Tec Empresarial
P-ISSN: 1659-2395; E-ISSN: 1659-3359

WORKPLACE WORKLOAD AND BURNOUT SIGNALS AMONG CLINICAL LABORATORY PROFESSIONALS: IMPLICATIONS FOR QUALITY CONTROL ADHERENCE

A Cross-Sectional Analysis of Occupational Strain and Quality Performance in Tertiary Care Laboratories

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Abstract

Background: Clinical laboratory professionals operate under sustained analytical workloads, staffing pressures, and shift demands that may predispose them to occupational burnout. Burnout is increasingly recognized as a determinant of error-prone behavior in healthcare settings, yet its specific relationship with quality control (QC) adherence in laboratory medicine has received limited empirical attention.

Methods: A cross-sectional survey-based design was used to examine workload, burnout dimensions (emotional exhaustion, depersonalization, personal accomplishment), and QC adherence among 312 laboratory professionals across hematology, chemistry, microbiology, blood bank, and histopathology sections of a tertiary care hospital. Workload was measured using a NASA Task Load Index-derived composite score. Burnout was assessed using Maslach Burnout Inventory-consistent subscales. QC adherence was measured via a composite adherence score (0-100) and the count of QC non-conformances over the preceding six months. Associations were examined using Pearson correlation, multiple linear regression, logistic regression, and negative binomial regression.

Results: High burnout (elevated emotional exhaustion and depersonalization) was identified in 24.4% of participants. Workload index correlated strongly with emotional exhaustion (r = 0.64, p

< .001). Participants meeting high-burnout criteria had significantly lower QC adherence scores than those who did not (82.1 ± 7.6 vs. 89.4 ± 7.0; Welch t(122.0) = -7.36, p < .001). In multiple linear regression, emotional exhaustion (β = -0.37, p < .001) and depersonalization (β = -0.29, p < .001) were independent negative predictors of QC adherence, while workload index, years of experience, and weekly working hours were not independently significant after adjustment. Workload index was an independent predictor of high-burnout status (OR = 1.14, 95% CI 1.10-1.18, p < .001). Emotional exhaustion and depersonalization were independently associated with higher rates of QC non-conformances (negative binomial regression, p < .001 and p = .018, respectively).

Conclusions: Workload-driven emotional exhaustion and depersonalization are independently associated with reduced QC adherence and increased non-conformance rates among laboratory professionals, independent of raw workload or working hours. These findings support burnout surveillance as a component of laboratory quality management systems and suggest that interventions targeting emotional exhaustion may have direct benefits for analytical quality and patient safety.

Keywords: laboratory medicine; occupational burnout; workload; quality control; patient safety; Maslach Burnout Inventory; medical technologists

1. Introduction

Clinical laboratories function as the diagnostic backbone of modern healthcare systems, generating the majority of objective data used in clinical decision-making. The reliability of this data depends on strict adherence to quality control (QC) procedures across the pre-analytical, analytical, and post-analytical phases of testing. However, laboratory professionals increasingly report conditions of high workload, chronic staffing shortages, extended shift patterns, and escalating test volumes, all of which are recognized contributors to occupational burnout in healthcare settings.

Burnout, conceptualized within the Maslach framework as a syndrome comprising emotional exhaustion, depersonalization, and reduced personal accomplishment, has been extensively studied among nurses and physicians, with consistent evidence linking burnout to medical errors, reduced hand hygiene compliance, and degraded patient safety culture (Manomenidis et al., 2019; Mansour & Abu Sharour, 2021). A recent systematic review and meta-analysis of 85 studies involving over 288,000 nurses found that nurse burnout was associated with lower safety climate, more frequent medication errors and adverse events, more missed or omitted care, and lower patient satisfaction and nurse-assessed quality of care (Li et al., 2024). A 2022 survey of medical laboratory technologists and assistants reported substantial increases in stress and emotional exhaustion following the COVID-19 pandemic, alongside concerns regarding workforce capacity to sustain routine operations (Djukic & Nielsen, 2022). Among Ontario medical laboratory technologists surveyed during the second pandemic wave, burnout prevalence reached 72.3%, with high quantitative job demands, high work pace, job insecurity, and work-life conflict identified as significant occupational risk factors (Nowrouzi-Kia et al., 2022). A related study of medical laboratory professionals found that higher psychosocial stress was associated with lower job satisfaction, while a stronger sense of workplace community was protective (Lo et al., 2023). Among medical technologists in South Korea, job stress factors - particularly occupational climate and lack of reward - were significantly associated with burnout scores, with the magnitude of association varying by diagnostic department (Sim et al., 2024).

Despite this, the specific pathway linking laboratory workload and burnout to QC adherence - a process measure central to laboratory accreditation frameworks such as CAP, CBAHI, and ISO 15189 - remains underexamined. Laboratory work differs structurally from bedside nursing or physician practice: it is characterized by repetitive, protocol-driven analytical tasks, time-pressured turnaround targets, and a high density of discrete quality checkpoints (calibration verification, control material runs, delta checks, critical value reporting) where a lapse in vigilance can propagate undetected errors into patient results.

