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Relationships Between Nurses' Work System, Safety-Related Performance, and Outcomes: A Structural Equation Model

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Objectives: We examined relationships between nurses' work system, safety-related performance, and outcomes based on a modified Systems Engineering Initiative for Patient Safety model.

Methods: A cross-sectional survey was conducted with 408 nurses from 2 general hospitals. Data on work system factors (person, organization, environment, tools, and task), processes (safety-related performance), and outcomes (staff and clinical outcomes) were collected. Structural equation modeling was used to determine the relationships between nurses' work system factors, safety-related processes, and outcomes.

Results: Structural equation modeling yielded a comparative fit index of 0.918, standardized root mean square residual of 0.055, and root mean square error of approximation of 0.054, indicating an acceptable model fit. The person factor had a significant positive direct effect on nurses' safety-related performance, and significant negative direct and indirect effects on the clinical outcome. The organization factor had significant positive direct effects on nurses' safety-related performance and staff outcome, and a negative indirect effect on the clinical outcome. The task factor had a significant positive direct effect on staff outcome. However, the environment and tools factors had no significant effects on safety-related performance or outcomes.

Conclusions: The findings demonstrated the usefulness of the Systems Engineering Initiative on Patient Safety model to explain safety-related performance and outcomes, indicating differential effects of work system factors. Although the person factor significantly affected safety performance and clinical outcomes, the organization factor was the most influential component for promoting safety-related performance and staff and clinical outcomes. These results can be used to prioritize activities for patient safety.

Key Words: patient safety, structural equation modeling, medical errors, job satisfaction, burnout, general hospitals, nurses

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Preventing medical errors and improving patient safety are high-priority challenges in health care. Globally, the annual number of adverse events due to medical mismanagement in inpatient care settings has been estimated at 42.7 million.[1] Patient harm, including harm due to medical errors, is a leading cause of the global disease burden.[2] In particular, a high turnover rate among nurses as frontline care providers remains a challenging issue that affects patient safety. Because the retention of qualified health care providers is important for patient safety, preventing nurse burnout and improving their job satisfaction are a starting point.

Previous studies have shown that nurses' work environments affect their safety-related performance and processes. For instance, studies conducted at intensive care units found that supplies/equipment-related problems, poor physical environments, inadequate handoffs, delays, and patient/family-related issues hindered nurses' performance were related to patient safety.[3–5] Furthermore, patient safety climate significantly affected health care providers' adherence to standard precautions of health care–associated infection prevention.[6] In addition, nurses frequently experience obstacles regarding their performance because of breakdowns in work processes.[7] Therefore, additional studies exploring the relationships between these obstacles and safety-related performance are essential.

Regarding safety-related processes, hospitals and care providers have implemented a variety of practices such as hand hygiene, infection prevention bundles, and use of aspirin for venous thromboembolism prophylaxis.[8–10] Although the use of patient safety practices, with a moderate level of evidence or higher, has been recommended,[8] their implementation may differ depending on contextual factors across work systems where nurses work.[11,12]

Prior research also showed that the hospital work environment affects not only patient safety but also nurse outcomes. For instance, nurse work environments in European countries, China, and the United States affected patient safety and nurse outcomes, such as job satisfaction and burnout.[13–17] The organizational factors of safety culture and leadership were significantly associated with clinical outcomes such as patient/family satisfaction and medication errors.[18,19] Although many studies have explored the relationship between each work system factor and safety-related performance or outcomes, considering work system factors together and investigating complex relationships between them and safety-related performance and outcomes can provide a better understanding for enhancing safety-related performance and patient safety. Furthermore, identifying such relationships is critical to design work systems for safe care provision.

