BMJ Open

The association between human resources and risk of hospitalization in chronic kidney disease outpatients receiving hemodialysis

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2016-011319
Article Type:	Research
Date Submitted by the Author:	28-Jan-2016
Complete List of Authors:	Choi, Hoon-Hee; Graduate School of Public Health, Yonsei University, Department of Health Policy and Management; Health Insurance Review and Assessment Service Han, Kyu-Tae; Yonsei University College of Medicine, Department of Public Health & Institute of Health Services Research Nam, Chung Mo; Yonsei University College of Medicine, Biostatistics Moon, Ki Tae; National Evidence-Based Healthcare Collaborating Agency Park, Eun-Cheol; Yonsei University College of Medicine, Department of Preventive Medicine and Institute of Health Services Research
Primary Subject Heading:	Health services research
Secondary Subject Heading:	Renal medicine, Health policy
Keywords:	chronic kidney disease, health outcome, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, healthcare quality assessment, hemodialysis

Title: The association between human resources and risk of hospitalization in chronic kidney disease outpatients receiving hemodialysis

Hoon-Hee Choi, RN, MPH[1, 2]

Email: hee187@hanmail.net

*Co-first author

Kyu-Tae Han[3, 4, *]

*Co-first author

Email: kthan@yuhs.ac

Chung Mo Nam, PhD[5]

Email: CMNAM@yuhs.ac

Ki Tae Moon, MD, PhD[6]

Email: tubemed@hanmail.net

Eun-Cheol Park, MD, PhD[4, 5, †]

†Corresponding author

Email: ecpark@yuhs.ac
Tel.: 82-2-2228-1862, Fax: 82-2-392-7734

[1]Department of Health Policy and Management, Graduate School of Public Health, Yonsei University, Seoul, Republic of Korea

[2]Health Insurance Review and Assessment Service, Seoul, Republic of Korea

[3]Department of Public Health, Graduate School, Yonsei University, Seoul, Republic of Korea

[4]Institute of Health Services Research, Yonsei University College of Medicine, Seoul, Republic of Korea

[5]Department of Preventive Medicine, Yonsei University College of Medicine, Seoul, Republic of Korea

[6]National Evidence-Based Healthcare Collaborating Agency, Seoul, Republic of Korea

Abstract

Objective The number of patients requiring hemodialysis has gradually increased in South Korea. Due to this growth, concerns have been raised regarding hemodialysis quality of care, and healthcare professionals must consider alternatives for appropriate management of patients with chronic kidney disease (CKD). Therefore, we investigated the association between risk of hospitalization of outpatients who received hemodialysis due to CKD and the human resources of the hemodialysis unit.

Setting We used data from National Health Insurance (NHI) claims during Oct 2013–Sep 2014.

Participants These data consisted of 47,891 outpatients with CKD (6,028,712 outpatient cases) who received hemodialysis.

Interventions No interventions were made.

Outcome measure We performed Poisson regression analysis using the generalized estimating equation (GEE) that included both patient and hemodialysis unit characteristics to examine the factors associated with hospitalization of CKD outpatients.

Results Among 6,028,712 outpatient cases, 19,804 (0.59%) were hospitalized during the study period. A higher proportion of hemodialysis patient care specialists or a higher number of nurses experienced in hemodialysis had an inverse association with risk of hospitalization (per 10% increase in hemodialysis patient care specialists: relative risk [RR]=0.989, 95% confidence interval [CI]=0.980–0.998; per increase in 10 nurses experienced in hemodialysis: RR=0.886, 95% CI=0.817–0.983). In addition, a low-quality hemodialysis unit, as

determined by healthcare quality assessment, had a positive association with risk of hospitalization.

Conclusions Our findings suggest that hemodialysis units with high-quality, hemodialysis-specialized human resources, or hemodialysis units that observe hemodialysis standards, could prevent the deterioration of CKD outpatients. Based on our findings, health policy makers and professionals should implement strategies for the optimal management of patients with CKD.

Keywords: chronic kidney disease; health outcome; health policy; healthcare quality assessment; hemodialysis

Strength and limitation of this study

- Our results may prove useful for designing an effective strategy for managing CKD patients receiving hemodialysis.
- This study reflects the variety and severity of each patient and the medical institution situation.
- We could not include other factors which could affect outcome variables in this study because the data used were secondary data of the NHI claim data.
- We could not identity whether each patient actually received treatment from specific human resources in each hemodialysis unit.

Introduction

As the overall health status of South Koreans improved due to economic and health technology development during the late 20th century, the elderly population has grown, and South Korea is expected to become an aged society [1]. Naturally, health problems related to aging, such as chronic diseases, have become more prevalent compared to past centuries, leading to a gradual increase in utilization of healthcare due to diabetes and hypertension, as well as problems related to such diseases (hypertension: 27.3% and diabetes: 7.7% among those >30 years of age in 2013) [2]. One of these related diseases is chronic kidney disease (CKD). CKD is defined as a progressive loss of kidney function, and generally causes neurological, cardiovascular, and digestive symptoms, as well as anemia or hemorrhage, and in severe cases, death [3].

Patients with CKD receive medical services for preventing comorbid conditions or progression of CKD, including hemodialysis and kidney transplantation, based upon the severity of their CKD [4 5]. Hemodialysis is a common treatment for severe cases of CKD. According to the reports of the Health Insurance Review and Assessment (HIRA), the number of patients who underwent hemodialysis and the associated average medical cost due to hemodialysis have rapidly increased (56,896 patients in 2009 to 69,837 in 2013; ~1,241 billion KRW average medical cost in 2009 to 1,640 billion KRW in 2013) [6].

Previous studies have found that several factors, such as workload, hemodialysis unit human resources, and unit characteristics could reduce the quality of care in managing patients with CKD [7 8]. However, as the number of patients receiving hemodialysis increases, the quality of care in providing hemodialysis for CKD is expected to decrease due to increasing workload.

Although the South Korean government introduced healthcare quality assessment for hemodialysis unit resources (human and device or management level) to improve the level of and quality of care in providing hemodialysis for patients with CKD after 2009, there are few studies examining the relationship between hemodialysis unit resources and quality of hemodialysis care after the introduction of healthcare quality assessment [9]. Therefore, there are remaining concerns with respect to optimal care and reduction in quality of hemodialysis due to hospital competition and overcrowding. Thus, we focused only on the diagnosed CKD patients who received hemodialysis, and investigated which factors, including human resources, in each hemodialysis unit were associated with hospitalization due to CKD as indicators for quality of care. The results of this study provide important information regarding healthcare quality assessment for hemodialysis, and may aid in providing solutions for possible future problems related to the care of patients with CKD.

Materials and methods

Data source and study population

We used two datasets from the National Health Insurance (NHI) claim data. The first dataset was claim data for 53,583 patients previously diagnosed with CKD (International Classification of Diseases [ICD]-10: N18) who received hemodialysis at medical institutions during October 2013–September 2014. The second dataset included claim data regarding utilization of a medical institution due to CKD during October 2008–September 2013 and claim data regarding hospitalization due to CKD during October 2012–September 2013; this dataset reflected the severity and duration of illness of patients with CKD receiving

hemodialysis. These two datasets were merged for the final analysis to investigate the association between factors including human and medical resources in each hemodialysis unit and hospitalization. We excluded patients diagnosed with CKD stages 1–3 to reduce variation between patients. Patients with duration of illness of less than 1 year were also excluded to remove the possibility of including hospitalization due to arteriovenous fistula formation for hemodialysis and not due to worsening status of the patient. Finally, 6,028,712 outpatient cases of 47,891 patients were included for analysis. The unit of analysis was outpatient cases due to hemodialysis.

Variables

The outcome variable used in this study was whether patients who were previously diagnosed with CKD were hospitalized after outpatient care due to hemodialysis. If a patient with CKD was hospitalized after specific outpatient care for hemodialysis, we assumed that this outpatient care caused the hospitalization due to the worsening status of the patient receiving hemodialysis treatment [10 11].

The primary variables of interest in this study were the human resources at each medical institution, listed as follows: number of total doctors who provided hemodialysis, proportion of hemodialysis patient care specialists, number of total nurses who provided hemodialysis, and proportion of nurses experienced in hemodialysis. The number of total doctors or nurses was defined as the actual number of doctors or nurses who provided hemodialysis services for patients with CKD. The proportion of hemodialysis patient care specialists was defined as the proportion of specialists in either internal medicine or pediatrics with a focus on

nephrology, who were trained in hemodialysis or had more than 3 years of experience with hemodialysis. The proportion of nurses experienced with hemodialysis was defined as the proportion of nurses who had more than 2 years of experience with hemodialysis.

We also adjusted for patient and hemodialysis unit characteristics when analyzing the relationship between human resources and hospitalization after hemodialysis. The included patient characteristics were: age, sex, type of insurance coverage, major diagnosis, experience of pre-hospitalization during 1 year, duration of illness, and Charlson Comorbidity Index (CCI). Age was classified into ≤49 years, 50–59 years, 60–69 years, and ≥70 years. Types of insurance coverage, as defined by NHI, are: the general population and the beneficiaries of Medical Aid (those with low income, disability, or the elderly, who are provided with free inpatient and outpatient care by the government). Therefore, types of insurance coverage could represent the socio-economic status of each inpatient. Major diagnosis was used based on ICD-10 coding. Pre-hospitalization during 1 year was defined as whether a patient was hospitalized due to CKD (ICD-10: N18) during October 2012–September 2013 to reflect the severity of each patient who was previously diagnosed with CKD. The duration of illness was defined as the period from the first diagnosis of CKD; it was classified into a yearly unit. CCI was calculated using the comorbid conditions upon hospitalization and was weighted and scored with additional points added to consider comorbidities that could affect outcomes of CKD patients.

