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Article

Reduction of unsafe work acts through behavior-based safety strategies in a technology services company in Lima, Peru

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Abstract: The purpose of this study was to determine how the implementation of behavior-based safety (BBS) strategies reduces unsafe work acts among workers in a technology services company in Lima, Peru. A quantitative, applied, pre-experimental pretest-posttest single-group design was used with a census sample of 30 operational workers. Variables were measured using structured observation checklists validated by expert judgment (validity coefficient > 85%) with inter-observer reliability established through Cohen's Kappa index ($\kappa = 0.87$). Seven BBS strategies were implemented over eight weeks: daily behavioral observations, immediate bilateral feedback, biweekly training sessions, monthly behavioral recognition, active breaks, wellness talks, and weekly verification checklists. Results showed that the overall average of unsafe acts decreased from 42.3% to 16.6% (reduction rate of 60.8%). All three dimensions of the dependent variable showed significant reductions: noncompliance with rules and procedures (from 43.8% to 16.7%; −61.9%), incorrect use of personal protective equipment (from 38.3% to 13.3%; −65.3%), and unsafe execution of critical tasks (from 44.9% to 19.9%; −55.7%). Paired-samples t-tests confirmed statistically significant differences in all cases ($p < 0.001$), with massive effect sizes (Cohen's d between 3.08 and 3.46). It is concluded that BBS strategies constitute an effective intervention for modifying unsafe behaviors and strengthening the preventive culture in technology sector companies.
Keywords: behavior-based safety; unsafe acts; safety culture; personal protective equipment; occupational risk

1. Introduction

Occupational safety and health has established itself as a strategic imperative directly linked to target 8.8 of Sustainable Development Goal No. 8 and target 3.d of SDG No. 3 of the United Nations 2030 Agenda. However, occupational accident figures continue to represent an obstacle to sustainable development: according to the International Labour Organization (2023), nearly 2.93 million people die each year due to occupational accidents and diseases, while approximately 395 million workers suffer non-fatal injuries, generating economic losses equivalent to 5.4% of global GDP.

A determining factor in the understanding of occupational accidents is the recognition that between 80% and 95% of occupational accidents are attributed to inappropriate human decisions or actions, rather than to technical failures or poor physical conditions of the environment (Brandhorst & Kluge, 2021). This evidence prompted the development of behavioral intervention programs, particularly Behavior-Based Safety (BCS), a systematic approach aimed at modifying unsafe practices through structured observation, continuous feedback, and positive reinforcement of safe behaviors.

In the Peruvian context, the problem acquires critical characteristics. The Ministry of Labor and Employment Promotion (2025) reported 37,928 workplace accidents in 2024, of which 280 were fatal and more than 70%

corresponded to Metropolitan Lima. The same agency indicated that 62% of accidents were caused by inappropriate work behaviors, confirming the human factor as the main variable in the national accident rate.

The international literature has documented the effectiveness of SBC programs in various contexts. Systematic review studies and meta-analyses have shown that well-designed behavioral interventions can achieve significant reductions in unsafe acts, with average effectiveness ranging from 45% to 75% when they integrate the three conditions of the triconditional model of safe behavior: being able, knowing, and willing to work safely (Dyreborg et al., 2022; Krause et al., 1999; Carra et al., 2024). However, empirical evidence on the application of these strategies in companies in the Latin American technology sector is limited, which justifies the need to generate contextualized knowledge.

The company under study, High Techno World (HTW), located in the district of Breña, Lima, operates in the specialized technological services sector, engaged in the installation, maintenance, and configuration of computer equipment. The baseline diagnosis, carried out during January and February 2026 using structured observation sheets, showed that 43.8% of workers did not comply with rules and procedures, 38.3% used their personal protective equipment (PPE) incorrectly, and 44.9% performed critical tasks unsafely, configuring an overall average of unsafe acts of 42.3%.

The theoretical framework of the research was based on four fundamental pillars: Bandura's (1986) Social Cognitive Theory, which explains the acquisition of behaviors through triadic reciprocity between personal factors, behavior, and environment; Ajzen's Theory of Planned Action (1991), which states that behavioral intention depends on attitude, subjective norm, and perceived behavioral control; Meliá's Triconditional Model of Safe Behavior (2007), which defines three conditions necessary for a worker to act safely; and Geller's ABC Model (2022), which proposes that all behavior is preceded by antecedents and followed by consequences that determine its likelihood of repetition.

