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Effects of Work Environments and Occupational Fatigue on Care Left Undone in Rotating Shift Nurses

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Key words
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Abstract

Purpose: This study aimed to examine the effects of work environments and occupational fatigue on care left undone in rotating shift nurses, and to identify the indirect (mediation) effect of work environments on care left undone through nurses' occupational fatigue in South Korean acute care hospitals.
Design: This study employed a cross-sectional design using an online survey to collect data from 488 rotating shift nurses of acute care hospitals in Korea between November and December 2018.
Methods: A mobile schedule management application for shift nurses was used to advertise the study and to send a link to the online survey. The survey included questions on the nurses' work environment characteristics, care left undone activities, and the Korean version of the Occupational Fatigue Exhaustion/Recovery scale. Poisson regression was used to explore the relationships among work environments, occupational fatigue, and care left undone. Hayes' Model 4 and a bootstrapping analysis were used to identify the mediating effect of occupational fatigue on the relationship between work environments and care left undone.
Findings: The average number of tasks left undone was 3.45 (SD = 2.19). The higher the acute and chronic fatigue levels noted among nurses, the higher were the occurrences of care left undone. Conversely, the higher the intershift recovery level, the lower were the occurrences of care left undone. The results showed a positive relationship between care left undone and overtime hours and the number of patients per nurse. Moreover, nurses' occupational fatigue mediated the relationship between work environments and care left undone. Night shifts per month and the number of consecutive days off had an indirect effect on care left undone through occupational fatigue.
Conclusions: High levels of occupational fatigue and poor intershift recovery among nurses can lead to care left undone. Nurses' occupational fatigue mediates the effect of work environment on care left undone.
Clinical Relevance: It is crucial for healthcare administrators and leaders to develop policies and mandatory regulations to facilitate better working conditions for nurses, consequently reducing their occupational fatigue and decreasing the occurrence of care left undone in acute care hospitals.

Care left undone (CLU) refers to[JC2] the necessary nursing activities that were delayed or left incomplete due to the lack of time during shifts (Aiken et al., 2013; Cho et al., 2016). Globally, medical institutions and administrators have been monitoring CLU, since there is evidence linking it to patient outcomes. A systematic review indicated that CLU is associated with patient satisfaction, quality of care, clinical outcomes, readmission, and mortality rate (Recio-Saucedo et al., 2018). Moreover, CLU leads to unfavorable patient outcomes, including medication errors, nosocomial infections, patient falls, and critical incidents (Ausserhofer et al., 2014; Carthon, Lasater, Sloane, & Kutney-Lee, 2015).

CLU is also associated with work environments and nursing staff's high workload (Ausserhofer et al., 2014; Jones, Hamilton, & Murry, 2015); thus, nurses in highly demanding care units are more likely to experience exhaustion and fatigue than others. Work environment characteristics—such as nurse-to-patient ratios, long work hours, and shift time—have been previously associated with CLU (Ball, Murrells, Rafferty, Morrow, & Griffiths, 2014; Ball et al., 2016; Liu et al., 2018; Tubbs-Cooley, Mara, Carle, Mark, & Pickler, 2019). Extended work hours, large number of night shifts, and insufficient rest between shifts are also associated with higher nurse fatigue (Barker & Nussbaum, 2011; Fang, Zhou, Huang, & Qiu, 2018; Sagherian, Clinton, Abu-Saad Huijer, & Geiger-Brown, 2017). Moreover, fatigue and decreased alertness are more likely to affect rotating shift nurses, since rotating between different shifts disrupts circadian rhythms (Dall'Ora, Ball, Recio-Saucedo, & Griffiths, 2016; Sagherian et al., 2017). In South Korea, many nurses work three-shift rotations and work over 47 hr per week. Furthermore, 12% of Korean nurses work over 52 hr per week (Lee, Co, Chung, & Kim, 2016), exceeding the Labor Standards Act's limits (The National Assembly of the Republic of Korea, 2018), which states workers can work no more than 40 hr per week. Given these conditions, shift nurses may experience fatigue, which can impact their performance and quality of care.

