Baseline Work Engagement Moderates the Effect of a Nurse Engagement Intervention on Patient Safety Culture Among ICU Nurses: A Randomized Controlled Trial in Saudi Arabia

Thuwaini Sultan Alshammari[1], Faridah Mohd Said[1]

[1]Faculty of Nursing, Lincoln University College, Malaysia

Correspondence: Thuwaini Sultan Alshammari, Thuwainisultan@gmail.com

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ABSTRACT:

Background: Patient safety interventions may not benefit all nurses equally. Baseline work engagement may shape nurses' capacity to absorb and apply safety-focused training, but this effect has rarely been tested in intensive care settings.

Objective: To examine whether baseline work engagement moderated the relationship between a nurse engagement intervention and post-test patient safety culture.

Methods: This prespecified secondary analysis used data from a two-group randomized controlled trial involving 232 ICU nurses from three governmental hospitals in Hail, Saudi Arabia. Nurses were allocated 1:1 to a four-week, four-module engagement intervention or usual practice. The moderation analysis included 220 nurses with post-test data. Patient safety culture was measured using the four-item Primary Patient Safety Culture Index, and baseline work engagement using the 17-item Utrecht Work Engagement Scale. Hayes' PROCESS Model 1 adjusted for baseline patient safety culture and hospital and used 5,000 bootstrap resamples.

Results: Baseline work engagement averaged 3.76 (SD = 0.54). The model was significant, $F(6, 213) = 87.82$, $p < .001$, $R^2 = .712$. The intervention-by-engagement interaction was positive and significant (B = 0.528, bootstrap SE = 0.126, 95% bootstrap CI [0.288, 0.775], $p < .001$). Conditional intervention effects increased from B = 0.297 at low engagement to B = 0.580 at the mean and B = 0.863 at high engagement; all effects were significant.

Conclusion: Baseline work engagement amplified the intervention's effect on patient safety culture. Nurses with lower engagement still benefited, but may require added organizational and educational support to achieve comparable gains.

Keywords: intensive care nursing, patient safety culture, randomized controlled trial, moderation analysis, work engagement

1. Introduction

Patient safety culture reflects the shared values, norms, and practices through which healthcare organizations prioritize the prevention of harm, learning from errors, open communication, and coordinated action. Its importance is heightened in intensive care units (ICUs), where high patient acuity, rapid clinical decisions, advanced technologies, and interdependent teamwork create numerous opportunities for preventable harm. The World Health Organization's Global Patient Safety Action Plan emphasizes the development of safety systems and cultures that engage the health workforce in continuous improvement (World Health Organization [WHO], 2021).

Nurses are central to ICU safety because they continuously monitor patients, coordinate care, communicate changes, administer high-risk therapies, and identify emerging hazards. Evidence generally links healthcare staff engagement with better safety culture and fewer errors or adverse events, although the literature remains heterogeneous and is dominated by observational designs (Janes et al., 2021). In an ICU study, employee engagement correlated positively with multiple dimensions of safety culture, including overall safety perceptions and event reporting (Collier et al., 2016). Conversely, poorer staff wellbeing and burnout have been associated with adverse patient-safety outcomes (Hall et al., 2016). These findings suggest that safety improvement is partly dependent on whether staff have the psychological energy and organizational support required to participate actively in change.

Work engagement is commonly defined as a positive, fulfilling work-related state characterized by vigor, dedication, and absorption (Schaufeli et al., 2002). Within the Job Demands-Resources perspective, engagement develops when job and personal resources support motivation and help employees respond to demanding work environments (Schaufeli & Bakker, 2004). For ICU nurses, greater engagement may increase attention to safety information, participation in training, willingness to communicate concerns, and persistence in applying new practices. The Utrecht Work Engagement Scale (UWES) operationalizes this construct through vigor, dedication, and absorption and has been used across diverse occupational and national samples (Schaufeli et al., 2006).

Interventions can improve work engagement, but their effects vary across participants and contexts (Knight et al., 2017). A uniform nurse engagement programme may therefore produce different safety-culture gains depending on nurses' initial engagement. Nurses entering an intervention with greater vigor and dedication may more readily convert programme content into changed safety perceptions and behaviors. Nurses with lower engagement may still benefit, but competing job demands, reduced psychological resources, limited autonomy, or weaker trust in organizational follow-through may constrain their response. Despite this plausible effect modification, prior research has largely treated engagement as an exposure or outcome rather than as a baseline condition that changes the effect of a safety-focused intervention.