The included hemodialysis unit characteristics (excluding human resources) were: type of medical institution, presence of a nephrologist, hemodialysis volume per one doctor, number of beds, criteria for hemodialysis machine for patients with hepatitis B, emergency equipment in the hemodialysis unit, fulfillment rate of criteria for duration of water analysis, number of

hemodialysis machines, and proportion of medical cost due to CKD. Types of medical institution were classified into "general hospital" or "clinics or hospital". The criteria for hemodialysis machines for patients with hepatitis B was whether the hemodialysis unit met the minimum number of hemodialysis machines for only those with hepatitis B, calculated as follows: number of patients with hepatitis B / [(3×days of hemodialysis in nighttime) + (2×days of hemodialysis in daytime)]. Emergency equipment in the hemodialysis unit indicated the presence of emergency equipment in the unit. Fulfillment rate of criteria for the duration of water analysis was whether each hemodialysis unit met the criteria for frequency of the water analysis. The proportion of medical cost due to CKD was the proportion of medical cost due to CKD of the total medical cost of each hemodialysis unit, which is used to reflect the specialties of each hemodialysis unit for managing CKD patients.

Statistical analysis

We examined the distribution of each categorical variable by examining the frequencies and percentages, and then performed χ^2 tests to investigate associations with hospitalization after hemodialysis in patients diagnosed with CKD. In addition, we also performed analysis of variance (ANOVA) to compare average values and standard deviations for continuous variables. In order to investigate the relationship between human resources in a hemodialysis unit and the risk of hospitalization after hemodialysis in patients with CKD, we performed Poisson regression analysis using the generalized estimating equation (GEE) model. GEE models with link logit that included both patient and hospital characteristics were analyzed, as the data used in this study were hierarchically structured and had binary outcome variables.

Additionally, to examine the differences in risk of hospitalization, we performed subgroup analyses according to the presence of a nephrologist, duration of illness, and CCI. All statistical analyses were performed using SAS statistical software, version 9.2.

Results

The data used in this analysis consisted of 6,028,712 outpatient cases of 47,891 patients. Table 1 shows the univariate associations between various independent variables including patient and hemodialysis unit characteristics and hospitalization due to CKD after hemodialysis. Among 6,028,712 outpatient cases, 19,804 (0.59%) were hospitalized due to CKD during the study period. Those in the elderly group were more frequently hospitalized after hemodialysis than all other age groups. Outpatient cases in those with Medical Aid also had more frequent hospitalization than cases with other insurance types (NHI: 0.58%, Medical Aid: 0.65%), and outpatient cases in those with pre-hospitalization during 1 year had more frequent hospitalization than cases without pre-hospitalization (yes: 0.90%, no: 0.41%). In addition, patients with a shorter duration of illness were more frequently hospitalized after hemodialysis than those with a longer duration of illness. Regarding hemodialysis unit characteristics, the cases in general hospitals were more frequently hospitalized due to CKD than cases in clinics or hospitals. Furthermore, cases in hemodialysis units with a nephrologist were more frequently hospitalized than cases in hemodialysis units without a nephrologist. The average number of total doctors in a hemodialysis unit was higher in hospitalization cases whereas the average number of total nurses, proportion of hemodialysis patient care specialists, and proportion of nurses with hemodialysis experience had lower

numbers of hospitalization cases. The average values of hemodialysis volume were lower in hospitalization cases and similar results were obtained regarding numbers of hemodialysis machines. In addition, the average value for proportion of medical cost due to CKD was lower in hospitalization cases (Table 1).

Table 2 shows the results of Poisson regression analysis using the GEE model to investigate the relationship between human resources and risk of hospitalization. The age of the patient was correlated with risk of hospitalization due to CKD. By type of insurance coverage, outpatient cases of beneficiaries of Medical Aid were associated with risk of hospitalization due to CKD more than other types of insurance coverage (Medical Aid=relative risk [RR]: 1.326, 95% confidence interval [CI]: 1.274–1.380; ref=NHI). In addition, patients who experienced pre-hospitalization during 1 year were associated with risk of hospitalization (yes=RR: 1.849, 95% CI: 1.771–1.931). A higher CCI had a positive trend with risk of hospitalization due to CKD, but it was not statistically significant. Regarding hemodialysis unit characteristics, a higher proportion of hemodialysis patient care specialists and a higher number of total nurses who provided hemodialysis were inversely associated with risk of hospitalization (proportion of hemodialysis patient care specialists, per 10% increase=RR: 0.989, 95% CI: 0.980–0.998; number of total nurses who provided hemodialysis=RR: 0.896, 95% CI: 0.817–0.983). Cases of hemodialysis units that satisfied criteria for hemodialysis machines for hepatitis B patients had a higher risk of hospitalization (RR: 1.427, 95% CI: 1.176–1.733). A higher proportion of medical cost due to CKD among total medical costs in each hemodialysis unit was inversely associated with risk of hospitalization (RR: 0.928, 95% CI: 0.913–0.943) (Table 2).

We also performed subgroup analysis to examine differences in relation to risk of hospitalization by duration of illness, CCI, and presence of a nephrologist at a hemodialysis unit. By duration of illness, the higher number of total nurses who provided hemodialysis was inversely associated with risk of hospitalization in the presence of a nephrologist at a hemodialysis unit, but a higher proportion of hemodialysis patient care specialists was inversely associated with risk of hospitalization in the absence of a nephrologist at a hemodialysis unit. By duration of illness, a higher proportion of hemodialysis patient care specialists or a higher number of total nurses who provided hemodialysis was inversely associated with risk of hospitalization only in patients with a longer duration of illness. Similar results were also obtained in the subgroup analysis by CCI; higher hemodialysis unit staffing was inversely associated with risk of hospitalization in cases with a CCI of more than 3 (Table 3).

Discussion

After the late 20th century, new problems related to chronic diseases have rapidly emerged in South Korea. The prevalence of hypertension and diabetes, along with their associated diseases such as CKD, has gradually increased [12 13]. Concerns regarding the quality of care in managing CKD patients have been raised; to solve and prevent these issues, the South Korean government introduced healthcare quality assessment for human and medical resources regarding hemodialysis [9]. Nevertheless, the reduction of quality of care and the worsening status of patients diagnosed with CKD continue to be debated. Therefore, we set out to investigate the relationship between hospital resources, particularly human resources,

and the risk of hospitalization, which were assumed to be indicators of worsening patient status due to a reduction in quality of care.

Our findings suggest that outpatient care for hemodialysis at hemodialysis units with superior human resources, such as a higher proportion of hemodialysis patient care specialists and a higher number of total nurses who provide hemodialysis, was positively associated with better health outcomes in managing CKD patients needing hemodialysis. In addition, patients at hemodialysis units that did not satisfy the criteria for the use of hemodialysis machines for patients with hepatitis B, were negatively associated with health outcomes after treatment. Although previous studies show similar results to those reported in this study, such as better outcomes being associated with better hemodialysis unit resources, ours is one of only a few studies conducted after the introduction of healthcare quality assessment [14-16].

In South Korea, HIRA has evaluated the structure, process, and outcome indicators of hemodialysis for each hemodialysis unit through healthcare quality assessment, and has provided adjustment payment to medical institutions that were applied to the upper 10% or were of lower quality based on the evaluation results after 2009. Given the positive impact of superior human resources on patient outcomes as shown in our study, our findings provide helpful information for healthcare quality assessment of hemodialysis due to CKD. However, we found that the number of total nurses who provided hemodialysis had a positive association with patient outcomes in this study even though it was not included in the evaluation criteria of healthcare quality assessment. Therefore, based upon our results, health policy makers should consider this criteria in healthcare quality assessment, as well as the weight given each factor in an evaluation. In addition, vulnerable patient groups, such as those receiving Medical Aid and the elderly, were negatively associated with healthcare

outcomes after hemodialysis due to CKD, suggesting an imbalance between the ability to pay and copayment when it comes to receiving healthcare [17]. Similarly, healthcare professionals also assert a need to relax copayment for vulnerable populations [18]. Thus, support for vulnerable populations should be afforded careful consideration by health policy makers. There was also an inverse association between the proportion of medical cost due to CKD and risk of hospitalization, which could be caused by specialty differences of each medical institution. Similar results were obtained in previous studies, suggesting a positive function for specialty hospitals in South Korea [19]. Therefore, healthcare professionals might consider increasing their specialties, and policy makers should consider designating additional specialty hospitals for hemodialysis.

Our subgroup analysis also showed interesting results related to efficiency issues. There were some differences in the relationship between human resources and the risk of hospitalization after hemodialysis due to CKD. The positive impact of better human resources was greater in patients with a more severe condition, as evidenced by CCI or duration of illness. Thus, the worsening status of a severely ill patient could be more effectively managed by better hemodialysis unit characteristics, such as a hemodialysis unit with a hemodialysis specialty. However, the role of each human resource was different in each hemodialysis unit based on subgroup analysis by presence of a nephrologist. These results suggest that a hemodialysis patient care specialist could be a viable alternative if a hemodialysis unit does not have a nephrologist. Therefore, the importance of professional manpower is also effectively evaluated in establishing health policy regarding management of CKD patients [20].

These findings have many strengths compared to previous studies. First, the data used in this study was NHI claim data, which consists of overall CKD patients in South Korea who received hemodialysis during 1 year. Thus, our findings have external validity, and would be helpful in establishing evidence-based health policy related to CKD. Second, to the best of our knowledge, ours is the first South Korean study to investigate the relationship between human resources, such as hemodialysis patient care specialists or nurses experienced in hemodialysis, and the risk of hospitalization, as indicators of health outcomes in CKD patients receiving hemodialysis after the introduction of healthcare quality assessment for hemodialysis. Therefore, our results may prove useful for designing an effective strategy for managing CKD patients receiving hemodialysis. Third, we included both patient and hemodialysis unit characteristic variables in this study. Therefore, this study reflects the variety and severity of each patient and the medical institution situation, reducing the limitations of secondary data.