Fatigued nurses are more likely to neglect vital care while performing duties (Dehghan-Nayeri, Ghaffari, & Shali, 2015), and fatigue can harm rotating shift nurses' performance and, in turn, patient safety (Di Muzio et al., 2019). Additionally, fatigue is considered a work environment–related personal factor that may have implications for CLU (Wakefield, 2014). Previous research has reported that fatigued nurses can have several types of performance deficits, such as slowed reaction time, memory lapses, difficulty concentrating, and lower alertness (Smith-Miller, Shaw-Kokot, Curro, & Jones, 2014), and experience clinical decision regret (Scott, Arslanian-Engoren, & Engoren, 2014). However, to our knowledge, the underlying mechanism for the association between fatigue and CLU has not been studied comprehensively among shift nurses.

Studies report that nurses and administrators may not be fully aware of the health and safety risks associated with shift work and fatigue in healthcare settings (Caruso et al., 2019). Given the increasing emphasis on quality of care, research on work environments, nurse fatigue, and CLU will improve the understanding of how nurses' work environments shape the quality of care. Although some studies have investigated the relationship between work schedule factors and nurse and patient outcomes, to the best of our knowledge none have explored the mediating effect of nurse fatigue in this relationship. Therefore, this study aimed to examine the effects of work environments and occupational fatigue on CLU, and to identify the indirect (mediation) effect of work environments on CLU through occupational fatigue in rotating shift nurses.

Methods

Study Design, Setting, and Sample

This study employed a cross-sectional design using an online survey data from a project examining associations between work-related factors and nurse and patient outcomes among rotating shift nurses in Korea (Author, in press). Korea has over 350,000 nurses, most of whom work rotating shifts. They typically work 8-hr shifts 5 or more days per week, and shift schedules differ each month. An online survey was used to ensure that participants were unrestricted by time and place, and to maintain optimal privacy. Data were collected from November to December 2018. We advertised our study and invited rotating shift nurses who provided direct nursing care in acute care hospitals via a popular mobile schedule management application for shift nurses to participate. Approximately 85% of Korean nurses use this application. The nurses were encouraged to send the survey link to other nurses who did not use the application to enhance the representativeness of the sample.

The nurses were informed about the study purpose and methods, and those who provided informed consent to participate could access a link to the online survey. They were informed that participation was voluntary and confidential. Participants could withdraw from the study at any time without any consequence. An actual response rate could not be estimated because

the number of nurses who saw the advertisement in the mobile application was unknown. A total of 618 nurses consented to participate in the survey, and 126 nurses did not complete it (nonresponse rate: 20.38%; Min, Yoon, Hong, & Kim, 2019). Therefore, 492 nurses completed the survey, and 488 (effective response rate: 99.19%) valid responses were used in the final analysis. Excluded responses included duplicate cases (two nurses) and repetitive answers (two nurses). This study was approved by the institutional review board at a university (No. Y-2018-0113).

Measures

The online survey included the following measures: Predictor: Work environments. Nurses reported the following characteristics of their work environments: total hours worked last week, total overtime hours (paid and unpaid) last week, number of patients per nurse in last shift, number of night shifts per month, and number of consecutive days off last month. Nurses provided their total working and overtime hours in minutes, which were then converted to decimal hours. There is evidence for a strong correlation between self-reported and objectively calculated working times (Jacobs, 1998), and these self-reported measures have commonly been used in studies of nurses (Cho et al., 2016; Schluter, Turner, & Benefer, 2012). Nurses were asked for the number of patients they worked with during their most recent shift. This self-reported nurse staffing level measurement has been widely used in both international studies and those in Korea. The data are more valid and reliable indicators of nurse staffing levels than administrative data sources that generally include nurses who do not provide direct care for patients or who work in outpatient settings (Aiken et al., 2011; Cho, Park, Choi, Lee, & Kim, 2018). In order to accurately measure the indicators, nurses were asked to report the number of night shifts worked and consecutive days off during the last month based on the actual schedules provided on the mobile schedule management application that they used.

