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An integrated safety framework for the diamond mines: A case study from Namibia

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ABSTRACT

The Integrated Diamond Safety Maturity Framework is a novel, innovative approach to safety maturity that embraces four Cs, viz. Culture, Competence, Cultivate and Connectedness (4Cs) in a single framework, underpinned by corporate values. As a novel people engagement approach, this framework allows for considering the complexity found in the dynamic reciprocal relationships between these 4Cs and how these enable people to be the strongest link in safety. This safety framework was, for the first time, applied to a Namibian marine diamond recovery company to enhance the safety of its workers at the frontline and support the mines' safety maturity journey.

The objective of this paper is to examine the extent to which the application of the Integrated Diamond Safety Maturity Framework has assisted to enhance the safety of frontline workers as well as support growth in safety maturity. For this purpose, a longitudinal research design methodology was applied to determine changes in safety maturity. Data triangulation was used. It included qualitative safety climate assessments where the whole employee population participated in semi-structured interviews as well as document analysis, which entailed reviewing the leading and lagging data that was collected by the company.

The main findings of the study indicated that the application of the 4Cs approach can significantly shift an organisation towards Inherent maturity where people are ready to respond to the next risk.

The most advanced area was found to be the culture of leadership, in which many more employees took responsibility for and were accountable for their safety and that of their work teams. The selected lagging and leading indicators also showed improvements, which implied that the number of serious injuries was reduced, with fatalities eliminated.

The entire undertaking brings to light new field-based knowledge on how the implementation of the Integrated Diamond Safety Maturity Framework can significantly shift an organisation towards improved safety maturity. Further research is underway as new insights are revealed about the value of the Integrated Diamond Safety Maturity Framework and the role of leadership in eliminating fatalities.

1. Introduction

The Integrated Diamond Safety Maturity Framework is a novel safety framework that was developed and introduced to the diamond mining industry by Govender et al. (2022). It aims to pioneer safety maturity by embracing an integrated approach to safety that focuses on the 4Cs – Culture, Competence, Cultivate and Connectedness. The goal of the Integrated Diamond Safety Maturity Framework is to improve the safety performance of active diamond mines. The framework accommodates an integrated approach to managing safety. It focuses on a holistic view of the organisations' efforts to improve their safety in terms of both systems and culture while taking cognisance of the context of the organisation.

This novel framework was, for the first time, applied to a high-risk

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marine diamond recovery operation. The intent was to eliminate fatalities and engage its people, as the strongest link in safety, towards an improved safety maturity. As a case study, this paper provides a brief overview of the application of the framework and describes the outcomes of the application of this framework through a longitudinal method. The application of this framework was evaluated by reviewing and comparing the results of the baseline assessment with that of a follow-up assessment conducted in 2020 as well as by reviewing the lagging and leading indicators from 2017 up to 2022. The results indicated that the application of the 4Cs approach can significantly shift an organisation towards Inherent maturity where people were ready to respond to the next risk.

This case study assists with understanding the relevance of the Integrated Diamond Safety Maturity Framework in improving the safety maturity of the high-risk diamond recovery industry. The study brings new knowledge on mine safety to the fore, based on the introduction and application of the novel safety framework, illustrating how an integrated approach to safety can assist in improving safety performance.

1.1. Background to the current study

The current study was conducted within a high-risk offshore diamond recovery operation in Namibia. High-risk industries are those that have the potential for huge accidents since they have significant risks to humans, the environment and equipment (Grote, 2012).

At the Namibian offshore operations, diamond recovery is made possible using active vessels manned by crews of about 50 persons each, 365 days a year, with each person working a 28-day on-and-off-work rotation. Although recovering this treasure of gem-quality alluvial diamonds offshore has huge rewards, it is a risky operation (Richardson, 2007). The crew remotely carries out diamond recovery, processing, navigation, and other support activities using highly advanced drill technology and supported by sophisticated tracking, positioning and surveying equipment. Throughout these operations, the crew is required to deal with any eventuality that may arise while out at sea, with minimum assistance from shore. The operations are certified to applicable international standards for safety and environment.

Putting safety first is the offshore Namibian Diamond operations' number one value. This required that they move beyond the level of Compliance to a more mature level of Inherent where all management and staff have a deeply held conviction that safety risk management is essential for the well-being of people, the company, and the environment (Dekker and Pitzer, 2016; Pitzer, 2007). To truly live this value, they embarked on a safety maturity journey aimed at entrenching a fully inclusive culture of resilient beliefs and practices in everyone in the organisation. The journey was guided by the learnings from the Integrated Diamond Safety Maturity Framework (Govender et al., 2022), which included an integrated approach to improve its safety culture by focusing on people, systems, and processes.

2. Attitudes to risk and safety: the past, the present and the future

2.1. Safety risk management

Safety risk management is a process in which a company strives to maintain the safety of its employees. This is done by identifying and analysing all its threats and opportunities, considering various possible scenarios and responses, and implementing controls to minimise risks (Anju and Uma, 2017; Meagher and O'Neil, 2000). In many companies, the idea of 'risk' has negative connotations and is considered something to be avoided at all costs (Fraser and Simkins, 2010). A risk-mature approach recognises that risks are inherent in the daily operations of certain industries, and cannot be altogether avoided; they can, however, be managed and beneficially exploited (Fraser and Simkins, 2010). Risk-mature organisations move beyond the idea that risk is negated through employee compliance and view certain risky undertakings as opportunities for growth and profit. Nor are they reckless; they weigh possible benefits against creating and protecting value.

Bierc (2003) holds this view, finding that organisations that treat risk management as an exercise in compliance, with departments working in isolation from one another, invariably fail at adding value to their organisations. In this regard, the 'silo' effect is particularly challenging, creating inefficiencies owing to a lack of coordination across departments (Quon et al., 2012). Organisations should fully accept the reality of inherent risks and confront them with a coherent policy and practice. Risks should not be viewed as something to avoid at all costs or to deal with as a tick-box exercise. If an organisation can properly manage its risks, it stands a much higher chance of exploiting these risks to realise a competitive advantage (Ungerer et al., 2016).

Risk management frameworks are commonly used to facilitate risk management processes (Annamalah et al., 2018; Fraser and Simkins, 2010). The benefits of an effective risk management framework are that it creates value for the organisation; it ensures safety, minimises harm, boosts reputation and generates revenue. A sound risk management framework helps businesses to comprehend and manage the uncertainties of daily operations, and to be prepared to respond to a wide variety of possible scenarios (Fraser and Simkins, 2010). An organisation's safety culture framework can assist with managing risk.

2.2. Safety culture to Manage Risk

Organisations frequently reach a plateau in their safety performance, where the reporting of incidents, both actual and potential, dwindles to a minimum. This may be an indicator that a review of the safety management system is called for, suggesting either that too few considered risks are being taken, so that opportunities are lost, or that incidents are being underreported. When an organisation finds itself in this situation, most controls are likely to have lost their efficacy. A complete change of culture is then required for the organisation to advance it to the next safety maturity level (Stemn et al., 2019).

The concept of safety culture was first introduced after the 1986 Chernobyl disaster. In response to this disaster, the OECD Nuclear Agency Report (International Nuclear Safety Advisory Group, 1991) defined safety culture as "that assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, …safety issues receive attention warranted by their significance."

