The Role of Safety Beliefs in Influencing Safety Outcomes in the Mining Sector in South American Countries

Researchers:	**Daniela Andrei, Mark Griffin, Belinda Cham, Jelena Opacic, Raul Diaz* and Paola J. Ochoa Pacheco****
School/Centre:	Accelerated Learning Laboratory
University/Institutions:	The University of Western Australia * Hochschild Mining PLC ** ESPAE – ESPOL, Ecuador

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Research aims:

The aim of this follow-up research was to:

- develop a more refined measurement of individual safety beliefs, to allow an improved understanding of how safety beliefs influence safety related outcomes in the mining sector in South America
- complement the existing data for Asia-Pacific and African countries collected through the 'International Safety Benchmark' survey, with new data from South American countries

For further information on this action research:

Contact person: Daniela Andrei

Daniela.andrei@uwa.edu.au

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Summary of Action Research Activity

The role of safety beliefs in influencing safety outcomes in the mining sector in South American countries

The economic losses associated with incidents, illnesses and accidents in the workplace are considerable and developing countries in particular are shown to experience increasingly higher rates of workplace accidents.

Previous IM4DC-funded Action Research gathered information about the risks, practices and beliefs in companies across seven developing countries in the Asia-Pacific and Africa engaged in mining or associated activities. This research was used to identify areas of safety that require targeted training interventions as well as providing initial benchmarks that can be used by regulators and training agencies.

Through collaborations in Peru and Ecuador, in this follow-up Action Research a new safety beliefs scale was developed and the pre-existing 'International Safety Benchmarking' survey was adapted and translated in Spanish to facilitate data collection in Peru, Ecuador and Argentina. The new scale is anchored in rich qualitative data obtained from employees in the mining industry in Peru that has greater potential to capture significant differences in safety beliefs at different hierarchical levels and in different countries.

Surveys were completed by 403 respondents from Ecuador, with 92% of the respondents working in operational roles, and 8% working in non-operational roles (e.g. supervisory roles). Further data collection is ongoing in Peru and Argentina. Three main types of safety beliefs were identified:

- safety controllability (that safety is something that people themselves can control and influence)
- internalised responsibility (that people are themselves responsible for their safety and the safety of others)
- attitudes towards safety procedures and professionals (that safety procedures/professionals negatively interfere with one's work)

Extending the work to South American countries succeeded in generating a high level of interest and focus on safety issues, particularly on safety beliefs and safety culture, and their role in supporting desired safety outcomes.

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RESEARCH REPORT to:

IM4DC

The role of safety beliefs in influencing safety outcomes in the mining sector in South American countries

ALL@UWA Team Members Involved in This Report:

Dr Daniela Andrei
Prof. Mark Griffin
Belinda Cham
Jelena Opacic

International Collaborators Involved in this Report:

Dr. Raul Diaz
Dr. Paola Jackeline Ochoa Pacheco

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1 EXECUTIVE SUMMARY

The economic losses associated with incidents, illnesses and accidents in the workplace are considerable (International Labour Organization, 2012) and developing countries in particular are shown to experience increasingly higher rates of workplace accidents (Kheni et al., 2008; Hamalainen et al., 2006). Due to this identifiable risk, it is becoming increasingly important to understand the mechanisms that influence safe behaviour at work in developing countries and the possible variations in these mechanisms across different countries and regions.

Although the International Safety Benchmarking survey used by Andrei et al. (2014) provided initial insights into the factors that might be related to safety in developing countries, the current research aimed to address the lack of in-depth understanding of how safety beliefs influence safety-related outcomes in the mining sector. Secondly, the research aimed to complement and expand on existing data collected through the International Safety Benchmarking survey by including data from developing countries in South America.

Data was collected using the International Safety Benchmarking survey, with the addition of a new safety beliefs scale. The new scale was anchored in rich qualitative data obtained from employees in the mining industry in Peru and had greater potential to capture significant differences in safety beliefs at different hierarchical levels and in different countries. In addition to this, the pre-existing International Safety Benchmarking survey was adapted and translated into Spanish to facilitate data collection in South American countries. Surveys were completed by 403 respondents from Ecuador, with 92% of the respondents working in operational roles, and 8% working in non-operational roles (e.g. supervisory roles). Further data collection is ongoing in Peru and Argentina.

Regarding the first aim about understanding how safety beliefs influence safety related outcomes, the results identified three main types of safety beliefs. These were safety controllability (that safety is something that people themselves can control and influence), internalised responsibility (that people are themselves responsible for their safety and the safety of others) and attitudes towards safety procedures and professionals (that safety procedures/professionals negatively interfere with one's work). These types of beliefs were associated with other individual factors influencing safety, but were shown to add explanatory power for behaviours such as compliance and participation. Moreover, they were shown to interact with organisational level variables in predicting safety behavioural outcomes.

Secondly, by adding this new data the research extended the previous International Safety Benchmarking survey project to South America and the research succeeded in generating a high level of interest and focus on safety issues, particularly on safety beliefs and safety culture, and their role in supporting desired safety outcomes. Overall, the results for this aim show that the data considered here are so far very similar to the data from the previous countries that participated in the International Safety Benchmarking survey. Similarly to the other countries, the data suggests that mining represents a high risk environment in Ecuador too, with the likelihood and severity of accidents/incidents being perceived to be situated above the scale average and with predefined risks being identified more often by participants.

Despite the similar results and recommendations to the International Safety Benchmarking survey there were many benefits associated in undertaking this follow-up research project, such as building capacity and skills for measuring safety-related constructs and creating a network of safety professionals that are interested in the individual and cultural aspects of safety. The research also brought the safety culture and safety leadership to the attention of safety professionals that work in companies operating in South America, empowered change agents and expanded the research and academic network by consolidating the collaboration we had already started in Peru, as well as by initiating new contact and collaboration in Ecuador.

2 PROJECT BACKGROUND

In 2013, the Accelerated Learning Laboratory at The University of Western Australia (ALL@UWA) worked closely with IM4DC on The International Safety Benchmarking survey, which was funded by an IM4DC Action Research grant and successfully completed in 2014 (Andrei et al., 2014). The purpose of this research was to gather information about the risks, practices and beliefs in companies across developing countries engaged in mining or associated activities. This research was used to identify areas of safety that require targeted training interventions as well as providing initial benchmarks that can be used by regulators and training agencies. Data was collected using the International Safety Benchmarking survey – a survey that assesses 17 distinct factors contributing to safety at the individual, team and organisational level. The surveys were completed by 873 respondents from seven different countries: Mongolia, Zambia, Kenya, Gambia, Nigeria, Ivory Coast, Indonesia and Philippines. The results from the survey showed respondents from all countries identified a large number of risks as being present in their worksite. Besides the most common risks present in the mining sector in Western countries, a number of risks specific to mining in developing countries were also identified such as: hygiene and sanitation, poor working conditions and the adequacy of safety equipment and protocols.

The International Safety Benchmarking survey has provided initial insights into the factors that might be related to safety in developing countries. However, in-depth understanding of differences within specific developing countries is needed to extend our insights. Moreover, the International Safety Benchmarking survey did not have data provided by the priority South American countries targeted by IM4DC. Recently, ALL@UWA developed collaborations with professionals from Peru, a priority South American country targeted by IM4DC. These professionals had undertaken a complex qualitative approach at identifying specific beliefs that employees in the mining sector hold about safety, which builds a solid foundation to extend our cross-cultural safety research in South America.

This pre-existent qualitative research conducted by our collaborator, Dr Raul Diaz, represented a good opportunity for our research team to refine some of the measurements used previously, more notably the individual safety beliefs items. This was even more important as the previous items we used proved to have low inter-correlations and split into two main factors, suggesting there might be several sub-dimensions that could not be investigated with the reduced initial set of items.

Moreover, our collaborator, Dr Diaz was placed in an excellent position to stimulate industry interest in the research and actively involved several

safety professionals working with mining companies. These professionals became committed to work on improving the items, adapting them to their company needs and collecting the data once the survey was finalised. To this, interest coming from the academic domain was added, with Dr Paola Ochoa from ESPAE – ESPOL Ecuador becoming an active collaborator in our project and committing three mining companies in Ecuador to the data collection.