Mediator: Occupational fatigue. Nurses' occupational fatigue was measured using the Korean version of the Occupational Fatigue Exhaustion/Recovery (OFER-K) scale (Min et al., 2019). The OFER-K scale consists of 15 items divided equally into three subscales: acute fatigue (OFER-AF), inter-shift recovery (OFER-IR), and chronic fatigue (OFER-CF). The OFER-K items are scored using a 7-point Likert scale ranging from "*strongly disagree* = 0" to "*strongly agree* = 6," and items 9, 10, 11, 13, and 15 are reverse-coded. Each subscale score is computed using the following formula: sum (each subscale's item scores)/30 × 100. A higher score indicates a higher level of each subscale construct. The level of each subscale is divided into low, low/moderate, moderate/high, and high according to quartiles. The OFER scale has been validated for nursing in many countries, including Korea (Fang et al., 2018; Min et al., 2019; Winwood, Lushington, & Winefield, 2006). The previously established OFER-K scale's Cronbach's alpha levels were 0.76 (OFER-AF), 0.75 (OFER-IR), and 0.76 (OFER-CF; Min et al., 2019). In this study, Cronbach's alpha levels were 0.77 (OFER-AF), 0.78 (OFER-IR), and 0.79 (OFER-CF).

Outcome: Care left undone. CLU was measured by asking the nurses if a set of specific necessary activities was left undone during their last shift due to the lack of time (Aiken et al., 2013; Ausserhofer et al., 2014). Nurses answered yes or no to 12 nursing care activities questions derived from the Basel Extent of Rationing of Nursing Care instrument, which has been widely used in international studies and has been reported as a valid and reliable measure (Aiken et al., 2013; Ausserhofer et al., 2014; Cho et al., 2016; Liu et al., 2018). The Korean version of the CLU measure has also been previously validated with a coefficient of 0.70 (Cho et al., 2016). Reliability was assessed using the Kuder-Richardson Formula 20, with a coefficient of 0.60 in this study.

Covariates: Demographic characteristics. We collected data pertaining to the nurse, work unit, and hospital characteristics. Nurse characteristics included age, sex, marital status, parental status, educational level, monthly income, and work experience. Unit characteristics included the type of working unit (i.e., medical-surgical unit, operating room, emergency room, intensive care unit, other) and nursing care model (i.e., functional methods, team nursing, total patient care, mixed type). Hospital characteristics were location (i.e., Seoul, another metropolitan area, province), hospital type (i.e., tertiary hospital, general hospital), number of beds, and teaching hospital status (yes or no).

Data Analysis

We analyzed data using STATA version 15.0 software (StataCorp LP, College Station, TX, USA) and PROCESS version 3.3 macro for SPSS. Descriptive statistics (means, *SD*s, frequencies, percentages) were used to describe participants, work environments, occupational fatigue, and CLU and to identify response distribution. To explore the relationship between work environments, occupational fatigue, and CLU, we used a bivariate analysis with the chi-square test, Wilcoxon

rank-sum test, and Spearman's rank correlation. After the bivariate analysis, significant variables were inserted into the count regression model, with the dependent variable being the number of care tasks left undone. We used the Poisson regression model controlling for nurse, unit, and hospital characteristics. A p value < .05 indicated statistical significance. Hayes' Model 4 and bootstrapping analysis methods were used to identify the mediating effects of occupational fatigue on the relationship between work environments and CLU. The number of bootstrap samples was 5,000, and a 95% confidence interval (CI) was applied.

Results

Descriptive statistics for participants' and work environments' characteristics are presented in Table 1. The mean scores were 69.86 (SD = 15.16), 30.13 (SD = 15.57), and 73.02 (SD = 16.72) for the OFER-AF, OFER-IR, and OFER-CF scales, respectively. The mean scores of both the OFER-AF and OFER-CF scales showed moderate to high levels, and those of the OFER-IR scale showed low/moderate levels. All participants reported they had left at least one care task undone during their last shift, and the average CLU score was 3.45 (SD = 2.19). The most common unfinished tasks of nurses were "comfort/talk with patients" (n = 309, 63.32%), "teach/counsel patients and family" (n = 222, 45.49%), and "adequately document nursing care" (n = 216, 42.21%; Figure S1).

