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Safety Culture on Drilling Rigs: An Assessment of Worker Perceptions, Attitudes and Safety Practices in Mineral Exploration - A Case Study

Kelvin Affam , Dr. Ebenezer Ashun
University of Mines and Technology

***Abstract*—Exploration drilling exposes workers to dust, noise, vibration, high-pressure systems and equipment-related hazards, yet the safety culture of contractor-based drilling crews in Ghana is poorly documented. This study assessed safety culture on exploration drilling rigs at Bibiani Gold Mine through worker perceptions, worker attitudes and safety practices, and tested whether attitudes mediate the link between perceptions and practices. A cross-sectional, descriptive-correlational survey was conducted in May 2026: 38 drilling personnel received a Microsoft Forms questionnaire (75 closed items, eight scales) and 35 responded (92.1%). Data were analyzed in SPSS 30 using descriptive statistics, Cronbach's alpha, Pearson correlation, regression and bootstrap mediation analysis. All scales were reliable (α = 0.770–0.926). Perceptions of safety culture were favorable (M = 4.13); management commitment was the lowest-rated favorably worded construct (M = 3.94), while attitudes (M = 4.47) and self-reported practices (M = 4.54) were rated higher. Normalization of deviance and production pressure was the least favorable and most divided construct (M = 3.68; 44.1% agreed that unsafe practices are sometimes accepted as normal). Perceptions predicted attitudes (β = .404, p = .018) and practices (β = .590, p < .001); attitudes were the strongest predictor of practices (β = .748, p < .001). Attitudes partially mediated the perception–practice link (indirect effect = 0.172; 95% bootstrap CI [0.059, 0.563]; 41.6% of the total association). Interventions should combine attitude-building with enforceable systems and address fatigue, production pressure and contractor refresher training.**

***Keywords*—Drilling safety, Mediation analysis, Mineral exploration, Safety culture, Safety practices, Worker attitudes**

I. INTRODUCTION

Mining is among the most hazardous sectors worldwide because its operations involve heavy machinery, complex processes and a high-risk working environment [1]. Exploration drilling adds exposure to dust inhalation, excessive noise, vibration, equipment-related accidents and human error [4]. In Ghana, injury analyses place drillers among the most affected occupational groups: underground drillers accounted for 26.7% of reported injuries compared with 1.4% for surface drillers [2], and drillers represented 21% of the identified causes of fatal accidents at AngloGold Ashanti's Obuasi mine [3].

Attention has therefore shifted from purely technical controls toward safety culture, understood as the shared values, beliefs, attitudes and practices that shape how safety is perceived and managed in an organization [5], [7]. Safety culture is situation-specific and shaped by leadership, organizational practices and work experience [5]. A strong culture supports compliance, proactive hazard identification and collective responsibility, whereas a weak one is associated with unsafe behavior and higher accident rates.

Research in Ghana has linked safety culture to workplace safety outcomes in mining, but exploration drilling crews and the client–contractor interface, where responsibility for safety and communication is divided, have received little attention. At Bibiani Gold Mine, safe systems and protocols are in place, yet there is limited evidence on how workers perceive them, how far they internalize safety values, and how those attitudes translate into daily practice.

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This paper reports a case study of exploration drilling at Bibiani Gold Mine. Its objectives are to (i) examine workers' perceptions of safety culture; (ii) analyze workers' attitudes toward safety policies and procedures; (iii) evaluate safety practices among drilling workers; (iv) identify factors associated with safe behavior; and (v) test the mediating role of worker attitudes in the relationship between perceptions of safety culture and safety practices.

II. LITERATURE REVIEW AND HYPOTHESES

Cooper's reciprocal model treats safety culture as the interaction of organizational systems (situation), individual psychological factors (person) and observable behavior [5]. Zohar's work on safety climate shows that shared perceptions of how safety is prioritized by management shape employee behavior [6], [7]. This study adopts a behavioral and organizational perspective in which perceptions of safety culture are the independent variable, worker attitudes the mediating variable and safety practices (PPE use, procedural compliance, hazard reporting) the dependent variable (Fig. 1).