Workforce retention research among Saudi laboratory technologists has identified workload dissatisfaction as a substantial driver of turnover intention, alongside compensation and career development concerns, with downstream implications for productivity and healthcare quality (Al-Qathmi & Zedan, 2021). Total laboratory automation has been proposed as one structural response to rising test volumes and labor shortages, with reported benefits for staff well-being and QC consistency, though implementation barriers including cost and workforce training remain substantial (Nam & Park, 2025).

This study examines the relationships among self-reported workload, burnout dimensions, and two QC adherence outcomes - a composite adherence score and the frequency of QC non-conformances - among laboratory professionals working across multiple diagnostic sections of a tertiary care hospital. We hypothesized that (1) higher workload would be associated with higher emotional exhaustion and depersonalization, and (2) burnout dimensions, independent of workload and working hours, would be associated with reduced QC adherence and higher non-conformance rates.

2. Methods

2.2 Study design and setting

This was a cross-sectional, survey-based study conducted across five diagnostic sections (hematology, clinical chemistry, microbiology, blood bank/transfusion medicine, and histopathology) of a tertiary care hospital laboratory. The study examines associations between workload, burnout, and QC adherence at a single time point and does not establish causal or temporal sequence.

2.3 Participants

A total of 312 laboratory professionals (medical technologists, technicians, and laboratory assistants) participated. Inclusion criteria were active clinical duty status with direct involvement in specimen processing, analytical testing, or QC procedures during the preceding six months. Department, shift pattern (day vs. rotating/night), years of professional experience, and average weekly working hours were recorded.

2.4 Measures

Workload index: A composite workload score (range 0-100) was derived from a NASA Task Load Index-based instrument, incorporating mental demand, time pressure, and effort subscales, consistent with prior application of the NASA-TLX in nursing workload-burnout research (Mansour & Abu Sharour, 2021).

Burnout: Burnout was assessed using Maslach Burnout Inventory-consistent subscales for emotional exhaustion (EE, range 0-54), depersonalization (DP, range 0-30), and personal

accomplishment (PA, range 0-48). High burnout was operationally defined as the co-occurrence of high emotional exhaustion (EE ≥ 27) and high depersonalization (DP ≥ 10), consistent with established MBI cut-off conventions.

QC adherence score: A composite QC adherence score (0-100) was constructed from supervisor-rated and self-reported compliance with QC scheduling, control-run documentation, calibration verification, and corrective action completion.

QC non-conformances: The number of documented QC non-conformance events (failed control runs not appropriately actioned, missed QC scheduling, documentation gaps) attributed to each participant over the preceding six months was extracted from quality management records.

2.5 Statistical analysis

Continuous variables were summarized as mean ± standard deviation (SD) and assessed for normality using the Shapiro-Wilk test. The workload index and emotional exhaustion scores were approximately normally distributed (Shapiro-Wilk $p > .05$); the QC adherence score showed minor deviation from normality ($p < .001$) but was retained for parametric analysis given the sample size ($n = 312$) and approximate symmetry.

Group differences in QC adherence between high-burnout and non-high-burnout participants were assessed using Welch's t-test (unequal variances). Pearson correlation coefficients were calculated to examine bivariate associations between workload, burnout subscales, and QC adherence. A multiple linear regression model was fitted with QC adherence score as the dependent variable and emotional exhaustion, depersonalization, personal accomplishment, workload index, years of experience, and weekly working hours as predictors. Logistic regression was used to model high-burnout status as a function of workload index, weekly working hours, and years of experience, with results reported as odds ratios (OR) and 95% confidence intervals (CI). Negative binomial regression was used to model QC non-conformance counts (an overdispersed count outcome) as a function of the three burnout subscales. One-way ANOVA was used to compare QC adherence scores across departments. All analyses were performed in Python (pandas, scipy, statsmodels); statistical significance was set at $p < .05$.

3. Results

3.2 Sample characteristics

The sample (N = 312) had a mean of 6.8 ± 6.0 years of professional experience and a mean weekly working time of 48.3 ± 7.4 hours. The mean workload index was 60.8 ± 15.3 (range 10-100). High burnout, defined by co-occurring elevated emotional exhaustion and depersonalization, was present in 76 participants (24.4%). Descriptive statistics for all study variables are presented in Table 1.

Table 1. Descriptive statistics for workload, burnout, and quality control adherence variables (N = 312)

Variable	Mean ± SD	Median	Range
Years of professional experience	6.8 ± 6.0	5.1	0.5-35.0

Weekly working hours	48.3 ± 7.4	48.0	35-72
Workload index (0-100)	60.8 ± 15.3	60.4	10.0-100.0
Emotional exhaustion (MBI, 0-54)	22.8 ± 10.4	22.7	0-49.2
Depersonalization (MBI, 0-30)	10.1 ± 6.8	9.8	0-30.0
Personal accomplishment (MBI, 0-48)	42.1 ± 5.7	43.5	0-48.0
QC adherence score (0-100)	87.6 ± 7.8	88.2	20.0-100.0
QC non-conformances (past 6 months)	0.67 ± 0.88	0	0-4

3.3 **Burnout prevalence by department**

High-burnout prevalence varied across diagnostic sections, ranging from approximately 15% to over 35% (Figure 1). Sections with higher reported workload index values tended to show higher burnout prevalence, although a formal department-level statistical test of burnout prevalence was not performed given subgroup sample sizes.