Through this collaboration a new safety beliefs scale was developed and the pre-existing International Safety Benchmarking survey was adapted and translated in Spanish to facilitate data collection in South American countries. The new scale is anchored in rich qualitative data obtained from employees in the mining industry in Peru that has greater potential to capture significant differences in safety beliefs at different hierarchical levels and in different countries. This new measurement was added to other well-established measures of factors that were shown to exert influence on safety outcomes and a survey process was initiated in Peru, Ecuador, and Argentina. As the data collection process proved to be slower in Peru and Argentina due to challenges associated with multiple stakeholder coordination, we decided to increase the sample in Ecuador, where data collection proved to run more smoothly. Therefore, the present report is based solely on data coming from Ecuador samples but data collection is ongoing in Peru and Argentina, with more than 500 surveys being sent to 10 companies. We expect these surveys to be returned to us by the end of July 2015 for analysis, at which point we could submit an updated results section to this report.

The project team at the ALL@UWA who were involved in developing the research design included: *Dr Daniela Andrei* who coordinated the project grant proposal, managed the project, communicated with collaborators and supervised the data collection, data analysis and reporting; *Winthrop Professor Mark Griffin* who oversaw this action research and was heavily involved in the design of the research and data collection tool; and *MSc Student Belinda Cham* who was responsible for data-basis integration, data analysis and report writing as part of her master thesis project.

Research collaborators who became involved in the project were, as mentioned above, Dr Raul Diaz and Dr Paola Ochoa. Dr Diaz provided the initial qualitative data for developing the new safety beliefs items and coordinated activities and discussions to adapt and finalise the survey in Peru, as well as data collection in Peru and Ecuador. Dr Ochoa contributed to survey development by adding several new variables looking at empowerment, but also technology, and coordinated the data collection in Ecuador.

3 AIMS OF THE ACTION RESEARCH

3.1 Research Aims

The present project had two main aims. The first was to develop a more refined measurement of individual safety beliefs, grounded in pre-existent qualitative data, which would allow an improved understanding on how safety beliefs influence safety related outcomes in the mining sector in South America. The second aim was to complement the existing data collected through the International Safety Benchmarking survey initiative in eight countries across the Asia-Pacific and Africa (Andrei et al., 2014) by including data coming from developing countries in another region of interest for IM4DC – South America.

The economic losses associated with incidents, illnesses and accidents in the workplace are considerable (World Health Organisation, 2008) and developing countries in particular are shown to experience increasingly higher rates of workplace accidents (Kheni et al., 2010; Hamalainen et al., 2006). Mining and associated industries in these countries are no exception to this trend. Therefore, it is more important than ever to understand the mechanisms that influence safe behaviour at work in developing countries and the possible variations in these mechanisms across different countries and regions.

The existing literature on safety performance underlines the importance of certain variables such as safety climate and safety leadership (Clarke, 2006; Nahrgang et al., 2011), but there is very limited information available on how individual safety beliefs relate to safe behaviour at work and how climate and individual beliefs relate to each other in determining safety outcomes. This is even more critical considering the fact that national culture can exert a powerful influence on individual beliefs (Ralston et al., 1997). Moreover, the instruments of measuring individual safety beliefs are underdeveloped and provide reduced support for attempts to study their impact.

A first step in improving our understanding of the factors that contribute to safety behaviour in the mining sector in developing countries was achieved by the implementation of the International Safety Benchmarking survey in 2013-2014. The present project built upon this initiative by adding a more refined focus on safety beliefs, by expanding the set of interest variables to include aspects related to empowerment and technology and also by extending data collection process in a new region – South America.

The above mentioned research aims were pursued in two phases. In the first phase a safety beliefs scale was developed that is anchored in rich

qualitative data obtained from employees in the mining industry in Peru. In the second phase the relative importance of safety beliefs compared to other variables that have been shown to influence safety behaviours (work motives, empowerment, safety climate variables) was evaluated, by collecting extensive data from Ecuador and other two targeted countries in South America. Last but not least, new data was integrated with pre-existing results coming from the International Safety Benchmarking survey, across the common variables assessed.

It is important to learn more about differences in individual safety beliefs among developing countries and how they contribute to safety relative to other more established variables, especially due to the fact that these safety beliefs are more closely grounded in the national culture and therefore harder to modify. This research is a unique opportunity to further develop links with IM4DC participants and alumni and form new links in an effort to develop networks for the purpose of collecting systematic data about factors that could influence safety in the mining sector.

At the same time, we are aware this research is just an initial step in a longer-term process that is needed in order to collect systematic data about safety practices. This further step will provide an overall picture of the status of safety across developing countries in South America and, ideally, it will be followed by more in-depth research designs in each country that will be able to further contribute to our understanding of these relationships.

3.2 Research Methods and Measures

3.2.1 Participants

There were 403 total respondents included in this study. At this point, all the participants included in this report come from Ecuador, as the data collection is still ongoing in Peru and Argentina and sample sizes of returned and completed questionnaires in participating companies in these countries are still small.

As displayed in Figure 1, out of the 403 respondents, 92% worked in operational roles, and 8% worked in supervisory roles.

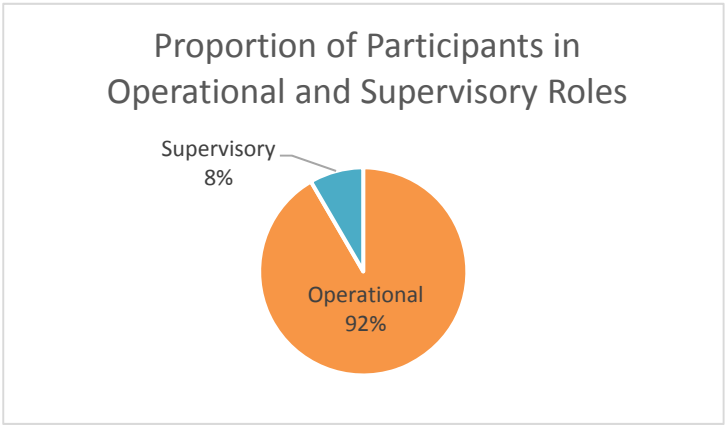

Figure 1. *Proportion of participants in operational and supervisory roles.*

A total of 3 different companies were included in the survey. All companies were primarily involved in mining operations. Figure 2 below displays the proportion of responses from the three companies, based on the size of the company.

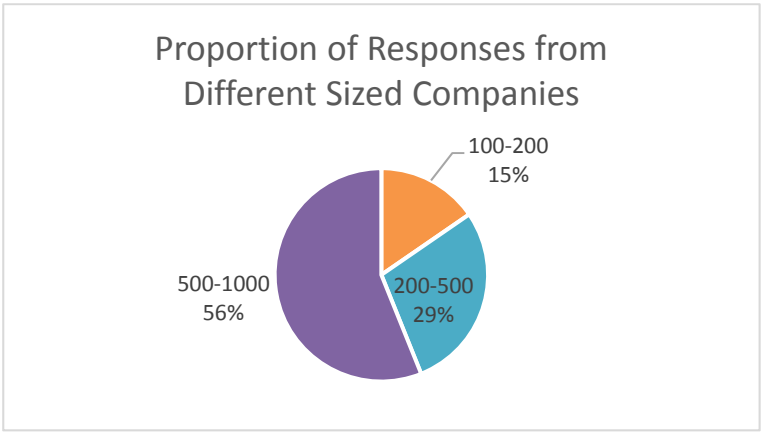

Figure 2. *Proportion of responses from different sized companies.*

The average tenure of respondents was 3.61 years, and ranged from 0 years to 18 years. Figure 3 displays a breakdown of tenure for the respondent sample.

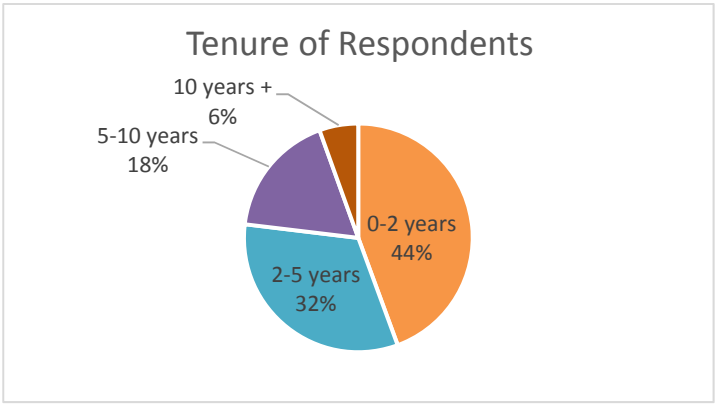

Figure 3. *Tenure of respondents*

Figure 4 below displays the proportion of contractors and permanent employees.