As an approach integrating human factors and systems, the Systems Engineering Initiative for Patient Safety (SEIPS) model has been suggested for work system design for patient safety.[11,12] This model is based on a framework comprising the work system (person, task, tool/technology, organization, environment factors), processes, and outcomes. The work system factors shape care and other processes, and subsequently impact outcomes; additionally, the work processes and outcomes feed back into the work system.[11,12]

This study examined relationships between work system factors, safety-related performance, and staff and clinical outcomes among hospital nurses based on the SEIPS model. Hence, we hypothesized that work system factors would affect safety-related performance, and safety-related performance would influence staff and clinical outcomes. We expanded the SEIPS model by adding direct

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relationships between the work system factors and outcomes.[13–18] The specific hypotheses are shown as paths in Figure 1.

METHODS

Study Design

A cross-sectional observational study was conducted as part of a prospective patient safety assessment project. The study protocol was approved by the institutional review boards at hospital A and a university (nos. KHUH 2018-06-060 and KHSIRB-18-032(RA), respectively).

Participants and Setting

Participants were nurses at adult care units in 2 teaching hospitals in Seoul, South Korea. Hospital A (907 beds, <2.0 patient-nurse ratio) was a tertiary general hospital, and hospital B (702 beds, <2.5 patient-nurse ratio) was a general hospital. Based on the patient-nurse ratio, nurse staffing was classified as "level 1" for both hospitals. We obtained written informed consent from all participants.

A sample size of approximately 400 was determined based on the recommendation of at least 10 cases per item in factor analysis and the response rate in a similar study.[20] At hospital A, we first sampled 15 care units and then invited all nurses in the selected units to reduce sampling bias (n = 265). At hospital B, we invited nurses working at 15 care units (n = 163). After excluding questionnaires with incomplete data, the data from 408 nurses were analyzed. This sample size meets the recommendations in structural equation modeling: (1) at least 10 times the ratio of indicators to latent variable and (2) at least 5 times the number of free parameters.[21]

Measures

Work System Factors

Work system factors consisted of person, organization, environment, tools, and task factors. For the person factor, we measured nurses' situational awareness using the Workplace Cognitive Failure Scale (WCFS).[22] This comprised 3 subscales: memory, attention, and action failure.

The organization factor comprised 4 indicators: teamwork, safety climate, management/leadership, and handoff quality. Teamwork was measured using the Teamwork Perceptions Questionnaire (TPQ).[20,23] Safety climate and management/leadership were measured using Safety Attitudes Questionnaire (SAQ) subscales: the 7-item safety climate subscale and 8 items from the management and working condition subscales.[24,25] Handoff quality was measured using 12 items from the patient handoff quality assessment tool,[26] after excluding 1 item on tensions because of very low item-to-total correlation (r = 0.005). An exploratory factor analysis (EFA) of the 12-item tool yielded 2 factors with eigenvalues ≥1.0. A subsequent confirmatory factor analysis (CFA) of the 2-factor model revealed an acceptable fit to the data (comparative fit index [CFI] = 0.952, standardized root mean square residual [SRMR] = 0.042, and root mean square error of approximation [RMSEA] = 0.064).

We measured environment, tools, and task factors using 3 scales to assess obstacles to nurses' work performance in work environments related to patient safety: 4 items for physical environment, 6 items for tools, and 3 times for task. These scales were developed for this study based on previous studies.[3–5,27] Content validity was assessed by 3 nurse managers and 4 experts in quality improvement and patient safety using a 4-point scale (1, *very irrelevant*; 4, *very relevant*). The content validity index of the items was 0.86 or higher, indicating good content validity.[28] Furthermore, the EFA yielded 3 factors with eigenvalues ≥1.0, and the CFA on the 3-factor model revealed an acceptable fit to the data (CFI = 0.926, SRMR = 0.054, RMSEA = 0.071).

Safety-Related Performance

Safety-related performance comprised 3 indicators: safety compliance, safety participation, and patient safety practices implementation. Nurses' safety compliance and participation were measured using 3 items on safety compliance and 4 items on safety participation, based on a meta-analysis on workplace safety.[29] The EFA yielded 2 factors with eigenvalues ≥1.0, and the CFA on the 2-factor model revealed an acceptable fit to the data (CFI = 0.980, SRMR = 0.035, RMSEA = 0.077).

