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Identifying safety culture and safety climate variables that predict reported risk-taking among Australian coal miners: An exploratory longitudinal study

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ABSTRACT

The present study undertook an exploratory investigation of the causes of risk-taking among Australian coal miners. A range of safety culture and climate variables were measured in a survey of open-cut and underground coal miners from New South Wales and Queensland. A repeat survey of 233 of these miners was conducted an average of 10 months after the initial survey. Participants' age and perceived safety norms at their mine site were significant longitudinal predictors of reported frequency of risk-taking. These findings suggest that young miners and miners who perceive it to be normal for miners at their mine site to ignore safety procedures are more likely to report taking safety risks in the future. Suggestions for safety interventions are considered.

1. Introduction

1.1. Background

Mining is one of the highest risk occupations in the world (Harris et al., 2014; Verma and Chaudhari, 2016; Wei et al., 2017). Australia is the fourth largest mining country in the world, after China, the United States, and Russia (export.gov, 24/07/2018). Work-related injuries cost the Australian mining industry AUD$2.44 billion in the period 2012–2013 (Safe Work Australia, 2015), and the fatality rate of Australian coal miners is approximately 3.84 deaths per 100,000 workers, which is 70% higher than the Australian workplace average (Codrington, 2015). In real terms, 45 coal miners were killed at work during the period 2012–2016 (Safe Work Australia, 2018).

1.2. Motivation

The present study was motivated by the need to reduce work-related injuries and fatalities in the Australian coal mining industry. We approached this problem from the perspective of risk-taking. Specifically, we assumed that an increased frequency of dangerous risk-taking would be associated with an increased frequency of injuries and fatalities among miners.

1.3. Objectives

The research aimed to identify predictors of dangerous risk-taking in the Australian coal mining industry. In particular, we aimed to identify safety culture and safety climate variables that predicted reports of dangerous risk-taking among Australian coal miners.

We adopted an explicitly exploratory approach in our research. Prior research in this general area has tended to develop broad theoretical models and then test them using confirmatory factor analysis (e.g., Clarke, 2010). This confirmatory approach allows relatively clear "yes/no" decisions about the fit of theoretical models to the observed data. However, it is less appropriate when the research aim is to explore which of a range of different variables are most influential in an applied research setting. The aim of the current study was to do exactly this. In particular, we aimed to identify which safety culture and climate variables are likely to cause reported risk-taking among Australian coal miners.

Given our exploratory approach, we did not develop any specific a priori hypotheses about which variables would and would not predict risk-taking among Australian coal miners. Instead, we measured a range of potentially influential safety culture and climate variables based on prior research in this area. These variables were included in a survey of open-cut and underground coal miners from New South Wales and Queensland. We then identified which of these variables predicted self-reported risk-taking in a subsequent survey that was administered on average 10 months after the initial survey.

2. Literature review

Prior research has investigated safety culture and safety climate in

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the mining industry (e.g., Allen, 2014; Jebb, 2015; Mines Occupational Safety and Health Advisory Board, 2002; Parker et al., 2017; Stephan, 2001). Some of this research has shown that safety culture and climate predict better safety performance, compliance, and participation. For example, two studies have shown these associations in Ghanaian gold mine sites (Froko et al., 2015; Stemn et al., 2019).

However, relatively little research has considered safety culture and climate variables as predictors of risk-taking behavior in the mining industry and related high risk industries. The Mines Occupational Safety and Health Advisory Board (2002) Safety Behaviour Survey concluded that managerial support for risk-taking and perceived pressure to take short cuts were potential causes of Australian miners' risk-taking. A UK study found that coal miners' risk-taking was positively related to (a) perceived time pressure linked to payment by productivity (e.g., incentive bonuses), (b) social influence within work teams to be productive, (c) the perception that management implicitly prioritizes productivity over safety, and (d) miners' perceived lack of ability to control and effectively manage risk (Weyman et al., 2003). A study of two Indian underground coal mines found that job dissatisfaction and negative affect positively predicted risk-taking (Paul and Maiti, 2007). Finally, a study with workers at a UK power-generating company showed that senior management commitment to safety positively predicted knowledge and training in safety, which positively predicted reduced risk-taking behaviours (Yule et al., 2007). Table 1 provides a summary of the above literature review.

Taken together, the current literature suggests that safety culture and climate variables operate as important predictors of risk-taking. In particular, the perceived attitudes and norms of management and other workers seem to be important. Critically, however, none of this previous work has attempted to address the difficult issue of causation. In particular, it is relatively unclear whether the putative predictor variables *cause* risk-taking. For example, does a perceived change in management's attitudes cause increases in workers' risk-taking, or does workers' increased risk-taking cause a perceived change in management's attitudes, or are both causal directions operating simultaneously?

It is important to consider causal associations in this research area in order to make recommendations regarding potential interventions to reduce risk-taking and, consequently, improve safety. The present study used an exploratory longitudinal research approach in order to reach firmer causal conclusions. Although longitudinal research designs cannot provide incontrovertible evidence of causation (Selig and Little, 2012, p. 271), they can help to reduce confidence in the existence of reverse causal paths and thereby increase confidence in the putative casual direction (Selig and Little, 2012, p. 268).

To our knowledge, the current research is the first study to use a longitudinal approach to investigate the association between safety culture or safety climate and risk-taking. To substantiate this view, we searched the SCOPUS database using the following search term: TITLE-ABS-KEY (("safety climate" OR "safety culture") AND "risk-taking" AND longitudinal). This search returned a single article that called for future research using a longitudinal research design but that did not itself use a longitudinal research design.

3. Method

3.1. Procedure

The research procedure had ethical clearance from the University of Newcastle's Human Research Ethics Committee (Approval number: H-2016-0178). We recruited participants using a number of different strategies, including emails; information flyers distributed on-site; notices in company newsletters and internal memos; a snowballing approach in which miners were asked to email the online survey link to workmates; social media (Twitter and Facebook); presentations at pre-shift onsite briefings; and recruitment at training and utility days. The last two approaches proved to be the most effective.

Participants were recruited from open-cut and underground mine sites in New South Wales and Queensland, Australia. The sample included 33.48% of participants ($n = 78$) from one open-cut mine site, 30.90% from one underground mine site ($n = 72$), and 35.62% ($n = 83$) from a variety of other open-cut and underground mine sites. In total, 37.68% of participants ($n = 88$) were from open-cut mines and 61.37% ($n = 143$) were from underground mines, with 2 participants not indicating their mine site.

Wave 1 data collection began on August 08, 2016 and ended on March 31, 2018. Wave 2 data collection began on August 17, 2017 and ended on September 20, 2018. Although there was an overlap between these two data collection periods, the minimum time between completing Wave 1 and Wave 2 for any participant was 4 months. The mean lag time was 10.24 months ($SD = 4.93$), and the maximum lag time was 22 months.