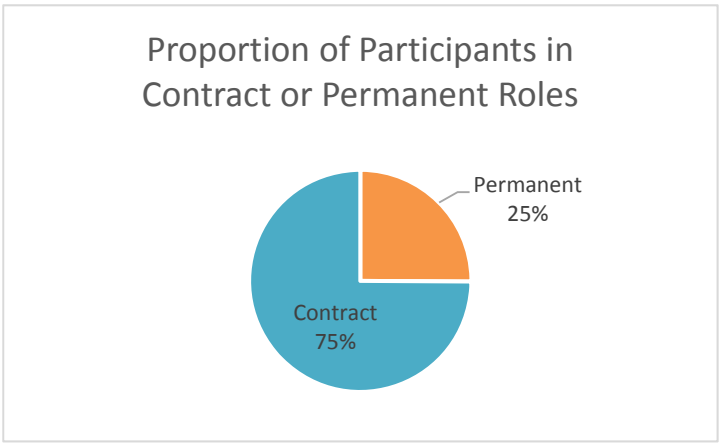

Figure 4. *Type of employee.*

The average age of respondents was 28.9 years, and ranged from 18 years to 67 years. Figure 5 below displays a breakdown of the age of respondents.

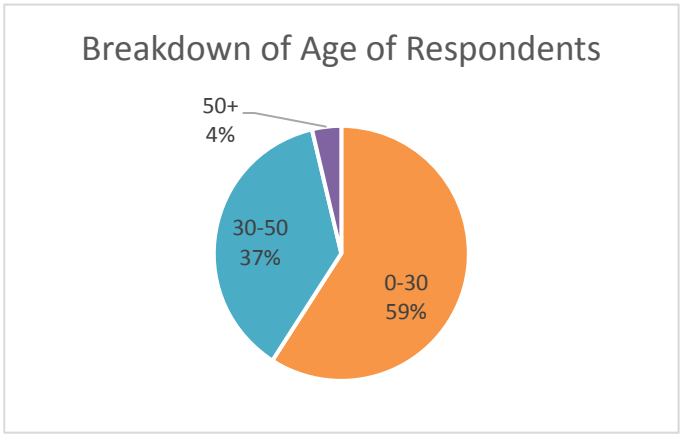

Figure 5. *Age of respondents.*

3.2.2 Measures

Data was collected using a survey that measured factors contributing to safety at the individual, team and organisational level. The survey was divided into three major sections: Risk Factors, Individual Factors and Organisational Factors.

3.2.2.1 Risk Factors

The Risk Factors section is comprised of three subscales: Risk likelihood, Risk severity and Risk assessment. The Risk likelihood and Risk severity subscales are derived from theories of risk perception. Both subjective expected utility theory (Edwards, 1954) and expectancy-value theory (Feather, 1959; Fishbein & Ajzen, 1975) propose that the likelihood of taking precautions against a risk is related to the perceived likelihood of that risk occurring and the perceived severity of that risk.

Risk Likelihood

Two items assessed individuals' perceptions of risk likelihood in their worksite. These items were "How likely is it that there will be a serious accident (such as a fatality or an irreversible disability/health effect) in your workplace" and "How likely is it that you will be personally affected by a serious accident in your workplace". Individuals responded on a five-point scale ranging from "Not at all" (1) to "Extremely" (5).

Risk Severity

Four items sought to assess the perception of risk severity, if there was to be a serious accident in the workplace. Individuals were asked the severity of both short and long-term consequences for their workplace and also for them personally. Example items included "How severe would the short term consequences be for the workplace" and "How severe would the long term consequences be for you personally". Individuals responded on a five-point scale ranging from "Not at all" (1) to "Extremely" (5).

Risk Assessment

The risk assessment subscale consisted of 13 hazards that had been identified as the most common industry hazards in the mining sector. Individuals were asked to answer "Yes" if the hazard was a risk of injury to themselves in the workplace, "No" if the hazard exists but does not provide a risk of injury to them personally and "N/A" if the hazard does not exist in their workplace. Some examples of hazards were "Working with vehicles", "Falling objects" and "Ground failure, cave-ins, etc. (geo-technical)". There were also 3 spaces for open-ended responses where respondents were able to list additional hazards that they believed were not covered.

3.2.2.2 Individual Factors

Five subscales were targeted at measuring safety factors on an individual level: Psychological Empowerment, Safety Beliefs, Work Attitudes, Work Responses and Safe Working.

Psychological Empowerment

Spreitzer's (1995) psychological empowerment scale consists of 12 items designed to measure four dimensions of empowerment: meaning, competence, self-determination, and impact. These four dimensions are suggested to reflect an active, rather than a passive orientation to work, in which an individual wishes and feels able to shape his or her work role and context. Together, these four dimensions have been argued to combine additively to create an overall construct of psychological empowerment. Example items include "The work I do is meaningful to me", and "I have considerable opportunity for independence and freedom in how I do my job". Responses to all the items were recorded using a 7-point Likert scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). This subscale was only used in Ecuador.

Safety Beliefs

The safety beliefs subscale consists of 17 items that assessed an individual's beliefs about the importance of safety in their workplace. To create this subscale, a collaborator in Peru conducted focus groups on safety beliefs at a participating company, and the results of these focus groups allowed the identification of possible items. These items were then discussed by the collaborator and a group of occupational safety and health experts in order to agree on a final set of items. Example items include "My health at work is my responsibility" and "The safety and health of my colleagues also depends on me". Responses to all the items were recorded using a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Work Motives

The work motives scale consists of 12 items that were developed by Johnson, Chang, Meyer, Lanaj and Way (2013). The Work Motives Scale measures an individual's approach and avoidance motivation in the workplace. Approach motivation guides behaviour toward positive objects and possibilities. In contrast, avoidance motivation guides behaviour away from negative objects and possibilities. Individuals with high approach motivation tend to focus more strongly on positive stimuli while individuals with high avoidance motivation tend to focus more strongly on negative information and stimuli.

Of the 12 items, 6 measured approach motivation. Examples of these items include "My goal at work is to fulfil my potential to the fullest in my job" and

"In general, I tend to think about the positive aspects of my work". The other 6 items measured avoidance motivation. Examples of these items include "I am focused on failure experiences that occur while working" and "I am fearful about failing to prevent negative outcomes at work".

Work Responses

The work responses subscale consisted of 5 items taken from the Error Orientation Questionnaire by Rybowiak, Garst, Frese and Batinic (1999). The 5 items relate to how an individual tends to think about errors that occur in the workplace. Example items include "After I have made a mistake, I think about how it came about" and "After a mistake has happened, I think long and hard about how to correct it"

Safety Behaviours

The safety behaviours (safe working) subscale consists of 8 items from Neal, Griffin and Hart (2000). The first four items assessed individual compliance with safety procedures. Example items are "I carry out my work in a safe manner", and "I ensure the highest level of safety when I carry out my job". The second four items assessed the extent which individuals participated in safety related activities. Example items are "I voluntarily carry out tasks or activities that help to improve workplace safety", and "I help my co-workers when they are working under risky or hazardous conditions".

3.2.2.3 Organisational Factors

Ten subscales measured factors contributing to safety in the organisation itself: Safety Rewards, Safety Vision, Safety Learning, Safety Vigilance, Management Values, Communication, Training, Safety Systems, Physical Work Environment and High Performance Safety Systems. Responses to all the subscales, except for High Performance Safety Systems, were recorded using a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Safety Climate Scales

Four subscales were derived from a study by Neal, Griffin and Hart (2000) into safety climate in organisations. Sixteen total items assessed perceptions of safety within the organisation, specifically: management values, communication, training, and safety systems. Example items include "Management is concerned for the safety of individuals", "There is open communication about safety issues within this workplace", "Safety issues are given high priority in training programs", and "Safety procedures and practices are sufficient to prevent incidents occurring". Responses were recorded using a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Safety Rewards

Four items measured the perception of how well safety was integrated and rewarded into the work systems of the organisation. Example items include "Safety is integrated effectively into all reward and feedback systems" and "All teams understand how they contribute to the safety process". Responses were recorded using a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Safety Vision

The safety vision subscale consists of four items measuring attitudes to safety throughout the organisation. Example items include "Safety is an inspiring part of the work environment" and "Responsibility for safety is owned by all employees". Responses were recorded using a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Safety Learning

The safety learning subscale consists of 4 items and is based on theories of error orientation (Rybowiak, Garst, Frese & Batinic, 1999) and seeks to measure the extent to which organisations are seeking to improve and update their safety systems based on past experiences, such as near misses. Example items include "Near misses are valued as an opportunity to learn" and "Information derived from monitoring is analysed and acted upon". Responses were recorded using a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).'