Cooper (2000) calls for recognizing the interactive and dynamic reciprocal relationship between the psychological, behavioural and situational factors that constitute any given organisation's safety culture. It introduces the holistic, multi-faceted nature of the safety culture construct where safety culture encompasses the subjective internal psychological factors (i.e., attitudes and perceptions), the observable ongoing safety-related behaviour and actions including safety leadership and the objective situational features (i.e., policies, procedures, safety management systems). By acknowledging this dynamic reciprocal relationship between psychological factors, safety-related behaviour and situational features, one can focus on how these practices interact with each other resulting in safety culture as a product (Cooper, 2000). Grote and Künzler (2000), relying on the sociotechnical systems theory (STS), also claimed that safety culture is to be understood as the product of the interplay of people, technology and organisation. STS theory recognises that at the interface between the two complex sub-systems of technology (equipment, machines, tools, technology as well as work organisation) and social (individuals and teams who need coordination, control and boundary management), collaboration towards a common goal needs to be facilitated (Carayon et al., 2015). According to STS theory, it is through the interdependency between these sub-systems and how they co-engage that a certain goal is reached. In this instance, the goal is to reach a resilient or inherent safety maturity where safety becomes the way of life and work.

Most organisations face a range of uncertainties and would benefit from a structured process for managing risk (Anju and Uma, 2017). The diamond industry has long needed a clearly defined safety culture framework that would mitigate against its high rate of accidents and failures. This would propel companies towards a higher level of safety maturity that, in turn, would enable appropriate exploitation of the risks. A safety framework is a structured approach to managing the processes, people and systems of an organisation (Le Coze, 2019).

The Integrated Diamond Safety Maturity Framework (Govender et al., 2022) is a novel, innovative approach to safety maturity that embraces four Cs, viz. Culture, Competence, Cultivate and Connectedness in a single framework, underpinned by corporate values. Table 1 summarises the focus areas of each C. Any intervention to improve the safety maturity of a mine, needs to take cognisance of all the C facets.

Underpinned by corporate values, the framework propagates that safety behaviours are informed by personal convictions instead of mere compliance. Being compliant with regulations is a necessary and respectful starting point since it accounts for the minimum requirements to be safe in most conditions. However, in high-risk environments, unforeseen conditions emerge which require responses beyond the boundaries of defined rules. Values are a resource for proactive resilience to be guided towards doing what is right, unaffected by external pressure. Values navigate the belief system that underpins how people are likely to perceive, feel, choose, and act in the moment when faced with challenges and danger (Maré et al., 2021).

Viewing safety as an emergent property that results from the interactions between the different sub-systems (Carayon et al., 2015) requires this framework to recognise people as the strongest, not the weakest, link in safety. Early researchers such as Lowrance (1976) saw safety as simply the absence of accidents, but this definition is now considered inadequate. As Cooper (2000) points out, there are many reasons why accidents may appear to be reduced. These could be that employees may simply fail to mention certain incidents in reports, to maintain an impressive number of 'accident-free' days in the workplace and so earn favour with their superiors. Hollnagel (2014) states that safety is more than a situation where 'nothing happens'; rather than being about the absence of accidents or incidents, it refers to avoiding unplanned, adverse outcomes. This requires that managers pay attention to how staff interact with equipment, with systems and with one another. Deliberate actions need to be taken to identify, prevent and mitigate emerging hazards. Safety is created and compromised constantly under varying conditions, so that safety is less an 'absence of something' than a 'presence of something' (Dekker, 2015). Safety requires the presence of an adaptive capacity in employees. This adaptive capacity entails the capability to identify, absorb and adapt to deviations that fall outside the normal parameters of a system. Safety management is about recognizing and improving the positive capabilities of employees and organisations in ways that enable them to adapt effectively and safely under changing and resource-constrained circumstances (Dekker, 2015).

Ultimately, this means creating a company culture in which employees are empowered to consider risk in all their decisions, rather than striving simply to comply with a list of requirements (Altuntas et al., 2011). Such a culture would encourage openness and honesty about reporting incidents, on the understanding that only when incidents are made known can steps be taken to prevent and mitigate against their re-occurrence. Similarly, Reason (1998) stated that a safe culture is an *informed culture* where the members of the organisation understand, respect, and remain alert to the hazards in their work environment. To enable an informed culture, it is necessary to socially engineer a *reporting culture* where people feel psychologically safe to report any safety-related mistakes and near-misses. Psychological safety is underpinned by a *just culture* which represents how the organisation handles acceptable and unacceptable behaviour. For this sort of culture to evolve within an organisation, leaders need to work at creating a participative and safety-orientated environment. Here, employees feel empowered to talk about problems they are encountering without fear of punitive consequences– even when their actions may have contravened established work practices (Sax and Torp, 2015). Company leaders have a critical role to play in creating an open, collaborative, and non-punitive environment that enables workers to be the strongest link in responding to risks.

The Integrated Diamond Safety Maturity framework (Fig. 1) allows for considering the complexity found in the dynamic reciprocal relationships between several sub-systems, which in turn, influences the safety culture of a given organisation.

Table 1
The four Cs unpacked (adapted from Govender et al., 2022).

C	Operational Actions	Focus Areas
Culture of leadership in all people	Care for all	• Mindsets & beliefs • Trust and respect • Creating a context through a common purpose and values • Teamwork • Psychological safety to speak up • Leadership • Fair approach to consequence management (culture of fairness)
Competence of all people	Can do work safely	• Risk competence • Safety competence • Leadership competence • Skills development
Cultivate value in and by people through dynamic risk awareness	Commit to improve	• Innovation • Optimisation of systems • Risk reporting (reporting culture) • Incident review and learning (learning culture)
Connectedness of people and systems	Couple safety in every task	• Connectedness of systems • Technology integration and readiness • Employee/Contractor analysis

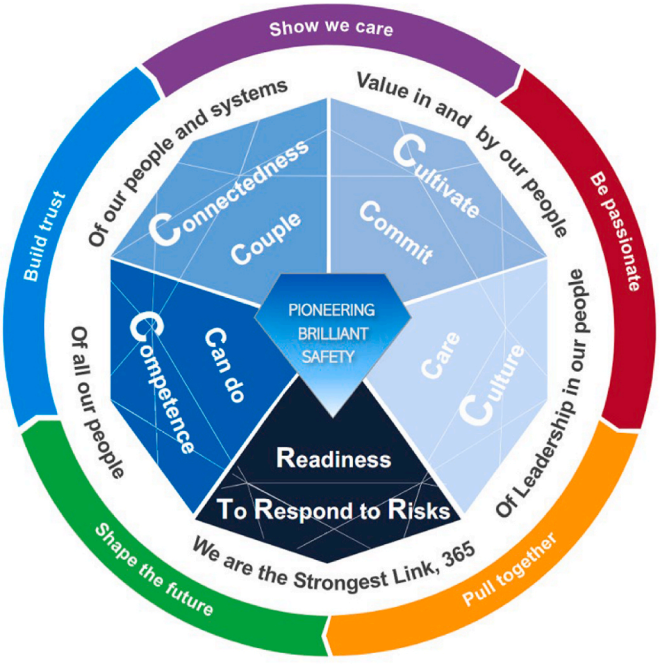


Fig. 1. The integrated diamond safety maturity framework (De Beers, 2020).

2.3. Maturity models to evaluate safety performance

Most maturity models comprise a series of maturity levels, each defined by certain key features (Becker et al., 2009; Wendler, 2012; Filho and Waterson, 2018). They are widely used in high-risk industries such as the offshore, logistics and oil and gas industries (Foster and Hoult, 2013), and have recently been implemented in other, non-safety-related disciplines such as the Management Sciences, Digital space, Enterprise Risk Management and Insurance and Processing (Parker et al., 2006; Becker et al., 2009; Maier et al., 2012; Wendler, 2012; Farrell and Gallagher, 2015).