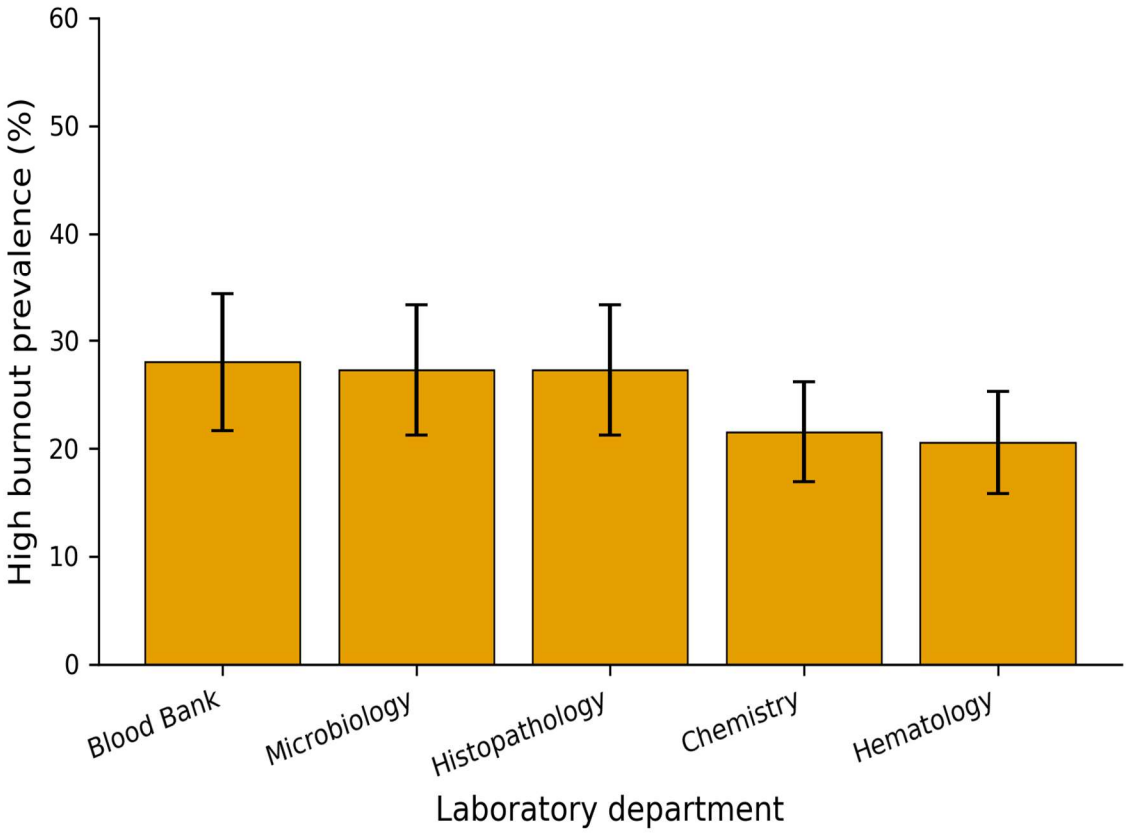

Figure 1. High-burnout prevalence (%) by laboratory department. Bars represent the percentage of participants meeting the operational definition of high burnout (emotional exhaustion ≥ 27 and depersonalization ≥ 10) within each department. Error bars represent the standard error of the proportion. n = 312.

3.4 Workload, burnout, and QC adherence: bivariate associations

Workload index was strongly and positively correlated with emotional exhaustion (Pearson r = 0.64, p < .001; Figure 3). Emotional exhaustion was negatively correlated with QC adherence score (r = -0.585, p < .001), and workload index was negatively correlated with QC adherence score (r = -0.431, p < .001). The full correlation matrix among study variables is presented in Figure 5.