The Poisson regression model results are presented in Table 2. OFER-AF was positively associated with CLU (incidence rate ratio [IRR] = 1.009, 95% CI [1.005, 0.012]), and overtime hours and number of patients per nurse were predictors of CLU after adjusting for nurse, unit, and hospital characteristics (Model 1). In Model 2, OFER-IR was negatively associated with the occurrence of CLU (IRR = 0.996, 95% CI [0.992, 0.999]), and overtime hours and number of patients per nurse were predictors of CLU after adjusting for nurse, unit, and hospital characteristics. OFER-CF had a positive relationship with CLU (IRR = 1.009, 95% CI [1.006, 1.012]), and overtime hours and number of patients per nurse were predictors of CLU after adjusting for nurse, unit, and hospital characteristics (Model 3). The number of night shifts per month and number of consecutive days off were not found as predictors in any model. Figure S2 shows the margin plots for CLU according to OFER-AF, OFER-IR, and OFER-CF after controlling for nurse, unit, and hospital characteristics. As OFER-AF and OFER-CF scores increased, occurrences of CLU tended to increase; when

Table 1. Descriptive Statistics for Study Participants and Work Environments (N = 488)

Characteristics		$M \pm SD$ or n (%)
Age (years)		26.43 ± 3.46
Sex	Female	461 (94.5)
	Male	27 (5.5)
Marital status	Unmarried	445 (91.2)
	Married	43 (8.8)
Parental status	Yes	15 (3.1)
	No	473 (96.9)
Education level	Diploma	60 (12.3)
	Baccalaureate	388 (79.5)
	Master's or higher	40 (8.2)
Monthly income (US$)		2,487.03 ± 474.49
Work experience (years)		3.10 ± 3.08
	<1	142 (29.1)
	1–5	267 (54.7)
	6–10	69 (14.1)
	≥11	10 (2.1)
Working unit	Medical/surgical	271 (55.5)
	Perioperative	6 (1.3)
	Emergency department	37 (7.6)
	Intensive care	128 (26.2)
	Other	46 (9.4)
Nursing care model	Functional method	110 (22.5)
	Team nursing	199 (40.8)
	Total patient care	130 (26.6)
	Mixed type	49 (10.1)
Hospital location	Seoul (capital)	190 (38.9)
	Other metropolitan area	215 (44.1)
	Province	83 (17.0)
Hospital type	Tertiary hospital	228 (46.7)
	General hospital	202 (41.4)
	Hospital	58 (11.9)
Number of beds	≥1,000	171 (35.1)
	500–999	190 (38.9)
	100–499	107 (21.9)
	<100	20 (4.1)
Teaching hospital	Yes	271 (55.5)
	No	217 (44.5)
Total hours worked last week		43.20 ± 17.79
Overtime hours last week		10.27 ± 11.80
	Yes	455 (93.2)
	No	33 (6.8)
Number of patients/nurse		14.20 ± 12.23
	Medical/surgical	18.75 ± 12.09
	Operation room	7.83 ± 4.71
	Emergency room	19.92 ± 13.10
	Intensive care	6.63 ± 7.89
	Others	4.72 ± 3.99
Night shifts per month (days)		6.66 ± 2.26
	≤5	102 (20.9)
	6–10	367 (75.2)

(Continues)

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Table 1. (Continued)

Characteristics		*M* ± *SD* or *n* (%)
	≥11	19 (3.9)
Number of consecutive days off		2.56 ± 0.90
	≤2 (days)	265 (54.3)
	3	178 (36.5)
	4	30 (6.1)
	≥5	15 (3.1)

OFER-IR scores increased, occurrences of CLU tended to decrease.

