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Organizational and Safety Culture Determinants of Nurses' Psychosocial Well-being: A Hierarchical Multiple Regression Study in Greek Tertiary Hospitals

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Research Article

Keywords: psychosocial risks, patient safety culture, nurses, COPSOQ III, hierarchical regression

Posted Date: September 11th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10582427/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

Nursing personnel in tertiary care hospitals are exposed to complex psychosocial risks that can adversely affect both their well-being and patient safety. This manuscript aimed to examine the relationships between psychosocial risk factors, patient safety culture, and self-reported medication errors, while identifying predictors of key psychosocial dimensions using hierarchical multiple regression models.

Method

A cross-sectional survey was conducted between September 2022 and December 2023 in four large tertiary hospitals in Greece. Data were collected through a self-administered questionnaire incorporating the COPSOQ III for psychosocial risks, the HSOPSC for patient safety culture, and items on self-reported medication errors. For ten COPSOQ III dimensions, hierarchical linear regression models were constructed in three blocks: (1) demographic characteristics, (2) work-related variables, and (3) patient safety culture dimensions.

Results

The analysis revealed significant associations between workplace factors and psychosocial outcomes. Use of electronic medication management systems was associated with both reduced work pace and was positively associated with role conflicts. Frequent participation in continuing education and interruptions during medication administration were linked to higher emotional demands and work–life conflict. Inadequate staffing was correlated with greater job insecurity but, paradoxically, also with higher job satisfaction and work engagement in demanding environments. Patient safety culture dimensions—such as teamwork, organizational learning, and management support—demonstrated both protective and adverse associations depending on the outcome examined.

Conclusion

These findings emphasize that staffing, workflow, and safety culture jointly shape nurses' psychosocial well-being, calling for adequate staffing and supportive leadership to sustain safe, high-quality care.

1. Background

Nursing staff play a pivotal role in healthcare systems, providing continuous monitoring, medication administration, clinical decision-making, and emotional support. Their work is frequently performed under high workload and staffing constraints. Evidence from European hospitals and nursing studies links staffing and workload conditions with nurses' occupational strain, burnout, job outcomes, and patient-safety perceptions [1–4]. Continuing professional development is also essential, although its effective integration into practice depends on protected time, staffing, leadership, and a supportive workplace learning culture [5].

Beyond physical workload, nurses are exposed to psychosocial hazards including workplace bullying, work–life imbalance, interpersonal conflict, job insecurity, and emotional exhaustion [6–10]. These conditions can affect psychological well-being, engagement, job satisfaction, and retention. Emotional strain and insufficient leadership support may further intensify exhaustion, whereas constructive workplace relationships and supportive leadership are associated with more favourable occupational outcomes [11–13].

Patient safety culture is another important feature of the organizational environment. The Hospital Survey on Patient Safety Culture (HSOPSC) assesses dimensions such as teamwork, communication openness, staffing, leadership, handoffs, and nonpunitive responses to error [14, 15]. Studies in hospital and nursing settings have linked these dimensions with nurses' perceptions of safety, workload, and safety practices [16–19]. A stronger safety culture may support collaboration and error reporting, whereas workplace violence, burnout, missed care, and staffing constraints are associated with less favourable staff and patient outcomes [20–22].

Medication administration is particularly sensitive to interruptions and workflow disruption. Reviews and observational studies consistently associate interruptions during medication administration with procedural failures, increased error risk, and greater workload [23–26]. Electronic medical records and electronic medication-administration systems may improve information availability and reduce some errors, but their effects depend on usability and implementation and may also introduce workflow difficulties or technostress [27–32].

A previous analysis of the present Greek multicentre dataset found that psychosocial risks were associated with nurses' safety attitudes and self-reported medication-error rates [33]. Evidence from another recent Greek nursing study also links the quality of the work environment with work engagement and withdrawal-related behaviour [34]. Together, these findings support examining psychosocial working conditions and patient-safety culture within the same organizational framework.

Although relationships among psychosocial hazards, safety culture, and occupational or patient outcomes have been documented, much of the available evidence is cross-sectional and focuses on selected variables or individual outcomes [3, 4, 17, 20, 21, 27, 30–34]. Evidence from multivariable frameworks

that simultaneously consider demographic characteristics, working conditions, and multiple dimensions of patient-safety culture remains comparatively limited, particularly in Greek tertiary hospitals.

The present study is a distinct secondary analysis of the dataset used in the earlier publication [33]. Whereas that publication examined psychosocial risks in relation to safety attitudes and self-reported medication errors, the current study uses hierarchical multiple regression to examine demographic characteristics, work-environment factors, and patient-safety-culture dimensions as correlates of ten selected COPSOQ III outcomes. The regression models and outcome-specific results reported here have not been published previously.

2. Method

2.1. Study design

This was a cross-sectional study conducted between September 30, 2022, and December 31, 2023, in four tertiary care hospitals in Greece. The selection of hospitals was based on population and geographical criteria. Initially, all tertiary hospitals across the country were identified. From this pool, hospitals meeting the following thresholds were considered eligible: more than 500 inpatient beds, an annual number of hospitalized patients exceeding 28,000, and at least 100,000 patient days per year. Eligible hospitals were then stratified into three zones according to size and service load:

Zone A: Hospitals with more than 500 beds, over 60,000 hospitalized patients per year, and more than 200,000 patient days annually.

Zone B: Hospitals with more than 500 beds, between 28,000 and 35,000 hospitalized patients per year, and more than 100,000 patient days annually.

Zone C: Hospitals with more than 500 beds, between 35,000 and 70,000 hospitalized patients per year, and between 100,000 and 200,000 patient days annually.

Based on these criteria, four hospitals were selected to ensure representativeness across different Health Regions: The General University Hospital of Larissa, the General Hospital of Thessaloniki “G. Papanikolaou”, the General Hospital of Nikaia “Agios Panteleimon”, and the Athens General Hospital “O Evangelismos.”