The present manuscript reports the moderation objective from a larger sequential exploratory mixed-methods study conducted among ICU nurses in the Hail Region of Saudi Arabia. The objective was to examine whether baseline work engagement moderated the relationship between a structured nurse engagement intervention and post-test patient safety culture. It was hypothesized that the intervention effect would be stronger at higher levels of baseline work engagement.

2. Methodology

2.1 Study Design and Setting

This study is a prespecified secondary moderation analysis of the quantitative phase of a sequential exploratory mixed-methods project. The quantitative phase used an individual-level, two-group, pre-test/post-test randomized controlled trial in the adult medical, surgical, cardiac, and high-dependency ICUs of King Salman Specialist Hospital, King Khalid Hospital,

and Hail General Hospital in the Hail Region, Saudi Arabia. The intervention lasted four weeks, with assessments conducted immediately before randomization and after completion of the programme.

2.2 Participants and Randomization

Eligible participants were registered nurses who worked in direct patient care in participating ICUs and had at least six months of critical-care experience. Charge nurses were eligible when they provided direct clinical care. Nurses working exclusively in administrative or supervisory roles, those unavailable during the intervention or follow-up period, and nurses who had participated in the qualitative needs assessment or pilot trial were excluded. All participants provided informed consent and completed the baseline assessment before allocation.

A total of 232 nurses were randomized in a 1:1 ratio to the intervention group (n = 116) or control group (n = 116). Randomization was stratified by hospital using block allocation to preserve balance across the three sites. The study protocol specified an independently generated sequence and concealed allocation after baseline assessment. Because participants and facilitators knew whether training was received, they could not be blinded; standardized self-administered questionnaires were used in both groups, and the analyst was blinded to group identity.

2.3 Intervention and Control

The intervention was developed from interviews with ICU nurses and reviewed by five experts. It comprised four weekly modules: (1) orientation and baseline awareness of nurse engagement and patient safety culture; (2) safety training covering reporting, communication, root-cause analysis, and prevention; (3) motivation and empowerment, including leadership support, recognition, psychological safety, and involvement in safety activities; and (4) competency development through clinical judgment, critical thinking, safe-practice scenarios, and applied learning. Trained facilitators used standardized materials and session plans. Intervention-group nurses attended the programme in addition to routine activities. Control-group nurses continued usual nursing orientation, in-service education, incident-reporting procedures, safety meetings, and quality-improvement activities and were offered programme materials after post-test data collection.

2.4 Measures

Patient safety culture. The outcome was post-test Primary Patient Safety Culture Index, operationalized as the four-item Overall Perceptions of Patient Safety measure derived from Version 1.0 of the Hospital Survey on Patient Safety Culture. Items were scored from 1 to 5 after reverse-coding negatively worded items; higher scores indicated more favorable perceptions. The index demonstrated acceptable internal consistency at baseline (Cronbach's α = .724). The original Hospital SOPS comprises 42 items and 12 patient-safety culture composites (Sorra et al., 2014).

Baseline work engagement. Work engagement was measured before randomization using the 17-item UWES, which assesses vigor (six items), dedication (five items), and absorption (six items). Responses ranged from 1 (never) to 5 (always), with higher averages indicating greater engagement. The baseline total UWES score demonstrated excellent internal consistency in this sample (α = .937).

Covariates. The moderation model adjusted for baseline Primary Patient Safety Culture Index and hospital affiliation. Hospital was represented by two indicator variables, with King Salman Specialist Hospital as the reference site.

2.5 Statistical Analysis

Data were analyzed using SPSS version 28. The moderation analysis was conducted among the 220 nurses who completed the post-test assessment. Hayes' PROCESS macro, Model 1, was used to estimate whether the effect of randomized group assignment on post-test patient safety culture depended on baseline work engagement (Hayes, 2022). Group was coded 0 for control and 1 for intervention. Baseline UWES scores were mean-centered before forming the group-by-engagement interaction

term. The model included group, baseline patient safety culture, centered baseline work engagement, two hospital indicators, and the group-by-engagement interaction.

