliances and projects around the country.

The objectives of this project were to:

- Demonstrate that SCIRT has, on average, over the duration of the alliance performed better than the Benchmarking Report produced by the Business Leaders' Health and Safety Forum.
- Investigate what SCIRT has done differently to create a more mature safety culture than other alliances/projects in New Zealand.
- Identify how other organisations could replicate SCIRT's health and safety initiatives to improve their own health and safety performance.

1.3. Safety Culture Maturity Model (SCMM)

In the journal article *Safety Culture – Theory and Practise*, Patrick Hudson proposed that organisational safety culture could be divided into five stages of maturity, shown in Figure 2. He suggested that all organisations fit into the model depending on their attitudes and values towards workplace health and safety.

Figure 2 illustrates this hierarchy and is referred to during the qualitative analysis. Dr Mark Fleming defines each of the five stages as follows (Fleming, 2014):

- In a pathological culture, there is little or no concern for safety. Safety rules and regulations are just seen as a barrier to getting the job done.
- In a reactive culture there is an acceptance that the organisation should try to prevent accidents.
- In a calculative culture, the focus is on employee engagement and ensuring a systematic approach to safety.
- A proactive culture is typified by a collective effort to prevent harm.
- The generative tier of the model is an idealised or aspirational level. As organisations approach this level of maturity, they become more aware of their weaknesses and therefore organisations at this level would not describe themselves as having a generative culture.

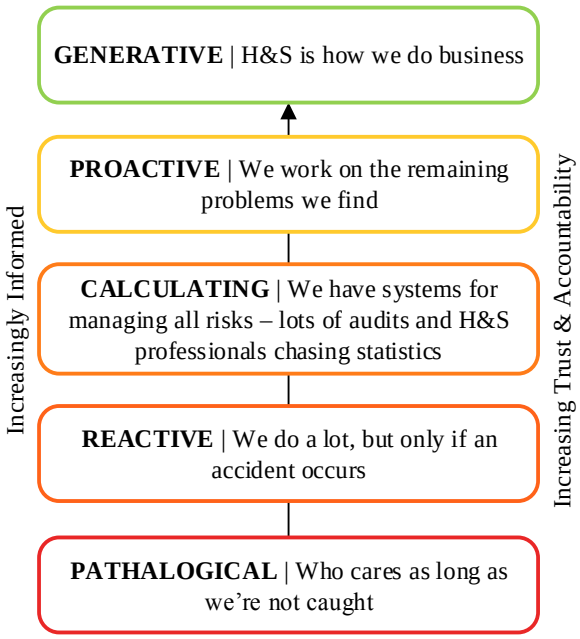

Figure 2. The Safety Culture Ladder, Maturity Model (adapted from Lawrie et al., 2006).

From literature it can be assumed that SCIRT has a safety culture maturity that is approaching proactive culture.

2. METHODOLOGY

Data was obtained from SCIRT records and the Benchmarking Report published by the Business Leaders' Health and Safety Forum. Statistical analyses were performed on the data to demonstrate SCIRT had exceeded the performance of the set New Zealand benchmark.

A qualitative survey of health and safety representatives from both client organisations and principal contractors was undertaken. This was conducted to gauge their understanding of SCIRT's performance and their perception of why the observed improvements occurred.

3. DATA

The quantitative data from SCIRT and the Business Leaders' Health and Safety Forum included a count for commonly measured health and safety statistics. These included lost time injuries, medically treated injuries, total recordable injuries and near miss events.

To ensure that the classification of terms used in this report was consistent between the organisations. The following definitions were used for this project:

- Lost Time Injury (LTI) - A work-related injury, illness or disease that prevented a return to work for one day/shift or more.
- Medically Treated Injury (MTI) - When an employee or contractor received any medical treatment from a Registered Medical Professional as a result of a work-related injury, illness or disease that was beyond the scope of first aid.
- Total Recordable Injuries (TRI) - Includes medically treated injuries, return to work injuries, lost time injuries and fatal injuries.
- Near Miss Event - A documented event where property damage, system failure, environmental conditions, injury or illness was likely to occur.

For the purpose of this study, the Benchmarking Report produced by the Business Leaders' Health and Safety Forum in 2015 was assumed to represent the performance of New Zealand's construction industry. The Benchmarking Report collected data from construction companies throughout New Zealand of varying sizes and work types; thus it can be reasonably assumed that the sample data is representative of the entire industry. Therefore the contents of the Benchmarking Report will be referred to as the New Zealand benchmark.