Our study also has some limitations. First, in managing patients with CKD who needed hemodialysis, there were many factors, including clinical conditions, which could affect outcomes of patients with CKD according to previous studies [21-24]. However, we could not include these factors in this study because the data used were secondary data of the NHI claim data. In addition, detailed information, such as procedures or medications provided to patients with hemodialysis was not included in this study. Therefore, more detailed studies are needed. Second, the study period was relatively short (1 year); we excluded patients with duration of illness of less than 1 year because patients in the early stages of CKD could be hospitalized due to arteriovenous fistula formation for hemodialysis. Therefore, to avoid including uncertain causes of hospitalization by either worsening status or arteriovenous

fistula formation, we excluded these patients from this study. Third, we considered human resources as independent variables of major interest in this study, but we could not identity whether each patient actually received treatment from specific human resources in each hemodialysis unit due to limitation of data.

Despite the above limitations, our findings suggest that better human resources, such as specialists and nurses experienced in hemodialysis, could positively affect outcomes in patients who received hemodialysis. In particular, these associations were greater in patients in an economically or clinically vulnerable population, and the role of human resources was different depending upon hemodialysis unit characteristics, such as presence of a nephrologist. Although more detailed studies are needed in the future, health policy makers and healthcare professionals should establish an effective health policy for appropriate management of patients needing hemodialysis due to CKD.

Conclusions

Our findings suggest that outpatient care for hemodialysis at a hemodialysis unit with superior human resources, such as a higher proportion of hemodialysis patient care specialists and a higher number of total nurses who provide hemodialysis, was positively associated with better health outcomes in the management of patients with CKD receiving hemodialysis. Based on our findings, health policy makers and professionals should endeavor to implement strategies for optimal management of patients with CKD.

Authors' Contributions

H.H.C. and K.T.H. designed the study, performed the research and statistical analyses, and wrote the manuscript. K.T.H., J.M.N., K.T.M., and E.C.P. contributed to the discussion and reviewed and edited the manuscript. E.C.P. is the guarantor of this work and as such, has full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. The English in this document has been checked by at least two professional editors, both native English speakers.

Competing interests

The authors report no conflicts of interest in this work.

Funding statement

There is no funding source.

Data sharing statement

No additional data are available.

References

1. Kim EY, Kim Cy. Who Wants to Enter a Long-Term Care Facility in a Rapidly Aging Non-Western Society? Attitudes of Older Koreans Toward Long-Term Care Facilities. J Am Geriatr Soc 2004;**52**(12):2114-19.
2. Korea Centers for Disease Control and Prevention. Korea National Health and Nutrition Examination Survey, 2013.
3. Levey AS, Coresh J. Chronic kidney disease. Lancet 2012;**379**(9811):165-80.
4. Wyld M, Lisa Morton R, Hayen A, et al. A systematic review and meta-analysis of utility-based quality of life in chronic kidney disease treatments. PLoS Med 2012;**9**(9):1435.
5. Levey AS, Coresh J, Balk E, et al. National Kidney Foundation practice guidelines for chronic kidney disease: evaluation, classification, and stratification. Ann Intern Med 2003;**139**(2):137-47.
6. Health Insurance Review & Assessment Service. Statistics for diseases 2009-13.
7. Argentero P, Dell'Olivo B, Santa Ferretti M, et al. Staff burnout and patient satisfaction with the quality of dialysis care. Am J Kidney Dis 2008;**51**(1):80-92.
8. Klersy C, Callegari A, Martinelli V, et al. Burnout in health care providers of dialysis service in Northern Italy—a multicentre study. Nephrol Dial Transplant 2007;**22**(8):2283-90.
9. Kim SM, Jang WM, Ahn HA, et al. Korean National Health Insurance value incentive program: achievements and future directions. J Prev Med Public Health 2012;**45**(3):148.
10. Go AS, Chertow GM, Fan D, et al. Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. N Engl J Med 2004;**351**(13):1296-305.
11. Forman DE, Butler J, Wang Y, et al. Incidence, predictors at admission, and impact of worsening renal function among patients hospitalized with heart failure. J Am Coll Cardiol 2004;**43**(1):61-67.
12. Ayodele OE, Alebiosu CO. Burden of chronic kidney disease: an international perspective. Adv Chronic Kidney Dis 2010;**17**(3):215-24.
13. Couser WG, Remuzzi G, Mendis S, et al. The contribution of chronic kidney disease to the global burden of major noncommunicable diseases. Kidney Int 2011;**80**(12):1258-70.

14. Needleman J, Buerhaus P, Mattke S, et al. Nurse-staffing levels and the quality of care in hospitals. N Engl J Med 2002;**346**(22):1715-22.
15. Thomas-Hawkins C, Flynn L, Clarke SP. Relationships between registered nurse staffing, processes of nursing care, and nurse-reported patient outcomes in chronic hemodialysis units. Nephrology nursing journal: journal of the American Nephrology Nurses' Association 2008;**35**(2):123.
16. Gardner JK, Thomas-Hawkins C, Fogg L, et al. The relationship between nurses' perceptions of the hemodialysis unit work environment and nurse turnover, patient satisfaction, and hospitalizations. Nephrol Nurs J 2007;**34**(3):271.
17. Choi JW, Park E-C, Chun S-Y, et al. Health care utilization and costs among medical-aid enrollees, the poor not enrolled in medical-aid, and the near poor in South Korea. Int J Equity Health 2015;**14**(1):128.
18. Kim J-H, Lee K-S, Yoo K-B, et al. The Differences in Health Care Utilization between Medical Aid and Health Insurance: A Longitudinal Study Using Propensity Score Matching. PLoS One 2015;**10**(3):e0119939.
19. Kim SJ, Park E-C, Jang SI, et al. An analysis of the inpatient charge and length of stay for patients with joint diseases in Korea: specialty versus small general hospitals. Health Policy (New York) 2013;**113**(1):93-99.
20. Mandel SR, Martin PL, Blumoff RL, et al. Vascular Access in a University Transplant and Dialysis Program: Results, Costs, and Manpower Implications. Arch Surg 1977;**112**(11):1375-80.
21. Hsu C, Ordonez J, Chertow G, et al. The risk of acute renal failure in patients with chronic kidney disease. Kidney Int 2008;**74**(1):101-07.
22. Lo LJ, Go AS, Chertow GM, et al. Dialysis-requiring acute renal failure increases the risk of progressive chronic kidney disease. Kidney Int 2009;**76**(8):893-99.
23. Tonelli M, Wiebe N, Culleton B, et al. Chronic kidney disease and mortality risk: a systematic review. J Am Soc Nephrol 2006;**17**(7):2034-47.
24. Chawla LS, Amdur RL, Amodeo S, et al. The severity of acute kidney injury predicts progression to chronic kidney disease. Kidney Int 2011;**79**(12):1361-69.

Table 1. General characteristics of the study population and hemodialysis unit by hospitalization after hemodialysis

Variables	Hospitalization after hemodialysis (N=6,028,712)				P-value
	Yes		No		
	N/Mean	%/SD	N/Mean	%/SD	
Patient characteristics					
Age (years)					
≤49	5,194	0.41	1,274,842	99.59	<0.0001
50–59	8,363	0.51	1,619,384	99.49	
60–69	10,125	0.64	1,579,779	99.36	
≥70	11,835	0.77	1,519,190	99.23	
Sex					
Male	20,276	0.58	3,471,086	99.42	0.0016
Female	15,241	0.60	2,522,109	99.40	
Type of insurance coverage					
NHI	26,369	0.57	4,585,136	99.43	<0.0001
Medical Aid	9,148	0.65	1,408,059	99.35	
Major diagnosis					
CKD, Stage 4–5	28,207	0.59	4,747,864	99.41	0.3606
CKD, Unspecified	7,310	0.58	1,245,331	99.42	
Experience of pre-hospitalization during 1 year					
Yes	19,851	0.90	2,194,915	99.10	<0.0001
No	15,666	0.41	3,798,280	99.59	
Duration of illness (years)					
2–3	3,530	0.74	470,697	99.26	<0.0001
3–4	4,564	0.69	653,879	99.31	
4–5	3,964	0.65	607,844	99.35	
5–6	4,780	0.65	727,949	99.35	
>6	18,679	0.53	3,532,826	99.47	
CCI					
0	4,227	0.42	1,000,334	99.58	<0.0001
1, 2	15,817	0.58	2,723,732	99.42	
3, 4	12,461	0.71	1,752,950	99.29	
5+	3,012	0.58	516,179	99.42	
Hemodialysis unit characteristics					
Type of medical institution					
General hospital (N=240)	18,400	0.87	2,213,923	99.18	<0.0001
Clinic or hospital (N=485)	17,117	0.47	3,779,272	99.55	
Presence of nephrologist					
Yes (N=115)	10,278	0.85	1,281,310	99.20	<0.0001
No (N=610)	25,239	0.55	4,711,885	99.47	
Number of total doctors who provided hemodialysis	1.94	±1.49	1.80	±1.33	<0.0001
Proportion of hemodialysis patient care specialists	80.90	±36.29	81.09	±35.91	0.5411
Number of total nurses who provided hemodialysis	10.46	±6.72	10.82	±6.87	<0.0001
Proportion of nurses experienced in hemodialysis	74.27	±17.21	75.03	±16.68	<0.0001
Volume of hemodialysis per one doctor	1.75	±0.99	1.97	±1.09	<0.0001
Number of beds	319.26	±378.29	235.99	±365.23	<0.0001
Criteria for hemodialysis machines for hepatitis B patients					
Satisfied (N=723)	35,446	0.59	5,986,694	99.41	<0.0001
Unsatisfied (N=2)	71	1.08	6,501	98.92	
Emergency equipment in hemodialysis unit					
Yes (N=645)	33,279	0.59	5,625,825	99.41	0.1794
No (N=80)	2,238	0.61	367,370	99.39	
Fulfillment rate of criteria for duration of water analysis	90.73	±19.94	90.44	±19.87	0.0058
Number of hemodialysis machines	33.60	±17.92	33.95	±18.26	0.0003
Proportion of medical cost due to CKD	38.40	±38.46	53.27	±40.36	<0.0001
Total	35,517	0.59	5,993,195	99.41	