The survey was presented online and in paper format, although most participants completed the paper version (96.57% in Wave 1; 88.84% in Wave 2). The survey was titled "safety and risk-taking survey," and it was introduced as "investigating safety and risk-taking in Australian coal mines." Participants responded to the safety culture and climate items first, followed by the risk-taking items. They then responded to the accident and near miss measures, followed by the demographic items. Details about these measures are provided in Section 3.2. The median completion time for the online version of the survey was 16.53 min (averaged across Waves 1 and 2).

Participants completed the survey anonymously. However, they were asked to provide their email address and mobile phone number in a separate survey. This information was used to contact them to ask them to complete the second survey.

Participants were also asked to provide a longitudinal identification code at the end of each survey. This code consisted of the first letter of the participant's first name, the first letter of their mother's first name, the date of the day of the participant's birthday, and the month of the participant's birthday, written as a number. This four-item code (e.g., RP226) was used to match surveys from Waves 1 and 2.

Table 1
Summary of Literature Review.

Study	Country	Industry	Key Findings
Froko et al. (2015); Stemn et al. (2019)	Ghana	Gold mining	Safety culture and climate predict better safety performance, compliance, and participation.
MOSHAB (2002) Safety Behaviour Survey	Australia	Mining (all types)	Risk-taking is predicted by (a) managerial support for risk-taking and (b) perceived pressure to take short cuts.
Weyman et al. (2003)	UK	Coal mining	Risk-taking is predicted by (a) perceived time pressure linked to productivity, (b) social influence within work teams, (c) the perception that management prioritizes productivity, and (d) perceived lack of ability to control and manage risk.
Paul and Maiti (2007)	India	Underground coal mining	Risk-taking is predicted by job dissatisfaction and negative affect.
Yule et al. (2007)	UK	Power-generating company	Risk-taking is predicted by (a) senior management's commitment to safety and (b) knowledge and training in safety.

3.2. Measures

The survey included a range of scales that aimed to assess constructs from the safety culture and safety climate literature (e.g., Alruqi et al., 2018; Brondino et al., 2013; Clarke, 2010). Unless otherwise indicated here and below, scales consisted of three items, and participants indicated their responses using a 7-point Likert-type scale anchored *strongly disagree* (1) and *strongly agree* (7). The scales assessed participants' perceptions of (a) the clarity and accessibility of safety systems, (b) management's commitment to safety, (c) the adequacy of the number of workers at the mine site (single item), (d) pay bonuses for productivity, and (e) the safety norms at the mine site. Participants also judged their own (a) safety knowledge, (b) safety motivation, (c) safety training, (d) level of on-the-job risk, (e) control over risk, (f) risk awareness, and (g) risk assessment ability. Participants also indicated perceptions of (a) time pressure to get the job done, (b) work team identification, and (c) work team pressure to take safety risks. Supplementary File 1 on the Open Science Framework webpage for this project provides a full list of the items in each scale and the scales that are described below as well as their response scales. The Open Science Framework webpage can be found at: https://osf.io/2vhmr/.

The survey included scales that assessed health-related variables, including lack of sleep, work-related stress, and general health (1 = *poor*, 5 = *excellent*). The survey also assessed job evaluation scales and items, including job satisfaction (based on Thompson and Phua's, 2012, Index of Affective Job Satisfaction), job stability (single item), and job performance (single item; 1 = *bottom performer*, 9 = *top performer*). Single items were used to assess fly-in-fly-out status (*yes, no, don't know*), career number of work-related major accidents, mine site location, shift type, and working hours. The measures of shift type and working hours were problematic because they did not take into account the fact that many miners were on a rotating roster (e.g., seven days on, seven days off). Consequently, these two variables were not included in the analyses. In addition to the demographic variables mentioned in the Participants section, we also measured relationship status (*single, in a casual relationship, in a serious relationship, married*), social class (based on the MacArthur Scale of Subjective Social Status; 1 = *bottom level*, 11 = *top level*; Adler and Stewart, 2007), and social desirability (three items adapted from Stöber's, 2001, Social Desirability Scale-17).

The main outcome variables were measures of the perceived frequency and magnitude of risk-taking. In our survey, we explained to participants: "safety risks are work-related risks that people take intentionally or unintentionally, that violate safety policies or procedures or common sense, and that have the potential to result in either minor or major injury or damage." To assess the frequency of risk-taking, we asked participants to indicate the extent to which they had taken (a) major and (b) minor safety risks (c) intentionally and (d) unintentionally in the past two months. Participants responded to these four items using an 8-point Likert-type scale anchored *never* (1) and *all the time* (8). Magnitude of risk-taking was assessed using a 3-item measure. Each item began "the safety risks that I've taken over the last two months could have resulted in:" The remaining part of each item was (a) "injuries to me," (b) "damage to equipment or the mine site," and (c) "injuries to others." Participants responded to these three items using a 7-point scale anchored *not at all* (1) and *a massive amount* (7).

Participants also responded to two items that assessed their frequency of accidents and near misses. In the survey, we defined accidents as "specific events that have resulted in injuries to yourself or others or damage to equipment or property" and near misses as "specific events that had the potential to result in injuries or damage but did not actually result in any injuries or damage on that particular occasion." The two items stated "in the last two months, approximately how many work-related accidents [near-misses] (major and minor; reported and unreported) have you been involved in?" Participants responded on a scale from 0 to "10 or more." If participants did not respond with "0," then they proceeded to indicate the magnitude of their accidents and/or near misses using a similar item and response scale to that for the magnitude of risk-taking items.

3.3. Data collection

Participants were eligible to complete the survey if they were 18 years or older and an employee or contract worker at an Australian coal mine. We collected data from 2410 surveys across two waves of data collection. We identified 16 cases of duplicate responses in which participants had completed the survey twice during either Wave 1 or Wave 2. In these cases, the second response was deleted, leaving only the first response. The remaining 2144 responses included responses from 250 participants who had completed both waves of the study (attrition rate = 88.34%). Of these, the Wave 1 responses of participants indicated that 12 were "management" and 5 were "administration." These 17 participants were excluded from the analyses because they were not directly involved in coal extraction/production. Hence, our final longitudinal sample consisted of 233 participants.

A sensitivity analysis was conducted to determine the minimum effect size that we could expect to detect using this sample size using a power level of 0.80 and an alpha level of 0.05. Using G*Power 3 (Faul et al., 2007), we found that a two-sided zero-order correlation test could be expected to detect an effect as small as $r = 0.18$ with these parameters. This degree of sensitivity was deemed satisfactory given that an effect size of $r = 0.19$ is typical in the field of psychology (Stanley et al., 2018).

3.4. Demographic composition of the sample

Based on their Wave 1 responses, 95.28% of participants were men ($n = 222$) and 3.43% were women ($n = 8$), with 1.29% missing responses ($n = 3$). Participants' average age was 39.21 years ($SD = 10.93$) and ranged from 18 to 65 years. On average, participants had worked 11.80 years in the mining industry ($SD = 8.98$). In addition, 60.94% of participants ($n = 142$) indicated that they were company employees, and 37.77% ($n = 88$) indicated that they were contract workers ($n = 2$ missing data).

