Influence of the Workload and Years of Experience of Nurses on Hemodialysis Quality Using Korean National Hemodialysis Adequacy Evaluation Data

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Abstract

The aim of this study is to examine the influence of nurses' workload and years of experience on the rate of patients with normal calcium–phosphorus products levels and the adequacy evaluation grade of hemodialysis (HD) facilities using 2015 and 2018 national HD adequacy evaluation data. The data of 616 hospital-level outpatient HD facilities were analyzed using multiple linear regression and ordinal logistic regression. A higher rate of nurses with ≥2 years of HD experience was correlated with a higher rate of patients with normal calcium–phosphorus levels. As the average daily number of HD cases per nurse increased, the probability of HD facilities' receiving the higher adequacy evaluation grade decreased by 83% (odds ratio (OR)=.17, 95% confidence interval (CI)=.14–.22), whereas it increased by 4% as the rate of nurses with ≥2 years of HD experience increased by 1%p (OR=1.04, 95% CI=1.03–1.05). Reducing the nursing workload by maintaining sufficient nurses and increasing the rate of nurses with ≥2 years of HD experience would improve the quality of HD and patient outcomes.

Keywords
nursing staff, workload, hemodialysis units, calcium, phosphorus

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What do we already know about this topic?

The workload and years of experience of nurses is an important factor influencing patient and hospital outcomes.

How does your research contribute to the field?

The higher the rate of nurses with more than two years of hemodialysis experience and the lower the daily number of hemodialysis cases per nurse, the higher the rate of hemodialysis patients with normal calcium–phosphorus levels and the better quality of hemodialysis facility.

What are your research's implications towards theory, practice, or policy?

Since this study revealed that nurses' workload and years of experience is related to ensuring high-quality hemodialysis, the results of this study can be used as evidence to suggest the importance of securing sufficient quality nursing personnel.

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Introduction

Chronic kidney disease (CKD) imposes a global health burden to health systems.[1] 697.5 million people worldwide suffer from CKD and 1.2 million people died from CKD in 2017.[2] Renal replacement therapy (RRT), such as dialysis or kidney transplantation, is required when kidney function declines. By 2010, 2.618 million people received RRT worldwide, and it is expected to more than double to 5.439 million people by 2030, with the most growth in Asia.[3] The best treatment for kidney failure is kidney transplantation, but finding a suitable donor is difficult. The only alternative to kidney transplantation is dialysis. Hemodialysis (HD), in particular, is a much more common type of dialysis, accounting for 89% of all dialysis patients.[4] Korea ranks sixth in the world for the cumulative number of patients with end-stage renal disease (ESRD) after Taiwan, Japan, the United States, Singapore, and Portugal.[5] As of 2019, the total number of patients who received RRT in Korea was 108 873, representing a 271% increase since 2000. Of these, 81 760 (75.1%) are receiving HD.[5]

In 2006, the National Kidney Foundation–Kidney Disease Outcomes Quality Initiative (NKF-K/DOQI) developed clinical practice guidelines for HD adequacy in response to the expanding number of HD patients and the need for HD quality control in the United States.[6] In Korea, Korean Society of Nephrology developed clinical practice guideline for optimal HD Treatment,[7] and the Health Insurance Review and Assessment Service (HIRA) has routinely conducted HD adequacy evaluations to manage the quality of HD facilities since 2009.[8]

Cardiovascular diseases (CVD) is very common in HD patients and causes a high risk of mortality.[9] Mortality related to cardiovascular diseases are 20 times higher for HD patients than for the general population, presenting both a social problem and a financial burden on the medical system.[9] Elevated calcium and phosphorus product (Ca×P) levels is significant predictor of CVD, bone mineral disease, and mortality in HD patients.[10,11] Poor control of patients' Ca×P levels during HD can result in vascular calcification. When the Ca×P levels is high, the likelihood of developing CVD complications and bone metabolic diseases increase in patients with ESRD, thereby increasing patient mortality. Thus, patients' Ca×P levels is an important factor that must be managed during HD.[11] According to NKF-K/DOQI clinical practice guidelines for bone metabolism and disease in CKD, a patient's Ca×P levels is recommended to be maintained at 55 mg^2/dL^2 or below.[12,13] In a cohort study of patients with CKD stage V, Ca × P levels above 55 mg^2/dL^2 was associated with a 48% higher risk of death.[10] In Korea, HIRA has designated the Ca×P levels as an important evaluation factor in the adequacy evaluation of HD facilities.[14,15]

