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Behavior-Based Safety Interventions for Multilingual High-Risk Workforces: Evidence from a Cross-Sectional Survey of Construction Safety Practitioners

Oluwaranti A. Omowami

Department of Occupational Risks and Safety Sciences, University of Central Missouri, Warrensburg, United States

Abstract: Construction consistently ranks among the most hazardous occupational sectors globally, yet behavior-based safety (BBS) programs have rarely been examined in multilingual workforce settings where language barriers and cultural diversity complicate implementation. This study investigates the design features, reported safety outcomes, and perceived effectiveness of BBS programs deployed in multilingual construction environments through a cross-sectional survey administered to 167 construction safety professionals and site supervisors across multiple organizations. Respondents were recruited via professional safety networks using SurveyMonkey between January and March 2025. The analytical sample comprised 134 participants who reported direct experience with BBS implementation in settings with three or more workforce nationalities. Results indicate that respondents reported a 34.7% reduction in the mean total recordable incident rate (TRIR) following BBS implementation, with observer participation rates averaging 78.4%. Programs incorporating pictographic observation checklists achieved significantly higher participation rates than those relying solely on text-based tools ($M = 84.2\%$ vs. $M = 67.1\%$, $p < .001$). Reflexive thematic analysis of open-ended responses identified four mechanisms of BBS effectiveness: language-adaptive communication, peer observation as social norm reinforcement, supervisory behavioral modeling, and cultural humility in program adaptation. The findings provide actionable, practitioner-sourced guidance for designing culturally responsive BBS programs in linguistically diverse construction settings.

Keywords: behavior-based safety, multilingual workforce, construction safety, safety climate, survey research, cultural adaptation, incident reduction, pictographic tools

I. INTRODUCTION

Construction is one of the most dangerous occupational sectors in the world. In the United States, the construction industry recorded 1,069 fatalities in 2022, representing 19.4% of all private industry worker deaths despite employing only 6.6% of the private-sector workforce [1]. The total cost of all work-related injuries in the United States reached $167 billion in 2022, encompassing medical expenses, wage and productivity losses, and administrative costs [2]. Globally, the International Labour Organization (ILO) estimates that more than 374 million non-fatal occupational injuries and illnesses occur annually, with construction workers consistently overrepresented relative to their workforce share [3]. These figures represent not only a public health imperative but also a significant drag on economic productivity and organizational performance in the construction sector [4].

Addressing this burden requires approaches that move beyond regulatory compliance toward proactive behavioral interventions. Forty years of safety research have established that most workplace incidents are preceded by observable unsafe behaviors [5]. Behavior-based safety (BBS), a systematic approach to identifying, observing, and positively reinforcing safe behaviors at the point of work, has demonstrated significant effectiveness in reducing incident rates across diverse industrial contexts [6, 7]. BBS programs typically engage workers as peer observers, training them to conduct structured behavioral observations, identify at-risk behaviors, deliver constructive feedback, and generate data to guide continuous safety improvement [8, 9].

The effectiveness of BBS interventions is sensitive to the organizational and cultural contexts in which they are deployed. Large-scale construction projects in international and multicultural settings present a particularly challenging environment for BBS implementation. The workforce of a major infrastructure project may encompass dozens of nationalities, include workers with limited proficiency in the project's primary language, and bring together individuals with widely varying safety cultures and regulatory experiences [10]. Safety communication strategies designed for a homogeneous workforce may fail in such settings, not because the underlying methodology is technically flawed, but because they are culturally and linguistically misaligned with the population they are designed to serve [11, 12].

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Despite the growing prevalence of multilingual construction workforces, particularly across the Arabian Gulf, Southeast Asia, and North America, the peer-reviewed literature on BBS implementation in explicitly multilingual construction environments remains sparse. The majority of published BBS efficacy research has been conducted in domestic, single-language industrial contexts [5, 6], leaving HSE practitioners who manage diverse international workforces without sufficient empirical guidance. Recent work by Hussain et al. [13] and Chellappa et al. [14] has begun to address migrant worker safety training gaps through technology-assisted approaches; however, BBS-specific adaptations for multilingual workforces remain understudied.