The proliferation of maturity models in recent years is unsurprising, as they have been around for some time, first coming into effect in the 1970s. While there has been some evolution in the models, the key features have remained consistent; most comprise discrete stages in a journey from low-risk maturity to high-risk maturity, with some overlap.

From the plethora of safety maturity models available, The Mineral Industry Risk Management Maturity, Ghanaian mining industry, UK coal and the Integrated Diamond Safety Maturity Framework are novel models with limited data (Stemn et al., 2019; Govender et al., 2022) Westrum's (1993) seminal study is frequently cited. Filho and Waterson (2018) reviewed 41 publications describing safety maturity models and found that over two-thirds were based on Westrum's model, with some notable differences. Westrum's (1993) work is fairly limiting in that it allows for only three stages, which are ambiguous and difficult to apply to organisations that may be at different levels in the maturity continuum. Fleming's (2007) model covers a significant number of elements; however, it places a premium on organisations with a high safety maturity. Hudson (2001) builds on the work of Westrum (1993) by changing the naming of the maturity levels and adding two levels, giving it more depth and application to assessing safety maturity than Westrum's model. A summary of the main safety maturity models, including the novel Integrated Diamond Safety Maturity Framework (Govender et al., 2022) is shown in Table 2 (Westrum, 1993; Parker et al., 2006; Foster and Hoult, 2013; Stemn et al., 2019).

Most organisations have not progressed very far along the safety maturity journey, by whichever of the models they may be assessed. A key feature of low-maturity organisations is that they view humans as a weakness, not as a potential source of strength. Rather than investing the requisite time and expense in thorough education and training, they opt for safety practices based on control, compliance, and quantification (Dekker and Pitzer, 2016). Organisations at higher maturity levels recognise that every safety-related incident is unique, and that compliance alone will not result in an incident-free workplace. Mature organisations acknowledge that their greatest asset in maintaining safety is an informed, educated and empowered workforce that can respond appropriately to any given safety risk. In organisations like these, humans are the strongest link (Dekker and Pitzer, 2016). An example of a low level of safety maturity was the Deepwater Horizon explosion of 2010, in which all who complied with the regulation to stay onboard unless otherwise instructed died in the flames, while those who abandoned the rig without waiting for command survived (Reader and Oconnor, 2014).

Progress on the safety maturity journey requires that companies move away from a blame-centred culture towards one where mutual respect and trust characterise the relationship between managers and employees. Managers begin to value the experiences and insights of employees who work in hazardous circumstances. Employees are recognised as the key to maintaining an incident-free environment. Hudson (2007) stated that as organisations advance along the journey to safety maturity, accountability and trust inevitably increase.

The Integrated Diamond Safety Maturity framework is also applied against a maturity model, as illustrated in Fig. 2. The safety maturity model that Govender et al. (2022) introduce, adapted from Hudson (2007), brings an integrated approach towards reaching safety maturity at the business and site level. It also offers more flexibility in practically

Table 2
Summary of maturity models adapted from Ndeunyema (2020).

	Safety Risk Management Maturity Models and frameworks			
	Typology of organisational cultures Westrum (1993)	Safety Culture Maturity Model Fleming (2007)	5 Stages of Safety Maturity Hudson (2001)	4C's Integrated Framework Govender et al. (2022)
Level descriptors	Pathological, bureaucratic, and generative	Dependent, independent, and interdependent	Pathological, reactive, calculative, proactive, and generative	Basic, responsive, participative, citizenship and inherent
Elements	–	10 Elements	11 SMS and 7 Culture	4Cs: Cultivate, Culture, Competence and Connectedness
Adapted from	Seminal	Capability maturity models used in software	Westrum	Adapted from Hudson and included new elements
Advantages (A) Disadvantages (D)	**(D)** The three stages are ambiguous and lack sufficient depth to make any real impact on organisations.	**(D)** Only applicable to organisations with: 1) a functional safety management system 2) technical failures that are not dominant 3) a no-blame culture … and that are compliant with safety laws	**(A)** Has been around for many years and has been used extensively. **(D)** Places greater emphasis on the system's components than on the culture's components.	**(A)** Integrated approach towards reaching safety maturity at business and site level. Includes both, qualitative and quantitative analysis. Developed for practical applications. **(D)** A new approach with limited data.
Industry	General	Offshore	Aviation, Healthcare, Oil & Gas	Diamond Mining
	Mineral Industry Risk Management Maturity Stemn et al. (2019)	**Ghanaian mining industry** Stemn et al. (2019)	**UK Coal** Stemn et al. (2019)	
Level descriptors	Vulnerable, reactive, compliant, proactive, and resilient	Basic, reactive, compliant, proactive, and resilient	Basic, reactive, planned, proactive and resilient	
Elements	3 SMS and 10 Culture	3 SMS and 10 Culture	12 integrated elements	
Adapted from	Hudson	Westrum	Westrum	
Advantages (A) Disadvantages (D)	**(A)** Recognises that culture and systems must progress up the ladder.	**(D)** Culture aspects are limited.	**(A)** Culture and system elements overlap. Focuses on the effectiveness of standards and continuous improvement	
Industry	Minerals	Minerals	Minerals	

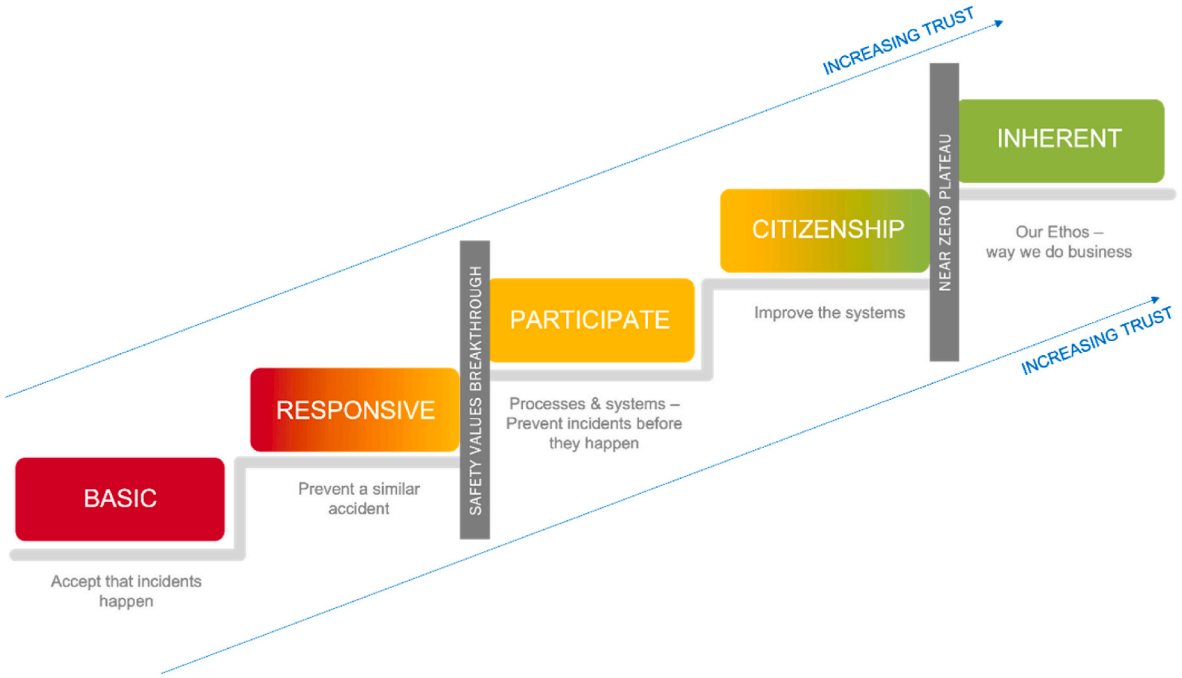


Fig. 2. Maturity model as adapted from Hudson (2007).

understanding the levels of maturity across the different sub-systems in the organisation.