Safety Vigilance

The safety vigilance subscale consists of four items that measure how alert to risks people within the organisation are. Examples items include "People at all levels of the organisation are alert for risks to safety", and "Monitoring for safety is comprehensive across all organisational role and functions". Responses were recorded using a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Physical Work Environment

Three items measured the perceived safety of the physical work environment in the organisation. Respondents rated the following statements on a 5-point scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The items were "There are sufficient dangers inherent in the workplace", "The physical work environment is safe", and "Employees are frequently exposed to risky situations".

High Performance Safety Systems

Based on past research into high performance work systems and occupational safety, 15 high performance safety systems were identified that are theoretically and empirically associated with occupational safety. These items asked the respondent whether their organisation had a particular system in place. Respondents were required to tick a box to indicate that their organisation had those systems in place. Items in this scale included “Employing a safety officer”, “Prioritise safety over productivity”, “Conduct regular safety assessments”, and “Have a system through which you can report safety related concerns”.

3.2.3 Procedure

After the survey tool was developed, it was translated into Spanish and sent to each collaborator for data collection. The collaborators managed data collection independently. All the surveys were collected in paper and pencil format due to lack of resources for online data collection. Before filling in the survey, each participant was provided with an information sheet describing the aims of this research and the overall procedures and all gave informed consent to participate in this research. No identification data beyond country, company, location and level of job was collected from any of the participants, protecting their anonymity.

Collaborators were instructed to distribute surveys at all hierarchical levels in the company, where possible, and to comply with the Australian ethical guidelines for research data collection.

After completing the surveys, the data was collected and entered into an SPSS database by the collaborator, and the data file sent to ALL@UWA researchers.

3.2.4 Data Analysis and Reporting Approach

Before presenting the main results of this research, we must draw attention on some of its limits and the way they impact on our data analysis and reporting approach.

The samples in this research are convenience samples and are not representative for the entire countries that they come from, or for the mining industry in these countries. Our research collaborators worked with limited resources and each used pre-existent relationship with industries to collect data. As a result, the samples might not be representative and the results cannot be generalised at the company or country level. They are only illustrative for the convenience sample that we used in the present project.

All limits considered, we do believe that this research is an important step to gaining a more thorough understanding of safety issues related to mining in developing countries. It is our hope that this research will be followed up by more systematic data collection so that a more comprehensive picture of safety and the factors that contribute to it can be created.

4 RESULTS

We will present results starting with a focus on the safety beliefs measurement and their association with other safety outcomes and then we will provide a short descriptive overview of the results that can be linked with the previous International Safety Benchmarking survey.

4.1 The Role of Safety Beliefs

The first phase of this research consisted in directing efforts towards building a more refined measurement of safety beliefs and attitudes by using pre-existent qualitative data coming from focus-groups on safety beliefs. These focus groups had been conducted by Dr Diaz in Peru were used to identify possible items. These initial proposed items were afterwards subjected to a process of discussion and refinement in several meetings of safety specialists in Peru. The resulting items were then discussed with the Australian research team and further refined to a final set of 17 items. These were included in the final survey that was used for data collection.

In this section, we first report preliminary data regarding the structure and qualities of the instrument we developed. In the first step we assessed the underlying structure of the items that were developed. We conducted exploratory factor analysis on the initial 17 items using Principal Components Analysis and a Direct Oblimin Rotation as we were expecting the resulting factors to be related to each other. The KMO measure of sampling adequacy indicated that the sample was factorable (KMO = .790) and the Bartlett's test of sphericity was also significant (p = .000) indicating that the factor analysis was suitable.

The analysis identified 5 main factors with eigenvalues >1 that together explained 55.22 % of the variance. The loading on each of the initial items on the 5 factors identified are presented in Table 1 (loadings <0.3 have been removed in order to improve comprehension).

Table 1. *Factor loadings from exploratory factor analysis conducted on the safety beliefs measure.*

Items	Factors				
	1	2	3	4	5
Safety cannot be implemented well because mining works with nature which is unpredictable	.686				
Technical training on the job comes first and then comes safety and health	.663				
The most important thing is to meet production targets	.492			.338	
For some reason I seem to think that nothing can happen to me	.406				
Human error is the main cause of any accident		.668			
Any unsafe behaviour should be sanctioned		.664			
Any hazard/danger can be controlled		.557			
Safety procedures makes us loose time			.783		
Safety and health is simple but the safety people complicate it			.702		
Mining can be a very safe activity	-.346	.394	.567		
Safety people just make our work more complicated	.420		.556		
Safety should be done well by the Safety people and they shouldn't disturb other areas with it			.414		
There is too much communication on safety and health at work				.823	
Safety and health is a lost cause in mining because mining is too dangerous				.591	
I still behave safe even when I'm at home or during my days off					.780
The safety and health of my colleagues also depends on me					.585
My health at work is my responsibility					.509

The first factor consists of items that reflect an external attribution of control over safety and brings together items that refer to the inherent dangerous character of mining and a sense of predestined fate and uncontrollability. It is interesting that items that reflect precedents of production over safety are loading on the same factor. However, the combination of such different items loading together on factor makes this factor less theoretically interpretable and future work is needed in order to refine these items.

The second factor is comprised of items that reflect an internal attribution for safety. Safety is seen as something that is controllable and achievable by the people and therefore it should be sanctioned or rewarded.

The third factor reflects attitudes towards safety procedures, safety professionals and their role in companies.

The fourth factor, comprised from only two items with main loading, was not theoretically interpretable. Therefore, we have discarded these two items from future analysis together with item 10 that had loadings on multiple factors and items from the first factor which was also theoretically unclear.

The fifth factor is composed of items that reflect an internalised sense of personal responsibility for safety.

In the next analysis exploring associations of safety beliefs with different other safety related variables, we used the 4 factors identified in this analysis.

A next phase in our data analysis consisted in examining the inter-correlations between individual safety beliefs and the other individual factors considered in this research. A full correlation matrix is provided in the Appendix.

Results showed significant correlations between the safety beliefs subscales identified in our instrument and some of the other individual variables measured. Beliefs of controllability and internalised responsibility for safety as expected, correlated positively with all empowerment aspects (r ranged between $r = .143$, $p < 0.01$ and $r = .353$, $p < 0.001$), while negative attitudes towards safety procedures/professionals correlated positively with the self-determination ($r = .195$, $p < 0.01$) and impact ($r = .197$, $p < 0.01$) components of psychological empowerment. These associations were expected as the self-determination component reflects autonomy in initiating work behaviours and processes (Spreitzer, 1995) while impact reflects the degree in which people can influence different types of outcomes at work and it is more a contextual variable (Spreitzer, 1995). It is somehow expected that employees that are more self-determined and feel they can impact

outcomes see procedures and safety professionals' roles as more superfluous and develop more negative attitudes towards them.

In terms of motivational tendencies, approach-motivated people seem to also develop more control oriented beliefs ($r = .300$, $p<0.01$) and more internalised responsibility towards safety ($r = .345$, $p<0.01$) while avoidance-motivated people appear to develop more negative attitudes toward safety procedures and safety professionals ($r = .247$, $p<0.01$).

The safety beliefs factors identified were also associated with safety-related behaviours. Learning from errors appeared to be more strongly associated with beliefs of controllability ($r = .276$, $p<0.01$), while internalized responsibility for safety had stronger associations with safety compliance ($r = .362$, $p<0.01$) and safety participation respectively ($r = .283$, $p<0.01$). At the same time, negative attitudes towards procedures and safety professionals correlated negatively with compliance ($r = -.106$, $p<0.01$) suggesting that when these negative attitudes form they might lead to less compliance from employees.