The data from SCIRT has not been verified by any other organisation and hence the accuracy of it is the most critical assumption to the analysis. It is also worth noting that, whilst the SCIRT data is only representative of horizontal infrastructure works, the Benchmarking Report is representative of the entire construction industry – both horizontal and vertical works.

4. STATISTICAL ANALYSIS

4.1. Frequency Rate

In order to statistically analyse the data samples, it was necessary to create non-dimensionalised parameters. A frequency rate (FR) per 200,000 hours worked was calculated for each health and safety parameter.

4.2. T-Test

A t-test was used to determine if the two data sets were reliably different from each other. The independent sample t-test was used as it was assumed that the two data sets were continuous, independent and normally distributed (McCarthy, B. C 2013). The samples were said to be reliably different if the p value, the probability that the pattern of data in the sample could be replicated by random data, was less than 5%.

4.3. Null Hypothesis

The null hypothesis stated that there was no reliable difference between SCIRT and the New Zealand benchmark. Rejecting the null hypothesis would indicate that the two groups were reliably different (Motulsky, H 2010).

The p-value produced infers the likelihood that the null hypothesis was true. It was assumed that the null hypothesis was false if $p < 0.05$ and therefore the null hypothesis could be rejected. As the p values obtained from the t-tests varied between 2.8×10^{-7} and 1.8×10^{-3} the null hypothesis could be confidently rejected.

4.4. Bootstrap Resampling

Bootstrapping is a method of creating additional data sets to estimate the distribution. The new data sets are formed through random selection from the original set. It is most often used for deriving confidence intervals of a parameter such as a mean, median or correlation coefficient.

A confidence range for the TRI performance of SCIRT compared with the New Zealand benchmark was determined using two 500 sample bootstrap simulations. The results illustrate the magnitude to which SCIRT's performance exceeded the New Zealand benchmark.

4.5. Monte Carlo Simulations

Monte Carlo simulation is a numerical process of repeatedly calculating a mathematical problem in which the random variables of the problem are simulated from random number generators. In this sense, each Monte Carlo Simulation produces a result which can be considered parallel with a single observation from a physical experiment in reality. For this analysis 5000 simulations were calculated to represent 5000 months of health and safety data.

The simulations were used to illustrate different combinations of occurrence and severity frequencies. This was performed to determine the number of days of lost production per month due to injuries.

5. RESULTS AND DISCUSSION

5.1. Direct Comparison

The New Zealand benchmark's average FR for each parameter was calculated over 13 quarters. SCIRT's average quarterly FR for each parameter was calculated and plotted against the New Zealand benchmark average. A trend line for SCIRT's data was also plotted so the averages could be compared.

Figure 3 shows SCIRT's average quarterly FR compared to the New Zealand Benchmark. To date it can be seen that every quarter the SCIRT alliance performed better than the New Zealand average. The trend seen in the data illustrates a continued improvement and less recorded injuries.

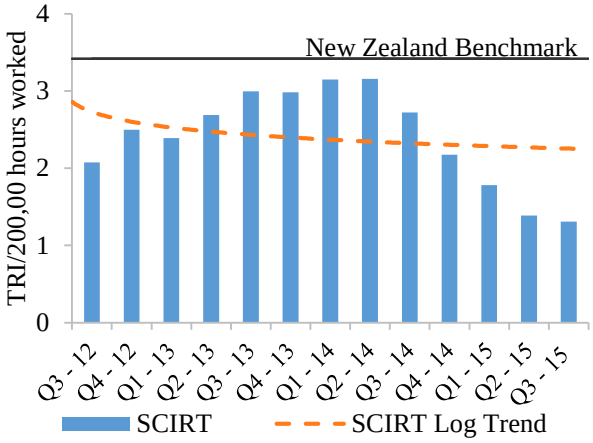

Figure 3. Total Recordable Injury Average Quarterly Frequency Rate.

As the safety culture in the New Zealand construction industry matures reaching new tiers on the SCMM, the number of injuries will decrease and ideally approach zero. The relationship between increasing safety maturity culture and the number of injuries is expected to be logarithmic approaching an asymptote at zero, as there will always be a number of incidents. A logarithmic trend was selected as it clearly depicts human behaviours. The trend shown on Figure 3 illustrates a continuous improvement but as seen by the blue bars the data did not always succumb to this trend.