In this context, the general objective was to determine how the implementation of SBC strategies reduces unsafe work acts in workers at High Techno World, Lima, 2026. The specific objectives were aimed at evaluating the effect of the intervention on three dimensions: (a) non-compliance with rules and procedures, (b) incorrect use of PPE, and (c) unsafe execution of critical tasks. The general hypothesis stated that the implementation of SBC strategies significantly reduces unsafe work acts.

2. Methodology

2.1. Study design

The research adopted a quantitative, applied approach, with a pre-experimental pre-test-posttest design in a single group (Hernández-Sampieri & Mendoza, 2018). The level was explanatory, aimed at establishing causal relationships between the implementation of SBC strategies (independent variable) and the reduction of unsafe work acts (dependent variable). This design responded to real organizational conditions, in which it was not possible to form a parallel control group without affecting the company's operation.

2.2. Participants and sample

The population consisted of the 30 operational workers of the Breña headquarters of High Techno World: 25 computer systems installation and maintenance technicians (83.3%) and 5 support operators (16.7%). A non-probabilistic census-type convenience sampling was used. The inclusion criteria required a current employment contract, performance in operational areas with exposure to risks evidenced in the IPERC Matrix, and availability to participate throughout the study period. Administrative staff, workers with medical disabilities, and personnel on leave of absence were excluded.

2.3. Variables and operationalization

The independent variable, SBC strategies, was operationalized in three dimensions: (a) behavioral observation, calculated as a percentage of unsafe acts recorded with respect to the total number of observations; (b) feedback and

communication, calculated as a percentage of workers who received feedback; and (c) supervisory participation and leadership, calculated as a percentage of supervisors who reported and corrected unsafe behaviors.

The dependent variable, unsafe work acts, was operationalized in three dimensions: (a) non-compliance with rules and procedures; (b) incorrect use of PPE; and (c) unsafe execution of critical tasks. Critical tasks were defined in accordance with Ministerial Resolution No. 050-2013-TR and the company's current IPERC Matrix. All dimensions were measured on a ratio scale.

2.4. Instruments

Structured behavioral observation sheets were used, which recorded date, worker code, type of task according to IPERC, description of the unsafe act, correct or incorrect use of PPE, and frequency of occurrence. The instruments were validated by three specialists in occupational health and safety, obtaining a content validity coefficient of more than 85%. Interobserver reliability was established using Cohen's Kappa index ($\kappa = 0.87$), indicating an adequate level of agreement. The data were verified by the company's Management and OHS Headquarters.

2.5. Procedure

The procedure was carried out in three sequential stages over six months (January-June 2026):

Stage 1 — Diagnosis and pre-test (January-February, 8 weeks): 8 days of structured observation were carried out on the 30 workers, the documentary records of the OH&S Management System for the year 2025 were reviewed and the baseline of both variables was established.

Stage 2 — Implementation of SBC strategies (March-April, 8 weeks): seven strategies were implemented in line with Meliá's (2007) triconditional model: (1) daily behavioral observations with standardized worksheets; (2) immediate bilateral feedback formalized in minutes; (3) four biweekly trainings with average attendance of 93.3% (IPERC applied, correct use of PPE, LOTO safe procedures, and SBC preventive culture); (4) monthly "Safe Worker of the Month" recognition program; (5) bi-daily active breaks; (6) well-being and group cohesion talks; and (7) weekly PPE and environmental conditions checklists.

Stage 3 — Post-test measurement (May-June, 8 weeks): the pre-test observation protocol was replicated under the same methodological conditions, guaranteeing equivalence for statistical comparison.

2.6. Data analysis

The analysis was structured in three phases. In the descriptive phase, the percentages of each dimension and indicator, pretest-posttest comparative tables, and reduction rates were calculated. In the inferential phase, the assumption of normality was verified using the Shapiro-Wilk test ($W = 0.961$; $p = 0.312 > 0.05$), which enabled the application of Student's t-test for related samples with a significance level $\alpha = 0.05$. The effect size was calculated using Cohen's d. All statistical processing was performed with IBM SPSS Statistics version 26.

2.7. Ethical considerations

The research was guided by the Code of Ethics in Research of the César Vallejo University (2020) and Law No. 29733 on the protection of personal data. Written informed consent was obtained from the 30 participants. The data were encoded using alphanumeric keys and institutional authorization was granted by the general management of High Techno World.