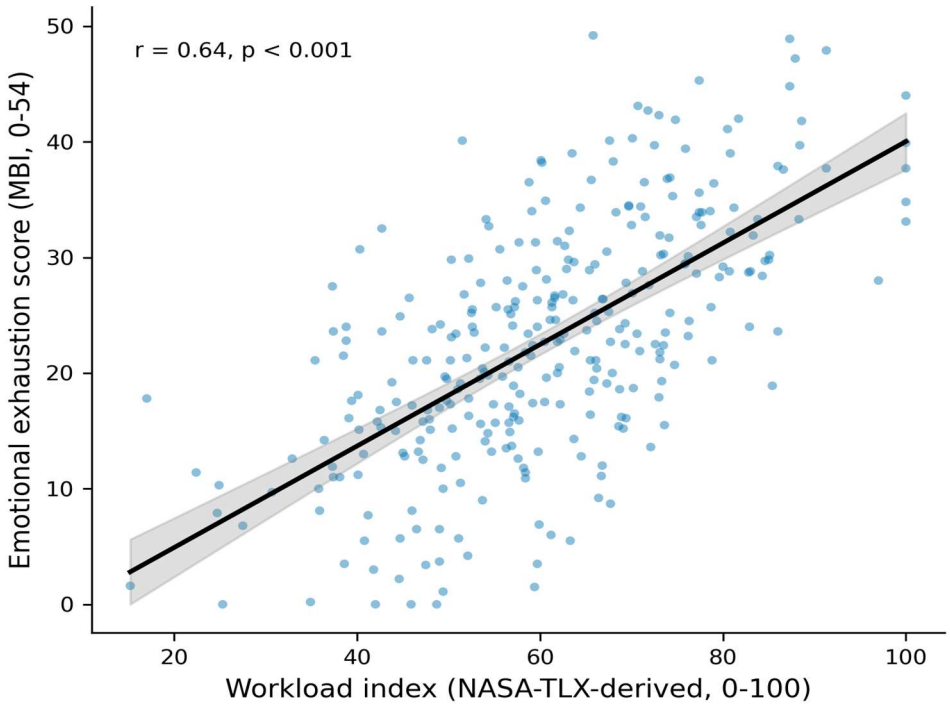

Figure 3. Relationship between workload index and emotional exhaustion score. Scatter points represent individual participants (n = 312); the solid line represents the fitted linear regression, with the shaded band representing the 95% confidence interval of the mean prediction. r = Pearson correlation coefficient.

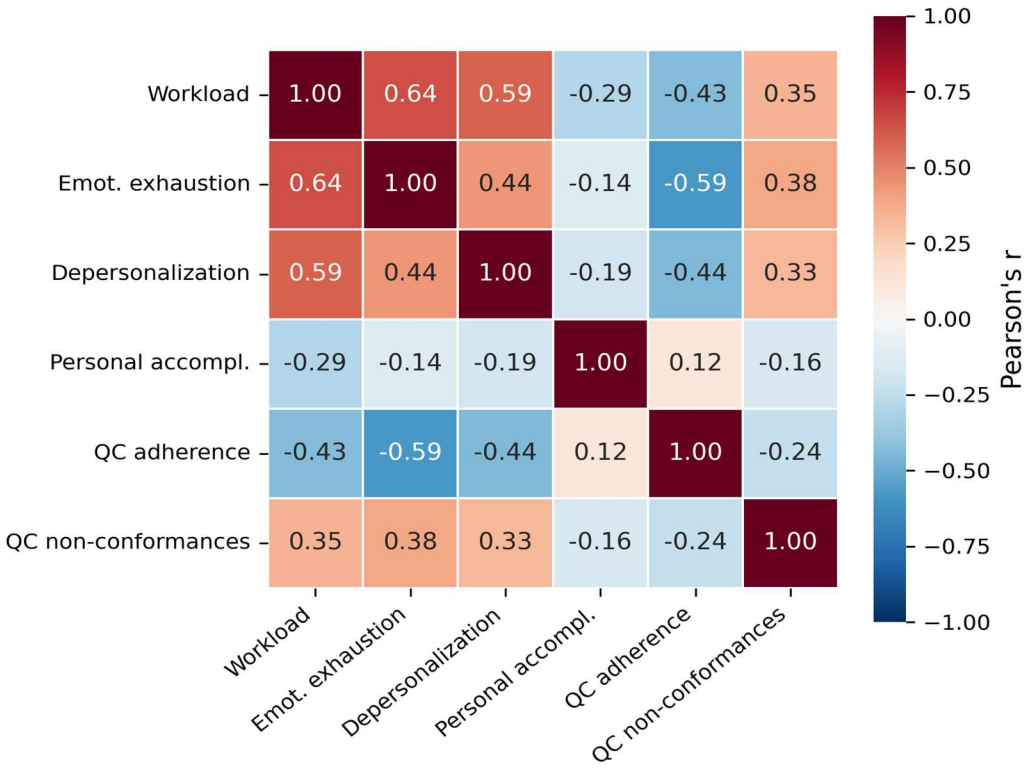

Figure 5. Correlation matrix (Pearson's r) among workload, burnout subscales, and quality control outcomes. Cell values represent pairwise Pearson correlation coefficients; color scale ranges from -1 (dark blue, strong negative correlation) to +1 (dark red, strong positive correlation). n = 312.

3.5 QC adherence by burnout status

Participants meeting criteria for high burnout had significantly lower QC adherence scores (mean 82.1 ± 7.6) than those who did not (mean 89.4 ± 7.0), a difference of 7.3 points (Welch t = -7.36, p < .001; Figure 2).