SD, standard deviation; NHI, National Health Insurance; CKD, chronic kidney disease; CCI, Charlson Comorbidity Index

Table 2. Risk of hospitalization after hemodialysis by patient and hemodialysis unit characteristics

Variables	Hospitalization after hemodialysis			
	RR	95% CI		P-value
Patient characteristics				
Age (years)				
≤49	1.000	-	-	-
50–59	1.221	1.107	1.346	<0.0001
60–69	1.506	1.367	1.658	<0.0001
≥70	1.789	1.608	1.990	<0.0001
Sex				
Male	1.006	0.976	1.037	0.7037
Female	1.000	-	-	
Type of insurance coverage				
NHI	1.000	-	-	-
Medical Aid	1.326	1.274	1.380	<0.0001
Major diagnosis				
CKD, Stage 4–5	1.016	0.956	1.080	0.6108
CKD, Unspecified	1.000	-	-	-
Experience of pre-hospitalization during 1 year				
Yes	1.849	1.771	1.931	<0.0001
No	1.000	-	-	-
Duration of illness (years)				
2–3	1.000	-	-	-
3–4	1.005	0.946	1.067	0.8826
4–5	0.995	0.930	1.065	0.8876
5–6	1.020	0.955	1.090	0.5578
>6	0.925	0.874	0.977	0.0057
CCI				
0	1.000	-	-	-
1, 2	1.029	0.932	1.136	0.5748
3, 4	1.013	0.906	1.132	0.8246
5+	1.048	0.921	1.193	0.4736
Hemodialysis characteristics				
Type of medical institution				
General hospital (N=240)	1.000	-	-	-
Clinic or hospital (N=485)	0.964	0.851	1.092	0.5670
Presence of nephrologist				
Yes (N=115)	1.008	0.937	1.085	0.8275
No (N=610)	1.000	-	-	
Number of total doctors who provided hemodialysis (per 10 doctor increase)	0.977	0.526	1.815	0.9429
Proportion of hemodialysis patient care specialists (per 10%)	0.989	0.980	0.998	0.0201
Number of total nurses who provided hemodialysis (per 10 nurse increase)	0.896	0.817	0.983	0.0202
Proportion of nurses experienced in hemodialysis (per 10%)	0.993	0.977	1.009	0.3707
Volume of hemodialysis per one doctor	0.974	0.928	1.021	0.2672
Number of beds (per 10 bed increase)	1.000	0.998	1.001	0.7075
Criteria for hemodialysis machine for hepatitis B patients				
Satisfied (N=723)	1.000	-	-	-
Unsatisfied (N=2)	1.427	1.176	1.733	0.0003
Emergency equipment in hemodialysis unit				
Yes (N=645)	1.000	-	-	-
No (N=80)	0.997	0.870	1.143	0.9674
Fulfillment rate of criteria for duration of water analysis (per 10%)	0.983	0.966	1.001	0.0569
Number of hemodialysis machines (per 10 machine increase)	1.034	0.995	1.074	0.0871
Proportion of medical cost due to CKD (per 10%)	0.928	0.913	0.943	<0.0001

RR, relative risk; CI, confidence interval; NHI, National Health Insurance; CKD, chronic kidney disease; CCI, Charlson Comorbidity Index

Table 3. Subgroup analysis by presence of nephrologist, duration of illness, and CCI*

Subgroup		Variables	RR	95% CI		P-value
Presence of nephrologist	Yes	Number of total doctors who provided hemodialysis	1.107	2.843	0.431	0.8319
		Proportion of hemodialysis patient care specialists	0.973	1.017	0.931	0.2263
		Number of total nurses who provided hemodialysis	0.872	0.985	0.772	0.0280
		Proportion of nurses experienced in hemodialysis	0.999	1.036	0.963	0.9403
	No	Number of total doctors who provided hemodialysis	0.894	1.657	0.482	0.7229
		Proportion of hemodialysis patient care specialists	0.990	0.999	0.981	0.0387
		Number of total nurses who provided hemodialysis	0.908	1.031	0.799	0.1367
		Proportion of nurses experienced in hemodialysis	0.991	1.008	0.973	0.2959
Duration of illness (years)	-5	Number of total doctors who provided hemodialysis	1.058	2.457	0.456	0.8960
		Proportion of hemodialysis patient care specialists	0.990	1.001	0.978	0.0804
		Number of total nurses who provided hemodialysis	0.905	1.018	0.804	0.0977
		Proportion of nurses experienced in hemodialysis	0.993	1.011	0.975	0.4487
	6+	Number of total doctors who provided hemodialysis	0.901	1.468	0.553	0.6759
		Proportion of hemodialysis patient care specialists	0.989	0.998	0.980	0.0222
		Number of total nurses who provided hemodialysis	0.894	0.984	0.812	0.0222
		Proportion of nurses experienced with hemodialysis	0.993	1.011	0.974	0.4423
CCI	0	Number of total doctors who provided hemodialysis	1.157	2.296	0.584	0.6755
		Proportion of hemodialysis patient care specialists	0.986	1.002	0.969	0.0922
		Number of total nurses who provided hemodialysis	0.880	1.015	0.762	0.0800
		Proportion of nurses experienced in hemodialysis	0.976	1.004	0.949	0.0973
	1, 2	Number of total doctors who provided hemodialysis	0.866	1.797	0.417	0.6983
		Proportion of hemodialysis patient care specialists	0.993	1.005	0.982	0.2726
		Number of total nurses who provided hemodialysis	0.925	1.037	0.825	0.1798
		Proportion of nurses experienced in hemodialysis	0.996	1.016	0.976	0.6856
	3, 4	Number of total doctors who provided hemodialysis	1.194	2.340	0.608	0.6072
		Proportion of hemodialysis patient care specialists	0.990	0.999	0.980	0.0372
		Number of total nurses who provided hemodialysis	0.881	0.975	0.797	0.0145
		Proportion of nurses experienced with hemodialysis	0.991	1.011	0.971	0.3764
	5+	Number of total doctors who provided hemodialysis	0.512	1.369	0.192	0.1823
		Proportion of hemodialysis patient care specialists	0.973	0.989	0.957	0.0010
		Number of total nurses who provided hemodialysis	0.827	0.982	0.696	0.0305
		Proportion of nurses experienced in hemodialysis	0.986	1.026	0.947	0.4855

*Table 3 shows the results of subgroup analysis for the relationship between human resources and risk of hospitalization by presence of a nephrologist, duration of illness, and CCI. The results were analyzed by an increase of 10 units for each independent variable. CCI, Charlson Comorbidity Index; RR, relative risk; CI, confidence interval

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	6-7
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	7-8
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	None
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*7-9*
Bias	9	Describe any efforts to address potential sources of bias	8-10
Study size	10	Explain how the study size was arrived at	7-8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, explain how loss to follow-up was addressed	None
		(*e*) Describe any sensitivity analyses	10
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11-12
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	None
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-12
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) Summarise follow-up time (eg, average and total amount)	11-12
Outcome data	15*	Report numbers of outcome events or summary measures over time	11-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-13
		(*b*) Report category boundaries when continuous variables were categorized	9-10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	None
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	13
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-14
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	16-17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

The association between human resources and risk of hospitalization in end-stage renal disease outpatients receiving hemodialysis: a longitudinal cohort study using claim data during 2013-2014

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2016-011319.R1
Article Type:	Research
Date Submitted by the Author:	09-May-2016
Complete List of Authors:	Choi, Hoon-Hee; Graduate School of Public Health, Yonsei University, Department of Health Policy and Management; Health Insurance Review and Assessment Service Han, Kyu-Tae; Yonsei University College of Medicine, Department of Public Health & Institute of Health Services Research Nam, Chung Mo; Yonsei University College of Medicine, Biostatistics Moon, Ki Tae; National Evidence-Based Healthcare Collaborating Agency Kim, Woorim; Yonsei University College of Medicine, Department of Public Health Park, Eun-Cheol; Yonsei University College of Medicine, Department of Preventive Medicine and Institute of Health Services Research
Primary Subject Heading:	Health services research
Secondary Subject Heading:	Renal medicine, Health policy
Keywords:	chronic kidney disease, health outcome, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, healthcare quality assessment, hemodialysis

Title: The association between human resources and risk of hospitalization in end-stage renal disease outpatients receiving hemodialysis: a longitudinal cohort study using claim data during 2013-2014

Hoon-Hee Choi, RN, MPH[1, 2]

Email: hee187@hanmail.net

*Co-first author

Kyu-Tae Han[3, 4, *]

[*]Co-first author

Email: kthan@yuhs.ac

Chung Mo Nam, PhD[5]

Email: CMNAM@yuhs.ac

Ki Tae Moon, MD, PhD[6]

Email: tubemed@hanmail.net

Woorim Kim[3, 4]

Email: woorimk@yuhs.ac

Eun-Cheol Park, MD, PhD[4, 5, †]

[†]Corresponding author

Email: ecpark@yuhs.ac
Tel.: 82-2-2228-1862, Fax: 82-2-392-7734

[1]Department of Health Policy and Management, Graduate School of Public Health, Yonsei University, Seoul, Republic of Korea
[2]Health Insurance Review and Assessment Service, Seoul, Republic of Korea
[3]Department of Public Health, Graduate School, Yonsei University, Seoul, Republic of Korea
[4]Institute of Health Services Research, Yonsei University College of Medicine, Seoul, Republic of Korea
[5]Department of Preventive Medicine, Yonsei University College of Medicine, Seoul, Republic of Korea
[6]National Evidence-Based Healthcare Collaborating Agency, Seoul, Republic of Korea

Abstract

Objective The number of patients requiring hemodialysis has gradually increased in South Korea. Due to this growth, concerns have been raised regarding hemodialysis quality of care, and healthcare professionals must consider alternatives for appropriate management of patients with chronic kidney disease (CKD). Therefore, we investigated the association between risk of hospitalization of outpatients who received hemodialysis due to end-stage renal disease (ESRD) and the human resources of the hemodialysis unit.