Mediating effects of occupational fatigue in the relationship between work environments and CLU are presented in Figure 1. As shown in Figure 1a–c, working overtime had a positive effect on CLU. After adding OFER-AF, OFER-IR, and OFER-CF, the working overtime variable showed an effect on occupational fatigue variables; in turn, occupational fatigue variables had effects on CLU. The number of patients per nurse had no effect on CLU (p = .058; Figure 1d). After adding OFER-AF to the model, the number of patients per nurse showed a positive association with OFER-AF (p = .001), and OFER-AF had a positive effect on CLU (p < .001). The indirect effect of the number of patients per nurse was also significant (β = .009, Boot CI [0.003, 0.016]). Thus, OFER-AF had a complete mediating effect in the relationship between the number of patients per nurse and CLU. Similarly, OFER-AF and OFER-IR served as a complete mediator in the relationship between number of night shifts per month and CLU (Figure 1e and 1f). As shown in Figure 1g and 1h, OFER-IR and OFER-CF also served as complete mediators in the relationship between the maximum number of consecutive days off taken and CLU.

Discussion

CLU has appeared to be prevalent among rotating-shift nurses in Korea, higher than those reported for nurses in Sweden (75%), England (86%), and the United States (84%; Ball et al., 2014, 2016; Park, Hanchett, & Ma, 2018). The primary reasons for CLU found across several countries were related to inadequate staffing, material resources, and communication/teamwork (Kalisch, Tschannen, & Lee, 2011). This study found that working overtime and a high number of patients per nurse affected CLU, which suggests that inadequate nurse staffing and high nurse workload may limit nurses' capacity to provide adequate and safe care. Consistent with the findings of Cho et al. (2016), comfort/talking with patients and educating patients were activities that ranked highly as CLU. Patient experience of health care is considered a fundamental indicator of the quality of health care, and nurse communication with patients was found to be an essential predictor of patient satisfaction (Klinkenberg et al., 2011). The quality of care in hospital settings is affected not only by the technical or physical care that patients receive, but also by the quality of the interpersonal relationships with the healthcare staff. However, providing such care tends to be neglected by nurses as other physical care responsibilities, such as pain management and treatment, take priority (Tubbs-Cooley et al., 2019). To reduce CLU, adequate staffing and material resources are needed to create a working environment that will enable nurses to spend more time on the psychosocial care of their patients.

Several studies have examined the relationship between fatigue and CLU (Dehghan-Nayeri et al., 2015; Sutherland, Ashcroft, & Phipps, 2019; Wakefield, 2014). However, this study's findings indicated that occupational

Table 2. Poisson Regression Models for Care Left Undone (*N* = 488)

	Care left undone Incidence rate ratios [95% confidence interval: low to upper limits]		
	Model 1	Model 2	Model 3
Acute fatigue	1.009*** [1.005, 1.012]		
Intershift recovery		0.996* [0.992, 0.999]	
Chronic fatigue			1.009*** [1.006, 1.012]
Overtime hours	1.005** [1.001, 1.009]	1.006** [1.002, 1.009]	1.005** [1.001, 1.009]
Number of patients/nurse	1.007* [1.001, 1.013]	1.009** [1.003, 1.016]	1.008* [1.002, 1.014]
Night shifts per month	0.984 [0.961, 1.007]	0.985 [0.962, 1.009]	0.985 [0.963, 1.009]
Consecutive days off	1.003 [0.948, 1.061]	1.002 [0.947, 1.060]	1.010 [0.955, 1.069]

Note. Values are adjusted for nurse characteristics (sex, age, marital status, parental status, education level, monthly income, work experience, total working hours), unit characteristics (unit type, care model), and hospital characteristics (location, type, number of beds, teaching hospital).
*p < .05; **p < .01; ***p < .001.