In terms of occupation, 51.20% of participants ($n = 128$) indicated that they were "mineworkers," 24.00% ($n = 60$) "maintenance," 11.20% ($n = 28$) "supervisors," 5.6% ($n = 14$) "other," and 1.20% ($n = 3$) did not provide a response and so were considered most likely to fall into one of these previous four categories. Finally, 12.45% ($n = 29$) of participants classed themselves as "fly-in, fly-out" workers, and 16.31% ($n = 38$) indicated that they were a member of the mines rescue team.

3.5. Analytical approach

We followed Rubin's (2017a, 2017b, 2017c) approach to exploratory data analysis. First, it should be noted that multiple testing in exploratory research can inflate the studywise Type I error rate (e.g., Nosek and Lakens, 2014). To address this issue, we did not test the joint studywise null hypothesis that there is no association between any of the variables in the study. Instead, we undertook more focused tests of individual null hypotheses and, for each test, we used a conventional significance threshold of $p \leq 0.05$ (Rubin, 2017b). Second, following the Fisherian and Bayesian approaches to hypothesis testing, we conditioned each of our probability statements on the relevant test that we actually conducted. We did not condition probability statements on potential tests that could eventuate if a long run of repeated sampling were to be performed (Rubin, 2017a). Third, we conducted a robustness analysis that indicated any changes in the pattern of reported results when tests were performed after (a) excluding outliers and (b) including theoretically relevant covariates (Rubin, 2017a, 2017b). This robustness analysis provides a degree of reassurance in the face of concerns about *p-hacking* and selective reporting in exploratory

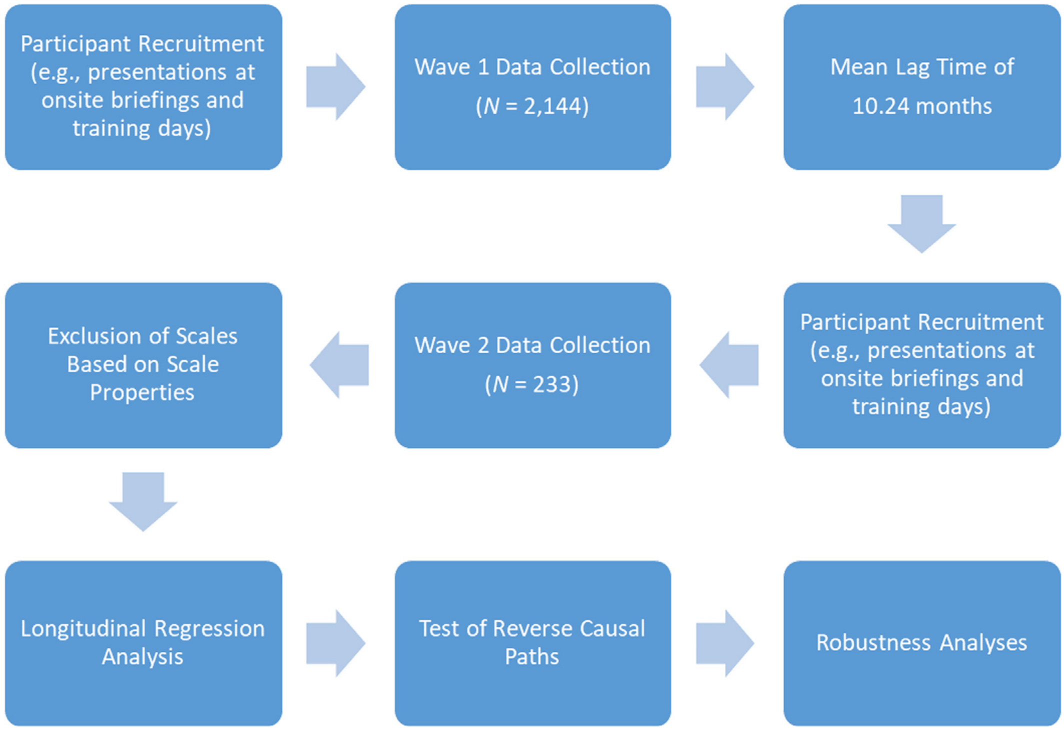

Fig. 1. Summary of Methodological and Analytical Approach.

research (Simmons et al., 2011). Fourth, and to provide further reassurance on this matter, we have reported all variables in our survey and provided a copy of our research survey and deidentified data set at https://osf.io/2vhmr/ (Rubin, 2017b). Finally, we have been explicit that this research is exploratory, rather than confirmatory, and we have not provided any falsely a priori hypotheses in our Introduction (Rubin, 2017c). Hence, we have not engaged in any undisclosed hypothesizing after their results are known (HARKing; Kerr, 1998; Rubin, 2017c).

Our methodological and analytical approach is summarised in Fig. 1. Following the second wave of data collection, we excluded measures from our analyses that did not have satisfactory psychometric properties. We then conducted a longitudinal regression analysis in order to identify predictors of the frequency of risk-taking at Time 2 after controlling for frequency of risk-taking at Time 1. We tested the reverse causal paths of any significant predictors and then undertook a robustness analysis to corroborate our statistical conclusions.

4. Results and discussion

4.1. Analysis of the safety climate and culture scales

We reverse-coded negatively worded items and then computed Cronbach alpha values for each scale. Seven scales had poor alpha values (αs ≤ 0.53), and these values did not improve after excluding items. Consequently, these scales were not included in the analyses. They included the measures of social desirability, magnitude of accidents, risk assessment ability, safety motivation, clarity and accessibility of safety systems, risk awareness, and control over risk. The remaining scales either had Cronbach alphas at or above the 0.70 threshold or, in the case of safety training and work team pressure, they met this criterion after removing a problematic item from the scale. Consequently, we computed the mean scores for the items in these scales.

The measures of the frequency and magnitude of accidents and near misses were skewed (≥3.83 for Wave 2). In Wave 2, 77.25% of participants (n = 180) indicated that they had not experienced any accidents or near misses over the past two months. This large percentage may indicate a genuine rarity of accidents and near misses. However, it may also indicate the operation of a number of biases. First, miners may have discounted some accidents and near misses because they thought that these incidents did not meet the criteria stated in our survey. For example, they may have discounted slips, trips, and falls from their count of accidents and near misses because they considered them too minor in nature. Second, miners may have failed to report some accidents and near misses because they lacked trust in the anonymity and/or confidentiality of their responses, and they felt that they may receive a penalty for reporting their accidents. Finally, social desirability concerns may have motivated miners to forget about or fail to disclose their accidents and near misses (e.g., Geddes, 2012). Whatever the reasons for the low level of reporting accidents and near misses, we decided that it would be problematic to include these secondary outcome measures in the data analyses. Similarly, 55.56% of participants (n = 125) indicated that they had zero major accidents during their career (skewness = 4.33). Again, we excluded this measure from our analyses. All other variables had acceptable levels of skewness, ranging from −1.30 to 1.74.