As Fig. 2 shows, trust increases across the maturity levels, with more control defining lower levels of maturity. Trust is inversely related to control; low trust requires stringent control measures, while high trust requires a loosening of formal control measures. In some organisations, trust has developed to the point where control is no longer the primary means of managing behaviour (Costa and Frankema, 2007; Dekker and Pitzer, 2016). Dekker and Pitzer (2016) point out that a compliance culture does not allow for innovation, flexibility, and adaptation when circumstances alter. They recommend that high-risk industries re-examine and move away from models that stress risk control and compliance to a model that allows for uncertainty, flexibility, and constant adaptation.

In the ideal situation, employees are trained to become 'risk competent' and to assess every situation with risk in mind. Where a culture of trust prevails, and the prerequisite investment in training has been made, those who are most exposed to risk are given greater control and decision-making powers. Greater control and decision-making power enable employees to respond exactly as the situation demands in any given situation (Dekker and Pitzer, 2016). This is not an argument for flouting established procedures. Relationships of trust are based on a thorough assurance that those invested with risk-related decision-making powers have been well-trained to assess and respond to every eventuality. In organisations with low levels of trust, incident secrecy occurs, with workers in effect incentivised to hide incidents from fear of being penalised (Dekker and Pitzer, 2016). More trust among employees and managers, based on employees' levels of experience and knowledge, would engender a greater propensity to acknowledge and report incidents and to learn from adverse incidents. Trust is an essential component of a mature safety model when coupled with a high standard of training. Such training drills the workforce in the basics of safety management and yet acknowledges the dynamic nature of the workplace, and therefore the need for flexibility and a measure of independent thinking when under duress. However, high levels of trust should not be viewed as the only route to risk maturity. Trust must be coupled with a high level of initial training and ongoing updates to the risk response as technologies and systems change. A situation to be avoided is one where a manager suspends all judgement of an employee and remains entirely 'hands-off', which can result in betrayal and disappointment (Costa and Frankema, 2007). Trust must be coupled with sufficient high-quality training in hazard identification, appropriate readiness to respond to incidents, ongoing monitoring, honest reporting and open discussion.

3. Application of the integrated 4C framework

The safety maturity journey that the Namibian offshore diamond recovery mine embarked on, included an integrated approach to improve its safety culture by focusing on people, systems, and processes. The journey commenced in 2017 with a baseline safety maturity review. It encompassed a safety climate assessment by reviewing the shared perceptions of employees regarding underlying values, beliefs and practices related to safety as well as an audit of its Fatal and Major Risk control standards by reviewing specific controls that are associated with identified fatal risks. The audit included a review of the infrastructure, systems and behaviours required to encourage effective management of fatal risks relevant to the marine diamond recovery industry.

The company used the assessment outcomes as a starting point to inform an integrated approach towards resilience in safety maturity. The safety maturity journey was based on the company values, spearheaded by the value of Putting Safety First. The values defined a meaningful social agreement regarding behaviours that are visibly displayed and enacted by employees.

The journey interventions were aimed at decentralising the ownership of safety from systems, policies, and supervisory responsibility to a fundamental matter of importance for individuals at all levels. Aimed at empowering employees to be the strongest link, required encouraging people to be non-positional safety leaders - regardless of whether someone has a leadership title or not, everyone is accountable for ensuring safe production (Maré et al., 2021).

The intent was to create a climate of transparent safety conversations and accountability where employees fear less to speak up and leaders are prepared to deal with different interpretations, suggestions, and appeals. The required shift involved moving from fear and blame to opportunities for learning and prevention. As a workforce becomes more resilient, it

requires of the organisation a level of adaptability and responsiveness to lead on at least the same maturity level as most of the team members reporting to them. Also, a culture that promotes every team member as a safety leader must treat all individuals with the trust, dignity, and respect that such a mandate implies (Maré et al., 2021). This required critical competencies from their leadership team that were addressed as part of the journey interventions. It included targeted leadership psychometric assessments and a custom-made development process based on a leadership competency success profile that was defined per leadership level and informed by the existing leadership frameworks, company values and business priorities. Approximately 160 leaders participated in this development process. It included over 250 h of individual feedback sessions for all the leaders based on the results of the psychometric assessments. Over a duration of three year, the leaders also attended bi-monthly group leadership coaching and development processes.

Unique to the integrated approach of this framework, the targeted focus was not only aimed at the psychological and behavioural factors of safety but also the situational factors. Between 2018 and 2019, the company reviewed and simplified the Safety Management System to support a consistent approach to safe practices across the fleet. Experts in risk management practices were also onboarded to support employees with methods to improve risk awareness and mitigation. Several training programmes, such as SafeSentry were offered to this end, each with a particular focus proven across industries globally. This training was based on the Integrated Safety Maturity framework's premise that people are the solution and not the problem. SafeSentry is a front-line employee-driven risk discovery system, focusing on the continuous identification of randomly shifting risks. With SafeSentry, employees are mandated as non-positional safety leaders. Daily, people are identified as a 'safe sentry' with the goal being to identify risks, observe team members' behaviour and support people in working safely. Metrics were reviewed as some of the traditional metrics were viewed as insufficient because lagging indicators do not allow for proactivity and resilience in a more mature safety culture. These metrics included Readiness, Respond, Risk, and Resilience. Significant effort was also put into simplifying and improving the Operational Risk Management (ORM) system's overall effectiveness. All the interventions were backed by the senior leadership team and driven by a relentless effort to ensure sustained momentum for change to succeed (Maré et al., 2021).

The interventions speak of the integrated approach to adapting processes and engaging people to influence the safety performance of this organisation. The follow-up assessments conducted were aimed at the validation of the application of the integrated 4C framework.

4. Methodology

Lawrie et al. (2006) state that a valid safety culture assessment needs to consider quantitative indicators as well as the experiences and opinions of staff. Quantitative indicators would include audits, training documents and accident reports and investigations. Assessors will gain a more accurate and balanced view of the safety culture in an organisation by casting the net wide and considering all aspects of the company.

A longitudinal research design was used in which data were collected during three different time intervals to measure and analyse change over time (Menard, 2004). This assessment was done to determine the extent to which the application of this integrated framework has assisted the high-risk diamond recovery operation in Namibia to grow in safety maturity. To enhance the confidence of the findings, triangulation was used. With triangulation, multiple sources of evidence are used to develop converged findings (Yin, 2018; Bryman, 2004). Triangulation assists in improving the construct validity of the study (Yin, 2018). Data triangulation (Denzin, 1970) was used, with the sources of evidence being documentation and interviews (Yin, 2018). According to Cooper (2000), a triangulation methodology allows for a multi-level analysis of the safety culture as a construct.

The assessment took place at three different time intervals. Interviews (both individual and group interviews) were conducted in 2017 to assess the safety climate. During the last quarter of 2019 and the first quarter of 2020 follow-up interviews were done to assess the safety climate again. The document analysis included a review of leading and lagging data collected between 2017 and 2022.