Patient safety practices implementation was assessed by the degree of its implementation. The relevance of the practices with a moderate level of evidence or higher[8,30] for frontline nurses was reviewed by 3 nurse managers in the nursing department of the study hospitals. Consequently, 17 practices were included in this study. We provided brief descriptions regarding the practices for clarity and consistent understanding. Nurses rated each practice for the degree of implementation in their workplace using a 5-point scale (1, *very low*; 5, *very hi*gh). Then, patient safety practices

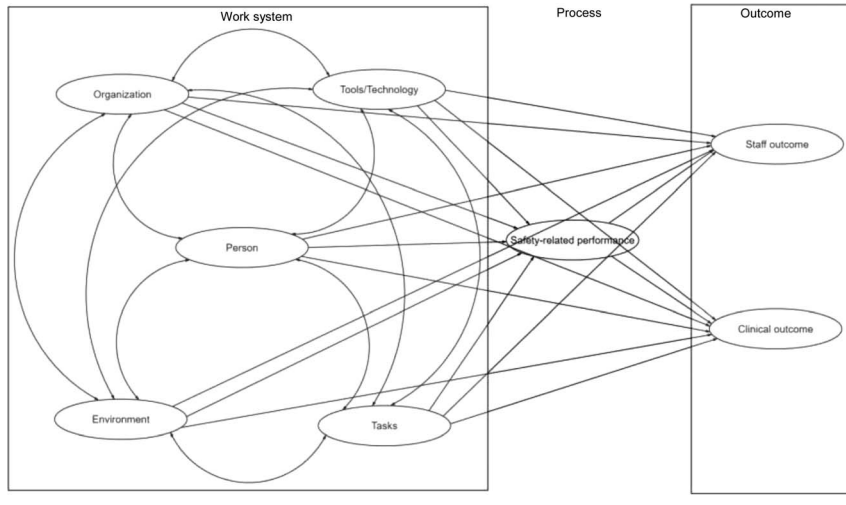

FIGURE 1. Hypothetical model based on the SEIPS model.

implementation was calculated as the proportion of "high" and "very high" responses.

Staff and Clinical Outcomes

Staff outcome comprised 2 indicators: job satisfaction and burnout. Job satisfaction was measured using the 5-item job satisfaction subscale of the SAQ.[24] Burnout was measured using the 9-item emotional exhaustion subscale of the Maslach Burnout Inventory.[31] Clinical outcome was nurses' perceived frequency of clinical errors in the last 6 months (1, *never*; 5, *very often*).

Questionnaire items, response categories, and scoring systems are provided in Appendix A, http://links.lww.com/JPS/A401.

Translation of Measurement Tools

Translation and back-translation of the WCFS, TPQ, SAQ, handoff quality, and burnout measures that have been used internationally (Appendix A, http://links.lww.com/JPS/A401) were conducted by the first author and a professional translator.[13,17,20,26,32–37] Semantic equivalence was reviewed and validated by the authors. The resulting questionnaire was pretested for comprehensibility and time to complete with 6 nurses at one medical ward.

Data Collection

A survey package, with a return envelope, was distributed to nurses at 30 care units via nursing departments at the 2 study hospitals from July to September 2018. Completed questionnaires were returned to a predetermined location in each care unit. As an appreciation of participation, a small gift was provided, regardless of survey completion. We also collected participants' sex, age, years in nursing, educational level, and job position.

Data Analysis

Data were analyzed using SAS 9.4 (SAS Institute Inc, Cary, North Carolina) and AMOS 25 (IBM Corp, Armonk, New York). Participants' general characteristics and study variables were summarized using descriptive statistics. Responses of the WCFS, perceived obstacles to work performance, and burnout items were reverse coded to indicate that higher scores refer to higher situational awareness, more positive perceptions, and a lower level of burnout, respectively. Scores for handoff quality, patient safety practices implementation, and burnout were converted into a 5-point scale to use the same response scoring within constructs. The validity of the tools was assessed by an EFA and a CFA. Internal consistency reliability was measured with Cronbach α. Pearson correlation coefficients between study variables were calculated.