Given the fact that individual factors were associated significantly, another question that needs to be answered is whether the aspects measured by the newly developed items can contribute to predicting different safety behaviours beyond the already measured items. Therefore, we conducted a series of hierarchical regression analyses to identify the best prediction models for safety compliance and safety participation behaviours. Models we have identified for both safety compliance and safety participation included subscales identified in proposed new items. As seen in Table 2, safety compliance was positively predicted by approach motives, the meaning component of empowerment and internalised responsibility for safety, and negatively predicted by negative attitudes towards safety procedures/professionals. Safety participation was positively predicted by approach motives, competence and internalised responsibility for safety. While approach motives seem to be the most powerful predictors for both compliance and participation, internalised responsibility and negative attitudes contribute significantly to the prediction.

Table 2. *Standardised regression coefficients for individual factors predicting safety compliance and safety participation.*

Individual factors predicting safety behaviours	Dependent variable: Safety Compliance	Dependent variable: Safety participation
Approach motivation	.328***	.334***
Empowerment: Meaning	.179***	ns
Empowerment: Competence	ns	.175***
Negative attitudes towards safety professionals	-.131**	ns
Internalised responsibility for safety	.198***	.125**
Adjusted R square	.311	.233

*** p<0.001; ** p<0.01

Last, but not least, we investigated how safety beliefs interact with perceptions of management safety values in predicting safety behavioural outcomes for employees in our sample.

In the case of safety compliance, we found a significant interaction between perceived management safety values and internalised responsibility for safety (Figure 6). Compliance appeared to be the highest when employees had high scores on internalised responsibility for safety and perceived strong management safety values.

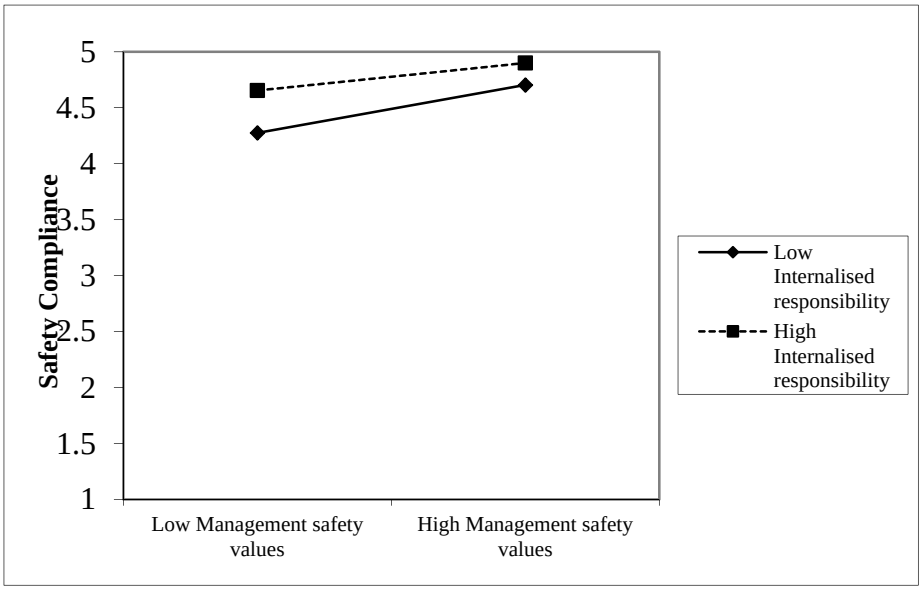

Figure 6. *Interaction between Management Safety Values and Internalised Responsibility Beliefs in predicting Safety Compliance behaviours.*

For safety participation, we found a significant interaction between management safety values and beliefs of controllability (Figure 7). Safety participation was highest when people perceived high safety management values but also had high beliefs of safety being something controllable.

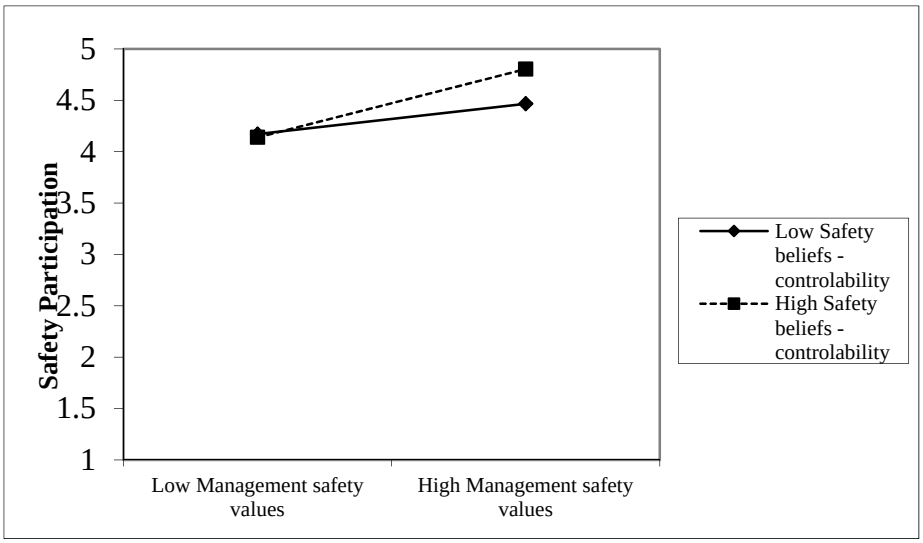

Figure 7. *Interaction between Management Safety Values and Controllability Beliefs in predicting Safety Compliance behaviours.*

Summary of Results

- Overall, we found that the items that we developed to investigate more aspects of individual safety beliefs reflect several factors that can be theoretically meaningful: controllability beliefs, internalised responsibility for safety and negative attitudes towards safety procedures/professionals.
- These factors display meaningful associations with other individual factors that have been shown to be associated with safety outcomes.
- Beliefs appeared to improve our ability to predict safety behaviours based on individual variables.
- Beliefs interacted with perceived management safety values to predict safety compliance and safety participation. Communication of safety values by management need to be complemented by internalised responsibility for safety to facilitate higher levels of compliance and by high controllability beliefs to facilitate participation.

4.2 Descriptive Overview Risks, Individual and Organisational Safety Variables

The first section of our results focused on safety beliefs but the survey we used in this research also contained many of the variables used in the previous International Safety Benchmarking survey with the aim to expand data collection and offer more comparison possibilities. In this section we aim to provide a descriptive overview of these main variables and how they compare with the overall scores from the International Safety Benchmarking project.

4.2.1 Risks

Pre-defined Risks

The pre-defined risks section of the survey required participants to answer whether a hazard was present in their workplace and whether or not they were personally at risk from that hazard. From this section, the percentage of respondents identifying each risk as a hazard in their workplace was calculated. Figure 8 below shows the percentage of the total sample that identified each pre-defined risk as a hazard in their workplace.

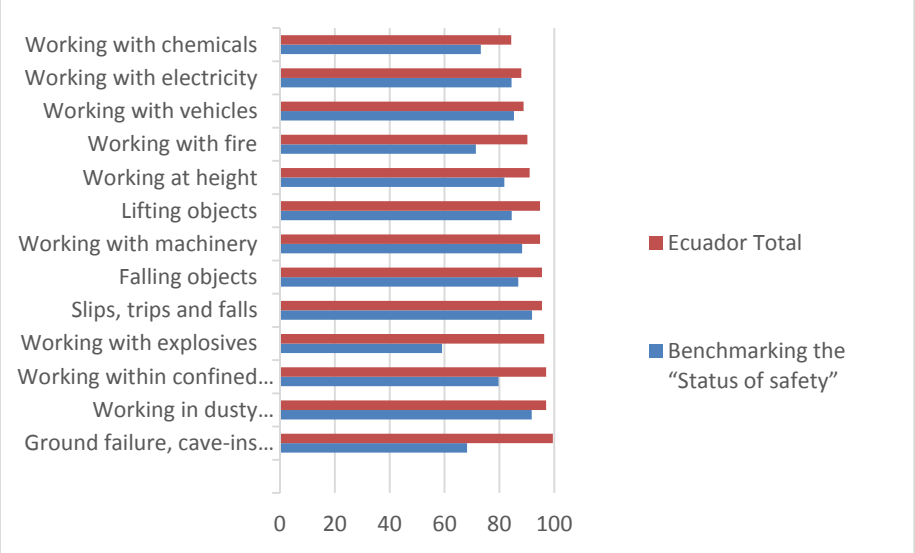

Figure 8. *Percentage Prevalence of Risks in the overall Ecuador sample.*

Overall, our data suggests that employees in this sample report predefined risks more often compared with participants coming from the 8 countries who participated previously in the benchmarking initiative.

