University of Strathclyde

The Centre for Lifelong Learning

Safety in Data Centre Construction: An investigation into safety climate and its relationship with safety performance.

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Abstract

This research investigates the relationship between safety climate and safety performance on a data centre construction project. Safety Climate, the subcomponent or ‘snapshot’ of safety culture, is a valuable construct to measure to gain insight into how workers and managers perceive safety and indicate the current state of safety culture. Despite this, the rate of fatal accidents in the Swedish construction industry remains consistent over the past ten years. Therefore, an extensive literature review was conducted to investigate the relationship, followed by the implementation of practical research. The latter was carried out by measuring two construction contractors' safety climate and safety performance using a cross-sectional survey. The survey consisted of the NOSAQC-50 to measure safety climate, and an additional questionnaire to measure safety performance was developed from information acquired through literature review.

This outcome of this research produced several key findings. Firstly, safety climate can influence and also be influenced by safety compliance and safety participation – two representative behaviours of safety performance. In addition, the findings from both contractors highlight issues with management safety communication, management commitment and empowerment, which tends to influence managements voluntary safety participatory behaviours and their compliance behaviours. Lastly, the findings show that the level of work pressure also plays a key role in safety participation and safety compliance behaviours.

Key recommendations for the general contractor to improve safety culture and safety performance include:

- Engaging with the contractor supply chain to implement a safety leadership program.
- Establish an on-site continuous improvement team consisting of workers and managers from the general contractor and subcontractors.
- Review current safety observation reporting system to include frequent management feedback, targets for improvement and contact rate.

- Implementing ‘area owners’ on-site to subcontractor and general contractor management and supervisory members.
- Implement a process of coaching and feedback concerning the frequency of management and supervisory safety-related communication with workers.
- Implement confidential support mechanisms so those suffering from stress can receive assistance, followed by a review of the project planning process, emphasising resourcing.
- Initiate a program of regular risk-based auditing and reviews of particular safety system aspects to ensure their relevance and value.

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Glossary of Terms

Contractor 1 (C1)	A subcontractor of the General Contractor. Contracted to complete a specific scope of work as part of the overall construction project.
Contractor 2 (C2)	A subcontractor of the General Contractor. Contracted to complete a specific scope of work as part of the overall construction project.
Compliance (COM)	In context of safety performance: The capacity to comply with site rules, risk assessments and procedures.
Dimension (DIM)	One of the elements or factors making up a complete construct.
Health and Safety Management System (HSMS)	A systematic and organised approach to manage and reduce safety and health hazards by integrating safety and health programs, policies, and objectives into the organisation.
Key Performance Indicator (KPI)	A metric used to help an organisation define and measure progress toward organisational goals.
Mission Critical	Term used to describe any factor of a system that is essential to business operation or to an organisation.
Nordic Occupational Safety and Climate Questionnaire (NOSACQ)	A tool developed to assess the perceptions of individuals within an organisation towards health and safety.
Participation (PAR)	In the context of safety performance: Discretionary participation in activities that help develop a worksite that stimulates safety but may not directly contribute to an individual's safety.
Personal Protective Equipment (PPE)	Equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses.

Risk Assessment and Method Statement (RAMS)	Document produced by contractors and used widely in construction. Consists of a hazard identification risk assessment and a step-by-step guide for the control measures put in place to reduce or remove each hazard.
Safety Observation Reports (SORs)	A method of collecting information about the safety of working conditions observed by workers on site.
Safety Outcomes	In the context of a construction project: A project's safety outcome is determined by the number of accidents and incidents sustained during the project.
Safe Plan of Action (SPA)	A systematic procedure that breaks each job/task into steps, identifies safety elements of each task step, and coaches the employee on how to avoid potential safety hazards.

1 Introduction

1.1 Background

The construction industry is renowned for being a high-risk industry globally. For example, in Sweden (where this research takes place), the industry has had more fatalities than any other industry for the past two consecutive years – 2019/2020. Furthermore, it has consistently been one of the top two industries, along with agriculture, for the highest fatal workplace accident rate over the past ten years (Arbetsmiljöverket, 2020).

With the world adoption of cloud-based data storage, technology giants such as Amazon, Microsoft, Facebook and Google have favoured the Nordic countries for their data centres as the cool climate reduces the energy (and associated costs) required to cool the equipment within. The combination of excellent climate conditions and a stable electricity supply results in an ideal location for the construction and housing of such equipment. The growth of data centre construction activities in Nordic countries is forecasted to continue for the foreseeable future (Christensen et al., 2018). With such exponential growth and the need to deliver to market as quickly as possible, high demands are placed upon construction companies to complete works in short timescales. Data centre infrastructure is 'mission critical' in nature. This means clients wish to go from concept to construction and delivery to market as quickly as possible to guarantee uptime reliability to their customers with high transaction volume.

The inherent complexity of such construction work complicates the development of a safety culture to improve safety performance. The multi-organisation characteristics of the construction project team means that a project's characteristics are multicultural and diverse, with various behaviours, attitudes, mannerisms, and workplace safety perceptions. Measuring the workers' perceptions of safety is a facet of many construction safety management systems to gain a 'snapshot' of the current workplace safety culture. Coined as 'safety climate', there is much debate about the validity of its relationship with safety performance (Cooper and Phillips, 2004; Törner and Pousette, 2009).

1.2 Motivation

From the author’s experience, a data centre construction project is a dynamic environment he has become familiar with recently. The conventional approach is often one where the General Contractor (GC) must attempt to persuade subcontractors into a unified perception of safety to improve the overall project safety culture. Despite acknowledging the importance of promoting and fostering a positive safety culture, the author questions the validity of the relationship between the safety climate and the safety performance of contractors. Does a good safety climate result in good safety performance?

It is hoped that recommendations can be made to the GC directors to positively impact project safety culture leading to improved safety performance whilst reducing current and future projects’ associated costs.

1.3 Research Aim and Objectives

The overall aim is to investigate the relationship between safety climate and safety performance on a data centre construction project.

The objectives of this research are to;

1. *Define* the safety culture construct and its relation with safety climate.
2. *Critically evaluate* safety climate, how it is measured and its relation to safety performance.
3. *Explore* contractor safety climate perceptions respective to their safety performance on a single data centre construction project.
4. *Formulate* recommendations on construction project safety culture and safety performance improvement.

1.4 Outline Structure

This project is presented in six chapters which are outlined below;

Chapter 1: Introduction

This chapter provides an introduction to the topic and the background information surrounding the data centre construction industry. The motivation for this research is discussed and justified, and the overall research aim and objectives are identified.

Chapter 2: Literature Review

This chapter defines the safety culture and safety climate constructs. Next, it clarifies how safety climate is measured (safety climate questionnaire) and its relation to safety performance. Finally, methods of safety performance measurement are explored (key performance indicators) and discussed.

Chapter 3: Methodological Approach

This chapter discusses and justifies the research strategy and data collection techniques to collect empirical data for this study.

Chapter 4: Survey Findings: Description and Analysis

This chapter reports on the findings from the survey. In the first instance, a description is provided for the overall results for both contractors subject to the study. Next, the empirical findings from the safety climate and safety performance questionnaires are described and analysed.

Chapter 5: Discussion and Recommendations

In this chapter, a discussion occurs in terms of comparing and contrasting the findings from the primary research with the secondary research. Recommendations are also provided to improve the overall safety culture and safety performance.

Chapter 6: Conclusion and Reflection

This chapter revisits the specific research objectives of this study. Conclusions from the research are derived and the author provides a personal reflection from the based on his experience throughout the project.

2 Literature Review

2.1 Introduction

This chapter contains a review of existing literature relevant to both the investigation objectives outlined in Chapter 1 and the overall research dissertation entitled:

Safety in Data Centre Construction: An investigation into safety climate and its relationship with safety performance.

This comprehensive literature review has been carried out to identify what is already known about this topic so that analysis and discussion can be provided on ‘safety culture’ and ‘safety climate’ to facilitate a critical understanding of the relationship between contractor safety climate their safety performance. By the end of this section, a justification for the need for empirical data collection will emerge and that the reader will be better informed about the subject area.

The focus of this literature review will be on objectives 1 and 2 below (objective 3 will be met through the collection and analysis of empirical data. Objective 4 will be satisfied from the findings of objectives 1, 2 and 3):

1. *Define* the safety culture construct and its relation with safety climate.
2. Critically *evaluate* safety climate, how it is measured and its relation to safety performance.
3. *Explore* contractor safety climate perceptions respective to the safety performance of a single data centre construction project.
4. *Formulate* recommendations on construction project safety culture and safety performance improvement.

2.2 Defining Safety Culture

The ‘safety culture’ construct and its implementation is a complex and indefinite process. The construct is not clearly defined, and there are more than 50 definitions of the safety culture construct to date (Vu and De Cieri, 2014). This often leads to much confusion within both academe and industry (Hale, 2000). However, even with this confusion, there is no uncertainty about the concept's significance as many public enquiries into industrial disasters have attributed safety culture as a contributing factor (Cullen, 1990; Columbia Accident Investigation Board, 2003).

One such definition provided by the UK Advisory Committee on the Safety of Nuclear Installations tends to cover the key elements and is often cited when defining the construct;

> *"The safety culture of an organisation is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management."* (ACSNI, 1993)

Keeping within the theme of this research, Fang and Wu (2013) offer their definition of safety culture for a construction project as;

> *"…a mixture of attitudes, beliefs, values, behaviours and norms held by the individuals and groups from different parties in a construction project team, and it is gradually formed and evolved in the construction project environment…"*

Presented are only two examples of definitions. However, many offer similarity regardless of industry, and all tend to encapsulate a presence of perceptions, beliefs, and attitudes shared amongst a group of individuals (Cooper, 2000). The following subsections will delve a little more into the various contrasting perspectives of safety culture that have been debated throughout the past four decades.

The Interpretive and Functionalist Perspectives

The 'interpretive perspective' is one of two contrasting approaches to an organisational culture that emerged from studies during the 1980s to early 2000s (Glendon and Stanton, 2000). The anthropological viewpoint represents a 'bottom-up' approach. The organisational culture is not owned by any particular group and allows for sub-cultures (i.e. safety culture) to be developed solely by the organisation's members (Glendon and Stanton, 2000). The workers themselves create a safety culture utilising unspoken rules of behaviour called ‘social norms’. Introducing a new worker into an existing group of workers should result in the new worker adopting the group’s safety norms.

The 'functional perspective' is a top-down approach. This approach promotes a managerial ambition to engineer, control and own the culture to suit the prevailing situation. Such conceptualisations can add to the complexities of establishing a safety culture due to the need to view all construction work practices as either ‘unsafe’ or ‘safe’. Sherratt and McAleenan (2015) describe that ‘unsafe’ and ‘safe’ are difficult to define within a construction environment due to the consistent changes within the environment, people, tasks, cultures and such defined states of safety may be challenging to implement.

One example of this within the construction industry would be the policy of PPE usage on site. Normatively, it has become the most common manifestation of safety culture in practice throughout a construction project. Sherratt and McAleenan (2015) argue that PPE, as a cultural indicator, raises concerns from an interpretive perspective. If it is only worn to avoid sanctions, then a shared belief that PPE is a vital way of controlling risks is unlikely to be obtained. The reasons why PPE is worn must be explored to reveal the underlying culture of safety, which leads to the following perspective.

Inclusive Normative, Pragmatic and Anthropological Perspective

Three primary dimensions of safety culture proposed by Cooper (2000) are the person (anthropological), the behaviour (pragmatic), and the situation (normative/management). Each of these dimensions is said to both influence and is influenced by the other constructs.

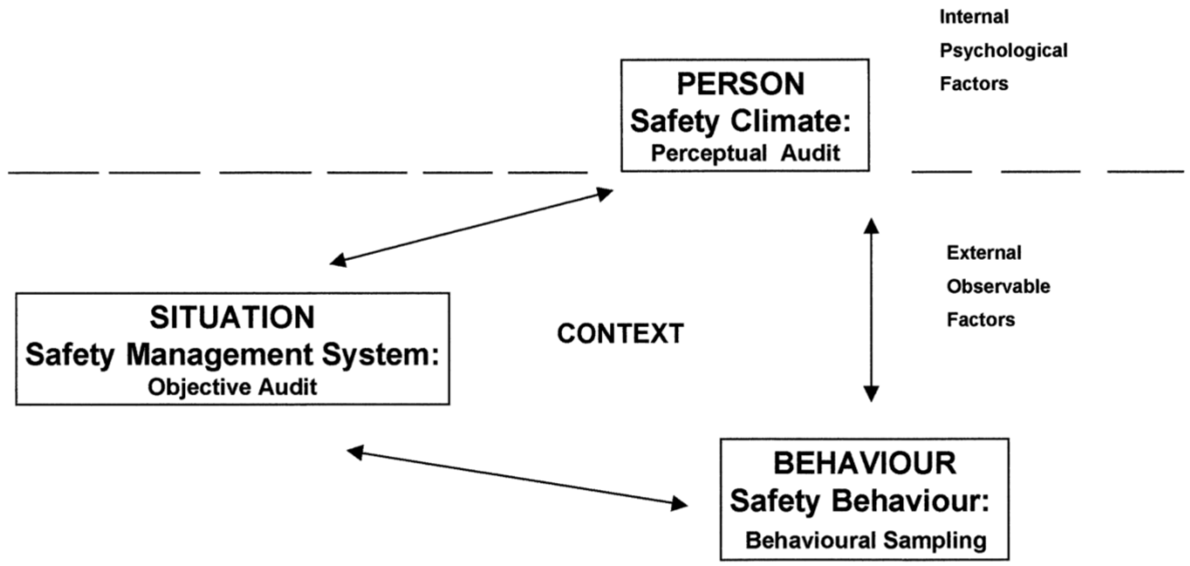

Figure 1- Reciprocal safety culture model.

Several safety culture theories and 'models' have been developed to assist with theory, guidance, practice and research (Reason, 1997; Cooper, 2000; Guldenmund, 2000). The metaphor "standing on the shoulders of giants" can be considered appropriate for safety culture model development. Most models use the understanding gained from previous attempts to provide a framework for which safety culture should be embedded into an organisation.

The reciprocal safety culture model (Cooper, 2000) was developed further to create a synthesised conceptualisation of safety culture (Edwards et al., 2013). Thus, three distinctive conceptualisations of culture are intertwined to create a modern new meaning to the concept cohesively.

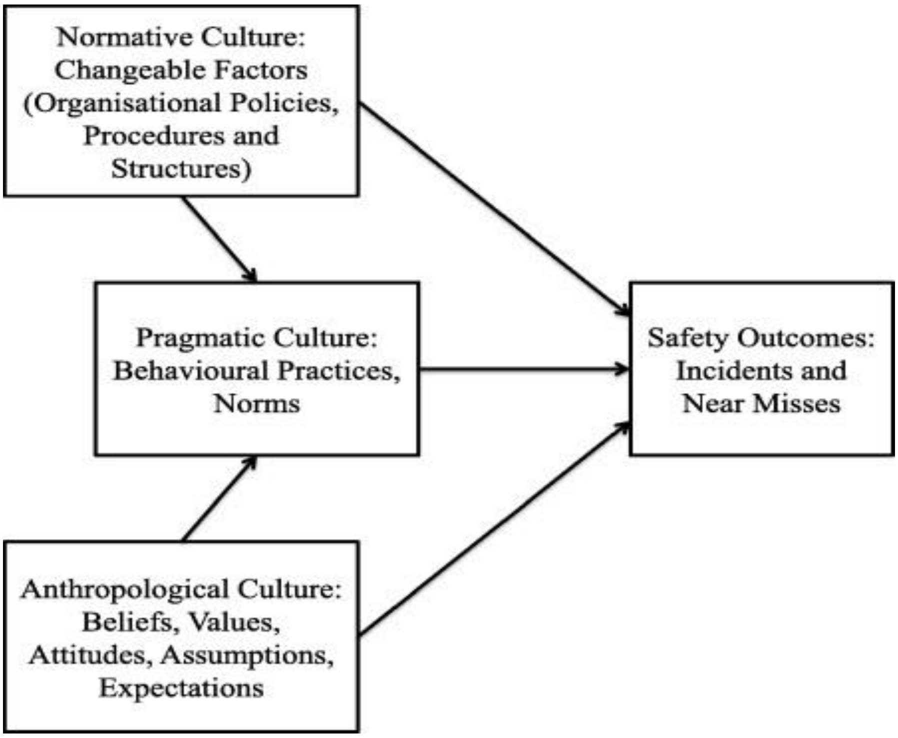

Figure 2 - A synthesised conceptualisation of safety culture.

Using the same PPE example above to assist explanation - the normative component (i.e. a policy of PPE usage on-site) is driven by managerial control and implemented to foster safe behaviours. However, its effectiveness is limited by the importance of the anthropological component - a shared belief, values and assumptions that PPE is essential. However, these two constructs are insignificant unless they can be tied directly to form a pragmatic element: the practice of PPE usage being implemented by workers and the observable safety behaviour. This provides a rounder, holistic perspective of the safety culture construct.

2.3 Safety Climate and Safety Culture

Safety Culture is sometimes confused with safety climate, and the terms are used interchangeably. Like safety culture, there is also no universally agreed-upon definition for safety climate. Zohar (1980) - one of the first researchers of the topic, suggests that safety climate is the sum of all perceptions regarding safety shared by employees. Since this initial introduction, authors have since added to this, such as Glendon and Stanton (2000), who suggest that safety climate is the organisation's current position and should be viewed as superficial to safety culture. Schneider et al. (2013) add that the safety climate can only indicate the underlying culture and not the 'full richness'. Cooper (2000) earlier demonstrated this point by identifying it as a ‘subcomponent’ of safety culture and coining the much-used term - a *‘snapshot’* of the culture that shows ‘how we do things around here’. Gadd and Collins (2002) concur with this and describe safety climate as the indicator of an organisation’s overall safety culture. In essence, safety climate the employee’s current perception and attitudes towards safety at that moment.

Ademola (2020) proposes a conceptual framework for optimising safety culture and climate on construction sites. Building on previous models mentioned above, this model emphasises top management, ensuring that the internal psychological factor is put in place towards an improved safety climate. As shown in figure 3 below, this factor encompasses management commitment to safety, increased safety compliance, participation and knowledge. Additionally, improved safety culture is dependent on the external observation factor – safety management systems, improved behaviour and incident rate reduction.

The data centre construction project is multi-party in nature and consists of contractors brought together under the direction of the GC to achieve a specific task-oriented goal for which they were assigned to. After which, this temporary organisation that was created for the project will generally be dissolved. Workers on the construction site may perceive safety differently depending on which part of the overall organisation they are in, i.e. the contractor, trade, hierarchical position. This is primarily due to the strong influence of top-level management and their ability to create and extend organisations' safety culture. Therefore, safety management practices from the top ultimately determine the creation of the person, behaviour and situation dimensions of safety culture.

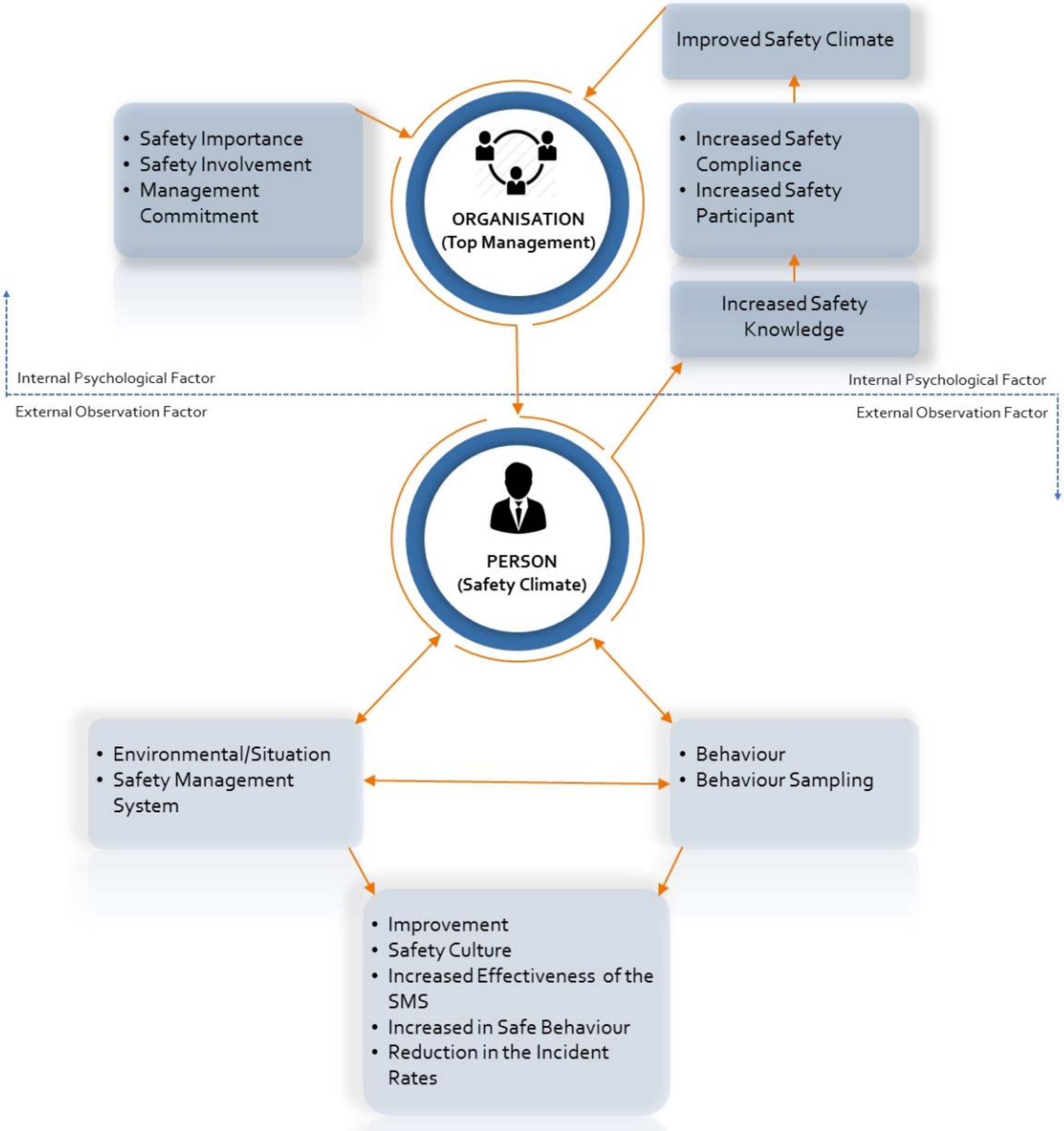

Figure 3 - Conceptual framework for optimising safety culture and climate on construction sites.

Measuring Safety Climate

As discussed previously, there are three core emergent constructs to safety culture. The situational/environmental, measured with audits and inspections; behavioural, measured with behaviour based safety observations and psychological. (Choudhry, Fang and Mohamed, 2007). From the author's experience, within a data centre construction setting, the internal psychological factor to safety culture is often measured with safety climate questionnaires designed to measure workers' safety perceptions.

In the past four decades, a variety of safety climate questionnaires have been developed by researchers to identify the factors that encompass safety climate – whether industry-specific or general (Zohar, 1980; Lee and Harrison, 2000; Kines et al., 2011). In a recent review of safety climate literature, Schwatka et al. (2016) further identify that only 7% of 56 studies reviewed used safety climate surveys developed for use in construction-oriented studies. Most of the studies (66%) used questionnaires previously developed and then adapted to the construction industry. The large variety of safety climate measurement questionnaires available adds to the complexity of how the results are interpreted, measured and analysed, predominantly with the use of questions (items) related to safety climate indicators and applicable contextual dimensions.

Safety Climate Dimensions

Although there is a general agreement on what safety climate is, there is much debate on the construct's dimensionality. Researchers agree that safety climate is multi-dimensional, although disagree on the number of dimensions that constitute it (Cooper and Phillips, 2004; Zohar and Luria, 2005). Cooper and Phillips (2004) stress that these differences in dimensionality are most likely due to the differences in the sample population, the method of question generation and the wording used. Despite this, there appear to be emergent themes amongst the differences in dimensionality. A review of 18 safety climate scales across multiple industries and countries by Flin et al., (2000) identified five common dimensional themes used in questionnaires;

1. Management/Supervision (Leadership)
2. Safety System
3. Risk
4. Work Pressure
5. Competence

These emergent themes also appear in questionnaires used in the construction industry (Mohamed, 2002; Li et al., 2017). One such questionnaire in which these themes are emergent is the NOSACQ-50. It has been used to measure perceptions of workers, co-workers and management commitment to safety and is said to be reliable in predicting safety motivation, self-rated safety behaviour and perceived safety level. (Kines et al., 2011) The questionnaire consists of seven dimensions;

1. **Management safety priority, commitment and competence**

   This dimension encompasses management attitudes, and ability towards safety, and commitment to workplace safety. Early research by Zohar (1980) identifies the priority of safety matters and top management involvement as themes when defining the first safety climate scale. The perception of such is later found by Flin et al., (2000) to be the most commonly assessed dimensions of safety climate research. It is the management that holds the key to safety culture creation.

   In the NOSACQ-50, items suggestive of work pressure tend to fall under the other dimensions labelled management, risk or systems. For example – *Item a5r: Management accepts employees here taking risks when the work schedule is tight.* This item is suggestive of management's ability (or inability) to control the work such that safety is prioritised and workers do not feel pressured.

2. **Management safety empowerment**

   This dimension is concerned with managements' ability to empower and encourage employees to work safely. Kines et al., (2011) describe safety empowerment as beneficial to encourage reciprocation and reinforce safety behaviour. However, to sustain an empowered employee responsibility for safety, it must be realised that employees under these conditions may make honest mistakes, and these mistakes must be treated fairly, which leads to the following dimension. (Törner and Pousette, 2009).

3. **Management safety justice**

   Dekker (2012) advocates a culture whereby employees can report errors without fear of retribution. This culture must comprise an atmosphere of trust yet have clear definitions of unacceptable and acceptable behaviour. Those who intentionally violate must be held accountable. Weiner, Hobgood, and Lewis (2008) agree, stating;

> *"Failing to discipline those who commit unsafe acts due to incompetence or recklessness is just as much a violation of widely accepted moral principles as is punishing those who commit honest mistakes."*

Therefore, management safety justice is not about blame but about workers feeling assured that workers will receive fair treatment when they report safety incidents or observation reports.

4. **Workers' safety commitment**

   Workers commitment to safety involves activities undertaken such as assisting other colleagues, taking responsibility for safety, actively engaging in workplace housekeeping and tackling risks on discovery. Umar (2020) stresses that workers perception of risk and control can be directly linked to their participation and responsibility for safety. Thus, workers' safety involvement and safety commitment are important factors considered in many safety climate assessment tools reviewed by Flin et al., (2000).

5. **Worker's safety priority and risk non-acceptance**

   It has been shown that using risk as a safety climate dimension can result in individual personality traits such as self-efficacy, stereotyping, optimism bias and individual risk behaviour influencing individual risk perception (Sjöberg, 2000). This has led to some researchers, such as Kines et al., (2011), excluding risk perception as an appropriate indicator and instead opting for workers perceptions of how they relate to workplace safety regarding the acceptance of risks or hazardous conditions.

6. **Safety communication, learning, and trust in co-worker's safety competence**

   Health and safety training is commonplace in organisations to improve knowledge and increase competence to reduce workplace incidents. Mohamed (2002) elaborates, identifying a link between competence and safety climate, and therefore, a higher level of competence will positively impact the overall safety climate. Regarding safety communication, Huang et al., (2018) describe this involving two aspects:

- How comfortable workers are conversing about safety issues with management and the quality of management communication (bottom-up communication)
- The workers' perception of how well management provides them with safety information (top-down approach)

7. **Trust in the efficacy of safety systems**

   This dimension measures workers perceptions of the different aspects that form safety systems. For example, frequent safety inspections, the emphasis on safety training and the high status of the safety officer are safety system themes identified by Zohar (1980). Such themes were later identified by Flin et al., (2000) in their review of 18 safety climate scales.

2.4 Safety Performance

A Health and Safety Management System (HSMS) can be described as an "… approach aimed at harmonising, rationalising and integrating management processes, safety culture, and operational risk assessment." (Li and Guldenmund, 2018) The general aim of a HSMS is to establish and achieve occupational H&S goals whilst continuously improving safety performance. The HSMS forms part of the external observational factor (situational) of safety culture. Lagging and leading safety indicators are generally measured to confirm they the HSMS is achieving its overall objective and to support the organisation to achieve continual improvement.

Lagging Indicators

Safety performance is traditionally measured using injury statistics, sickness-related absence from work, occupational diseases. Whilst this result-based approach is helpful to a certain extent, it can be problematic to gain a picture of the actual performance. Lagging indicators do have their place to provide data for reporting purposes and organisational safety statistics; however, many scholars dispute their effectiveness in the overall measurement of safety performance (Mearns, Whitaker and Flin, 2003; Zwetsloot, 2016). The historical data derived from accident occurrence renders any interventions to improve performance to be implemented after the fact. Lagging indicators generally do not capture a worker's exposure to adverse working conditions but can confirm and clarify a trend occurring over time.

Leading Indicators

Proactive management of construction safety performance also requires performance indicators that emphasise early primary or proactive intervention. Toellner (2001) describes such leading indicators as measurements linked to actions taken to prevent accidents instead of indicators linked to an accident's outcome. Safety performance can also be measured by employee's safety behaviours. Researchers have suggested that employee safety participation and employee safety compliance are more viable measures and leading indicators of safety performance (Hon, Chan and Yam, 2014). Additionally, some studies term safety compliance and safety participation as safety behaviours (Cooper and Phillips, 2004; Guo, Yiu and González, 2016). Therefore, for the purpose of this study, it can be considered that such participation and compliance behaviours are representative of safety performance.

The GC typically sets a level of the safety standard that all contractors are expected to meet. Safety compliance refers to the activities carried out by contractors to adhere to procedures and carry out work in a safe way. Safety participation is discretionary and comprises activities that help develop a worksite that stimulates safety but may not directly contribute to an individual's safety.

Suitable Key Performance Indicators (KPIs) using such leading measures are practicable to maintain a more accurate measurement of a HSMS effectiveness (Hinze, Thurman and Wehle, 2013; Podgórski, 2015).

Measuring Safety Performance

KPIs must be selected for measuring aspects of safety compliance and safety participation. They should ideally be tailored to the project's specific characteristics, such as the types of occurring high-risk activities, the number of subcontractors, or the maturity of the safety management process embedded within the project. Podgórski (2015) describes the criteria for the selection of KPIs utilising the 'SMART' acronym. Therefore, the KPIs selected must be;

- Specific
- Measurable
- Achievable
- Relevant
- Time-Bound

Keeping the above selection criteria in mind, suitable KPIs can be identified from the literature and selected.

Safety Compliance

Safety compliance and safety participation are measured at an individual level by assessing the frequency workers engage in such behaviours. In a construction setting, safety compliance can be construed as the capacity to adhere to the site rules and follow the procedures and controls outlined in the Risk Assessment and Method Statement (RAMS). The RAMS is a formal plan carried out by the subcontractor before commencing their scope of work. It contains a comprehensive sequence of works and detailed risk assessments. A lagging KPI often used in the construction industry is 'the number of RAMS approved for use'. However, a more appropriate leading KPI to measure compliance is how often workers and managers follow the procedures and controls outlined in the RAMS.