2.2. Participants and Eligibility Criteria

A total of 600 nurses were invited to participate in the study, of whom 514 returned fully completed questionnaires, resulting in a response rate of 86%. All participants were licensed nurses employed for at least 12 months in their current clinical position within medical, surgical, intensive care, or long-term care units of the participating hospitals. Nurses working exclusively in administrative roles or those absent on extended leave during the data collection period were excluded.

The demographic distribution of the sample is presented in Table 1. Most participants were women (74.0%), while 26.0% were men. Age was collected in predefined categorical groups: 16.3% were 18–25 years old, 42.2% were 26–35, 30.0% were 36–45, 11.1% were 46–55, and 0.4% were 56–65 years old. Because age was captured in grouped format, mean age and standard deviation could not be computed. The majority of nurses were married (63.2%), followed by unmarried (23.7%) and divorced participants (13.0%). Most held a technological education degree (61.6%), followed by secondary education (35.3%) and university degrees (3.1%). Additional qualifications included specialty training (11.7%), postgraduate studies (15.6%), and doctoral diplomas (0.6%).

2.3. Ethical issues

Ethical approval

was granted by the Scientific Councils of all participating hospitals. Written informed consent was obtained from all participants following a detailed explanation of the study objectives, assurance of anonymity, and confirmation of voluntary participation.

2.4. Data collection/instrument

The sample size was determined to ensure both scientific validity and representativeness of the results. Based on the total population of interest, it was calculated that at least 382 participants were required to achieve a 95% confidence level with a margin of error of ± 5%. Participants were selected using a simple random sampling method within the aforementioned Greek hospitals. The sampling strategy was designed to guarantee representativeness across hospitals, minimize estimation error, and secure an adequate number of subjects from all relevant subpopulations. The population was stratified by hospital (stratum), and within each stratum, nurses were randomly selected through simple random sampling.

The structured questionnaire included demographic and occupational characteristics, the validated Greek version of the Copenhagen Psychosocial Questionnaire III (COPSOQ III), the Greek Hospital Survey on Patient Safety Culture (HSOPSC), and items concerning medication-administration practices and self-reported errors. The instruments and related measures were also described in the previous publication from this dataset [33].

2.4.1 Measurement Tools

The study used the validated Greek version of COPSOQ III. The COPSOQ III was developed to assess psychosocial working conditions across domains including work demands, interpersonal relations and leadership, work–individual interface, health and well-being, and work engagement [35]. The Greek validation demonstrated the instrument’s suitability for assessing psychosocial factors in Greek workplaces [36]. The present analysis focused on Work

Pace, Emotional Demands, Work–Life Conflict, Role Conflicts, Burnout, Job Insecurity, Conflicts and Quarrels, Quality of Leadership, Work Engagement, and Job Satisfaction.

The HSOPSC assesses hospital patient-safety culture through dimensions including teamwork, communication openness, handoffs and transitions, staffing, feedback about errors, management support, and nonpunitive response to error [14]. The Greek version has demonstrated acceptable psychometric properties for assessing patient-safety culture in Greek healthcare settings [15].

For the present study, internal consistency was assessed with Cronbach's α, with all major dimensions meeting acceptable thresholds. These instruments, together with items on medication-administration practices and self-reported errors, formed the composite questionnaire used for data collection.

2.5. Statistical analysis

The Kolmogorov–Smirnov criterion was used to examine the distributions of quantitative variables. Normally distributed variables were summarized using means and standard deviations (SD), whereas non-normally distributed variables were additionally summarized using medians and interquartile ranges. Categorical and ordinal variables were described using absolute (n) and relative (%) frequencies. The Mann–Whitney test was used to compare quantitative variables between two groups, and the Kruskal–Wallis test was used for comparisons involving more than two groups. Associations between quantitative and/or ordinal variables were examined using Spearman's correlation coefficient (rho); the magnitude of correlations was interpreted using established guidance [37].

Prior to conducting regression analyses, all core statistical assumptions were examined. Linearity between predictors and dependent variables was assessed through partial regression plots, while homoscedasticity was evaluated using scatterplots of standardized residuals. Independence of errors was assessed using the Durbin–Watson statistic. Multicollinearity was examined using Variance Inflation Factors (VIF) and tolerance values, with all VIF values remaining below accepted thresholds, indicating absence of problematic collinearity among predictors.

Ten COPSOQ III dimensions were selected as dependent variables for the hierarchical regression analyses: Work Pace, Emotional Demands, Work–Life Conflict, Role Conflicts, Burnout, Job Insecurity, Conflicts and Quarrels, Quality of Leadership, Work Engagement, and Job Satisfaction. Their selection was guided by a combination of theoretical and empirical criteria. Specifically, these dimensions demonstrated meaningful variation across key sociodemographic or occupational groups in the preliminary analyses and have an established relevance to occupational stress, psychological strain, burnout, organizational functioning, and employee well-being. Collectively, they represent complementary aspects of nurses' psychosocial work experience, including job demands, adverse psychological outcomes, interpersonal and organizational conditions, and positive work-related outcomes. Limiting the analysis to these theoretically relevant and empirically informative dimensions also reduced model proliferation, conceptual overlap, and the risk of chance findings arising from multiple statistical comparisons. To fulfill the assumptions of the multivariate models and facilitate interpretation, the categorical age variable was transformed into a dichotomous dummy variable (interpreting nurses aged 36 years or older against the reference group of 18–35 years) prior to entry into the regression models.

Although COPSOQ III and HSOPSC variables are based on Likert-type ordinal scales, their composite scores were treated as continuous, following established international practice in occupational health research, allowing the implementation of multivariate linear models. All regression assumptions were verified before model estimation.

The internal consistency reliability of the questionnaires was tested using Cronbach's α. The significance levels were two-tailed and the statistical significance was set at 0.05. The statistical program SPSS 26.0 was used for the analysis.

3. Results

The study sample consisted of 514 nurses and nursing assistants, with their demographic characteristics presented in Table 1. Among the participants, 74% were women, while 42.2% were aged 26–35 years. A total of 63.2% of the nursing staff were married, and 61.6% held a Technological Educational Institute degree. In addition, 15.6% of participants had completed postgraduate studies, while 11.7% held a specialty qualification.