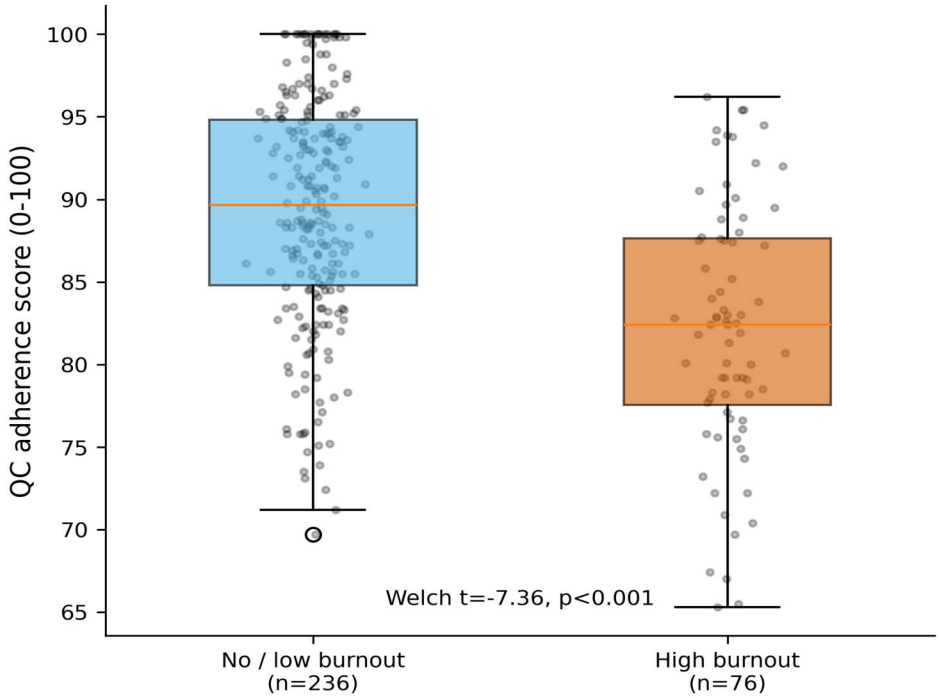

Figure 2. Quality control adherence scores by burnout status. Box plots show median, interquartile range (box), and 1.5x IQR whiskers; individual data points are overlaid with jitter. High burnout was defined as emotional exhaustion ≥ 27 and depersonalization ≥ 10 on Maslach Burnout Inventory-consistent subscales. ***p < .001 (Welch's t-test).

3.6 Multiple linear regression: predictors of QC adherence

A multiple linear regression model including emotional exhaustion, depersonalization, personal accomplishment, workload index, years of experience, and weekly working hours explained approximately 39.7% of the variance in QC adherence score ($R^2 = 0.397$, adjusted $R^2 = 0.385$, $F(6, 305) = 33.48$, $p < .001$). In this adjusted model, emotional exhaustion ($\beta = -0.374$, 95% CI -0.460 to -0.288, $p < .001$) and depersonalization ($\beta = -0.291$, 95% CI -0.417 to -0.165, $p < .001$) remained significant independent negative predictors of QC adherence. Personal accomplishment, workload index, years of experience, and weekly working hours were not independently significant predictors after adjustment for burnout subscales (Table 2, Figure 4), suggesting that the burnout dimensions - particularly emotional exhaustion - mediate much of the apparent workload-QC association observed in bivariate analysis.

Table 2. Multiple linear regression results for predictors of QC adherence score (N = 312)

Predictor	β (unstandardized)	95% CI	p-value
Intercept	93.056	85.16 to 100.95	< .001
Emotional exhaustion	-0.374	-0.460 to -0.288	< .001

Depersonalization	-0.291	-0.417 to -0.165	< .001
Personal accomplishment	0.031	-0.094 to 0.156	.624
Workload index	0.014	-0.054 to 0.083	.677
Years of experience	0.100	-0.014 to 0.214	.085
Weekly working hours	0.065	-0.030 to 0.160	.179

Note. $R^2 = 0.397$, adjusted $R^2 = 0.385$, $F(6, 305) = 33.48$, $p < .001$. CI = confidence interval.