Safety Participation

A literature review of 10 articles carried out by Versteeg et al. (2019) identifies a total of 15 leading and 4 lagging indicators most commonly used to measure safety performance within the construction industry. The leading KPIs that suggest safety participation include the following;

1. **Site Inspections**

   A formal inspection of the workplace or work practice typically made by managers and accompanied by workers. The purpose is to identify hazardous conditions to be addressed, which is most effective with both parties' input. If they are absent from safety inspections or inspections are not carried out, potentially hazardous conditions will not be anticipated. A meta-analysis of 114 studies by Alruqi and Hallowell (2019) reveals that frequently measured safety inspections and pre-task briefings could significantly improve future safety outcomes – construction injury rates. Therefore, the frequency of participation by management and workers is one such measurement to indicate effectiveness.

2. **Pre-Task Safety Plan/Briefing**

   In industry, it is often referred to as a Safe Plan of Action (SPA). It is a one-page plan and briefing carried out by the subcontractor each morning at the location of work to define and control hazards associated with a specific process, job, or procedure. Not to be confused with the RAMS, which comprises broadly defined works, the SPA encompasses a particular task, for example, "operating a grinder to cut material". One of the requirements for an effective SPA is the input from both workers and supervisors involved in the task. Therefore, a viable KPI would be the frequency of participation.

3. **Job Safety Talks**

   In industry, job safety talks are known as 'Toolbox Talks', an event whereby safety information is exchanged between supervisors/management and workers. Results from earlier studies demonstrate a consistent and robust association between safety communication and safety improvement (Zohar and Luria 2003; Kines et al. 2010). Hence the frequency of toolbox talk participation is a viable KPI for safety performance.

4. **Worker Safety Behaviour**

   In industry, safety observation reports (SORs) by supervisors/managers and workers aim to identify good and bad safety behaviours. As a KPI, there is much disagreement between researchers on the effectiveness of SORs. A case study in the construction industry reveals its contribution to blame culture on site, loss of trust and low data value (Oswald, Sherratt and Smith, 2018). Others argue that within a more comprehensive behaviour-based safety system, the more supervisors and managers pro-actively undertake SORs, the more workers will voluntarily engage in the process (Cook and McSween 2000).

2.5 Safety Climate and Safety Performance

Between 1980 and 2006, approximately 32 studies across various industries have been carried out to validate safety climate and its ability to predict safety performance (Clarke 2012). These studies consisted of safety climate perceptions and assessments of employee outcomes beyond these regarding safety. However, inconsistency in the inclusion of safety climate dimensions across studies points toward a lack of a comprehensive and universal method to assess safety behaviours concerning the use of different dimensions and items. Thus, the consistency of results from such studies is difficult to obtain.

Alruqi, Hallowell and Techera (2018) acknowledge this inconsistency, arguing that the core dimensions of construction safety climate remain unknown. Their meta-analysis of 11 studies identifies a strong correlation between construction site injuries and safety climate dimensions such as management commitment to safety, training, individual responsibility for safety, and procedures/safety rules.

Studies have also identified trust in management and their leadership abilities as a crucial component of proactive safety culture and a key predictor of safety performance (Umar, 2020). The construction manager's role and the safety leadership practices it encompasses – discipline, vision, commitment, engagement and promotion – make it an integral aspect of safety climate and building trust amongst the workforce. If workers perceptions show trust in management and their abilities, then their engagement in safety-related behaviours will be positively affected – improving safety outcomes (Zacharatos, Barling and Iverson, 2005).

Subsequent studies in other industries such as nursing and transport conclude that leadership safety empowerment is directly related to safety compliance and safety participation (Thurston and Glendon, 2018; Al-Bsheish et al., 2019). Furthermore, when leadership safety communication is of high quality, the relationship between safety climate and safety performance is stronger (Huang et al., 2018).

Safety Compliance and Safety Participation

As discussed earlier, concerning Ademola's (2020) conceptual framework in Figure 3, safety leadership practices influence safety climate through the effect on workers' safety compliance and safety participation, with safety knowledge as a determinant of these. Saedi, Ab. Majid and Isa (2020) draw attention to employees' good understanding of safety climate when there is a high level of management commitment, including management communication to workers. Workers' safety priority is improved when there is an understanding and knowledge of policies and procedures. This is consistent with previous research by Clarke (2006). He agrees that a positive safety climate raises awareness of procedures and increases motivation to comply with and the importance of following them. These policies and procedures form part of the overall safety systems implemented. The perception of the safety systems in play is essential as employees are less likely to engage in risky behaviour if they perceive that the system's aspects are relevant and useful (Cooper, 2000).

Authors (Saedi, Ab. Majid and Isa, 2020) have found that safety climate has a stronger link to safety participation than safety compliance, revealing it has a significant influence over employee commitment and involvement in safety. They argue that a positive safety climate can predict safety participation, improving performance to control safety outcomes - i.e. accidents and incidents. In addition to this, research on a Swedish construction site concluded that safety climate successfully predicted self-reported safety behaviour seven months after assessment and therefore supports an interconnected relationship between safety climate, safety participation and how workers behave regarding safety (Tholén, Pousette and Törner, 2013). A study concerning the Hong Kong construction industry's safety climate yields a similar result demonstrating that workers' involvement in safety and health had the most extensive influence on safety outcomes (Chan et al., 2017). Safety climate has a positive effect on unsafe behaviours by reducing scepticism attitudes surrounding the efficacy of safety measures and procedures.

2.6 Literature Review Summary

This literature review has shown that both safety culture and its subcomponent safety climate are complex constructs, with much of the existing research agreeing that top-level management actions define both culture and climate. An appropriate safety climate measurement method is with the use of appropriate questionnaire items and contextual dimensions.

Furthermore, previous research to date reveals a consistency in safety climate's ability – through safety leadership practices – to influence safety knowledge, compliance and participation. This, in turn, influences safety-related behaviours, potentially leading to improved safety outcomes. The author aims to build upon previous research and understand the relationship between safety climate and safety participatory and compliance behaviours to provide appropriate recommendations specific to the current data centre construction project. The following chapter outlines the research strategy, data collection techniques and approach to data analysis.

3 Methodological Approach

3.1 Introduction

This chapter discusses and justifies the research strategy and data collection techniques relevant to the objectives outlined for the overall research dissertation entitled:

Safety in Data Centre Construction: An investigation into safety climate and its relationship with safety performance.

This research study has specific inter-related objectives set within the context of higher education:

1. *Define* the safety culture construct and its relation with safety climate.
2. *Critically evaluate* safety climate, how it is measured and its relation to safety performance.
3. *Explore* contractor safety climate perceptions respective to their safety performance on a single data centre construction project.
4. *Formulate* recommendations on construction project safety culture and safety performance improvement.

The empirical research relates specifically to objective 3 – *Explore* contractor safety climate perceptions respective to the safety performance of a single data centre construction project. The need for empirical data collection is justifiable as the author wishes to produce recommendations to positively impact the safety culture and performance of the current and future construction projects.
For the reader's benefit, a research strategy flow diagram has been created to assist the explanation. The diagram in Figure 4 will form the basis for this chapter using relevant subheadings concerning the boxes identified in the diagram.

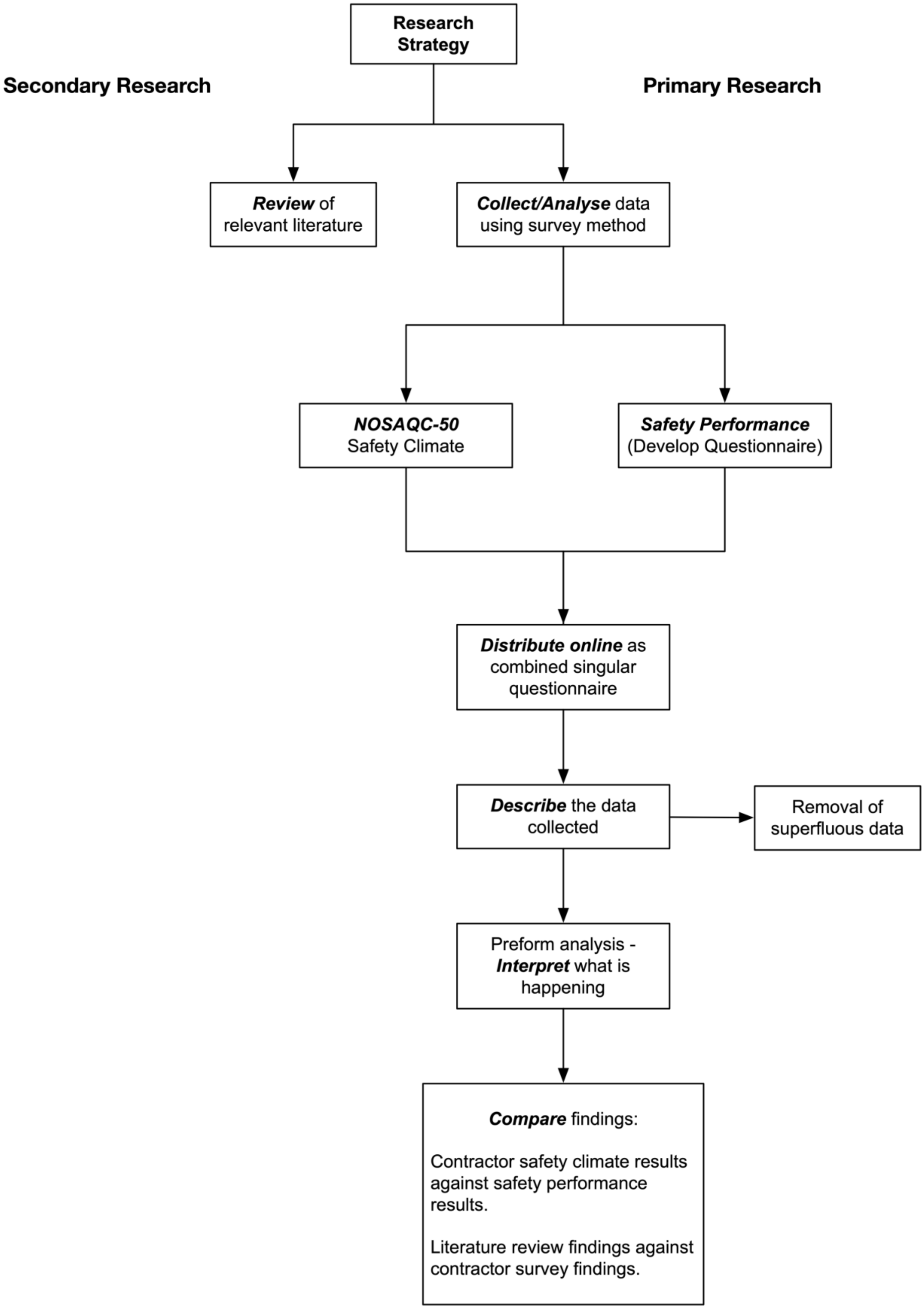

Figure 4 - Research strategy diagram.

3.2 Secondary Research

The secondary research aims to meet objectives 1 and 2. This research consists of information included in Chapter 2 Literature Review of this research report. The author reviewed literature from various sources to obtain the required information, including research journals/articles, books, websites, and reports.

3.3 Primary Research

To meet objective 3, the chosen primary research method for this study involves using a cross-sectional survey. Within the context of higher education research, a survey can is described as a method to;

> "…gather data at a particular point in time with the intention of describing the nature of existing conditions, or identifying standards against which existing conditions can be compared, or determining the relationships that exist between specific events" (Cohen, Manion and Morrison, 2017).

This type of research strategy is more suitable than others. The aim is to gather data from contractors at one particular point in time to explore and describe their existing perceptions to determine the relationship's extent with the safety performance.

The information obtained from the secondary research identified methods of measuring safety climate and safety performance within the construction industry. This information has been carried forward for further investigation.

The Nordic Safety Climate Questionnaire (NOSACQ-50)

Many safety climate questionnaires are available in the existing literature to measure the psychological dimension of safety culture. After comparing the options available, the Nordic Occupational Safety Climate Questionnaire (NOSACQ-50) was selected to assess safety climate perceptions at the work-group level (Kines et al., 2011). A copy of the questionnaire (English version) is included in Appendix B.

The tool was developed by a Nordic network of occupational safety researchers and is utilised for measuring the current status of safety climate within the organisation, or in this case, the construction project. The NOSACQ-50 is a validated tool based on previous safety and organisational climate theories, psychological theories and practices. It comprises 50 items spread across seven dimensions which relate to;

a. The respondent's perceptions of how their managers deal with safety.
b. The respondent's perceptions of how they deal with safety.

Each of the 50 items is formulated in a positive or reversed format. The responses are based on a 4-point Likert scale, as shown in Table 1. Thus, the number of points awarded for each response is based on how the item is formulated. Table 2 shows each dimension (Dim) and their respective formulated items numbers.

	Strongly Disagree	**Disagree**	**Agree**	**Strongly Agree**
Points for Positive Items	1	2	3	4
Points for Reversed Items	4	3	2	1

Table 1 - 4-point Likert scale.

Dimensions		**Positively Formulated Items**	**Reversed Formulated Items**
Dim 1	Management safety priority, commitment, and competence	a1, a2, a4, a6, a7	a3r, a5r, a8r, a9r
Dim 2	Management safety empowerment	a10, a11, a12, a14, a16	a13r, a15r
Dim 3	Management safety justice	a17, a19, a20, a22	a18r, a21r
Dim 4	Workers' safety commitment	a23, a24, a27	a25r, a26r, a28r

Dim 5	Workers' safety priority and risk non-acceptance	a33	a29r, a30r, a31r, a32r, a34r, a35r
Dim 6	Peer safety communication, learning, and trust in co-worker's safety competence	a36, a37, A38, a39, a40, a42, a43	a41r
Dim 7	Worker's trust in the efficacy of safety systems	a44, a46, a48, a50	a45r, a47r, a49r

Table 2 - Dimensions and item numbers.

The reasons for choosing the NOSACQ-50 are as follows;

1. The language differences; the NOSACQ-50 has already been translated into 40+ languages that are available for use.
2. The development of a new safety climate tool (with Swedish translation) is a time-consuming process.
3. The process of validating a newly developed safety climate tool and ensuring its reliability is a significant undertaking and not possible within the timescale for this study.
4. It allows the ability to measure at the group level, i.e., workers and managers.

Safety Performance Questionnaire

The secondary research recognises that a valid measure of safety performance is safety participation and safety compliance behaviours that lead to improved safety outcomes (Clarke 2006; Hon, Chan and Yam, 2014; Chan et al., 2017). KPIs were also identified from the literature and were carried forward to develop a questionnaire for the study that allowed the author to measure safety culture's situation/environment dimension. These are:

- Safety Compliance
    - How often workers and managers follow the procedures and controls outlined in the RAMS.

    - Compliance with general site rules.

- Safety Participation
    - Pre-Task Safety Plans (Safe Plan of Action – SPA)
    - Job Safety Talks (Toolbox Talks)
    - Worker Safety Behaviour (Safety Observation Reports)
    - Site Inspection (Attendance)

The safety performance questionnaire displayed in Table 3 below comprises seven items. Three items are used to measure safety compliance and four to measure safety participation.

Safety Compliance	
Item No.	**Statement**
Com 1	I follow the procedures and controls outlined in RAMS for the tasks that I perform.
Com 2	My co-workers follow the procedures and controls outlined in RAMS for the tasks that they perform.
Com 3	All of the workers in my company follow the site rules implemented by the general contractor.
Safety Participation	
Par 1	I frequently submit SORs to the general contractor.
Par 2	I frequently provide input and give suggestions for improvement at toolbox talks.
Par 3	I frequently speak up and ask for opinions about workplace risks when completing the SPA.
Par 4	I frequently volunteer to attend safety inspections to improve workplace safety.

Table 3 - Safety Performance Questionnaire.

The responses for safety compliance and safety participation items are based on the same 4-point Likert scale in Table 3 above.

Additionally, the respondents were also requested to elaborate further on each item in the safety performance questionnaire as an optional comment. The intention is to produce additional data representative of the group sampled. This data may identify issues that might complement the closed questionnaire style and provide further insight into the contractor's safety participatory and compliance behaviours.

The reasons for developing this specific tool are as follows;

1. The use of closed questions is suitable where measurement is sought and does not discriminate unduly based on how articulate the respondents are.
2. The additional use of open questions has the potential to increase the response rate, elaborate responses to closed questions, and potentially identify new issues not captured in closed questions.
3. The questionnaire is anonymous and encourages greater honesty when responding to items.
4. It is more economical and efficient than interviewing in terms of time expenditure; data is captured at ease and relatively quickly.

3.4 Distribution of Questionnaires

Data from the NOSACQ-50 and the Safety Performance questionnaire was collected using Microsoft Forms. This allowed the author to create a digital survey using English and Swedish language versions of the tools, prompting the respondent to select the appropriate language at the beginning of the questionnaire. It also allowed both questionnaires to be combined to form one unified questionnaire to streamline data collection.

With the permission of company directors (Appendix A) the responses were collected by a questionnaire app installed on the author's tablet and via a webpage hyperlink distributed by email. A participant information sheet was also displayed upon opening the questionnaire and a copy of this is available in Appendix A. The responses collected for questionnaires (in both language versions) were consolidated into one data set, then exported for subsequent analysis. Given the time constraints involved, it was not feasible to collect data from the whole target population; thus, a suitable sampling method was selected.

Target Population and Sample Size

The target population were workers on a large-scale datacentre construction project in northern Sweden. At the time of research, the project was two months away from completion, and there were 166 workers on site, predominantly Irish and Swedish nationals. A stratified random sampling technique was used. The target population is divided into segments consisting of Contractor No.1 (C1) and Contractor No.2 (C2), with each segment further divided into Worker and Leader.

It is important to note that the term 'Leader' used throughout this research project is made in reference to those in a management or senior supervisory position.

Random samples were taken from each of the 'Worker' and 'Leader' segments of C1 and C2 over two weeks. An adequate representative sample size was set at 120 responses – 65% of the target population.

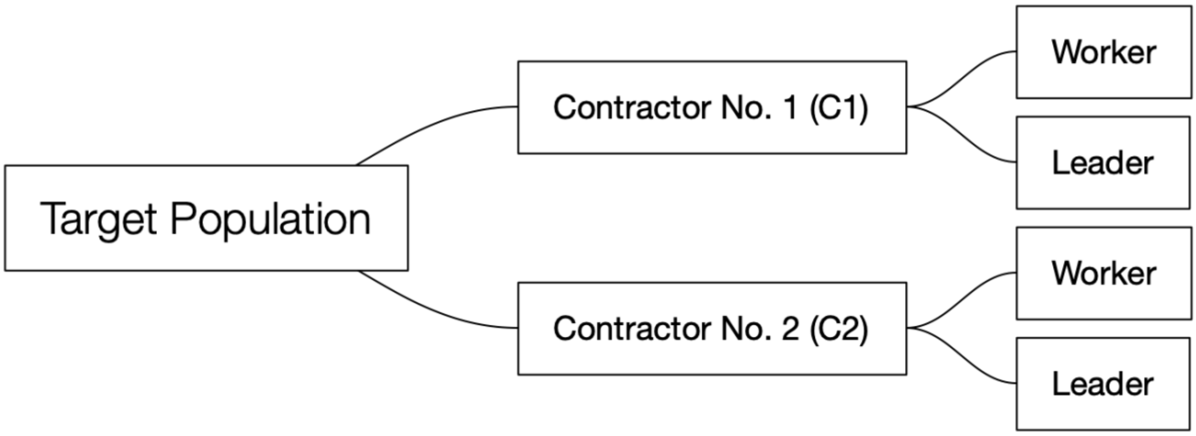

Figure 5 - Breakdown of the target population.

- C1
  An electrical contractor with responsibility for the installation and commissioning of electrical switchgear, generators and transformers.

- C2
  A civil works contractor with responsibility for the external groundworks and installation of services and landscaping.

Response Rate

Initially, the author distributed the combined questionnaire webpage hyperlink by email to 140 personnel; however, only 41 responses were gathered using this method. Five of these questionnaires were returned blank with no information other than demographic data and were later removed from the research. Another 56 responses were gathered on the construction site via tablet by the author. Thus, there were 91 questionnaire responses, albeit not the 120 responses envisaged; it is still sufficient to conduct the research – 55% of the target population.

At the time of this research:

- C1 had a total workforce of 62 workers with 37 respondents. Therefore, 60% of the contractor's workforce were surveyed.

- C2 had a total workforce of 84 with 54 respondents. Therefore, 64% of the of the contractor's workforce were surveyed.

3.5 Approach to Data Analysis

The data obtained from each questionnaire response was collated by numerical value in a Microsoft Excel spreadsheet. The data was initially explored, and the superfluous data was also removed due to a total lack of completion.
The use of Cronbach's Alpha followed this to determine the reliability of the questions.

The data enabled a graphical representation of the results in the format of text, tables and figures. The mean value is calculated for each dimension. This value ranges between 1 and 4, where 1 is the lowest level, and 4 is the highest. For example, the mean for the scale of 1, 2, 3, 4 is 2.5. Therefore, in theory, a result of 2.5 or above is positive.

Information from the NOSACQ-50 website allowed the author to devise a simple guide to assist with interpretation of the result range and serve as a visual aid (NFA, 2021). Table 4 shows the mean result range, its denoted rating and colour code.

Result Range	Colour Code	Rating	Action
>3.30	Blue	Good	Maintain and continue developments
3.00 – 3.30	Green	Fairly Good	Slight need for improvement
2.70 – 2.99	Amber	Fairly Low	Need of improvement
<2.70	Red	Low	Great need of improvement

Table 4 - Result Range, Colour Code and Rating.

3.6 Acknowledged Limitations

With any type of research strategy, there are going to and be both advantages and disadvantages. In this case, the author has identified and acknowledged some limitations to the chosen research strategy – a cross-sectional survey.

- The data captured is a “snapshot in time” and therefore does not represent the changing social dynamics over the construction project’s lifecycle.
- Some participants can decline to take part or omit to answer specific questions, thereby weakening the sample.
- Although the questionnaire is presented with options of both English and Swedish languages, it may present some difficulty to people of limited literacy.

4 Research Findings: Description and Analysis

4.1 Introduction

This chapter reveals the results of the survey described in Chapter 3, Methodological Approach. This research concentrates on two contractors working on a data centre construction project. Each contractor consists of two groups of stakeholders – ‘Workers’ and ‘Leaders’.

- C1 – Contractor 1
  An electrical contractor with responsibility for the installation and commissioning of electrical switchgear, generators and transformers. At the time of research, the contractor had amassed a total of 127,435 labour hours worked.

- C2 – Contractor 2
  A civil works contractor with responsibility for the external groundworks and installation of services. At the time of research, the contractor had amassed a total of 165,724 labour hours worked.

The analysis of the combined questionnaire is approached in a structured way. First, a description of the overall results is provided for each contactor. This is then followed by a discussion and integrative analysis of the empirical data against the literature review findings.

4.2 Participant Demographics

Minimum demographic information has been gathered to ensure the anonymity of the participants. Therefore, only the pre-existing demographic questions within the NOSACQ-50 have been used. These questions include the participant's age, sex and whether they have a managerial position or not.

Figure 6 below represents a breakdown of the individual participants by age group. It can be seen that the majority of participants are between the age of 21 and 50.

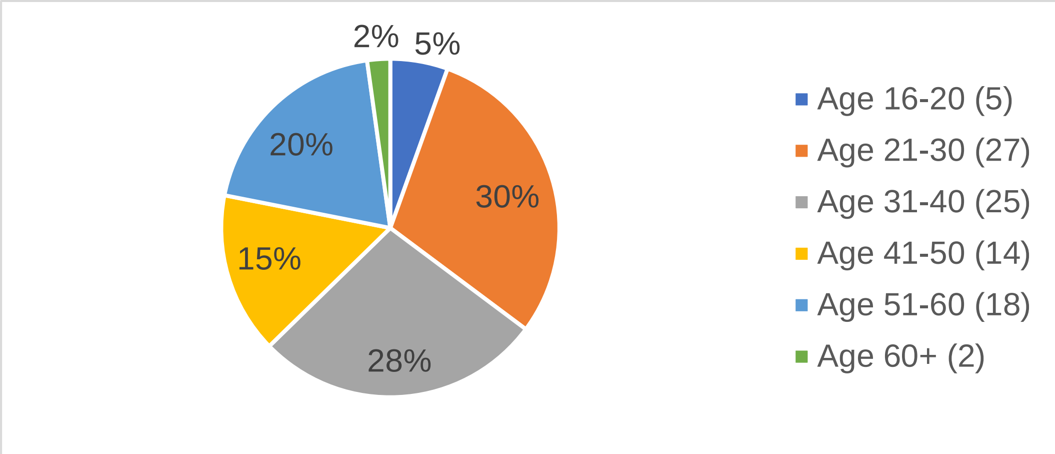

Figure 6 - Percentage of participants by age.

Figures 7 and 8 show a breakdown of participants by contractor and the breakdown of the participants' role type for each contactor.

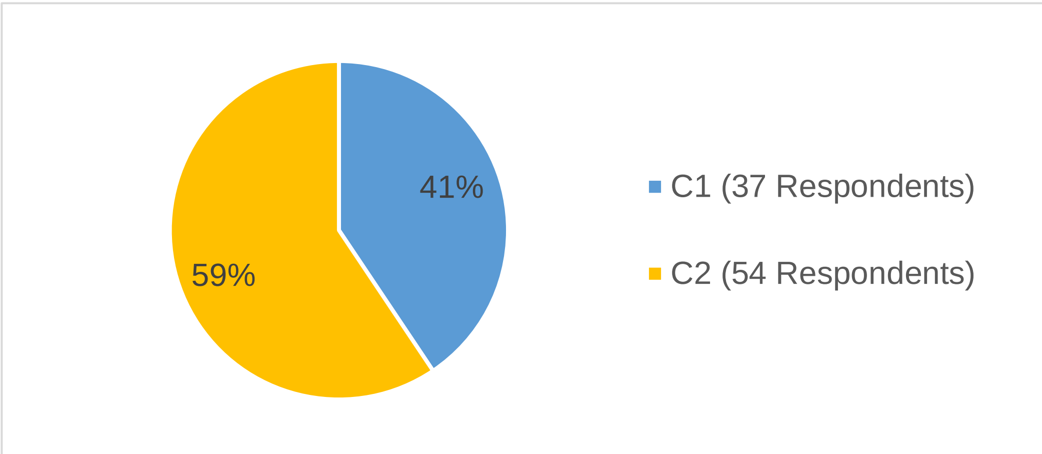

Figure 7 - Percentage of participants by contractor.

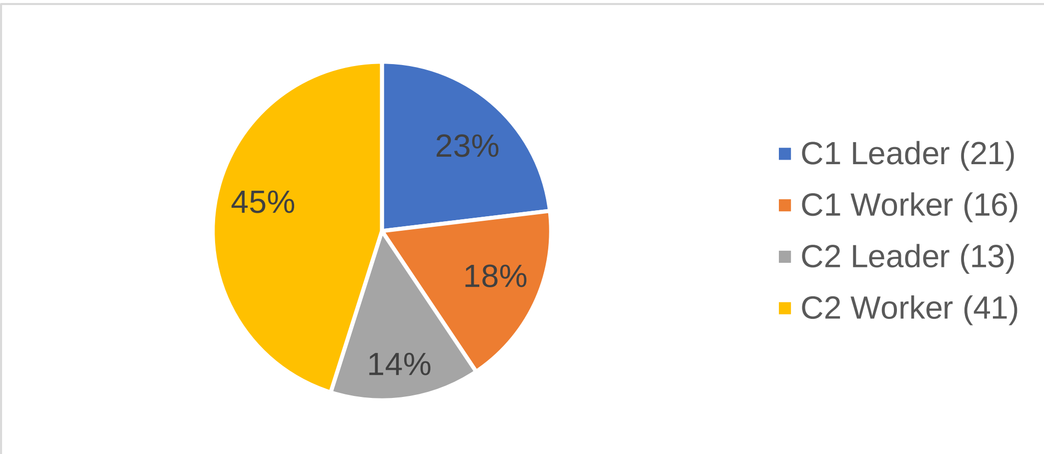

Figure 8 - Percentage of participants by role type.

Figure 9 shows a breakdown by participant gender.

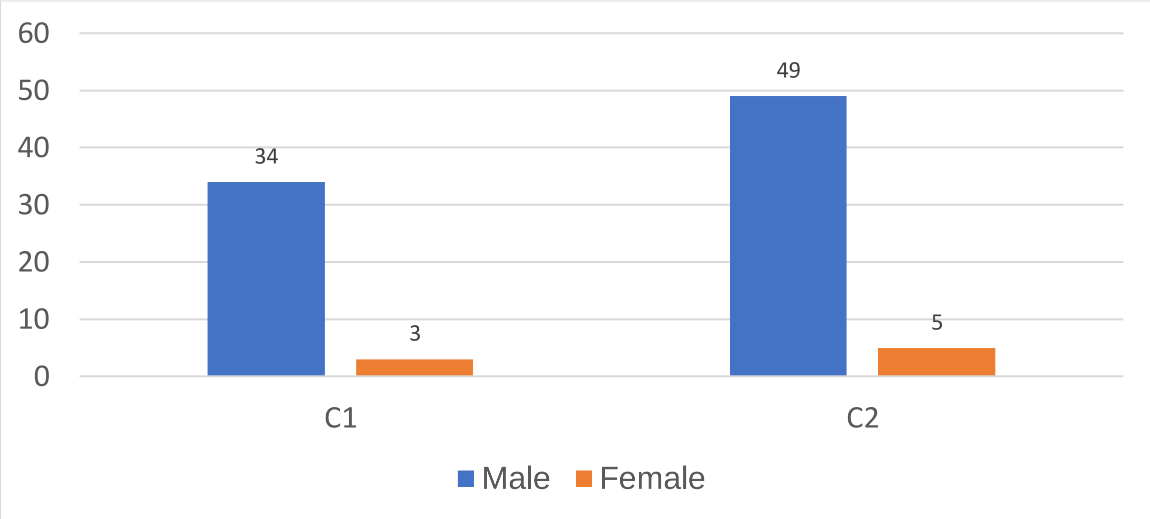

Figure 9 - Breakdown of participants by gender.

4.3 Description – C1 Overall Results

Table 5 shows all dimensions have a rating of 'fairly good' to 'good'. Many of the safety climate dimensions have a Cronbach's Alpha value of 8 showing a high level of scale reliability. Appendix C contains the full internal consistency analysis. Key points to note are:

- Leaders are more optimistic about their safety empowerment (Dim 2), and safety justice (Dim 3) than the workers perceive.
- Workers are more optimistic about their manager's safety priority, commitment and competence (Dim 1) than the managers are themselves.
- Workers are self-critical in dimensions relating to their safety commitment (Dim 4), safety priority and risk non-acceptance (Dim 5).
- Workers show more positivity in their peer's safety communication and trust in co-worker's safety competence (Dim 6).

The highest performing dimension was Dim 7. It shows that the workers have much trust in the safety systems that management have put in place. The leaders also concur with this showing a positive result, albeit not as high as the workers.

Safety compliance and safety participation results are shown in Table 6. The result is ‘fairly good’ overall and Cronbach’s Alpha are above 7 which is an acceptable value. The main takeaways are:

- Workers are more compliant with task RAMS than management (Com 1, Com 2).
- Workers are less susceptible to follow the site rules implemented by the GC (Com 3).
- The leaders do not volunteer to attend safety inspections as much as workers do (Par 4).
- Workers participate more in reporting safety observation and asking for opinions about the risks when completing the SPA (Par 1, Par 3).

Dimension	Overall	Worker Mean	Worker Std. Deviation	Leader Mean	Leader Std. Deviation
Dim 1	3.30	3.47	0.58	3.17	0.53
Dim 2	3.22	3.19	0.45	3.25	0.40
Dim 3	3.22	3.31	0.43	3.34	0.50
Dim 4	3.35	3.34	0.54	3.36	0.48
Dim 5	3.20	3.08	0.57	3.29	0.48
Dim 6	3.38	3.44	0.47	3.33	0.44
Dim 7	3.54	3.59	0.36	3.50	0.41

Table 5 - Results: C1 Safety Climate.