Setting We used data from National Health Insurance (NHI) claims during Oct 2013–Sep 2014.

Participants These data consisted of 40,543 outpatients with ESRD (4,751,047 outpatient cases) who received hemodialysis.

Interventions No interventions were made.

Outcome measure We performed Poisson regression analysis using the generalized estimating equation (GEE) that included both patient and hemodialysis unit characteristics to examine the factors associated with hospitalization of ESRD outpatients.

Results Among 4,751,047 outpatient cases, 27,997 (0.59%) were hospitalized during the study period. A higher proportion of hemodialysis patient care specialists or a higher number of nurses experienced in hemodialysis had an inverse association with risk of hospitalization (per 10% increase in hemodialysis patient care specialists: relative risk [RR]=0.987, 95% confidence interval [CI]=0.981–0.993; per increase in 10 nurses who provided to

hemodialysis: RR=0.876, 95% CI=0.833–0.921). In addition, such associations were greater in severe patients.

Conclusions Our findings suggest that hemodialysis units with high-quality, hemodialysis-specialized human resources, or hemodialysis units that observe hemodialysis standards, could prevent the deterioration of ESRD outpatients. Based on our findings, health policy makers and professionals should implement strategies for the optimal management of patients with CKD.

Keywords: chronic kidney disease; health outcome; health policy; healthcare quality assessment; hemodialysis

Strength and limitation of this study

- Our results may prove useful for designing an effective strategy for managing CKD patients receiving hemodialysis.
- This study reflects the variety and severity of each patient and the medical institution situation.
- We could not include other factors which could affect outcome variables in this study because the data used were secondary data of the NHI claim data.
- We could not identity whether each patient actually received treatment from specific human resources in each hemodialysis unit.

Introduction

As the overall health status of South Koreans improved due to economic and health technology development during the late 20th century, the elderly population has grown, and South Korea is expected to become an aged society [1]. Naturally, health problems related to aging, such as chronic diseases, have become more prevalent compared to past centuries, leading to a gradual increase in utilization of healthcare due to diabetes and hypertension, as well as problems related to such diseases (hypertension: 27.3% and diabetes: 7.7% among those >30 years of age in 2013) [2]. One of these related diseases is chronic kidney disease (CKD). CKD is defined as a progressive loss of kidney function, and generally causes neurological, cardiovascular, and digestive symptoms, as well as anemia or hemorrhage, and in severe cases, death [3].

Patients with CKD receive medical services for preventing comorbid conditions or progression of CKD, including hemodialysis, peritoneal dialysis, and kidney transplantation, based upon the severity of their CKD [4-6]. Hemodialysis is a common treatment for severe cases of CKD. According to the reports of the Health Insurance Review and Assessment (HIRA), the number of patients who underwent hemodialysis and the associated average medical cost due to hemodialysis have rapidly increased (56,896 patients in 2009 to 69,837 in 2013; 1.1 billion US dollars average medical cost in 2009 to 1.4 billion US dollars in 2013) [7].

Previous studies have found that several factors, such as workload, hemodialysis unit human resources, and unit characteristics could reduce the quality of care in managing patients with CKD [8 9]. However, as the number of patients receiving hemodialysis increases, the quality of care in providing hemodialysis for CKD is expected to decrease due to increasing workload.

Although the South Korean government introduced healthcare quality assessment for hemodialysis unit resources (human and device or management level) to improve the level of and quality of care in providing hemodialysis for patients with CKD after 2009, there are few studies examining the relationship between hemodialysis unit resources and quality of hemodialysis care after the introduction of healthcare quality assessment [10]. Therefore, there are remaining concerns with respect to optimal care and reduction in quality of hemodialysis due to hospital competition and overcrowding. Thus, we focused only on the diagnosed end-stage renal disease (ESRD) patients who received hemodialysis, and investigated which factors, including human resources, in each hemodialysis unit were associated with hospitalization due to ESRD as indicators for quality of care. The results of this study provide important information regarding healthcare quality assessment for hemodialysis, and may aid in providing solutions for possible future problems related to the care of patients with ESRD.

Materials and methods

Data source and study population

We used two datasets from the National Health Insurance (NHI) claim data. The first dataset was claim data for 53,583 patients previously diagnosed with CKD (International Classification of Diseases [ICD]-10: N18) who received hemodialysis at medical institutions during October 2013–September 2014. Since South Korea had introduced the NHI after 1989, this patients could be identified based on electronic data interchange (EDI) claim code which was provided to reimbursement for healthcare services. The second dataset included claim data regarding utilization of a medical institution due to CKD during October 2008–

September 2013 and claim data regarding hospitalization due to CKD during October 2012–September 2013; this dataset reflected the severity and duration of illness of patients with CKD receiving hemodialysis. These two datasets were merged for the final analysis to investigate the association between factors including human and medical resources in each hemodialysis unit and hospitalization. We then excluded patients diagnosed with CKD stages 1–4 to reduce variation between patients and included only patients diagnosed with ESRD (ICD-10-CM: N18.6). Patients with duration of illness of less than 1 year were also excluded to remove the possibility of including hospitalization due to arteriovenous fistula formation for hemodialysis and not due to worsening status of the patient. In addition, we excluded the hospital which did not meet the criteria for hemodialysis machine for hepatitis B patients, because most of hospitals meet such criteria (unsatisfied: 2 hospitals). Finally, 4,751,047 outpatient cases of 40,543 patients were included for analysis. The unit of analysis was outpatient cases due to hemodialysis. Since this study used secondary data from the NHI claim data, the requirement of informed consents was waived in the study, because the patient`s information was anonymized and de-identified prior to analysis.

Variables

The outcome variable used in this study was whether patients who were previously diagnosed with ESRD were hospitalized by ESRD based on major diagnosis after receiving outpatient care due to hemodialysis. If a patient with ESRD was hospitalized after specific outpatient care for hemodialysis, we assumed that this outpatient care caused the hospitalization due to the worsening status of the patient with ESRD receiving hemodialysis treatment [11 12].

The exposures of interest in this study were the human resources at each medical institution, listed as follows: Total number of doctors who provided hemodialysis, proportion of hemodialysis patient care specialists, total number of nurses who provided hemodialysis, and proportion of nurses experienced in hemodialysis. The total number of doctors or nurses was defined as the actual number of doctors or nurses who provided hemodialysis services for patients with ESRD. The hemodialysis patient care specialists was defined as follows: 1) specialists who trained nephrologist among internal medicine or pediatric specialists; 2) specialists who trained in hemodialysis more than 1 year after training internal medicine or pediatric specialists; 3) internal medicine or pediatric specialists who have experience for caring patients with hemodialysis more than 3 years after. The proportion of hemodialysis patient care specialists was defined as the proportion of such specialist among total number of doctors who provided to hemodialysis.

We also adjusted for patient and hemodialysis unit characteristics when analyzing the relationship between human resources and hospitalization after hemodialysis. The included patient characteristics were: age, sex, type of insurance coverage, experience of pre-hospitalization during 1 year, duration of illness, and Charlson Comorbidity Index (CCI). Age was classified into ≤49 years, 50–59 years, 60–69 years, and ≥70 years. Types of insurance coverage, as defined by NHI, are: the general population and the beneficiaries of Medical Aid (those with low income, disability, or the elderly, who are provided with free inpatient and outpatient care by the government). Therefore, types of insurance coverage could represent the socio-economic status of each inpatient. Pre-hospitalization during 1 year was defined as whether a patient was hospitalized due to ESRD during October 2012–September 2013 to reflect the severity of each patient who was previously diagnosed with

ESRD. The duration of illness was defined as the period from the first diagnosis of ESRD; it was classified into a yearly unit. We assumed that patients with short-term duration of illness could not well manage their status or were more unstable as relatively[13 14]. CCI was calculated using the comorbid conditions except to CKD upon hospitalization. The data used in this study included the information for maximum 10 comorbidities except to major diagnosis. This information was collected from previous outpatient /inpatient care or the comorbidities when each patient visits to hospital. These comorbid symptoms were weighted and scored with additional points added to consider comorbidities that could affect outcomes of ESRD patients.

The included hemodialysis unit characteristics (excluding human resources) were: type of medical institution, presence of a nephrologist, hemodialysis volume per one doctor, number of beds, emergency equipment in the hemodialysis unit, fulfillment rate of criteria for duration of water analysis, number of hemodialysis machines, and proportion of medical cost due to CKD. Types of medical institution were classified into "general hospital" or "clinics or hospital". Emergency equipment in the hemodialysis unit indicated the presence of emergency equipment in the unit. Fulfillment rate of criteria for the duration of water analysis was whether each hemodialysis unit met the criteria for frequency of the water analysis. The proportion of medical cost due to CKD was the proportion of medical cost due to CKD of the total medical cost of each hemodialysis unit, which is included to reflect the expertise for managing CKD patients in each hemodialysis unit.

Statistical analysis

We examined the distribution of each categorical variable by examining the frequencies and percentages, and then performed χ^2 tests to investigate associations with hospitalization after hemodialysis in patients diagnosed with ESRD. In addition, we also performed analysis of variance (ANOVA) to compare average values and standard deviations for continuous variables. In order to investigate the relationship between human resources in a hemodialysis unit and the risk of hospitalization after hemodialysis in patients with ESRD, we performed Poisson regression analysis using the generalized estimating equation (GEE) model. GEE models with link logit that included both patient and hospital characteristics were analyzed, as the data used in this study were hierarchically structured and had binary outcome variables. Additionally, to examine the differences in risk of hospitalization, we performed subgroup analyses adjusting both patient and hospital characteristics by the presence of a nephrologist, duration of illness, and CCI. All statistical analyses were performed using SAS statistical software, version 9.2.