Unstandardized regression coefficients (B), bootstrap standard errors, and 95% bootstrap confidence intervals were estimated using 5,000 bootstrap resamples. A statistically significant interaction indicated moderation. The intervention effect was probed at one standard deviation below the baseline engagement mean, at the mean, and one standard deviation above the mean. Statistical significance was set at $p < .05$. The model F statistic and R^2 were used to summarize overall fit.

2.6 Ethical Considerations

Participation was voluntary, informed consent was obtained, and participant identifiers were replaced with researcher-assigned codes. The study documents describe secure, separate storage of the identification key and survey data and protection of group allocation and individual responses from hospital managers.

3. Results

3.1 Participant Flow and Baseline Profile

All 232 randomized nurses completed baseline assessment. At post-test, 111 of 116 intervention-group nurses (95.7%) and 109 of 116 control-group nurses (94.0%) provided outcome data, giving 220 complete post-test cases (94.8% retention). Twelve participants were lost to follow-up because of schedule conflicts, leave or work absence, or withdrawal of consent. Post-test non-completion was not associated with group allocation or key baseline outcomes in the source analysis.

Participants had a mean age of 33.87 years (SD = 5.98), 65.5% were women, and mean ICU experience was 3.69 years (SD = 2.81). The groups were similar at baseline in demographic, professional, patient safety culture, and work-engagement characteristics, except that prior patient safety training was more common in the control group (67.2% vs. 50.9%, p = .016). Baseline work engagement averaged 3.76 (SD = 0.54) and the Primary Patient Safety Culture Index averaged 3.20 (SD = 0.62).

Table 1. Selected Baseline Characteristics by Randomized Group

Characteristic	Intervention (n = 116)	Control (n = 116)	p-value
Age, years, mean ± SD	34.17 ± 6.39	33.57 ± 5.54	0.443
Female, n (%)	71 (61.2)	81 (69.8)	0.214
Bachelor's degree, n (%)	91 (78.4)	98 (84.5)	0.311
Previous patient safety training, n (%)	59 (50.9)	78 (67.2)	0.016
ICU experience, years, mean ± SD	3.59 ± 2.62	3.79 ± 2.99	0.584
Rotating shifts, n (%)	83 (71.6)	70 (60.3)	0.195
Primary Patient Safety Culture Index, mean ± SD	3.24 ± 0.62	3.15 ± 0.62	0.234
Total work engagement, mean ± SD	3.73 ± 0.58	3.80 ± 0.49	0.329

Note. Continuous variables were compared with independent-samples t tests; categorical comparisons used chi-square or Fisher's exact tests as appropriate. Both study scales ranged from 1 to 5, with higher scores indicating more favorable patient safety culture or work engagement.

3.2 Main Intervention Effect

The moderation analysis was conducted in the context of a clear overall intervention effect. The mean Primary Patient Safety Culture Index increased from 3.24 (SD = 0.62) to 3.80 (SD = 0.81) in the intervention group, compared with 3.15 (SD = 0.62) to 3.17 (SD = 0.67) in the

control group. In the intention-to-treat linear mixed-effects analysis of the main trial, the adjusted group-by-time effect was B = 0.526 (SE = 0.074, 95% CI [0.381, 0.671], p < .001).

3.3 Moderating Role of Baseline Work Engagement

The complete moderation model was statistically significant, F(6, 213) = 87.82, p < .001, and explained 71.2% of the variance in post-test patient safety culture (R^2 = .712; adjusted R^2 = .704). After controlling for baseline patient safety culture and hospital, assignment to the intervention group was associated with higher post-test patient safety culture (B = 0.580, bootstrap SE = 0.060, 95% bootstrap CI [0.459, 0.695], p < .001). Baseline work engagement also had a positive conditional association with post-test patient safety culture in the control group (B = 0.255, bootstrap SE = 0.101, 95% bootstrap CI [0.053, 0.444], p = .005).

The group-by-baseline-engagement interaction was positive and statistically significant (B = 0.528, bootstrap SE = 0.126, 95% bootstrap CI [0.288, 0.775], p < .001). Thus, each one-point increase in centered baseline engagement was associated with an additional 0.528-point intervention effect on the 1-to-5 patient safety culture scale.