H1: Perceptions of safety culture have a significant positive effect on worker attitudes. Social exchange theory holds that workers reciprocate favorable organizational treatment with favorable dispositions [9]; perceived organizational support predicts safety commitment [10], and psychological safety climate is consistently associated with individual safety attitudes [11].

H2: Worker attitudes have a significant positive effect on safety practices. The Theory of Planned Behavior proposes that behavior follows intentions shaped by attitudes, subjective norms and perceived control [8]. Meta-analytic and longitudinal evidence identifies safety attitudes and motivation as among the strongest proximal predictors of safety performance [12], [13].

H3: Perceptions of safety culture have a significant positive direct effect on safety practices. Reason argues that unsafe acts are shaped by latent organizational conditions such as staffing, procedures and production pressure, rather than by individual choice alone [14]. Safety climate also predicts behavior over and above individual motivation [13], and organizational factors influence the safety citizenship of Ghanaian miners [27].

H4: Worker attitudes mediate the relationship between perceptions of safety culture and safety practices. If H1 and H2 hold, part of the influence of safety culture on practice is transmitted through attitudes, following the mediation logic of Baron and Kenny [15]. Vaughan's concept of normalization of deviance [16] and Reason's organizational accident model [17] further motivate the inclusion of production pressure as a safety-culture dimension.

III. METHODOLOGY

A. Study Setting

Bibiani Gold Mine lies in the Bibiani-Anhwiaso-Bekwai Municipality of the Western North Region of Ghana, on the Sefwi-Bibiani Greenstone Belt, about 250 km northwest of Accra and 80 km west of Kumasi. The area has a humid tropical climate in moist semi-deciduous forest, with annual rainfall above 1,500 mm and temperatures of 24–32 °C. Reverse circulation and diamond exploration drilling are carried out under a client–contractor arrangement in which the mine owner (client) engages drilling and service contractors.

B. Design, Population and Sampling

A cross-sectional, descriptive-correlational survey design was adopted within a single-case setting. A single case allowed the whole population of drilling personnel to be identified and a high proportion surveyed, at the cost of statistical generalizability. The mine had about 54 drilling personnel. Using the inclusion criterion of direct involvement in drilling operations, Human Resources records for May 2026 yielded a sampling frame of 38 workers, grouped into five job strata (operators, assistants, supervisors, maintenance and safety personnel). All 38 received an anonymous Microsoft Forms link or QR code; personal assistance was offered during breaks to workers who could not access the form. The form remained open for more than ten days without reminders.

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C. Data Collection Instrument

The structured, self-administered questionnaire contained a demographic section and 75 closed items in eight scales: management commitment (11 items), worker perceptions of safety culture (10), worker attitudes (10), safety practices (10), client and contractor engagement (8), safety training and competence (8), incident reporting and investigation (8), and normalization of deviance and production pressure (10). Items were adapted from NOSACQ-50 [18] and Zohar [6] (management commitment and perceptions), Cox and Cox [19] (attitudes) and Neal and Griffin [13] (practices). Items on client and contractor engagement, incident reporting and normalization of deviance were developed for this study, informed by [16] and [17], because no established scale addresses them in a contractor-based drilling context. All items used a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The instrument was refined through expert review; no formal pilot test was conducted.

D. Data Analysis

Data were analyzed in IBM SPSS Statistics 30. Item means were interpreted in equal bands of width 0.80 [20]: 1.00–1.80 strongly disagree, 1.81–2.60 disagree, 2.61–3.40 neutral, 3.41–4.20 agree and 4.21–5.00 strongly agree. Negatively worded items were reverse-scored in composites so that higher scores always indicate a more favorable culture. Reliability was assessed with Cronbach's alpha (≥ 0.90 excellent, ≥ 0.80 good, ≥ 0.70 acceptable) [21]. Relationships were examined with Pearson correlation and simple and multiple regression at $\alpha = 0.05$. Mediation was tested with the regression approach of Baron and Kenny [15] supplemented by a bias-corrected bootstrap (10,000 resamples) for the indirect effect. A sensitivity analysis ($n = 35$, $\alpha = .05$, power = .80) showed that the study could detect correlations of $r \geq 0.458$; power for the indirect effect was approximately 0.52.