HD is a complex treatment that demands highly trained individuals with a variety of skills and more than a certain period of patient care experience.[7] Both physicians and nurses are responsible for the direct and indirect care of patients who undergo HD. Physicians must make their own decisions, taking into account all factors of each patient's situation even when standardized treatment is available in HD.[7] Nurses supervise the HD procedure, administer HD medications, and are responsible for monitoring patients overall and educating them about HD. With increasing emphasis of continuous quality improvement as a means for guaranteeing high-quality patient care, nurses play an important role in improving the HD quality. Nurses are responsible for administering appropriate medications, providing dietary education, and continuously monitoring the patient's blood levels to control their Ca×P levels.[16]

If the nurse's work experience is short or their workload is excessive, identifying issues related to Ca×P levels and providing suitable interventions and education can be difficult.[17,18] The workload of nurses is an important factor that affects patient outcomes, such as mortality, and their overall condition.[19,20] The working year of nurses is also an important factor related to nursing and patient outcomes.[21] Technical and patient-level experience gathered over months is required for dialysis management proficiency.[22] In the US, a head nurse is required to have at least 12 months of clinical experience and an additional 6 months of dialysis experience. In Germany, a nurse should have at least 2 years of clinical experience and 6 months of nephrology work experience to participate in dialysis nurse training.[8] In Korea, nurses are required to have at least 2 years of experience to no longer be considered novices and be considered capable of setting nursing goals and priorities, taking preceptor roles, providing opinions on nursing unit operations, and participating in decision-making.[23] The item for evaluating the HD adequacy also includes the percentage of nurses with two or more years of HD experience.[8,14]

As such, the workload and years of experience of nurses influence the outcomes of HD patients, which is becoming a socioeconomic problem as the number of these patients continues to increase. Therefore, it is necessary to objectively analyze the influence of the workload and years of experience of nurses at HD facilities on HD quality.

Aim

The aim of this study is to analyze the influence of the average workload and years of experience of nurses at HD facilities on the Ca×P levels of patients and the adequacy evaluation grade of HD facilities, which affect patient outcomes, using national HD quality assessment data. The specific objectives are as follows.

- Identification of the workload and rate of nurses with ≥2 years of HD experience in HD facilities.
- Analysis of differences in the rate of patients with normal Ca×P levels and HD adequacy grades according to the workload and rate of nurses with ≥2 years of HD experience.

- Analysis of the influence of nursing workload and rate of nurses with ≥2 years of HD experience on the rate of patients with normal Ca×P levels and HD adequacy evaluation grades.

Methods

Study Design

This is a cross-sectional study designed to analyze the influence of the workload and years of experience of nurses at hospital-level outpatient HD facilities in Korea on the rate of patients with normal Ca×P levels and HD adequacy evaluation grades using 2015 and 2018 national HD quality assessment data from the HIRA.

Data Source and Sample

The HIRA, a national institution in Korea, has conducted the national HD quality assessment on outpatient HD facilities every 3 years since 2009 and publishes the results, from which this study collected data on hospital-level outpatient HD facilities. In addition, to identify the number of artificial kidney machines each facility used for HD, we used data from the HIRA website on the medical equipment status of each facility. The required sample size was calculated using G-Power 3.1.9.7. In order to examine the factors that influenced the rate of patients with normal Ca×P levels, linear multiple regression analysis was conducted with a significance level of .05, a power of .95, and 7 predictors. When the effect size for R^2 was set at .05, as suggested in a previous study,[24] the minimum required sample size was 444 facilities. Only 318 facilities had no missing values for all variables from the most recent set of data from 2018; thus, since the number of facilities was insufficient, data from 2015 on 298 facilities were also included in the analysis. This study ultimately analyzed a total of 616 hospital-level outpatient HD facilities for which no data on both staffing and the number of HD machines were missing.