Monthly hours worked increased from approximately 50,000 in 2011 and 2012 to over 150,000 hours throughout 2013 and 2014. A larger workforce was required to increase the alliance's capacity. National and international recruitment brought staff into SCIRT from around New Zealand and the world. A challenge for the construction project was the continued influx of new workers of varying background and skill. The increased work rate and the changing dynamic of the international workforce could explain the increased number of injuries during this period. Improvement within the alliance caused the frequency of injuries to decrease towards the end of 2014 rather than a decrease in size or an increase in skilled labour.

Figure 4 demonstrates a similar trend to that of Figure 3, in terms of improvement and overall betterment. Again, in can be seen that in early 2013 there was an increase in the number of injuries, which as stated above could be explained by the increased size of the workforce.

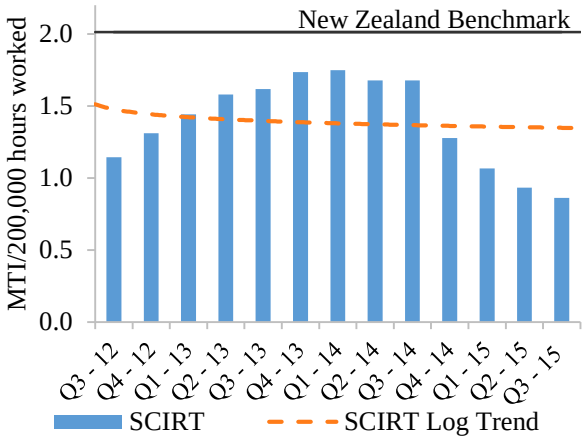

Figure 4. Average Quarterly Medically Treated Injury Frequency Rate.

It can be seen in Figure 5 that LTI data is more sporadic than the other parameters. This figure does not account for the seriousness of the incident i.e. the number of days lost, only the fact there was an incident. The greater distribution within the data is due to the potential skew that a single event can have on the general trend. Again, it can be observed that SCIRT exceeded the performance of the set New Zealand benchmark. The trend line and bar plot also illustrates a substantial improvement over time.

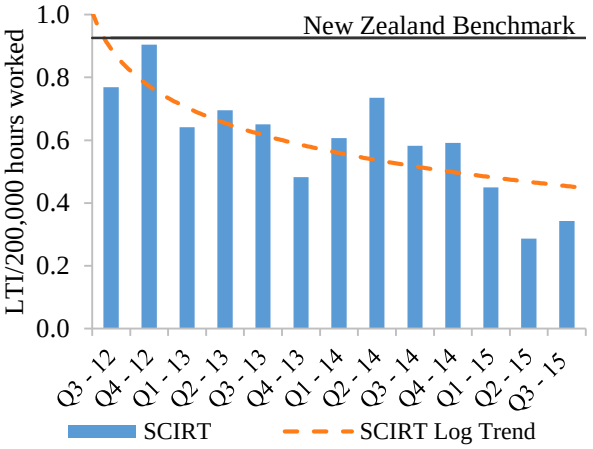

Figure 5. Average Quarterly Lost Time Injury Occurrence Frequency Rate.

All three figures show positive results for the SCIRT alliance in that they have exceeded the performance of the set New Zealand benchmark. The trend lines also show that SCIRT has continually improved over the duration of the project.

The sharing of ideas and innovations amongst competing parties is unique in New Zealand. It is an intentional component of the alliance's business model, and contributes to the learning legacy, improving the New Zealand construction industry.

5.2. Data Reliability

The t-tests were carried out to ensure that the SCIRT data was reliably different from the New Zealand benchmark. Table 1 shows the results from the TRI t-test. The t-stat indicates that the two sets of data are 5.84 times as different from each other. As mentioned above, the p-value is less than 0.05 and hence the null hypothesis could be rejected.

Table 1. T-Test Results for Total Recordable Injuries.

	SCIRT TRI	NZ TRI
Mean	2.005	3.421
Variance	0.185	2.582
Standard Deviation	0.430	1.607
Observations	37	48
T Stat	5.84	
P (Two-Tail)	0.00000028	

Similarly, the t-stat for the MTI data indicates that the data was reliably different. The p-value is sufficiently smaller than 0.05, therefore the null hypothesis for the medically treated injuries can also be rejected.

Table 2. T-Test Results for Medically Treated Injuries.