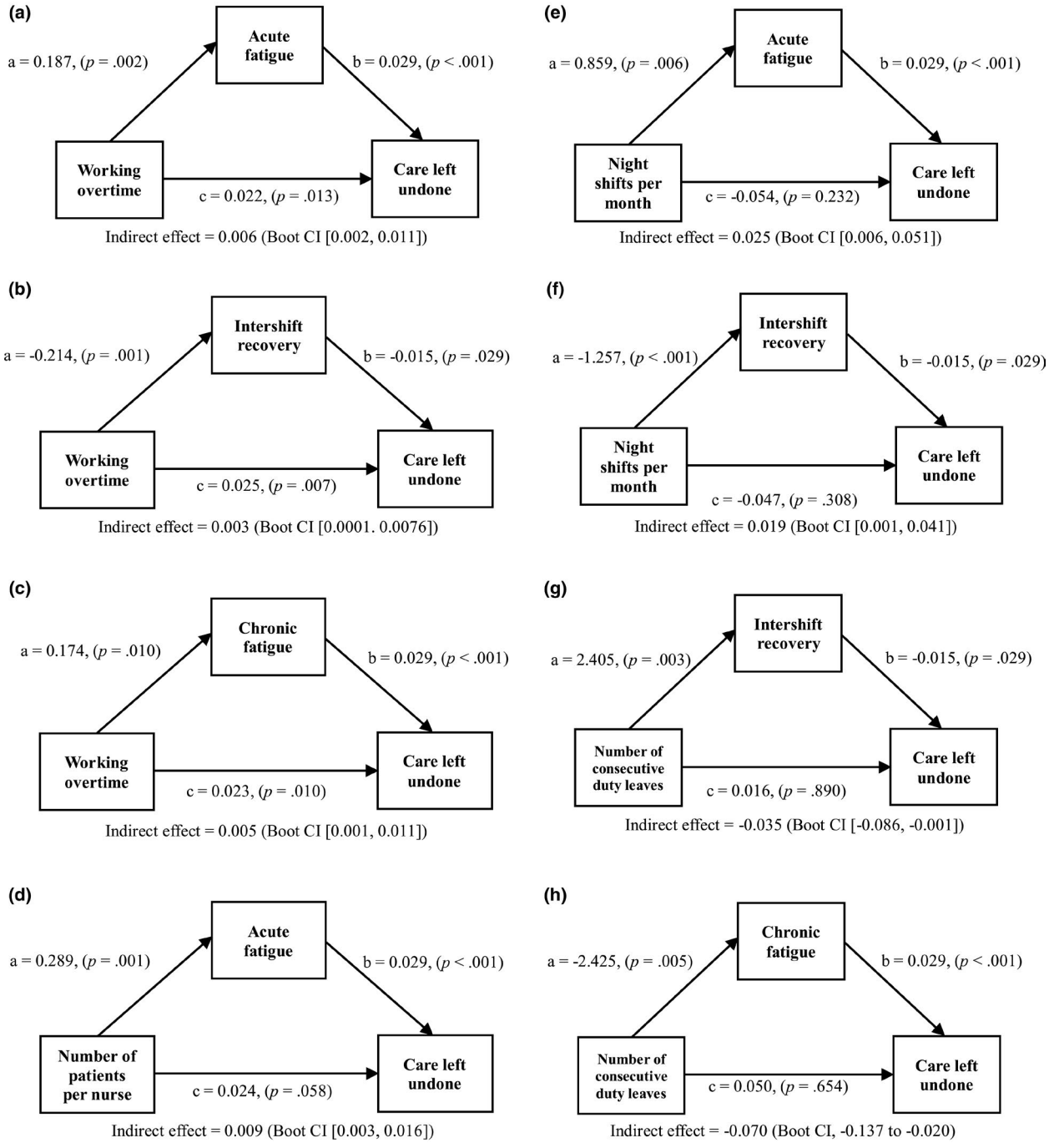

Figure 1. Mediating effects of occupational fatigue in the relationship between work environments and care left undone. All models were adjusted for nurse, unit, and hospital characteristics.

fatigue is a crucial mediator between work environments and CLU. We also found that Korean nurses showed higher OFER-AF and OFER-CF levels and poor OFER-IR compared to those in the United States (Barker & Nussbaum, 2011) or New Zealand (Yu, Somerville, & King, 2019). Efforts to reduce nurses' occupational fatigue may decrease CLU, which has been previously linked to favorable patient outcomes. For example, mitigating occupational fatigue may minimize slips and lapses during filling prescriptions (Sutherland et al.,

2019). Occupational fatigue can be reduced with interventions, such as modifying work schedules, enhancing sleep patterns, and reducing the number of patients allotted per nurse while ensuring sufficient rest and breaks (Richter, Acker, Adam, & Niklewski, 2016). However, helping nurses and administrators may require gathering further evidence. Since our study is the first to identify the mediating effect of occupational fatigue in the relationship between work environments and CLU, further research is necessary.