Research Variables

Nursing workload and years of experience. Nursing workload, defined as the amount of time and care that a nurse can dedicate directly or indirectly to patients, the workplace, and professional development, has traditionally been regarded as the ratio of demands or task load for available resources.[25] In this study, nurses' workload was measured as the average daily number of HD cases per nurse. This is the total number of HD cases per year divided by the number of annual working days of all nurses in the HD facility. The years of experience generally means how many years worked as a nurse. In this study, it was measured as the rate of nurses with ≥2 years of HD experience, since it is a hospital-level study

and requires at least 2 years of work in one field to be considered competent.[23] This rate was obtained by dividing the sum of the number of working days of nurses with ≥2 years of HD experience by the sum of the number of working days of total nurses in the HD facility.

HD quality. HD quality can be defined as complying with established targets for clinical indicators such as HD dose, time, and implement processes.[26] In this study, the rate of patients with normal Ca×P levels and the final HD adequacy evaluation grade were used as the outcome variables, HD quality indicators. The rate of patients with normal Ca×P levels was calculated as the rate of patients with a Ca×P levels of 55 mg^2/dL^2 or less among patients who underwent HD at least once during the evaluation period. The HD adequacy evaluation grades score using a total of 13 HD quality assessment indicators consisting of structure-process-result categories and then weighted to calculate the overall score. The HD adequacy evaluation grades ranged from grade 1 (the best) to grade 5 (the worst).

Control Variables. The average daily number of HD cases per physician, the rate of physicians specializing in HD, and the number of artificial kidney machines for HD at each facility were set as control variables. The average daily number of HD cases per physician is the total number of HD cases per year divided by the number of annual working days of all physicians in the HD facility. The rate of physicians specializing in HD is obtained by dividing the sum of the working days of physicians specializing in HD by the sum of the working days of all physicians in HD facility.

Data Analysis

Descriptive analysis was conducted to describe the general characteristics of HD facilities. One-way analysis of variance and the *t*-test were conducted to analyze differences in the rate of patients with normal Ca×P levels according to the workload and years of experience of nurses. The Scheffe test was performed as a post-hoc test. The chi-square test was conducted to analyze differences in HD adequacy evaluation grades. The influence of the workload and years of experience of nurses on the rate of patients with normal Ca×P levels were analyzed using simultaneous multiple linear regression. Factors that affected the HD adequacy evaluation grades were analyzed using ordinal logistic regression. There was no problem of autocorrelation, even for facilities that were assessed in both 2015 and 2018 (Durbin–Watson=1.625). In addition, to test the assumption of regression analysis for independent variables, multicollinearity, residuals, and singular values were examined to confirm that the regression model of this study satisfied all assumptions of the regression equation. All statistical analyses were conducted using SPSS version 25 (IBM Corp, Armonk, NY, USA).

Table 1. General characteristics of HD facilities (N=616).

Categories		N	%
Year	2015	298	48.4
	2018	318	51.6
Type	Tertiary hospital	84	13.6
	General hospital	401	65.1
	Primary hospital	131	21.3
Average daily number of HD cases per nurse (cases)	mean±SD (min, max)	5.5±1.4 (2.4, 17.4)	
	≤4 cases	38	6.2
	>4 cases and <6 cases	416	67.5
	≥6 cases	162	26.3
Rate of nurses with ≥2 years of HD experience (%)	mean±SD (min, max)	70.2±18.6 (.0, 100.0)	
	≤60%	176	28.6
	>60% and <80%	243	39.4
	≥80%	197	32.0
Average daily number of HD cases per physician (cases)	mean±SD (min, max)	23.5±10.6 (4.8, 79.6)	
	≤15 cases	129	20.9
	>15 cases and <30 cases	341	55.4
	≥30 cases	146	23.7
Rate of physicians who specialized in HD (%)	mean±SD (min, max)	80.0±38.5 (.0, 100.0)	
	0%	110	17.9
	>0% and <100%	32	5.2
	100%	474	76.9
Number of artificial kidney machines for HD (machines)	mean±SD (min, max)	29.2±16.3 (7, 184)	
	≤20 machines	200	32.5
	21–39 machines	295	47.9
	≥40 machines	121	19.6
Rate of patients with normal Ca×P levels (%)	mean±SD (min, max)	85.9±11.3 (25.0, 100.0)	
	≤80%	173	28.1
	>80% and <95%	296	48.0
	≥95%	147	23.9
HD adequacy evaluation grade (grade)	Grade 1 (highest)	130	21.1
	Grade 2	222	36.0
	Grade 3	168	27.3
	Grade 4	65	10.6
	Grade 5 (lowest)	31	5.0

HD: Hemodialysis.