Structural equation modeling was performed using the maximum likelihood estimation method, which is robust when the multivariate normality assumption is violated.[38,39] Normality for each indicator was examined using skewness (absolute values <3.0) and kurtosis (absolute values <10.0).[40] The absolute values for skewness ranged from 0.03 to 0.50, and those for kurtosis ranged from 0.02 to 1.96. Univariate analyses on differences in staff and clinical outcomes by hospital and workplace revealed that there was no level effect (Appendix B, http://links.lww.com/JPS/A401).

In the measurement model, reliability and convergent validity were examined using composite reliability (CR) and average variance extracted (AVE), respectively.[41] CR ≥ 0.7 was considered satisfactory, and CR ≥ 0.6 was considered acceptable.[42] The criteria for acceptable convergent validity were as follows: (1) AVE not significantly smaller than 0.5 and (2) standardized factor loadings of all items not significantly smaller than 0.5.[43] Discriminant validity of the constructs was assessed using the Fornell and Larcker criterion[44] and the heterotrait-monotrait (HTMT) ratio of correlations.[45,46]

Values of χ^2/degree of freedom (df) ≤ 3, CFI ≥ 0.90, SRMR ≤0.08, and RMSEA ≤0.08 were used as cutoffs for an acceptable model fit.[42,47] For the single-item indicator, we used conservative values of 0.95 times the variance of the measurement variable for factor loadings and 0.1 times the variance of the measurement variable for error terms.[38,48] In addition, we confirmed the findings of the structural equation modeling after fixing the factor loading at 1 and error variance at 0 for the single-item indicator.[48] This did not change any outcomes of significance tests, and the resulting model fit was the same. Item parceling was used, which has benefits to obtain more stable parameter estimates and a better model fit.[49] Direct, indirect, and total effects as well as path coefficients were considered significant at $P < 0.05$.

RESULTS

Participants' General Characteristics

Of the 408 participants, 99.5% were women, and 50.3% were younger than 30 years. The mean (SD) years of nursing was 9.7 (9.2) years (range, 0.1–36.0 years); 65.2% had 4-year baccalaureate degrees; 12.1% were in managerial positions; and 72.1% worked in general wards, 17.6% in intensive care units, and 10.3% in Korean traditional medicine wards (Table 1).

Measurement Model

Standardized factor loadings of indicators were ≥0.50, and the AVEs ranged 0.42 to 0.90 (Table 2). Composite reliabilities were >0.6 for all constructs. The square roots of the AVEs for constructs were greater than the intercorrelation values between the constructs, with the exception of the values between

TABLE 1. Participants' General Characteristics

Variable	Category	n	%
Sex	Female	406	99.5
	Male	2	0.5
Age*	<29 y	205	50.9
	30–44 y	136	33.7
	≥45 y	62	15.4
Years in nursing	<3	120	29.4
	3–<5	50	12.3
	5–<10	86	21.1
	≥10	152	37.3
Education level	3-y college	42	10.3
	4-y university	266	65.2
	Graduate school or higher	100	24.5
Shift work	Yes	366	89.7
	No	42	10.3
Job position	Staff	358	87.7
	Manager	50	12.3
Hospital type	A	256	62.7
	B	152	37.3
Workplace	General ward	294	72.1
	Intensive care unit	72	17.6
	Korean traditional medicine ward	42	10.3

*Excluding missing data (n = 5).