Table 1
Demographic characteristics of participants.

Distribution of participants in terms of their demographic characteristics		n	%
Sex	Men	127	26.0
	Women	362	74.0
Age	18–25	84	16.3
	26–35	217	42.2
	36–45	154	30.0
	46–55	57	11.1
	56–65	2	0.4
Marital status	Single	122	23.7
	Married	325	63.2
	Divorced	67	13.0
Basic training	Secondary	160	35.3
	Technological	279	61.6
	University	14	3.1
Other studies	Specialty	60	11.7
	Postgraduate studies	80	15.6
	Phd	3	0.6
	Other	2	0.4

Information regarding the working conditions of the participants is presented in Table 2. Specifically, 52.3% of the nursing staff worked on a rotating shift schedule. An electronic medication management system was available in 52.3% of the participants' units, while 47.9% reported the existence of a formal system for reporting and recording nursing errors. In addition, 51% stated that their unit had a nursing protocol for medication administration. With regard to education, 37.4% of the nursing staff reported that continuing education programs were frequently implemented in their hospital, whereas 35.6% indicated that such programs were rarely applied. During medication administration, 46.9% stated that their attention was very often or often distracted or interrupted by external factors, while 33.9% reported that this occurred frequently. Regarding the provision of supportive technological tools and consumables, 49.2% of participants rated them as good, and 32.3% rated them as moderate. Finally, 38.7% of the nursing staff stated that they always apply critical thinking before executing medical medication orders, while 31.7% reported that they do so frequently.

Table 2
Organizational Characteristics of Departments and Psychosocial Factors of Work.

Job characteristics		n	%
Are you working on a circular work schedule?	No	245	47.7
	Yes	269	52.3
Is there an electronic system for managing (administering) medicines in your department?	No	245	47.7
	Yes	269	52.3
Is there a system of official reporting and recording of nursing errors in place in your department?	No	268	52.1
	Yes	246	47.9
Are there protocols of nursing procedures, related to the administration of drugs, in your department?	No	252	49.0
	Yes	262	51.0
How often are continuing education programs implemented in the hospital?	Always	10	1.9
	Very often	129	25.1
	Often	192	37.4
	Seldom	183	35.6
	Never	0	0.0
How often is your attention distracted or interrupted by external factors during medication?	Always	35	6.8
	Very often	241	46.9
	Often	174	33.9
	Seldom	64	12.5
	Never	0	0.0
Providing supporting technological means and consumables to your department is:	Excellent	6	1.2
	Very good	89	17.3
	Good	253	49.2
	Moderate	166	32.3
	Bad	0	0.0
Do you apply critical thinking before executing medical pharmaceutical instructions for their correctness?	Always	199	38.7
	Very often	146	28.4
	Often	163	31.7
	Seldom	6	1.2
	Never	0	0.0

Significant Determinants of Work Pace and Emotional Demands are shown in Table 3. Analysis of the Work Pace dimension showed that employment in a nursing unit with an electronic medication management system was associated with lower perceived work pace. More frequent implementation of continuing education programs and more frequent distractions or interruptions during medication administration were associated with higher work pace scores. Regarding patient safety culture, higher scores for Supervisor/Manager Expectations and Actions Promoting Patient Safety, Overall Perceptions of Patient Safety, Staffing, and Nonpunitive Response to Errors were associated with lower work pace scores. Conversely, higher scores for Organizational Learning and Continuous Improvement and Communication Openness were associated with higher perceived work pace. These findings represent statistical associations and should not be interpreted as evidence of causal or moderating effects.

Regarding Emotional Demands, more frequent implementation of continuing education programs and more frequent distractions or interruptions during medication administration were associated with higher emotional demands. More frequent application of critical thinking before implementing medication orders was associated with lower emotional demands. Among the patient safety culture dimensions, higher scores for Teamwork Within Units, Feedback and Communication About Error, and Communication Openness were associated with higher emotional demands. In contrast, stronger Management Support for Patient Safety and more positive Overall Perceptions of Patient Safety were associated with lower emotional demands.

Table 3
Significant Determinants of Work Pace and Emotional Demands.

Dependent Variable	Predictor	β	SE	p-value
Work Pace Model fit: F = 7,16, p < 0.001; R^2=0.28; Adjusted R^2=0.24				
	Presence of an electronic medication management system in the nursing unit (Yes vs No)	−0.060	0.013	< 0.001
	Implementation of continuing education programs in the hospital	+ 0.021	0.008	0.007
	Frequency of distractions or interruptions from external factors during medication administration	+ 0.023	0.008	0.006
	HSOPSC – Supervisor/Manager Expectations and Actions Promoting Patient Safety	−0.007	0.0003	0.013
	HSOPSC – Organizational Learning and Continuous Improvement	+ 0.0007	0.0003	0.005
	HSOPSC – Overall Perceptions of Patient Safety	-0.001	0.0003	< 0.001
	HSOPSC – Communication Openness	+ 0.0008	0.0003	0.003
	HSOPSC – Staffing	−0.0007	0.0003	0.023
	HSOPSC – Nonpunitive Response to Errors	−0.0007	0.0002	0.003
Emotional Demands **Model fit**: F = 7.20, p < 0.001, R^2 = 0.28, Adjusted R^2 = 0.24				
	Implementation of continuing education programs in the hospital	+ 0.024	0.008	0.003
	Frequency of distractions or interruptions caused by external factors during medication administration	+ 0.026	0.009	0.003
	Application of critical thinking before implementing medical medication orders	−0.036	0.008	< 0.001
	HSOPSC – Teamwork Within Units	+ 0.0007	0.0003	0.011
	HSOPSC – Management Support for Patient Safety	−0.0013	0.0003	< 0.001
	HSOPSC – Overall Perceptions of Patient Safety	−0.0011	0.0003	< 0.001
	HSOPSC – Feedback and Communication About Error	+ 0.0015	0.0003	< 0.001
	HSOPSC – Communication Openness	+ 0.0009	0.0003	0.002

Significant Determinants of Work–Life Conflict and Role Conflicts are shown in Table 4. Analysis of the “Work–Life Conflict” dimension showed that nurses aged 36 years or older reported significantly higher scores than those aged 18–35 years. Conversely, a greater number of total years of service was associated with slightly lower work–life conflict scores. More frequent distractions or interruptions caused by external factors during medication administration and more frequent application of critical thinking before executing medication orders were independently associated with higher levels of work–life conflict. Regarding patient safety culture, higher ratings in “Teamwork Within Units” and “Teamwork Across Units” were associated with higher work–life conflict scores. In contrast, higher ratings in “Organizational Learning and Continuous Improvement,” “Handoffs and Transitions,” and “Nonpunitive Response to Errors” were associated with lower scores, suggesting that continuous organizational improvement, effective information transfer, and a nonpunitive safety culture may contribute to a more supportive working environment.