The measure of risk magnitude was less skewed than the measures of accidents and near misses (1.74). Nonetheless, 42.92% of participants indicated that the safety risks that they had taken over the past two months had no chance of injuring themselves, others, or equipment. Again, this rather high percentage casts doubt on the usefulness of this measure. In contrast, the measure of risk frequency, which was our primary outcome measure, was not particularly skewed (1.30). Furthermore, only 19.74% of participants responded with the lowest mean value of 1.00 on this measure, indicating that although 46 participants reported that they had never taken any major or minor safety risks intentionally or unintentionally over the past two months, 80.26% of participants reported that they had.

4.2. Descriptive Statistics

Table 2 provides the means, standard deviations, minimum and maximum values, and Cronbach alpha values for the continuous variables at Time 1 (i.e., during Wave 1).

Table 2
Descriptive Statistics, Cronbach Alphas, and Zero Order Correlation Coefficients for Continuous Variables at Time 1.

Measure	*M*	*SD*	α	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Perceived frequency of risk-taking	2.34	1.15	0.85	–																		
2. Age	39.21	10.93	–	**−0.26**	–																	
3. Years in industry	11.80	8.98	–	**−0.14**	**0.69**	–																
4. Social class	6.65	1.52	–	−0.10	0.00	0.06	–															
5. Health	3.62	0.79	–	−0.08	−0.10	−0.09	**0.15**	–														
6. Lack of sleep	4.22	1.37	0.80	**0.39**	−0.09	−0.08	**−0.15**	−0.01	–													
7. Work-related stress	3.35	1.25	0.84	**0.32**	−0.02	0.05	−0.09	−0.07	**0.45**	–												
8. Safety training	5.27	1.11	0.70	**−0.30**	0.03	0.10	0.11	0.13	**−0.29**	**−0.32**	–											
9. Safety knowledge	5.26	1.00	0.72	**−0.35**	**0.16**	0.07	0.13	0.07	**−0.25**	**−0.24**	**0.35**	–										
10. Perceived management commitment to safety	4.74	1.36	0.84	**−0.42**	0.03	−0.07	0.12	**0.14**	**−0.35**	**−0.34**	**0.56**	**0.31**	–									
11. Poor safety norms at mine site	3.20	1.29	0.80	**0.50**	−0.06	0.05	**−0.14**	−0.09	**0.42**	**0.45**	**−0.44**	**−0.33**	**−0.74**	–								
12. Adequate number of miners at site	4.30	1.82	–	**−0.18**	0.01	−0.13	0.05	0.03	**−0.24**	**−0.35**	**0.35**	**0.15**	**0.40**	**−0.29**	–							
13. Pay bonuses for productivity	2.96	1.67	0.84	0.12	0.04	0.07	0.11	0.01	0.10	**0.18**	−0.06	−0.12	**−0.19**	0.06	**−0.26**	–						
14. Time pressure to get job done	4.55	1.47	0.88	**0.30**	−0.02	0.14	−0.06	−0.08	**0.40**	**0.46**	**−0.39**	**−0.25**	**−0.54**	**0.47**	**−0.47**	**0.24**	–					
15. Work team identification	5.44	0.97	0.72	**−0.24**	0.04	0.13	0.09	0.04	**−0.28**	**−0.23**	**0.15**	0.12	**0.18**	**−0.24**	0.06	0.11	−0.03	–				
16. Work team pressure	2.70	1.32	0.84	**0.50**	**−0.16**	−0.13	**−0.13**	−0.09	**0.36**	**0.38**	**−0.28**	**−0.25**	**−0.42**	**0.53**	**−0.21**	0.15	**0.41**	**−0.26**	–			
17. Perceived level of on-the-job risk	4.13	1.29	0.81	**0.35**	−0.11	0.01	0.02	0.03	**0.21**	**0.22**	**0.20**	−0.10	**−0.31**	**0.31**	**−0.14**	**0.17**	**0.20**	−0.01	**0.23**	–		
18. Job stability	5.42	1.52	–	**−0.15**	−0.07	**−0.18**	0.06	0.08	**−0.18**	**−0.28**	**0.22**	**0.15**	**0.21**	**−0.20**	**0.16**	0.04	**−0.28**	**0.19**	**−0.15**	−0.01	–	
19. Job satisfaction	5.08	1.19	0.86	**−0.35**	0.03	0.00	**0.14**	0.09	**−0.44**	**0.51**	**0.27**	**0.28**	**0.40**	**−0.45**	**0.28**	**0.14**	**−0.29**	**0.54**	**−0.28**	**−0.18**	**0.40**	–
20. Job performance	6.32	1.30	–	−0.13	−0.06	−0.02	**0.18**	0.11	−0.12	−0.09	0.09	0.08	**0.14**	**−0.16**	0.02	0.03	−0.04	**0.22**	**−0.18**	0.01	**0.24**	**0.20**

Note. All *ns* ≥ 229 apart from age (n = 201) and years working in industry (n = 215). In general, higher scores indicate more agreement with the issue (e.g., more of a lack of sleep, more job satisfaction, etc.). All scales have a theoretical range from 1 to 7 apart from perceived frequency of risk-taking (1 = *never*, 8 = *all the time*), health (1 = *poor*, 5 = *excellent*), social class (1 = *bottom level*, 11 = *top level*), job performance (1 = *bottom performer*, 9 = *top performer*), and age and years in industry, which were measured in years. Significant coefficients are indicated in bold (*ps* ≤ 0.050).

Table 3
Longitudinal Regression Testing Predictors of Frequency of Risk-Taking at Time 2.

Time 1 predictor variable (controlling for Time 1 risk-taking)	β	*t*	*p*
Age	**−0.12**	**−2.28**	**0.024**
Number of years in the industry	0.02	0.39	0.701
Lack of sleep	0.05	0.88	0.381
Work-related stress	−0.00	−0.02	0.981
Safety training	−0.08	−1.49	0.138
Safety knowledge	−0.03	−0.63	0.532
Perceived management commitment to safety	−0.10	−1.85	0.066
Poor safety norms at mine site	**0.14**	**2.47**	**0.014**
Adequate number of miners at mine site	0.02	0.41	0.683
Time pressure to get job done	0.03	0.48	0.632
Work team identification	0.01	0.11	0.916
Work team pressure	0.03	0.43	0.670
Perceived level of on-the-job risk	0.04	0.73	0.465
Job stability	0.01	0.10	0.924
Job satisfaction	0.02	0.45	0.657

Note. The outcome variable is Time 2 frequency of risk-taking. Significant effects are indicated in bold (*ps* ≤ 0.050).

Looking at Table 2, it is notable that participants' mean score in relation to reported frequency of risk taking over the past two months (M = 2.34) was substantially below the scale midpoint of 4.5 and closest to the *almost never* scale point. Hence, although there was suitable variability in participants' responses (SD = 1.15), participants generally reported a low level of risk-taking. It is also notable that miners tended to partially agree that they had good safety training (M = 5.27) and safety knowledge (M = 5.26), and they tended to partially disagree that their mine site had poor safety norms (M = 3.20) and that they got paid bonuses for their productivity (M = 2.96).