Risk Likelihood and Severity

The risk likelihood and risk severity subscales measured the perceived likelihood of a serious accident (such as a fatality, or an irreversible disability/health effect) occurring in the workplace and perceived severity of the risk on the respondent personally, and for the company. Participants rated items on a 5-point scale ranging from 1 (Not at all) to 5 (Extremely).

Mean scores for each subscale can be found in Table 3 below and an overview of mean scores for each item measuring risk severity and likelihood can be found in Figure 9.

Table 3. *Means (S.D.) of Risk Likelihood and Risk Severity subscale items.*

Item	Ecuador Total	Operational	Supervisory
Risk Likelihood	3.09 (1.22)	3.14 (1.21)	2.53 (1.12)
Risk Severity	3.48 (.97)	3.51 (.97)	3.19 (.96)

Overall, means were above the theoretical mean of the scale for both risk likelihood and severity, with operational people reporting consistently higher scores compared to employees in supervisory positions. These means were also higher than means for the same factors reported in the previous participating countries and inspecting the values for each item, we can observe that the difference is more pronounced for the severity items, indicating that employees in Ecuador perceive more severe consequences to be associated with possible accidents.

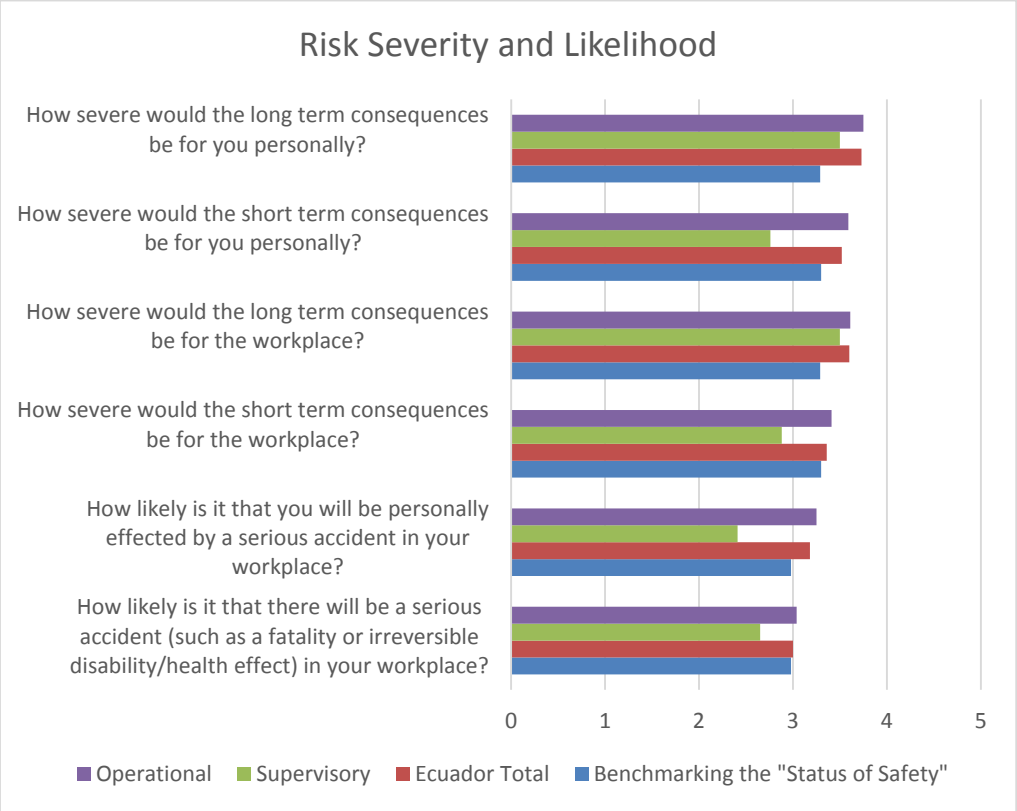

Figure 9. *Means of Risk Likelihood and Risk Severity subscale items for Operational and Supervisory employees.*

4.2.2 Individual Factors

Psychological Empowerment

The psychological empowerment subscale measured the extent to which participants felt they had an active orientation to work, in which they wish to and feel able to shape their work role and context. Participants rated items on a 5-point scale ranging from 1 (Not at all) to 7 (Extremely).

Mean scores for each subscale can be found in Table 4 below.

The measurement of empowerment was newly introduced in this project; therefore there are no comparison scores with previous countries. Results obtained reflect relatively high scores for all empowerment subscales, with meaning and competence displaying the higher scores. However, a trend can be observed in the results, with participants in supervisory roles reporting consistently higher scores on empowerment compared to employees in operational roles.

Table 4. *Means (S.D.) of Psychological Empowerment subscales for operational and supervisory employees.*

Item	Ecuador Total	Operational	Supervisory
Overall Psychological Empowerment	5.98 (.85)	5.93 (.84)	6.50 (.80)
Meaning	6.34 (.78)	6.30 (1.03)	6.74 (.80)
Competence	6.43 (.78)	6.41 (.79)	6.63 (.64)
Self-Determination	5.53 (1.37)	5.48 (1.36)	6.16 (1.28)
Impact	5.63 (1.24)	5.55 (1.25)	6.49 (.82)

Work Motivation

The work motivation scale measured individuals' approach and avoidance motivation at work, or whether they tend to think and focus on positive or negative stimuli and occurrences whilst at work versus negative stimuli and consequences. Table 5 below shows means of both types of motivation.

Table 5. *Means (S.D.) of Work Attitudes subscale items for Operational and Supervisory employees*

Item	Overall Sample	Operational	Supervisory
Approach Motivation	4.46 (.61)	4.45 (.62)	4.63 (.55)
Avoidance Motivation	3.50 (.86)	3.51 (.85)	3.38 (.87)

Results obtained for this scale reveal a very similar pattern with that obtained in the previous participant countries (Figure 10). Overall, participants reported higher scores for approach motives but avoidance motivation scores were also above average. This indicates that while participants tend to think about and be driven towards positive aspects at work, they are also sensitive to negative stimuli.

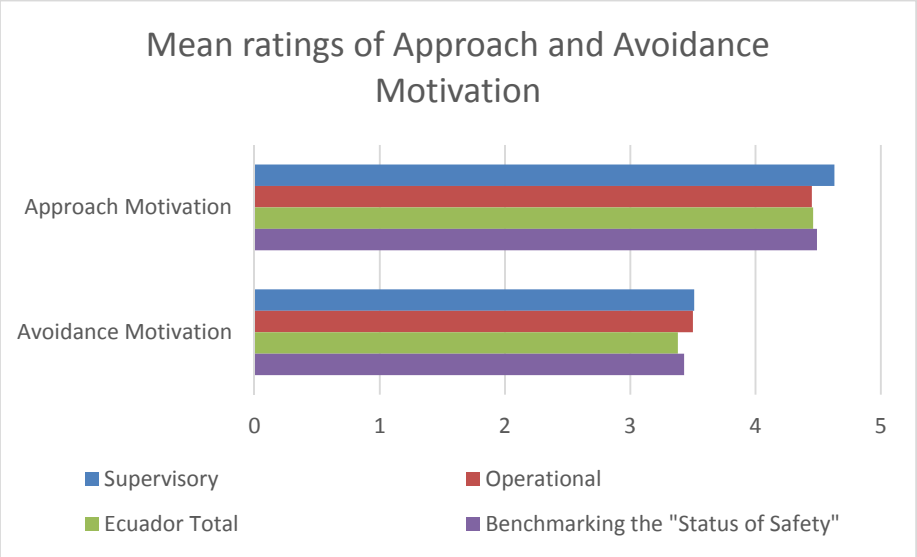

Figure 10. *Means of Work Attitudes subscale items for Operational and Supervisory employees.*

Error Orientation

Error orientation is the extent to which individuals analyse and try to improve from mistakes. Table 6 shows the means of each error orientation subscale item.