Similarly, analysis of the “Role Conflicts” dimension showed that women reported significantly lower scores than men. More frequent implementation of continuing education programs and more frequent distractions or interruptions during medication administration were associated with higher role conflict scores. Among the patient safety culture dimensions, higher ratings in “Teamwork Within Units,” “Organizational Learning and Continuous Improvement,” “Staffing,” and “Nonpunitive Response to Errors” were associated with higher levels of role conflict. Conversely, higher ratings in “Supervisor/Manager Expectations and Actions Promoting Patient Safety,” “Management Support for Patient Safety,” “Overall Perceptions of Patient Safety,” and “Handoffs and Transitions” were associated with lower role conflict scores. These findings represent independent associations within the adjusted multivariable model and should not necessarily be interpreted as causal relationships.

Table 4
Significant Determinants of Work–Life Conflict and Role Conflicts.

Dependent Variable	Predictor	β	SE	p-value
Work–Life Conflict Model fit: F = 8.14, p < 0.001, R^2=0.30, Adjusted R^2=0.27				
	Age (36 + vs. 18–35 years)	+ 0.084	0.042	0.048
	Total years of service	−0.004	0.002	0.041
	Frequency of distractions or interruptions caused by external factors during medication administration	+ 0.133	0.021	< 0.001
	Application of critical thinking before implementing medical medication orders	+ 0.081	0.018	< 0.001
	HSOPSC – Teamwork Within Units	+ 0.0023	0.0006	0.001
	HSOPSC – Organizational Learning and Continuous Improvement	−0.0022	0.0006	0.001
	HSOPSC – Teamwork Across Units	+ 0.0014	0.0006	0.021
	HSOPSC – Handoffs and Transitions	−0.0034	0.0006	< 0.001
	HSOPSC – Nonpunitive Response to Errors	−0.0011	0.0006	0.048
Role Conflicts Model fit: F = 8.17, p < 0.001, R^2=0.30, Adjusted R^2=0.27				
	Gender (Women vs. Men)	−0.073	0.036	0.045
	Implementation of continuing education programs in the hospital	+ 0.059	0.021	0.005
	Frequency of distractions or interruptions caused by external factors during medication administration	+ 0.070	0.022	0.002
	HSOPSC – Teamwork Within Units	+ 0.0034	0.0007	< 0.001
	HSOPSC – Supervisor/Manager Expectations and Actions Promoting Patient Safety	−0.0025	0.0007	0.001
	HSOPSC – Organizational Learning and Continuous Improvement	+ 0.0019	0.0007	0.007
	HSOPSC – Management Support for Patient Safety	−0.0018	0.0006	0.005
	HSOPSC – Overall Perceptions of Patient Safety	−0.0047	0.0007	< 0.001
	HSOPSC – Staffing	+ 0.0031	0.0008	< 0.001
	HSOPSC – Handoffs and Transitions	−0.0015	0.0006	0.018
	HSOPSC – Nonpunitive Response to Errors	+ 0.0014	0.0006	0.021

**Note: Age was dichotomized into a dummy variable (36 + years vs. 18–35 years) for the requirements of the regression analysis, with the 18–35 years group serving as the reference category.*

Significant Determinants of Burnout, Job Insecurity, and Conflicts & Quarrels are shown in Table 5. Analysis of the “Burnout” dimension showed that nurses working in units with an electronic medication management system reported significantly lower burnout scores. More frequent implementation of continuing education programs was also independently associated with lower burnout. Regarding patient safety culture, higher ratings in “Supervisor/Manager Expectations and Actions Promoting Patient Safety,” “Organizational Learning and Continuous Improvement,” “Staffing,” and “Handoffs and Transitions” were associated with lower burnout scores. Conversely, higher ratings in “Management Support for Patient Safety,” “Feedback and Communication About Error,” and “Frequency of Events Reported” were associated with higher burnout scores. The final model explained 35% of the variance in burnout (adjusted R^2 = 0.32). Given the unexpected direction of some HSOPSC associations, these findings should be interpreted cautiously as independent associations within the multivariable model rather than as evidence of causal or harmful effects.

Analysis of the “Job Insecurity” dimension showed that nurses with technological or university-level education reported significantly lower insecurity scores than those with secondary education. Nurses working in units equipped with electronic medication management systems reported higher job insecurity

scores, while more frequent implementation of continuing education programs was also associated with higher insecurity. Conversely, more frequent application of critical thinking before executing medical or pharmaceutical instructions was associated with lower job insecurity. Regarding patient safety culture, higher ratings in “Supervisor/Manager Expectations and Actions Promoting Patient Safety,” “Organizational Learning and Continuous Improvement,” and “Staffing” were associated with higher job insecurity scores. In contrast, higher ratings in “Management Support for Patient Safety,” “Feedback and Communication About Error,” “Frequency of Events Reported,” and “Handoffs and Transitions” were associated with lower job insecurity. The final model explained 34% of the variance in job insecurity (adjusted $R^2 = 0.30$). The unexpected positive associations observed for certain safety-culture dimensions should be interpreted cautiously and not considered evidence of causal effects.