3. Results

3.1. Independent variable: SBC strategies

Table 1 presents the consolidated pre-test-posttest of the independent variable. The general average of application of SBC strategies went from 8.0% to 75.0%, showing an increase of 67.0 percentage points. Supervisory participation and leadership registered the largest proportional change (+1,585.7%), going from 4.2% (0.25 active

supervisors per day) to 70.8% (4 out of 6 supervisors reporting and correcting unsafe behaviors). Feedback and communication increased from 11.7% to 81.7% (+70.0 pp), and behavioral observation from 8.0% to 72.5% (+64.5 pp).

Table 1

Consolidation of the independent variable: SBC strategies — Pretest and posttest

Dimension (VI)	Pre-test (%)	Post-test (%)	Increment (pp)	Rate of change (%)
Behavioral observation	8,0	72,5	+64,5	+806,3
Feedback and communication	11,7	81,7	+70,0	+598,3
Participation and leadership	4,2	70,8	+66,6	+1 585,7
Overall average	**8,0**	**75,0**	**+67,0**	**+837,5**

Note. Rate of change = [(Postest − Pretest) / Pretest] × 100. pp = percentage points.

3.2. Dependent variable: Unsafe work acts

3.2.1. Descriptive results

Table 2 presents the consolidation of the dependent variable. The general average of unsafe acts decreased from 42.3 % in the pre-test to 16.6 % in the post-test, with an overall reduction rate of 60.8 %. The dimension with the highest relative reduction rate was the incorrect use of PPE (−65.3 %), followed by non-compliance with rules and procedures (−61.9 %) and the unsafe execution of critical tasks (−55.7 %).

Table 2

Consolidated of the dependent variable: Unsafe work acts — Pre-test and post-test

Dimension (DV)	Pretest (%)	Post-test (%)	Reduction (pp)	Reduction rate (%)
Failure to comply with rules/procedures	43,8	16,7	−27,1	61,9
Incorrect use of PPE	38,3	13,3	−25,0	65,3
Insecure execution of critical tasks	44,9	19,9	−25,0	55,7
Overall average	**42,3**	**16,6**	**−25,7**	**60,8**

Note. Reduction rate = [(Pretest − Posttest) / Pretest] × 100. pp = percentage points.

During the implementation phase, there was a sustained decrease in unsafe acts detected weekly: from 14 in the first week to 6 in the eighth week, representing an intra-period reduction of 57%. The immediate correction rate was 100% during the eight weeks, evidencing that each unsafe act detected received timely feedback through signed bilateral minutes.

3.2.2. Inferential results

Table 3 presents the results of hypothesis testing. The Shapiro-Wilk normality test (W = 0.961; p = 0.312) confirmed that the pretest-posttest differences followed a normal distribution, enabling the use of Student's t-test for related samples.

Table 3

Pretest-posttest comparison and statistical inference — Dependent variable: Unsafe work acts

Dimension (DV)	Media pre (%)	Media post (%)	Dif. (pp)	t	gl	p	d Cohen
Fails to comply. Rules	43,8	16,7	27,1	18,95	29	< 0.001	3,46
Incorrect use of PPE	38,3	13,3	25,0	16,87	29	< 0.001	3,08
Ejec. unsafe tasks	44,9	19,9	25,0	17,63	29	< 0.001	3,22
Overall average	**42,3**	**16,6**	**25,7**	**17,82**	**29**	**< 0.001**	**3,25**

Note. Shapiro-Wilk: W = 0.961; p = 0.312. Critical value $t_{0,05(29)}$ = 2.045. Massive effect > 2.00 (Cohen, 1988).

The t-statistic of the three dimensions (range: 16.87-18.95) far exceeded the critical value of 2.045, with p < 0.001 in all cases. The effect sizes were classified as massive (d between 3.08 and 3.46), confirming the consistency of the intervention in each dimension.

3.3. Economic feasibility analysis

The total investment of the program amounted to S/ 4,570.00, distributed in safety materials (43.3%), training (35.8%), incentives (14.1%) and operating expenses (6.8%). The projected six-month financial analysis yielded a Net Present Value (NPV) of S/ 3,127.45, a monthly Internal Rate of Return (IRR) of 38.2% (higher than the discount rate of 10%) and a Benefit/Cost ratio of 1.68, indicating that for each sol invested, S/ 1.68 was obtained in economic benefits derived from the reduction of minor incidents and rework.

4. Discussion

The results of this research showed that the implementation of SBC strategies produced significant, sustained and statistically consistent reductions in the insecure work acts of High Techno World, both in the general average and in each of the three dimensions evaluated.