Table 6. *Means (S.D.) of Error Orientation subscale items for Operational and Supervisory employees*

Item	Ecuador Total	Operational	Supervisory
If something goes wrong at work, I think it over carefully	4.42(.94)	4.42 (.91)	4.38 (1.26)
After a mistake has happened, I think long and hard about how to correct it	4.41 (.87)	4.40 (.88)	4.53 (.79)
I often think: How could I have prevented this?	4.35 (.97)	4.36 (.97)	4.32 (.98)
When a mistake occurs, I analyse it thoroughly	4.30 (1.01)	4.27 (1.03)	4.59 (.70)
After I have made a mistake, I think about how it came about	4.21 (1.14)	4.24 (1.10)	3.94 (1.45)
Work Responses Total	4.34 (.76)	4.34 (.76)	4.35 (.82)

Overall, the results for error orientation reflect participants reporting high levels of learning from and improving after mistakes. The scores are very similar compared to the previous eight participating countries (Figure 11), with slightly lower scores for the items reflecting deep analysis of how the mistake occurred.

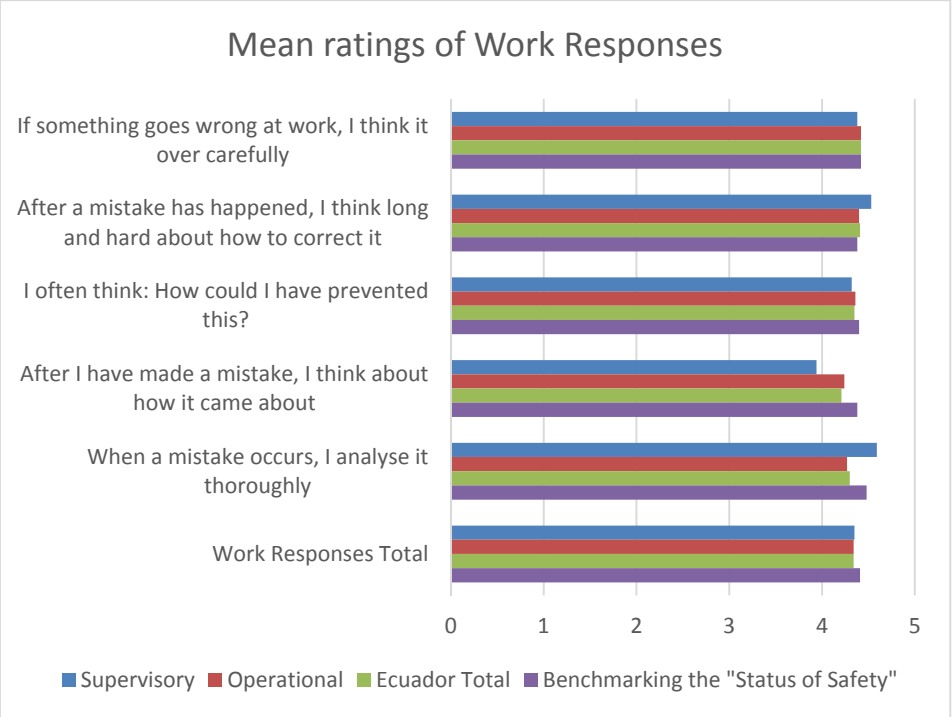

Figure 11. *Means of Error Orientation subscale items for Operational and Supervisory employees*

Safe Working

The safe working scale was comprised of two subscales: compliance and participation. Compliance measured the extent to which individuals complied with safe working protocols whilst participation measured the extent to which individuals actively participated and promoted safety behaviours and safe working. Table 7 shows the means of each safe working subscale.

Table 7. *Means (S.D.) of Safe Working subscale items for Operational and Supervisory employees*

Item	Ecuador Total	Operational	Supervisory
Safety Participation	4.43 (.60)	4.40 (.61)	4.81 (.33)
Safety Compliance	4.62 (.59)	4.60 (.60)	4.70 (.40)

Scores reported for safety compliance and safety participation were both high, with compliance being slightly higher than participation. The pattern is similar with that reported in the 'Status of Safety' but the scores for both behaviours were higher in the South American sample. Again, employees in the supervisory positions report more compliance and participation compared to employees in operational roles (Figure 12).

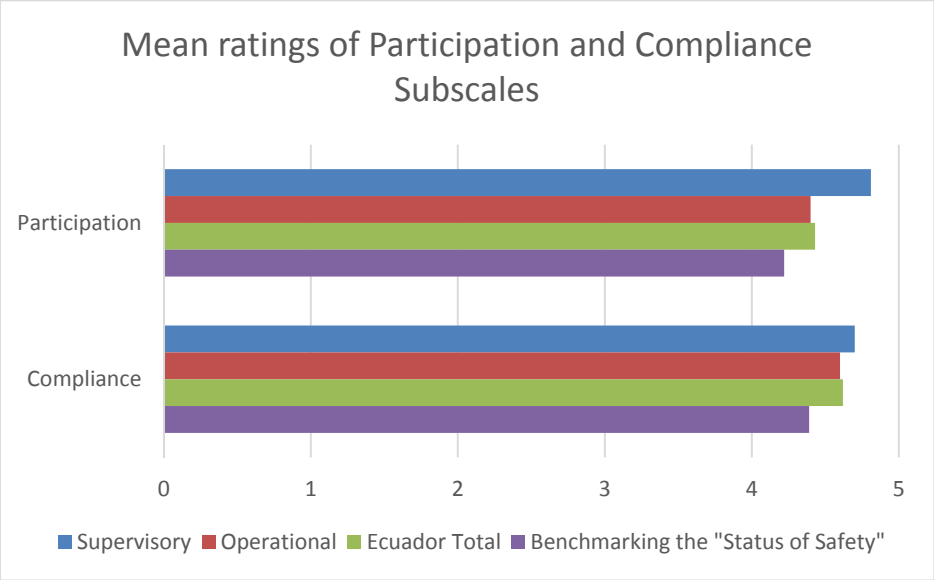

Figure 12. *Means of Safe Working subscale items for Operational and Supervisory employees.*

4.2.3 Organisational Factors

The organisational factors section was comprised of 9 subscales: Safety Rewards; Safety Vision; Safety Learning; Safety Vigilance; Management Values; Communication; Training; Physical Work Environment; and Safety Systems.

Table 8 below shows the overall means of the sample for each subscale as well as the means for Operational and Supervisory level staff.

Table 8. *Means (S.D.) of Organisational Factors for Operational and Supervisory employees*

Item	Ecuador Total	Operational	Supervisory
Safety Vision	4.41 (.60)	4.40 (.60)	4.59 (.51)
Management Values	4.28 (.90)	4.24 (.92)	4.76 (.48)
Safety Vigilance	4.21 (.71)	4.20 (.71)	4.48 (.59)
Safety Rewards	4.18 (.80)	4.15 (.80)	4.53 (.71)
Communication	4.16 (.75)	4.12 (.75)	4.63 (.64)
Safety Learning	4.16 (.71)	4.13 (.72)	4.49 (.54)
Training	4.00 (.83)	3.97 (.84)	4.34 (.68)
Safety Systems	3.96 (.82)	3.94 (.80)	4.17 (.97)
Physical Work Environment	2.66 (.76)	2.64 (.76)	2.96 (.69)

Figure 13. *Means of Organisational Factors overall and separated for Operational and Supervisory employees*

Overall means for organisational factors reported in the present samples were consistently higher than those found in the previous overall sample of eight countries (Figure 13). But the trend we observed is revealed in this data too. The highest scores are reported for safety vision and management safety values, indicating that management and the organisation overall are seen to place a great emphasis and value on safety. However, the lowest scores are reported for more tangible aspects such as safety training, safety systems and quality of physical work environment. This pattern raises some questions regarding how well participant organisations actually implement the vision of safety that they communicate to employees.