Item	Overall	Worker Mean	Worker Std. Deviation	Leader Mean	Leader Std. Deviation
Com 1	3.15	3.31	0.70	3.09	0.83
Com 2		3.18	0.65	3.14	0.79
Com 3		3.06	0.57	3.14	0.79
Par 1	3.04	3.18	0.54	3.00	0.54
Par 2		3.00	0.81	3.04	0.49
Par 3		3.18	0.65	3.04	0.86
Par 4		3.06	0.85	2.90	0.70

Table 6 - Results: C1 Safety Compliance and Safety Participation

4.4 Description – C2 Overall Results

Table 7 shows the overall safety climate result ranges from ‘fairly good’ to ‘good’. Again, many Cronbah’s Alpha values are above 8 indicating high internal consistency. Key points include:

- Management safety empowerment (Dim 2) is rated as ‘fairly low’ for both groups with a need for improvement.
- Workers show a higher level of safety climate than leaders in five dimensions.
- Leaders have greater levels of communication, learning and trust in both co-worker’s safety competence (Dim 6) and efficacy of the systems in place (Dim 7).
- Workers are more positive about their leaders than the leaders were about themselves in the three dimensions relating specifically to management – safety priority, commitment and competence (Dim 1), safety empowerment (Dim 2), and safety justice (Dim 3).

Table 8 shows C2 safety compliance rated as ‘fairly good’ and safety participation as ‘fairly low’. Cronbach’s Alpha values are acceptable with all items scoring above 7.

- Workers show fairly good compliance with the site rules (Com 3).
- Workers compliance with the RAMS is lacking (Com 1, Com 2).
- Leaders have a higher level of compliance regarding both RAMS and site rules, yet their participation in safety activities needs improvement.

Dimension	Overall	Worker Mean	Worker Std. Deviation	Leader Mean	Leader Std. Deviation
Dim 1	3.16	3.23	0.61	2.94	0.84
Dim 2	2.96	2.97	0.60	2.92	0.59
Dim 3	3.18	3.26	0.64	2.91	0.59
Dim 4	3.47	3.52	0.46	3.29	0.54
Dim 5	3.06	3.06	0.65	3.05	0.60
Dim 6	3.41	3.41	0.47	3.42	0.32
Dim 7	3.34	3.30	0.50	3.46	0.49

Table 7 - Results: C2 Safety Climate

Item	Overall	Worker Mean	Worker Std. Deviation	Leader Mean	Leader Std. Deviation
Com 1	3.05	2.82	0.86	3.07	0.49
Com 2		2.78	1.03	3.30	0.63
Com 3		3.00	1.11	3.38	0.65
Par 1	2.91	3.04	0.54	2.92	0.75

Par 2		3.12	0.71	2.61	0.50
Par 3		3.31	0.72	2.61	0.50
Par 4		3.19	0.60	2.53	0.77

Table 8 - C2 Safety Compliance and Safety Participation

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4.5 Research Findings

This subsection will delve into the results of the seven safety climate dimensions for each contractor in more detail. The following analysis will attempt to clarify the extent of the relationship between the specific safety climate dimensions with safety compliance and safety participation – i.e., safety performance.

A box and whisker plot has been produced for each dimension to assist in this process.

Dim 1: Management Safety Priority, Commitment, and Competence

Figure 9 shows the Dim 1 responses for C1 Leaders and C1 Workers.

C1 Workers and C1 Leaders

The leaders are self-critical with positive responses to items on management placing safety before production (a4), confidence in their ability (a6), and ensuring issues discovered during safety inspections are resolved (a7). These items have the most significant variation between leaders and workers with a mean value difference of 0.35, 0.34 and 0.46, respectively. Furthermore, leaders have a stronger positive response to the reverse formulated item on management accepting risk-taking when the schedule is tight (a5r).

The Leader's participation in safety inspections shows to be lacking (Par 4). By not attending safety inspections, their perception of their confidence in abilities and ensuring issues are resolved will remain self-critical. Item comments on Par 4 also hints that they are too busy to attended therefore self-critical when perceiving that safety is placed before production.

One Leader admits that pressure is placed upon them: *"I put my name down but when the time comes, I'm normally tied up with something else." – C1 Leader.*

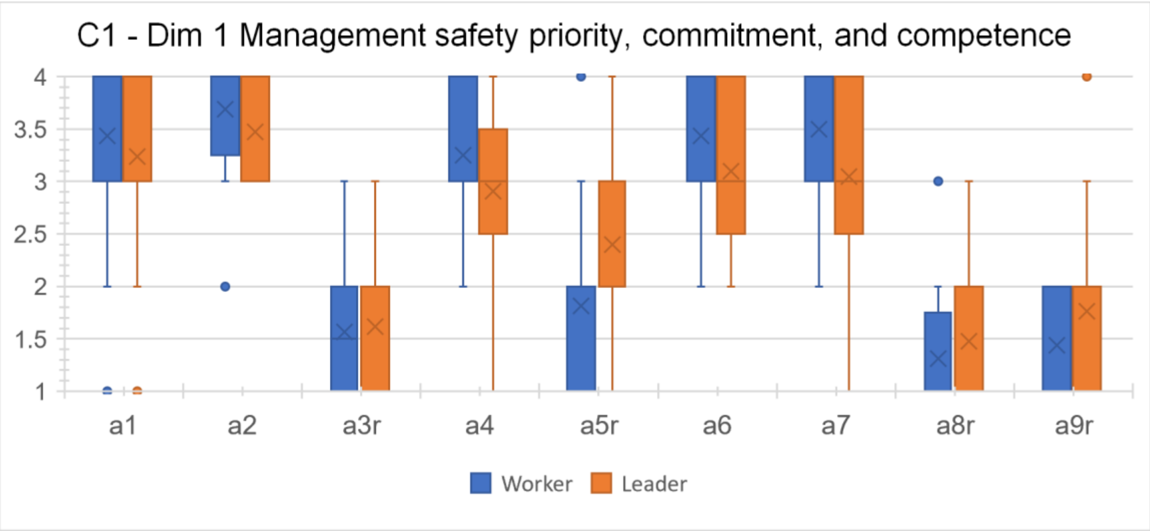

Figure 10 - C1: Dim 1 (Management safety priority, commitment, and competence)

Figure 10 shows the Dim 1 responses for C2 Leaders and C2 Workers.

C2 Workers and C2 Leaders

C2 worker data is skewed towards a strong agreement for items concerning management placing safety before production (a4) and ensuring safety inspection issues are corrected immediately (a7). These two items have the greatest mean value variance between both groups, with 0.51 and 0.60.

C2 leaders' data shows many agree that they look the other way when someone is careless with safety (a3r). This, is interesting as leaders' responses show good levels of safety compliance with site rules and RAMS (Com 1-3).

Leaders have poor participation in safety inspections (Par 4), which is reflected in how they perceive the ability to ensure issues identified from safety inspections are corrected. The leaders also show poor participation in sharing their input in toolbox talks (Par 2) or SPAs (Par 3) and raising safety observations (Par 1) which further implies that safety issues raised during these conversations are potentially missed by management. Worker's and Leader's comments suggest that an accelerated construction programme seems to be a factor in managements lack of participation and why they perceive it this way.

"…management is busy all the time and won't join our meetings. I think the [client name removed for confidentiality] programme is too demanding for them to keep up with." – C2 worker

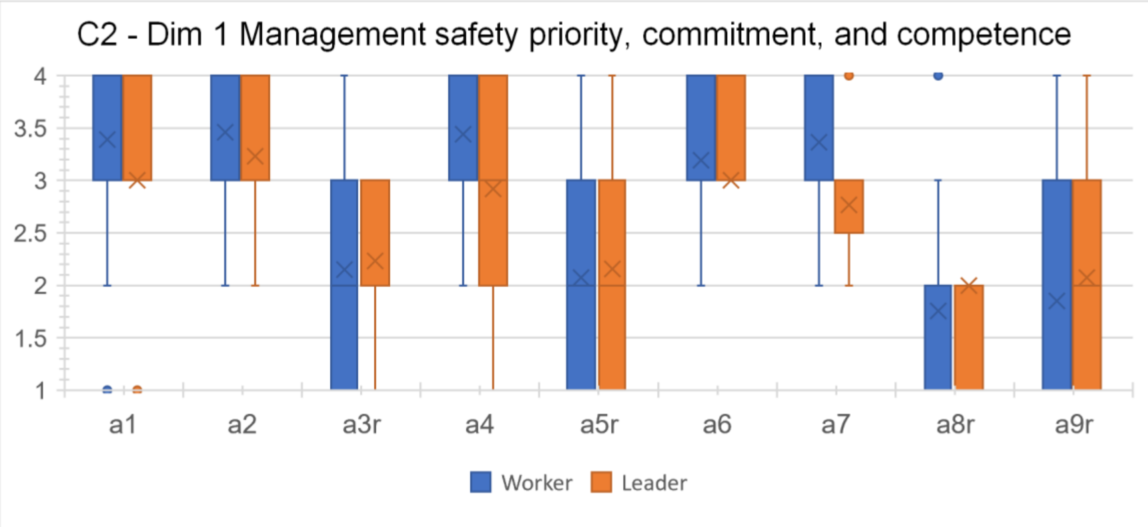

Figure 11 - C2: Dim 1 (Management safety priority, commitment, and competence)

Dim 2: Management safety empowerment

Figure 11 shows the Dim 2 responses for C1 Leaders and C1 Workers.

C1 Workers and C1 Leaders

Dim 2 has a good result overall, however, there is slight variation between C1 workers and C1 leaders. Leaders are slightly more optimistic than workers with their level of safety empowerment with 25% in solid agreement that they involve workers in decisions regarding safety (a16). Nevertheless, leaders have fairly good participation in speaking up, asking for opinions and providing input at toolbox talks – this is suggestive the C1 management safety empowerment is effective.

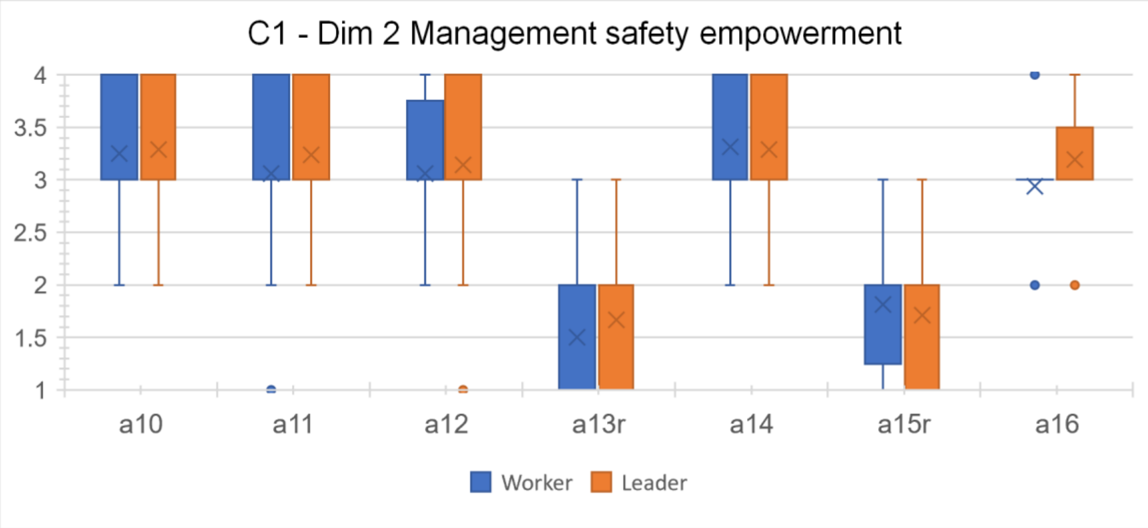

Figure 12 - C1: Dim 2 (Management safety empowerment)

Figure 12 shows the Dim 2 responses for C2 Leaders and C2 Workers.

C2 Workers and C2 Leaders

Dim 2 has the lowest overall result of all dimensions for C2. Items with a significant difference in mean value are those related to management designing meaningful and purposeful safety routines (a10 – 0.35), not considering workers suggestions (a13r – 0.56), or opinions regarding safety before making decisions (a15r – 0.59).

Workers and leaders show a similar result indicating they perceive management as weak at involving employees in safety decisions (a15r) with mean values of 2.70 and 2.76, respectively. However, both groups' data have a negative skew for the reverse formulated item concerning management never asking employees for their opinions before making decisions.

Leaders perceive themselves as not designing meaningful and purposeful safety routines, yet their participation in all safety activities is low. Participation in safety inspections, offering suggestions, and asking for opinions would allow leaders to create a dialogue with workers to design meaningful and purposeful safety routines whilst including workers in the decision process.

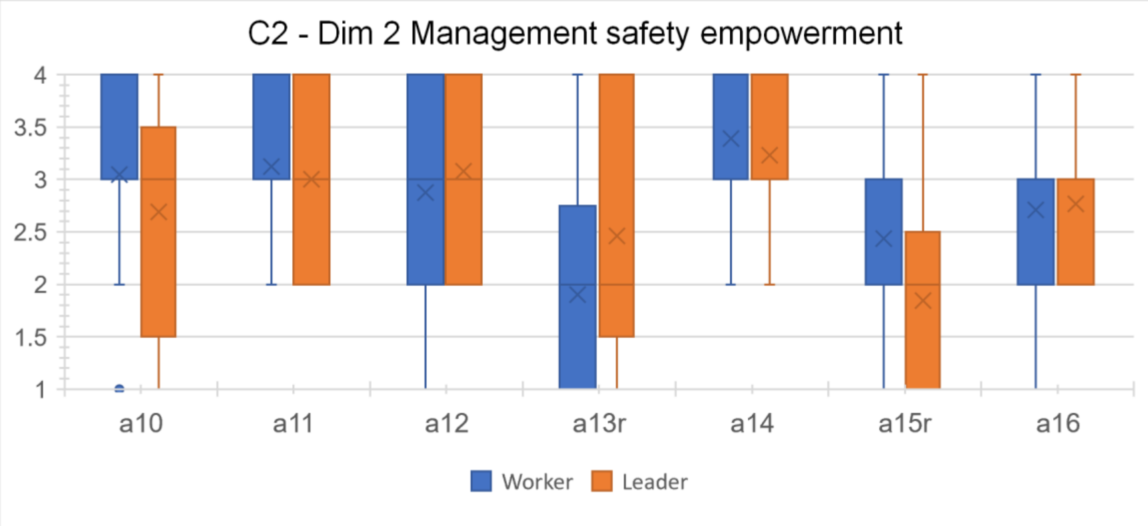

Figure 13 - C2: Dim 2 (Management safety empowerment)

Dim 3: Management safety justice

Figure 13 shows the Dim 3 responses for C1 Leaders and C1 Workers.

C1 Workers and C1 Leaders

Dim 3 result for C1 is good overall; leaders show a larger spread regarding workers being discouraged from reporting near misses/accidents due to fear of sanctions (a18r). Conversely, workers perceive this differently, with a mean value of 1.62 compared to 2.04. Workers also have a good level of SOR participation (Par 1), suggesting no discouragement of reporting, with one worker stating: *"We don't have many first aid cases or near misses, so when it does happen, we report it to the safety team. Who reports it to the GC." – C1 worker*

Workers strongly perceive that management does listen to those involved in accidents (a19), with all workers scoring between 3 and 4 on the Likert scale. Despite this, workers show an extensive spread in response to management treating those involved in an accident fairly (a22). This denotes uncertainty amongst workers and suggests that some workers may perceive management listening - but listening to reprimand instead of restore.

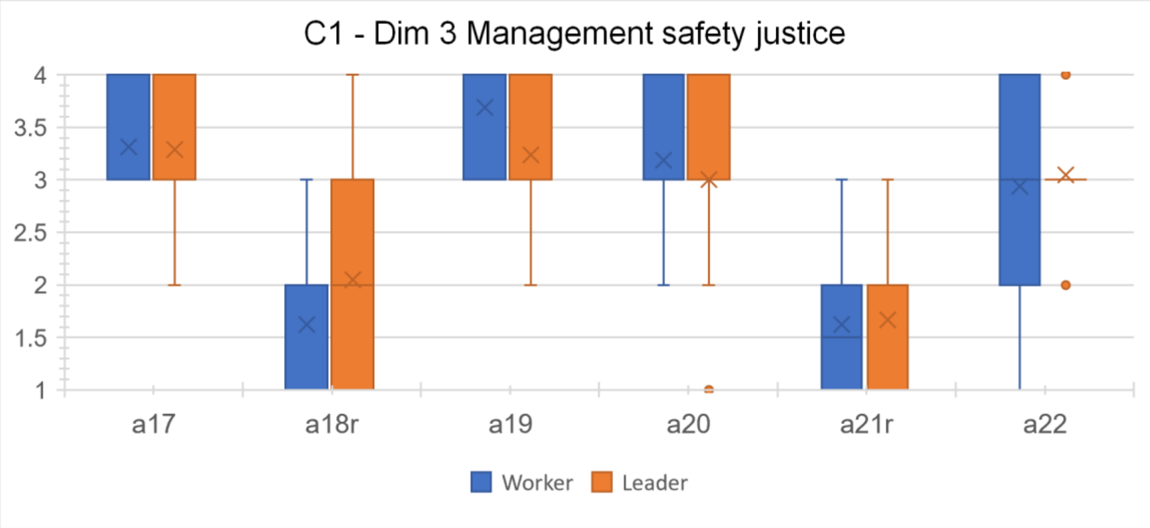

Figure 14 - C1: Dim 3 (Management safety justice)

Figure 14 shows the Dim 3 responses for C2 Leaders and C2 Workers.

C2 Workers and C2 Leaders

Some C2 leaders perceive that C2 workers are discouraged from reporting for fear of sanctions (a18r), with a considerable difference of 0.42 between mean values and 25% of leaders scoring positively. In contrast to this, the workers' data is skewed towards negative, reflecting the workers' participation with a high level of SORs (Par 1). However, the worker's feedback suggests that management don't use the information to solve problems: *"I was involved in an accident where I cut my arm. I reported this and do SORs too but don't see management fixing the issues." – C2 worker.*

Worker's data is also skewed towards negative regarding management blaming them (a21r), yet more leaders than workers responded positively to this item. Also, leader data shows they have a slightly more negative response to the reverse formulated item on management looking for causes not guilty persons when an accident occurs (a20).

The Leader's safety climate data for Dim 3 suggests that management are somewhat 'disconnected' from the workers. For example, workers actively submit reports and are happy to do so, yet leaders perceive them as fearful of reporting, hinting at a blame culture.

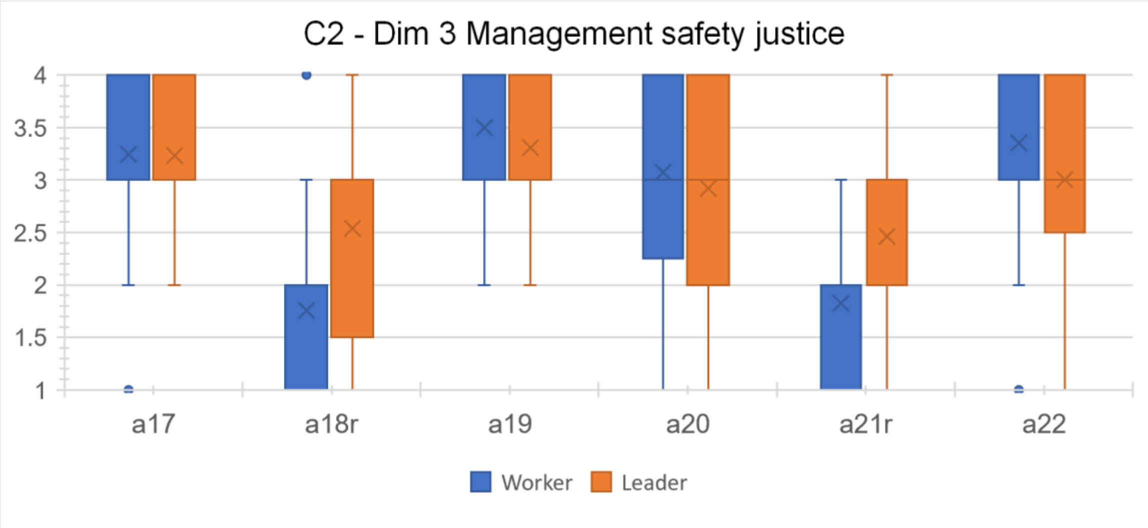

Figure 15 - C2: Dim 3 (Management safety justice)

Dim 4: Workers' safety commitment

Figure 15 shows the Dim 4 responses for C1 Leaders and C1 Workers.

C1 Workers and C1 Leaders

More workers than leaders perceive the workforce as confident in their ability to take joint responsibility to ensure housekeeping standards are maintained (a24) and collaborative attempts to achieve a high safety level (a23). Housekeeping procedures are outlined in RAMS and site rules which the workers show a high level of compliance. Similarly, their high level of SOR (Par 1) and having and input during SPA completion (Par 3) demonstrates their collaborative attempts to achieve safety.

Leaders are slightly less positive than workers in how they perceive themselves avoiding tackling risks that are discovered (a26r). Perhaps this is because they don't volunteer to attend safety inspections as often as the workers (Par 4). Therefore, they do not see or gain insight into the risks discovered.

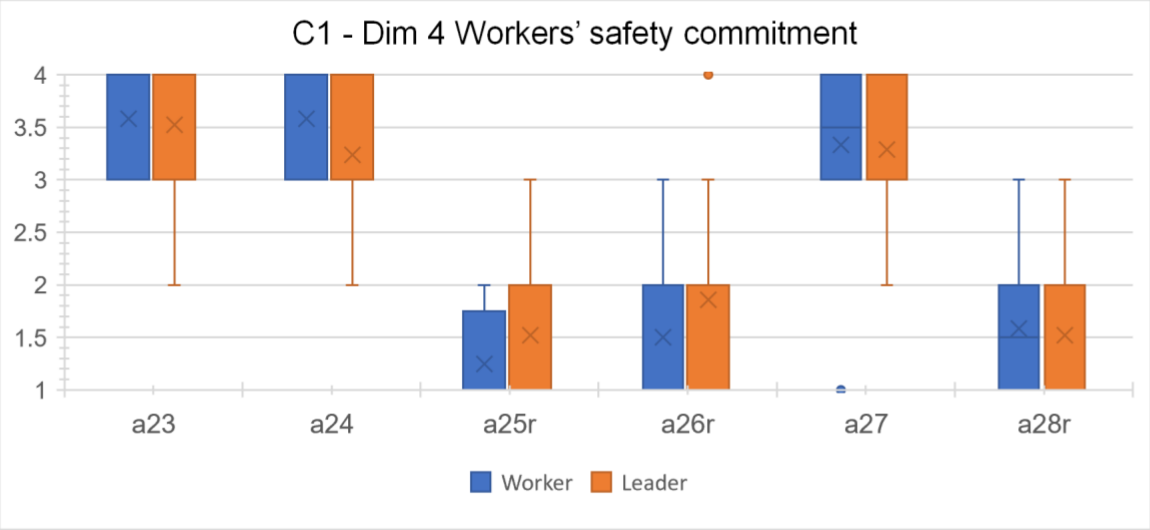

Figure 16 - C1: Dim 4 (Workers' safety commitment)

Figure 16 shows the Dim 4 responses for C2 Leaders and C2 Workers.

C2 Workers and C2 Leaders

The C2 leaders perceive their joint housekeeping responsibility with less positivity than C2 workers (a24), albeit their compliance with the RAMS is excellent (Com 2).

Moreover, the leaders' data shows more positive responses than workers to reverse formulated questions on the workforce not caring about each other's safety (a25r) or taking no responsibility for each other's safety (a28r). However, participation results would disagree with this as workers show fairly good levels across all safety activities, suggesting some responsibility and care for safety.

Twenty-five percent of leaders scored between 3 and 4 on the Likert scale regarding the avoidance of tackling risks discovered (a26r). Leaders lack participation in safety inspections (Par 4), and therefore it is plausible they will perceive an avoidance of risk tackling. Comments from workers and leaders' further compound this, highlighting a lack of leadership attendance and items not getting closed out.

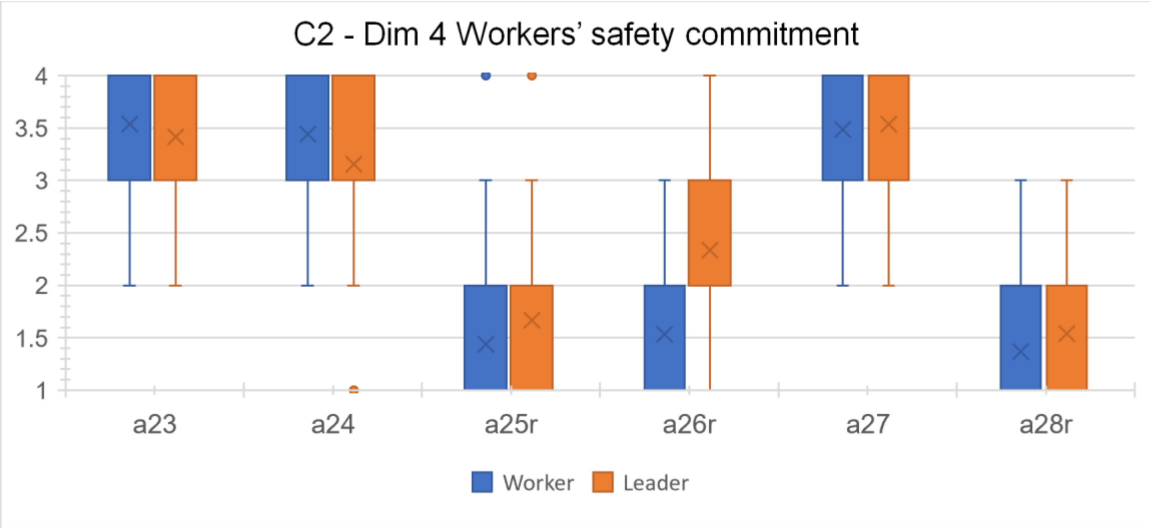

Figure 17 - C2: Dim 4 (Workers' safety commitment)

Dim 5: Workers' safety priority and risk non-acceptance

Figure 17 shows the Dim 5 responses for C1 Leaders and C1 Workers.

C1 Workers and C1 Leaders

Workers have a lower mean value than leaders (2.75 and 3.00) regarding the reverse formulated item on workforce never accepting risk even when the schedule is tight (a33). Coincidently, workers' lower-level compliance with site rules (Com 3). Comments suggest that imposed time pressures play a role in procedural non-compliance and risk acceptance:

"Ladders last rule is stupid. I'll keep using the ladder for smaller jobs as it's quicker than setting up a scaffold." - C1 worker.

"Sometimes the work changes and there isn't time to revise the RAMS, that's the only occasion when they are not followed." - C1 Leader.

Workers show a spread in their responses to items on the workforce, considering their work unsuitable for cowards (a34r) and the workforce accepting risk-taking at work (a35r). Workers have a mean value of 2.00 for both items compared to the leaders 1.28 and 1.66, denoting more workers in agreement, yet the overall response for the two items is skewed negatively.

Interestingly, workers also show a good level of participation in providing input and asking for opinions during SPA completion (Par 3). Some workers may have responded to item a35r with the impression that there is always some degree of controlled risk-taking involved with work. One worker commented, *"The SPA is good to help point of things that will cause us harm, but some jobs there will always be an element of risk involved even with the SPA done." – C1 worker.*

Figure 18 - C1: Dim 5 (Workers' safety priority and risk non-acceptance)

Figure 18 shows the Dim 5 responses for C2 Leaders and C2 Workers.

C2 Workers and C2 Leaders

Whilst negatively skewed with a larger spread, 25% of leaders strongly agree about the workforce breaking safety rules to complete work on time (a32r). This is in comparison with workers who show 0.19 less than leaders in the item mean values. Additionally, workers are more positive in their response regarding the workforce never accepting risk-taking if the schedule is tight (a33). Leaders show a smaller spread with most responses to this item between 2.5 and 3.5 and a lower mean value than workers.

Workers are less compliant with their RAMS (Com 2), although they perceive that they do not break the rules to get the job done. However, the leaders are more likely to accept risk-taking when the schedule is tight.

A common theme is developing from the dimension results. The work schedule plays a prominent role in the Leader's ability to participate in safety-related activities and increases potential risk-taking. For example, one Leader remarks the following; *"I don't have time to attended any of these [toolbox talks]. There are too many meetings, and we are behind schedule." – C2 Leader.*

Figure 19 - C2: Dim 5 (Workers' safety priority and risk non-acceptance)

Dim 6: Safety communication, learning, and trust in co-worker's safety competence

Figure 19 shows the Dim 6 responses for C1 Leaders and C1 Workers.

C1 Workers and C1 Leaders

Leaders show some self-criticism with a lower mean value than workers in all of the positively formulated items. Workers are significantly more positive than leaders in how they perceive themselves taking each other's opinions and suggestions seriously (a40). Both show promising results in participation, specifically speaking up and asking for opinions (Par 3).

Workers show a larger spread and a slightly more positive mean value than leaders in response to the workforce seldom talking about safety (a41). One worker's remark suggests some may perceive this as conversing with leaders on safety walks; *"The supervisors don't come on many inspections with us, so we don't get to talk to them about safety issues much." – C1 worker.*

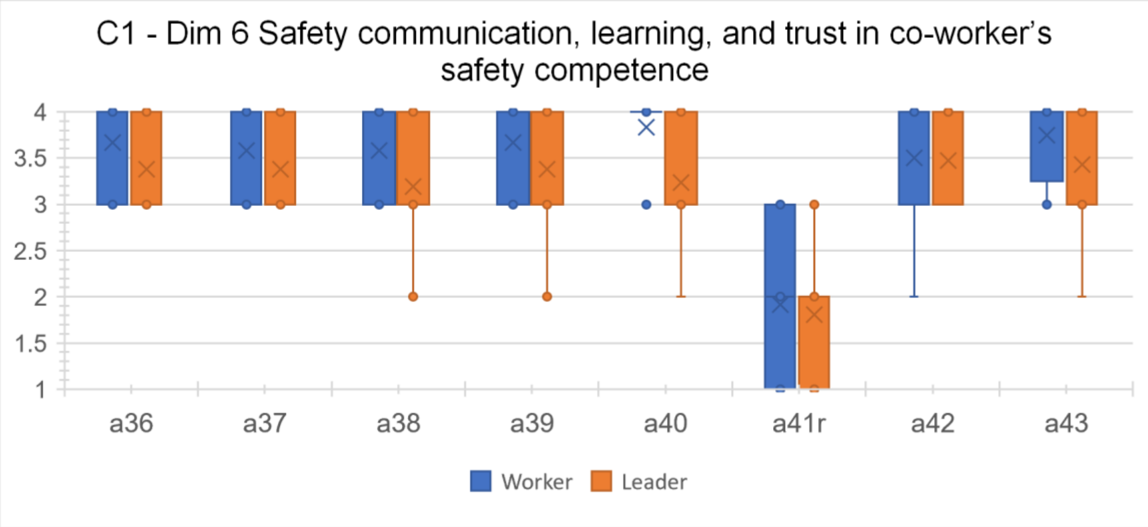

Figure 20 - C1: Dim 6 (Safety communication, learning and trust in competence)

Figure 20 shows the Dim 6 responses for C2 Leaders and C2 Workers.

C2 Workers and C2 Leaders

The overall result for C2 Dim 6 is also excellent, with just a 0.01 difference in mean value between the groups. One item worth noting is the reverse formulated question on the workforce seldom talking about safety (a41r). Both groups' responses are skewed negatively; the workers have more variance and a higher mean value than leaders (2.00 – 1.66). Also, 25% of workers responded positively on the Likert scale.