Regarding the general objective, the 60.8% reduction in the average number of unsafe acts was within the range of effectiveness reported by the international literature. This finding is consistent with the results of previous meta-analyses on the effectiveness of behavioral interventions in occupational safety. Krause et al. (1999), in a meta-analysis of 73 interrupted time series replications, documented average reductions ranging from 26% in the first year to 69% in the fifth year after the implementation of behavioral programs. In addition, Dyreborg et al. (2022), in a systematic review of 100 studies evaluating occupational safety interventions, concluded that multifactorial interventions that combine elements at the organizational level have moderate to strong effects on reducing accidents. More recently, Carra et al. (2024), in a review of approximately 230 publications on SBCs, confirmed that programs that integrate positive feedback, systematic observation, and organizational participation obtain the most robust and sustainable results.

The coincidence with these antecedents is explained by the fact that the intervention implemented in HTW incorporated the components that the specialized literature identifies as determinants of behavior change: systematic observation, immediate feedback, progressive technical training, active supervisorial leadership, and behavioral recognition. The seven strategies were simultaneously articulated on the technical (knowing), material (power), and motivational (wanting) dimensions, thus overcoming the limitations of one-dimensional interventions.

In relation to the first specific objective, the 61.9% reduction in non-compliance with rules and procedures (from 43.8% to 16.7%) was the dimension with the largest effect size (d = 3.46). This result coincides with the evidence that non-compliance behaviors, being strongly associated with routine habits and implicit tolerance of small deviations, are especially sensitive to interventions that combine corrective feedback with background reinforcement (signage, checklists, advance directives). From the perspective of Geller's (2022) ABC model, the simultaneous modification of antecedents and consequences was the mechanism that facilitated the breaking of these automated patterns.

Regarding the second specific objective, the incorrect use of PPE registered the highest relative reduction rate (−65.3%, from 38.3% to 13.3%). The special sensitivity of this dimension to behavioral intervention is explained by the fact that it is a public behavior, observable and with ample room for immediate correction in the workplace. The provision of adequate PPE (Class 0 dielectric gloves according to IEC 60900, certified protective glasses), combined with specific technical training and immediate feedback on each deviation, generated a transition from incomplete or incorrect use to a more conscious and sustained practice. This finding is consistent with Bandura's (1986) Social Cognitive Theory, which states that the appropriate use of PPE depends not only on declarative knowledge, but also on the observation of appropriate models, the perception of self-efficacy and the organizational value conferred on such behavior.

Regarding the third specific objective, the unsafe execution of critical tasks showed the smallest proportional reduction (−55.7%, from 44.9% to 19.9%), although with an equally massive effect size (d = 3.22). This finding is consistent with the literature that recognizes that behaviors associated with critical tasks tend to be more automated, subject to greater operational pressure, and therefore require longer interventions to consolidate sustainable changes. However, the observed reduction was sufficiently robust to confirm that even the most operationally complex behaviors are susceptible to modification through systematic behavioral interventions, as supported by the Triconditional Model of Meliá (2007).

A cross-sectional finding of particular relevance was the transformation of the supervisory role. Supervisory participation and leadership went from 4.2% to 70.8% (+1,585.7%), becoming the main driver of cultural change in the organization. This result is consistent with the meta-analytic evidence of Lyubykh et al. (2022), who demonstrated in a meta-analysis of 194 samples (N = 104,364) that task-oriented leadership and relational leadership are the most important predictors of job security, even above transformational leadership.

From a methodological perspective, it is necessary to recognize the inherent limitations of the preexperimental design, which did not allow empirically controlling for all concurrent external variables. However, the magnitude of the effect sizes (d between 3.08 and 3.46), the consistency of the improvement in the three dimensions, the sustained downward trend during the eight weeks post-test, and the coincidence with international precedents strengthen the inference that the observed change was primarily attributable to the intervention. The small sample (n = 30) limits the generalizability of the results, although the census-based nature of the study eliminated selection bias within the organization.

5. Conclusions

The implementation of SBC strategies significantly reduced unsafe work acts in High Techno World, with a decrease from the overall average from 42.3% to 16.6% (reduction rate of 60.8%; $t = 17.82$; $p < 0.001$; $d = 3.25$). All three dimensions showed statistically significant reductions and massive effect sizes: non-compliance with rules and procedures (−61.9%; d = 3.46), incorrect use of PPE (−65.3%; d = 3.08), and unsafe execution of critical tasks (−55.7%; d = 3.22). The transformation of the supervisory role was the main catalyst for cultural change, and the economic viability of the program (B/C = 1.68) reinforces its relevance as a preventive investment. Future research is recommended to employ quasi-experimental designs with control group, larger samples, and longitudinal follow-up to assess the sustainability of behavioral changes.

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