This study addresses this gap by surveying 167 construction safety professionals and site supervisors across multiple organizations and geographic contexts to examine: (1) the design features of BBS programs deployed in multilingual construction settings; (2) self-reported safety performance outcomes; (3) perceived effectiveness of specific program design features; and (4) the mechanisms through which BBS programs achieve safety improvements in linguistically and culturally diverse environments. By drawing on practitioner experience across multiple organizations, the study provides broadly generalizable guidance that a single-site case study could not [15].

II. Literature Review

A. Foundations and Evolution of Behavior-Based Safety

The intellectual origins of behavior-based safety lie in operant conditioning theory and its application to occupational safety. BBS programs typically involve three core components: critical behavior identification, structured peer observation, and performance-contingent feedback designed to reinforce safe behaviors and extinguish at-risk ones [6, 5]. Over five decades, BBS has evolved from early laboratory applications to comprehensive organizational safety management systems deployed across manufacturing, oil and gas, construction, and healthcare sectors. Fabiano et al. reviewed 230 BBS studies spanning five decades and documented the methodology's progressive evolution toward greater worker involvement, technology integration, and sensitivity to organizational culture [6].

Spigener et al. presented important contemporary evidence updating the knowledge base, drawing on data from 88 international organizations and more than 1.3 million observational data points [5]. Their findings demonstrated that a smaller number of highly trained, dedicated observers is more effective than mass-participation models in some contexts; that observation frequency interacts with feedback specificity in determining program effectiveness; and that BBS generates measurable improvements in safety climate alongside reductions in incident rates. These findings have direct implications for multilingual construction settings, where the quality of observer training and the delivery of feedback are constrained by language barriers. Related studies have examined occupational stress and mental health burden among U.S. construction workers using national surveillance data [25], as well as incident recurrence patterns and root cause analysis quality in federal enforcement records [24].

Yang et al.'s two-year empirical evaluation of a BBS observation program in an electrical contracting company documented improvements in incident rates, unsafe behavior frequencies, and safety climate scores across eight dimensions [7]. Zakaria et al. similarly demonstrated cross-industry and cross-cultural applicability of core BBS principles in Malaysian chemical manufacturing [9]. Grill et al. extended BBS research to supervisory leadership through a randomized controlled trial demonstrating that targeted BBS-leadership training improved managers' positive feedback and active listening behaviors, with downstream improvements in worker safety engagement [8].

B. Safety Climate, Safety Culture, and Behavioral Outcomes in Construction

The safety climate, defined as workers' shared perceptions of the policies, procedures, and practices relating to safety in their work environment, has been established as a robust predictor of safety behavior and accident outcomes across industrial sectors [16, 17]. Han et al. conducted a systematic literature review identifying management commitment, risk perception, safety communication, and worker involvement as the most consistently measured safety climate dimensions in the construction industry [16]. Nygren et al. emphasized the importance of context-specific approaches to safety culture, noting that programs are most effective when they account for the specific operational realities of construction, including diverse workforce composition [17].

Fruhen et al. found that leaders perceived as both motivators and meaning-makers produce significantly higher levels of safety compliance and participation, with transformational leadership predicting safety participation more strongly than compliance-based approaches [18]. Ni et al. demonstrated that safety culture effects on behavior operate through workers' psychological engagement with their work, suggesting that BBS programs attending to motivational and cultural dimensions of worker engagement produce more durable safety culture change [19]. Lee and Kim further demonstrated that safety-reminding interventions effectively counteract risk habituation among experienced construction workers [20].

C. Multilingual Workforce Safety Challenges in Construction

Ahmed et al. found that language barriers, cultural isolation, and perceived exclusion from safety decision-making were among the strongest predictors of stress and reduced safety engagement among ethnic minority construction workers

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[21]. Foreign-born workers constitute 28.3% of the United States construction workforce [1], and comparable or higher proportions are found in Gulf Cooperation Council countries, the European Union, and Australia. Fellows et al. documented that informal bilingual workers serve as critical communication intermediaries whose language work extends far beyond simple translation to include mediation, cultural interpretation, and social bridging [10].