Workers perceive that safety is rarely spoken about, and they assert that management never participates in toolbox talks (Par 2) or inspections (Par 4). For example, one worker stated, *"I attend these [toolbox talks] but they are not as good as I've had on other sites. Management are never there." – C2 worker.*

Leaders' participation results do reflect this with low scores across all participation items.

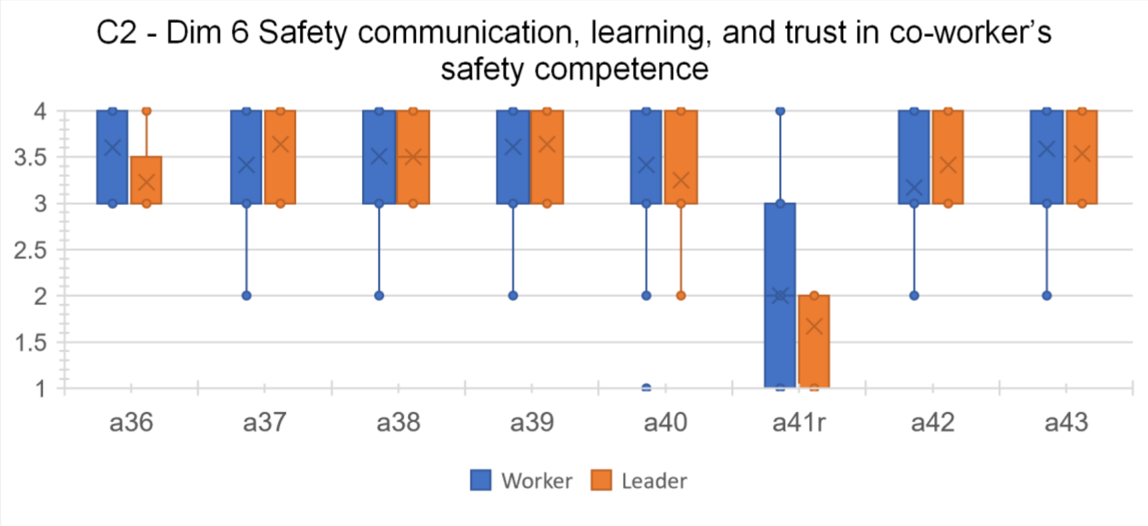

Figure 21 - C2: Dim 6 (Safety communication, learning and trust in competence)

Figure 21 shows the Dim 7 responses for C1 Leaders and C1 Workers.

C1 Workers and C1 Leaders

Overall result for Dim 7 is excellent for both workers and leaders – with workers having slightly more trust in the safety systems. However, item a45r has a considerable difference in mean value between workers (1.41) and leaders (1.95). Therefore, a larger number of leaders perceive that that safety rounds/evaluations do not affect safety. Leaders also scored lower concerning their consideration that safety rounds/evaluations help find serious hazards (a48), yet they perceive it is important to have clear goals for safety (a50).

Coincidentally, the Leader's participation in such safety rounds is lower than the workers, with the Leader's feedback pointing towards other work activities taking precedence.

"I put my name down but when the time comes, I'm normally tied up with something else." – C1 Leader.

"I've been to one but there were no managers so it was called off." – C1 worker.

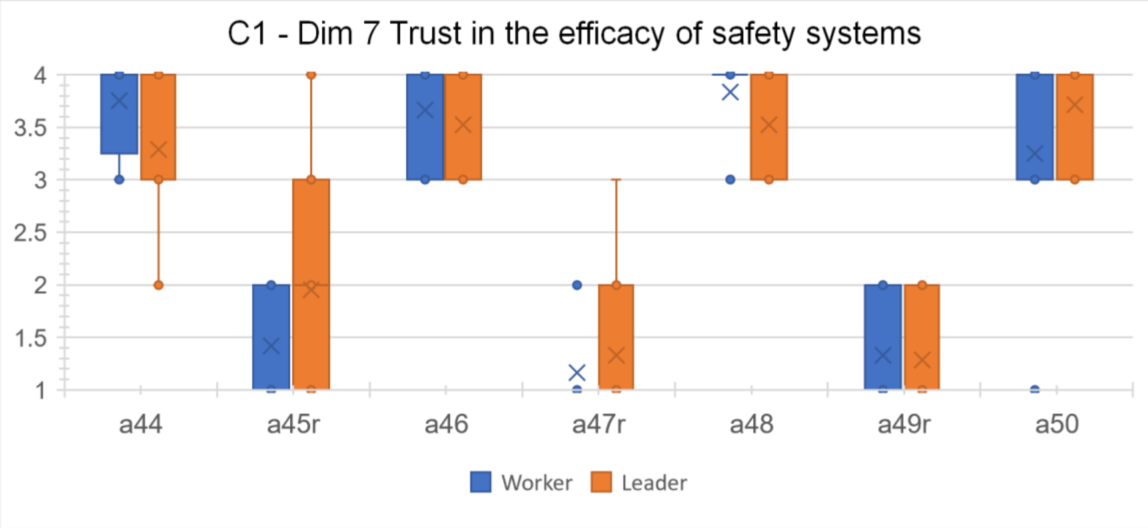

Figure 22 - C1: Dim 7 (Trust in the efficacy of safety systems)

C2 Workers and C2 Leaders

Two items have a notable difference in responses. A greater number of workers than leaders perceive that safety inspections have no effect on safety (a45r) and early planning for safety as meaningless (a47r). Several workers comments also refer to the poor participation of leaders in safety activities, which suggests the reason for workers having such a perception.

"I go, but management is busy all the time and won't join our meetings. I think the [client name removed for confidentiality] programme is too demanding for them to keep up with." – C2 Worker

"I'm not so sure that many of the items get closed out because management are never on the walks." – C2 worker.

Leaders perceive this differently and responded negatively with the two reverse formulated items. However, they strongly lack participation in safety inspections and other activities. One Leader recognises this and also hints at the hectic work schedule by stating: *"The safety inspections are important but to be honest I never get a chance to join them. I don't think half the items get closed out."- C2 Leader.*

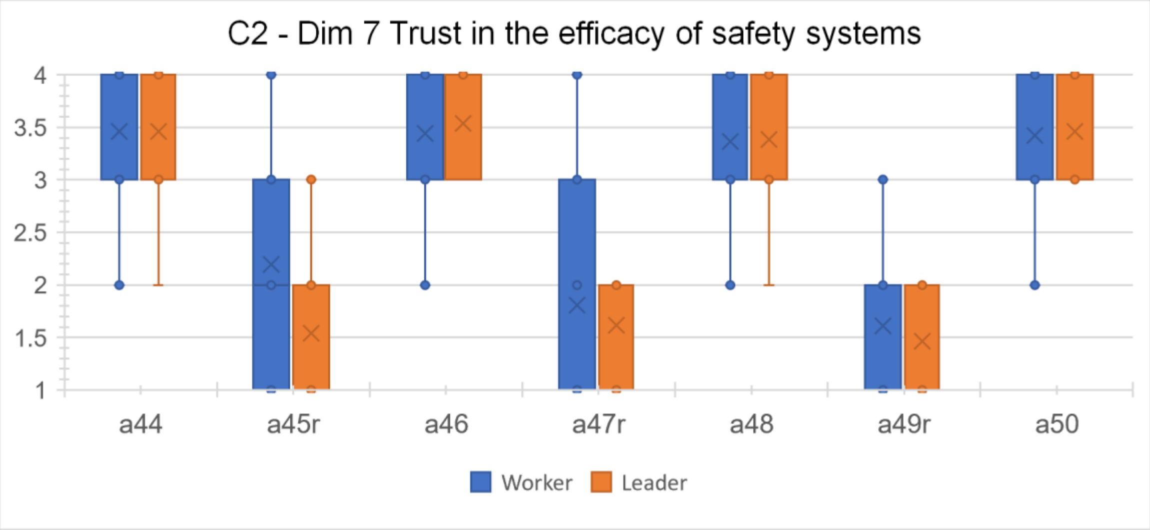

Figure 23 - C2: Dim 7 (Trust in the efficacy of safety systems)

4.6 Research Findings Summary

The research findings have been interpreted, and possible areas for improvement have been identified. The findings also show that some results are discordant and vary between the two contractors. It is likely this is due to the temporary multi-party characteristics of the construction project e.g., management practices, organisational structure and working environment. For example,

Nevertheless, in general the results show safety climate can influence, and also be influenced by safety compliance and safety participation behaviours of workers and leaders.

The findings show a commonality between the two contractors sampled; those in supervisory and management roles (leaders) are self-critical of themselves in many dimensions and show lower levels of safety participation. In addition, many of the responses from both workers and leaders point towards the work schedule as a culprit for poor participation in safety activities. This has confirmed to the author that leadership development and safety commitment, communication and project resourcing are areas that the GC needs to invest appropriate time and effort into to drive safety culture forward and improve safety performance.

The following chapter discusses these results to identify recommendations to present to the GC directors to begin the safety culture and performance improvement process.

5 Discussion and Recommendations

5.1 Introduction

The purpose of this study is to explore the relationship between contractor safety climate and their safety performance on a single data centre construction project. This chapter discusses the empirical findings and the findings from the literature review in the context of the specific interrelated objectives outlined below:

1. *Define* the safety culture construct and its relation with safety climate.
2. *Critically evaluate* safety climate, how it is measured and its relation to safety performance.
3. *Explore* contractor safety climate perceptions respective to their safety performance on a single data centre construction project.
4. *Formulate* recommendations on construction project safety culture and safety performance improvement.

Strategies will be recommended to improve the safety culture and safety performance of both current and future construction projects. Limitations of the project will also be discussed that will open avenues for further research.

5.2 Research Findings Discussion

The findings from the primary research are in line with previous studies discussed in Chapter 2. They show that safety climate dimensions related to managerial commitment, empowerment and justice had the most significant role in influencing the two representatives of safety performance – influencing safety participation more than safety compliance. The following discusses the results of each dimension and how it relates to the contractor's safety performance. Associated recommendations are also provided for improved safety culture and safety performance.

Management Safety Priority, Commitment, and Competence

It has been identified in both contractors that leaders are self-critical in how they perceive placing safety before production and their ability to resolve safety issues discovered. Additionally, leader participation (both contractors) in safety inspections is poor. Taken together, safety culture may be improved if leaders initiated and participated in safety inspections. Ademola's (2020) conceptual framework for optimising safety culture and climate requires top management commitment to be in place. To improve contractor management commitment to safety, the author recommends that the GC engages with their contractor supply chain to organise and implement a safety leadership program. The program's focus should be on using a mixture of assessments, mentoring and working sessions to engage safety leadership.

Future safety climate measurements would indicate that perception has improved due to the increased management participation in safety inspections. The amplified level of commitment will build workers trust in management and therefore improve upon the level of workers' engagement in safety-related behaviours improvement the overall safety performance (Zacharatos, Barling and Iverson, 2005).

Management safety empowerment

The primary research indicates that C2 perceive management as poor at involving employees in safety decisions at the group level. The leaders being self-critical in their perceived level of employee involvement are also shown to have low participation in all safety activities measured. Al-Bsheish et al., (2019) found that psychologically empowered employees had higher perceived safety compliance and participation through perceived management commitment to safety. If the top management committed more to participate in activities that encouraged empowerment and employee inclusion, then safety climate perceptions of employee involvement will change, and culture may improve. This is evident with C1, as leaders show commitment through participation in safety activities which is reflected in the overall safety climate result.

To empower employees and encourage involvement in safety decisions, the author recommends that the GC establishes an on-site continuous improvement team consisting of workers and managers from the GC and contractors on site. Managers act as the 'champions' to monitor resourcing and progress. Training, control and ownership are provided to workers to review work and safety participatory activities and make recommendations to management for improvement. The empowerment of workers to take control and ownership of safety will increase their level of reciprocation and subsequently reinforce safety behaviour (Kines et al., 2011). The level of perceived management empowerment will improve, which will be reflected in the associated safety participation KPIs - improving overall safety culture and performance.

Management safety justice

It has been identified that some leaders from both contractors perceive themselves as blaming workers resulting in fear of reporting. However, the workers of both contractors have a higher level of SOR participation than leaders suggesting a positive reporting culture amongst the workers. Their perception hints at management not using SOR information to resolve issues on-site (C2) and potentially not treating those involved in an accident fairly (C1). These results are suggestive of low trust levels when it comes to management taking action. Oswald, Sherratt and Smith's (2018) case study offers similar results regarding the SOR system contributing to a 'blame culture' and the attrition of trust between workers and management on the construction site.

Therefore, to improve trust and reduce levels of perceived ill-treatment or blame, it is recommended that the GC reviews the current SOR aspect of behaviour-based safety to include the introduction of frequent feedback from management using written, verbal and graphical methods. Additionally, consideration of targets for improvement and contact rate; the number of observations made over a fixed period of time will encourage pro-active management participation leading to workers voluntary engagement (Cook and McSween 2000).

Workers' safety commitment

Chan et al., (2017) conducted a study within the construction industry which showed that workers' commitment and personal involvement in safety was the most influential safety climate factor on safety outcomes. The primary research indicates that workers of both contractors strongly perceive their confidence in their ability to maintain high standards. Their commitment is demonstrated by complying with procedures outlined in their RAMS. The findings concur with Clarke's (2006) argument that a positive safety climate increases the awareness of procedures and the motivation to comply with them. Conversely, the research shows that the leaders of both contractors perceive an avoidance of risk tackling, yet it is the leaders who lack participation in safety inspections.

To demonstrate the continual improvement of safety commitment and participation, the author recommends that the GC considers introducing assigned work areas of the construction site to contractor and GC management and supervisory members. The area owners will retain responsibility, including oversight of safety inspections and participation in their respective area. Leaders' perceived avoidance of risk tackling should change with their commitment to participation and therefore the associated KPI will reflect this. This visible commitment that management and supervisors demonstrate will also further inspire the workers to put in additional efforts to improve workplace safety.

Workers' safety priority and risk non-acceptance

Both Cooper (2000) and Ademola (2020) describe in their models that improved safety culture is dependent on top-level management creating and extending the safety culture in terms of placing safety importance, commitment and involvement at the forefront. Relating this to the primary research findings, items and comments suggestive of perceived work pressure, stress and lack of resources is evident throughout many dimensions indicating that the level of managerial commitment is not evident.

The C1 workers perceive themselves as accepting risks when there is pressure to complete works to meet the schedule. The findings for C2 show a similar result, albeit the leaders perceive the C2 workforce as likely to accept risk-taking when the schedule is tight. This perception of risk acceptance due to work pressure negatively influences the worker compliance with site rules in both contactors. Therefore, top management must allocate sufficient resources to address the issue of work pressure. Subsequently, it will improve the workforce compliance with site rules and how workers and leaders perceive their risk acceptance - improving overall safety culture and performance.

In the short term, the author recommends that the GC implements confidential support mechanisms so those suffering from stress can receive assistance without concern that it will negatively impact their careers. For the long term, it is recommended that the GC reviews its project planning process to ensure a robust system is in place to allocate sufficient resources to meet the demands of the construction schedule.

Safety communication, learning and trust in co-worker's safety competence

The secondary research findings show that the quality of safety communication has a moderating effect on safety behaviours (Huang et al., 2018). The primary research findings concur with this; workers and leaders of C1 perceive that other's opinions and suggestions are taken seriously - albeit, leaders are slightly self-critical. The safety participation of both C1 groups is also indicative of a bottom-up approach (speaking up and asking for opinions) and a top-down approach (toolbox talk participation) being utilised. The results agree with previous studies demonstrating an association between effective safety communication and safety improvement (Zohar and Luria 2003; Kines et al. 2010).

Some workers of C2 perceive that safety is seldom spoken about with comments and survey results describing management's lack of participation in toolbox talks. Such poor communication practices from management can inhibit efforts to promote safety, even when workers perceive safety as a priority. To improve communication and safety culture, it is recommended that the GC implements a process of coaching and feedback concerning the frequency of management and supervisory safety-related communication with workers. As a result of improved safety-related communication, worker's perceptions will improve, and the appropriate KPI (frequency of toolbox talk participation) would show that performance, i.e., safety participation behaviours, has improved.

Trust in the efficacy of safety systems

The findings point towards some mistrust in the efficacy of safety systems by management (C1) and workers (C2), specifically how they perceive the effectiveness of safety inspections/rounds. Further comments by workers and leaders suggest the perceived ineffectiveness of safety inspections are not because of mistrust in the safety system itself but because of the lack of management participation in those inspections needed to make the safety system efficient and worthwhile. The results agree with Cooper's (2000) argument concerning employees' level of engagement in risky behaviour depending on how they perceive the relevance and usefulness of system aspects.

The author has provided previous recommendations to improve the level of management commitment and participation in safety activities. To further enhance the management commitment level and the level of trust in the efficacy of safety systems, it is recommended that the GC initiates a system of regular risk-based auditing and reviews of particular system aspects to ensure their relevance and value. Consultation with workers is included in this process, encouraging workers to speak openly about where they feel additional improvement is needed.

5.3 Limitations of the Project

This study comes with some limitations that highlight areas for further research. Firstly, the project used a cross-sectional design to gather all of its data. This design is suitable to make inferences about the extent of possible relationships between safety climate and safety performance at a single point in time. However, further research on this topic could involve measuring safety climate and performance at multiple time points throughout the construction project lifecycle, subsequently testing these measurements with different models and comparing the possibilities of the relations and their effect on safety outcomes over this period.

Another potential limitation of the study is the overall participation figure. The proportion of surveyed workers is significantly higher in Contractor 2 than Contractor 1. Whilst this could have resulted in a biased result, it has not affected the research outcome on this occasion due to Contractor 2 leaders being self-critical in many dimensions. Finally, safety outcomes i.e., the number of accidents and incidents, were not included in the research project. Consideration of these was given initially; however, the author decided to focus solely on safety participation and compliance due to such low incident numbers recorded on the construction project.

5.4 Discussion Summary

This chapter has discussed the primary research findings and linked certain aspects to the secondary research in Chapter 2. Additionally, seven recommendations to improve safety performance and safety culture have been made to the GC based on the findings surrounding objectives 1, 2 and 3 of this research project. Lastly, like any research, this project also has some limitations. These limitations have been openly identified in an attempt to highlight areas of further research.

6 Conclusion and Reflection

6.1 Introduction

This research aimed to advance understanding of the relationship between the safety climate and safety performance of a data centre construction project. To remind the reader, the objectives were, within the context of higher education to:

1. *Define* the safety culture construct and its relation with safety climate.
2. *Critically* evaluate safety climate, how it is measured and its relation to safety performance.
3. *Explore* contractor safety climate perceptions respective to their safety performance on a single data centre construction project.
4. *Formulate* recommendations on construction project safety culture and safety performance improvement.

This chapter sets out to conclude the research project and includes a personal reflection from the author.

6.2 Conclusion

The secondary research reviewed the definition of safety culture in the construction industry and explored several safety culture theories and models. Particular focus was given to evaluating safety climate, the psychological component or commonly known as the ‘snapshot’ of safety culture. The literature review has shown that multiple scales exist within the construction industry to measure safety climate, including the established NOSACQ-50, which was chosen to collect empirical data for the primary research.

Safety compliance and safety participation behaviours were found to be representative of contractor safety performance. Therefore, based on the literature review, suitable leading KPIs were chosen to carry forward and develop the ‘safety performance’ questionnaire to measure the contractor’s safety compliance and safety participation behaviours as part of the empirical data collection for the primary research.

To conclude, the combination of knowledge acquired through literature review and the collection and analysis of empirical data confirm a relationship between safety climate and safety performance. Specifically, safety climate can influence and be influenced by the two representatives of safety performance – safety compliance and safety participation behaviours. Managers and supervisors who are self-critical of themselves, their competence and their abilities have lower levels of voluntary safety participation and safety compliance. It is evident that without top-management commitment and visible leadership and safety engagement, both workers and peers will continue to have a low level of perceived safety climate.

As a result of this research, several recommendations have been identified and should be considered by the GC's directors to improve the overall project safety culture and safety performance of the current and future data centre construction projects. These include:

- Engaging with the contractor supply chain to implement a safety leadership program.
- Establish an on-site continuous improvement team consisting of workers and managers from the general contractor and subcontractors.
- Review current safety observation reporting system to include frequent management feedback, targets for improvement and contact rate.
- Implementing 'area owners' on-site to subcontractor and general contractor management and supervisory members.
- Implement a process of coaching and feedback concerning the frequency of management and supervisory safety-related communication with workers.
- Implement confidential support mechanisms so those suffering from stress can receive assistance, followed by a review of the project planning process, emphasising resourcing.
- Initiate a program of regular risk-based auditing and reviews of particular safety system aspects to ensure their relevance and value.

6.3 Personal Reflection

This research project was a challenging new experience for the author and brought him on a journey to the frontline of the workforce to understand their opinions and the difficulties they face. This has led to the author believing that management should spend more time with the ‘sharp end’ of the organisation to understand these difficulties and embrace the idea that the workers are the solution instead of the problem. However, despite the challenges associated with time constraints, data interpretation and presentation – the author found this research project to be an invaluable process of continual improvement.

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Appendix A

Consent Form – Organisations

&

Participant Information Sheet

Consent Form – Contractor Organisations

University of Strathclyde - Department of Humanities & Social Sciences

Safety in Data Centre Construction: An investigation into safety climate and its relationship with safety performance.

Introduction

This research project is being undertaken by Blaine Ryan, a post-graduate research student with the University of Strathclyde. The research will form part of a dissertation presented in fulfilment of the requirements for the degree of Master of Science in Safety and Risk Management.

Purpose

The purpose of this investigation is to advance understanding of the relationship between a data centre construction project's safety climate and safety performance. The project consists of secondary research in the form of a literature review and primary research in the form of empirical data collection from the workplace.

The Request

You, the company Director, are being requested to allow the student, Blaine Ryan, to invite a selection of your employees currently working on the construction project to participate in completing a sort survey. The survey will consist of two parts.

- The first part aims to measure the level of safety climate of the workforce.
- The second part aims to measure the level of safety compliance and safety participation behaviours of the workforce.

The survey will be distributed electronically via email and via tablet on-site. Survey responses will be confidential and anonymised. No personal information or company information will be retained as part of this process. Minimal participant demographic information is used as part of the research such as sex, age and whether the participant holds a management/supervisory role or not.

Your employees are under no obligation to participate in this survey. Their participation is voluntary and they can refuse to participate at any time. Participation in this research does not post any risk to your employees personal, physical or psychological wellbeing.

Should you wish to allow your employees to participate in this research, please sign below and return. If you do not wish to allow participation, please disregard this letter. Thank you for taking the time to read this information. On completion of the research, the findings will be made available to you on approval of the University of Strathclyde.

____

I, the Company Director, give Blaine Ryan permission to conduct the research study involving personnel under my employment.

Researcher contact details:
Name: Blaine Ryan
Email: blaine.ryan.2017@uni.strath.ac.uk
Phone: 00353 85 855 22 88

Chief Investigator details:
Name: Professor Norrie McPherson
Email: norman.mcpherson@strath.ac.uk

Participant Information Sheet

Safety in Data Centre Construction: An investigation into safety climate and its relationship with safety performance.

This research project is being undertaken by Blaine Ryan, a post-graduate research student with the University of Strathclyde. The research will form part of a dissertation presented in fulfilment of the requirements for the degree of Master of Science in Safety and Risk Management.

The purpose of this survey is to get your view on safety at this workplace. Your answers will be processed on a computer and will be dealt with confidentially. No individual results will be presented in any way. All information provided as part of this investigation will be completely confidential and anonymous.

Although we want you to answer each and every question, you have the right to refrain from answering any one particular question, a group of questions, or the entire questionnaire.

Thank you for reading this information. Please feel free to ask any questions regarding your participation in this study.

If you decide to participate in this investigation please answer "yes" to the question below. If you do not want to be involved in the project, please answer "No" and there will be no need to take any further action.

On completion of the research, and approval by Strathclyde University, the findings will be made available to you, if requested, either in hard copy or soft copy (by email).

Researcher contact details:
Name: Blaine Ryan
Email: blaine.ryan.2017@strath.ac.uk
Phone: 00353 85 855 22 88

Chief Investigator details:
Name: Professor Norrie McPherson
Email: norman.mcpherson@strath.ac.uk

I have read the above information and agree to participate in this study.

- ◯ Yes
- ◯ No

Appendix B

NOSACQ-50

&

Safety Performance Questionnaire

Nordic Occupational Safety Climate Questionnaire

Background information

1. You work for *

- ◯ [redacted]
- ◯ [redacted]

2. Year of Birth?

3. You are

- ◯ Male
- ◯ Female

4. Do you have a managerial position, e.g. manager, supervisor?

- ◯ No
- ◯ Supervisor
- ◯ Manager

Describe how you perceive that the managers/supervisors at this workplace deal with safety

Although some questions may appear very similar, please answer each one of them.

5. Management encourages employees here to work in accordance with safety rules even when the work schedule is tight

Strongly disagree	Disagree	Agree	Strongly agree
◯	◯	◯	◯

6. Management ensures that everyone receives the necessary information on safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

7. Management looks the other way when someone is careless with safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

8. Management places safety before production

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

9. Management accepts employees here taking risks when the work schedule is tight

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

10. We who work here have confidence in the management's ability to deal with safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

11. Management ensures that safety problems discovered during safety rounds/evaluations are corrected immediately

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

12. When a risk is detected, management ignores it without action

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

13. Management lacks the ability to deal with safety properly

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

14. Management strives to design safety routines that are meaningful and actually work

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

15. Management makes sure that everyone can influence safety in their work environment

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

16. Management encourages employees here to participate in decisions which affect their safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

17. Management never considers employees' suggestions regarding safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

18. Management strives for everybody at the worksite to have high competence concerning safety and risks

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

19. Management never asks employees for their opinions before making decisions regarding safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

20. Management involves employees in decisions regarding safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

21. Management collects accurate information in accident investigations

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

22. Fear of sanctions (negative consequences) from management discourages employees here from reporting near-miss accidents

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

23. Management listens carefully to all who have been involved in an accident

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

24. Management looks for causes, not guilty persons, when an accident occurs

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

25. Management always blames employees for accidents

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

26. Management treats employees involved in an accident fairly

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

Describe how you perceive that employees at this workplace deal with safety

Although some questions may appear very similar, please answer each one of them.

27. We who work here try hard together to achieve a high level of safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

28. We who work here take joint responsibility to ensure that the workplace is always kept tidy

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

29. We who work here do not care about each others' safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

30. We who work here avoid tackling risks that are discovered

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

31. We who work here help each other to work safely

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

32. We who work here take no responsibility for each others' safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

33. We who work here regard risks as unavoidable

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

34. We who work here consider minor accidents to be a normal part of our daily work

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

35. We who work here accept dangerous behaviour as long as there are no accidents

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

36. We who work here break safety rules in order to complete work on time

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

37. We who work here never accept risk taking even if the work schedule is tight

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

38. We who work here consider that our work is unsuitable for cowards

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

39. We who work here accept risk-taking at work

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

40. We who work here try to find a solution if someone points out a safety problem

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

41. We who work here feel safe when working together

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

42. We who work here have great trust in each others' ability to ensure safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

43. We who work here learn from our experiences in order to prevent accidents

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

44. We who work here take each others' opinions and suggestions concerning safety seriously

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

45. We who work here seldom talk about safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

46. We who work here always discuss safety issues when such issues come up

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

47. We who work here can talk freely and openly about safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

48. We who work here consider that a good safety representative plays an important role in preventing accidents

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

49. We who work here consider that safety rounds/evaluations have no effect on safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

50. We who work here consider that safety training to be good for preventing accidents

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

51. We who work here consider early planning for safety as meaningless

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

52. We who work here consider that safety rounds/evaluations help find serious hazards

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

53. We who work here consider safety training to be meaningless

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

54. We who work here consider it important to have clear-cut goals for safety

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

55. If you wish to elaborate on some of your answers, or if you have any comments regarding the study, you are welcome to write them here.

Safety Performance Questionnaire

1. I follow the procedures and controls outlined in RAMS for the tasks that I perform.

   Please elaborate on your answer in the text box below.

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

2. My co-workers follow the procedures and controls outlined in RAMS for the tasks that they perform.

   Please elaborate on your answer in the text box below.

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

3. All of the workers in my company follow the site rules implemented by the general contractor.

   Please elaborate on your answer in the text box below.

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

4. I frequently submit SORs to the general contractor.

Please elaborate on your answer in the text box below.

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

5. I frequently provide input and give suggestions for improvement at toolbox talks.

Please elaborate on your answer in the text box below.

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

6. I frequently speak up and ask for opinions about workplace risks when completing the SPA.

Please elaborate on your answer in the text box below.

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

7. I frequently volunteer to attend safety inspections to improve workplace safety.

Please elaborate on your answer in the text box below.

Strongly disagree	Disagree	Agree	Strongly agree
○	○	○	○

Appendix C

Cronbach's Analysis

&

NOSACQ-50 / Safety Performance Survey

Results

Tables

Figures

C1. Cronbach's Alpha

Cronbach's alpha (Cronbach, 1951) is a measure of internal consistency reliability or item interrelatedness of a scale or questionnaire. In the case of this research, it refers to the extent that the grouped items in the safety performance questionnaire contribute positively towards their respective component i.e. safety compliance and safety participation.

The simplified formula for Cronbach's alpha (α) is;

$$\alpha = (N \cdot \bar{c}) / [\bar{v} + (N - 1) \cdot \bar{c}]$$

Where;

- N = The number of items.
- $\bar{c}$ = The average inter-item among the items.
- $\bar{v}$ = The average variance,

Computer software packages are available to assist with the data analysis whilst producing the results in a timely manner. The IBM SPSS (Statistical Package for the Social Sciences) software was used to analyse the data collected from the 91 questionnaires completed.

C2. Results of Cronbach's Alpha

Cronbach's Alpha analysis has been undertaken on the data collected from the 91 questionnaires completed. A Cronbach's Alpha range of 0.7 or above is often cited as acceptable however to assist with understanding, a tiered approach is suggested by George and Mallery (2007) and outlined in Table C. 1 below.

Table C. 1 - Cronbach's Alpha lower limits of acceptability.

Cronbach's Alpha Score	Internal Consistency
α ≥ 0.9	Excellent
0.9 > α 0.8	Good
0.8 > α 0.7	Acceptable
0.7 > α 0.6	Questionable
0.6 > α 0.5	Poor
0.5 > α	Unacceptable

The data obtained from both the workers and leaders can be considered reliable with all Cronbach Alpha values above 0.7 for each dimension shown in Table C. 2 for Safety Performance and Table C. 3 for Safety Climate.