Finally, analysis of the “Conflicts and Quarrels” dimension showed that more frequent application of critical thinking before executing medical or pharmaceutical instructions was associated with higher conflict and quarrel scores. Regarding patient safety culture, higher ratings in “Teamwork Within Units,” “Organizational Learning and Continuous Improvement,” and “Handoffs and Transitions” were also associated with higher scores in this dimension. Conversely, higher ratings in “Communication Openness” and “Staffing” were associated with lower levels of conflicts and quarrels. The final model explained 31% of the variance in conflicts and quarrels (adjusted $R^2 = 0.27$). As these findings derive from an adjusted multivariable model, particularly the counterintuitive positive associations should be interpreted as independent statistical relationships and not as evidence that teamwork, organizational learning, or effective handoffs cause workplace conflict.

Table 5
Significant Determinants of Burnout, Job Insecurity, and Conflicts & Quarrels.

Dependent Variable	Predictor	β	SE	p-value
Burnout $\varvec{F} = 10.12, \varvec{p} < 0.001, \varvec{R}^2 = 0.35, Adjusted \varvec{R}^2 = 0.32$				
	Existence of an electronic medication management system in the nursing unit (Yes vs No)	−0.038	0.018	0.035
	Implementation of continuing education programs in the hospital	−0.044	0.010	< 0.001
	HSOPSC – Supervisor Expectations & Actions Promoting Patient Safety	−0.0011	0.0004	0.002
	HSOPSC – Organizational Learning – Continuous Improvement	−0.0018	0.0003	< 0.001
	HSOPSC – Management Support for Patient Safety	+ 0.0009	0.0003	0.001
	HSOPSC – Feedback and Communication About Error	+ 0.0010	0.0004	0.016
	HSOPSC – Frequency of Events Reported	+ 0.0023	0.0003	< 0.001
	HSOPSC – Staffing	−0.0021	0.0004	< 0.001
	HSOPSC – Handoffs and Transitions	−0.0010	0.0003	0.001
Job Insecurity $\varvec{F} = 9.54, \varvec{p} < 0.001, \varvec{R}^2 = 0.34, Adjusted \varvec{R}^2 = 0.30$				
	Education (Technological/University Degree vs Secondary Education)	−0.164	0.066	0.014
	Existence of an electronic medication management system in the nursing unit (Yes vs No)	+ 0.283	0.067	< 0.001
	Implementation of continuing education programs in the hospital	+ 0.233	0.039	< 0.001
	Application of critical thinking before executing medical/pharmaceutical instructions	−0.160	0.036	< 0.001
	HSOPSC – Supervisor Expectations & Actions Promoting Patient Safety	+ 0.0027	0.0014	0.048
	HSOPSC – Organizational Learning – Continuous Improvement	+ 0.0049	0.0013	< 0.001
	HSOPSC – Management Support for Patient Safety	−0.0029	0.0012	0.016

Dependent Variable	Predictor	β	SE	p-value
	HSOPSC – Feedback and Communication About Error	−0.0058	0.0016	< 0.00
	HSOPSC – Frequency of Events Reported	−0.0035	0.0011	0.00
	HSOPSC – Staffing	+ 0.0035	0.0016	0.02
	HSOPSC – Handoffs and Transitions	−0.0061	0.0011	< 0.00
Conflicts & Quarrels $\varvec{F} = 8.45, \varvec{p} < 0.001, \varvec{R}^2 = 0{,}31, Adjusted\varvec{R}^2 = 0.27$				
	Application of critical thinking before executing medical/pharmaceutical instructions	+ 0.086	0.024	< 0.00
	HSOPSC – Teamwork Within Units	+ 0.0045	0.0009	< 0.00
	HSOPSC – Organizational Learning – Continuous Improvement	+ 0.0029	0.0009	0.00
	HSOPSC – Communication Openness	−0.0026	0.0009	0.00
	HSOPSC – Staffing	−0.0048	0.0011	< 0.00
	HSOPSC – Handoffs and Transitions	+ 0.0027	0.0008	0.00

Significant Determinants of Quality of Leadership, Work Engagement, and Job Satisfaction are shown in Table 6. Analysis of the “Quality of Leadership” dimension showed that employment in a nursing unit with an electronic medication management system was significantly associated with lower leadership quality scores. Among the patient safety culture dimensions, higher scores in “Supervisor/Manager Expectations and Actions Promoting Patient Safety,” “Overall Perceptions of Patient Safety,” “Teamwork Across Units,” “Staffing,” and “Nonpunitive Response to Errors” were also associated with lower leadership quality scores. In contrast, higher “Communication Openness” scores were positively associated with perceived leadership quality.

With respect to “Work Engagement,” a higher number of nurses in the department was significantly associated with higher engagement scores. More frequent implementation of continuing education programs was also positively associated with work engagement, although this association was only marginally significant (p = 0.050). In contrast, more frequent application of critical thinking before executing medical or pharmaceutical instructions was associated with lower work engagement. Higher scores in “Organizational Learning–Continuous Improvement,” “Management Support for Patient Safety,” “Staffing,” and “Nonpunitive Response to Errors” were likewise associated with lower engagement scores.

Finally, analysis of “Job Satisfaction” showed that more frequent distractions or interruptions during medication administration were significantly associated with lower satisfaction scores. Conversely, more frequent application of critical thinking before executing medical or pharmaceutical instructions and higher scores in “Feedback and Communication About Error” were associated with higher job satisfaction. Higher scores in “Teamwork Within Units,” “Supervisor/Manager Expectations and Actions Promoting Patient Safety,” “Organizational Learning–Continuous Improvement,” “Management Support for Patient Safety,” “Teamwork Across Units,” and “Staffing” were associated with lower satisfaction scores.

Table 6
Significant Determinants of Quality of Leadership, Work Engagement, and Job Satisfaction.