Results

The data used in this analysis consisted of 4,751,047 outpatient cases of 40,543 patients. Table 1 shows the univariate associations between various independent variables including patient and hemodialysis unit characteristics and hospitalization due to ESRD after hemodialysis. Among 4,751,047 outpatient cases, 27,997 (0.59%) were hospitalized due to ESRD during the study period. Those in the elderly group were more frequently hospitalized after hemodialysis than all other age groups. Outpatient cases in those with Medical Aid also had more frequent hospitalization than cases with other insurance types (NHI: 0.57%,

Medical Aid: 0.65%), and outpatient cases in those with pre-hospitalization during 1 year had more frequent hospitalization than cases without pre-hospitalization (yes: 0.89%, no: 0.41%). In addition, patients with a shorter duration of illness were more frequently hospitalized after hemodialysis than those with a longer duration of illness. Regarding hemodialysis unit characteristics, the cases in general hospitals were more frequently hospitalized due to ESRD than cases in clinics or hospitals. Furthermore, cases in hemodialysis units with a nephrologist were more frequently hospitalized than cases in hemodialysis units without a nephrologist. The average number of total doctors in a hemodialysis unit was higher in hospitalization cases whereas the average number of total nurses, proportion of hemodialysis patient care specialists, and proportion of nurses with hemodialysis experience had lower numbers of hospitalization cases. The average values of hemodialysis volume per doctor were lower in hospitalization cases. In addition, the average value for proportion of medical cost due to CKD was lower in hospitalization cases (Table 1).

Table 2 shows the results of Poisson regression analysis using the GEE model to investigate the relationship between human resources and risk of hospitalization due to ESRD. The age of the patient was correlated with risk of hospitalization due to ESRD. By type of insurance coverage, outpatient cases of beneficiaries of Medical Aid were associated with risk of hospitalization due to ESRD more than other types of insurance coverage (Medical Aid=relative risk [RR]: 1.334, 95% confidence interval [CI]: 1.281–1.389; ref=NHI). In addition, patients who experienced pre-hospitalization during 1 year were associated with risk of hospitalization (yes=RR: 1.837, 95% CI: 1.773–1.903). A higher CCI had a positive trend with risk of hospitalization due to ESRD, but it was not statistically significant. Regarding hemodialysis unit characteristics, a higher proportion of hemodialysis patient care specialists

and a higher number of total nurses who provided hemodialysis were inversely associated with risk of hospitalization (proportion of hemodialysis patient care specialists, per 10% increase=RR: 0.987, 95% CI: 0.981–0.993; number of total nurses who provided hemodialysis=RR: 0.876, 95% CI: 0.833–0.921). A higher proportion of medical cost due to CKD among total medical costs in each hemodialysis unit was inversely associated with risk of hospitalization (RR: 0.924, 95% CI: 0.915–0.933) (Table 2).

We also performed subgroup analysis to examine differences in relation to risk of hospitalization by duration of illness, CCI, and presence of a nephrologist at a hemodialysis unit. The higher proportion of hemodialysis patient care specialists was more inversely associated with risk of hospitalization in presence of a nephrologist at a hemodialysis unit, but the higher number of total nurses was more inversely associated with outcome variable in the absence of a nephrologist at a hemodialysis unit. By duration of illness, a higher proportion of hemodialysis patient care specialists or a higher number of total nurses who provided hemodialysis was inversely associated with risk of hospitalization in both groups, and the magnitude also similar. Similar results were also obtained in the subgroup analysis by CCI, but higher number of nurses was more inversely associated with risk of hospitalization in cases with a CCI of more than 3 (Table 3).

Discussion

After the late 20th century, new problems related to chronic diseases have rapidly emerged in South Korea. The prevalence of hypertension and diabetes, along with their associated diseases such as CKD, has gradually increased [15 16]. Concerns regarding the quality of care in

managing CKD patients have been raised; to solve and prevent these issues, the South Korean government introduced healthcare quality assessment for human and medical resources regarding hemodialysis [10]. Nevertheless, the reduction of quality of care and the worsening status of patients diagnosed with CKD continue to be debated. Therefore, we set out to investigate the relationship between hospital resources, particularly human resources, and the risk of hospitalization in patients with ESRD, which were assumed to be indicators of worsening patient status due to a reduction in quality of care.

Our findings suggest that outpatient care for hemodialysis at hemodialysis units with superior human resources, such as a higher proportion of hemodialysis patient care specialists and a higher total number of nurses who provide hemodialysis, were positively associated with better health outcomes in managing CKD patients needing hemodialysis. Although previous studies show similar results to those reported in this study, such as better outcomes being associated with better hemodialysis unit resources, ours is one of only a few studies conducted after the introduction of healthcare quality assessment [17-19].

In South Korea, HIRA has evaluated the structure, process, and outcome indicators of hemodialysis for each hemodialysis unit through healthcare quality assessment, and has provided adjustment payment to medical institutions that were applied to the upper 10% or were of lower quality based on the evaluation results after 2009. Given the positive impact of superior human resources on patient outcomes as shown in our study, our findings provide helpful information for healthcare quality assessment of hemodialysis due to CKD. However, we found that the number of total nurses who provided hemodialysis had a positive association with patient outcomes in this study even though it was not included in the evaluation criteria of healthcare quality assessment. Therefore, based upon our results, health

policy makers should consider this criteria in healthcare quality assessment, as well as the weight given each factor in an evaluation. In addition, vulnerable patient groups, such as those receiving Medical Aid and the elderly, were negatively associated with healthcare outcomes after hemodialysis due to ESRD, suggesting an imbalance between the ability to pay and copayment when it comes to receiving healthcare [20]. Similarly, healthcare professionals also assert a need to relax copayment for vulnerable populations [21]. Thus, support for vulnerable populations should be afforded careful consideration by health policy makers. There was also an inverse association between the proportion of medical cost due to CKD and risk of hospitalization, which could be caused by specialty differences of each medical institution. Similar results were obtained in previous studies, suggesting a positive function for specialty hospitals in South Korea [22]. Therefore, healthcare professionals might consider increasing their specialties, and policy makers should consider designating additional specialty hospitals for hemodialysis.

Our subgroup analysis also showed interesting results related to efficiency issues. There were some differences in the relationship between human resources and the risk of hospitalization after hemodialysis due to ESRD. The positive impact of better human resources was greater in patients with a more severe condition, as evidenced by CCI. Thus, the worsening status of a severely ill patient could be more effectively managed by better hemodialysis unit characteristics, such as a hemodialysis unit with better staffing. However, the role of each human resource was different in each hemodialysis unit based on subgroup analysis by presence of a nephrologist. These results suggest that a hemodialysis patient care specialist could be a viable alternative if a hemodialysis unit does not have a nephrologist.

Therefore, the importance of professional manpower is also effectively evaluated in establishing health policy regarding management of CKD patients [23].

These findings have many strengths compared to previous studies. First, the data used in this study was NHI claim data, which consists of overall ESRD patients in South Korea who received hemodialysis during 1 year. Thus, our findings have external validity, and would be helpful in establishing evidence-based health policy related to CKD. Second, to the best of our knowledge, ours is the first South Korean study to investigate the relationship between human resources, such as hemodialysis patient care specialists or nurses experienced in hemodialysis, and the risk of hospitalization, as indicators of health outcomes in ESRD patients receiving hemodialysis after the introduction of healthcare quality assessment for hemodialysis. Therefore, our results may prove useful for designing an effective strategy for managing CKD patients receiving hemodialysis. Third, we included both patient and hemodialysis unit characteristic variables in this study. Therefore, this study reflects the variety and severity of each patient and the medical institution situation, reducing the limitations of secondary data.

Our study also has some limitations. First, in managing patients with ESRD who needed hemodialysis, there were many factors, including type of vascular access, laboratory data (e.g. serum albumin, hemoglobin), adherence to medical therapy, particularly hemodialysis sessions, more detailed quality indicators, and clinical conditions, which could affect outcomes of patients with CKD according to previous studies [24-27]. However, we could not include these factors in this study because the data used were secondary data of the NHI claim data. In addition, detailed information, such as procedures or medications provided to patients with hemodialysis was not included in this study. Also, by the nature of claim data,

we could not identify the hospitalization due to HD, because the hospitalization was recorded based on major diagnosis. Therefore, we assumed that patient who received the HD progress to hospitalization due to ESRD, this hospitalization might be caused by the worsening status after HD. Therefore, more detailed studies are needed. Second, the study period was relatively short (1 year); we excluded patients with duration of illness of less than 1 year because patients in the early stages of ESRD could be hospitalized due to arteriovenous fistula formation for hemodialysis. This is because that there were some difficulties in accessing patient information due to issues such as ethics. Therefore, we needed to effectively extract patient`s information samples from NHI data. Unfortunately, we could not obtain such details. Therefore, to avoid including uncertain causes of hospitalization by either worsening status or arteriovenous fistula formation, we excluded these patients from this study. Third, we considered human resources as independent variables of major interest in this study, but we could not identity whether each patient actually received treatment from specific human resources in each hemodialysis unit due to limitation of data. Fourth, to reflect the hospital and patient characteristics in this study, we included the variable such as structural characteristic or severity indicators of each patient. Nevertheless, there were some other factors which could affect to risk of hospitalization. However, we could not consider more detailed variables due to limitation of data.

Despite the above limitations, our findings suggest that better human resources, such as specialists and nurses experienced in hemodialysis, could positively affect outcomes in patients who received hemodialysis. In particular, these associations were greater in patients in a clinically vulnerable population, and the role of human resources was different depending upon hemodialysis unit characteristics, such as severity of patients. However,

improving the hospital staffing to reduce risk of hospitalization in such patients would not optimal alternatives as perspective on cost effective even if there were many concerns about medical cost related to CKD. Therefore, more detailed studies are needed in the future. Based on this findings and further studies, health policy makers and healthcare professionals should establish an effective health policy for appropriate management of patients needing hemodialysis due to CKD.