	SCIRT MTI	NZ MTI
Mean	1.408	2.014
Variance	0.102	1.495
Standard Deviation	0.320	1.223
Observations	37	48
T Stat	3.29	
P (Two-Tail)	0.0018	

The LTI severity and LTI occurrence FR were both investigated to determine a range for the total number of days lost per month due to injuries. Modelling these parameters together calculated the expected range of lost time injury days.

Table 3. T-Test Results for Lost Time Injuries (Occurrence).

	SCIRT LTI	NZ LTI
Mean	0.597	0.939
Variance	0.033	0.064
Standard Deviation	0.181	0.253
Observations	37	47
T Stat	3.40	
P (Two-Tail)	0.0013	

Table 4. Lost Time Injury (Severity).

	SCIRT LTI	NZ LTI
Mean	6.338	6.190
Variance	4.97	9.139
Standard Deviation	2.230	3.023
Observations	37	47

The t-tests show that the SCIRT and New Zealand benchmark LTI data sets were reliably different and aging the null hypotheses were rejected. This can be said for both the LTI occurrence and severity frequency rate.

5.3. Confidence Interval

Bootstrap resampling was performed on the SCIRT and New Zealand benchmark TRI data. This involved resampling the original data until it formed a new set that was the same size. This was performed 500 times and the average taken of each new data set produced. The variations in the data set's averages were tallied and the results can be seen in Figure 6.

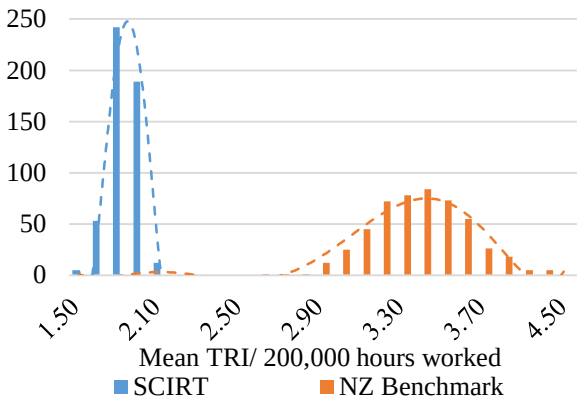

Figure 6. Bootstrap resampling for the average TRI frequency rate per month.

Figure 6 illustrates the expected monthly average TRI per 200,000 hours worked. It shows that SCIRT's average is considerably lower than that of the New Zealand benchmark. Table 5 provides the exact confidence range for the average monthly TRI frequency. It should be noted that SCIRT's upper confidence bound of 2.10 is significantly less than the New Zealand benchmark lower bound of 2.98. These results imply that there is very high certainty that SCIRT performs to a higher standard than the New Zealand benchmark.

Table 5. 95% confidence interval for the average Total Recordable Injuries per month.

	95% Confidence Interval
SCIRT	1.84 – 2.10
NZ Benchmark	2.98 – 3.90

5.4. Lost Time Injuries – Duration

Four Monte Carlo simulations were run with the SCIRT and New Zealand benchmark LTI information. One pair of simulations was the LTI occurrence FR (Table 3) the other was the LTI severity FR (Table 4). Each simulation calculated these for each organisation. The two simulations were then combined to calculate the distribution of the total number of LTI days per month.

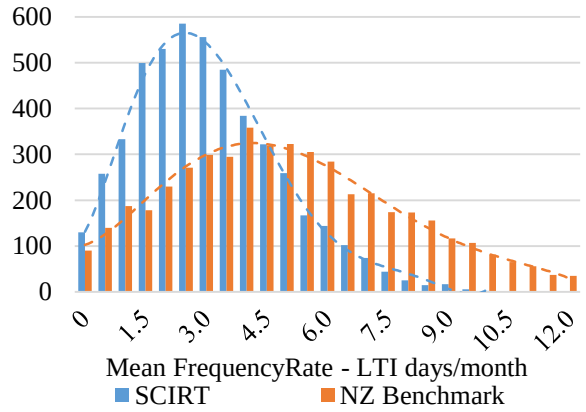

Figure 7. Monte Carlo Simulation of Lost Time Injury (Days) per month.

Figure 7 illustrates the simulations results. It can be seen that the peak of SCIRT's normally distributed data is less than that of the New Zealand benchmark's. SCIRT's monthly frequency rates (FR) range between 0 and 10 days whereas the upper limit of the New Zealand benchmark simulations reached over 12 lost time injury days per month. This showed that SCIRT has less LTI days per month than the average construction project in New Zealand. However, as mentioned above, this statistic is susceptible to a single event skewing the data due to the limited data sample.