Dependent Variable	Predictor	β	SE	p-value
Quality of Leadership $\varvec{F} = 14.38, \varvec{p} < 0{,}001, \varvec{R}^2 = 0.43, Adjusted\ \varvec{R}^2 = 0.40$				
	Existence of an electronic medication management system in the nursing unit (Yes vs No)	−0.147	0.037	< 0.001
	HSOPSC – Supervisor Expectations & Actions Promoting Patient Safety	−0.0042	0.0007	< 0.001
	HSOPSC – Overall Perceptions of Patient Safety	−0.0017	0.0008	0.029
	HSOPSC – Communication Openness	+ 0.0025	0.0007	0.001
	HSOPSC – Teamwork Across Units	−0.0036	0.0007	< 0.001
	HSOPSC – Staffing	−0.0031	0.0009	< 0.001
	HSOPSC – Nonpunitive Response to Errors	−0.0023	0.0006	< 0.001
Work Engagement $\varvec{F} = 10.89, \varvec{p} < 0.001, \varvec{R}^2 = 0.37, Adjusted\ \varvec{R}^2 = 0.33$				
	Number of nurses in the department	+ 0.004	0.002	0.003
	Implementation of continuing education programs in the hospital	+ 0.041	0.021	0.050
	Application of critical thinking before executing medical/pharmaceutical instructions	−0.104	0.019	< 0.001
	HSOPSC – Organizational Learning – Continuous Improvement	−0.0021	0.0007	0.002
	HSOPSC – Management Support for Patient Safety	−0.0018	0.0007	0.006
	HSOPSC – Staffing	−0.0030	0.0009	< 0.001
	HSOPSC – Nonpunitive Response to Errors	−0.0013	0.0006	0.038
Job Satisfaction $\varvec{F} = 14.74, \varvec{p} < 0.001, \varvec{R}^2 = 0.44, Adjusted\ \varvec{R}^2 = 0.41$				
	Frequency of distraction or interruption during medication administration	−0.034	0.014	0.016
	Application of critical thinking before executing medical/pharmaceutical instructions	+ 0.031	0.012	0.009

Dependent Variable	Predictor	β	SE	p-value
	HSOPSC – Teamwork Within Units	−0.0023	0.0004	< 0.001
	HSOPSC – Supervisor Expectations & Actions Promoting Patient Safety	−0.0020	0.0005	< 0.001
	HSOPSC – Organizational Learning – Continuous Improvement	−0.0027	0.0004	< 0.001
	HSOPSC – Management Support for Patient Safety	−0.0010	0.0004	0.012
	HSOPSC – Feedback and Communication About Error	+ 0.0039	0.0005	< 0.001
	HSOPSC – Teamwork Across Units	−0.0015	0.0004	< 0.001
	HSOPSC – Staffing	-0.0027	0.0005	< 0.001

4. Discussion

The multivariable models revealed a complex pattern of adjusted associations between nurses' psychosocial experiences and individual, professional, and organizational factors. Regarding Work Pace, employment in a nursing unit with an electronic medication management system was associated with lower scores, consistent with evidence that electronic records may reduce perceived workload when they improve information availability and workflow [27]. More frequent continuing-education programs were associated with higher Work Pace scores. This may reflect the difficulty of integrating education into demanding schedules when protected time, staffing, and organizational support are limited [5]. Interruptions during medication administration were also associated with higher Work Pace scores, consistent with observed links between interruptions and nurses' workload [26]. Lower staffing adequacy was similarly associated with higher Work Pace scores, in line with the broader literature on staffing constraints, workload, and patient safety [1, 2, 22]. The unexpected directions of several adjusted HSOPSC coefficients should be interpreted cautiously because shared variance, suppression effects, and reverse causation cannot be excluded.

Regarding Emotional Demands, more frequent continuing-education programs and more frequent interruptions during medication administration were associated with higher scores. The former association may reflect scheduling pressure, although the available evidence supports this interpretation only indirectly. The association with interruptions is consistent with literature showing disruption of attention, workload, and medication safety [23–26]. More frequent application of critical thinking before medication orders was associated with lower Emotional Demands scores. Critical thinking has been associated with better nursing job performance [38], but the present cross-sectional finding does not demonstrate that it causally reduces emotional demands. Supportive leadership is generally associated with stronger safety culture [39]; therefore, the unexpected positive coefficients for some communication-related HSOPSC dimensions may instead reflect greater visibility of safety concerns in emotionally demanding units or suppression among correlated predictors.

Regarding Work–Life Conflict, nurses aged 36 years or older reported higher scores, whereas greater years of service were associated with lower scores. Interruptions during medication administration were associated with higher Work–Life Conflict. This is consistent with evidence that demanding work conditions, emotional workload, and limited job control or support can compromise nurses' work–life balance [7, 40]. More frequent application of critical thinking was also associated with higher Work–Life Conflict, an unexpected finding that should not be interpreted as evidence that critical thinking itself causes work–life imbalance. Structured workplace interventions may strengthen resilience [41], but they do not establish the direction of the association observed here. The mixed directions of the adjusted teamwork and safety-culture coefficients may reflect reverse causation or suppression among correlated HSOPSC dimensions.

Regarding Role Conflicts, interruptions during medication administration and higher burnout were associated with higher scores. Interruptions can disrupt attention and workflow [23, 24], while role conflict has been linked with stress and resilience among nurses [42]. Burnout is also consistently associated with unfavourable working conditions and poorer occupational outcomes [3, 10, 20, 43]. The positive association with critical thinking was unexpected; prior evidence instead links critical thinking with better nursing performance [38]. The use of an electronic medication management system was also associated with higher Role Conflicts. Qualitative and quantitative evidence suggests that electronic systems can create usability difficulties, workflow changes, and technostress when poorly implemented [28–32], but the present study did not directly test these mechanisms.

Regarding Burnout, the presence of an electronic medication management system and more frequent continuing-education programs were associated with lower scores. Better electronic-record usability has been associated with lower professional burnout among nurses [32]. Burnout is common across nursing settings [44], while effective continuing professional development depends on workplace support and meaningful integration with practice [5, 45]. Stronger ratings for several leadership, learning, staffing, and handoff dimensions were also associated with lower burnout, broadly consistent with evidence on

leadership and nursing work environments [12, 39, 43]. Conversely, some error-feedback and reporting dimensions showed positive adjusted coefficients. These should not be interpreted as evidence that safety-support mechanisms cause burnout; reverse causation, increased visibility of safety problems, and suppression effects are plausible, underscoring the need for cautious, context-sensitive interpretation of these adjusted associations.