Miners also tended to partially agree that they felt a sense of identification with their work team (M = 5.44) and to partially disagree that people in their work team pressured them to take safety risks (M = 2.70). Finally, miners tended to partially agree that they would be working in the same job next year (job stability M = 5.42) and that they were satisfied with their job (M = 5.08).

4.3. Zero-Order correlations

Table 2 also shows the zero-order correlations between the continuous level variables at Time 1, with significant effects highlighted in bold ($ps \leq 0.05$). Considering demographic variables first, it can be seen that reported frequency of risk-taking was negatively associated with participants' age ($r = -0.26$), indicating that older miners reported taking fewer risks in the past two months compared to younger miners. A similar but smaller association was found between reported risk-taking and number of years in the industry ($r = -0.14$).

Turning to the safety culture and safety climate variables, reported frequency of risk-taking had large associations with safety culture and climate variables (average $r = |0.47|$). These associations were positive in relation to poor safety norms at mine site and work team pressure and negative in relation to perceived management commitment to safety. Reported frequency of risk-taking also had a large positive association with lack of sleep ($r = 0.39$).

Reported frequency of risk-taking had medium-sized associations with other safety culture and climate variables (average $r = |0.32|$). These associations were positive in relation to perceived level of on-the-job risk, work-related stress, and time pressure to get job done, and they were negative in relation to safety knowledge, job satisfaction, safety training, and work team identification. Finally, there were smaller negative associations (average $r = -0.17$) with adequate number of miners at the mine site and job stability.

4.4. Occupation and employment type

We investigated the potential influence of occupation and employment type on reported frequency of risk-taking. In particular, we performed a one-way ANOVA with Time 1 occupation as the independent variable (mineworker, maintenance, supervisor, other) and Time 1 reported frequency of risk-taking as the dependent variable. There was no significant effect of occupation, $F(3, 226) = 2.21$, $p = .087$. We also performed an independent samples t test to check for differences in reported frequency of risk-taking between company employees and contract workers. There was no significant difference, $t(228) = 0.22$, $p = .826$. Finally, there was no significant difference in risk-taking between miners who were members of the mine rescue team and those who were not, $t(219) = 1.05$, $p = .295$, or between miners who were fly-in-fly-out workers and those who were not, $t(228) = -1.36$, $p = .176$.

4.5. Longitudinal analyses

Although informative, the results of the above cross-sectional correlation analyses do not facilitate an interpretation of the causal directions between variables. For example, it is possible that (a) higher levels of risk-taking cause greater work-related stress, and/or that (b) greater work-related stress causes higher levels of risk-taking. To increase confidence in conclusions about causal direction, we performed a series of separate longitudinal regression analyses that included frequency of risk-taking at Time 2 as the outcome variable and each of the above 15 Time 1 variables as predictor variables as well as Time 1 frequency of risk-taking. This analysis allowed us to examine the cross-lagged association between each putative predictor at Time 1 and the reported frequency of risk-taking an average of 10 months after Time 1 while controlling for associated autoregressive effects. Again, it is important to note that this approach cannot be used to prove causation. Nonetheless, it can assist in making clearer statements about causation than the cross-sectional correlational approach. Table 3 reports the results of these analyses.

As can be seen in Table 3, participants' Time 1 age had a significant negative association with their Time 2 reported frequency of risk-taking when controlling for their Time 1 reported frequency of risk-taking: Younger miners were more likely than older miners to report greater risk-taking at Time 2.

Poor safety norms at the mine site also showed a significant longitudinal association with Time 2 risk-taking. The three items in this scale were as follows: "There tends to be a poor attitude to safety at my mine site"; "people often ignore the safety procedures at my mine site"; and "unsafe risk-taking is common at my mine site." Stronger agreement with these items at Time 1 predicted greater reported frequency of risk-taking at Time 2. Fig. 2 summarises the significant results from Table 3.

We followed up on these two significant longitudinal effects by testing the reverse causal paths. Hence, we tested (a) Time 1 frequency of risk-taking as a predictor of Time 2 age while controlling for Time 1 age and (b) Time 1 frequency of risk-taking as a predictor of Time 2 safety norms while controlling for Time 1 safety norms. As expected, the reverse causal effect for age was nonsignificant, $\beta = -0.01$, $p = .229$: Risk-taking did not cause miners to become younger! The reverse effect for safety norms was also nonsignificant, $\beta = 0.12$, $p = .059$, although it was closer to the threshold for significance. Hence, the evidence is strongest for the causal direction in which age and safety norms cause risk-taking rather than vice versa. However, we cannot rule out the possibility that miners' own risking-taking causes an increase in their perception that safety norms for their site are generally poor. Indeed, this reverse causal effect would be consistent with a false consensus effect in which people assume that their own attitudes are more common in a population than they really are (Ross et al., 1977).

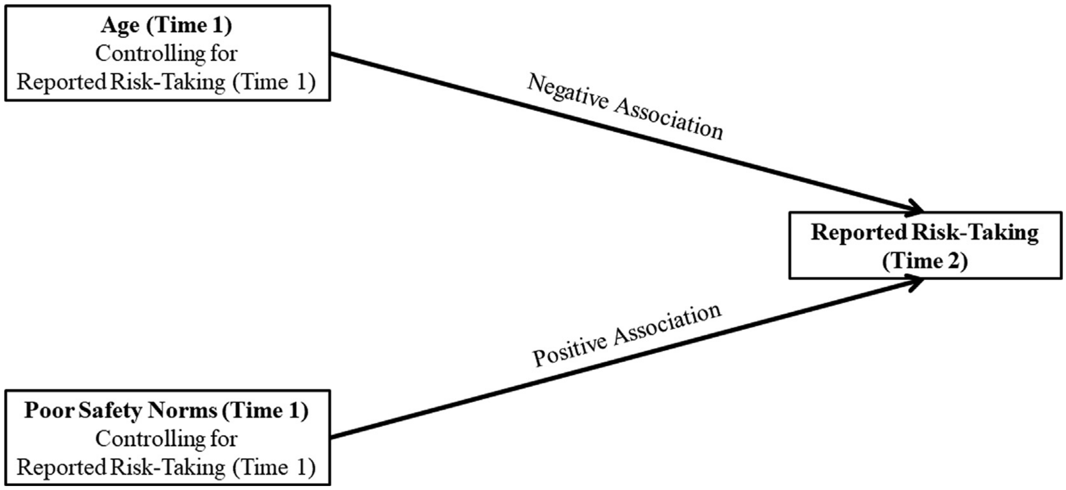

Fig. 2. Summary of Significant Result from the Longitudinal Analysis.

4.6. Robustness analyses

We conducted a set robustness analyses in order to demonstrate that our research results were not dependent on the inclusion or exclusion of outliers and covariates in our analyses. We also checked whether our results varied as a function of type of mine site (open-cut vs. underground). Finally, we checked whether our results were evident using Bayesian hypothesis testing as well as significance testing.