Ethical Consideration

Since this study did not collect and or record personal identification information and used publicly available hospital-level information disclosed to the public, it was approved that the review requirement was waived by the S Hospital Institutional Review Board (Request for decision on human subject research No. 2020-003).

Results

General Characteristics of HD Facilities

The daily number of HD cases per nurse across the 616 facilities included in this study ranged from 2.4 to 17.4, with an average of 5.5±1.4. The rate of nurses with ≥2 years of HD experience varied from 0% to 100%, with an average of 70.2±18.6%. The average daily number of HD cases per physician was 23.5±10.6, and the rate of

physicians who specialized in HD was 80.0±38.5%. The average number of artificial kidney machines for HD was 29.2±16.3. The rate of patients with normal Ca×P levels was 85.9±11.3% on average, with a minimum of 25.0% to a maximum of 100%. Grade 2 was the most common HD adequacy evaluation grade, covering 222 facilities (36.0%). Table 1

Rate of Patients With Normal Ca×P Levels According to the Workload and Years of Experience of Nurses

The rate of patients with normal Ca×P levels at facilities with ≥6 daily HD cases per nurse was significantly lower, at 82.9±11.3%, than other facilities (F=7.981, $P<.001$). The rate of patients with normal Ca×P levels was statistically significantly lower in facilities with 60% or lower of nurses with ≥2 years of HD experience (83.1±12.0%) than in facilities with more than 60% (F=8.456, $P<.001$). In addition, the rate

of patients with normal Ca×P levels at facilities that did not have physicians who specialized in HD was 80.2±13.2%, which was statistically significantly lower than other facilities (F=18.116, P<.001). Table 2

Table 2. Rate of patients with normal Ca×P levels according to the workload and years of experience of nurses.

Categories		Mean	SD	t/F (P)	Scheffe
Year	2015	84.7	11.4	2.502 (.013)	-
	2018	87.0	11.1		
Type	Tertiary hospital[a]	91.0	8.3	14.677 (<.001)	c<b<a
	General hospital[b]	85.9	11.2		
	Primary hospital[c]	82.6	12.3		
Average daily number of HD cases per nurse (cases)	≤4 cases[a]	86.1	11.7	7.981 (<.001)	c<b
	>4 cases and <6 cases[b]	87.1	11.2		
	≥6 cases[c]	82.9	11.3		
Rate of nurses with ≥2 years of HD experience (%)	≤60%[a]	83.1	12.0	8.456 (<.001)	a<bc
	>60% and <80%[b]	87.4	11.3		
	≥80%[c]	86.6	10.3		
Average daily number of HD cases per physician (cases)	≤15 cases[a]	85.1	14.3	.441 (.645)	-
	>15 cases and <30 cases[b]	86.2	10.5		
	≥30 cases[c]	86.0	10.2		
Rate of physicians who specialized in HD (%)	0%[a]	80.2	13.2	18.116 (<.001)	a<bc
	>0% and <100%[b]	85.9	10.2		
	100%[c]	87.2	10.5		
Number of artificial kidney machines for HD (machines)	≤20 machines[a]	82.8	12.3	15.106 (<.001)	a<b<c
	21–39 machines[b]	86.5	11.1		
	≥40 machines[c]	89.6	8.6		

SD, standard deviation; HD, Hemodialysis.

Table 3. HD adequacy evaluation grades according to the workload and years of experience of nurses.