Nielsen et al. established that language proficiency is a fundamental determinant of safety training effectiveness, with workers demonstrating significantly lower training transfer rates when instruction is delivered in a language they do not fully command [11]. Vignoli et al. designed a theory-based construction safety training program for migrant workers that explicitly addressed language barriers, cultural differences in safety orientation, and the social separation between migrant and native workers [12]. Hussain et al. demonstrated a 23% increase in safety knowledge scores across participants from five countries using a conversational AI-based virtual reality system, confirming the potential of technology-assisted multilingual approaches [13]. Chellappa et al. identified BBS adaptation as one of the most promising, yet insufficiently researched, intervention strategies for migrant construction worker safety [14].

D. Behavior-Based Safety in Construction and Leadership

Yang et al. found that BBS participation was associated with reductions in unsafe behavior frequency and improvements in safety climate across all eight measured dimensions, demonstrating the method's applicability in dynamic, diverse construction environments [7]. Al-Bayati et al. found that supervisor behavior fully mediates the effect of organizational safety culture on worker safety compliance and participation in construction, establishing supervisory engagement in BBS processes as mechanistically essential rather than merely supportive [22]. Guan et al. provided complementary evidence that learning from incidents significantly improves safety performance in construction when workers are engaged as active participants rather than passive recipients [4].

III. THEORETICAL FRAMEWORK

The present study is grounded in three complementary theoretical frameworks. First, social cognitive theory, particularly triadic reciprocal determinism, provides the overarching behavioral architecture for BBS methodology [6]. Triadic reciprocal determinism posits that human behavior is the product of continuous, dynamic interactions among personal, environmental, and behavioral contingencies. The peer observation process at the heart of BBS is a structured mechanism for creating observational learning, social modeling, and performance feedback. Spigener et al. empirically confirmed that BBS programs aligned with social cognitive principles outperform those focused narrowly on behavioral compliance [5].

Second, safety climate theory proposes that workers' shared perceptions of management commitment to safety shape individual safety motivation and behavior [16]. This theory suggests that BBS cannot be effective in isolation from an organizational context that visibly prioritizes safety. Fruhen et al. demonstrated that perceived leader safety commitment is a particularly powerful safety climate signal, consistent with safety climate theory's emphasis on management behavior as the primary cue workers use to calibrate organizational safety priority [18].

Third, reciprocal safety culture theory, which integrates psychological, behavioral, and situational determinants of safety performance into a unified framework, is particularly relevant to the multilingual construction context [17]. This model proposes that safety culture, safety climate, and safety behavior exist in a dynamic, mutually reinforcing relationship such that sustained behavioral interventions can shift the underlying culture that shapes future behavioral norms. Ni et al. provided empirical support for this reciprocal model, demonstrating that safety culture effects on behavior operate through workers' psychological engagement with their work [19].

IV. METHOD

A. Research Design

This study employs a cross-sectional survey design to examine practitioner-reported BBS program features, safety outcomes, and perceived effectiveness across multilingual construction settings. A cross-sectional survey was selected as the most appropriate methodology for this research objective because it enables the aggregation of practitioner experience across multiple organizations, geographic contexts, and workforce compositions, providing a breadth of evidence that single-site studies cannot achieve [15]. The mixed-methods approach integrates analysis of quantitative survey items with reflexive thematic analysis (RTA) of open-ended responses, following the complementary-strengths rationale of Braun and Clarke [23].

B. Survey Instrument

A structured survey instrument was developed specifically for this study and administered online via SurveyMonkey. The instrument was piloted with five experienced HSE professionals before full deployment and revised based on pilot feedback to improve clarity and reduce completion time. The final instrument comprised 39 items organized across six thematic sections, as summarized in Table I. Quantitative items in Sections 4 and 5 used either numerical entry fields (for TRIR and participation rate data) or five-point Likert scales ranging from 1 (not at all effective)

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to 5 (extremely effective). Section 6 comprised four open-ended questions that invited respondents to describe, in their own words, the greatest challenges encountered, the most effective adaptations made, the cultural factors that influenced program outcomes, and recommendations for practitioners designing BBS programs for multilingual workforces.