Outliers were defined as cases that were ± 3 *SD*s from the sample mean. For the Time 1 measures, we identified two outliers on the social class measure, one on the job satisfaction measure, one on the safety knowledge measure, two on the safety training measure, and two on the team identification measure. We also identified three outliers on the Time 2 reported frequency of risk-taking measure. Table 2 and 3's patterns of significant and nonsignificant associations with frequency of reported risk-taking remained the same when these outliers were excluded from the analyses.

We also tested the two longitudinal effects that we had identified while controlling for a selection of theoretically diagnostic covariates. In the case of the age effect, we controlled for number of years working in the industry, because older miners have had more opportunity to accrue a greater number of years in the industry. Indeed, the correlation between age and industry years was $r = 0.69$. The longitudinal effect of Time 1 age on Time 2 reported frequency of risk-taking remained significant when controlling for industry years ($\beta = -0.16$, $p = .043$). Hence, age significantly predicted reported risk-taking over and above number of years in the industry.

In the case of poor safety norms, we controlled for safety training because greater training should be associated with better safety norms, and this was the case in the current sample ($r = -0.44$). We also controlled for work team pressure to take safety risks because such pressure should be associated with poorer safety norms. Again, this was the case in the current sample ($r = 0.53$). The longitudinal effect of Time 1 poor safety norms on Time 2 reported frequency of risk-taking remained significant when controlling for these two covariates ($\beta = 0.14$, $p = .034$).

We also tested whether type of mine site (open-cut vs. underground) moderated the size of the two longitudinal effects. Specifically, we used Hayes' (2018) PROCESS Model 1 to test the interaction between mine site type (moderator) and either age or safety norms (predictor) in predicting Time 2 reported frequency of risk-taking (outcome) while controlling for Time 1 reported frequency of risk-taking (covariate). The interaction effect was nonsignificant in both cases ($ps \geq 0.110$). These results indicate that the longitudinal effects did not vary significantly as a function of mine site type.

Finally, we tested our two key findings using a Bayesian approach. Specifically, we computed two Bayesian longitudinal linear regression models using the default settings in JASP (Marsman and Wagenmakers, 2017). In these models, Time 2 reported frequency of risk-taking was the outcome variable, Time 1 reported frequency of risk-taking was a predictor variable, and either Time 1 age or Time 1 safety norms were also predictors. A default uniform prior was used. The Bayes factor for the model that included Time 1 age as a predictor was 3.49, and the Bayes factor for the model that included Time 1 safety norms as a predictor was 5.38. Hence, the data was around 3.5 to 5.0 times more likely under the proposed models than under the null models. This level of evidence is "moderate" in strength (Lee and Wagenmakers, 2014).

4.7. Summary

The present research tested a series of potential predictors of reported frequency of risk-taking among Australian coal miners using an exploratory longitudinal research approach. Participants' age and perceived poor safety norms at their mine site emerged as the only significant longitudinal predictors of reported risk-taking. These findings suggest that young miners and miners who perceive it to be normal for miners at their mine site to ignore safety procedures are more likely to report taking safety risks in the future.

4.8. Empirical contributions

The present research makes several novel empirical contributions to the literature. First, to our knowledge, the present study is the first to identify a significant association between age and risk-taking in the mining industry. Notably, Paul and Maiti (2007) tested for this association in Indian underground mines but found no significant effect ($r = 0.01$). The observed negative association between age and reported risk-taking is consistent with prior work that has found that age negatively predicts job risk (Mitchell, 1988). It is also consistent with work that has found that age negatively predicts injury rates (Breslin and Smith, 2006) but inconsistent with work that has found a positive association between these two variables (Paul and Maiti, 2007).

Importantly, the relation between age and reported risk-taking persisted when controlling for number of years in the industry. Hence, this association did not appear to be fully explained by age differences in experience (cf. Mitchell, 1988). Instead, it is possible that the association reflects a more general propensity for young people to take more risks.

We also found that perceived poor safety norms at the mine site predicted subsequent reported increased risk-taking. In her review of the safety culture and climate literature, Geddes (2012, pp. 27–32) found that the concept of coworker safety norms has not received sufficient attention in the safety literature. Nonetheless, Geddes found that the limited amount of available evidence is consistent with the idea that safety norms have a relatively large effect on safety behavior (e.g., Beus et al., 2010; Christian et al., 2009; Fogarty and Shaw, 2010; Fugas et al., 2012; Melia et al., 2008). The present research findings add to this small but important body of evidence by demonstrating the putative causal effect of safety norms on risk-taking in the mining industry.

4.9. Theoretical implications

Our research findings also have important theoretical implications. Workers' age and other demographic variables are rarely considered as influential factors in models of organizational safety behavior. For example, the models by Fogarty and Shaw (2010) and Clarke (2010) do not consider workers' age or any other demographic variables. Instead, their primary predictor variables are "management attitude" and "psychological climate." Certainly, broad social and organizational factors are likely to be important predictors of safety-related behavior. Indeed, our evidence regarding safety norms confirms this to be the case. However, we should not allow undue emphasis to be placed on organizational factors and at the expense of acknowledging the importance of individual level factors. Workers' age, other demographic variables (e.g., gender, full-time vs. part-time workers, etc.), and personality variables (conscientiousness) may all play an important role alongside organizational factors in determining risk-taking and safety behaviors.

The present findings also suggest that *other workers* should be regarded as important or more important than management and supervisors in safety culture and climate models. This point is consistent with several models of normative influence in the safety literature that have proposed that the flow of social influence moves from managers to supervisors to coworkers to individual workers (Cui et al., 2013; Geddes, 2012; Melia et al., 2008). According to these models, coworkers' safety norms are the most proximal influence on individual workers' safety attitudes and behaviors, possibly because they are the most salient norms in work groups' day-to-day operations (Choi et al., 2017), and because miners typically have a high degree of autonomy from management and supervisors when carrying out their duties (Weyman et al., 2003). Future research in this area needs to take into account this chain of social influence from managers to supervisors to coworkers. In addition, future research should investigate the subtleties of the safety norm concept in greater depth. For example, Fugas et al. (2012) distinguished between *injunctive* safety norms (what ought to be done) and *descriptive* safety norms (what is done).

4.10. Practical implications

In general, the association between age and risk-taking is complex and dependent on gender, the type of task, and the task domain (e.g., Figner and Weber, 2011; Mata et al., 2011; Rolison et al., 2013). The current sample consisted of 95.28% men. Hence, it is possible that risk-taking was perceived to be part of the norm for young men (e.g., Mast et al., 2008). If this is the case, then safety interventions that focus on changing the perceived appropriateness of risk-taking for young men may prove to be effective.

Our longitudinal evidence also suggested that poor safety norms may cause subsequent increases in risk-taking. Hence, interventions that focus on improving the perceived safety norms of a mine site may lead to a reduction in the frequency of risk-taking at that site.