TABLE 2. Descriptive Statistics, Reliability, and Validity of Study Variables

Constructs/Indicators	Mean	SD	α Coefficient	Factor Loading*	AVE	CR
Person factor	3.9	0.5			0.62	0.83
Item parcel: attention failure†	3.9	0.6	0.84	0.91		
Item parcel: action failure†	4.1	0.6	0.85	0.76		
Item parcel: memory failure†	3.8	0.5	0.75	0.68		
Organization factor	3.4	0.4			0.54	0.82
Item parcel: teamwork	3.6	0.5	0.96	0.88		
Item parcel: safety climate	3.3	0.6	0.83	0.77		
Item parcel: management/leadership	2.9	0.5	0.77	0.66		
Item parcel: handoff quality‡	3.7	0.5	0.87	0.61		
Physical environment factor	2.3	0.6	0.74		0.42	0.74
Disorganized patient rooms†	2.4	0.8		0.76		
Insufficient light†	2.6	0.8		0.69		
Insufficient space†	1.7	0.7		0.59		
Inadequate fixtures†	2.5	0.8		0.53		
Tools factor	2.5	0.5	0.84		0.47	0.84
Supplies and equipment: misplaced†	2.7	0.7		0.77		
Supplies: not being available†	2.5	0.7		0.71		
Supplies: delayed delivery†	2.4	0.6		0.68		
Supplies: not well stocked†	2.6	0.7		0.66		
Equipment: not being available†	2.4	0.7		0.66		
Equipment: in poor condition†	2.5	0.8		0.64		
Task factor	2.1	0.7	0.75		0.52	0.76
No time to eat/drink†	2.2	0.8		0.80		
No rest breaks†	2.0	0.7		0.78		
Overtime work†	2.1	0.9		0.56		
Safety-related performance	3.7	0.6			0.40	0.67
Item parcel: safety compliance	4.1	0.5	0.79	0.66		
Item parcel: safety participation	3.7	0.7	0.88	0.65		
Item parcel: patient safety practice implementation‡	3.2	1.1	0.87	0.60		
Staff outcome	2.4	0.8			0.52	0.67
Item parcel: job satisfaction	3.0	0.7	0.86	0.89		
Item parcel: burnout†‡	1.9	1.1	0.93	0.50		
Clinical outcome	2.3	0.7				
Frequency of clinical errors	2.3	0.7		0.95	0.90	0.90

Scores for indicators were converted into the same response scoring within each construct; scores for constructs were calculated by averaging the converted scores of the indicators.

*All standardized factor loadings were significant ($P < 0.001$).

†Reverse coding.

‡Scores on a 5-point scale.

organization factor and staff outcome (Table 3). All HTMT values were ≤0.85.

The descriptive statistics for the indicators of work system factors are shown in Table 2. Concerning nurses' safety-related performance indicators, the mean (SD) scores were 4.1 (0.5) for safety compliance, 3.7 (0.7) for safety participation, and 3.2 (1.1) for safety practices implementation, out of 5.0. On average, 63.6% of the safety practices were rated as being "highly" or "very highly" implemented (Appendix C, http://links.lww.com/JPS/A401).

Regarding the outcome indicators, the mean (SD) scores were 3.0 (0.7) for job satisfaction and 3.1 (1.1) for burnout, out of 5.0. The mean (SD) score for clinical error frequency was 2.3 (0.7), out of 5.0. Of the participants, 162 (39.7%) reported having experienced a clinical error in their work within the recent 6 months. Pearson correlation coefficients between measurement variables were ≤0.70 (Appendix D, http://links.lww.com/JPS/A401).