TABLE I. SURVEY INSTRUMENT STRUCTURE

Section	Focus	Items
1	Respondent demographics and credentials	7 items
2	Workforce diversity and language profile	5 items
3	BBS program design and implementation features	9 items
4	Reported safety performance outcomes (TRIR, participation, near-miss rates)	6 items
5	Perceived effectiveness of program features (5-point Likert)	8 items
6	Open-ended: challenges, enablers, and cultural adaptation strategies	4 items

C. Sampling and Recruitment

Participants were recruited through purposive sampling via three professional networks: the American Society of Safety Professionals (ASSP) LinkedIn community, the NEBOSH Alumni Network, and an international construction safety management online forum. Inclusion criteria required a minimum of two years' direct experience in construction safety management and at least one complete BBS program implementation or supervisory oversight role in a setting where three or more nationalities were present in the workforce. The survey was distributed between January and March 2025. Of 241 survey invitations distributed, 174 responses were initiated, and 167 were completed and included in the final dataset, yielding a completion rate of 69.3%. The 134 respondents who confirmed direct BBS implementation experience in multilingual settings constituted the primary analytical sample for the analyses of quantitative outcomes and effectiveness ratings.

D. Data Analysis

Descriptive statistics (means, standard deviations, frequencies, and percentages) were computed for all quantitative items. Respondent-reported TRIR values were analyzed using a paired comparison approach in which pre-BBS and post-BBS TRIR values reported by the same respondent were treated as paired observations; a paired-samples t-test was used to assess the statistical significance of the mean TRIR reduction. Independent-samples t-tests were used to compare participation rates and TRIR reductions between program subgroups defined by the presence or absence of specific design features (e.g., pictographic checklists, multilingual training). Effect sizes were reported as Cohen's d. Open-ended survey responses were analyzed using RTA [23], in which responses were read multiple times, initial codes were generated inductively from the text, and themes were developed through iterative analytical review. Thematic saturation was assessed when no new codes emerged from additional responses.

V. RESULTS

A. Respondent Characteristics

Of the 167 survey completers, 89 (53.3%) identified as HSE or safety professionals, and 78 (46.7%) identified as site supervisors with direct safety oversight responsibility. The mean years of construction safety experience was 13.6 years (SD = 4.8), with 44.3% reporting 11-20 years of experience. Most respondents (84.4%, n = 141) reported managing workforces comprising three or more nationalities, and 58.7% (n = 98) reported managing workforces comprising six or more nationalities. A total of 134 respondents (80.2%) confirmed direct experience implementing or supervising a BBS program in a multilingual construction setting and constituted the analytical sample for subsequent analyses. Table II summarizes key respondent characteristics.

TABLE II. RESPONDENT CHARACTERISTICS (N = 167)

Characteristic	N	%
Role: HSE/Safety Professional	89	53.3
Role: Site Supervisor	78	46.7
Experience ≤10 years	61	36.5
Experience 11–20 years	74	44.3

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Experience >20 years	32	19.2
Managed ≥3 nationalities	141	84.4
Managed ≥6 nationalities	98	58.7
Direct BBS implementation experience	134	80.2

B. BBS Program Design Features

Among the 134 respondents in the analytical sample, 91 (67.9%) reported that their BBS program incorporated pictographic observation checklists, fully or partially, designed to be usable regardless of language proficiency. Eighty-seven respondents (64.9%) reported that observer training was conducted in two or more languages. Seventy-six respondents (56.7%) reported using a safety partner or co-national pairing model during the initial implementation phase to reduce cultural friction in peer feedback. One hundred and nine respondents (81.3%) reported that graphical feedback was displayed at crew assembly points in formats accessible to workers with limited literacy in the primary project language. Only 38 respondents (28.4%) reported that their BBS program was implemented without any specific linguistic or cultural adaptation from a standard template.

C. Quantitative Outcomes: TRIR Reduction and Participation

Among the 134 respondents with direct BBS implementation experience, the mean reported TRIR declined from 7.84 per 200,000 worker-hours (SD = 2.13) before BBS implementation to 5.12 per 200,000 worker-hours (SD = 1.87) following implementation, representing a mean reduction of 34.7% (SD = 9.4%; range = 11.2%–54.6%). This reduction was statistically significant ($t(133) = 14.27$, $p < .001$, $d = 0.73$), indicating a large effect size. Mean observer participation rates across the analytical sample were 78.4% (SD = 12.3%), substantially above the 80% target reported by most respondents as their program's design objective. Mean near-miss reporting rates increased by 38.7% (SD = 14.2%) following BBS implementation. Table III summarizes the quantitative outcome data.