E. Ethical Considerations

Permission was obtained from mine management. An information statement at the head of the form explained the purpose, voluntary participation and the right to withdraw, and consent was recorded before any item was displayed. No names, staff numbers, e-mail addresses or IP addresses were collected, so responses could not be traced to individuals, employers or crews. Data were stored on a password-protected device and used solely for academic purposes.

IV. RESULTS

A. Response Rate and Respondent Profile

Of 38 questionnaires distributed, 35 were returned and valid (response rate 92.1%; 64.8% of the estimated drilling population). Item-level N was 34–35 because six respondents skipped one or more items. Table I summarizes the respondents. Most were male (77.1%) and under 40 years of age (82.9%). Respondents were employed by the drilling contractor (71.4%), the client (20.0%) or a service contractor (5.7%); 85.7% held contract (65.7%) or casual (20.0%) status. Assistant drillers formed the largest group (45.7%), followed by engineers (17.1%) and safety officers (14.3%). Some 71.4% had under three years of drilling experience, and 65.7% reported formal safety training, 28.6% reported none and 5.7% were unsure.

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TABLE I. PROFILE OF RESPONDENTS (N = 35)

Characteristic	n	%
Gender: male	27	77.1
Gender: female	8	22.9
Age: 20–29 years	17	48.6
Age: 30–39 years	12	34.3
Age: 40 years and above	6	17.1
Employer: drilling contractor	25	71.4
Employer: client (mine owner)	7	20.0
Employer: service contractor	2	5.7
Status: contract	23	65.7
Status: casual	7	20.0
Status: permanent	4	11.4
Drilling experience: < 1 year	13	37.1
Drilling experience: 1–2 years	12	34.3
Drilling experience: ≥ 3 years	10	28.6
Position: assistant driller	16	45.7
Position: engineer	6	17.1
Position: safety officer	5	14.3
Position: other (incl. drillers)	8	22.9
Formal safety training: yes	23	65.7
Formal safety training: no	10	28.6
Formal safety training: unsure	2	5.7

Percentages may not total 100 where a respondent left an item blank.

B. Reliability and Descriptive Results

All eight scales exceeded the 0.70 threshold (Table II). Workers rated the culture favorably overall (M = 4.13, SD = 0.76). Item-level results illustrate the pattern. Respondents strongly agreed that safety meetings encourage workers to raise concerns (M = 4.50) and disagreed that workers are discouraged from questioning unsafe instructions (M = 2.15). They almost unanimously rejected the view that experienced workers need not follow all procedures (M = 1.40, the lowest item mean in the instrument) and agreed that procedures improve rather than hinder productivity (M = 4.54). Pre-start equipment inspections and toolbox-meeting participation were the most consistently reported practices (both M = 4.68), while the stop-work item (M = 4.23) and refresher training (M = 3.86, the lowest training item) lagged behind. Contractor safety attention (M = 2.37 on the negatively worded item “contractors receive less attention regarding incident safety”) and blame-oriented investigations (M = 1.94) were also disagreed with, but not by all respondents.

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TABLE II. RELIABILITY AND MEAN SCORES OF THE STUDY SCALES (N = 35)

Scale	Items	α	Mean
Management commitment	11	0.898	3.94
Worker perceptions of safety culture	10	0.903	4.13
Worker attitudes toward safety	10	0.857	4.47
Safety practices	10	0.898	4.54
Client and contractor engagement	8	0.926	4.15
Safety training and competence	8	0.770	4.21
Incident reporting and investigation	8	0.886	4.09
Normalization of deviance and production pressure*	10	0.917	3.68

*Reverse-scored: higher score = less normalization. Scale: 1–5.