Conclusions

Our findings suggest that outpatient care for hemodialysis at a hemodialysis unit with superior human resources, such as a higher proportion of hemodialysis patient care specialists and a higher number of total nurses who provide hemodialysis, was positively associated with better health outcomes in the management of patients with ESRD receiving hemodialysis. Based on our findings, health policy makers and professionals should endeavor to implement strategies for optimal management of patients with CKD.

Authors' Contributions

H.H.C. and K.T.H. designed the study, performed the research and statistical analyses, and wrote the manuscript. K.T.H., J.M.N., K.T.M., and E.C.P. contributed to the discussion and reviewed and edited the manuscript. E.C.P. is the guarantor of this work and as such, has full access to all the data in the study and takes responsibility for the integrity of the data and the

accuracy of the data analysis. The English in this document has been checked by at least two professional editors, both native English speakers. In addition, W.K. provided re-editing services for our manuscript to improve quality of scientific writing.

Competing interests

The authors report no conflicts of interest in this work.

Funding statement

There is no funding source.

Data sharing statement

No additional data are available.

References

1. Kim EY, Kim Cy. Who Wants to Enter a Long-Term Care Facility in a Rapidly Aging Non-Western Society? Attitudes of Older Koreans Toward Long-Term Care Facilities. J Am Geriatr Soc 2004;**52**(12):2114-19.
2. Korea Centers for Disease Control and Prevention. Korea National Health and Nutrition Examination Survey, 2013.
3. Levey AS, Coresh J. Chronic kidney disease. Lancet 2012;**379**(9811):165-80.
4. Wyld M, Lisa Morton R, Hayen A, et al. A systematic review and meta-analysis of utility-based quality of life in chronic kidney disease treatments. PLoS Med 2012;**9**(9):1435.
5. Levey AS, Coresh J, Balk E, et al. National Kidney Foundation practice guidelines for chronic kidney disease: evaluation, classification, and stratification. Ann Intern Med 2003;**139**(2):137-47.
6. Kim H, Kim KH, Park K, et al. A population-based approach indicates an overall higher patient mortality with peritoneal dialysis compared to hemodialysis in Korea. Kidney Int 2014;**86**(5):991-1000.
7. Health Insurance Review & Assessment Service. Statistics for diseases 2009-13.
8. Argentero P, Dell'Olivo B, Santa Ferretti M, et al. Staff burnout and patient satisfaction with the quality of dialysis care. Am J Kidney Dis 2008;**51**(1):80-92.
9. Klersy C, Callegari A, Martinelli V, et al. Burnout in health care providers of dialysis service in Northern Italy—a multicentre study. Nephrol Dial Transplant 2007;**22**(8):2283-90.
10. Kim SM, Jang WM, Ahn HA, et al. Korean National Health Insurance value incentive program: achievements and future directions. J Prev Med Public Health 2012;**45**(3):148.
11. Go AS, Chertow GM, Fan D, et al. Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. N Engl J Med 2004;**351**(13):1296-305.
12. Forman DE, Butler J, Wang Y, et al. Incidence, predictors at admission, and impact of worsening renal function among patients hospitalized with heart failure. J Am Coll Cardiol 2004;**43**(1):61-67.

13. Jungers P, Massy ZA, Nguyen-Khoa T, et al. Longer duration of predialysis nephrological care is associated with improved long-term survival of dialysis patients. Nephrol Dial Transplant 2001;**16**(12):2357-64.
14. Termorshuizen F, Korevaar JC, Dekker FW, et al. Hemodialysis and peritoneal dialysis: comparison of adjusted mortality rates according to the duration of dialysis: analysis of The Netherlands Cooperative Study on the Adequacy of Dialysis 2. J Am Soc Nephrol 2003;**14**(11):2851-60.
15. Ayodele OE, Alebiosu CO. Burden of chronic kidney disease: an international perspective. Adv Chronic Kidney Dis 2010;**17**(3):215-24.
16. Couser WG, Remuzzi G, Mendis S, et al. The contribution of chronic kidney disease to the global burden of major noncommunicable diseases. Kidney Int 2011;**80**(12):1258-70.
17. Needleman J, Buerhaus P, Mattke S, et al. Nurse-staffing levels and the quality of care in hospitals. N Engl J Med 2002;**346**(22):1715-22.
18. Thomas-Hawkins C, Flynn L, Clarke SP. Relationships between registered nurse staffing, processes of nursing care, and nurse-reported patient outcomes in chronic hemodialysis units. Nephrology nursing journal: journal of the American Nephrology Nurses' Association 2008;**35**(2):123.
19. Gardner JK, Thomas-Hawkins C, Fogg L, et al. The relationship between nurses' perceptions of the hemodialysis unit work environment and nurse turnover, patient satisfaction, and hospitalizations. Nephrol Nurs J 2007;**34**(3):271.
20. Choi JW, Park E-C, Chun S-Y, et al. Health care utilization and costs among medical-aid enrollees, the poor not enrolled in medical-aid, and the near poor in South Korea. Int J Equity Health 2015;**14**(1):128.
21. Kim J-H, Lee K-S, Yoo K-B, et al. The Differences in Health Care Utilization between Medical Aid and Health Insurance: A Longitudinal Study Using Propensity Score Matching. PLoS One 2015;**10**(3):e0119939.
22. Kim SJ, Park E-C, Jang SI, et al. An analysis of the inpatient charge and length of stay for patients with joint diseases in Korea: specialty versus small general hospitals. Health Policy (New York) 2013;**113**(1):93-99.
23. Mandel SR, Martin PL, Blumoff RL, et al. Vascular Access in a University Transplant and Dialysis Program: Results, Costs, and Manpower Implications. Arch Surg 1977;**112**(11):1375-80.

24. Hsu C, Ordonez J, Chertow G, et al. The risk of acute renal failure in patients with chronic kidney disease. Kidney Int 2008;**74**(1):101-07.

25. Lo LJ, Go AS, Chertow GM, et al. Dialysis-requiring acute renal failure increases the risk of progressive chronic kidney disease. Kidney Int 2009;**76**(8):893-99.

26. Tonelli M, Wiebe N, Culleton B, et al. Chronic kidney disease and mortality risk: a systematic review. J Am Soc Nephrol 2006;**17**(7):2034-47.

27. Chawla LS, Amdur RL, Amodeo S, et al. The severity of acute kidney injury predicts progression to chronic kidney disease. Kidney Int 2011;**79**(12):1361-69.

Table 1. General characteristics of the study population and hemodialysis unit by hospitalization after hemodialysis

Variables	Hospitalization after hemodialysis (N=4,751,047)				P-value
	Yes		No		
	N/Mean	%/SD	N/Mean	%/SD	
Patient characteristics					
Age (years)					
≤49	4,124	0.41	1,011,407	99.59	<.0001
50–59	6,743	0.52	1,278,756	99.48	
60–69	7,889	0.63	1,241,225	99.37	
≥70	9,241	0.77	1,191,662	99.23	
Sex					
Male	15,815	0.58	2,719,129	99.42	0.0003
Female	12,182	0.60	2,003,921	99.40	
Type of insurance coverage					
NHI	20,734	0.57	3,621,256	99.43	<.0001
Medical Aid	7,263	0.65	1,101,794	99.35	
Experience of pre-hospitalization during 1 year					
Yes	15,647	0.89	1,743,611	99.11	<.0001
No	12,350	0.41	2,979,439	99.59	
Duration of illness (years)					
2–3	2,816	0.73	381,554	99.27	<.0001
3–4	3,624	0.68	529,343	99.32	
4–5	3,154	0.65	483,078	99.35	
5–6	3,806	0.65	581,142	99.35	
>6	14,597	0.53	2,747,933	99.47	
CCI					
0	3,351	0.42	797,328	99.58	<.0001
1, 2	12,579	0.58	2,173,291	99.42	
3, 4	9,824	0.70	1,385,868	99.30	
5+	2,243	0.61	366,563	99.39	
Hemodialysis unit characteristics					
Type of medical institution					
General hospital (N=234)	15,137	0.82	1,825,112	99.18	<.0001
Clinic or hospital (N=395)	12,860	0.44	2,897,938	99.56	
Presence of nephrologist					
Yes (N=114)	8,815	0.79	1,102,400	99.21	<.0001
No (N=515)	19,182	0.53	3,620,650	99.47	
Total number of doctors who provided hemodialysis	1.99	±1.57	1.83	±1.40	<.0001
Proportion of hemodialysis patient care specialists	83.59	±33.80	84.10	±33.09	0.0107
Total number of nurses who provided hemodialysis	10.84	±6.85	11.10	±7.04	<.0001
Proportion of nurses experienced in hemodialysis	74.53	±17.09	75.22	±16.65	<.0001
Volume of hemodialysis per one doctor	1.77	±0.97	1.97	±1.06	<.0001
Number of beds	330.98	±382.58	246.18	±375.48	<.0001
Emergency equipment in hemodialysis unit					
Yes (N=573)	26,483	0.59	4,469,487	99.41	0.1794
No (N=56)	1,514	0.59	253,563	99.41	
Fulfillment rate of criteria for duration of water analysis	90.74	±19.81	90.31	±19.93	0.0004
Number of hemodialysis machines	34.40	±18.18	34.36	±18.70	0.6967
Proportion of medical cost due to CKD	37.85	±38.61	53.05	±40.71	<.0001
Total	27,997	0.59	4,723,050	99.41	

SD, standard deviation; NHI, National Health Insurance; CKD, chronic kidney disease; CCI, Charlson Comorbidity Index

Table 2. Risk of hospitalization after hemodialysis by patient and hemodialysis unit characteristics