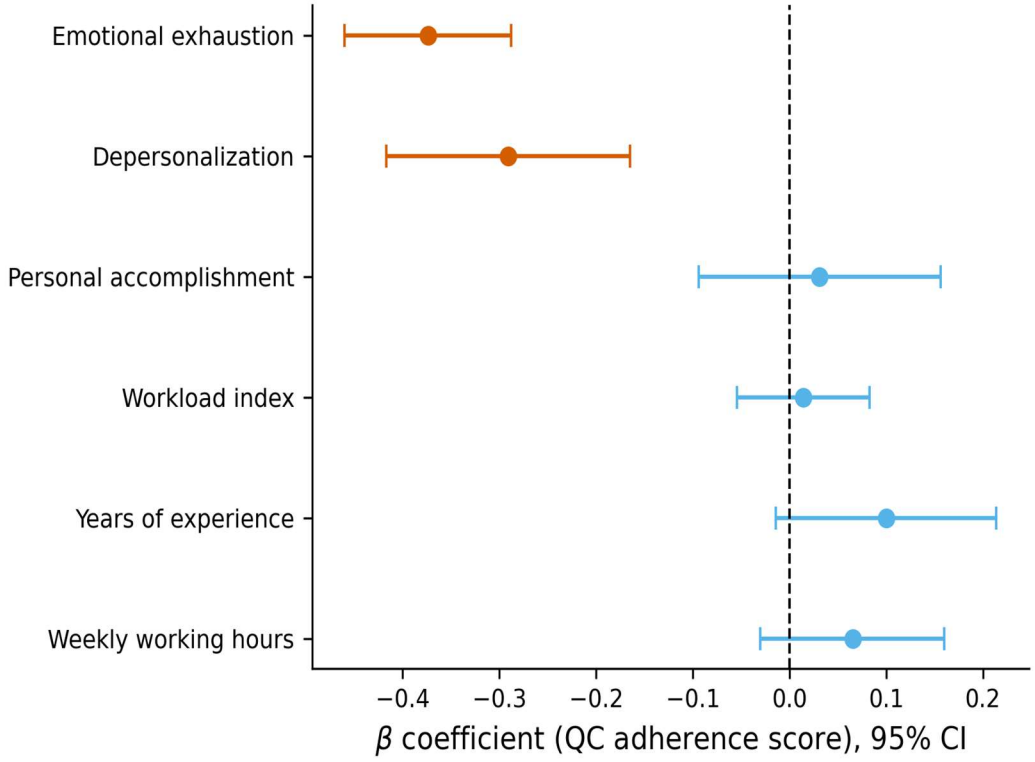

Figure 4. Forest plot of multiple linear regression coefficients (β) for predictors of QC adherence score, with 95% confidence intervals. Markers to the left of the dashed reference line (β = 0) indicate a negative association with QC adherence. Filled orange markers denote predictors whose 95% CI excludes zero (statistically significant at $p < .05$).

3.7 Logistic regression: predictors of high-burnout status

In a logistic regression model predicting high-burnout status from workload index, weekly working hours, and years of experience (pseudo-$R^2 = 0.357$, LLR $p < .001$), workload index was the only statistically significant independent predictor: each one-point increase in workload index was associated with a 14.3% increase in the odds of high burnout (OR = 1.143, 95% CI 1.104-1.182, $p < .001$). Weekly working hours (OR = 1.038, 95% CI 0.991-1.087, $p = .112$) and years of

experience (OR = 1.016, 95% CI 0.963-1.073, p = .553) were not independently significant (Table 3).

Table 3. Logistic regression results for predictors of high-burnout status (N = 312)

Predictor	OR	95% CI	p-value
Workload index	1.143	1.104 to 1.182	< .001
Weekly working hours	1.038	0.991 to 1.087	.112
Years of experience	1.016	0.963 to 1.073	.553

Note. OR = odds ratio; CI = confidence interval. High burnout defined as emotional exhaustion ≥ 27 and depersonalization ≥ 10.

3.8 Negative binomial regression: predictors of QC non-conformances

Given the overdispersed, count-based distribution of QC non-conformance events (mean 0.67, variance > mean), a negative binomial regression model was fitted with emotional exhaustion, depersonalization, and personal accomplishment as predictors. Emotional exhaustion (incidence rate ratio [IRR] = e^0.041 = 1.042 per unit, p < .001) and depersonalization (IRR = e^0.036 = 1.036 per unit, p = .018) were independently associated with higher rates of QC non-conformances. Personal accomplishment was not a significant independent predictor (p = .224) (Table 4).

Table 4. Negative binomial regression results for predictors of QC non-conformance counts (N = 312)

Predictor	Coefficient (log scale)	IRR	p-value
Emotional exhaustion	0.041	1.042	< .001
Depersonalization	0.036	1.036	.018
Personal accomplishment	-0.019	0.981	.224

Note. IRR = incidence rate ratio (exponentiated coefficient), interpretable as the multiplicative change in expected non-conformance count per one-unit increase in the predictor.

3.9 Departmental variation in QC adherence

One-way ANOVA did not detect a statistically significant difference in mean QC adherence scores across the five departments ($F(4, 307) = 1.14$, $p = .337$), indicating that differences in QC adherence were more strongly associated with individual burnout status than with department of work.

3.10 Quality monitoring trend

To illustrate the operational relevance of these findings, a simulated 12-month QC non-conformance run chart is presented (Figure 6), depicting a shift from a baseline monthly non-conformance rate to an elevated rate during a period of higher reported workload, consistent with the cross-sectional associations described above. This figure is intended to illustrate how burnout-related QC signals might be visualized within a continuous quality monitoring framework rather than to represent observed longitudinal data from this study.