Data triangulation for this project is shown in Fig. 3.

4.1. Interviews to assess safety climate

To assess the safety climate of the organisation, interviews were used during which people were allowed to share their experiences and the meanings they attach to those experiences related to workplace safety. According to Griffin and Curcuruto (2016), a safety climate is based on shared perspectives regarding safety policies, procedures, and practices in the work context. These perceptions provide cues and inform behaviours and outcomes related to safety. The interviews were conducted at two different interval points: September to November 2017 and again from December 2019 to January 2020.

4.1.1. Sampling

No sampling was done for both rounds of interviews. The work covered the full workforce complement of the company. All the employees (>900) were included in the assessment, with a participation rate of approximately 95%.

For the 2017 safety climate assessment, a total of 244 interviews were conducted. Of the 244 interviews, 113 interviews were focus group interviews with the frontline workers. Each focus group interview included a maximum of 10 people in a group. The group interviews were approximately 2 h in duration. Individual interviews were done with people in management positions, each ranging in length between 45 and 60 min, in total, 131 individual interviews were done. For the 2019 to 2020 safety climate assessment, a total of 227 interviews were conducted, inclusive of individual and focus groups. In total, 106 individual interviews took place, each ranging in length from 45 to 60 min. A total of 121 focus group interviews took place with the duration of each focus group interview being approximately 2 h. Focus groups included a maximum of 10 people in a group.

4.1.2. Data collection

Semi-structured individual and focus group interviews were conducted. The interview protocol featured several focus areas that were based on the 4Cs. Each focus area comprised sub-categories as follows.

- **Culture:** Commit to Safety (safety value); Trust in Leadership (people vs task orientated, communication); Response to Failure (discipline, performance management)
- **Competence:** Risk pressure (production pressure, risk incentives, rule knowledge); Empowered to make decisions (alignment of decisions, stop-work authority); Operational integration between safety and tasks
- **Connectedness:** Reinforcement of work well done; Engagement & inclusion (consultation, follow-up); Impact of Teams' actions (caring in team, teamwork)
- **Cultivate:** Safety practices (training, priorities), Employee stressors, Risk Transparency (risk reporting, incident reviews)

Questions were crafted to uncover the critical factors needed by the 'human system' to transform and meet the requirements of a mature safety culture (refer to Appendix 1 for an outline of the interview protocol).

Audio recordings of interviews were transcribed. These transcriptions were used as the raw data to be analysed.

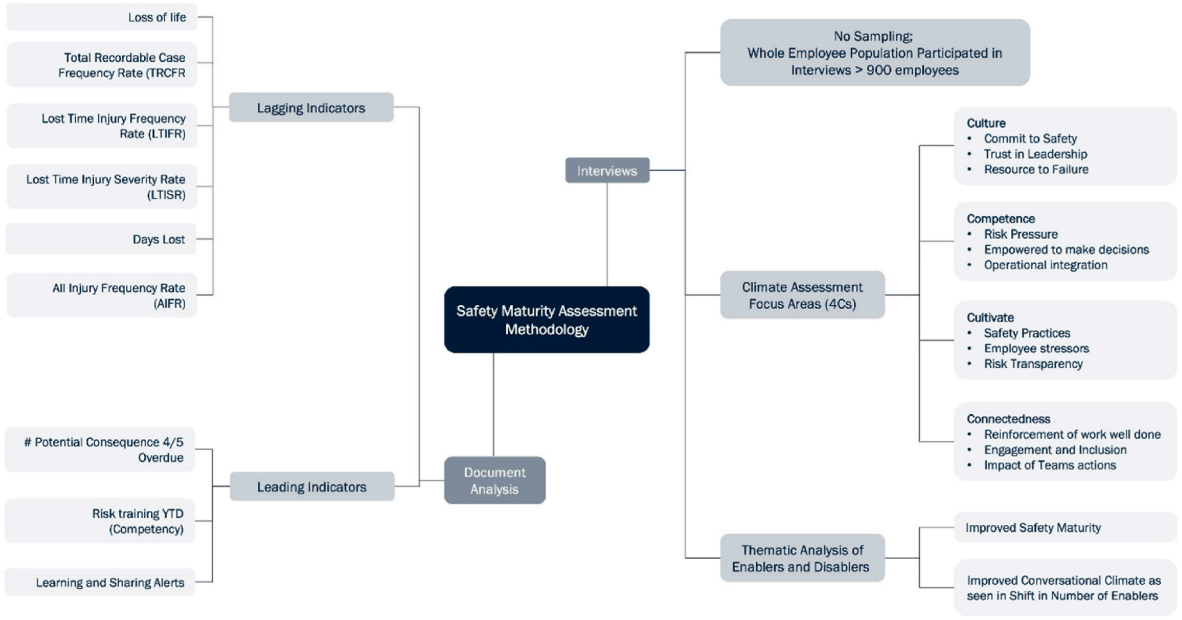


Fig. 3. Data triangulation.

4.1.3. Data analysis

4.1.3.1. Data coding. A qualitative data analysis programme, QDA Miner, was used to assist with the coding and management of the approximately 8200 pages of transcribed interviews.

During the thematic analysis (Nowell et al., 2017) a polyvocal process was applied, which entails acknowledging and analysing the multiple perspectives of people, whether or not they appear contradictory (Saldana, 2013). The intention was to include all data of relevance. This included magnitude coding (Saldana, 2013) which entailed identifying the frequency of themes coming up across the interviews. The purpose and value of the theme frequency ratings are that it indicates the relative importance of the theme in comparison to other themes identified. Frequency counts for themes were accounted for when it was mentioned in an interview. For the analysis of the focus group interviews, the frequency count of themes was done based on whether the theme was mentioned by respondents in each focus group. The total frequency count for the study in the results is therefore based on the frequency of reference to any theme across groups. The statistical capabilities of QDA Miner to provide code frequency counts across cases were used to assist with these frequency counts.

Apart from the prevalence of data saturation that became apparent when working through the data, the unsolicited recurring of themes across groups indicates the high credibility and importance of the themes. Additionally, this analysis process did not only augment but also allowed recurring nuanced themes to emerge. This process supported the credibility of the relevant themes/categories identified.

4.1.3.2. Data interpretation. Interviews were analysed to identify the enabling and disabling attitudes and behaviours related to safety. Enablers are positive attributes that contribute to a high safety risk maturity, while disablers are those that limit or inhibit progression to safety maturity. By focusing on enablers, organisations can reduce or eliminate disablers and move to higher levels of safety risk maturity.

The final themes identified per the 4Cs along with their frequency ratings were used to assess the level of safety maturity for both offshore and shore-based teams as well as to determine the level of safety maturity for the organisation.

4.2. Document analysis - leading and lagging metrics review

The document analysis included the leading and lagging data analytics approach and methodology described by Govender et al. (2022) Lagging metrics selected included: TRCFR (Total recordable case frequent rate); LTIF (Lost Time Injury Frequency Rate); LTISR (Lost Time Injury Severity Rate; AIFR (All Injury Frequency Rate) and HPH (High Potential Incident). Leading metrics that were included in the analysis are number of potential consequences, risk training as well as learning and shared alerts (e.g., SafeSentry).

These metrics are a proxy for the safety performance of the organization and provide leadership with trends, following analysis, to predict and avoid incidents (Govender et al., 2022).

5. Results

5.1. Qualitative safety climate assessment

What has been learned from this journey thus far is that safety improvement initiatives need to focus beyond improving the systems, procedures, and technology i.e., Connectedness. What is also required is a focus on culture and leadership and how culture and leadership influence and enable people to be the strongest link.