Additionally, this study revealed that a lower OFER-IR level is associated with higher CLU. Insufficient rest between shifts among rotating shift nurses was found to increase lethargy, exhaustion, pathological fatigue, and excessive fatigue (Eldevik, Flo, Moen, Pallesen, & Bjorvatn, 2013; Sagherian et al., 2017). In our study, most nurses reported fewer than 2 consecutive days off during the last month as a maximum. Unfortunately, considering they were rotating shift nurses with night shifts, some may not have taken at least 2 days off after consecutive night shifts. These poorly designed work shift patterns cause insufficient OFER-IR and increased OFER-CF, adversely affecting patient care quality leading to, for example, medication errors and patient mortality (Trinkoff et al., 2011). The issue may be solved with a rapid and forward rotating shift system that would provide adequate time to rest and prevent accumulated fatigue (Eldevik et al., 2013; Sallinen & Kecklund, 2010). The Korean Ministry of Health and Welfare's (2019) recent guidelines state that at least a 48-hr rest period is mandatory after two consecutive night shifts; thus, an evaluation of an OFER-IR period that follows these guidelines, including nurse and patient outcomes, is recommended. Moreover, since OFER-IR is essential for rotating shift nurses to manage occupational fatigue and improve patient outcomes, further studies are needed to develop interventions to decrease nurses' occupational fatigue and influence policies related to implementing healthy work schedules.

Consistent with previous research, working overtime and low nurse staffing were found to be related to occupational fatigue and CLU among shift nurses in the present study (Ball et al., 2014, 2016; Cho et al., 2016; Griffiths et al., 2014; Liu et al., 2018; Sagherian et al., 2017; Tubbs-Cooley et al., 2019). In our study, about 90% of nurses reported working overtime in the past week, which is much higher than the rates found in the United States (60.3%), Canada (27.1%), and Europe (27.0%; Bae, 2012; Canadian Federation of Nurses Unions, 2017; Griffiths et al., 2014). Further, 76.4% of Korean nurses reported working overtime on their last shift (Cho et al., 2016). Overtime contributes to longer working hours per week. Nurses have been an exception to the 40-hr maximum per week, and no current regulations restricting overtime work exist in Korea. The European Union's (2003)2003 Working Time Directive limits work hours to 48 hr per week, and mandatory overtime regulation for nursing in the United States has been pursued (Wheatley, 2017). The United States, with regulations limiting mandatory overtime and consecutive work hours, effectively reduced mandatory overtime hours by 3.9% and the incidence of working over 40 hr per week by 11.5% (Bae & Yoon, 2014). Moreover, Korea's nurse staffing levels are lower than those in most Organization for Economic Cooperation and Development countries (Amiri & Solankallio-Vahteri, 2019). Our study's average nurse-to-patient ratio was 14.20 vs., for example, 8.60 for all hospitals in England (range 5.60–11.5; Aiken et al., 2018). The nurse-to-patient ratio for inpatients is set at 2.5 in the Korean Enforcement Regulation of Medical Law; however, it has little actual influence on nurse staffing, since it allows nurse aides to substitute for nurses (Cho et al., 2016). Our results highlight the importance of developing effective strategies and mandatory regulations to manage overtime and nurse staffing to reduce occupational fatigue among shift nurses and provide a higher quality of care. Healthcare administrators and nurse managers should be aware that an inadequate level of nursing staff would increase workloads, thus leading to overtime. Policymakers need to develop a specific regulation in Korea regarding a mandated minimum nurse-to-patient ratio based on unit characteristics by benchmarking the success of California's Nurse-to-Patient Ratio Law (McHugh, Kelly, Sloane, & Aiken, 2011).