Table C. 2 - Safety Performance Cronbach's Alpha Results

. Contractor 1	No. of Items	Role Type	Cronbach's Alpha	Mean	Std. Deviation	Variance
Safety Compliance	3	Worker	0.71	3.18	0.64	0.41
		Leader	0.75	3.12	0.79	0.62
Safety Participation	4	Worker	0.72	3.10	0.71	0.51
		Leader	0.72	3.00	0.65	0.43

. Contractor 2	No. of Items	Role Type	Cronbach's Alpha	Mean	Std. Deviation	Variance
Safety Compliance	3	Worker	0.73	2.86	1.00	1.01
		Leader	0.71	3.25	0.59	0.35
Safety Participation	4	Worker	0.71	3.17	0.64	0.42
		Leader	0.72	2.67	0.63	0.42

Table C. 3 - NOSACQ-50 Overall Cronbach's Alpha Results

Dimension		No. of Items	Role Type	Cronbach's Alpha	Mean	Std. Deviation	Variance
Dim 1	Management safety priority, commitment, and competence	9	Worker	0.87	3.46	0.58	0.032
			Leader	0.91	3.16	0.53	0.044
Dim 2	Management safety empowerment	7	Worker	0.79	3.18	0.45	0.056
			Leader	0.75	3.25	0.40	0.009
Dim 3	Management safety justice	6	Worker	0.84	3.31	0.43	0.022
			Leader	0.71	3.14	0.50	0.036
Dim 4	Workers' safety commitment	6	Worker	0.82	3.34	0.54	0.005
			Leader	0.71	3.35	0.48	0.040
Dim 5	Workers' safety priority and risk non-acceptance	7	Worker	0.82	3.08	0.57	0.062
			Leader	0.79	3.28	0.48	0.061
Dim 6	Safety communication, learning, and trust in co-worker's safety competence	8	Worker	0.85	3.43	0.47	0.035
			Leader	0.86	3.33	0.44	0.011
Dim 7	Trust in the efficacy of safety systems	7	Worker	0.77	3.58	0.36	0.034
			Leader	0.83	3.49	0.41	0.024

C3. NOSACQ-50 Results by Individual Item

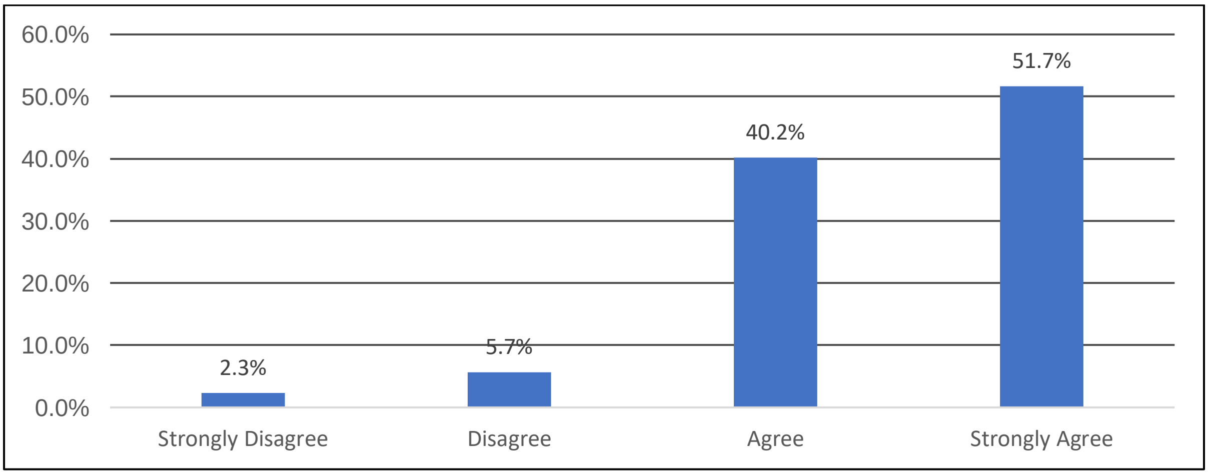
With such high Cronbach's Alpha scores for both workers and leaders across a large number of safety climate items, it is possible that there may be redundant items in the data set. This may provide an artificially high score. Therefore, there is some additional statistical information under each individual item result.

The 'Cronbach's Alpha if item deleted' in the final column presents the value that Cronbach's Alpha would be if that particular item was deleted from the scale.

For example, we can see removing any item other than item a4 from the first dimension would slightly lower the Cronbach's Alpha value. Removal of item a4 would lead to a minor improvement in Cronbach's Alpha. We can see that the 'item correlation' for both workers and leaders is slightly lower than that of the other items in the dimension. If this value was significantly lower it may lead us to consider whether the item should be removed.

Item a1 - Management encourages employees here to work in accordance with safety rules even when the work schedule is tight.

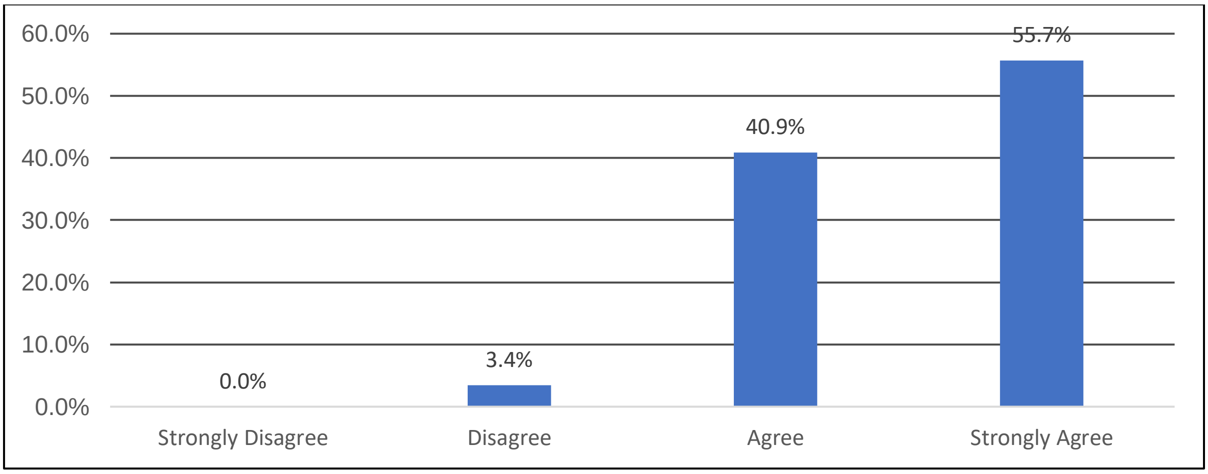
Figure C. 1 - NOSACQ-50 Item a1.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	26.14	23.034	0.765	0.673	0.843
Leader:	24.59	28.068	0.814	0.777	0.895

Item a2 - Management ensures that everyone receives the necessary information on safety.

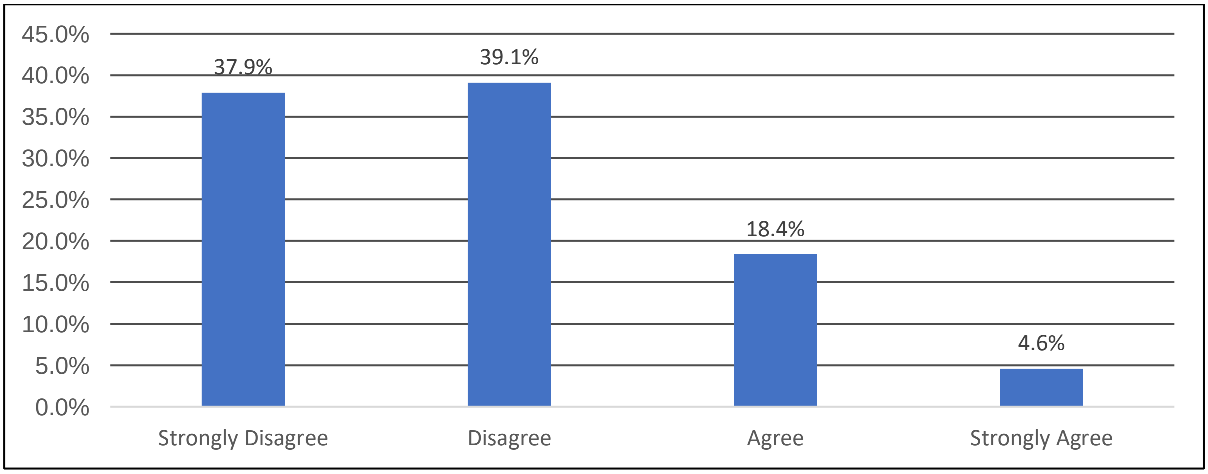
Figure C. 2 - NOSACQ-50 Item a2.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	26.02	24.891	0.741	0.658	0.851
Leader:	24.35	30.781	0.755	0.657	0.903

Item a3r - Management looks the other way when someone is careless with safety.

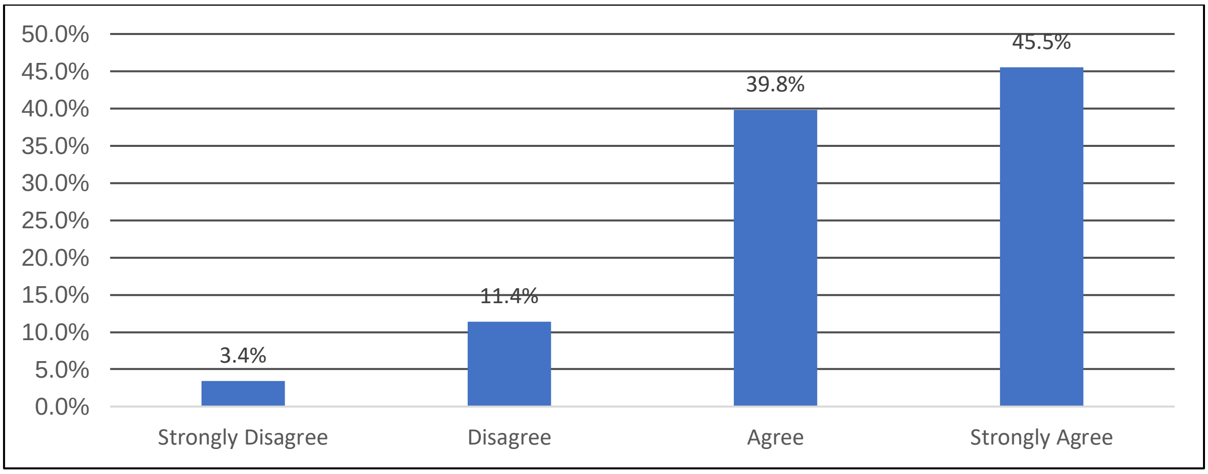
Figure C. 3 - NOSACQ-50 Item a3r.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	26.52	25.054	0.425	0.501	0.875
Leader:	24.59	30.553	0.619	0.437	0.908

Item a4 - Management places safety before production.

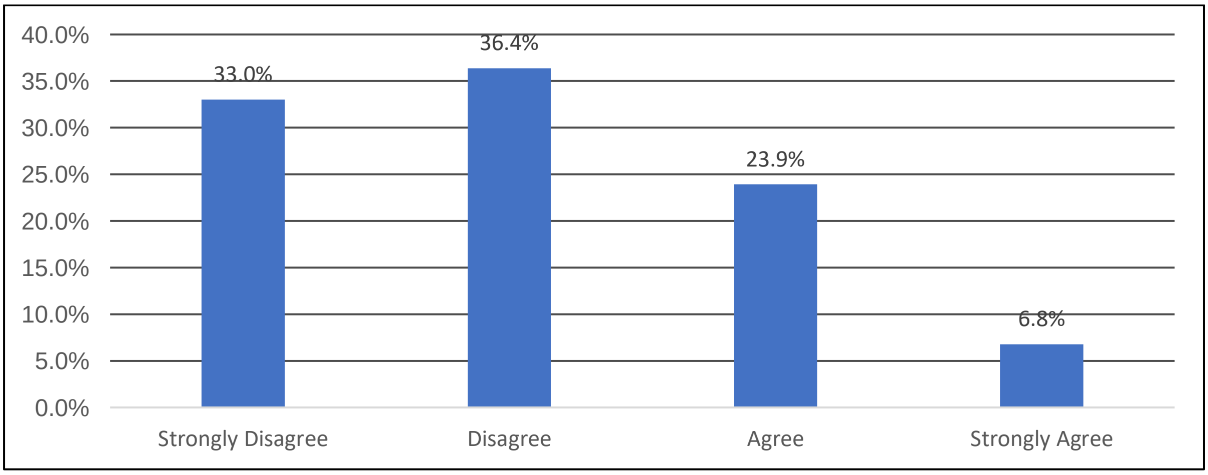
Figure C. 4 - NOSACQ-50 Item a4.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	26.16	25.592	0.462	0.401	0.870
Leader:	24.82	29.119	0.590	0.679	0.912

Item a5r - Management accepts employees here taking risks when the work schedule is tight.

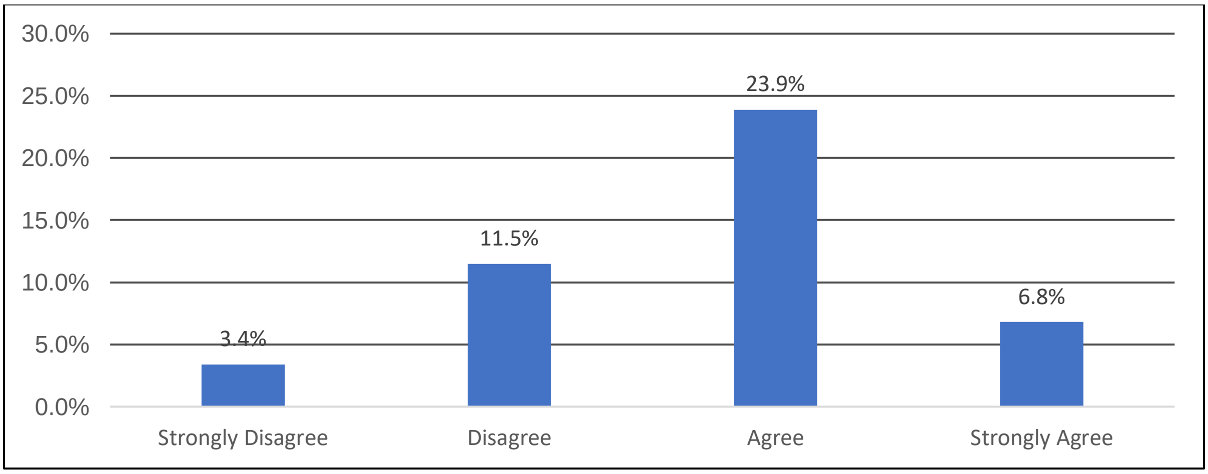
Figure C. 5 - NOSACQ-50 Item a5r.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	26.55	24.179	0.499	0.451	0.869
Leader:	25.03	30.151	0.502	0.332	0.918

Item a6 - We who work here have confidence in the management's ability to deal with safety.

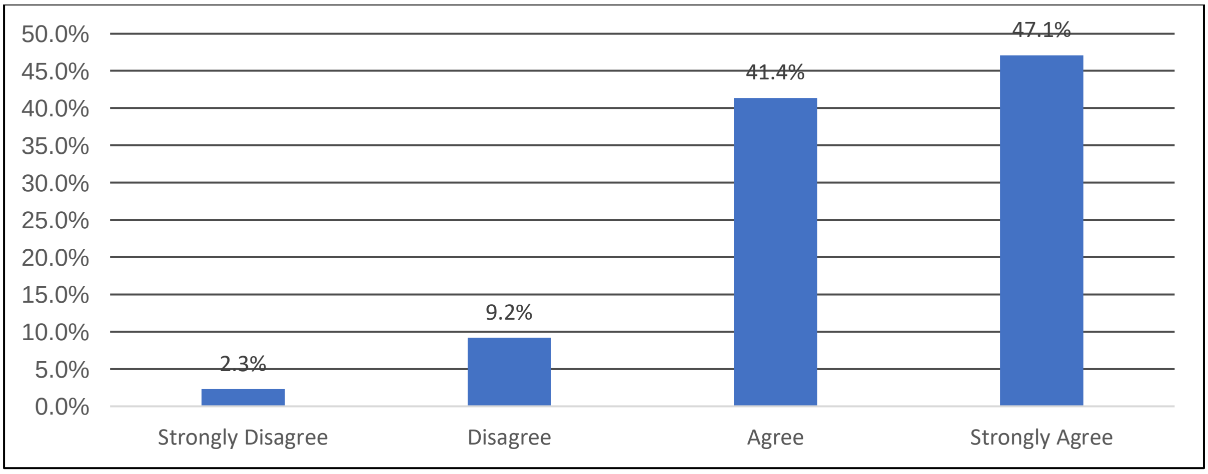
Figure C. 6 - NOSACQ-50 Item a6.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	26.29	23.226	0.665	0.685	0.852
Leader:	24.68	27.741	0.863	0.800	0.892

Item a7 - Management ensures that safety problems discovered during safety rounds/evaluations are corrected immediately.

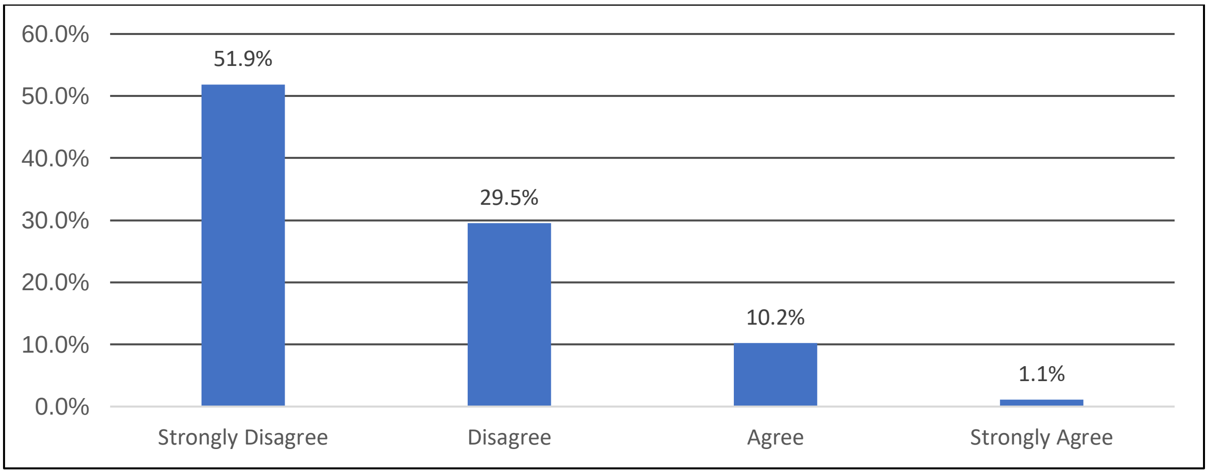
Figure C. 7 - NOSACQ-50 Item a7.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	26.14	23.979	0.705	0.547	0.850
Leader:	24.79	27.381	0.795	0.772	0.896

Item a8r - When a risk is detected, management ignores it without action.

Figure C. 8 - NOSACQ-50 Item a8r.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	26.18	23.640	0.627	0.544	0.856
Leader:	24.41	28.674	0.755	0.709	0.899

Item a9r - Management lacks the ability to deal with safety properly.

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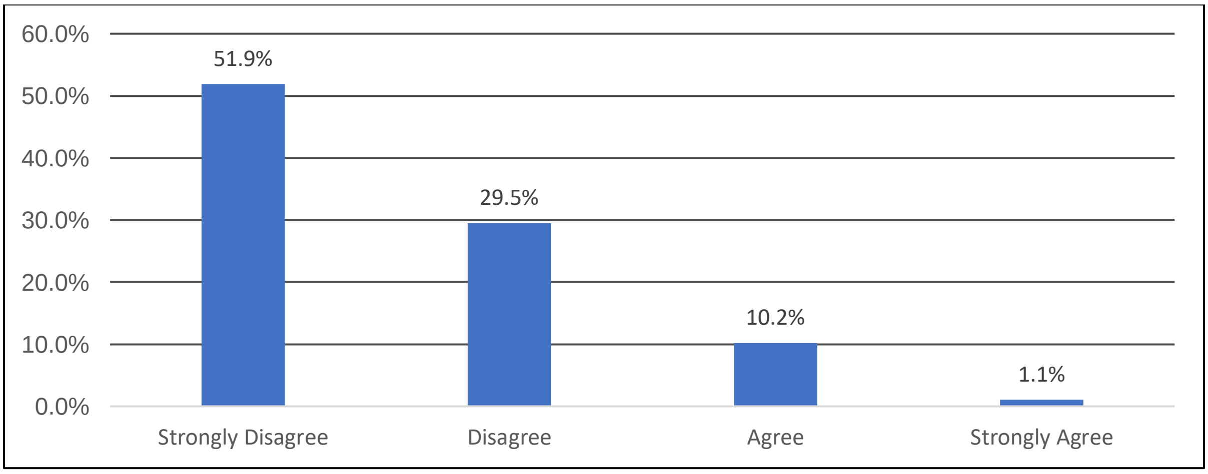
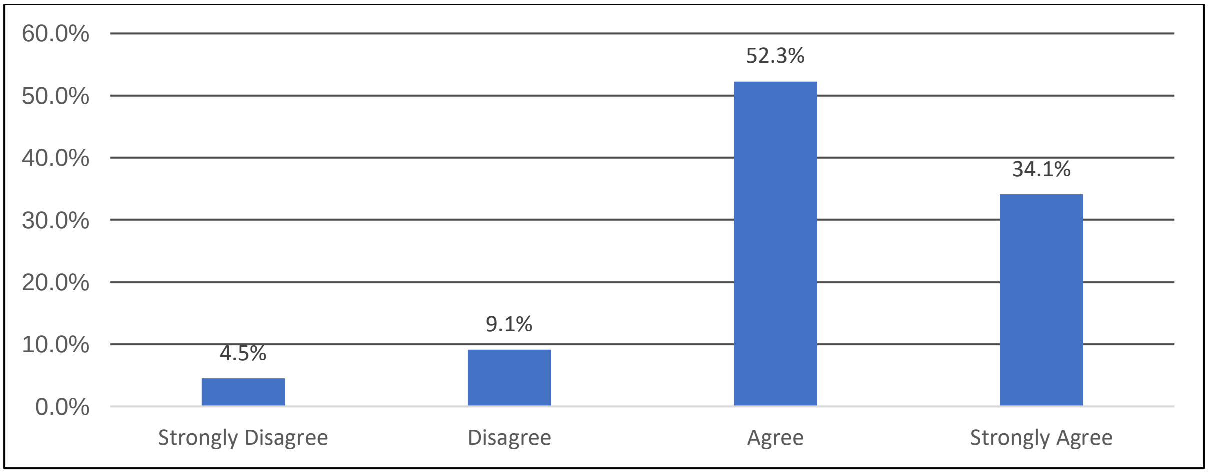
Figure C. 9 - NOSACQ-50 Item a9r.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	26.29	22.899	0.688	0.700	0.850
Leader:	24.62	27.758	0.699	0.589	0.904

Item a10 - Management strives to design safety routines that are meaningful and actually work

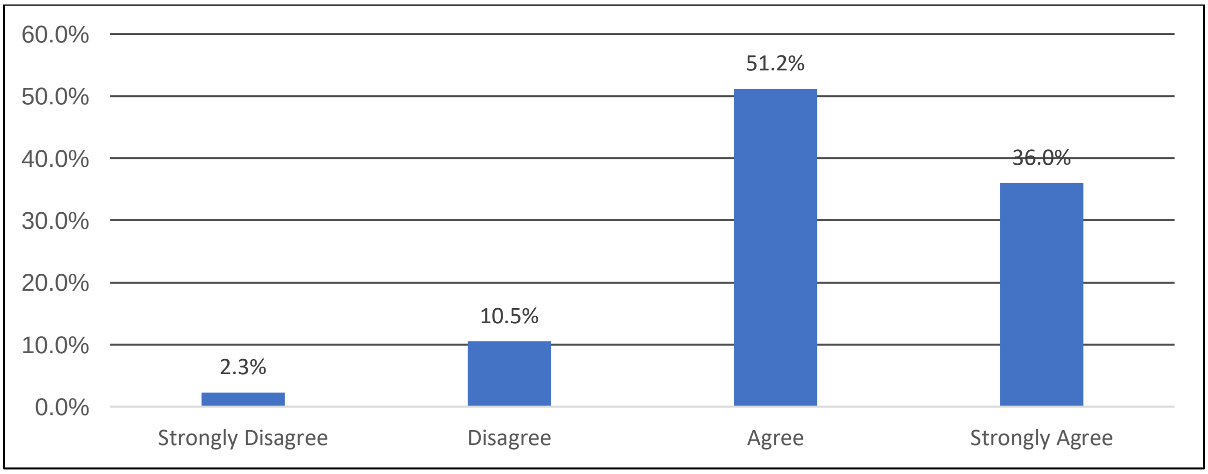
Figure C. 10 - NOSACQ-50 Item a10.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.20	12.561	0.401	0.315	0.797
Leader:	18.82	8.513	0.651	0.631	0.685

Item a11 - Management makes sure that everyone can influence safety in their work environment.

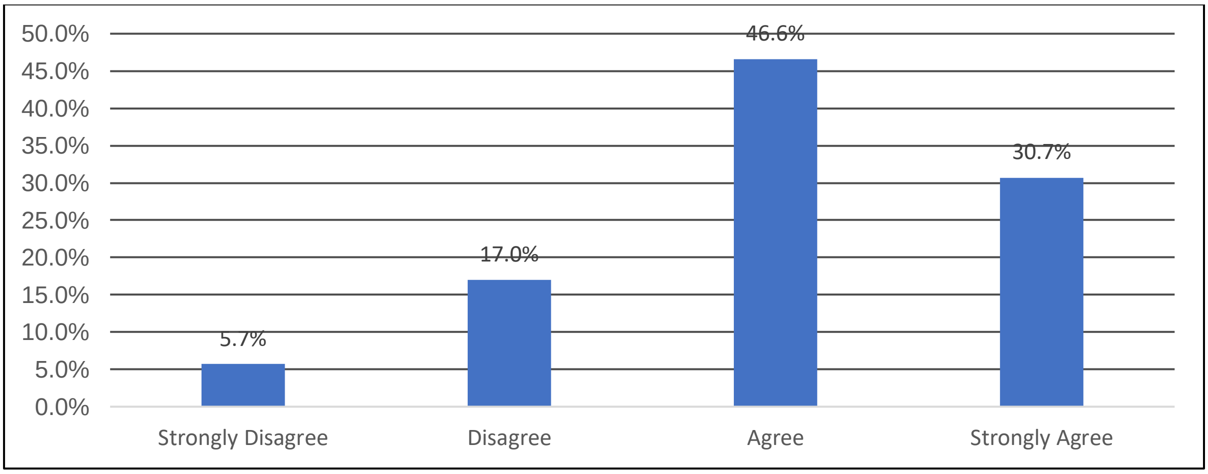
Figure C. 11 - NOSACQ-50 Item a11.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.18	11.604	0.592	0.395	0.761
Leader:	18.74	9.291	0.628	0.481	0.699

Item a12 - Management encourages employees here to participate in decisions which affect their safety.

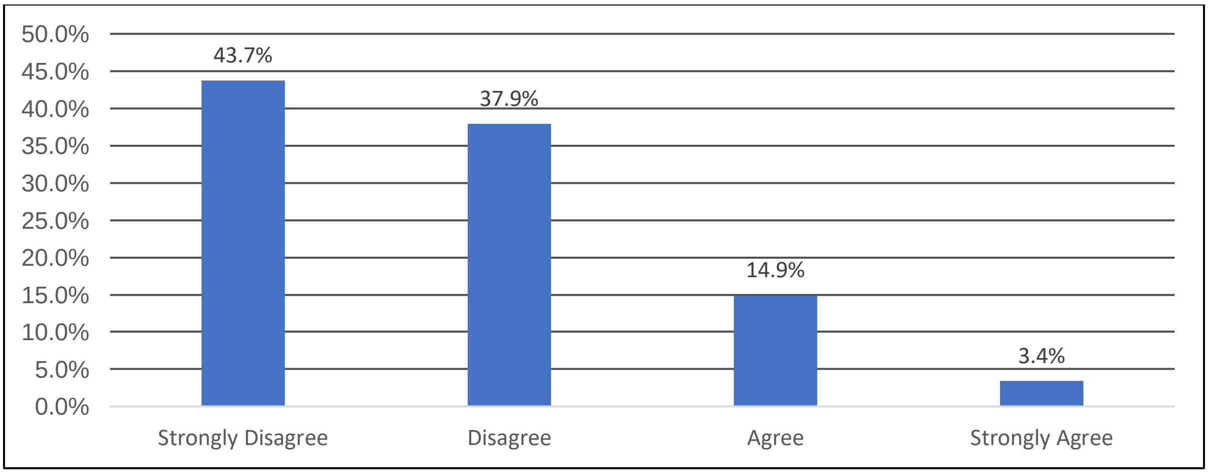
Figure C. 12 - NOSACQ-50 Item a12.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.36	11.834	0.521	0.343	0.775
Leader:	18.76	9.337	0.503	0.397	0.722

Item a13r - Management never considers employees' suggestions regarding safety.

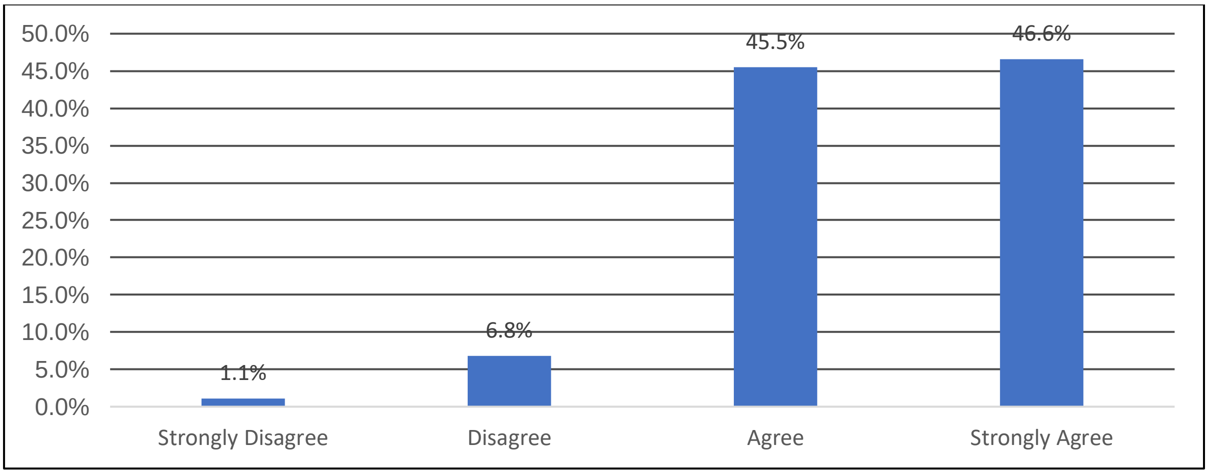
Figure C. 13 - NOSACQ-50 Item a13r.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.09	11.428	0.635	0.450	0.753
Leader:	18.85	9.402	0.338	0.267	0.769

Item a14 - Management strives for everybody at the worksite to have high competence concerning safety and risks.

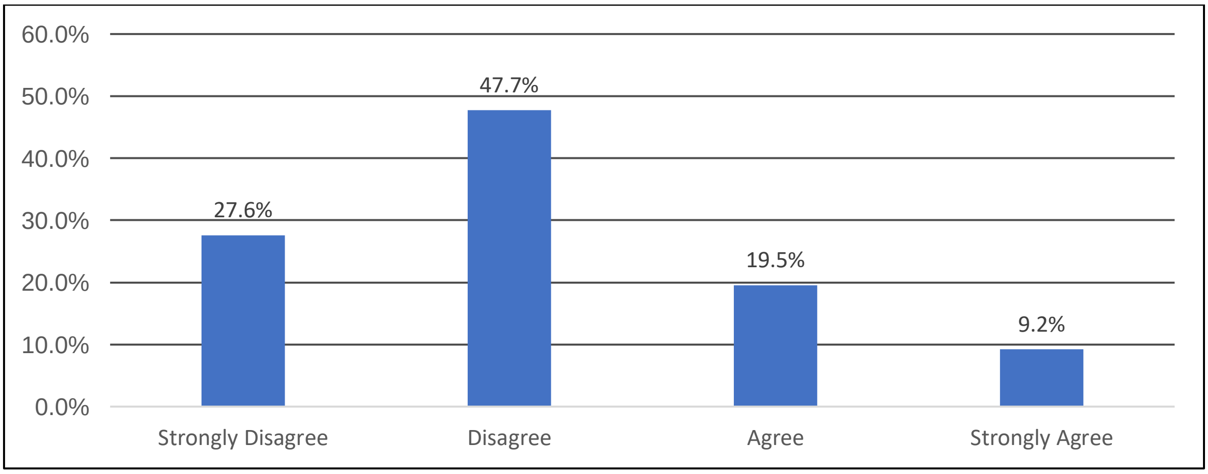
Figure C. 14 - NOSACQ-50 Item a14.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	17.91	12.701	0.541	0.367	0.774
Leader:	18.62	9.213	0.639	0.523	0.696

Item a15r - Management never asks employees for their opinions before making decisions regarding safety.