4.11. Limitations

It is important to note that the null findings regarding many of the safety culture and climate variables in our study do not necessarily imply that these variables are unrelated to risk-taking. These null findings may be due to insensitive or invalid measures or inadequate statistical power to detect effects that are smaller than average in this field.

A further limitation of the present research is that our measure of risk-taking was a self-report measure rather than a behavioral measure. This self-report measure may have been influenced by social desirability and other biases. In particular, these sorts of biases may have affected our measures of accidents and near misses. Future research should consider using more behavioral measures in order to overcome this problem.

The current results refer to risk-taking in the Australian coal mining industry. Different predictors may prove to be more influential in mining industries in different countries and/or in different industries. Finally, although we used a longitudinal research design, our causal conclusions are only provisional. Replications are required to confirm our longitudinal effects, rule out third variables, and consider potential mediating and moderating variables.

5. Conclusions

Mining is a high risk occupation in which risk-taking can have life-threatening consequences. Researchers need to investigate the factors that may cause miners to engage in dangerous risk-taking. The results of this research can inform the development of suitable interventions to reduce risk-taking.

Very little research in this area has considered safety culture and climate variables as potential causes of miners' risk-taking behavior. To address this issue, the present study used an exploratory longitudinal research approach to investigate self-reported risk-taking among 233 open-cut and underground coal miners from Australia.

The study produced two key findings. First, the study identified a negative longitudinal association between workers' age and their reported risk-taking in the mining industry. This result indicates that younger miners were more likely to report greater risk-taking. Theoretically, this result implies that more importance should be placed on workers' age in models of organizational safety behaviour. Practically, this result suggests that mining safety interventions may be more effective if they focus on changing the perceived appropriateness of risk-taking among young men. A second key finding relates to the role of safety norms. The current study adds to the small body of evidence showing that poor safety norms predict increased risk-taking at mine sites (Weyman et al., 2003) and in other industries (Yule et al., 2007). The longitudinal nature of the research design improves our confidence in the casual direction of this association. Consequently, this result points to risk-taking interventions that improve the perceived safety norms of mine sites.

The study had a number of important methodological limitations. In particular, risk-taking was (a) assessed using a self-report measure and (b) restricted to the Australian coal mining industry. Hence, it is important for future work in this area to consider using more behavioural measures of risk-taking in different countries and industries. Future research should also investigate the subtleties of the safety norm concept in greater depth by distinguishing between injunctive and descriptive safety norms (Fugas et al., 2012).

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References

Adler, N., Stewart, J., 2007. The MacArthur Scale of Subjective Social Status. MacArthur