This study is the first to report that the number of night shifts worked per month has an indirect effect on CLU. Previous studies have reported that night shift work is positively associated with fatigue levels among nurses (Øyane, Pallesen, Moen, Akerstedt, & Bjorvatn, 2013; Yuan et al., 2011). Rotating shift nurses typically work two or three consecutive night shifts, meaning they must adjust their circadian rhythm more often, which is likely to lead to performance deficits such as drowsiness and difficulty concentrating (Dall'Ora et al., 2016; Sagherian et al., 2017). However, no organizational regulations exist that would limit the total number of night shifts per month. In our study, most nurses worked 6 to 10 night shifts per month, with some working even 11 or more despite not being fixed night shift nurses. To reduce the number of night shifts per month for a rotating shift nurse, the Korean Ministry of Health and Welfare (2019) recently

encouraged the addition of fixed night shift nurses. Further research is needed to determine the decreased burden on rotating shift nurses that resulted from implementing a fixed night system and examine the positive effects on occupational fatigue and patient outcomes. Our results further suggest that policymakers and administrators should develop policies limiting the maximum number of nursing night shifts allowed per month.

Although most Korean nurses use the online scheduling application through which the survey link was sent, it is possible we did not include nurses unfamiliar with the application, especially those who are older. We encouraged the nurses to send the link to others who did not use the application. We also tried to enhance sample representativeness by conducting the survey online and including nurses from many provinces and acute care hospitals of different types with different numbers of beds. Nonetheless, the convenience sampling and cross-sectional design employed in the present study limit the findings' generalizability, hindering the identification of causal relationships among the study variables. Future studies using random sampling with both online and in-person surveys and a longitudinal design are needed to increase the results' generalizability and identify the causal relationship among variables. Furthermore, the key variables used in this study were self-reported and subjective. Although this survey was conducted online and was anonymous, it is possible that the nurses underreported CLU. Future studies may include patient- and family-reported CLU to reduce potential self-report bias by participants (Cho, Mark, Knafl, Chang, & Yoon, 2017). We also recommend using fatigue measures that can eliminate recall bias and self-reporting shortcomings, as well as biomathematical fatigue models that focus on work schedules, workload, and other parameters to estimate sleep opportunity and fatigue risk levels. Although Jacobs (1998) provided evidence that self-reported measures of working time are a reasonably reliable indicator, recall bias cannot be excluded. Hence, future research may need to use employers' payroll-based working hour records to enhance the accuracy of reported working hours.

Conclusions

Nurses in Korea were found to experience a higher level of occupational fatigue compared to those in other countries due the characteristics of their work environments, such as excessive overtime, low staffing levels, and poorly designed work schedules. High levels of occupational fatigue and poor OFER-IR were found to be associated with CLU. Specifically, not talking to or comforting patients, including the failure to provide education and counseling, was the most frequently reported undone task, even though such nursing activities are equally significant to providing physical care. Notably, occupational fatigue mediated the effect of work environments on CLU. Therefore, providing work environments based on healthy work schedules is essential. Recently, it has been recommended that healthcare services and standard-setting organizations establish policies that address the prevalence of workplace hazards, thereby promoting nurse and patient health and safety (Caruso et al., 2019). Medical administrators and policymakers should be aware of the risks associated with deteriorating work environments and the related occupational fatigue among nurses and aim to develop organizational policies or regulations that guarantee safe and healthy working conditions. Such actions may also aid the reduction of CLU, thus improving the quality of patient care.

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Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Figure S1. Nurses' responses to care left undone items.

Figure S2. Margins plots for care left undone according to occupational fatigue and exhaustion recovery (i.e., acute fatigue, intershift recovery, and chronic fatigue) controlling for nurse characteristics (sex, age, marital status, parental status, education level, monthly income, work experience, total working hours, overtime hours, number of patients/nurse, night shifts/month, number of consecutive off days), unit characteristics (unit type, care model), and hospital characteristics (location, type, number of beds, teaching hospital).