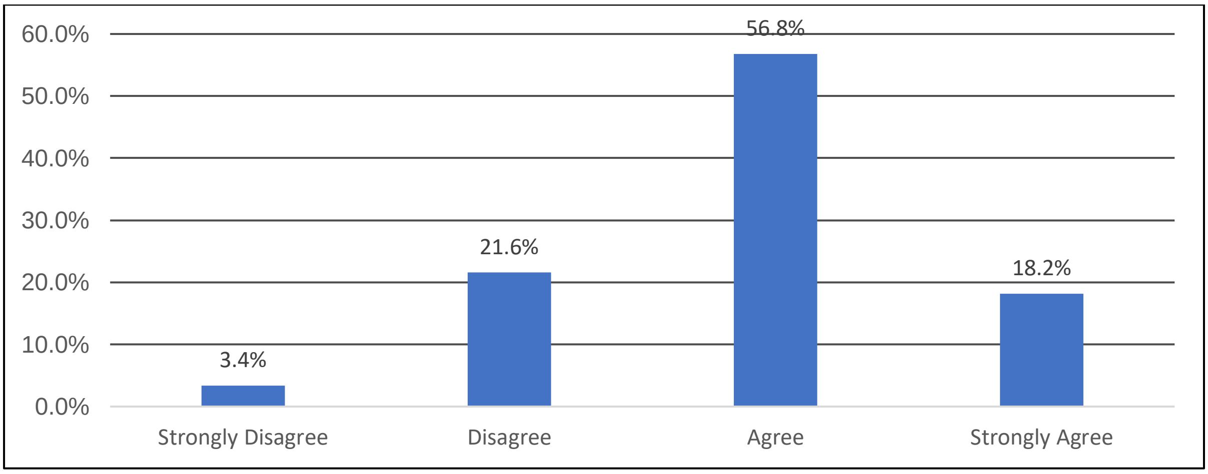
Figure C. 15 - NOSACQ-50 Item a15r.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.57	12.504	0.345	0.260	0.812
Leader:	18.65	11.508	0.067	0.242	0.807

Item a16 - Management involves employees in decisions regarding safety.

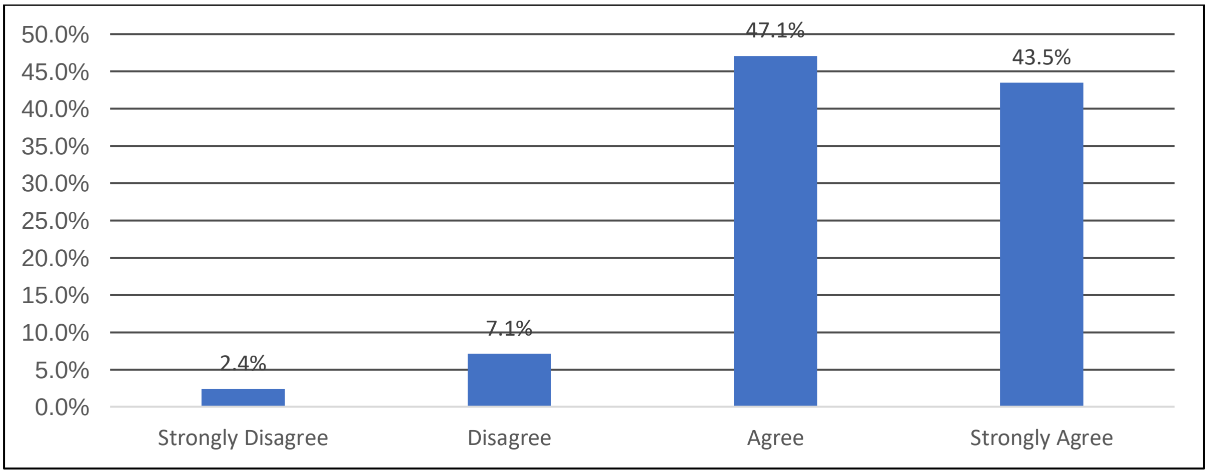
Figure C. 16 - NOSACQ-50 Item a16.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.52	11.236	0.753	0.573	0.734
Leader:	18.85	9.463	0.678	0.590	0.695

Item a17 - Management collects accurate information in accident investigations.

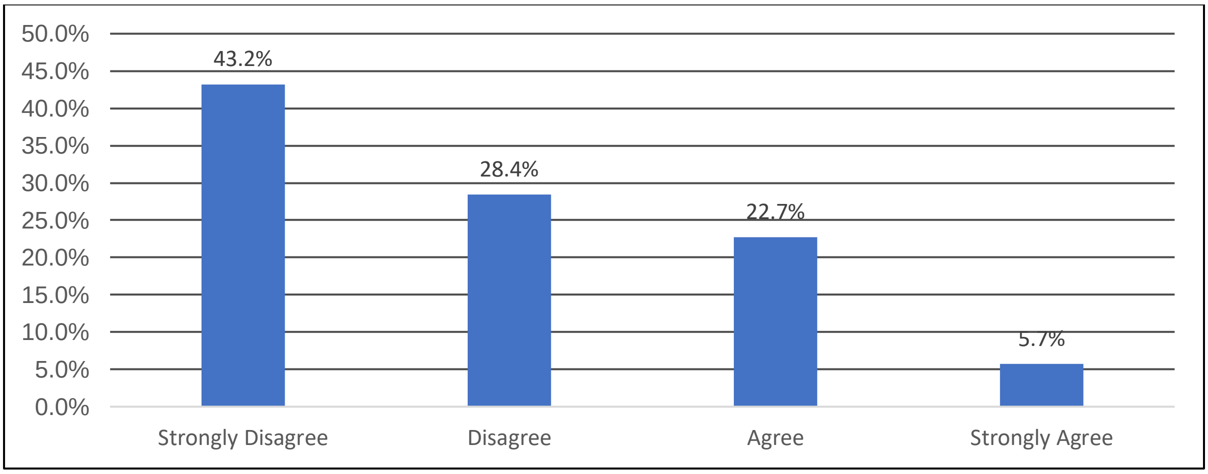
Figure C. 17 - NOSACQ-50 Item a17.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	16.38	9.039	0.636	0.483	0.814
Leader:	15.06	8.057	0.537	0.567	0.735

Item a18r - Fear of sanctions (negative consequences) from management discourages employees here from reporting near-miss accidents.

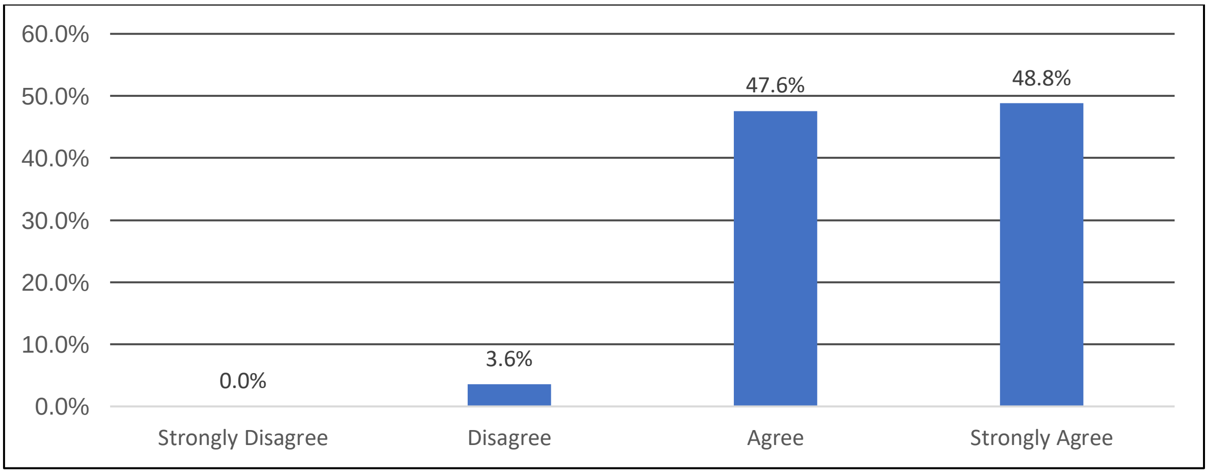
Figure C. 18 - NOSACQ-50 Item a18r.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	16.39	8.679	0.608	0.420	0.820
Leader:	15.56	6.799	0.565	0.377	0.726

Item a19 - Management listens carefully to all who have been involved in an accident.

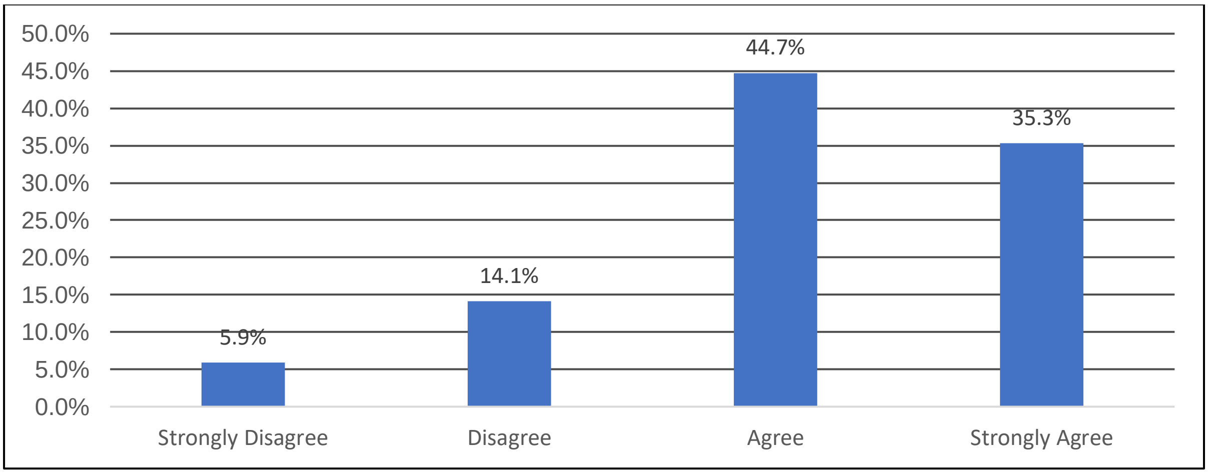
Figure C. 19 - NOSACQ-50 Item a19.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	16.11	9.988	0.643	0.438	0.820
Leader:	15.06	8.724	0.389	0.507	0.765

Item a20 - Management looks for causes, not guilty persons, when an accident occurs.

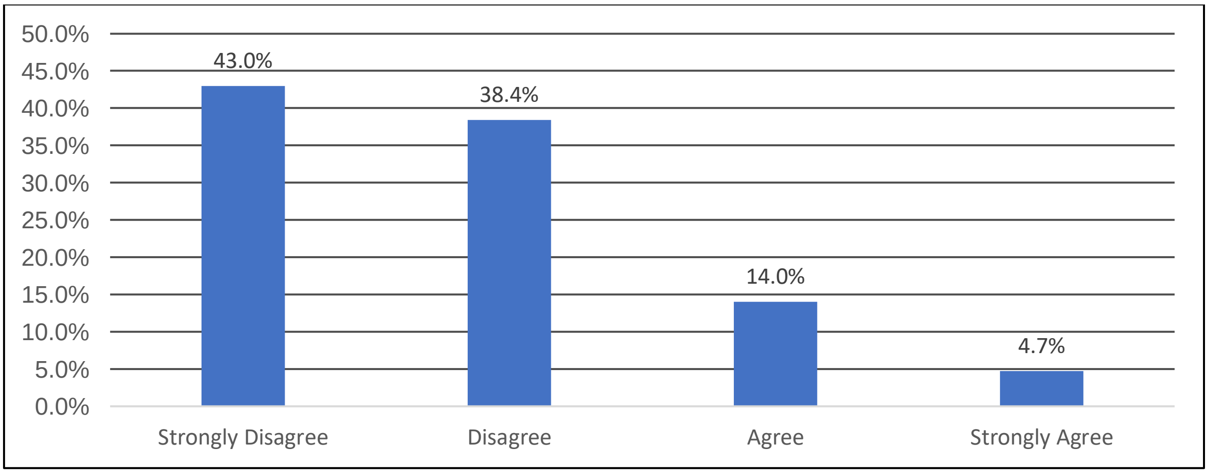
Figure C. 20 - NOSACQ-50 Item a20.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	16.55	8.324	0.762	0.630	0.787
Leader:	15.35	7.326	0.487	0.269	0.747

Item a21 - Management always blames employees for accidents.

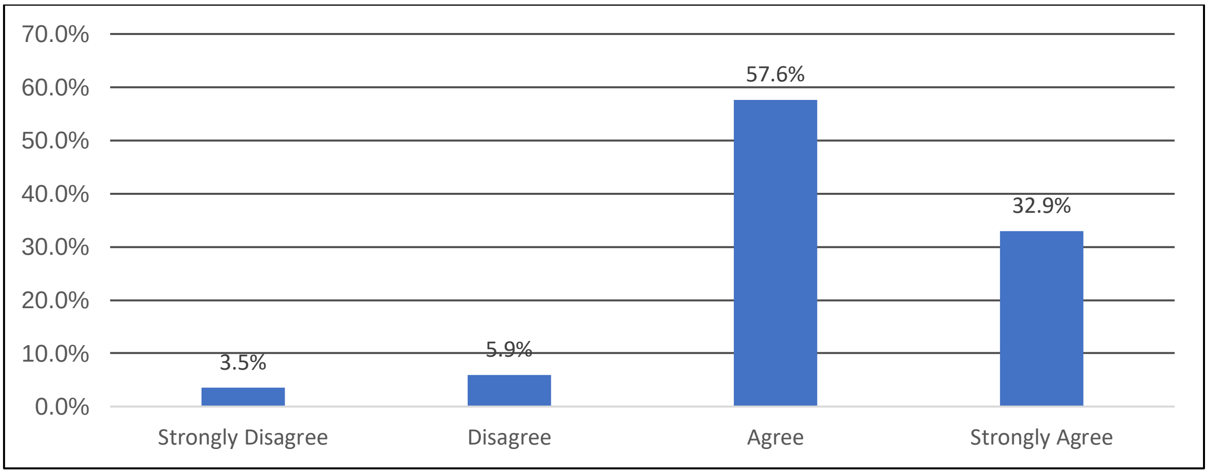
Figure C. 21 - NOSACQ-50 Item a21.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	16.45	8.761	0.629	0.598	0.815
Leader:	15.29	6.820	0.650	0.494	0.699

Item a22 - Management treats employees involved in an accident fairly.

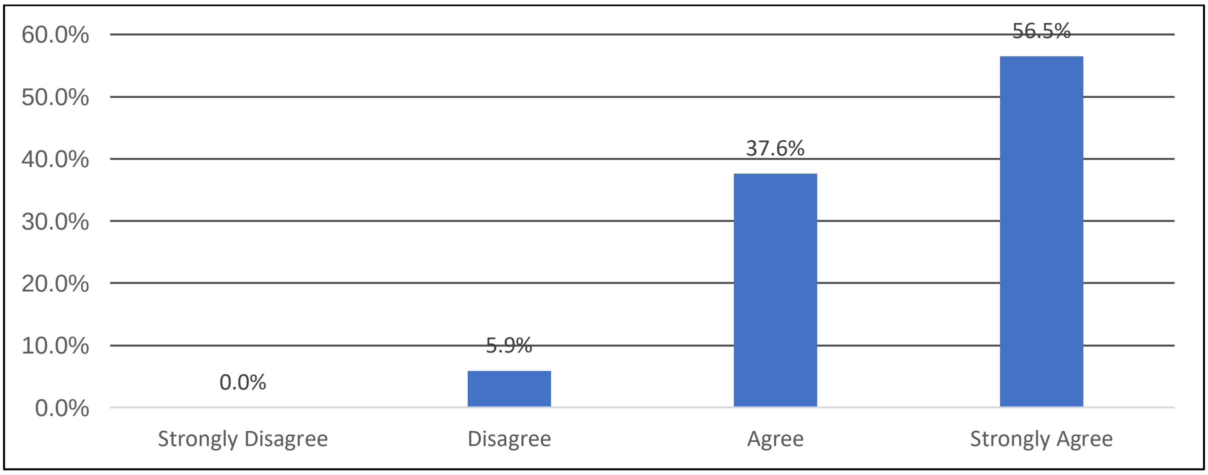
Figure C. 22 - NOSACQ-50 Item a22.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	16.43	9.486	0.499	0.421	0.840
Leader:	15.29	8.153	0.500	0.347	0.742

Item a23 - We who work here try hard together to achieve a high level of safety.

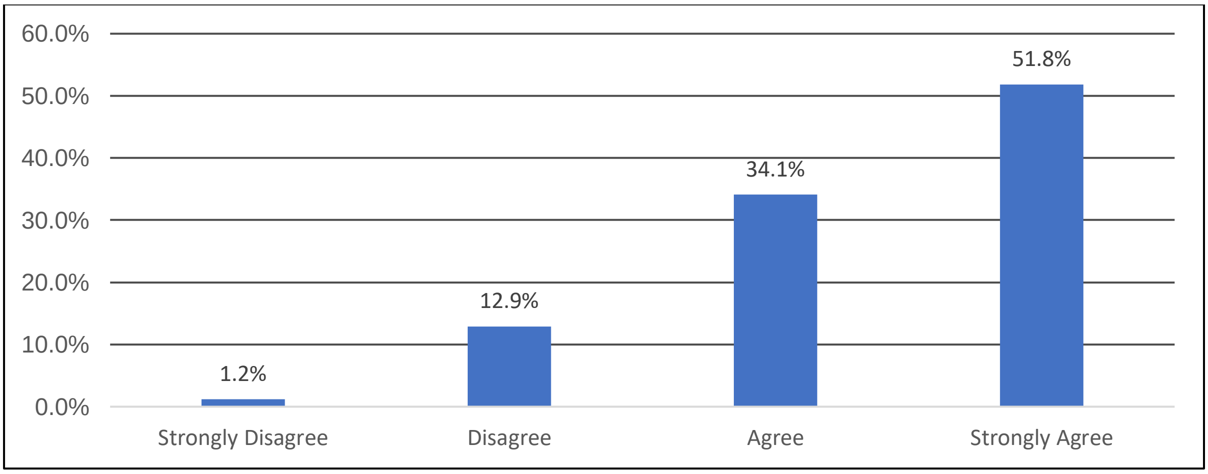
Figure C. 23 - NOSACQ-50 Item a23.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	17.33	6.333	0.657	0.460	0.787
Leader:	16.39	6.184	0.635	0.651	0.632

Item a24 - We who work here take joint responsibility to ensure that the workplace is always kept tidy.

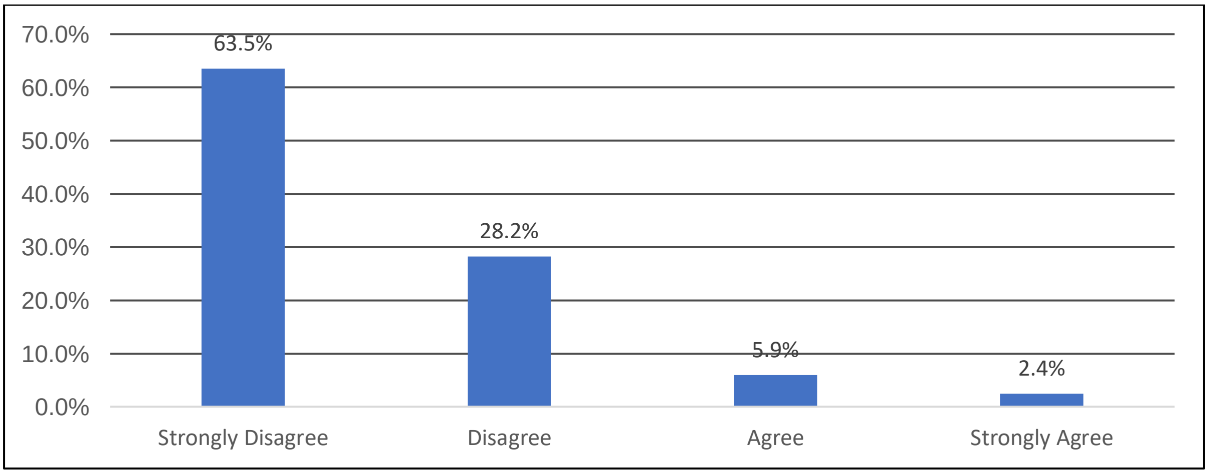
Figure C. 24 - NOSACQ-50 Item a24.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	17.44	5.643	0.664	0.471	0.783
Leader:	16.70	5.405	0.712	0.596	0.592

Item a25r - We who work here do not care about each other’s safety.

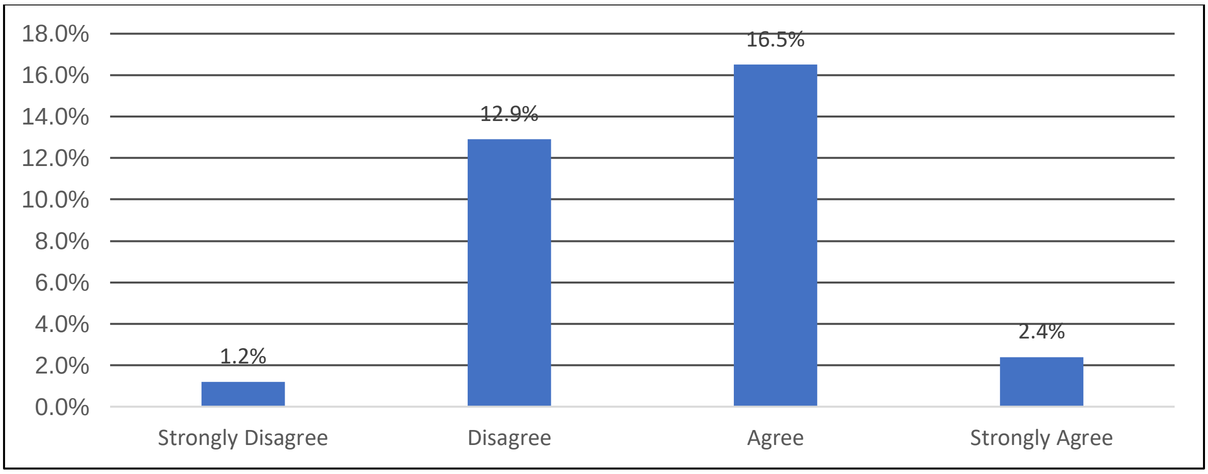
Figure C. 25 - NOSACQ-50 Item a25r.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	17.26	6.412	0.555	0.342	0.806
Leader:	16.45	5.881	0.538	0.356	0.653

Item a26 - We who work here avoid tackling risks that are discovered

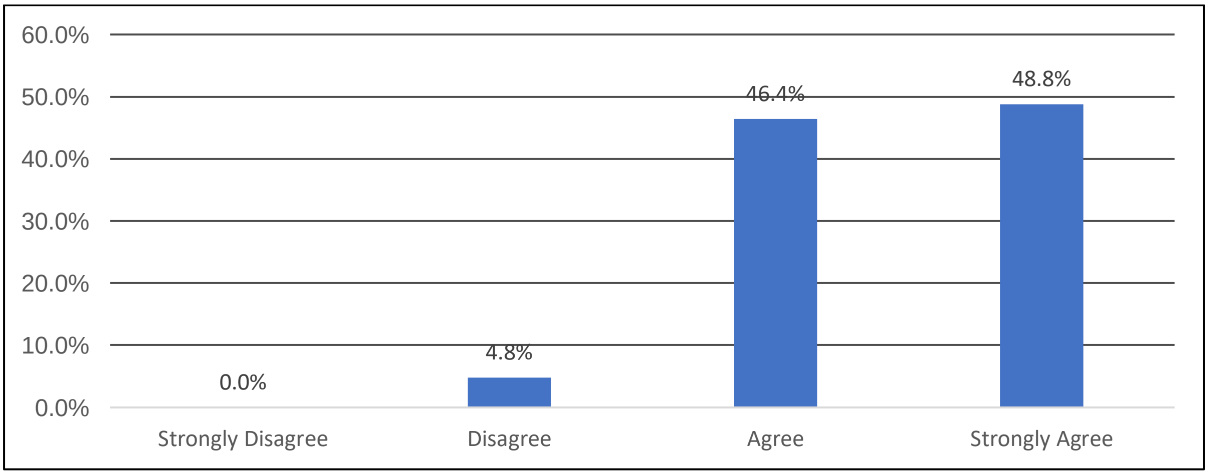
Figure C. 26 - NOSACQ-50 Item a26.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	17.39	6.063	0.578	0.371	0.802
Leader:	16.91	7.898	0.025	0.059	0.810

Item a27 - We who work here help each other to work safely.

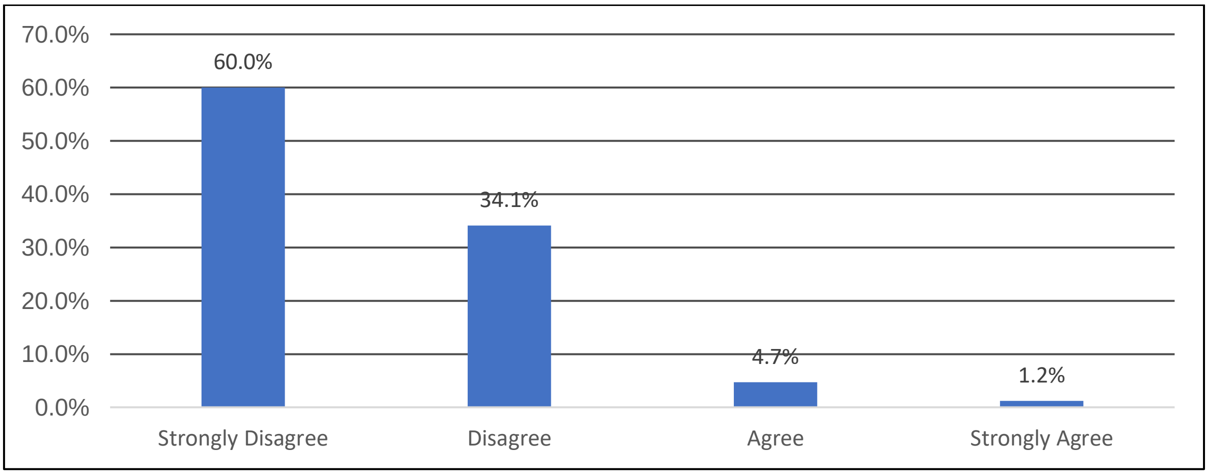
Figure C. 27 - NOSACQ-50 Item a27.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	17.42	6.427	0.523	0.310	0.812
Leader:	16.52	6.570	0.583	0.543	0.653

Item a28 - We who work here take no responsibility for each other's safety.

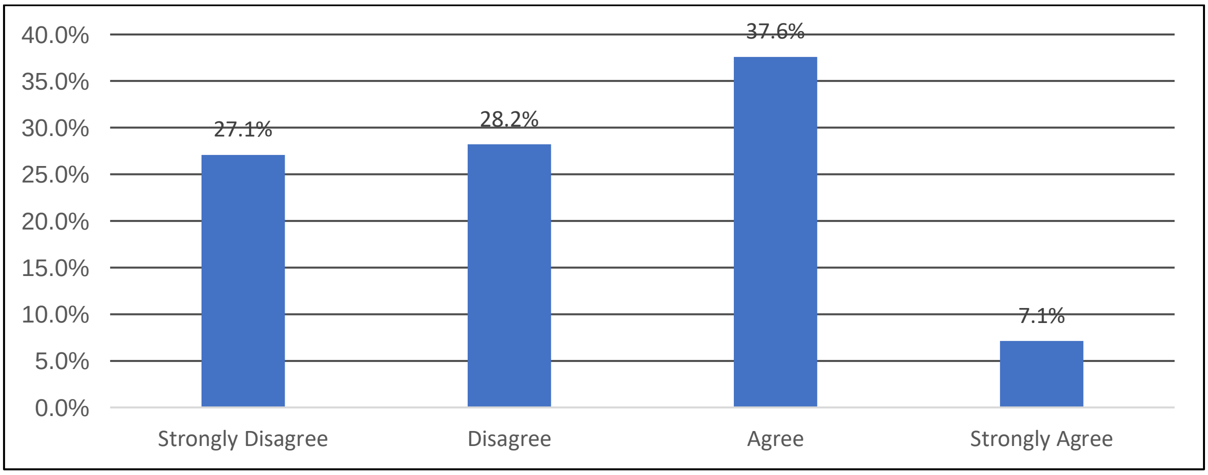
Figure C. 28 - NOSACQ-50 Item a28.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	17.28	6.563	0.616	0.399	0.796
Leader:	16.42	6.502	0.396	0.225	0.698

Item a29 - We who work here regard risks as unavoidable.

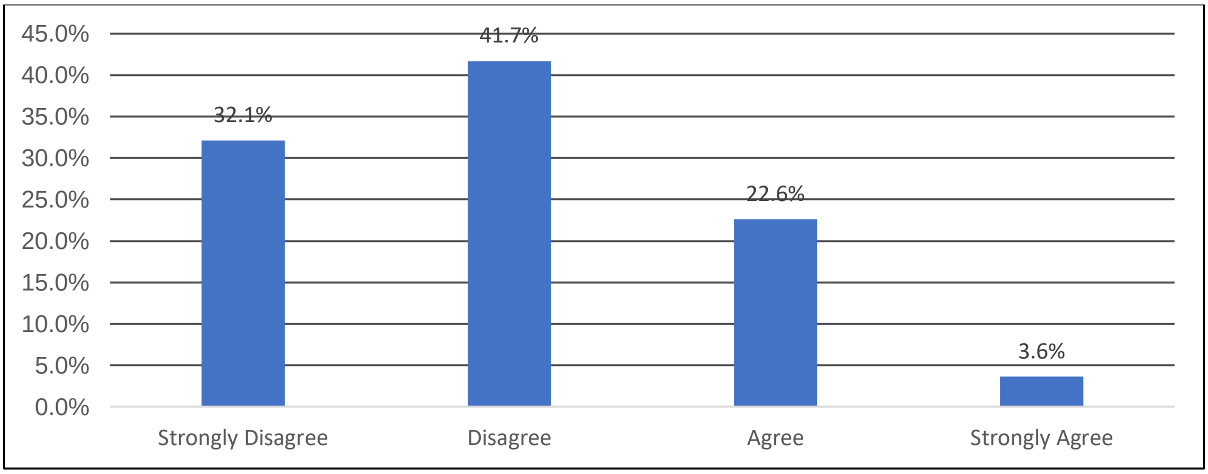
Figure C. 29 - NOSACQ-50 Item a29.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.89	15.370	0.411	0.316	0.822
Leader:	19.50	10.500	0.521	0.613	0.771

Item a30 - We who work here consider minor accidents to be a normal part of our daily work.