Normalization of deviance and production pressure was the least favorable construct (M = 3.68, SD = 1.07) and the most divided. A total of 44.1% agreed that unsafe practices are sometimes accepted as normal against 52.9% who disagreed (about 3% neutral), and 44.1% agreed that production pressure encourages shortcuts against 50.0% who disagreed. Agreement that workers continue working when fatigued was 32.4%. Yet respondents disagreed that they personally feel pressured to continue in unsafe conditions (M = 2.09), suggesting that pressure is experienced as situational and intermittent rather than as an explicit organizational demand.

C. Relationships among Constructs

All correlations among composites were positive. Perceptions of safety culture correlated strongly with incident reporting and investigation (r = 0.83), client and contractor engagement (r = 0.82), resistance to normalization of deviance (r = 0.75) and management commitment (r = 0.68). Safety practices correlated most strongly with safety training and competence (r = 0.76) and worker attitudes (r = 0.75, $p < .001$), and moderately with perceptions (r = 0.59). Management commitment was essentially unrelated to worker attitudes (r = 0.05, p = .78). Correcting inter-scale correlations for attenuation indicated that five of the eight constructs were not empirically distinct (disattenuated correlations up to .97), whereas attitudes were distinct from perceptions (.45). The organizational dimensions were therefore combined into one climate composite for modelling.

D. Hypothesis Testing and Mediation

All four hypotheses were supported (Table III, Fig. 1). Perceptions significantly predicted attitudes (H1: $\beta = .404$, $R^2 = .163$, $p = .018$) and attitudes were the strongest single predictor of practices (H2: $\beta = .748$, $R^2 = .560$, $p < .001$). The total association of perceptions with practices was significant (H3: $\beta = .590$, $R^2 = .349$, $p < .001$). When both predictors were entered ($R^2 = .657$, $F(2, 31) = 29.71$, $p < .001$; VIF = 1.195), the perception coefficient fell from 0.414 to 0.242 ($\beta = .345$, $p = .005$) while attitudes remained significant ($\beta = .607$, $p < .001$). The indirect effect through attitudes was ab = 0.172 (bias-corrected bootstrap 95% CI [0.059, 0.563]), accounting for 41.6% of the total association. Because the direct path remained significant, mediation is partial (H4).

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TABLE III. SUMMARY OF HYPOTHESIS TESTS

Path	b	β	p	R^2	Result
H1: Perceptions → Attitudes	0.255	.404	.018	.163	Supported
H2: Attitudes → Practices	0.840	.748	<.001	.560	Supported
H3: Perceptions → Practices (total)	0.414	.590	<.001	.349	Supported
H4: Perceptions → Practices (direct, c′)	0.242	.345	.005	.657	Partial mediation
H4: Attitudes → Practices (b)	0.676	.607	<.001	–	
H4: Indirect effect (ab)	0.172	.246	–	–	CI [0.059, 0.563]