5.1.1. Safety maturity across the 4Cs

After the 2017 assessment, the principles, and practices of the Integrated 4C Safety Framework were applied to assist with developing an intervention that will support the company to grow in its safety maturity. The results indicate an improved shift in safety maturity with Inherent and Citizenship maturity levels increasing whilst Participative maturity levels decreasing. Key insights from both the 2017 and 2020 assessments are further unpacked below.

5.1.1.1. Key insights from the 2017 assessment. The results, as shown in Fig. 4 indicated that the organisation's maturity in 2017 was mostly Participative, with elements of Responsive and Citizenship.

The themes identified in the analysis of the data, were dispersed across all 4C facets of the Integrated Safety Framework – Culture, Cultivate, Connectedness and Competence. This points to how the safety maturity of the organisation is influenced by the interaction of all 4C

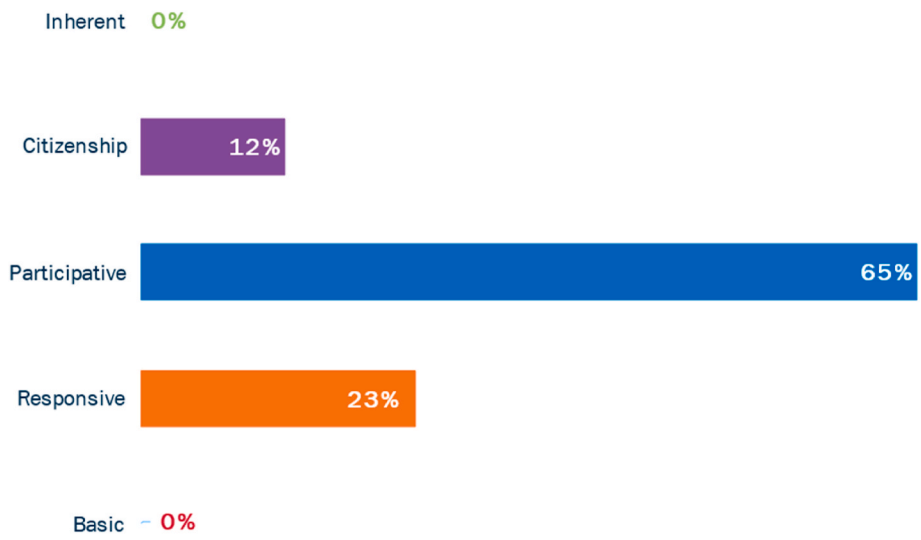


Fig. 4. Safety maturity results - 2017.

facets. It is therefore important to embrace an integrated approach toward managing safety whereby the 4C facets of the Safety Framework are translated into operational actions (Govender et al., 2022).

5.1.1.2. Key insights from the 2020 assessment. The 2017 results were used to inform an integrated approach to address the safety maturity of the organisations. In 2020, a follow-up qualitative assessment took place. Once again, all employees participated in interviews to share their experiences of the workplace by focusing on similar conversational topics as the 2017 assessment.

Fig. 5 introduces a maturity view for 2020 along with the 2017 results that serve as the baseline.

In the 2020 assessment, the results indicated that constructive movement had taken place specifically on the Citizenship and Inherent maturity levels. Maturity on the Citizenship level improved by 12% whilst themes for the Inherent level appeared for the first time since the baseline assessment. This indicates that new themes emerged during the 2020 conversations that point to resilient attitudes and experiences within the organisation.

Maturity shifted towards a Citizenship level across all 4Cs. During the interviews, employees indicated that the training introduced by the company, assisted people to remain alert regarding safety. These training initiatives were recognised as contributing towards a Citizenship level in the Competence facet. Creating Competence through constructive coaching approaches was also pointing towards a Citizenship maturity level whereby crew members believed that coaching was starting to replace discipline as a way to correct safety behaviour. Citizenship practices on the Connectedness facet also improved. Shifts in the Connectedness facet entailed for example people overlooking the burden of paperwork related to safety procedures by instead focusing on the value that safety procedures play in keeping people safe. Reluctance to apply stop-work authority had been replaced with a sense of psychological safety to apply this stop-work authority when needed. Practices related to the Cultivate facet also contributed to an improvement in the Citizenship maturity level. Employees indicated that they are not only encouraged to share their opinions and thoughts but are also listened to when they do share. This creates opportunities for innovation in how things are done. To this point, cognisance should also be taken regarding the change in the influence style of the leadership team. Managers and supervisors started changing their approach to people with a more engaged and inclusive approach. This change in approach resulted in creating more psychological safety for team members to speak up.

On the Inherent maturity level, a noted shift took place from 0% in 2017, to 14% in 2020. Employees have internalized safety as a value and thereby acknowledged safety behaviour as a preferred way of being instead of only complying with safety procedures out of respect for company rules. This internalization of safety has had a spill-over effect on their families, where safety is also becoming a value in their homes and not only a rule that needs to be adhered to when at work. The

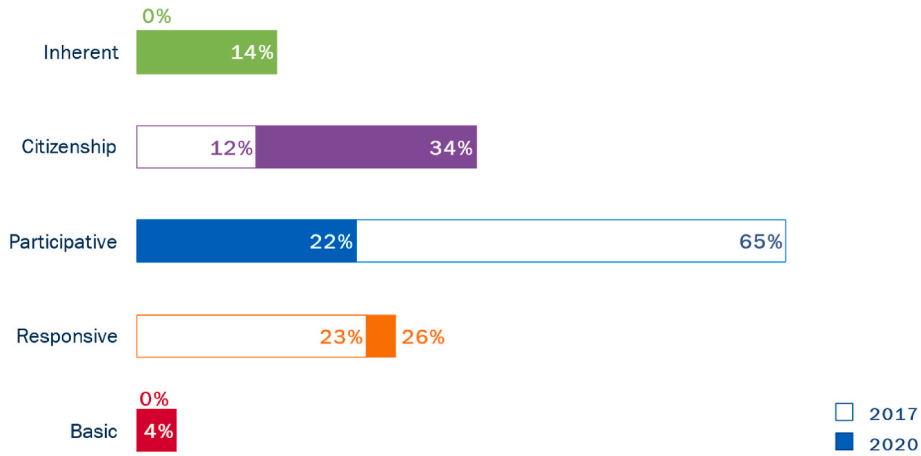


Fig. 5. Safety maturity Results – 2017 & 2020.

importance of coupling safety to production is also a theme that emerged. People are realizing that safe production is a company value that is prioritized in all that they do.

Interestingly, as Fig. 5 illustrates, a combined increase of 7% was recorded at the 'Responsive' and 'Basic' maturity levels. The Basic maturity level increased from 0% to 4% whilst the Responsive level increased from 23% to 26%. Against the lens of maturity, more responses on the 'Basic' and 'Responsive' levels present a realistic indication of increased maturity. This phenomenon reflects employees' increased comfort in raising unpopular and previously off-limits topics. In other words, as speaking up becomes safe and more important, people are comfortable raising matters that had been avoided during the first assessment in 2017. A high recurring theme across the interviews that have contributed to the Responsive level, is the frustration people are experiencing with an unwillingness from certain individuals to change their behaviour to allow for more collaboration in managing safety. This is specifically related to certain managers who seem unwilling to adjust their leadership style towards a more participatory approach which in turn allows for all employees, regardless of rank, to become safety leaders.