TABLE III. REPORTED SAFETY PERFORMANCE OUTCOMES (N = 134)

Outcome Measure	Mean (SD)	Range
TRIR pre-BBS (per 200K hrs)	7.84 (2.13)	3.9–13.1
TRIR post-BBS (per 200K hrs)	5.12 (1.87)	2.1–9.8
Mean TRIR reduction (%)	34.7 (9.4)	11.2–54.6
Observer participation rate (%)	78.4 (12.3)	48–98
Near-miss reporting increase (%)	38.7 (14.2)	10.4–68.9

Subgroup analysis by program design features revealed that programs incorporating pictographic observation checklists achieved significantly higher observer participation rates ($M = 84.2\%$, $SD = 9.7\%$) than programs without pictographic tools ($M = 67.1\%$, $SD = 11.4\%$; $t(132) = 8.43$, $p < .001$, $d = 0.81$). Programs delivering observer training in two or more languages also showed significantly greater TRIR reductions ($M = 38.4\%$, $SD = 8.9\%$) than English-only training programs ($M = 27.3\%$, $SD = 9.2\%$; $t(132) = 6.71$, $p < .001$, $d = 0.61$), consistent with the established relationship between language accessibility and safety training effectiveness [11].

D. Perceived Effectiveness of Program Design Features

Respondents rated eight specific BBS program design features on a 5-point Likert scale for perceived effectiveness in multilingual construction settings. Supervisory participation in BBS observations received the highest mean rating ($M = 4.51$, $SD = 0.61$), followed closely by pictographic observation checklists ($M = 4.43$, $SD = 0.67$) and multilingual observer training ($M = 4.28$, $SD = 0.72$). The full ratings are presented in Table IV. Notably, senior management's visible safety commitment, while rated effective, received a comparatively lower mean rating ($M = 3.76$, $SD = 1.02$) than direct supervisory participation, suggesting that practitioners perceive frontline-level leadership behavior as the more proximal driver of BBS outcomes, consistent with the findings of Al-Bayati et al. [22].

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TABLE IV. PERCEIVED EFFECTIVENESS RATINGS OF BBS DESIGN FEATURES (N = 134, SCALE: 1–5)

Program Feature	Mean Rating	SD
Supervisory participation in observations	4.51	0.61
Pictographic observation checklists	4.43	0.67
Multilingual observer training	4.28	0.72
Multilingual graphical feedback systems	4.19	0.78
Peer-led observation model	4.07	0.83
Cultural pairing of observers	3.94	0.91
Non-punitive observation framework	3.88	0.94
Senior management safety commitment	3.76	1.02

E. Qualitative Findings: Open-Ended Responses

RTA of 124 substantive open-ended responses (responses with sufficient content for coding) identified four primary themes characterizing the mechanisms through which BBS programs achieved safety performance improvements in multilingual settings [23]. These themes are consistent with theoretical predictions from safety climate theory [16], social cognitive theory [6], and recent empirical BBS research [8].

1) Language-Adaptive Communication as a Condition of Participation:

Language-adaptive communication was cited as a critical enabling condition for BBS participation by 112 respondents (90.3% of the 124 coded responses). Respondents described pictographic checklists, multilingual signage, and visual feedback displays as removing the participation barriers that had previously excluded non-English-speaking workers from meaningful engagement in safety programs. Multiple respondents noted that workers who had been passive recipients of English-language safety instruction became active observers once pictographic tools were introduced, consistent with the findings of Hussain et al. [13] and Vignoli et al. [12] that safety programs for multilingual workforces must be designed from the outset with the linguistic characteristics of all workforce subgroups in mind, not retrofitted with translations after the fact.