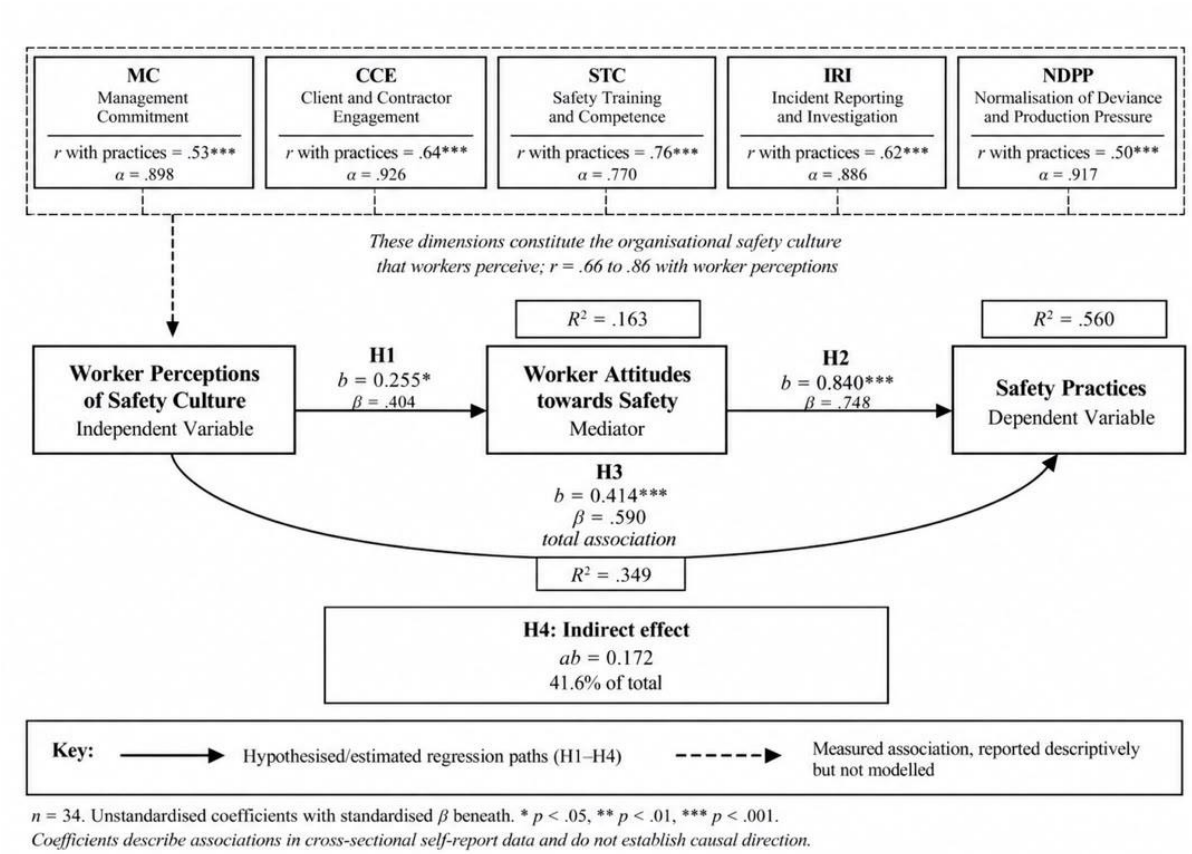


Fig. 1. Estimated mediation model of worker perceptions of safety culture, worker attitudes and safety practices (unstandardized coefficients b; standardized β in parentheses).

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E. Factors Associated with Safety Practices

Entering all seven organizational and attitudinal constructs together gave $R^2 = .795$ but coefficients that could not be interpreted: normalization of deviance reversed sign ($\beta = -0.813$) and several variance inflation factors reached 9.37. In the reduced model, organizational safety climate ($\beta = .357$, $p = .006$) and worker attitudes ($\beta = .561$, $p < .001$) jointly explained 65.2% of the variance in practices (adjusted $R^2 = .631$, $F(2, 32) = 30.01$, $p < .001$; VIF = 1.38; Durbin–Watson = 1.84; Shapiro–Wilk $p = .400$). Attitudes remained significant under heteroscedasticity-consistent estimation and after excluding the single influential case, whereas climate did not remain significant under the robust estimator. Alone, normalization of deviance predicted practices ($\beta = .500$, $p = .003$; 25.0% of variance): crews reporting less normalization reported safer practices.

V. DISCUSSION

A. Perceptions of Safety Culture

Workers' perceptions were favorable, yet respondents rated their own attitudes (M = 4.47) and practices (M = 4.54) above the organization that employs them, and management commitment was the lowest-rated favorable construct (M = 3.94). This is typical of self-report safety research, where respondents see their own compliance more clearly than management's commitment, and it is consistent with the modest association between perceptions and attitudes ($R^2 = .163$). Henson's survey of 163 crew on an offshore drilling rig in the Gulf of Mexico reported senior-management commitment of 4.7 [22], against 4.09 for the equivalent item here. The comparison is informative because operating risk is comparable but employment arrangements are not: Henson surveyed the contractor's core crew, whereas 85.7% of this sample were contract or casual workers. Distributions were compressed at the favorable end (53 of 75 items negatively skewed), so a ceiling effect cannot be ruled out.