Regarding Job Insecurity, higher educational attainment and greater years of service were associated with lower scores. Perceived job security has previously been linked with nurses' job satisfaction and turnover intentions [9]. More frequent critical thinking was also associated with lower Job Insecurity, although available evidence supports its relationship with performance rather than with employment security [38]. Electronic medication management and continuing education were associated with higher Job Insecurity. Concerns about technological change may be relevant, as awareness of automation has been associated with perceived job insecurity [46], but that evidence is not specific to eMAR systems. Higher burnout and inadequate staffing were also associated with higher Job Insecurity. Finally, more favourable feedback, handoff, and management-support scores were associated with lower insecurity; patient-safety culture has been linked with job satisfaction and intention to leave [47], although a direct effect on job insecurity has not been established.

Regarding Conflicts and Quarrels, electronic medication management and more frequent critical thinking were associated with lower scores. Electronic systems may standardize procedures and improve information availability [27, 28], while critical thinking is associated with nursing performance [38]; neither mechanism was directly tested here. Higher Organizational Learning–Continuous Improvement scores were unexpectedly associated with higher conflict scores. Previous research generally links organizational learning and interprofessional practice with more favourable team processes and job or workload outcomes [48, 49]. Research on nursing conflict also emphasizes the importance of communication and conflict-resolution approaches for professional functioning and patient care [50, 51]. The positive adjusted coefficient may therefore reflect units responding to existing conflict through improvement activities, or suppression among correlated predictors, rather than a harmful effect of organizational learning.

Regarding Quality of Leadership, electronic medication management was associated with lower scores. The available evidence does not establish that electronic systems reduce leadership quality, and this association may reflect implementation context, workflow disruption, or staff perceptions. Several otherwise favourable HSOPSC dimensions also had inverse adjusted associations with Quality of Leadership, whereas Communication Openness had a positive association. Transformational and supportive leadership are generally linked with stronger patient-safety culture and work engagement [52, 53]. Accordingly, the inverse coefficients should not be interpreted causally and may reflect conceptual overlap, shared variance, suppression, or differences between unit-level and organizational leadership constructs.

Regarding Work Engagement, a greater number of nurses in the department was associated with higher scores. Continuing education also showed a positive but borderline association ($p = 0.050$), which should not be treated as statistically significant without confirmation of the unrounded p value. Evidence reviews identify leadership, job resources, professional development, and the work environment as relevant correlates of nurses' engagement [52–55]. The inverse association between critical thinking and Work Engagement was unexpected; reflection and self-efficacy have instead been positively associated with engagement [56], although these constructs differ from the medication-related critical-thinking item used here. The inverse adjusted coefficients for several HSOPSC dimensions may reflect shared variance, suppression, or differences between objective staffing and perceived staffing adequacy.

Regarding Job Satisfaction, interruptions during medication administration were associated with lower scores, whereas critical thinking and Feedback and Communication About Error were associated with higher scores. Several teamwork, leadership, learning, management-support, and staffing dimensions showed unexpected inverse coefficients. Systematic and Greek evidence generally links the nursing work environment, staffing, organizational support, and professional expectations with job satisfaction [57–59]. The inverse coefficients in the present fully adjusted model should therefore not be interpreted as evidence that favourable teamwork, leadership, or staffing reduces satisfaction; shared variance, suppression, subjective appraisal, and reverse causation remain plausible explanations.

Overall, the models highlight the complex interplay of individual, occupational, technological, and organizational factors associated with the selected COPSOQ III dimensions. Strategies should address workload and avoidable interruptions, provide meaningful continuing education, strengthen supportive leadership and nonpunitive communication, and accompany digital interventions with training and workflow evaluation. Administrative and documentation burdens may reduce opportunities for clinical leadership and contribute to workload, dissatisfaction, emotional exhaustion, and turnover intentions [60, 61]. These implications remain provisional because the present cross-sectional models estimate associations, not causal effects.

These findings should be interpreted in light of several methodological considerations inherent in the study design and analytical approach. The cross-sectional design precludes the establishment of temporal or causal relationships between the examined variables. Furthermore, although the COPSOQ III and HSOPSC scale scores were treated as continuous variables, they were derived from ordinal response categories, and several exhibited non-normal distributions. While linear regression does not require the observed variables themselves to be normally distributed, departures from the assumptions concerning model residuals may affect statistical inference. In addition, the conceptual overlap and potential intercorrelations among several psychosocial and patient-safety-culture dimensions may have contributed to multicollinearity, shared variance, or suppression effects, potentially influencing the magnitude and direction of individual regression coefficients. These considerations warrant cautious interpretation of the adjusted associations and provide the rationale for the methodological limitations outlined in the following section.

5. Limitations

This manuscript presents several methodological limitations that should be considered when interpreting the findings. First, the use of self-reported questionnaires introduces the risk of information and recall bias, as responses may be related with subjective perceptions or social desirability. In addition, the cross-sectional design does not allow for causal inference between psychosocial risks, safety culture, and medication-error outcomes.

A further limitation concerns the psychometric nature of the COPSOQ III and HSOPSC variables. Although these tools are widely used internationally and their composite scores are commonly treated as continuous, their Likert-type response formats are ordinal. This characteristic, combined with the non-normal distribution of several variables, poses challenges for parametric modelling. To mitigate this, all core assumptions of linear regression—normality, linearity, homoscedasticity, independence of errors, and multicollinearity—were systematically examined and found to be acceptable; however, the underlying ordinal structure of the data should still be acknowledged.

Moreover, despite the acceptable diagnostic checks performed, the use of hierarchical linear regression may be affected by residual multicollinearity among conceptually related psychosocial and safety-culture constructs. Future studies may benefit from alternative modelling approaches, such as structural equation modelling (SEM), ordinal regression, or robust regression techniques, which can more effectively account for complex latent structures, non-normal distributions, and intercorrelated predictors.

Finally, age was collected in categorical groups, limiting the ability to compute mean values or control for age as a continuous variable. Although the response rate was high, enhancing sample representativeness, the study was conducted in hospitals within a single national healthcare system, which may limit generalizability to other settings.