2) Peer Observation as Social Norm Reinforcement:

Ninety-four respondents (75.8%) described the peer observation process as qualitatively different from conventional top-down safety inspections, emphasizing its role in creating and reinforcing social norms of safe behavior within work crews. Respondents consistently reported that workers found peer feedback more comfortable and motivating than supervisor feedback, particularly across hierarchical and cultural boundaries. This finding is consistent with social cognitive theory's prediction that observational learning from similar-status peers is particularly potent in shaping behavior [6], and with Yang et al.'s empirical finding that BBS participation is associated with significantly higher safety climate perceptions [7].

3) Supervisory Modeling and Visible Commitment:

One hundred and seven respondents (86.3%) identified the visibility of supervisory participation in BBS observations as a powerful signal of organizational commitment to safety, the theme most frequently cited across all four open-ended questions. Respondents reported that in work groups where supervisors conducted observations alongside workers, worker engagement with the BBS program was substantially higher than in groups where supervisory involvement was limited or performative. This finding corroborates Grill et al.'s experimental evidence that BBS-leadership training improves manager feedback behaviors with downstream effects on worker safety engagement [8] and is consistent with Fruhen et al.'s demonstration that perceived leader safety commitment is the most powerful predictor of employee safety participation [18].

4) Cultural Humility in Program Adaptation:

Eighty-nine respondents (71.8%) described an iterative process of cultural adaptation as essential to BBS effectiveness in multilingual settings. Respondents noted that initial BBS implementations based on standardized protocols frequently encountered resistance from workers from high-power-distance cultural backgrounds, for whom peer feedback from a co-worker was culturally inappropriate. Successful adaptations included co-national observer pairing, group-level rather than individual-level feedback, and culturally informed observer training content. This adaptation process resonates strongly with the findings of Fellows et al. [10] regarding the complexity of communication and cultural mediation on multilingual construction sites and with Nielsen et al.'s [11] demonstration that cultural norms governing interpersonal feedback are critical moderators of safety training effectiveness.

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VI. Discussion

This study makes three principal contributions to the BBS and construction safety literatures. First, it provides multi-organizational, practitioner-sourced evidence of BBS effectiveness in multilingual construction settings, documenting a mean TRIR reduction of 34.7% across 134 BBS implementations and a mean observer participation rate of 78.4%. These figures align with the upper range of BBS effectiveness estimates in recent empirical literature [5, 7] and were generated from a sample broad enough to support general conclusions rather than describing a single project's experience. Second, the study quantitatively establishes the performance differential associated with specific multilingual design adaptations: programs incorporating pictographic checklists achieved 17.1 percentage points higher participation rates, and programs with multilingual training achieved 11.1 percentage points greater TRIR reductions, compared to programs without these features. Third, the qualitative findings provide theoretically grounded mechanistic explanations for these quantitative effects.

The subgroup analysis findings are particularly important for practitioners. The statistically significant and practically large participation rate advantage associated with pictographic checklists ($d = 0.81$) provides the strongest available evidence that the investment in visual tool design is directly reflected in program uptake. By removing literacy and language proficiency as barriers to observer participation, these tools create conditions in which the full workforce can engage as active safety agents, in line with Hussain et al. [13] and Nielsen et al. [11], who found that language accessibility is a fundamental determinant of safety training effectiveness.

The qualitative theme of cultural humility emerged as the most theoretically significant finding. Respondents described the challenges of engaging workers from high-power-distance cultural backgrounds with the peer feedback component of BBS, reflecting a fundamental tension between the individualistic, egalitarian assumptions embedded in standard BBS methodology and the social norms governing interpersonal behavior in many construction workforce groups. The iterative cultural adaptation process described by respondents represents a form of implementation science that is poorly documented in the BBS literature [6]. Still, it appears essential to effectiveness in diverse settings, consistent with Chellappa et al. [14] and Fellows et al. [10].

The finding that supervisory participation in BBS observations received the highest mean effectiveness rating ($M = 4.51$) from practitioners is consistent with Al-Bayati et al.'s demonstration that frontline supervisors fully mediate the organizational culture-to-behavior pathway in construction [22], and with Fruhen et al.'s finding that perceived leader safety commitment is the strongest predictor of employee safety participation [18]. In culturally diverse settings with high power distance norms, the normative weight of visible supervisory engagement with BBS processes may be especially consequential [19].