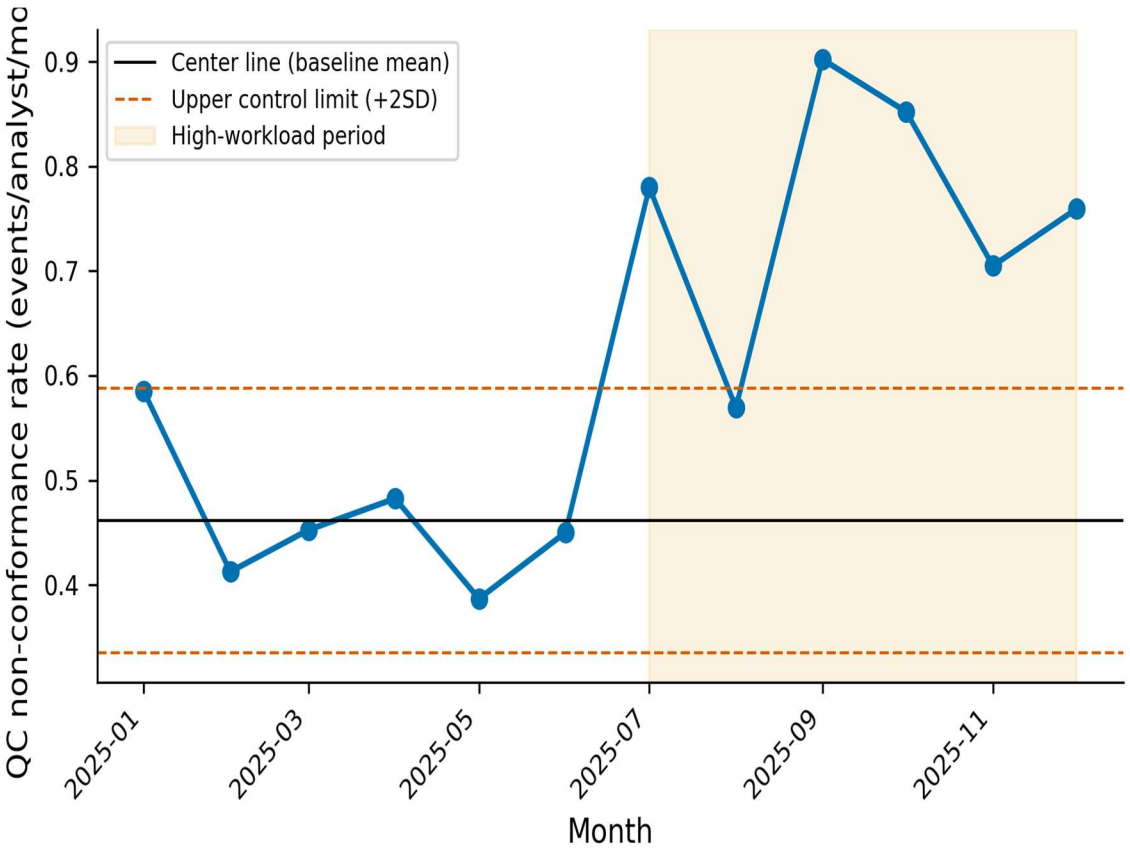

Figure 6. Illustrative run chart of monthly QC non-conformance rates over a 12-month period. The center line represents the mean non-conformance rate during the first six months (baseline); upper and lower control limits are set at ± 2 standard deviations from baseline. The shaded region indicates a hypothetical high-workload period during which non-conformance rates exceeded the upper control limit, illustrating the type of signal that burnout-related QC monitoring could detect. This figure is illustrative and based on simulated data.

4. Discussion

This study found that nearly one in four laboratory professionals in a tertiary care hospital met criteria for high burnout, and that burnout - specifically emotional exhaustion and depersonalization - was independently associated with reduced QC adherence and increased QC non-conformance rates, even after accounting for workload, working hours, and years of experience. These findings extend the well-established burnout-patient safety literature from nursing and physician populations (Garrouste-Orgeas et al., 2015; Kiymaz & Koç, 2018;

Manomenidis et al., 2019; Mansour & Abu Sharour, 2021; Li et al., 2024) to the laboratory workforce, a group whose contribution to diagnostic safety operates largely behind the scenes but is no less consequential. The meta-analytic effect sizes reported by Li et al. (2024) for the association between nurse burnout and medication errors (SMD = -0.30) and missed care (SMD = -0.58) are broadly consistent in direction, if not in absolute magnitude, with the QC adherence gap observed in the present sample.

The finding that workload index was strongly correlated with emotional exhaustion, but was not an independent predictor of QC adherence once burnout dimensions were included in the model, suggests a mediation pathway: workload appears to act on QC adherence primarily through its effect on emotional exhaustion and depersonalization, rather than through a direct mechanism such as time scarcity alone. This is consistent with the broader occupational health literature in which burnout functions as a proximal mechanism translating chronic job demands into degraded performance (Djukic & Nielsen, 2022). Practically, this implies that interventions focused solely on reducing raw workload (for example, hiring additional staff without addressing recovery time, recognition, or workflow design) may be insufficient if they do not also reduce emotional exhaustion.

The magnitude of the QC adherence gap between high-burnout and non-high-burnout participants (approximately 7 points on a 100-point scale) is operationally meaningful in laboratory quality systems, where small degradations in QC discipline - delayed control runs, incomplete corrective action documentation, or missed calibration verifications - can accumulate into systemic risk over time. The independent association between emotional exhaustion, depersonalization, and QC non-conformance counts reinforces this concern: burnout was associated not only with a lower self/supervisor-rated adherence score but with a higher frequency of documented quality events.

Findings regarding hand hygiene compliance among nurses experiencing burnout (Manomenidis et al., 2019) and the association between excessive workload, insufficient staffing, and self-reported medical error causation among emergency nurses (Kiymaz & Koç, 2018) parallel the present results in a different clinical context, reinforcing the generalizability of the burnout-to-procedural-compliance pathway across healthcare professions. Similarly, workforce retention data from Saudi laboratory technologists identifying workload dissatisfaction as a leading driver of turnover intention (Al-Qathmi & Zedan, 2021) suggest that the burnout signals identified here may also have downstream implications for staffing stability, compounding workload pressures on remaining staff in a feedback cycle.