5.5. Continuous Improvement

The qualitative survey was targeted at individuals in senior health and safety management positions in Downer, Fletcher Construction, Fulton Hogan, McConnell Dowell and NZTA.

The surveyed industry representatives agreed that SCIRT had exceeded the health and safety performance of the construction sector in New Zealand. While improvement was noted, SCIRT as a horizontal infrastructure alliance does not represent any vertical construction. Correlations and forecasting performance for vertical infrastructure projects based on these results must be conducted with caution.

A number of policies and procedures unique or new to SCIRT have been identified as improvements compared with previous approaches to construction practices. Although this has been acknowledged as a contributing factor towards SCIRT's development, lead indicators have been identified as the major basis of improvement.

Client organisations, such as NZTA have driven the advanced alliance model in the SCIRT project to align with the Government's objectives of reducing workplace fatalities and serious harm by 25%. They are also influenced by their own goals of achieving zero harm by 2020 (NZTA, 2014). NZTA as a client are looking for good lead indicator data as it is internationally recognised that this improves lag measurements (which can be easily measured).

Table 6. Lead and Lag indicators (adapted from NZTA, 2014).

Lead Indicators	Lag Indicators
Number of Drug and Alcohol tests	Number of Fatal Incidents
Proportion of drug and alcohol tests that are negative	Number of Serious Harm incidents
Number of site health and safety audits	Number of LTI
Number of safety briefings	Number of MTI
Number of near misses	Number of First Aid Injuries
Number of positive reinforcements	Number of staff on reduced/alternate duties
Number of traffic management inspections	Number of significant environmental incidents
Number of Safety in Design Workshops (Designers only)	Number of Underground service strikes
Number of Safety in Design Reviews (Design only)	Number of Overhead Service strikes
Number of sub-contractor reviews	Number of property damage incidents
Number of stop work actions	Total recordable frequency rate

Table 6 lists the lead and lag health and safety indicators as identified by NZTA in their 2014-2020 strategic plan. These lead indicators are similar to those that SCIRT has measured. Significant improvement in injury data could be seen as reported near misses increased illustrated in Figure 8, Figure 9 and Figure 10.

Industry has found that reporting lead indicators not only results in a decreased number of injuries but also reductions in plant damage, environmental incidents and quality improvements. All lead indicators are important but this study has only investigated the influence of near miss reporting.

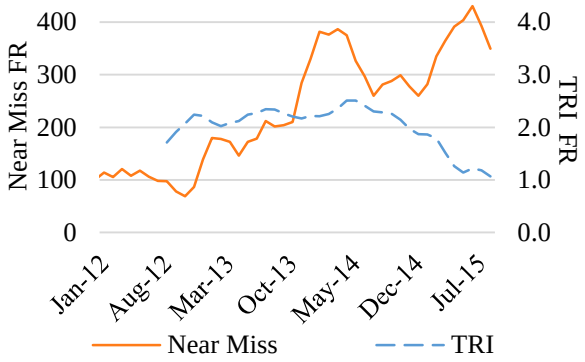

Figure 8. Near Miss Reporting's Influence on Total Recordable Injuries.

Figure 8, Figure 9 and Figure 10 illustrate a negative correlation between the lead and lag indicators, such that an increase in lead indicators results in a decrease in the lag measurements. Both client organisations and principal contractors in the qualitative survey reinforced this correlation. It was mutually agreed that a focus on lead indicators, particularly near misses, has driven improvement, removed risk and contributed to lower injury rates.

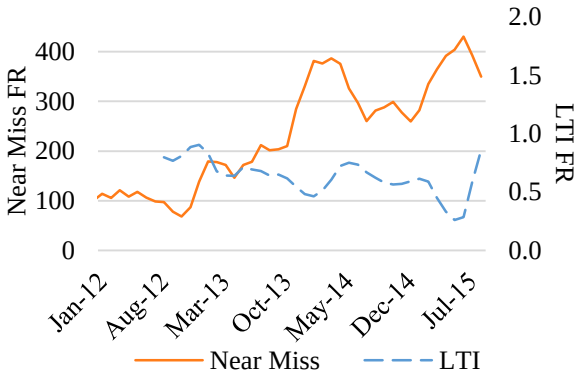

Figure 9. Near miss reporting's Influence on Lost Time Injuries.