Table 2. Moderation Model Predicting Post-Test Patient Safety Culture

Predictor	B	Boot SE	95% bootstrap CI	p-value
Intervention group vs. control	0.58	0.06	[0.459, 0.695]	< .001
Baseline patient safety culture	0.696	0.049	[0.603, 0.792]	< .001
Baseline work engagement	0.255	0.101	[0.053, 0.444]	0.005
Group × baseline work engagement	0.528	0.126	[0.288, 0.775]	< .001

Note. n = 220. Outcome: post-test Primary Patient Safety Culture Index. The model adjusted for hospital using two indicator variables; those coefficients are not displayed. Work engagement was mean-centered. Model: F(6, 213) = 87.82, p < .001, R^2 = .712, adjusted R^2 = .704. Bootstrap estimates used 5,000 resamples.

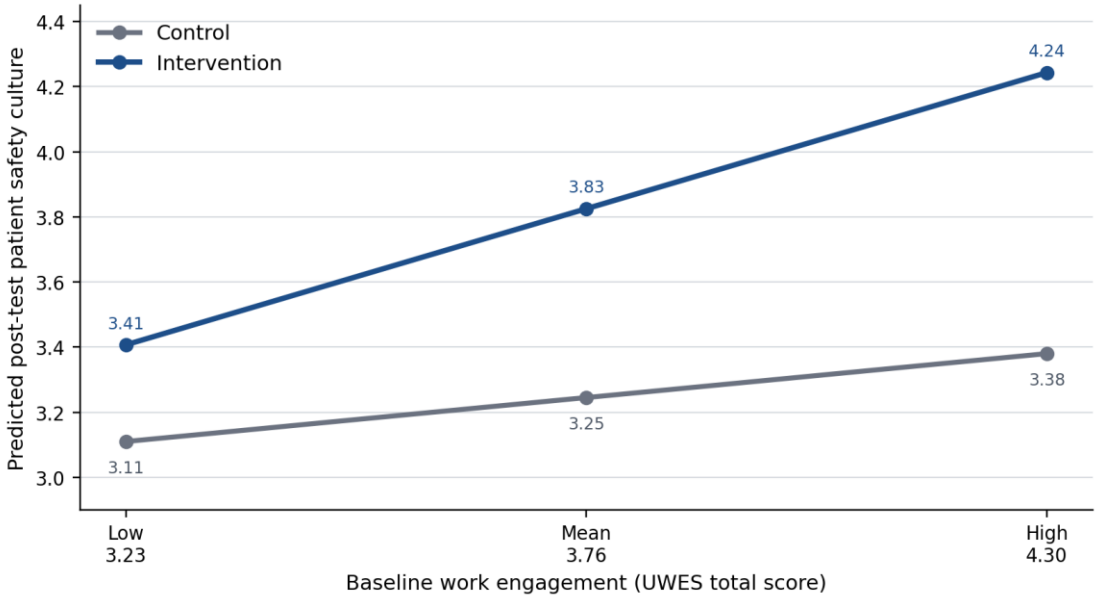
Conditional-effects analysis showed that the intervention was beneficial at all three prespecified levels of baseline engagement, but the estimated benefit became progressively larger as baseline engagement increased. At low engagement (3.23; one SD below the mean), the intervention effect was 0.297 points. At mean engagement (3.76), it was 0.580 points; and at high engagement (4.30; one SD above the mean), it was 0.863 points. Each confidence interval excluded zero.

Table 3. Conditional Intervention Effects Across Baseline Work-Engagement Levels

Baseline work engagement	Intervention effect (B)	Boot LLCI	Boot ULCI	p-value
Low: 3.23 (−1 SD)	0.297	0.103	0.481	0.001
Mean: 3.76	0.58	0.459	0.695	< .001
High: 4.30 (+1 SD)	0.863	0.702	1.032	< .001

Note. Conditional effects were estimated while controlling for baseline patient safety culture and hospital. LLCI = lower-limit confidence interval; ULCI = upper-limit confidence interval.

Figure 1. Predicted Post-Test Patient Safety Culture by Group and Baseline Work Engagement



Note. Low and high predicted values are those reported in the thesis; mean-level points lie on the linear fitted interaction. The widening separation between groups illustrates the positive interaction.

4. Discussion

Baseline work engagement significantly moderated the effect of the nurse engagement intervention on post-test patient safety culture. The programme improved patient safety culture even among nurses with low initial engagement, but the effect was nearly three times larger at high than at low baseline engagement (0.863 vs. 0.297 points). This pattern indicates treatment-effect heterogeneity: the intervention was broadly beneficial, yet nurses' initial motivational state influenced the magnitude of the benefit.