The absence of a significant departmental difference in QC adherence, despite apparent departmental variation in burnout prevalence, suggests that burnout status at the individual level may be a more sensitive marker of QC risk than department-level workload averages. This has implications for how laboratory quality managers might target burnout screening: rather than assuming uniform risk within a department, individual-level burnout indicators (for example, through periodic validated burnout screening integrated into staff wellness programs) may better identify professionals at elevated risk of QC lapses, regardless of their section assignment.

From an organizational quality management perspective, these findings support the integration of occupational burnout monitoring into laboratory quality management systems alongside traditional QC indicators. Total laboratory automation has been proposed as one structural approach to reducing manual workload and improving both QC consistency and staff well-being (Nam & Park, 2025), though implementation costs and workforce training requirements may limit

near-term feasibility in resource-constrained settings. In parallel, targeted interventions addressing emotional exhaustion specifically - workload redistribution during peak periods, protected non-clinical time, peer support structures, and recognition systems - may offer more immediate returns on QC reliability than workforce expansion alone.

The high-burnout prevalence observed here (24.4%) is notably lower than the 72.3% prevalence reported among Ontario medical laboratory technologists during the second wave of the COVID-19 pandemic (Nowrouzi-Kia et al., 2022), which may reflect differences in burnout operational definitions, pandemic-era acute stressors versus steady-state conditions, or contextual differences between healthcare systems. Nonetheless, the occupational risk factors identified in that study - high quantitative demands, high work pace, and work-life conflict - align closely with the workload index construct used in the present analysis, and the South Korean finding that occupational climate and lack of reward are dominant burnout drivers, with department-specific variation in their relative influence (Sim et al., 2024), is consistent with the departmental variation in burnout prevalence observed in Figure 1. Job satisfaction, found to be inversely related to psychosocial stress and positively related to workplace community among medical laboratory professionals (Lo et al., 2023), may represent an additional modifiable factor relevant to the burnout-QC pathway that was not directly measured in this study and warrants inclusion in future work.

4.2 Toward minority and equity-sensitive well-being interventions

Burnout interventions in healthcare have historically been designed without attention to subgroup differences in exposure or access to support. A systematic review of well-being interventions for minority healthcare workers found a near-absence of programs specifically designed for this population, despite mixed evidence on whether minority status confers additional burnout risk or relative resilience (Bafna et al., 2025). In multinational laboratory workforces - including those common in Gulf Cooperation Council tertiary care settings, where staff often include both local and expatriate professionals - this gap suggests that burnout-reduction and QC-protection strategies should be designed with attention to the diversity of the laboratory workforce rather than assuming uniform exposure or response to workplace stressors.

4.3 Strengths and limitations

This study benefits from a relatively large sample (N = 312) spanning multiple diagnostic sections, the use of validated burnout constructs consistent with the Maslach Burnout Inventory, and the application of regression methods appropriate to both continuous (QC adherence score) and count-based (non-conformance) outcomes.

Several limitations should be noted. First, the cross-sectional design precludes causal inference; the temporal relationship between workload, burnout, and QC adherence cannot be established, and reverse causation (for example, professionals who struggle with QC adherence experiencing greater stress) cannot be excluded. Second, the QC adherence score incorporates self-reported and supervisor-rated components, which may be subject to social desirability or rating bias. Third, the study was conducted in a single tertiary care institution, which may limit generalizability to laboratories with different staffing models, automation levels, or accreditation contexts. Fourth, the illustrative run chart (Figure 6) is based on simulated monthly data intended to demonstrate a quality-monitoring application of these findings and does not represent prospectively observed longitudinal QC data. Finally, while the operational definition of high burnout used established

MBI cut-offs, burnout is a continuous construct, and dichotomization may obscure dose-response relationships that were partially captured in the continuous regression analyses.

5. Conclusion

Among laboratory professionals in a tertiary care hospital, workload-driven emotional exhaustion and depersonalization were independently associated with reduced quality control adherence and increased QC non-conformance rates, independent of workload index, working hours, and years of experience. These findings suggest that burnout, rather than workload per se, may be the more proximal determinant of QC reliability in laboratory settings, and support the integration of burnout surveillance into laboratory quality management systems as a complement to conventional QC monitoring. Future prospective and multicenter studies are warranted to confirm temporal relationships and evaluate whether burnout-targeted interventions translate into measurable improvements in QC performance.

6. Declarations

Ethics approval and consent to participate: This study was conducted in accordance with institutional research ethics requirements. Participation was voluntary, and informed consent was obtained from all participants.

Consent for publication: Not applicable.

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflicts of interest: The author declares no conflicts of interest.

Data availability: De-identified data are available from the corresponding author upon reasonable request.

Author contributions: The author was responsible for study conception, data analysis, and manuscript preparation.

AI transparency statement: Statistical analyses and data visualizations were prepared with the assistance of an AI-based analytical tool (Claude, Anthropic) based on the study dataset and design specified by the author. All interpretations and conclusions were reviewed by the author.

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