Structural Model

The model had acceptable model fit ($\chi^2 = 596.30$; $\chi^2/df = 2.19$; $P < 0.001$): CFI = 0.918, SRMR = 0.055, and RMSEA = 0.054. Structural equation modeling showed significant relationships between work system factors, safety-related performance, and outcomes (Fig. 2; Appendix E, http://links.lww.com/JPS/A401). Specifically, the person (path coefficient [β] = 0.29, $P < 0.001$) and organization (β = 0.61, $P < 0.001$) factors had positive effects on safety-related performance. Subsequently, safety-related performance had a negative effect on the clinical outcome (β = −0.26, $P = 0.005$) but no significant effect on

TABLE 3. Intercorrelations Between the Constructs and Discriminant Validity

Construct	Organization	Environment	Person	Tools	Task	Performance	Staff Outcome	Clinical Outcome
Organization	**0.73**	0.40	0.37	0.42	0.35	0.67	0.83	−0.21
Environment	0.39	**0.65**	0.32	0.52	0.42	0.28	0.44	−0.11
Person	0.36	0.32	**0.79**	0.37	0.17	0.47	0.28	−0.46
Tools	0.45	0.53	0.39	**0.69**	0.42	0.26	0.36	−0.17
Task	0.37	0.43	0.17	0.45	**0.72**	0.17	0.50	−0.09
Performance	0.71	0.28	0.46	0.25	0.17	**0.71**	0.49	−0.37
Staff outcome	0.83	0.49	0.34	0.42	0.63	0.47	**0.70**	−0.13
Clinical outcome	0.23	0.10	0.44	0.16	0.09	0.35	0.15	**0.95**

The upper part above the diagonal indicates intercorrelations between the estimated constructs, and the lower part indicates the HTMT ratio of correlations. The square roots of AVEs were located in the diagonal matrix (in bold).

staff outcome. The staff outcome was positively affected by the organization ($\beta = 0.81$, $P < 0.001$) and task ($\beta = 0.24$, $P < 0.001$) factors. The clinical outcome was negatively affected by the person factor ($\beta = -0.37$, $P < 0.001$). In addition, the organization factor had a significant indirect effect on the clinical outcome. The specific direct, indirect, and total effects, as well as the coefficients of determination are provided in Table 4.

DISCUSSION

This study examined direct and indirect effects of work system factors on safety-related performance and outcomes in hospital settings, using a framework based on the SEIPS model. Unlike the original SEIPS model, we added and tested direct effects of work system factors on outcomes and demonstrated that the modified model had a good fit. However, the findings partially supported our research hypotheses. Only person and organization factors significantly and positively affected safety-related performance. Although the staff outcome was affected only by organization and task factors, the clinical outcome was affected directly by the person factor and safety-related performance, and indirectly by the organization factor. Therefore, when work systems are designed to improve safety-related performance, and staff and clinical outcomes, differential effects of work system factors should be considered. This study indicates that strengthening the organization factor should be prioritized.

Regarding safety-related performance, safety compliance and participation were moderately rated. Only about two-thirds of the safety practices were rated as being highly implemented. This indicates that evidence-based safety practices are not fully embedded in nurses' practice. Continued and wide dissemination of these practices needs to be encouraged. Safety-related performance was affected by organization and person factors. This was similar to the findings of previous studies—that patient safety climate and leadership and managerial support were significantly associated with nurses' adherence to standard precautions and health care providers' safety-related performance.[6,19] This also supports the importance of the role of health care providers' cognition in preventing, detecting, and mitigating clinical errors in practice.[22,50] Interestingly, the effect of the organization factor on nurses' safety-related performance was more influential than that of the person factor. Therefore, organizational factors such as teamwork, handoff communication, safety climate, and management/leadership support need to be primarily promoted.

Physical environment, tools, and task factors did not significantly affect nurses' safety-related performance. This differed from the previous reports that work environments such as resources, staffing, and nonprofessional tasks significantly affected the nursing care left undone.[15] Such differences may be due to a different conceptualization of work environments. We measured physical environment, tools, and task factors focusing on obstacles to work performance using the SEIPS model.[3,5,27] In addition, we did not