The Participative maturity level decreased from 65% in the 2017 assessment to 22% in the 2020 assessment. Due to the regulatory environment of the mining industry, it remains important to adhere to safety procedures and rules. Themes identified from the 2020 interviews that contributed to participative maturity level include recognizing the value of and adherence to safety procedures and rules. The theme of recognizing the value of stop-work authority in keeping others safe as well as applying one's stop-work authority when a situation is assessed as unsafe, all contribute to the Participative maturity level.

5.1.2. A continuous state of fluidity - enablers & disablers

The overall trajectory in the organisation is positive and dynamic in its continuous state of fluidity. A comparison between the 2017 and 2020 themes illustrates how the focus of the interviews shifted across the two assessment periods. Because all transcribed interviews were coded according to either enabling or disabling themes, it offers an opportunity to review the overall data in terms of the total percentage of themes coded as enablers and disablers. When comparing the shift in the percentage of the enablers for 2017 and 2020 in Fig. 6, the general conversational climate becomes apparent between the two assessment points.

In 2017, for example, the total percentage of disabler themes coded in the Connectedness facet was 59% whereas the total percentage of disabler themes coded in 2020 was 48%. On the other hand, for the 2020 data, the total percentage of themes coded as enablers in for example the Culture facet was 74%, compared to the 49% of enabler themes coded in 2017. This points to a shift in experiences for the crew, whereby what was front in mind for discussion during the 2020 interviews were much more constructive in terms of their experiences of the safety climate as compared to that of 2017.

5.2. Safety performance shifts based on lagging and leading metrics

The results from the quantitative safety performance data collated between 2017 and 2022 (October) are shown in Table 3, to demonstrate the impact of the safety maturity journey. It is expected that as the organisation becomes comfortable with small group conversations and is actively hunting for hazards, the number of high-risk related safety incidents would decrease. To further support a safe working environment, Govender et al. (2022) concluded that with an increase in SafeSentry observations by the frontline workers, who were trained to identify hazards and co-create solutions, there would be an elimination of fatalities and a reduction in serious injuries.

The targets were set to achieve a stretch in safety performance related to injury reduction and SafeSentry observations. The green status is indicative of improvements relative to the set targets being achieved, which applies to zero loss of life or achieving fatality-free operations. The business had achieved its target of eliminating fatalities and serious injuries.

There was one medical treatment and one lost time injury case across the business. The injury frequency rate targets were not achieved due to the extended period of recovery by the injured. The injury is related to low-risk areas, which in this instance was a finger injury with extended time to recover supported by direct access by the injured to a medical doctor to support full recovery.

Leadership stressed that safety is not the absence of incidents, rather it is the presence of capabilities to identify unsafe acts and conditions and proactively respond and prevent future incidents. This narrative encourages people to report all observations and incidents. The focus of leadership was therefore on increasing the SafeSentry observations as a proxy of people speaking up and stopping unsafe work. There was a threefold increase in SafeSentry reporting with mitigation actions being

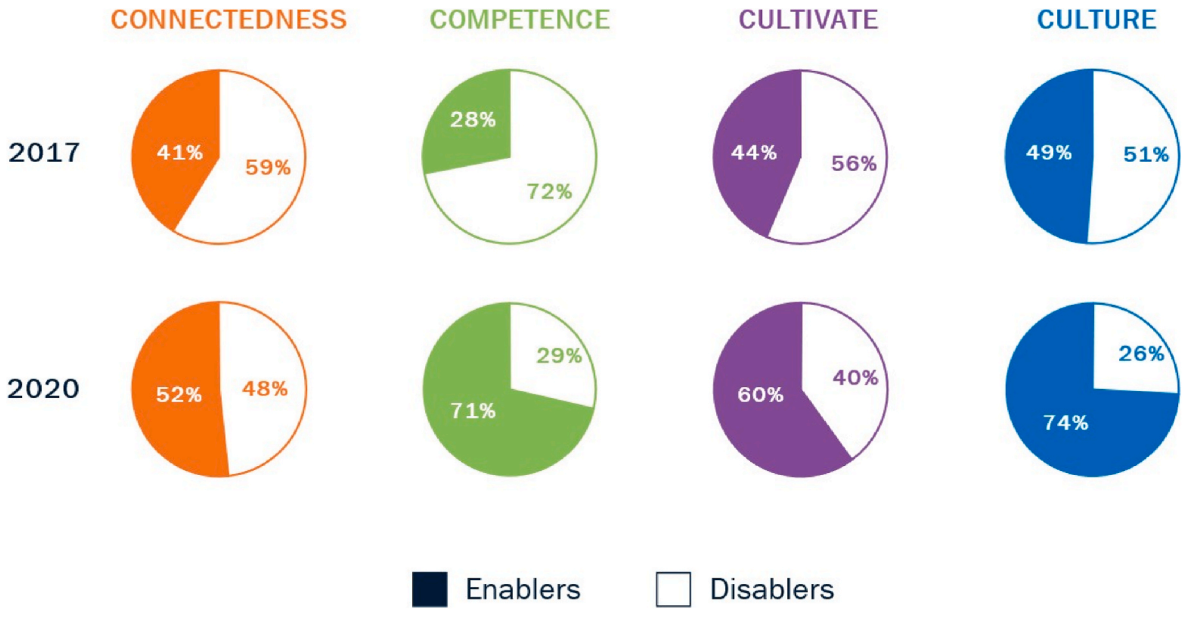


Fig. 6. Percentage of enablers and disablers – 2017 & 2020.

Table 3
Safety metrics for 2017 to 2022.

Metric	2017 FY	2018 FY	2019 FY	2020 FY	2021 FY	2022 Actual End Oct	2022 Limit End Oct
Loss of Life	0	0	0	0	0	0	0
All Injury Frequency Rate (AIFR)*	13.98	13.97	10.15	10.65	6.76	10.72	7,57
Total recordable case frequency rate (TRCFR)*	2.42	4.03	2.03	0.86	0.90	1.02	0,9
Lost time injury frequency rate (LTIFR)*	1.08	2.42	0.87	0.86	0.45	0.51	0,45
Lost time injury severity rate (LTISR)*	45.70	42.44	42.49	27.91	14.20	40.33	~
MPI and HPI (number)	5	4	4	1	4	1	~
MPH and HPH (number)	–	–	–	4	3	4	~
Lost Time Injuries (number)	4	9	3	3	2	1	≤2
Medical Treatment Cases (number)	5	6	4	0	2	1	≤1
First Aids Cases (number)	43	37	31	34	26	19	~
Days lost	170	158	96	97	63	79	~
SafeSentry Observations (number)	~	~	~	~	576	1505	1820

~ No Target Set.

tracked and fully implemented to prevent future incidents. The effectiveness of the SafeSentry action closeout was confirmed as the number of overdue actions related to the potential consequence 4/5 (single or multiple fatalities) hazards was 0% at the point of reporting.

6. Discussion

According to Govender et al. (2022), safety performance improvement approaches typically tend to adopt a reactive approach. Such an approach includes tracking lagging metrics, focusing on systems and processes as the required and effective controls for managing safety and a human factor analysis orientation which tends to result in a workforce who fears to report as people's errors become the focal point of the investigation. Instead, they argued that by applying the Integrated Safety Framework, which supports the belief that people are the strongest link, the organisation can increase its safety maturity, risk awareness and competency. This, in turn, enables people to respond to dynamically changing risks (Govender et al., 2022).