Res. Network SES Health. http://www.macses.ucsf.edu/Research/Psychosocial/subjective.php.
Allen, R.J., 2014. Safety culture within the Australian coal mining industry: Identifying the critical factors and measuring the construct. Research Doctorate, PhD. The University of Newcastle, NSW Australia. http://hdl.handle.net/1959.13/1048477.
Alruqi, W.M., Hallowell, M.R., Techera, U., 2018. Safety climate dimensions and their relationship to construction safety performance: a meta-analytic review. Saf. Sci. 109, 165–173. https://doi.org/10.1016/j.ssci.2018.05.019.
Beus, J.M., Payne, S.C., Bergman, M.E., Arthur, W., 2010. Safety climate and injuries: an examination of theoretical and empirical relationships. J. Appl. Psychol. 95, 713–727. https://doi.org/10.1037/a0019164.
Breslin, F.C., Smith, P., 2006. Trial by fire: A multivariate examination of the relation between job tenure and work injuries. Occup. Environ. Med. 63, 27–32. https://doi.org/10.1136/oem.2005.021006.
Brondino, M., Pasini, M., da Silva, S.C.A., 2013. Development and validation of an Integrated Organizational Safety Climate Questionnaire with multilevel confirmatory factor analysis. Qual. Quant. 47, 2191–2223. https://doi.org/10.1007/s11135-011-9651-6.
Choi, B., Ahn, S., Lee, S., 2017. Construction workers' group norms and personal standards regarding safety behavior: Social identity theory perspective. J. Manage. Eng. 33, 04017001. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000511.
Christian, M.S., Wallace, J.C., Bradley, J.C., Burke, M.J., 2009. Workplace safety: a meta-analysis of the roles of person and situation factors. J. Appl. Psychol. 94, 1103–1127. https://doi.org/10.1037/a0016172.
Clarke, S., 2010. An integrative model of safety climate: Linking psychological climate and work attitudes to individual safety outcomes using meta-analysis. J. Occup. Org. Psychol. 83, 553–578. https://doi.org/10.1348/096317909X452122.
Codrington, S., 2015. Worker dies after Queensland mining incident. Safety Culture OH&S News. Retrieved from http://content.safetyculture.com.au/news/index.php/02/worker-dies-queensland-mining-incident/#.W9BJ_vZoS70 export.gov. (24/07/2018). Australia country commercial guide. export.gov. Retrieved from https://www.export.gov/article?id=Australia-Mining.
Cui, L., Fan, D., Fu, G., Zhu, C.J., 2013. An integrative model of organizational safety behavior. J. Saf. Res. 45, 37–46. https://doi.org/10.1016/j.jsr.2013.01.001.
Faul, F., Erdfelder, E., Lang, A.-G., Buchner, A., 2007. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior Res. Methods 39, 175–191. https://doi.org/10.3758/BF03193146.
Figner, B., Weber, E.U., 2011. Who takes risks when and why? determinants of risk taking. Curr. Directions Psychol. Sci. 20, 211–216. https://doi.org/10.1177/0963721411415790.
Fogarty, G.J., Shaw, A., 2010. Safety climate and the theory of planned behavior: towards the prediction of unsafe behavior. Accid. Anal. Prev. 42, 1455–1459. https://doi.org/10.1016/j.aap.2009.08.008.
Froko, I.U.F., Maxwell, A., Kingsley, N., 2015. The impact of safety climate on safety performance in a gold mining company in Ghana. Int. J. Manage. Excellence 5, 556–566. https://doi.org/10.17722/ijme.v5i1.194.
Fugas, C.S., Silva, S.A., Meliá, J.L., 2012. Another look at safety climate and safety behavior: Deepening the cognitive and social mediator mechanisms. Accid. Anal. Prev. 45, 468–477. https://doi.org/10.1016/j.aap.2011.08.013.
Geddes, F.R., 2012. Managers, mates and the role of social exchange: A multilevel model of safety climate and proactive safety behavior. Doctoral dissertation. Curtin University. https://espace.curtin.edu.au/handle/20.500.11937/874.
Harris, J., Kirsch, P., Shi, M., Li, J., Gagrani, A., Krishna, E., ... Cliff, D., 2014. Comparative analysis of coal fatalities in Australia, South Africa, India, China and USA, 2006-2010. Paper presented at the 14th Coal Operators' Conference, University of Wollongong, The Australasian Institute of Mining and Metallurgy & Mine Managers Association of Australia, pp. 399–407. Retrieved from http://ro.uow.edu.au/coal/536.
Hayes, A.F., 2018. Introduction to mediation, moderation, and conditional process analysis: A regression-based approach, 2nd ed. Guildford Press, New York.
Jebb, S.E., 2015. Reducing workplace safety incidents: Bridging the gap between safety culture theory and practice. Doctoral dissertation. Queensland University of Technology. http://eprints.qut.edu.au/81626/.
Kerr, N.L., 1998. HARKing: Hypothesizing after the results are known. Personality Soc. Psychol. Rev. 2, 196–217. https://doi.org/10.1207/s15327957pspr0203_4.
Lee, M.D., Wagenmakers, E.J., 2014. Bayesian cognitive modeling: A practical course. Cambridge University Press, Cambridge, UK.
Marsman, M., Wagenmakers, E.J., 2017. Bayesian benefits with JASP. Euro. J. Develop. Psychol. 14, 545–555. https://doi.org/10.1080/17405629.2016.1259614.
Mast, M.S., Sieverding, M., Esslen, M., Graber, K., Jäncke, L., 2008. Masculinity causes speeding in young men. Accid. Anal. Prev. 40, 840–842. https://doi.org/10.1016/j.aap.2007.09.028.
Mata, R., Josef, A.K., Samanez-Larkin, G.R., Hertwig, R., 2011. Age differences in risky choice: a meta-analysis. Ann. N. Y. Acad. Sci. 1235, 18–29. https://doi.org/10.1111/j.1749-6632.2011.06200.x.
Melia, J.L., Mearns, K., Silva, S., Lima, M.L., 2008. Safety climate responses and the perceived risk of accidents in the construction industry. Saf. Sci. 46, 949–958. https://doi.org/10.1016/j.ssci.2007.11.004.
Mines Occupational Safety and Health Advisory Board. 2002. Safety behavior survey. Safety behaviour working party report and recommendations. Retrieved from http://www.dmp.wa.gov.au/Documents/Safety/MSH_R_SafetyBehaviourSurveyRecommendations.pdf.
Mitchell, O.S., 1988. The relation of age to workplace injuries. Monthly Labor Rev. 111, 8–13.
Nosek, B.A., Lakens, D., 2014. Registered reports: a method to increase the credibility of published results. Soc. Psychol. 45, 137–141. https://doi.org/10.1027/1864-9335/a000192.
Parker, A.W., Tones, M.J., Ritchie, G.E., 2017. Development of a multilevel health and safety climate survey tool within a mining setting. J. Saf. Res. 62, 173–180. https://doi.org/10.1016/j.jsr.2017.06.007.
Paul, P.S., Maiti, J., 2007. The role of behavioral factors on safety management in underground mines. Saf. Sci. 45, 449–471. https://doi.org/10.1016/j.ssci.2006.07.006.
Rolison, J.J., Hanoch, Y., Wood, S., Liu, P.J., 2013. Risk-taking differences across the adult life span: a question of age and domain. J. Gerontol. B Psychol. Sci. Soc. Sci. 69, 870–880. https://doi.org/10.1093/geronb/gbt081.
Ross, L., Greene, D., House, P., 1977. The "false consensus effect": An egocentric bias in social perception and attribution processes. J. Exp. Soc. Psychol. 13, 279–301.
Rubin, M., 2017a. An evaluation of four solutions to the forking paths problem: Adjusted alpha, preregistration, sensitivity analyses, and abandoning the Neyman-Pearson approach. Rev. General Psychol. 21, 321–329. https://doi.org/10.1037/gpr0000135.
Rubin, M., 2017b. Do *p* values lose their meaning in exploratory analyses? It depends how you define the familywise error rate. Rev. General Psychol. 21, 269–275. https://doi.org/10.1037/gpr0000123.
Rubin, M., 2017c. When does HARKing hurt? Identifying when different types of undisclosed post hoc hypothesizing harm scientific progress. Rev. General Psychol. 21, 308–320. https://doi.org/10.1037/gpr0000128.
Safe Work Australia. 2018. Fatality statistics by industry. Retrieved from https://www.safeworkaustralia.gov.au/statistics-and-research/statistics/fatalities/fatality-statistics-industry#number-of-fatalities-and-fatality.
Safe Work Australia. 2015. The cost of work-related injury and illness for Australian employers, workers and the community: 2012–13. Retrieved from https://www.safeworkaustralia.gov.au/system/files/documents/1702/cost-of-work-related-injury-and-disease-2012-13.docx.pdf.
Selig, J.P., Little, T.D., 2012. Autoregressive and cross-lagged panel analysis for longitudinal data. In: Laursen, B., Little, T.D., Card, N.A. (Eds.), Handbook of developmental research methods. The Guilford Press, New York, pp. 265–278.
Simmons, J.P., Nelson, L.D., Simonsohn, U., 2011. False-positive psychology undisclosed flexibility in data collection and analysis allows presenting anything as significant. Psychol. Sci. 22, 1359–1366. https://doi.org/10.1177/0956797611417632.
Stanley, T.D., Carter, E.C., Doucouliagos, H., 2018. What meta-analyses reveal about the replicability of psychological research. Psychol. Bull. 144, 1325–1346. https://doi.org/10.1037/bul0000169.
Stephan, S., 2001. Improving the safety culture of the Australian mining industry. J. Occup. Health Saf., Australia New Zealand 17, 237–249.
Stemn, E., Bofinger, C., Cliff, D., Hassall, M.E., 2019. Examining the relationship between safety culture maturity and safety performance of the mining industry. Saf. Sci. 113, 345–355. https://doi.org/10.1016/j.ssci.2018.12.008.
Stöber, J., 2001. The Social Desirability Scale-17 (SDS-17): Convergent validity, discriminant validity, and relationship with age. Euro. J. Psychol. Assessment 17, 222–232. https://doi.org/10.1027//1015-5759.17.3.222.
Thompson, E.R., Phua, F.T., 2012. A brief index of affective job satisfaction. Group Org. Manage. 37, 275–307. https://doi.org/10.1177/1059601111434201.
Verma, S., Chaudhari, S., 2016. Highlights from the literature on risk assessment techniques adopted in the mining industry: A review of past contributions, recent developments and future scope. Int. J. Mining Sci. Technol. 26, 691–702. https://doi.org/10.1016/j.ijmst.2016.05.023.
Wei, L.J., Hu, J.K., Luo, X.R., Liang, W., 2017. Study and analyze the development of China coal mine safety management. Int. J. Energy Sect. Manage. 11, 80–90. https://doi.org/10.1108/IJESM-08-2015-0002.
Weyman, A., Clarke, D., Cox, T., 2003. Developing a factor model of coal miners' attributions on risk-taking at work. Work Stress 17, 306–320. https://doi.org/10.1080/02678370310001646844.
Yule, S., Flin, R., Murdy, A., 2007. The role of management and safety climate in preventing risk-taking at work. Int. J. Risk Assessment Manage. 7, 137–151. https://doi.org/10.1504/IJRAM.2007.011727.