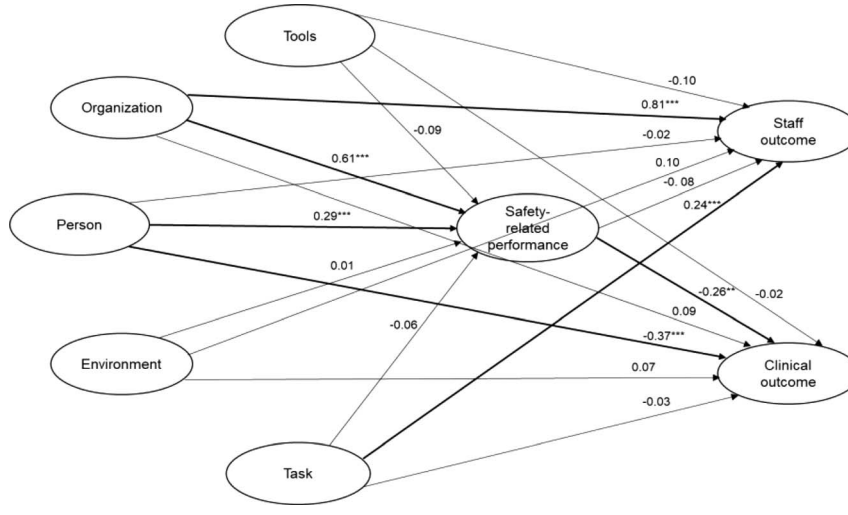

FIGURE 2. Standardized path coefficients of the final structural equation model.

TABLE 4. Total, Direct, and Indirect Effects on Safety-Related Performance, and Staff and Clinical Outcomes

Path	SMC	Direct Effect	*P*	Indirect Effect	*P*	Total Effect	*P*
Safety-related performance	0.51						
Person→		**0.29**	**0.016**	—	—	**0.29**	**0.016**
Organization→		**0.61**	**0.019**	—	—	**0.61**	**0.019**
Environment→		0.01	0.833	—	—	0.01	0.833
Tools→		−0.09	0.316	—	—	−0.09	0.316
Task→		−0.06	0.299	—	—	−0.06	0.229
Staff outcome	0.75						
Safety performance→		−0.08	0.364	—	—	−0.08	0.364
Person→		−0.02	0.815	−0.02	0.325	−0.04	0.697
Organization→		**0.81**	**0.016**	−0.05	0.338	**0.76**	**0.009**
Environment→		0.10	0.149	−0.001	0.504	0.10	0.130
Tools→		−0.11	0.154	0.01	0.340	−0.10	0.170
Task→		**0.24**	**0.004**	0.01	0.205	**0.25**	**0.004**
Clinical outcome	0.25						
Safety performance→		**−0.26**	**0.020**	—	—	**−0.26**	**0.020**
Person→		**−0.37**	**0.008**	**−0.08**	**0.016**	**−0.45**	**0.011**
Organization→		0.09	0.455	**−0.16**	**0.025**	−0.07	0.344
Environment→		0.07	0.433	−0.004	0.737	0.06	0.485
Tools→		−0.02	0.677	0.02	0.239	0.01	0.978
Task→		−0.03	0.756	0.02	0.222	−0.01	0.926

An arrow indicates a path from a latent variable to another latent variable.
SMC, squared multiple correlation.

include factors related to the use of recently advanced health information technologies. Therefore, further studies including various aspects of the work environments are needed.

Staff outcome was directly affected by organization and task factors. Nurses' job satisfaction was relatively low, and burnout level was higher than those in other studies with nurses.[13,17,36,37,51] Nurses engaging in strong teamwork, highly prioritizing safety, having managerial and leadership support, and communicating effectively during handoffs were more satisfied with their job and experienced less emotional exhaustion compared with their counterparts. This supports the findings of previous research.[19] Lower task demand was associated with higher job satisfaction and lower burnout. Excessive task demand can cause a feeling of being rushed without rest breaks, which could negatively impact job satisfaction and result in higher emotional exhaustion. This was similar to the findings of previous studies showing significant effects of nurse workload on job dissatisfaction or burnout.[15,52] Therefore, improving organization factors and pursuing adequate task design will increase nurses' job satisfaction and reduce emotional exhaustion, thereby enhancing patient safety.