Categories		n(%)					$\chi^2(P)$
		1	2	3	4	5	
Year	2015	52(40.0)	105(47.3)	87(51.8)	39(60.0)	15(48.4)	8.054 (.090)
	2018	78(60.0)	117(52.7)	81(48.2)	26(40.0)	16(51.6)	
Type	Tertiary hospital	59(45.4)	24(10.8)	1(.6)	0(.0)	0(.0)	230.187 (<.001)
	General hospital	65(50.0)	164(73.9)	127(75.6)	38(58.5)	7(22.6)	
	Primary hospital	6(4.6)	34(15.3)	40(23.8)	27(41.5)	24(77.4)	
Average daily number of HD cases per nurse (cases)	≤4 cases	16(12.3)	9(4.1)	8(4.8)	4(6.2)	1(3.2)	227.516 (<.001)
	>4 and <6 cases	114(87.7)	197(88.7)	72(42.9)	29(44.6)	4(12.9)	
	≥6 cases	0(0.0)	16(7.2)	88(52.4)	32(49.2)	26(83.9)	
Rate of nurses with ≥2 years of HD experience (%)	≤60%	10(7.7)	64(28.8)	60(35.7)	27(41.5)	15(48.4)	48.172 (<.001)
	>60% and <80%	74(56.9)	88(39.6)	56(33.3)	19(29.2)	6(19.4)	
	≥80%	46(35.4)	70(31.5)	52(31.0)	19(29.2)	10(32.3)	
Average daily number of HD cases per physician (cases)	≤15 cases	46(35.4)	27(12.2)	25(14.9)	19(29.2)	12(38.7)	73.491 (<.001)
	>15 cases and <30 cases	77(59.2)	141(63.5)	78(46.4)	30(46.2)	15(48.4)	
	≥30 cases	7(5.4)	54(24.3)	65(38.7)	16(24.6)	4(12.9)	
Rate of physicians who specialized in HD (%)	0%	1(.8)	1(.5)	33(19.6)	48(73.8)	27(87.1)	329.575 (<.001)
	>0% and <100%	4(3.1)	7(3.2)	16(9.5)	3(4.6)	2(6.5)	
	100%	125(96.2)	214(96.4)	119(70.8)	14(21.5)	2(6.5)	
Number of artificial kidney machines for HD (machines)	≤20 machines	23(17.7)	53(23.9)	67(39.9)	38(58.5)	19(61.3)	84.894 (<.001)
	21–39 machines	56(43.1)	128(57.7)	80(47.6)	20(30.8)	11(35.5)	
	≥40 machines	51(39.2)	41(18.5)	21(12.5)	7(10.8)	1(3.2)	

HD, Hemodialysis.

Table 4. Multiple linear regression analysis of factors related to the rate of patients with normal Ca×P levels.

Variables		B	SE	β	t	p
(Constant)		76.976	2.934		26.233	<.001
Year 2018 (ref. 2015)		1.913	.880	.085	2.173	.030
Type (ref. Primary hospital)	Tertiary hospital	3.013	1.938	.091	1.555	.121
	General hospital	1.011	1.174	.043	.862	.389
Average daily number of HD cases per nurse		−.450	.336	−.054	−1.338	.181
Rate of nurses with ≥2 years of HD experience		.055	.024	.091	2.331	.020
Average daily number of HD cases per physician		−.033	.046	−.031	−.708	.479
Rate of physicians who specialized in HD		.052	.013	.178	4.002	<.001
Number of artificial kidney machines for HD		.070	.032	.101	2.157	.031
F(p)		8.673(<.001)				
R^2		.103				
Adjusted R^2		.091				

HD, Hemodialysis.

HD Adequacy Evaluation Grades According to the Workload and Years of Experience of Nurses

Most tertiary hospitals were grade 1–2 facilities, and most of the grade 5 facilities were primary hospitals (χ^2=230.187, P<.001). Table 3 None of the grade 1 facilities had an average daily number of ≥6 HD cases per nurse, whereas 83.9% of grade 5 facilities did (χ^2=227.516, P<.001). Facilities where ≤60% of nurses had more than 2 years of HD experience accounted for 7.7% of grade 1 facilities and 48.4% of grade 5 facilities (χ^2=48.172, P<.001). All physicians specialized in HD at 96.2% of grade 1 facilities, while 87.1% of grade 5 facilities had no physicians who specialized in HD (χ^2=329.575, P<.001). The rate of facilities with ≤20 artificial kidney machines increased as the HD adequacy evaluation grade worsened (χ^2=84.894, P<.001).

Factors That Influenced the Rate of Patients With Normal Ca×P Levels

Table 4 shows the results of the multiple linear regression that was conducted to analyze the influence of nursing workload and rate of nurses with ≥2 years of HD experience on the rate of patients with normal Ca×P levels. The rate of nurses with ≥2 years of HD experience (β=.091, P=.020), the rate of physicians who specialized in HD (β=.178, P<.001), and the number of artificial kidney machines (β=.101, P=.031) were positively correlated with the rate of patients with normal Ca×P levels. The average daily number of HD cases per nurse and physician correlated to decreased rates of patients with normal Ca×P levels, but were not statistically significant.