VII. Implications for Practice

First, pictographic observation tools should be treated as a standard design requirement, not an optional enhancement, in BBS programs deployed in multilingual construction settings. The 17.1 percentage point participation rate advantage documented in this study provides a direct quantitative justification for the investment in visual tool development, consistent with the broader evidence base on language accessibility and safety training effectiveness [11, 13].

Second, observer training must be delivered in multiple languages. The 11.1 percentage additional TRIR reduction associated with multilingual training programs, documented across a large and diverse respondent sample, provides the strongest available evidence for this recommendation. Organizations should invest in bilingual safety professionals whose multilingual competency is treated as a professional credential rather than an informal supplementary role [10]. This finding aligns with Grill et al.'s evidence that targeted, behaviorally specific training produces measurable improvements in safety outcomes [8].

Third, cultural competency development must be embedded in BBS program planning from the outset. The co-national observer pairing model and the group-level feedback approaches described by respondents represent low-cost, high-impact adaptations that address the social-norm barriers that standard BBS protocols frequently encounter in diverse workforces. Regular consultation with worker representatives from all nationality groups should be established as a standard program governance mechanism [14].

Fourth, supervisory participation in BBS observations must be treated as a non-negotiable program element. Receiving the highest practitioner effectiveness rating in this study and supported by robust experimental and correlational evidence [8, 18, 22], active supervisory engagement with BBS processes is the single most consistently cited driver of program success and should be explicitly monitored as a key performance indicator rather than assumed.

VIII. Limitations and Future Research

The cross-sectional survey design presents several limitations. First, outcome data (TRIR reductions, participation rates) are self-reported by respondents and cannot be independently verified against organizational records. While self-report bias is an inherent limitation of survey-based safety research, the consistency of findings across 134 respondents from diverse organizations and contexts provides confidence that the aggregated results reflect genuine field experience

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rather than individual recall error. Second, respondents were recruited through professional safety networks, potentially introducing self-selection bias toward practitioners with positive BBS experiences; practitioners whose programs failed or were abandoned may be underrepresented. Future research should pursue administrative dataset linkage to verify self-reported outcomes [15].

Third, the cross-sectional design does not allow causal inference about the relationship between specific program design features and safety outcomes; the observed associations between pictographic tool use and participation rates may reflect underlying organizational capacity rather than the tool's effect. Quasi-experimental or randomized designs comparing BBS program variants in similar construction environments would provide stronger causal evidence [7]. Fourth, while the survey instrument was piloted and refined, it has not been formally validated as a psychometric scale; future research should develop and validate a standardized instrument for measuring BBS program quality in multilingual construction contexts. Future research priorities also include comparative longitudinal studies of BBS effectiveness and safety culture development across projects with varying degrees of workforce diversity, and investigation of AI-assisted multilingual BBS platforms building on Hussain et al. [13].

IX. Conclusion

This cross-sectional survey of 167 construction safety professionals and site supervisors provides the most comprehensive practitioner-sourced evidence to date on the effectiveness of BBS programs in multilingual construction settings. Across 134 BBS implementations, respondents reported a mean TRIR reduction of 34.7% and a mean observer participation rate of 78.4%, with significantly stronger outcomes in programs incorporating pictographic observation tools and multilingual observer training. Reflexive thematic analysis identified four mechanisms of BBS effectiveness: language-adaptive communication, peer observation as social norm reinforcement, supervisory behavioral modeling, and cultural humility in program adaptation, all of which are consistent with social cognitive theory, safety climate theory, and reciprocal safety culture theory [18, 16, 17].

The findings carry urgent practical implications. As the global construction sector continues to rely on internationally mobile, multilingual workforces [1, 3], the need for HSE methodologies designed to function across cultural and linguistic boundaries will only intensify. This study equips practitioners with quantified, field-validated evidence that specific, achievable BBS adaptations, pictographic tools, multilingual training, supervisory participation, and culturally humble implementation produce substantially better safety outcomes in diverse workforce settings. Construction workers across every language and culture deserve safety programs designed for their full participation. This study provides a practitioner-validated roadmap for delivering exactly that.

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