Person, environment, and tools factors, and safety-related performance were not significantly associated with staff outcome. This is partially similar to the finding that nursing care left undone (safety-related process) was not significantly associated with burnout.[15] However, our findings differed from the findings of previous studies in intensive care units showing that nurses' quality of work life was directly or indirectly affected by environment and tools factors.[5] Such differences may be due to differences in study samples and settings. Another possible explanation could be that nurses' situational awareness, favorable physical environments, availability of equipment and supplies, and safety-related performance are not important factors affecting job satisfaction or burnout. However, more studies are needed to conclude their effects on nurse outcomes.

Clinical outcome of error frequency was directly and indirectly affected by the person factor and safety-related performance, and indirectly affected by the organization factor. The WCFS, TPQ, and safety climate scores were not significantly different from those in previous studies[20,32–36] (Appendix A, http://links.lww.com/JPS/A401). This was consistent with the previous finding that care providers' situational awareness is important in ensuring patient safety, as cognitive failures can lead to slips, lapses, and mistakes in clinical practice.[50] A stronger safety-related performance led to reduced error occurrence. The significant indirect effect of the organization factor on this clinical outcome was similar to previous studies' findings that organizational factors such as safety climate and leadership and managerial support were positively associated with patient outcomes such as medication errors, falls, complications, and mortality.[18,19] Therefore, reducing clinical errors and patient safety risks can be achieved by strengthening safety-related processes, assisting nurses' situational awareness, and promoting teamwork, safety culture, leadership support, and handoff quality.

Physical environments, tools, and task factors did not significantly affect clinical outcome. This differed from previous findings in intensive care[5] and pediatric care units.[52] Such differences can be attributed to different clinical settings. These differences might also result from the distinctions of clinical error and workload measurements. A study showed that medication errors were significantly associated with task-level workloads during medication administration.[52] However, we measured the unspecified clinical error occurrences and general workloads, such as amount of work required; therefore, more studies on factors affecting clinical error occurrences are needed.

This study had several limitations. First, participants were nurses from only 2 teaching hospitals; generalization of the findings is thus limited. Second, because this was a cross-sectional study, causal relationships could not be established between work system, process, and staff and clinical outcomes, and a feedback mechanism of the SEIPS model could not be included. The feedback loops indicate pathways to design or redesign the work system,[11] and

they represent planed or unplanned adaptive mechanisms over time.[53] A longitudinal study is required to investigate causal relationships and feedback loops. Third, we relied on data from a self-report survey including the degree of safety practices implementation and clinical outcomes. Despite the assurance of anonymity, social desirability could have still affected nurses' responses. Nevertheless, nurses' reports of care quality and patient safety have been considered an appropriate estimate based on the finding of the direct association with independent clinical outcomes of mortality.[16,51,54] Future studies using different methodologies such as observations and record reviews of event reporting data or clinical data are suggested. Fourth, we did not include external environment factors such as policies and regulations. Furthermore, we did not investigate organization- and team-level characteristics in various health care settings, and joint effects based on various combinations of work system factors.[53,55] We suggest a multilevel study to explore the joint effects of work system factors, including external environment factors.

CONCLUSIONS

This study showed the usefulness of the modified SEIPS model in explaining safety-related performance and staff and clinical outcomes. Various effects of work system factors should be considered when designing work systems for patient safety. Person and organization factors had significant effects on safety-related performance and staff and clinical outcomes. The task factor affected staff outcome, and nurses' safety-related performance affected clinical outcome. Our findings provide useful insights for interventional strategies to improve hospital nurses' safety-related performance and outcomes. Particularly, the organization factor had the strongest positive effect on nurses' safety-related performance and outcomes; thus, promoting teamwork, safety climate, management and leadership, and handoff quality should be primarily encouraged to ensure safe, high-quality care.

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