SCIRT used KPI's/KRA's to motivate the alliance and contractors to encourage safe and reliable operations, contributing to the development of a strong safety focused culture. The industry experts surveyed agreed that KPI's/KRA's are a good starting point to initiate the process of health and safety improvement, and that they recognise the positives, rather than focusing on the negatives. However, ideally, reporting near misses and other lead indicators would result in innovations being implemented due to the benefit to the team being safer, more efficient, and better for business, rather than because there is opportunity for reward.

The KPI/KRA scheme also created a culture within the alliance where ideas and innovations were shared amongst all parties. The sharing is an intentional part of the alliance's business model, and contributes to the learning legacy, which will benefit the New Zealand construction industry.

The importance of front line leaders encouraging their teams to look for improvement opportunities was emphasised by SCIRT. The Business Leaders' Health and Safety Forum has also highlighted this fact through their desire to involve CEO's and other business leaders in the daily health and safety culture.

SCIRT considered reported near misses as opportunities for improvement; many other New Zealand organisations see them as a measure of weakness. It is anticipated this attitude is more common in smaller organisations, which are on the lower levels of the safety culture maturity model (SCMM), Figure 2.

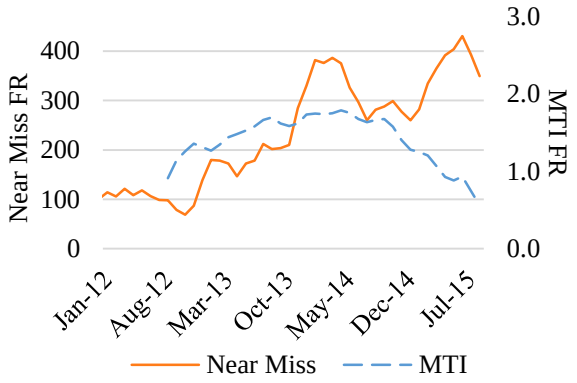

Figure 10. Near Miss reporting's Influence on Medically Treated Injuries.

From the qualitative results, it is thought that the SCIRT alliance performs at a proactive level in the SCMM, seen in Figure 2. The five delivery teams within the alliance most likely operate between the calculative and proactive levels on the SCMM scale. Due to their countrywide nature of the operations, it is challenging for management to implement and oversee such culture changes in their business as usual operations.

Medium to small size contractors, subcontracted to the SCIRT alliance have been required to participate and meet the standards of SCIRT's proactive safety principles. It is anticipated that these companies will have developed a more mature safety culture due to their involvement in the alliance.

6. CONCLUSIONS AND RECOMMENDATIONS

SCIRT has exceeded the health and safety performance published by the Business Leaders' Health and Safety Forum that was assumed as the New Zealand benchmark for this analysis. This was seen in all of the direct comparisons of medically treated injuries, lost time injuries and total recordable injures. Analysis showed that the health and safety results from SCIRT were indeed significantly different compared to the New Zealand benchmark.

To provide a level of confidence additional to the direct comparison bootstrap resampling of the total recordable injuries was conducted. This compared the possible variation in the means of the resampled data sets. The results showed that with very high certainty SCIRT performed better than the New Zealand benchmark.

A Monte Carlo simulation illustrated the number of days where there was a loss in performance due to injury. The simulations showed that SCIRT would experience notably fewer lost time injury days compared with the New Zealand benchmark.

Although new policies and procedures were identified as advances from previous techniques and responsible for workplace safety improvements, the strongest factor influencing SCIRT's performance was the focus on lead indicators. A lead indicator, such as a reported near miss event, is looking for opportunities to improve and reduce risk. Where there was a focus on lead indicator reporting, not only a decrease in injuries observed but improvement had also been noticed in areas such as plant damage, environmental incidents and quality.

In SCIRT KPI's and KRA's within their business model specifically addressed health and safety results, which led to an increased frequency of lead indicator reporting. Interviews with industry participants showed that KPI's were a good starting point to initiate the process of health and safety improvement as they recognised a positive safety culture rather than focusing on the negatives. Ideally, reporting and other positive innovations would be implemented due to the benefit to the team rather than due to monetary reward.

The culture that the alliance has created is considered to be in the fourth tier on the safety culture maturity model. This culture is characterised by a highly proactive safety culture that is always looking for opportunities to improve.

Further research into how KPI's could be integrated into other forms of contracting would be the next logical research step. This would be valuable to helping the New Zealand Government reach their goal of zero harm workplaces.

Implementing safety initiatives into smaller companies that currently have a less mature safety culture would further benefit the country's health and safety performance.

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