The finding extends earlier evidence that staff engagement and patient safety are positively related. Janes et al. (2021) reported a consistent association between healthcare staff engagement and both safety-culture scores and errors or adverse events, while Collier et al. (2016) identified strong unit-level links between engagement and ICU safety culture. Those studies largely established association. The present randomized intervention context adds evidence that baseline engagement can differentiate how strongly nurses respond to a structured safety and engagement programme, even after adjustment for baseline patient safety culture and hospital.

The result also helps explain variability reported in work-engagement interventions. Knight et al. (2017) found that interventions can improve engagement but that effects vary according to intervention design and context. Here, heterogeneity was detectable within the same programme: nurses with higher baseline engagement appeared better positioned to use training on communication, reporting, empowerment, and clinical competency. Evidence among nurses that work engagement contributes to job performance provides a compatible mechanism, although it does not directly establish a safety pathway (Hu et al., 2021).

The Job Demands-Resources model offers a coherent interpretation. Work engagement represents a motivational state supported by adequate resources and manageable demands (Schaufeli & Bakker, 2004). Nurses with greater baseline vigor, dedication, and absorption may have had more psychological capacity to attend to programme content, participate in reflective exercises, practise communication tools, and sustain new safety behaviors. Lower-engagement nurses may face workload strain, limited autonomy, weak recognition, burnout, or skepticism about organizational follow-through.

These conditions can reduce the dose of learning translated into practice even when attendance is adequate.

The moderation result should not be used to restrict the programme to highly engaged nurses. The intervention effect remained positive and statistically significant at low engagement, demonstrating that these nurses also benefited. Instead, baseline assessment can guide proportionate support. ICU managers could pair the programme with protected learning time, repeated session options, mentoring, supervisor access, recognition, workload review, and psychologically safe opportunities to discuss errors and concerns. Such supports may strengthen the resources that lower-engagement nurses need to obtain gains comparable with those of their more engaged colleagues.

Several strengths support confidence in the finding: multicenter recruitment, randomized intervention assignment, high post-test retention, reliable measures, adjustment for baseline patient safety culture and hospital, mean-centering of the moderator, and bootstrap confidence intervals. The model also explained a substantial proportion of post-test variation. Importantly, the conditional effects were estimated at transparent and clinically interpretable engagement levels rather than reporting the interaction coefficient alone.

The findings nevertheless require cautious interpretation. First, baseline work engagement was measured rather than randomized; the interaction identifies effect modification but does not prove that experimentally increasing baseline engagement would causally amplify the intervention. Second, moderation used the 220 post-test completers rather than all 232 randomized nurses, although missingness was low and unrelated to measured baseline outcomes. Third, the study was powered for the primary two-group comparison, not specifically for interaction detection. Fourth, both engagement and safety culture were self-reported, creating potential common-method and social-desirability bias. Fifth, post-test measurement followed the four-week programme immediately, so durability is unknown. Sixth, findings from nurses in three governmental hospitals in one Saudi region may not generalize to other professions, regions, or health systems. Finally, prior patient safety training was more common in the control group and was not included in the reported moderation model; residual influence from that imbalance cannot be excluded.

Future studies should replicate the interaction with longer follow-up, objective safety indicators, and samples large enough for prespecified moderator analyses. Stratified or adaptive designs could test whether an engagement-support component before or alongside safety training reduces the response gap. Multilevel models could also separate individual engagement from unit-level leadership, staffing, and safety climate, because safety culture is an organizational phenomenon as well as an individual perception (Reason, 1997).

5. Conclusion

Baseline work engagement amplified the effect of a four-week nurse engagement intervention on post-test patient safety culture among ICU nurses in Hail, Saudi Arabia. The programme was effective across low, average, and high baseline engagement, but gains increased markedly as initial engagement rose. Hospitals should therefore retain universal access to the intervention while providing additional organizational and educational support to nurses who begin with lower engagement. Screening baseline engagement may help tailor implementation intensity, but further trials are needed to determine whether actively strengthening engagement before programme delivery improves and sustains patient-safety outcomes.

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Author Declaration

Originality and conflicts of interest. This manuscript reports an objective derived from the author's doctoral thesis and has been prepared as an original journal article. The authors declare no conflicts of interest.

Informed consent. All participants provided informed consent before study procedures.

Data availability. De-identified data may be available from the corresponding author on reasonable request, subject to ethical and institutional permissions.