Factors That Influenced the HD Adequacy Evaluation Grades

Table 5 shows the results of the ordinal logistic regression analysis of the influence of nursing workload and rate of nurses with ≥2 years of HD experience on the HD adequacy evaluation grade. HD adequacy evaluation grades were found to be affected by the hospital type, the average daily number of HD cases per nurse, the rate of nurses with ≥2 years of HD experience, the average daily number of HD cases per physician, the rate of physicians who specialized in HD, and the number of artificial kidney machines. The probability of a facility receiving the higher grade for its HD adequacy evaluation decreased as the average daily number of HD cases per nurse increased (odds ratio (OR)=.17, 95% confidence interval (CI)=.14–.22) and the average daily number of HD cases per physician increased (OR=.92, 95% CI=.90–.94), whereas it increased as the rate of nurses with ≥2 years of HD experience increased (OR=1.04, 95% CI=1.03–1.05), the rate of physicians who specialized in HD increased (OR=1.07, 95% CI=1.06–1.08), and the number of artificial kidney machines increased (OR=1.03, 95% CI=1.01–1.04).

Discussion

In this study, it was found the nursing workload and rate of nurses with ≥2 years of HD experience had a positive influence on the rate of HD patients with normal Ca×P levels and the HD adequacy evaluation grades after adjusting the hospital type, physician's characteristics, and number of artificial kidney machines using data from 616 hospital-level outpatient HD facilities in Korea. The detailed discussion of this study is as follows.

First, the staffing level of the HD facilities vary greatly, and accordingly, the rate of patients with normal Ca×P levels and the HD adequacy evaluation grades were different. The average daily number of HD cases per nurse differed by 4 times depending on the facility, and the average daily number of HD cases per physician differed by 16 times. In addition, the rate of nurses with ≥2 years of HD experience and the rate of physicians who specialized in HD ranged from 0% to 100%. A study that analyzed 4800 HD facilities in the US

Table 5. Ordinal logistic regression analysis of factors related to HD adequacy evaluation grades.

Variables		OR	95% CI		p
Year 2018 (ref. 2015)		1.44	1.01	2.05	.043
Type (ref. Primary hospital)	Tertiary hospital	5.02	2.24	11.27	<.001
	General hospital	1.63	1.02	2.60	.040
Average daily number of HD cases per nurse		.17	.14	.22	<.001
Rate of nurses with ≥2 years of HD experience		1.04	1.03	1.05	<.001
Average daily number of HD cases per physician		.92	.90	.94	<.001
Rate of physicians who specialized in HD		1.07	1.06	1.08	<.001
Number of artificial kidney machines for HD		1.03	1.01	1.04	.002

OR, odds ratio; CI, confidence interval; HD, Hemodialysis.

also suggested that there was significant variation across facilities in the patient care staffing levels.[27] Although Korea manages HD facilities through the national HD quality assessment, more efforts are needed to reduce these deviations as there are still many deviations. Health care professionals are unlikely to desire to work in environments that provide little support for education and professional development.[28] Many nurses working in HD facilities exhausted due to heavy workload and lack of resources.[29] Institutional improvement and support are needed to improve the environment of the HD facilities to attract more experienced health care personnel.

Second, this study suggests a reference point for the HD nurse staffing level to improve patient's normal Ca×P levels. The rate of patients with normal Ca×P levels was high in facilities where the rate of nurses with ≥2 years of HD experience is more than 60%. Additionally, the rate of nurses with ≥2 years of HD experience was found to positively correlate with the rate of patients with normal Ca×P levels. Nurses play many roles in the treatment of HD patients and are responsible for ensuring a high quality of care while maintaining a cost-effective environment and promoting patient and staff safety and satisfaction.[16,29] Maintaining appropriate Ca×P levels is one way to reduce mortality and morbidity in HD patients.[9] Since nurses play an important role in monitoring, detecting, and educating patients, they can greatly affect the rate of patients with normal Ca×P levels. This is similar to the results of previous studies that the years of experience of nurses affects patient outcomes. Nurses with more experience provide better patient care and reduce the length of stay.[21] The ORs of pediatric cardiac surgery mortality increased as the rate of nurses with ≤2 years clinical experience increased and the ORs of mortality were highest when the rate of nurses with ≤2 years' clinical experience was 20% or greater in pediatric critical care unit.[30] As the years of experience of nurses increased, missed care tended to decrease in a tertiary university hospital.[31] In the randomized study, experienced (≥2 years) endoscopy nurse participation significantly increased the polyp detection rate and adenoma detection rate during screening colonoscopy.[32] Therefore, HD facilities must ensure a suitable level of experienced nurses. The HD facility regulations of Centers for Medicare &