6. Conclusions

Within the limitations of its cross-sectional design, the present manuscript provides evidence regarding the associations of occupational conditions, medication-related practices, electronic medication management, and patient-safety culture with selected psychosocial work-environment outcomes among nurses working in the participating Greek tertiary hospitals. Overall, the findings indicate demanding working conditions and highlight staffing conditions, interruptions during medication administration, continuing education, critical thinking before carrying out medication orders, electronic medication management systems, and several dimensions of patient-safety culture as relevant correlates of COPSOQ III outcomes.

The direction and magnitude of these associations varied across outcomes, and several adjusted associations were unexpected. Therefore, the findings should not be interpreted causally or as evidence that favourable organizational conditions adversely affect nurses' well-being. In particular, electronic medication management systems were associated with lower Work Pace scores but higher Role Conflicts and Job Insecurity scores. These findings do not demonstrate that electronic systems directly produce adverse psychosocial outcomes; rather, they suggest that their implementation may interact with workflow organization, role clarity, training, and staff perceptions. Accordingly, technological interventions should be accompanied by appropriate training, clear allocation of responsibilities, workflow evaluation, and continued organizational support.

The findings concerning staffing also require careful interpretation. A greater number of nurses employed in the department was associated with higher Work Engagement, whereas higher scores on the HSOPSC Staffing dimension were inversely associated with Work Engagement and Job Satisfaction in the adjusted models. These apparently contradictory findings may reflect differences between objective staffing levels and perceived staffing adequacy, as well as shared variance, suppression effects, subjective appraisal, or reverse causation. They should therefore be regarded as hypothesis-generating rather than as evidence that inadequate staffing promotes engagement or satisfaction.

From an organizational perspective, the findings support an integrated approach aimed at balancing workload and available resources, reducing avoidable interruptions during medication administration, strengthening supportive and transparent leadership, improving communication, and fostering a learning-oriented and nonpunitive safety culture. Continuing education should be appropriately designed and evaluated in relation to nurses' needs, clinical responsibilities, and workload. Recruitment and equitable personnel allocation may also form part of broader workforce planning, although their effects were not directly evaluated in the present manuscript.

Figure 1 synthesizes the central message and broader organizational implications of the present manuscript. The findings indicate that nurses' psychosocial working conditions and patient-safety-related practices are not solely matters of individual responsibility but are closely associated with the organizational environment. Leadership, staffing conditions, patient safety culture, continuing education, and the implementation of electronic medication management systems were associated with different dimensions of the psychosocial work environment. In parallel, clinical processes such as interruptions during medication administration, the application of critical thinking, and effective communication emerged as important potential targets for organizational intervention.

The relationships presented in the figure should be interpreted as potential pathways rather than as established causal sequences. Nevertheless, the findings suggest that improving patient safety cannot rely exclusively on education or the individual responsibility of healthcare professionals. It requires a safe, supportive, and well-organized working environment characterized by adequate resources, clearly defined procedures, supportive leadership, effective communication, and a nonpunitive approach to error management.

Therefore, protecting nurses' psychosocial safety and well-being should be regarded as an integral component of patient safety. The central message of this manuscript can be summarized as follows: **"When nurses work in safe conditions, patients are better protected."**

Future research should employ longitudinal, multicentre, and intervention-based designs to clarify temporal and causal relationships and to assess the effectiveness of organizational and technological interventions. Analytical approaches that account for the intercorrelations among psychosocial and patient-safety-culture dimensions, as well as the hierarchical structure of nurses within units and hospitals, may further clarify the unexpected associations observed. Such evidence could inform more targeted strategies to support nurses' psychosocial working conditions and promote the quality and safety of patient care.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Scientific Councils of all four participating hospitals: Athens General Hospital ‘Evangelismos’, General Hospital of Nikaia ‘Agios Panteleimon’, General Hospital of Thessaloniki ‘G. Papanikolaou’, and University General Hospital of Larissa. All participants received written information about the study objectives and procedures, the voluntary nature of participation, and the protection of anonymity and confidentiality, and provided written informed consent before participation.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Authors' information

Not applicable.

Note

The figure presents a conceptual synthesis of the study findings and their potential organizational and clinical implications. The pathways shown are interpretative and should not be considered empirically established causal or mediating relationships.

Funding

This research is conducted in the operating framework of the University of Thessaly Innovation, Technology Transfer Unit and Entrepreneurship Center "One Planet Thessaly", under the "University of Thessaly Grants for Scientific Publication Support" action and is funded by the Special Account of Research Grants of the University of Thessaly.

Author Contribution

VT and MM conceived the study. VT, MM, and EK developed the methodology. NT and PS conducted the investigation. IP and AK provided resources. IK contributed to the interpretation of the findings. VT prepared the original draft, and NT, IK, VT, and MM critically reviewed and edited the manuscript. MM supervised the study. All authors read and approved the final manuscript.

Acknowledgements

The authors thank the nursing personnel who participated in the study and the administrations and Scientific Councils of the participating hospitals for facilitating data collection.

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available because unrestricted public sharing is not permitted under the applicable ethical approvals and data-protection requirements. De-identified data may be made available by the corresponding author upon reasonable request and subject to approval by the relevant institutional authorities.

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Figures

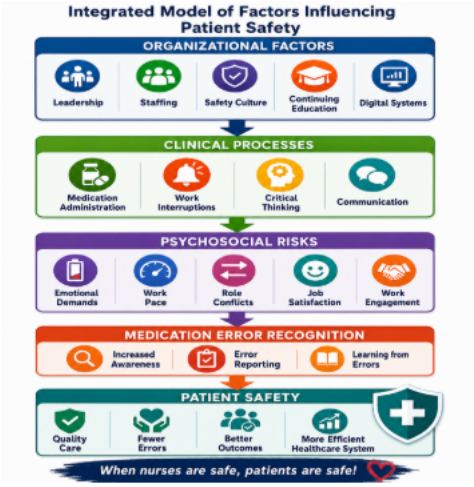


Figure 1

Integrated conceptual framework of the associations identified in the study and their potential implications for patient safety.