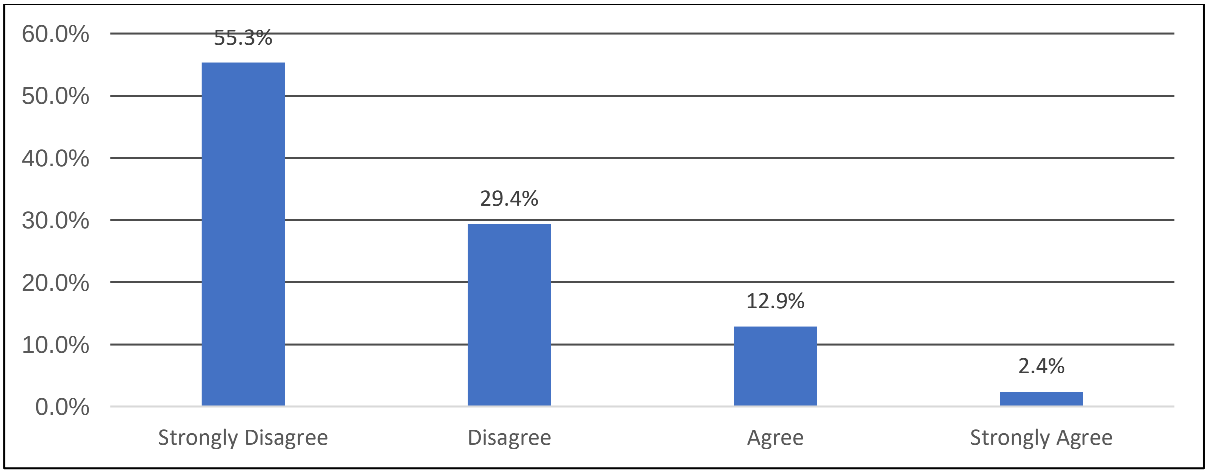
Figure C. 30 - NOSACQ-50 Item a30.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.54	15.017	0.567	0.485	0.795
Leader:	19.29	10.941	0.475	0.540	0.779

Item a31 - We who work here accept dangerous behaviour as long as there are no accidents.

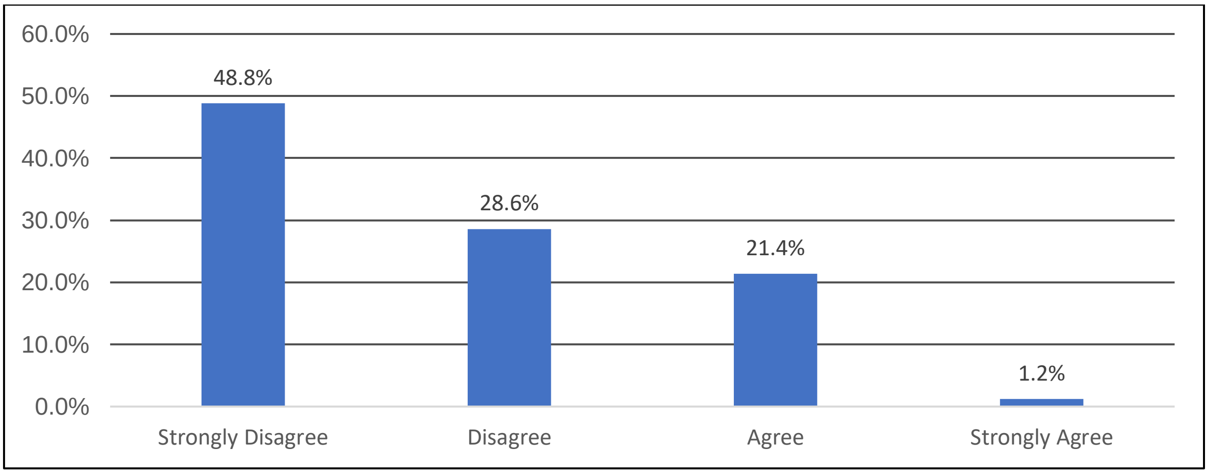
Figure C. 31 - NOSACQ-50 Item a31.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.18	14.440	0.680	0.605	0.777
Leader:	18.91	10.628	0.637	0.590	0.753

Item a32 - We who work here break safety rules in order to complete work on time.

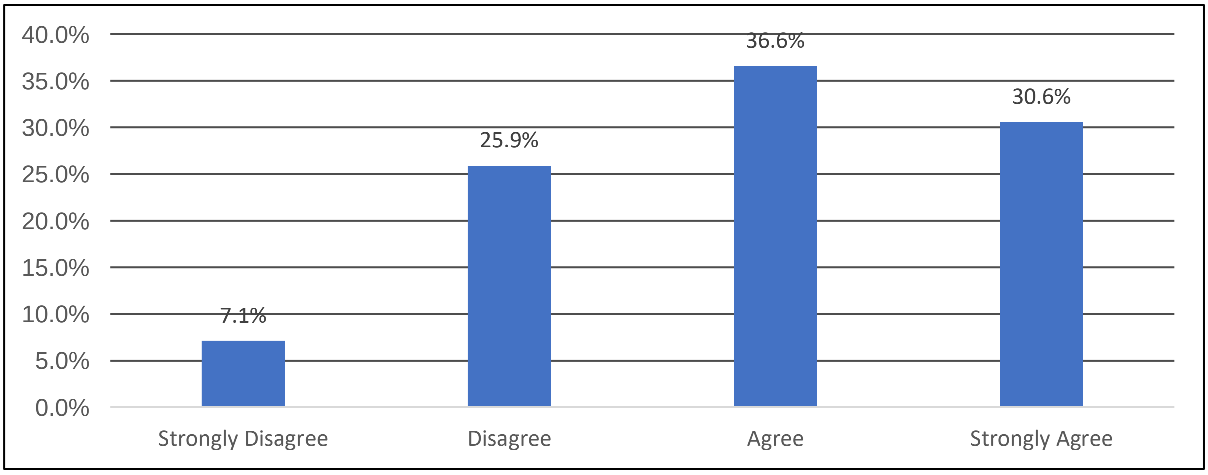
Figure C. 32 - NOSACQ-50 Item a32.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.29	14.244	0.696	0.566	0.773
Leader:	19.18	9.786	0.674	0.532	0.740

Item a33 - We who work here never accept risk-taking even if the work schedule is tight.

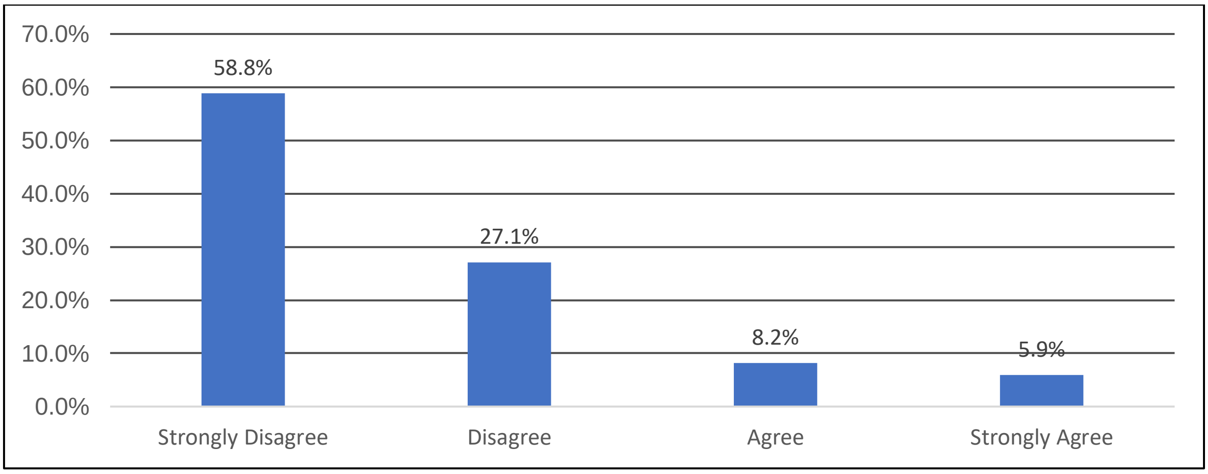
Figure C. 33 - NOSACQ-50 Item a33.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.57	15.740	0.389	0.307	0.824
Leader:	19.44	10.618	0.387	0.337	0.805

Item a34r - We who work here consider that our work is unsuitable for cowards.

Figure C. 34 - NOSACQ-50 Item a34r.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.23	14.981	0.489	0.367	0.808
Leader:	18.85	11.402	0.497	0.433	0.776

Item a35r - We who work here accept risk-taking at work.

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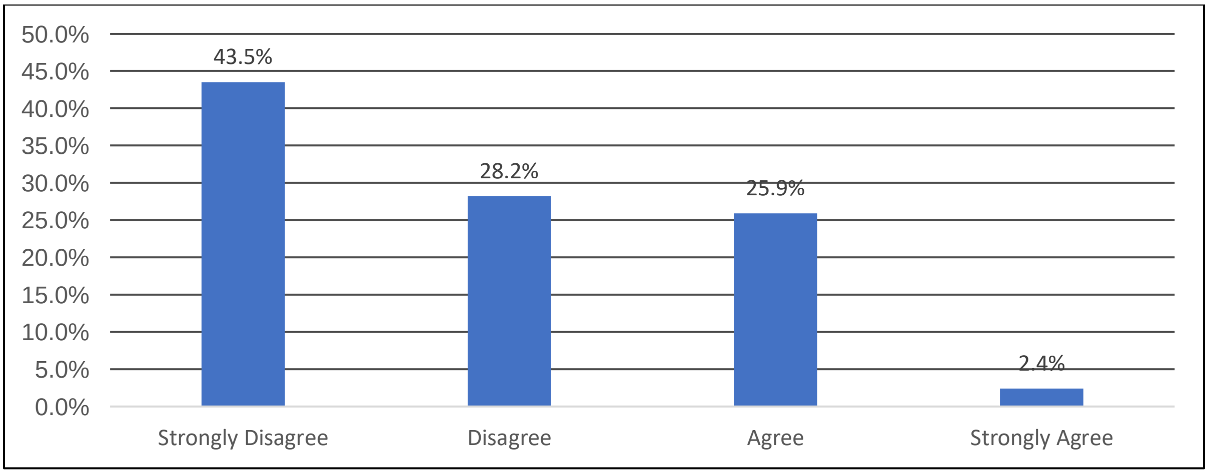
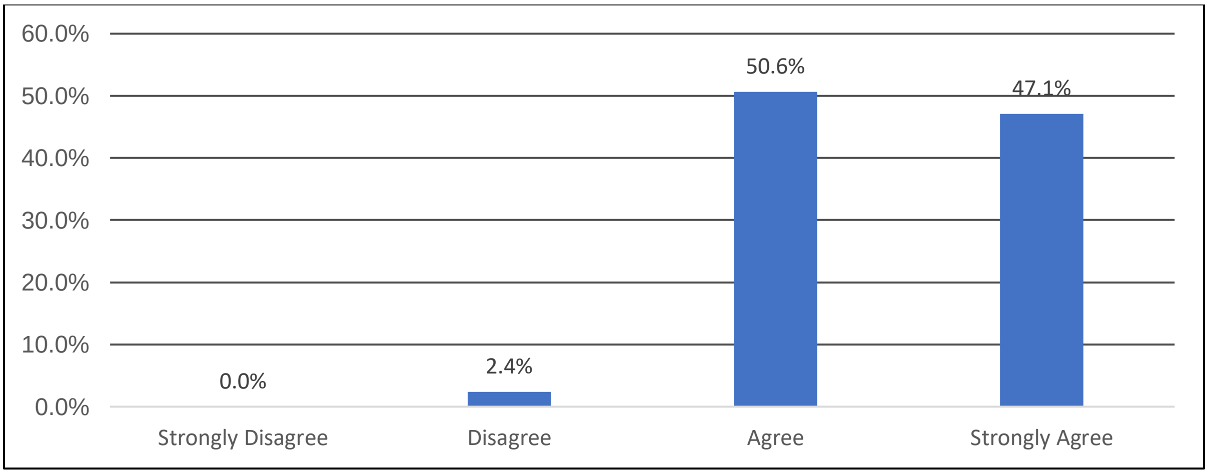
Figure C. 35 - NOSACQ-50 Item a35r.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.52	13.454	0.743	0.574	0.762
Leader:	19.12	10.895	0.568	0.586	0.764

Item a36 - We who work here try to find a solution if someone points out a safety problem.

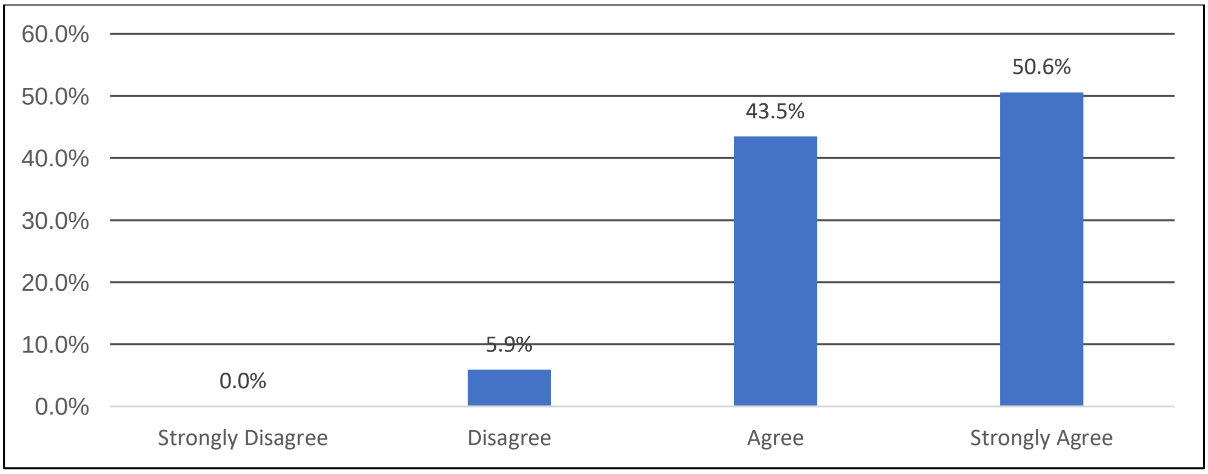
Figure C. 36 - NOSACQ-50 Item a36.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	23.88	11.602	0.559	0.409	0.845
Leader:	23.77	9.314	0.443	0.396	0.859

Item a37 - We who work here feel safe when working together.

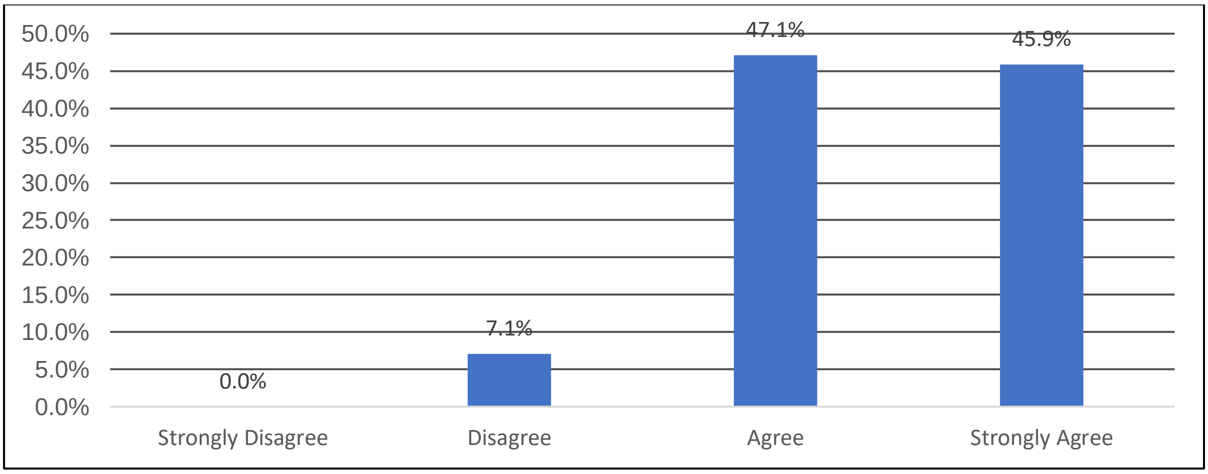
Figure C. 37 - NOSACQ-50 Item a37.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	23.98	10.636	0.708	0.621	0.827
Leader:	23.65	8.770	0.600	0.754	0.844

Item a38 - We who work here have great trust in each other's' ability to ensure safety.

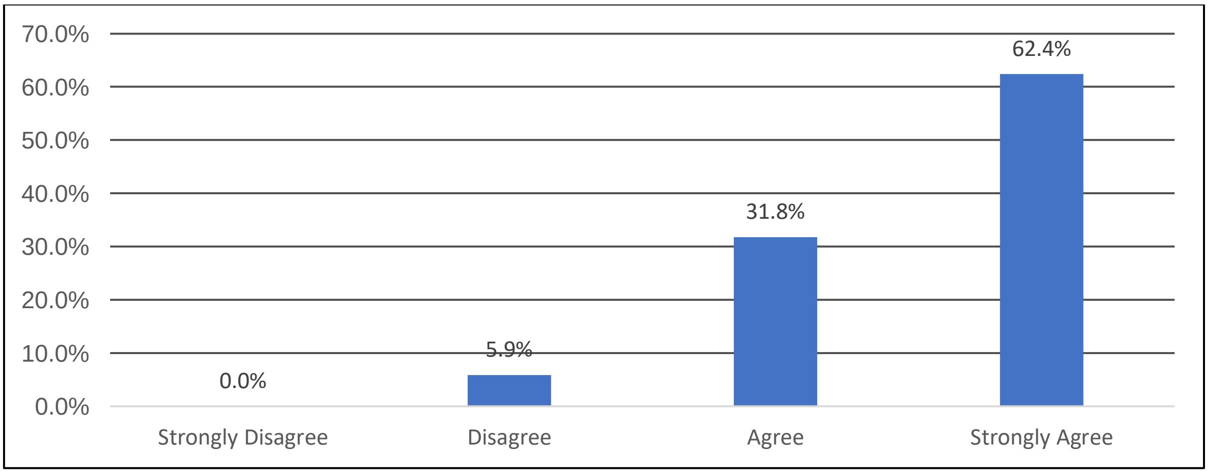
Figure C. 38 - NOSACQ-50 Item a38.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	23.93	10.831	0.733	0.646	0.826
Leader:	23.81	7.828	0.718	0.791	0.829

Item a39 - We who work here learn from our experiences in order to prevent accidents.

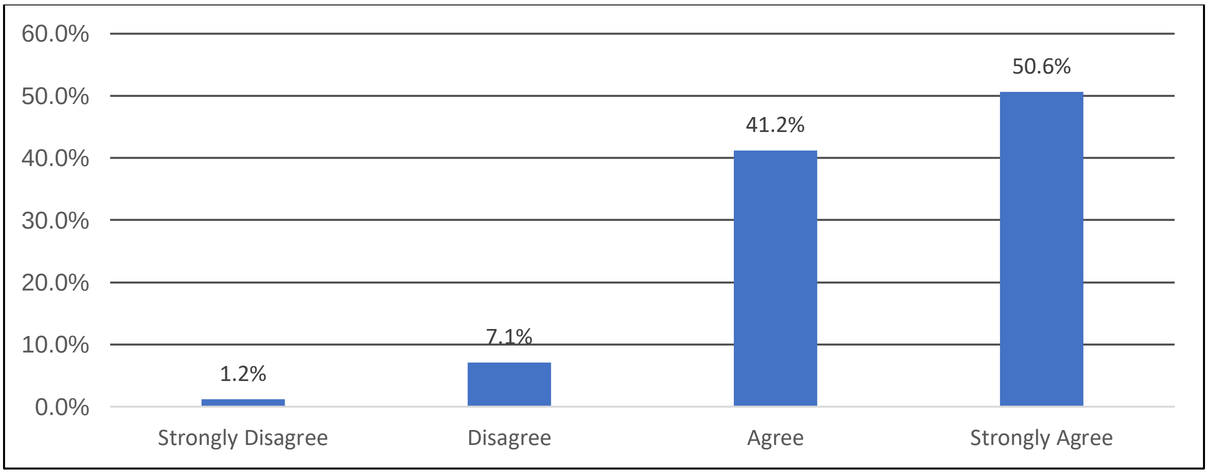
Figure C. 39 - NOSACQ-50 Item a39.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	23.80	11.252	0.627	0.503	0.838
Leader:	23.61	8.112	0.651	0.668	0.838

Item a40 - We who work here take each other's' opinions and suggestions concerning safety seriously.

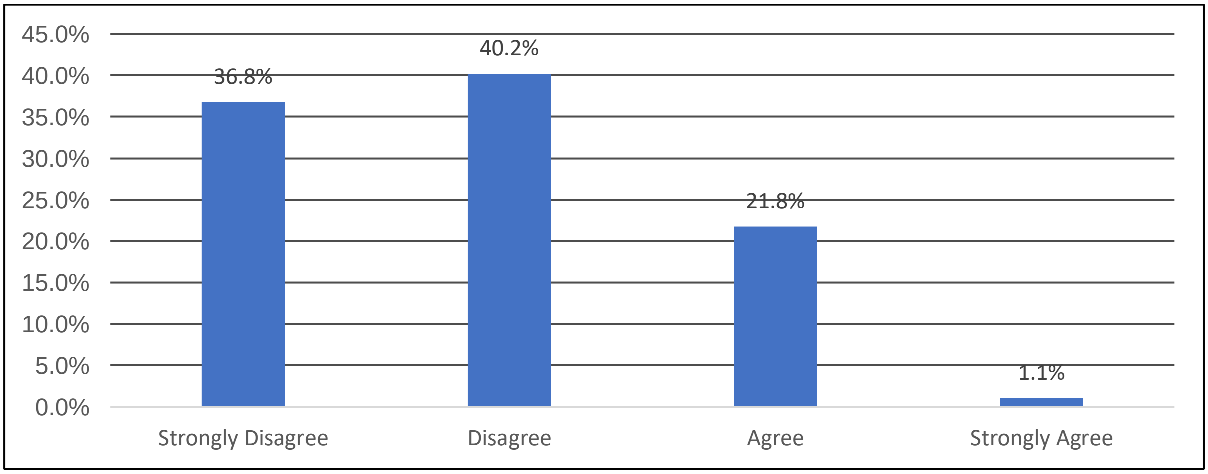
Figure C. 40 - NOSACQ-50 Item a40.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	23.95	10.706	0.619	0.587	0.838
Leader:	23.81	8.228	0.666	0.629	0.836

Item a41 - We who work here seldom talk about safety.

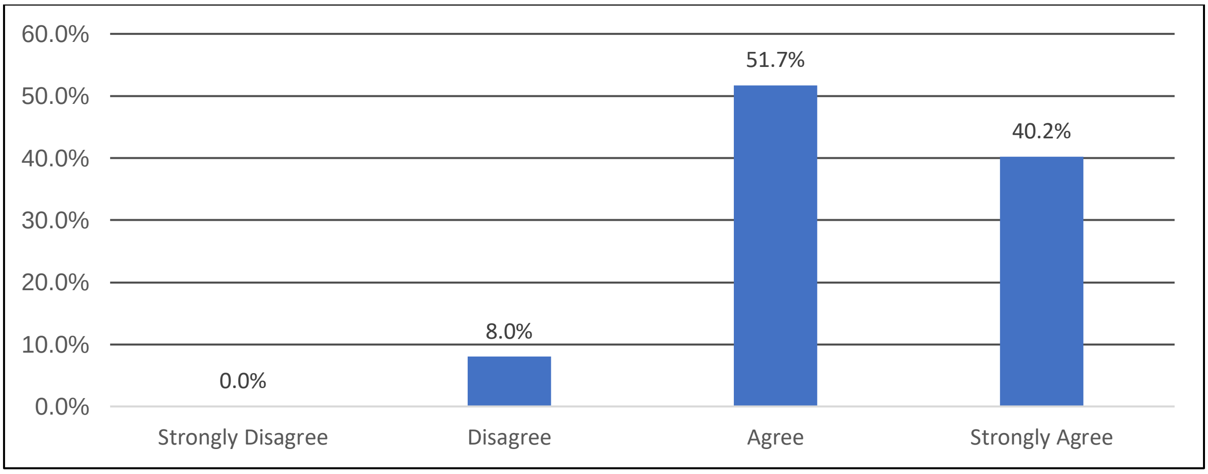
Figure C. 41 - NOSACQ-50 Item a41.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	24.36	10.961	0.404	0.266	0.875
Leader:	23.84	8.406	0.494	0.441	0.859

Item a42 - We who work here always discuss safety issues when such issues come up.

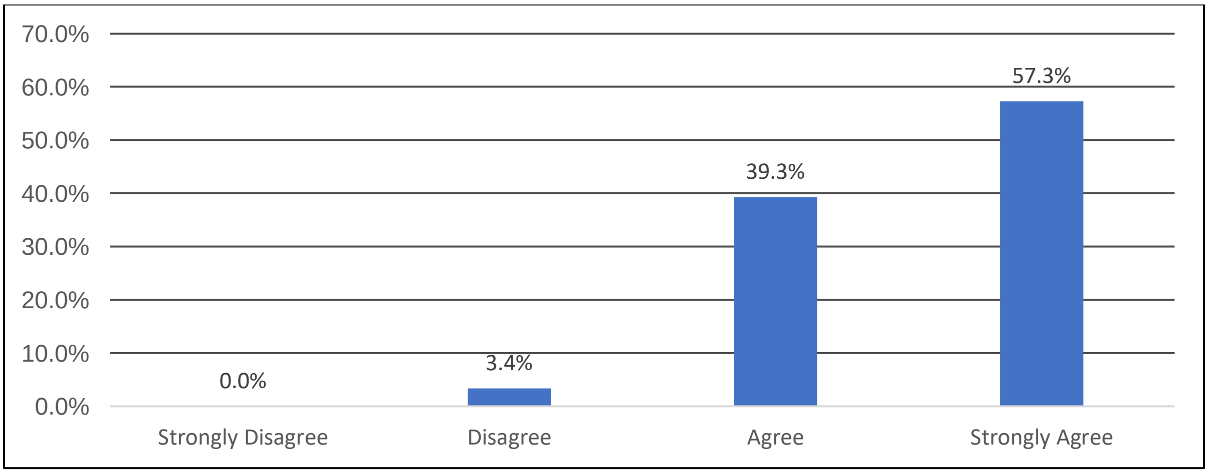
Figure C. 42 - NOSACQ-50 Item a42.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	24.16	10.901	0.625	0.513	0.837
Leader:	23.61	8.912	0.545	0.609	0.850

Item a43 - We who work here can talk freely and openly about safety.

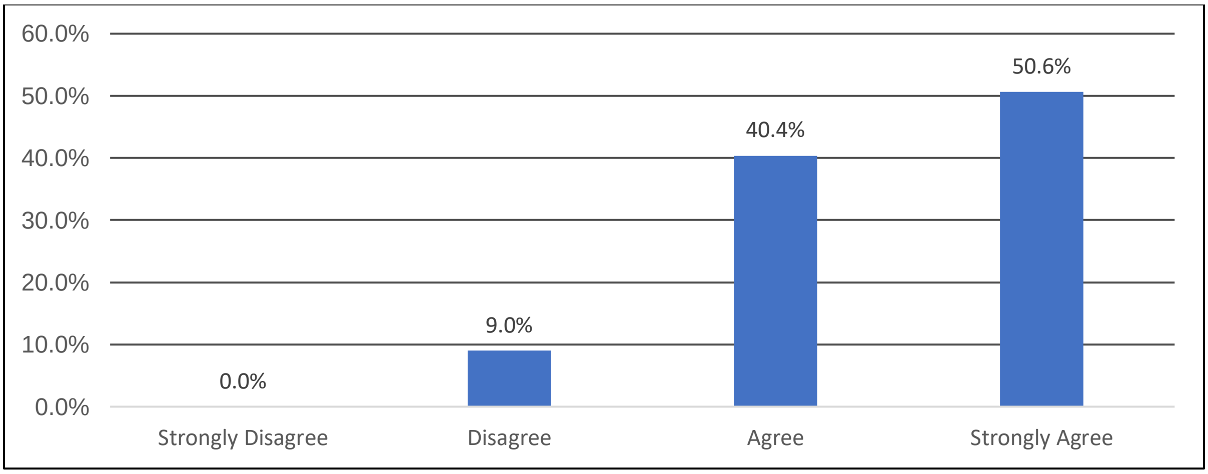
Figure C. 43 - NOSACQ-50 Item a43.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	23.82	11.240	0.671	0.492	0.834
Leader:	23.58	8.052	0.757	0.659	0.825

Item a44 - We who work here consider that a good safety representative plays an important role in preventing accidents.

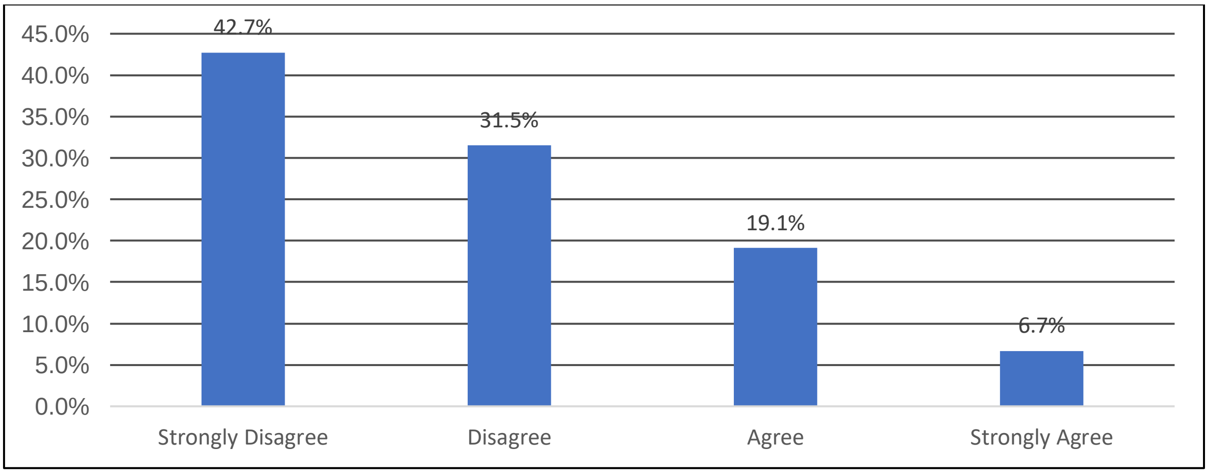
Figure C. 44 - NOSACQ-50 Item a44.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	20.20	10.088	0.228	0.186	0.799
Leader:	21.03	7.666	0.359	0.441	0.846

Item a45r - We who work here consider that safety rounds/evaluations have no effect on safety.

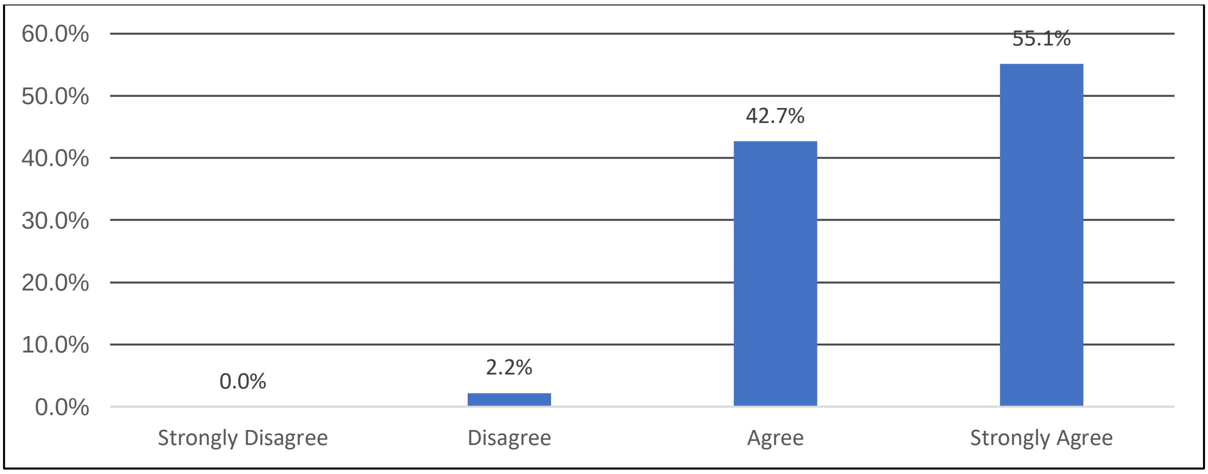
Figure C. 45 - NOSACQ-50 Item a45.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	20.71	7.553	0.541	0.514	0.751
Leader:	21.18	6.513	0.436	0.383	0.860

Item a46 - We who work here consider that safety training to be good for preventing accidents.