Summary of Results:

- Employees in the mining sector in Ecuador who have participated in this research perceive above average risks for accidents and incidents and in the case of accidents, the severity of the consequences is expected to be rather high also. Perceived risk severity appears to be higher than found overall in the 8 countries that participated previously in the International Safety Benchmarking initiative and predefined risks are identified more often in this sample.
- Respondents reported high levels of psychological empowerment, but the scores were consistently higher for employees in supervisory roles, compared to operational employees.
- Participants reported higher scores for approach motives but avoidance motivation scores were also above average. This indicates that while participants tend to think about and be driven towards positive aspects at work, they are also sensitive to negative stimuli. This pattern was identical compared to the previous countries.
- Participants reported high levels of learning from mistakes. The scores were very similar compared to the previous eight participating countries, with slightly lower scores for the items reflecting deep analysis of how the mistake occurred.
- As in the previous report, participants from South America reported that they complied slightly more than they participated to overall safety, but their scores for both behaviours were higher than the overall mean for the 8 previous countries.
- Among organisational factors, safety vision and management safety values were scored the highest. However, more tangible aspects such as safety training, safety systems and quality of physical work environment received lower scores. This pattern raises some questions regarding how well participant organisations actually implement the vision of safety that they communicate to employees

5 DISCUSSION AND CONCLUSIONS

We started this research having two main aims – the first was to refine our research approach on safety beliefs in order to better understand their role for behavioural safety outcomes. The second aim was to further stimulate systematic data collection on safety related factors in developing countries by expanding our data collection focus to incorporate South America.

Regarding the first aim, we believe that through this research we made a first step in refining approaches on safety beliefs. Our research indicates that there might be **multiple types of beliefs that could be further investigated and a more refined approach of these is necessary in order to better understand how they differentially relate to other individual factors and safety behaviours**. We believe that the research model we used here, actively involving country subject matter experts in the development phase of the research is a powerful one, and it could further stimulate an increased focus on understanding safety and a more systematic data collection in the future.

Overall, our results here identified three main types of beliefs about safety: controllability (that safety is something that people themselves can control and influence), internalised responsibility (that people are themselves responsible for their safety and the safety of others) and attitudes towards safety procedures and professionals (that safety procedures/professionals negatively interfere with one's work). These types of beliefs were associated with other individual factors influencing safety, but were shown to add explanatory power for behaviours such as compliance and participation. Moreover, they were shown to interact with organisational level variables in predicting safety behavioural outcomes.

Secondly, by adding this new data we extended the previous International Safety Benchmarking survey project to South America and we succeeded to generate a high level of interest and focus on safety issues, particularly on safety beliefs and safety culture and their role in supporting the desired safety outcomes. While the focus of this research was different, a number of variables used before were kept in order to facilitate data integration and comparison across all the participating countries. We have hopes that these efforts will be continued in the future with two other countries in South America still collecting data within this project.

Overall, our results for this aim show that the data considered here are very similar with the data coming from the previous countries that participated in the International Safety Benchmarking survey so far. Similar to the other countries, our data suggests that mining represents a high risk environment in Ecuador too, with likelihood and severity of accidents/incidents being

perceived to be situated above scale average and with predefined risks being identified more often by participants. If this trend is going to be visible in the other two participating countries, it would point to the fact that safety and **safety management should be a focus in these countries in order to support sustainable mining development**.

Moreover, the same questions we had in the previous report about companies' abilities to implement safety across all practices and procedures were stimulated by the results in this sample too. While aspects related to management safety values and safety vision were rated really high, safety training, safety systems, and physical work environment were again the lowest rated organisational factors. Therefore, **future interventions around safety should focus less on stimulating organisations to communicate a strong focus on safety and more on how to build organisational systems and practices able to convey managerial values and mission and to support individual safety values.**

The recommendations that were made in our previous report (Andrei et al., 2014) regarding the educational and training programs as well as the action research grants are still valid and we will not reiterate them here. However, we would like to end by highlighting some of the benefits associated with undertaking this follow-up research project.

1. Building capacity and skills for measuring safety related constructs.

Safety professionals in participating countries, especially Peru, have been involved actively in the development of the present research project. As part of this process they self-managed the discussions and efforts to adapt the pre-existing survey to data coming from qualitative investigations into safety beliefs and their own practical experience. We believe that this process has contributed to building their capabilities around measurement of safety related constructs and how to conduct and assessments in their own companies. We hope this capability will be used in the future to better monitor and manage safety related aspects in the participating countries.

2. Creating a network of safety professionals that are interested in individual and cultural aspects of safety and involving them in a specific program.

Throughout this project, a series of connections were made, both within and across countries. Within countries, this research allowed for safety professionals to come together and collaborate on a specific project that would provide valuable information about safety. Across countries, we have been able to connect our collaborators, who in this case were an academic team in Ecuador, and safety professionals in Peru and Argentina. We hope

that this connection will evolve and produce more collaboration between them in the future and also with our centre and lab.

3. Empowering change agents.

This action research has served as a good vehicle for identifying and empowering change agents within participating countries. Our main collaborators in this action research grant gained more visibility as a result of becoming involved in this research. Dr Raul Diaz has been invited to talk about culture and leadership aspects of safety in Chile, while Dr Paola Ochoa is extending the interest in safety research and is bringing other colleagues' interests into this area.

4. Bringing topics around safety culture and safety leadership to the attention of safety professionals that work in companies operating in South America.

We hope that by working in this action research safety professionals involved have gained an improved understanding of the safety related factors that should be considered and monitored more systematically. We hope that they will be able to integrate this knowledge into their everyday practice. There are already signs of this improved understanding especially in the increased interest that is given to culture and beliefs related to safety, as demonstrated by the topics that were proposed for the Safety Leadership Workshop organised in collaboration with IM4DC in Lima in March 2015.

5. Expanding the research and academic network of the C4S team by initiating contact and collaboration with ESPAE – ESPOL Ecuador.

As a result of this action research, we have identified a research group at ESPAE – ESPOL Ecuador that is keen to develop further collaborations with us in the future. In the future, this could lead to more projects contributing to a better understanding of safety in South America as well as more visibility of safety research conducted in developing countries.

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7 APPENDICES

Table 9. *Correlation indices between safety beliefs factors and the other individual factors considered in this research.*

	1	2	4	5	6	7	8	9	10	11	12
1. Safety Beliefs - Controlability											
2. Safety Beliefs - Attitude towards safety procedures	.172**										
3. Safety Beliefs - Internalised responsibility	.404**	.098*									
4. Empowerment_Meaning	.254**	-.016	.353**								
5. Empowerment_Competence	.261**	.017	.244**	.552**							
6. Empowerment_Self Determination	.151**	.195**	.143**	.356**	.453**						
7. Empowerment_Impact	.339**	.147**	.272**	.429**	.484**	.478**					
8. Approach Motivation	.300**	.026	.345**	.439**	.355**	.244**	.321**				
9. Avoidance Motivation	.108*	.247**	-.024	.072	.013	.109*	.130**	.252**			
10. Error learning	.276**	-.048	.217**	.343**	.380**	.130**	.265**	.521**	.231**		
11. Safety Compliance	.228**	-.106*	.362**	.395**	.286**	.103*	.244**	.472**	.090	.462**	
12. Safety Participation	.219**	.033	.283**	.294**	.324**	.214**	.284**	.439**	.097	.307**	.541**

Table 10. *Overall correlations between all individual (blue) and organisational (violet) factors.*

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Empowerment															
2. Safety Beliefs	.31**														
3. Approach Motivation	.43**	.28**													
4.Avoidance Motivation	.12*	.24**	.25**												
5. Work Responses	.34**	.17**	.52**	.23**											
6. Compliance	.31**	.18**	.47**	.09	.46**										
7. Participation	.35**	.24**	.44**	.097	.31**	.54**									
8. Safety Rewards	.39**	.21**	.32**	.08	.29**	.33**	.25**								
8. Safety Vision	.32**	.29**	.33**	.03	.26**	.29**	.25**	.62**							
9.Safety Learning	.34**	.21**	.38**	.03	.28**	.32**	.32**	.52**	.59**						
10. Vigilance	.46**	.37**	.39**	.02	.22**	.39**	.41**	.52**	.63**	.64**					
11. Communication	.50**	.30**	.44**	.08	.36**	.42**	.42**	.45**	.40**	.37**	.50**				
12. Mgmt. Values	.38**	.17**	.36**	.02	.22**	.39**	.38**	.46**	.37**	.36**	.44**	.59**			
13. Safety Systems	.32**	.33**	.47**	.17**	.47**	.41**	.39**	.45**	.33**	.32**	.41**	.53**	.52**		
14. Training	.48**	.29**	.38***	.03	.30**	.30**	.41**	.38**	.40**	.34**	.51**	.67**	.53**	.48**	
15. Physical Work Environment	.22**	.27**	.18**	.26**	.27**	.14**	.20**	.06	.07	.17**	.21**	.32**	.18**	.27**	.25**

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).