Medicaid Services presented requirements qualifications of the nurses, but did not provide the ratio of nurse staffing composition.[27] Based on our findings, HD facilities should aim to maintain a 60% or higher rate of nurses with ≥2 years of HD experience to provide high-quality nursing care.

Third, the workload of nurses and the rate of nurses with ≥2 years of HD experience had an influence on the HD adequacy evaluation grades. Through ordinal logistic regression, we found that an increase in the average daily number of HD cases per nurse decreased the probability of receiving the next higher grade by 83%, and an 1%p increase in the rate of nurses with ≥2 years of HD experience increased the probability of a facility receiving the next higher grade by 1.04 times. The relationship between the workload and patient outcomes has been demonstrated in many studies. As nursing workload increase, patient outcome tend to worsen, and the likelihood of missed care also increases.[18,20,33] In a study of chronic HD unit in the US, increased workload due to shortages of nursing personnel were significantly associated with high rates of incomplete tasks, shortened treatments, and skipped treatments.[34] A study of outpatient HD facilities in the US found that high workload among registered nurses had negative effects on patient safety.[35] Our results support the findings of previous studies that heavy workload and insufficient nursing experience are associated with a lack of patient monitoring, proper administration of medication, and proper education for HD patients, which can ultimately negatively affect the outcomes of HD patients.

Through the above discussion, this study provides evidence that nurses' workload and HD experience level lead to variations in the outcomes of HD facilities. The number of HD patients overall is increasing rapidly, and the cost of treatment is rising sharply.[1] Many countries, recognizing the importance of the workload and work experience of nurses, have implemented mandatory minimum nurse-to-patient ratios.[36] This has been found to positively affect not only patient outcomes but also nursing outcomes, such as burnout and job dissatisfaction.[19] Therefore, HD facilities should maintain manageable workload for nurses and ensure a high level of HD experience among nurses in order to provide quality care. If HD facilities maintained sufficient nurses, thus

reducing the workload of them, the HD quality would improve, allowing for high-quality patient management and education.

Our study has several limitations. First, this was a cross-sectional study, thus limiting its ability to examine the causal relationship between the workload and years of experience of nurses and HD quality. Second, although various indicators are used to evaluate the HD quality, this study only included the rate of patients with normal Ca×P levels and the HD adequacy evaluation grades of HD facilities as outcome variables. Third, the HD quality is affected by various variables, such as the location and size of the HD facility, emergency equipment, working environment, diverse healthcare personnel, the educational level of them, the rate of regular personnel, the actual nursing service time, etc., which were not included in this study. However, due to data limitations in this study, only hospital type, workload and work experience of nurses and physicians, and number of HD machines were included in our analysis. Finally, in this study, aggregated data at the hospital level were used rather than patient-level data. Therefore, this study was unable to consider patient-related factors such as the patient's disease, disease severity, comorbidity, age, and sex, all of which can affect patients' Ca×P levels. Accordingly, future studies should undertake a longitudinal study and more sophisticated analysis that accounts for patient-level data, characteristics of HD facility, various healthcare personnel, and outcome variables. Despite these limitations, this study is significant in that it objectively demonstrated the influence of workload and HD experience of nurses in improving the quality of care at HD facilities using nationally representative data.

Conclusions

This study examined the influence of the workload and years of experience of nurses on HD quality using the HIRA's HD quality assessment data. As a result, it was revealed that the workload of nurses and the rate of nurses with ≥2 years of HD experience are factors that affect the rate of HD patients with normal Ca×P levels and the adequacy evaluation grades of HD facilities. Therefore, HD facilities should strive to improve the HD quality by maintaining appropriate workload for nurses and ensuring a high rate of skilled nurses. Further studies that present objective evidence that can be used to design and implement appropriate standards for nurses' workload and work experience level must be conducted.

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