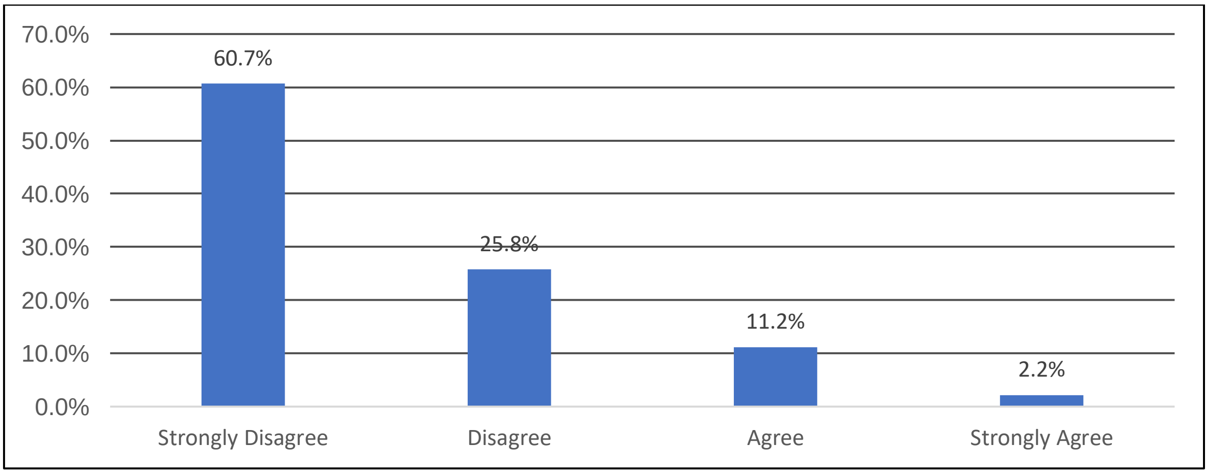
Figure C. 46 - NOSACQ-50 Item a46.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	20.20	9.324	0.524	0.431	0.752
Leader:	20.85	7.644	0.576	0.548	0.810

Item a47r - We who work here consider early planning for safety as meaningless.

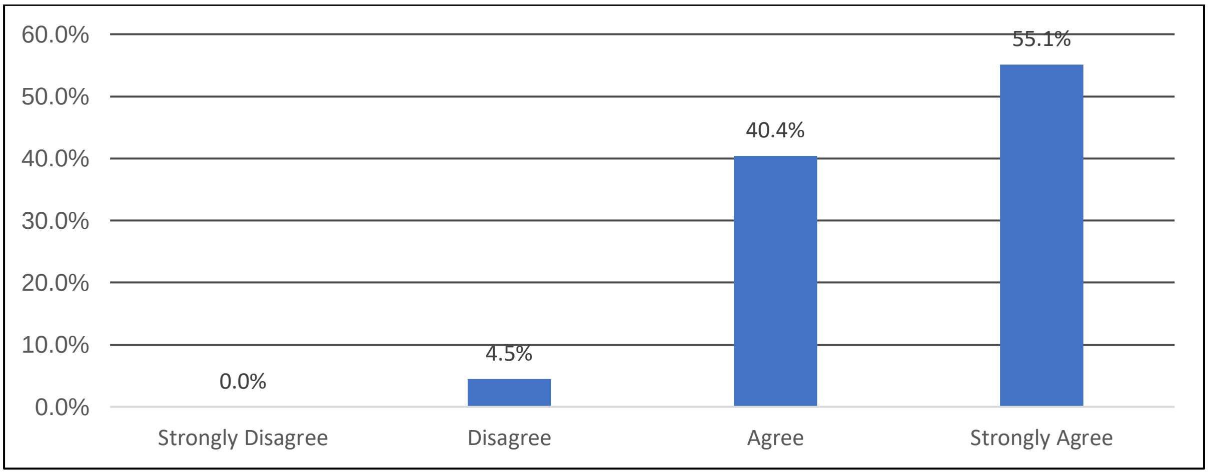
Figure C. 47 - NOSACQ-50 Item a47.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.54	15.017	0.567	0.485	0.795
Leader:	20.82	6.998	0.742	0.775	0.784

Item a48 - We who work here consider that safety rounds/evaluations help find serious hazards.

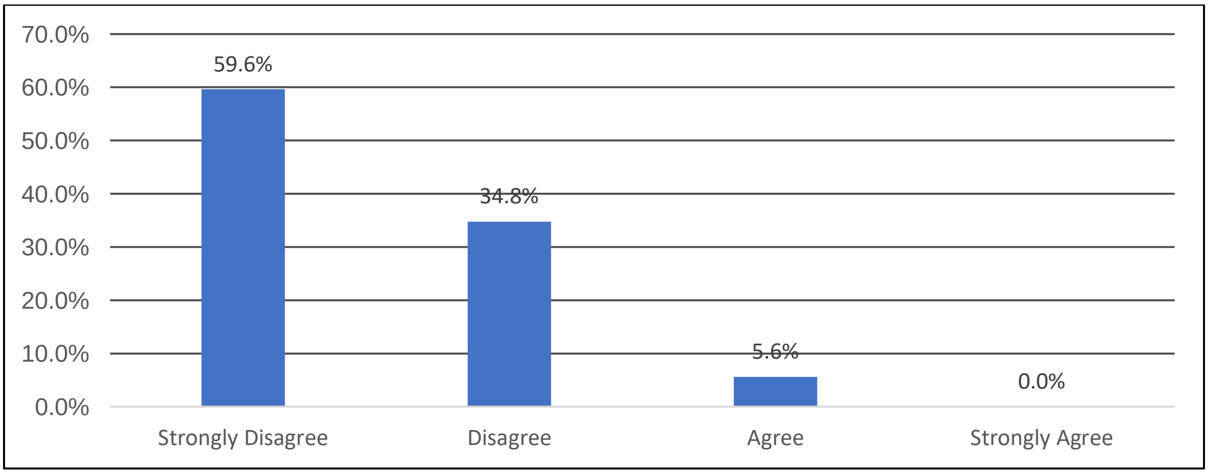
Figure C. 48 - NOSACQ-50 Item a48.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	20.21	8.499	0.700	0.547	0.718
Leader:	20.91	6.689	0.861	0.779	0.765

Item a49 - We who work here consider safety training to be meaningless.

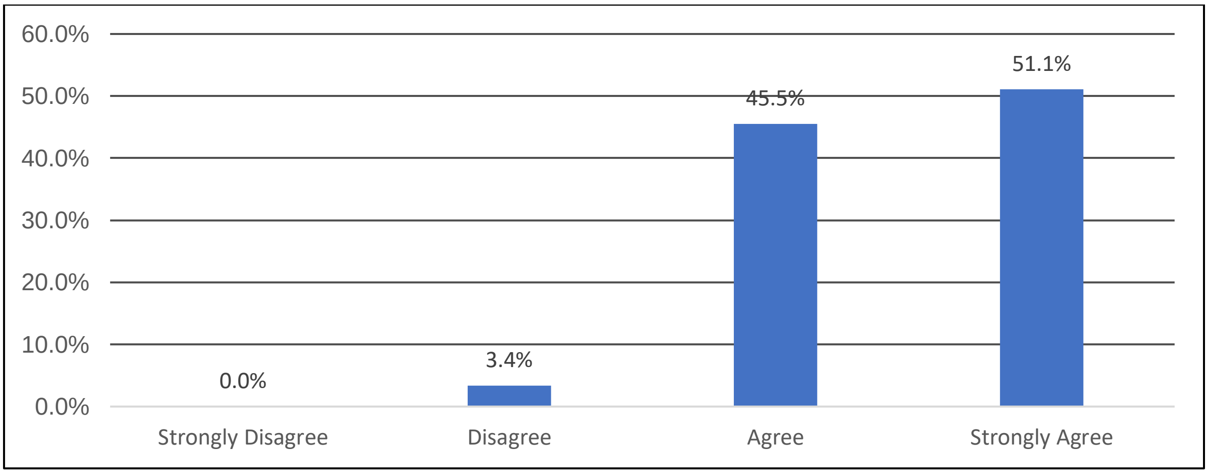
Figure C. 49 - NOSACQ-50 Item a49.



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	18.54	15.017	0.567	0.485	0.795
Leader:	19.29	10.941	0.475	0.540	0.779

Item a50 - We who work here consider it important to have clear-cut goals for safety.

Figure C. 50 - NOSACQ-50 Item a50.

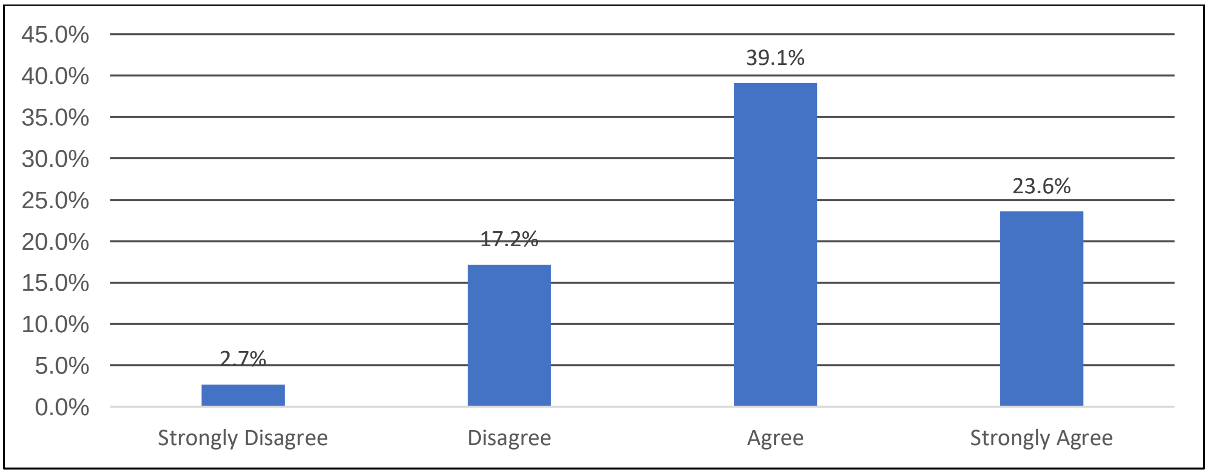


	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Worker:	20.36	9.725	0.333	0.153	0.781
Leader:	20.76	7.458	0.674	0.623	0.798

C4. Safety Performance Results by Individual Item

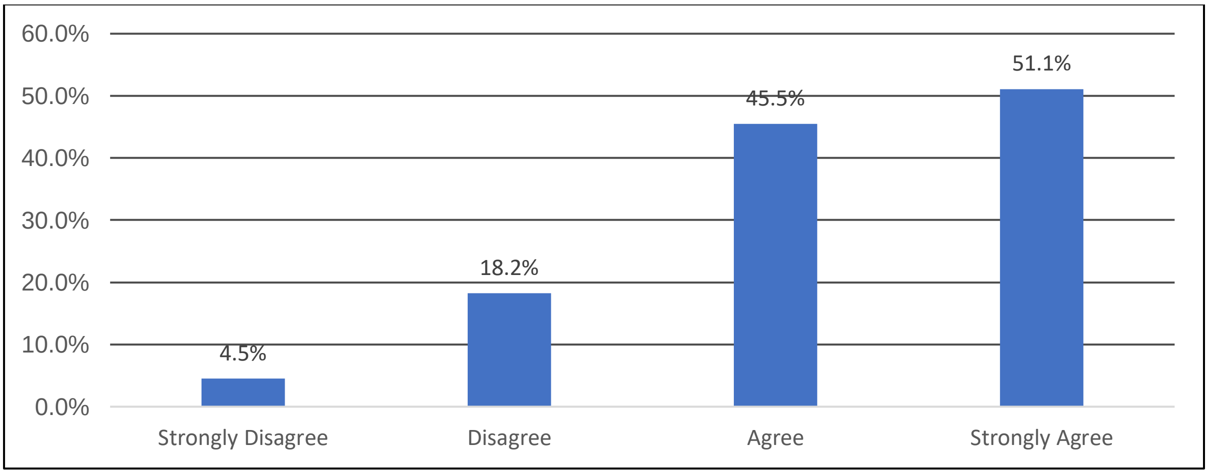
Item Com 1 - I follow the procedures and controls outlined in RAMS for the tasks that I perform.

Figure C. 51 - Safety Compliance Item Com 1.



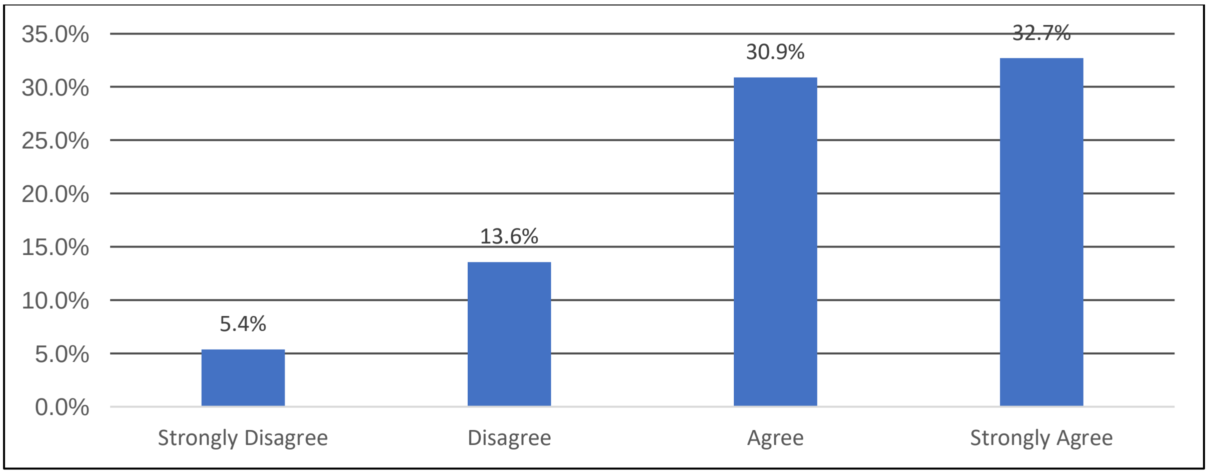
Item Com 2 - My co-workers follow the procedures and controls outlined in RAMS for the tasks that they perform.

Figure C. 52 - Safety Compliance Item Com 2.



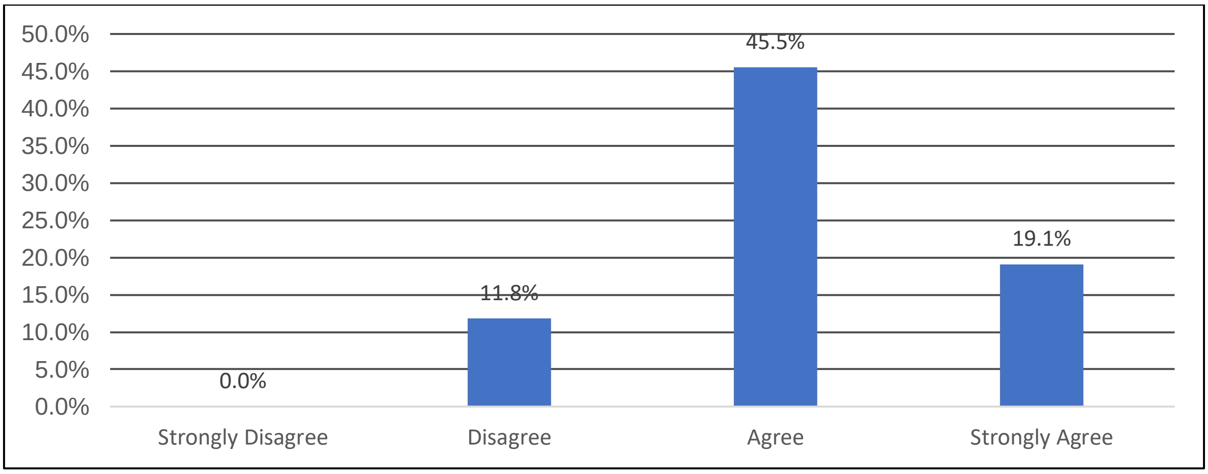
Item Com 3 - All of the workers in my company follow the site rules implemented by the general contractor.

Figure C. 53 - Safety Compliance Item Com 3.



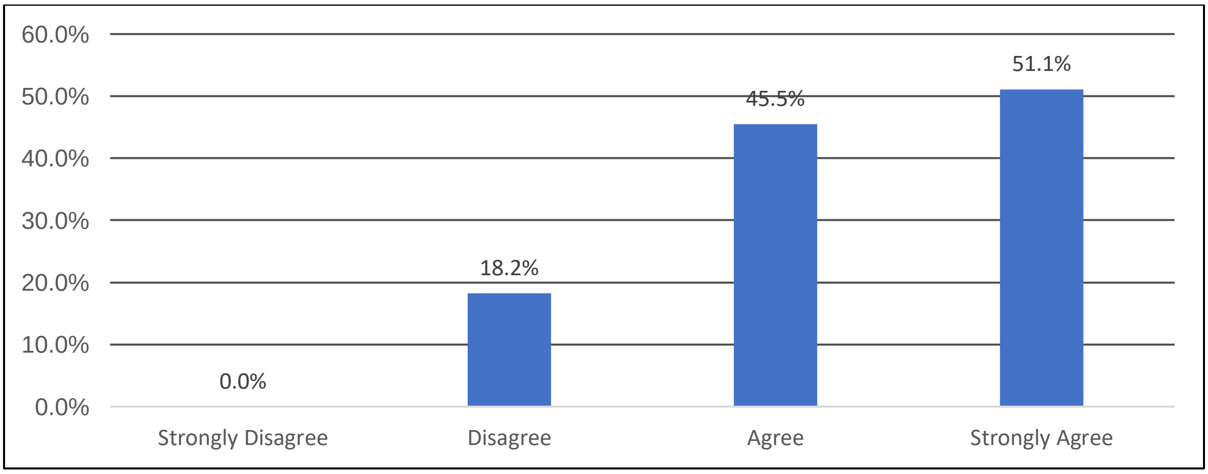
Item Par 1 - I frequently submit SORs to the general contractor.

Figure C. 54 - Safety Participation Item Par 1.



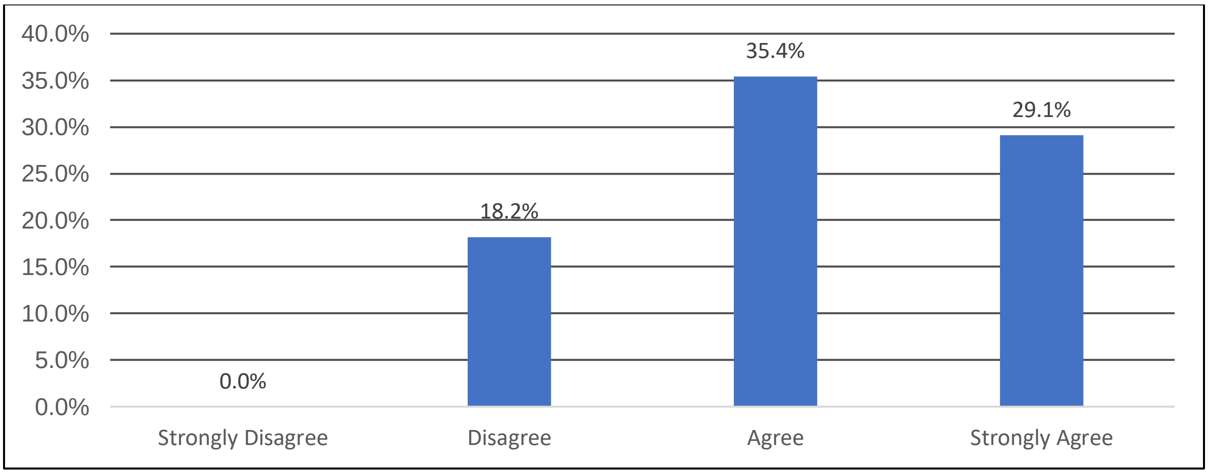
Item Par 2 - I frequently provide input and give suggestions for improvement at toolbox talks.

Figure C. 55 - Safety Participation Item Par 2.



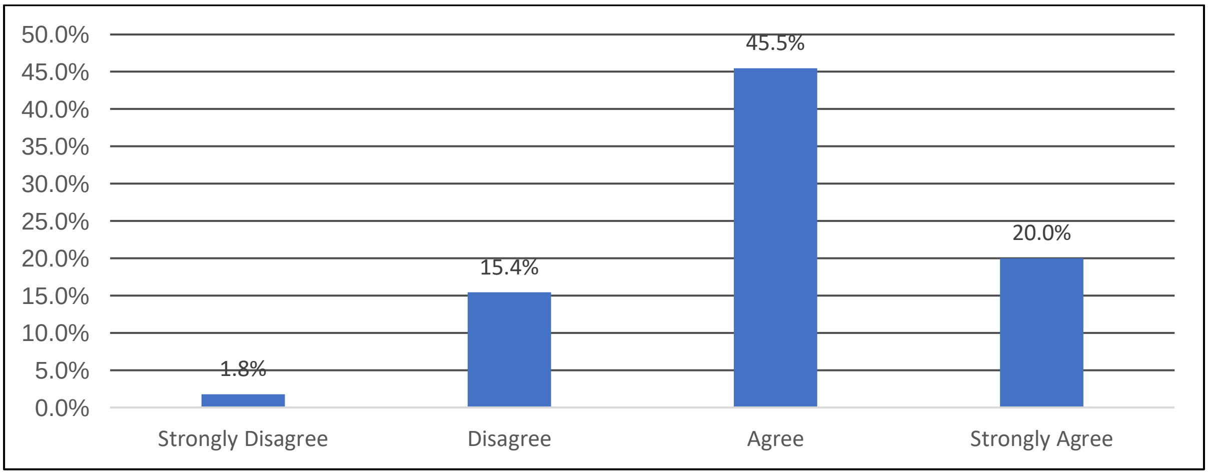
Item Par 3 - I frequently speak up and ask for opinions about workplace risks when completing the SPA.

Figure C. 56 - Safety Participation Item Par 3.



Item Par 4 - I frequently volunteer to attend safety inspections to improve workplace safety.

Figure C. 57 - Safety Participation Item Par 4.



C5. Safety Performance Results – Item Elaboration

Table C. 4 below shows the comments made by C1 workers and leaders in order to elaborate further on each safety compliance and safety participation item.

Table C. 4 - C1 Item Elaboration / Comments.

Com 1 - I follow the procedures and controls outlined in RAMS for the tasks that I perform.

Worker	*They were briefed to me after the induction, I follow what I can remember.*
Worker	*Yah, I think so.*
Leader	*No, not always. Sometimes things come up and you have to improvise.*
Worker	*I follow them. It's not rocket science.*
Leader	*The RAMS are important and we shouldn't be working if its covered in the risk assessment.*
Worker	*Yes, I do.*
Leader	*Sometimes the work changes and there isn't time to revise the RAMS, that's the only occasion when they are not followed.*

Com 2 - My co-workers follow the procedures and controls outlined in RAMS for the tasks that they perform.

Leader	*I played a role in writing them so I hope everyone is following them. I think the majority do.*
Leader	*I think everyone does. Most people seem to be working safe.*
Leader	*As a supervisor – I have to make sure they everyone follows them.*
Worker	*Not always. Sometimes you have to do things that are not on them.*
Worker	*Many of them do. I'd say about 90%.*

Com 3 - All of the workers in my company follow the site rules implemented

by the general contractor.

Worker	*Mostly, but the ladders last rule is stupid. I'll keep using the ladder for smaller jobs as it's quicker than setting up a scaffold.*
Worker	*We have to or else they will stand us down.*
Leader	*Some don’t. Mostly small things like not wearing glasses walking to the welfare.*
Leader	*Not all of them. Using a ladder when there are not supposed to.*
Worker	*I think every does generally, bar the odd few.*
Worker	*Yes.*
Leader	*We do, but a lot of other contractors don’t.*

Par 1 - I frequently submit SORs to the general contractor.

Worker	*We don’t have many first aid cases or near misses, so when it does happen, we report it to the safety team. Who reports it to the GC.*
Worker	*Yes, but only because I might win something for the best one.*
Leader	*Not as many as I probably should.*
Worker	*I do but I’m not sure what exactly the point is. Never really hear anything back about them.*
Leader	*Normally do 1 or 2 per shift.*
Leader	*Yeh usually do a couple every day.*
Leader	*I think it’s just a numbers game really, but I still put them in.*

Par 2 - I frequently provide input and give suggestions for improvement at toolbox talks.

Worker	*If I know the job then I normally will.*

Leader	*I normally lead some of the toolbox talks so I have to make the suggestions.*
Worker	*Just a tick box exercise.*
Worker	*Too many people at times and can't hear what is said.*
Worker	*I do.*
Leader	*Supervisor normally has to lead the toolbox talk so they all should be providing input.*

Par 3 - I frequently speak up and ask for opinions about workplace risks when completing the SPA.

Worker	*The SPA is good to help point of things that will cause us harm, but some jobs there will always be an element of risk involved even with the SPA done.*
Worker	*I give my opinion if something is missed out on. Other people need to do that too.*
Leader	*I think the supervisor should always have something to say or give input. It shows the others you care about safety.*
Leader	*I normally give an opinion if something needs to be said.*
Worker	*Only if I need to.*
Leader	*I normally do when I attend them but I don't always get the chance to attend.*

Par 4 - I frequently volunteer to attend safety inspections to improve workplace safety.

Leader	*I never been to one.*
Worker	*I go every second week normally.*
Leader	*Not as much as I should.*
Worker	*I've been to one but there were no managers so it was called off.*

Worker	*Every week. Normally me and the safety officer.*
Leader	I put my name down but when the time comes, I’m normally tied up with something else.
Worker	Sometimes but not all the time.
Worker	The supervisors don't come on many inspections with us, so we don't get to talk to them about safety issues much.
Leader	Kind of too busy to go to these.

Table C. 5 below shows the comments made by C2 workers and leaders in order to elaborate further on each safety compliance and safety participation item.

Table C. 5 - C2 Item Elaboration / Comments.

Com 1 - I follow the RAMS for the tasks that I perform.

Worker	*Not all the time, sometimes things come up and I need to get the job done quickly.*
Worker	*I try to but some things are just not covered in the RAMS and we need to get it done.*
Worker	*Don’t see the point in those RAMS.*
Worker	*Yeah, most of the time. Once or twice, I had to work away from them.*
Leader	*We have to as supervisors. You know, set the example.*
Leader	*I have to show the guys the right way to things, and that includes following what’s in the risk assessment.*
Leader	*Most of the time it works out. Sometimes I have to have the lads do things on short notice without time to revise the RAMS.*

Com 2 - My co-workers follow the RAMS for the tasks that they perform.

Worker	*Definitely not, but I don’t think there’s any bad intention.*

Worker	*No, they only see it once after induction. Most people would forget what's in it after a week.*
Worker	*They try to, I think. But pressure on them from management means they sometimes have to do things not included in the RAMS.*
Worker	*Yeah, I think most do.*
Worker	*Too much for to get done in short time doesn't help. The work changes so much the safety lads don't have time to revise the RAMS. When they do the job is already done.*
Leader	*I think everyone follows the RAMS. The safety does a good job of ensuring this.*
Leader	*The majority do. You will always get the odd one who does his own thing but we normally have zero tolerance towards that.*
Leader	*Pretty much all the workers do.*

Com 3 - All of the workers in my company follow the site rules implemented by the general contractor.

Worker	*Most do but only when the main contractor is on site. When they are not around, the gloves and glasses come off.*
Worker	*I always see them follow the rules.*
Worker	*All people do, even though some of the rules are stupid. They don't want to be kicked off site.*
Leader	*Everyone does or they'll be thrown off.*
Worker	*In general, I would say so.*
Worker	*Yes.*
Leader	*Most do. They know they will get yellow carded if they don't follow the rules.*
Leader	*I haven't had any complains about anybody not following the rules. I can only take that as everyone is following them.*

Par 1 - I frequently submit safety observation reports to the general

contractor.

Worker	*I was involved in an accident where I cut my arm. I reported this and do SORs too but don't see management fixing the issues.*
Worker	*We have to do one a week. I normally do 2 or 3. I was contacted about one before so they do get read.*
Worker	*I do but from what I've seen, it only seems to be me and my team doing them.*
Leader	*I've no idea what these even are.*
Leader	*I don't do them; I never think of it. Last time I actually did it was about a month ago.*
Leader	*I think these are just for numbers. I don't see the value so never do them.*
Leader	*Very rarely I submit them to be honest.*

Par 2 - I frequently provide input and give suggestions for improvement at toolbox talks.

Leader	*I don't have time to attended any of these [toolbox talks]. There are too many meetings, and we are behind schedule*
Leader	*I try to attend but when I do, I normally get pulled away to something else and can't give any input.*
Leader	*Never really go to them to be honest – I have other stuff to look after.*
Leader	*I do when I attend them.*
Worker	*It's mostly just the workers at these. We give our input but mostly never a supervisor there to give theirs.*
Worker	*I normally give my input or suggestion if its needed.*
Leader	*When I get to attended, I will normally lead the talk. It was fine at the start but now we are close to handover and just too busy.*
Worker	*Some people use these as a way to complain about the site.*

Par 3 - I frequently speak up and ask for opinions about workplace risks when completing the SPA.

Worker	*Most of the lads do this. Sometimes if it's a repetitive job though they will already know the risks.*
Worker	*I find when one person speaks up then the rest will follow and have their own say.*
Leader	*I don't get to join in when the SPAs are completed. I usually have run the morning whiteboard meeting at the same time.*
Leader	*Hardly ever on them.*
Leader	*I do if I get to go to them, lately it's been hardly ever.*
Worker	*It should be the supervisors leading these SPAs but they are never around in the mornings.*

Par 4 - I frequently volunteer to attend safety inspections to improve workplace safety.

Worker	*I go, but management is busy all the time and won't join our meetings. I think the [client name removed for confidentiality] programme is too demanding for them to keep up with.*
Leader	*We're not doing enough of these inspections. We're too stretched and can't get time to join.*
Leader	*The safety inspections are important but to be honest I never get a chance to join them. I don't think half the items get closed out.*
Leader	*Never on them – other more pressing issues at hand.*
Worker	*I'm not so sure that many of the items get closed out because management are never on the walks.*
Worker	*No point because the actions are left open for months and never closed off.*

C6. References

Cronbach, L. (1951) ‘Coefficient alpha and the internal structure of tests.’ *Psychometrika*, 16 (3), pp. 297-334. 10.1007/bf02310555.

George, D. and Mallery, P. (2007) *SPPSS for Windows Step By Step: A Simple Guide and Reference*. 14th . ed. Boston, Mass.: Pearson Allyn and Bacon.