In this case study, it becomes apparent how this integrated framework assisted the organisation to increase its safety maturity. The organisation studied used the results of the 2017 assessment to inform their approach to operationalising the Integrated Safety Framework within their unique contextual needs to ensure that interventions are locally internalized and practically adopted (Govender et al., 2022). In terms of the document analysis, zero fatality was achieved and there were no serious injuries reported. SafeSentry observations continued to increase with active closeout on deficient controls. Leadership actively articulates that safety is not the absence of incidents, but rather the presence of controls to prevent severe injury. This is done to ensure an open culture of reporting and focusing on the sharing of the lessons to systemically address control effectiveness. Based on the value added to learning from incidents, all incident alters, and investigation reports were timeously shared across the operations. In addition, where a potential event occurred that could have resulted in severe injuries or fatalities, the operations were stopped, and preliminary lessons were shared immediately. Any potential hazards for incidents on other vessels were systemically closed out.

Built on the foundation of the Framework, which is to enable people to be ready to respond to risk by being the strongest link, initiatives were designed to initiate change amongst people, processes and systems. A concerted effort was put into steering away from the practices that disable people to be the strongest link. The 2017 qualitative data assisted with identifying what these practices were and it was decided that the Culture facet would trigger exponential change across all the other facets resulting in enabling people to be the strongest link. The focus was placed on leadership and creating psychological safety for people to speak up as well as on non-positional safety leadership. Interventions were designed to assist leaders to create a climate where people could have crucial and difficult conversations maturely. Culture themes that were coded in the 2020 data, indicated a contribution towards the improvement in both the Citizenship and Inherent maturity levels. The psychological safety created for people to speak up as well as encouraging people to fulfil their role as a non-positional safety leader, resulted in people taking ownership to mitigate risk and contribute towards opportunities for improvement. Examples are people's confidence in using stop-work authority and improving risk awareness and risk competence by including people's opinions and experiences regarding risks which have all resulted in them taking greater ownership in managing safety. Culture was used as a key driver in transforming safety maturity, but to do this sustainably requires a holistic approach, including Competence, Connectedness and Cultivate. The methods that were applied in this safety maturity journey were specifically created to address the integrated approach of the 4Cs framework.

The qualitative data reflect a non-linear complexity of change, where shifts in all maturity levels took place. This is an expected result given the complex nature of maturity, safety and culture. A linear progression is not a realistic reflection of the dynamic complex nature of safety culture. The shift in the maturity graph (Fig. 5), especially on the 'Basic' and Responsive' levels, does not imply that the organisation is regressing. On the contrary, it makes the complexity of the safety reality more evident. The ability to recognise and navigate one's way through the complexity of experiences is also an important skill needed for resilient safety maturity. In a 'world where resilience is valued,' one recognises the paradoxes and contradictions that are introduced by a complex reality and need a both/and rather than an either/or binary mindset to successfully navigate one's way through this complexity.

7. Conclusion and implications for the industry

The Namibian diamond industry has applied the Integrated Diamond Safety Maturity Framework (shown in Fig. 1) as its preferred safety maturity framework to deliver improved safety performance. This integrated framework of Govender et al. (2022) focused on the '4Cs' to improve safety namely Culture, Competence, Cultivate and

Connectedness. This offered a novel and structured approach to drive the journey to inherent. A longitudinal empirical study was conducted to explore the effectiveness of the Integrated Diamond Safety Maturity Framework. Built on the foundation of the Framework, which is to enable people to be ready to respond to risk by being the strongest link, initiatives were designed to initiate change amongst people, processes, and systems. The conceptualization of initiatives was informed by the results of the 2017 qualitative climate assessment with the intent to inform an integrated approach towards an inherent level in safety maturity. 12% of people moved to Inherent in 2020 from 0% when the study commenced.

Both the qualitative and document analysis emphasised the success of the safety maturity shift towards Inherent. This was evidenced by the psychological safety created for people to speak up as well as encouraging people to fulfil their role as a non-positional safety leader. They took ownership to mitigate risk and contribute towards opportunities for improvement, as part of their way of work. This shift in safety maturity is also evident in the improved safety performance where there were zero fatalities across the business from 2017 to 2022. There was only a finger injury and a medical treatment case. The reporting of hazards increased threefold and there were zero outstanding close-out actions.

The scope of this study will be extended in future to nine active mines in Southern Africa and detail the culture of leadership component of the framework.

Author contributions

Conceptualization: Urishanie Govender, Data curation: Jan Nel, Formal analysis: Elonya Coetzee, Investigation: Elonya Coetzee, Urishanie Govender, Pombili Ndeunyema, Yuzanne Maré and Jan Nel, Methodology: Yuzanne Maré (Qualitative Analysis) and Gary van Eck (Quantitative Analysis), Project administration: Urishanie Govender, Supervision: Johann Roux (Qualitative Assessment) and Bekir Genc (Overall Paper Quality), Writing - original draft: Elonya Coetzee, Urishanie Govender, Pombili Ndeunyema, Yuzanne Maré, Johann Roux, Jan Nel and Gary van Eck, Writing - review and editing: Elonya Coetzee, Urishanie Govender, Pombili Ndeunyema and Bekir Genc.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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APPENDIX 1. PIONEERING BRILLIANT SAFETY FRAMEWORK: FOCUS AREAS FOR SEMI-STRUCTURED INTERVIEWS

Culture

Commitment to Safety	Is the company committed to safety?
	Are the company safety policies clear?
	Are safety goals clearly communicated?
	Does the company care about its employees?
Trust in Leadership	Do you trust the senior managers?
	Do the senior managers talk to you about safety?
	Do you trust your line managers or supervisors?
Response to Failure	Is discipline fair when you break a safety rule?
	Is the treatment fair toward the person when an accident happens?
	Do you try to do a good job every day?

Connectedness

Reinforcement	Do the managers always put safety first?
	Do your supervisors always put safety first?
	Are you recognised when you work safely?
Employee Engagement	Are you asked to share your ideas on safety (and on other matters)?
	Do you receive a response or follow-up when a concern was raised?
	Is it possible to achieve zero accidents at work?
	Are you asked to comment on the safety rules used at work?
Team Impact on Members	How does your team respond when someone takes chances/risks?
	Do the people you work with take short-cuts/risks?
	Do the people you work with follow the safety rules?
	Is there team spirit in your team?

Competence

Pressures on Risk	Do you have to cut corners to get the job done?
	How aware are people of the dangers in the workplace?
	Are you able to follow the safety rules, when you are under pressure?
	Do the people you work with know and understand the safety rules?
Decision-Making	How satisfied are you with the quality of management's decisions?
	Do you have the freedom to stop work if it feels unsafe?

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Operational Integration	Do safety rules help you to keep safe at work?
	Are the safety rules simple and easy to understand?
	Are jobs done in a careful and planned manner?
	Are the work and task instructions good enough to help you do the job?
	Does it make it easier to complete the day-to-day tasks if you follow the safety rules?

Cultivate

Formal Safety Practices	Is there a good balance between prioritising safety and production?
	Do the safety systems assist you in doing your work in the best possible manner?
	What is the quality of the safety training that you receive?
	Are safety rules put in place to keep people safe or to protect the company?
Employee Stressors	Are your jobs secure?
	Do you have a lot of stress because of work?
	Are you able to handle the amount of work you have to do?
	Do you feel that measures are put in place to protect you from being injured at work?
Risk Transparency	How quickly does someone take to ensure a safety hazard or risk is fixed?
	How willing are people to report safety problems (big or small)?
	Is the incident investigation process free of blame?
	Do people report accidents and/or mishaps which could be hidden if it is possible to do so or where an event went unnoticed?

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