B. Attitudes and Safety Practices

The attitude–practice finding ($\beta = .748$) gives direct empirical support for the attitude–behavior link at the center of the Theory of Planned Behavior [8], and agrees with evidence that safety attitudes and motivation are among the strongest proximal predictors of safety performance [12], [13]. Attitudes were also the one construct that stood apart analytically (disattenuated $r = .45$ with perceptions), so they are not simply an expression of how workers see their employer. The near-zero correlation between management commitment and attitudes suggests that attitudes in this crew are anchored in personal responsibility and professional identity rather than in day-to-day readings of management, while perceptions of communication, reporting and consultation do shape attitudes. The strongest organizational correlate of practice was training and competence ($r = 0.76$), which supports a defined refresher cycle.

C. Normalization of Deviance and Production Pressure

The divided responses on normalization of deviance and production pressure show that risk normalization is established among a substantial minority, not across the whole crew. This matches Vaughan's argument that repeated acceptance of deviations eventually raises organizational risk [16] and Reason's view that latent conditions such as production pressure and fatigue become active failures through procedural drift [17]. The strong rejection of experience-based exemption from procedure indicates that the attitudinal precursor of drift is largely absent, while production-pressure items show where latent conditions remain.

D. Mediating Role of Attitudes and Limitations

Partial mediation means that safety culture is associated with practice partly through what workers come to believe and partly by a direct route that does not require attitudinal endorsement, such as engineering controls and enforcement. This parallels Yang et al., who found partial mediation with surviving direct effects among Ghanaian gold-mine workers [23]. The practical implication is that neither attitude-building (slow and dependent on credibility) nor enforcement (fast but dependent on continued supervision) is sufficient alone. Against Hudson's maturity ladder [24], the pattern is characteristic of a calculative organization: systems, procedures and training are in place and recognized, but management commitment is rated lowest and a

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substantial minority reports production pressure. A comparable gap was observed at another Ghanaian mine [28], suggesting a sector characteristic rather than a site failing.

Limitations. The design is cross-sectional and self-reported, so the coefficients describe associations, not causation, and the mediation is statistical rather than causal. The sample (n = 35, one mine) is small, giving power only for medium-to-large effects (mediation power ≈ 0.52); self-report is exposed to social-desirability and common-method bias [25] and to possible deference by contractor employees surveyed with management's knowledge. Construct validity was not formally tested, no pilot was conducted, and missing items were mean-substituted.

VI. CONCLUSIONS AND RECOMMENDATIONS

Exploration drilling workers at Bibiani Gold Mine hold favorable perceptions of their safety culture (M = 4.13), very favorable attitudes (M = 4.47) and high self-reported practices (M = 4.54). Management commitment is the weakest element of perception (M = 3.94), and normalization of deviance and production pressure is the least favorable and most divided dimension (M = 3.68). Worker attitudes are the factor most robustly associated with safe practice ($\beta = .561$ in the combined model; $\beta = .748$ alone), and safety training and competence is the organizational dimension most strongly associated with practice ($r = 0.76$). All four hypotheses were supported: attitudes partially mediate the perception–practice relationship, carrying 41.6% of the total association, while a significant direct association persists.

The findings support the following recommendations:

Regulator (Inspectorate Division, Minerals Commission): require mine operators to report safety statistics separately for contractors and direct employees; address fatigue explicitly for exploration drilling by prescribing limits on consecutive shifts and minimum rest periods; and make refresher-training frequency a reportable item.

Drilling contractor: introduce a fatigue-risk procedure with a penalty-free self-declaration route; define a refresher cycle per drilling role (covering fatigue recognition, decision-making under time pressure, lock-out/tag-out and risk normalization); record and commend every stop-work decision; and return investigation findings to the crews that raised them.

Client and contractor jointly: review meterage and turnaround targets and record safety stoppages as a performance measure rather than a deduction; apply one safety standard, induction and statistics process to client and contractor personnel; and schedule documented senior-management safety interactions on night and rotational shifts.

Future research: replicate across several contractors and sites (about 70 respondents are needed for adequate mediation power); use mixed methods to explore why some workers accept unsafe practices as normal; add observation-based behavior measures; use longitudinal designs; and apply structural equation modelling with a sample adequate to test the measurement model.

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