Variables	Hospitalization after hemodialysis			
	RR	95% CI		P-value
Patient characteristics				
Age (years)				
≤49	1.000	-	-	-
50–59	1.205	1.090	1.332	0.0003
60–69	1.455	1.317	1.608	<.0001
≥70	1.732	1.560	1.921	<.0001
Sex				
Male	1.000	0.966	1.035	0.981
Female	1.000	-	-	
Type of insurance coverage				
NHI	1.000	-	-	-
Medical Aid	1.334	1.281	1.389	<.0001
Experience of pre-hospitalization during 1 year				
Yes	1.837	1.773	1.903	<.0001
No	1.000	-	-	-
Duration of illness (years)				
2–3	1.000	-	-	-
3–4	0.983	0.918	1.052	0.6158
4–5	0.987	0.917	1.063	0.7342
5–6	1.018	0.948	1.094	0.6185
>6	0.911	0.860	0.965	0.0016
CCI				
0	1.000	-	-	-
1, 2	1.058	0.955	1.173	0.2811
3, 4	1.065	0.956	1.186	0.2549
5+	1.104	0.982	1.241	0.0981
Hemodialysis characteristics				
Type of medical institution				
General hospital (N=234)	1.000	-	-	-
Clinic or hospital (N=395)	0.940	0.869	1.017	0.1220
Presence of nephrologist				
Yes (N=114)	0.982	0.936	1.029	0.4429
No (N=515)	1.000	-	-	
Total number of doctors who provided hemodialysis (per 10 doctor increase)	1.001	0.973	1.030	0.9541
Proportion of hemodialysis patient care specialists (per 10%)	0.987	0.981	0.993	<.0001
Total number of nurses who provided hemodialysis (per 10 nurse increase)	0.876	0.833	0.921	<.0001
Proportion of nurses experienced in hemodialysis (per 10%)	0.993	0.983	1.003	0.1576
Volume of hemodialysis per one doctor	0.963	0.936	0.992	0.0115
Number of beds (per 10 bed increase)	0.999	0.998	1.000	0.1065
Emergency equipment in hemodialysis unit				
Yes (N=573)	1.000	-	-	-
No (N=56)	0.930	0.856	1.011	0.0882
Fulfillment rate of criteria for duration of water analysis (per 10%)	0.978	0.969	0.987	<.0001
Number of hemodialysis machines (per 10 machine increase)	1.046	1.029	1.063	<.0001
Proportion of medical cost due to CKD (per 10%)	0.924	0.915	0.933	<.0001

RR, relative risk; CI, confidence interval; NHI, National Health Insurance; CKD, chronic kidney disease; CCI, Charlson Comorbidity Index

Table 3. Subgroup analysis by presence of nephrologist, duration of illness, and CCI*

Subgroup		Variables	RR	P-value
Presence of nephrologist	Yes	Total number of doctors who provided hemodialysis (per 10 doctor increase)	1.023	0.2614
		Proportion of hemodialysis patient care specialists (per 10%)	0.970	0.0062
		Total number of nurses who provided hemodialysis (per 10 nurse increase)	0.901	0.0045
		Proportion of nurses experienced in hemodialysis (per 10%)	0.991	0.3602
	No	Total number of doctors who provided hemodialysis (per 10 doctor increase)	0.980	0.3125
		Proportion of hemodialysis patient care specialists (per 10%)	0.989	0.0005
		Total number of nurses who provided hemodialysis (per 10 nurse increase)	0.864	<.0001
		Proportion of nurses experienced in hemodialysis (per 10%)	0.994	0.3191
Duration of illness (years)	-5	Total number of doctors who provided hemodialysis (per 10 doctor increase)	1.016	0.4756
		Proportion of hemodialysis patient care specialists (per 10%)	0.986	0.0016
		Total number of nurses who provided hemodialysis (per 10 nurse increase)	0.880	0.0009
		Proportion of nurses experienced in hemodialysis (per 10%)	0.996	0.5596
	6+	Total number of doctors who provided hemodialysis (per 10 doctor increase)	0.986	0.4495
		Proportion of hemodialysis patient care specialists (per 10%)	0.989	0.0078
		Total number of nurses who provided hemodialysis (per 10 nurse increase)	0.879	0.0002
		Proportion of nurses experienced in hemodialysis (per 10%)	0.990	0.1702
CCI	0,1,2	Total number of doctors who provided hemodialysis (per 10 doctor increase)	1.008	0.6615
		Proportion of hemodialysis patient care specialists (per 10%)	0.987	0.0021
		Total number of nurses who provided hemodialysis (per 10 nurse increase)	0.889	0.0003
		Proportion of nurses experienced in hemodialysis (per 10%)	0.993	0.3201
	3,4	Total number of doctors who provided hemodialysis (per 10 doctor increase)	0.998	0.9370
		Proportion of hemodialysis patient care specialists (per 10%)	0.987	0.0036
		Total number of nurses who provided hemodialysis (per 10 nurse increase)	0.856	<.0001
		Proportion of nurses experienced in hemodialysis (per 10%)	0.989	0.1336

*Table 3 shows the results of subgroup analysis for the relationship between human resources and risk of hospitalization by presence of a nephrologist, duration of illness, and CCI. In this analysis, we adjusted variables such as age, sex, type of insurance coverage, experience of pre-hospitalization during 1 year, duration of illness, Charlson Comorbidity Index (CCI), type of medical institution, presence of a nephrologist, hemodialysis volume per one doctor, number of beds, emergency equipment in the hemodialysis unit, fulfillment rate of criteria for duration of water analysis, number of hemodialysis machines, and proportion of medical cost due to CKD. We marked the results which statistically significant value as shadowing. CCI, Charlson Comorbidity Index; RR, relative risk; CI, confidence interval

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3-5
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	6-7
Methods			
Study design	4	Present key elements of study design early in the paper	7-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	7-8
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	None
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*7-9*
Bias	9	Describe any efforts to address potential sources of bias	8-10
Study size	10	Explain how the study size was arrived at	7-8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11
		(*b*) Describe any methods used to examine subgroups and interactions	11
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, explain how loss to follow-up was addressed	None
		(*e*) Describe any sensitivity analyses	11
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11-12
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	None
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-12
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) Summarise follow-up time (eg, average and total amount)	11-12
Outcome data	15*	Report numbers of outcome events or summary measures over time	11-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-13
		(*b*) Report category boundaries when continuous variables were categorized	9-10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	None
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	13
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-15
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	16-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

The association between human resources and risk of hospitalization in end-stage renal disease outpatients receiving hemodialysis: a longitudinal cohort study using claim data during 2013-2014

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2016-011319.R2
Article Type:	Research
Date Submitted by the Author:	19-Jul-2016
Complete List of Authors:	Choi, Hoon-Hee; Graduate School of Public Health, Yonsei University, Department of Health Policy and Management; Health Insurance Review and Assessment Service Han, Kyu-Tae; Yonsei University College of Medicine, Department of Public Health & Institute of Health Services Research Nam, Chung Mo; Yonsei University College of Medicine, Biostatistics Moon, Ki Tae; National Evidence-Based Healthcare Collaborating Agency Kim, Woorim; Yonsei University College of Medicine, Department of Public Health Park, Eun-Cheol; Yonsei University College of Medicine, Department of Preventive Medicine and Institute of Health Services Research
Primary Subject Heading:	Health services research
Secondary Subject Heading:	Renal medicine, Health policy
Keywords:	chronic kidney disease, health outcome, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, healthcare quality assessment, hemodialysis

Title: The association between human resources and risk of hospitalization in end-stage renal disease outpatients receiving hemodialysis: a longitudinal cohort study using claim data during 2013–2014

Hoon-Hee Choi, RN, MPH[1, 2]

Email: hee187@hanmail.net

*Co-first author

Kyu-Tae Han[3, 4, *]

*Co-first author

Email: kthan@yuhs.ac

Chung Mo Nam, PhD[5]

Email: CMNAM@yuhs.ac

Ki Tae Moon, MD, PhD[6]

Email: tubemed@hanmail.net

Woorim Kim[3, 4]

Email: woorimk@yuhs.ac

Eun-Cheol Park, MD, PhD[4, 5, †]

†Corresponding author

Email: ecpark@yuhs.ac
Tel.: 82-2-2228-1862, Fax: 82-2-392-7734

[1]Department of Health Policy and Management, Graduate School of Public Health, Yonsei University, Seoul, Republic of Korea
[2]Health Insurance Review and Assessment Service, Seoul, Republic of Korea
[3]Department of Public Health, Graduate School, Yonsei University, Seoul, Republic of Korea
[4]Institute of Health Services Research, Yonsei University College of Medicine, Seoul, Republic of Korea
[5]Department of Preventive Medicine, Yonsei University College of Medicine, Seoul, Republic of Korea
[6]National Evidence-Based Healthcare Collaborating Agency, Seoul, Republic of Korea

Abstract

Objective The number of patients requiring hemodialysis has gradually increased in South Korea. Due to this growth, concerns have been raised regarding hemodialysis quality of care, and healthcare professionals must consider alternatives for appropriate management of patients with chronic kidney disease (CKD). Therefore, we investigated the association between risk of hospitalization of outpatients who received hemodialysis due to end-stage renal disease (ESRD) and the human resources of the hemodialysis unit.

Setting We used data from National Health Insurance (NHI) claims during Oct 2013–Sep 2014.

Participants These data comprised 40,543 outpatients with ESRD (4,751,047 outpatient cases) who received hemodialysis.

Interventions No interventions were made.

Outcome measure We performed Poisson regression analysis using a generalized estimating equation (GEE) that included both patient and hemodialysis unit characteristics to examine the factors associated with hospitalization of ESRD outpatients.

Results Among 4,751,047 outpatient cases, 27,997 (0.59%) were hospitalized during the study period. A higher proportion of hemodialysis patient care specialists and a higher number of nurses experienced in hemodialysis were inversely associated with the risk of hospitalization (per 10% increase in hemodialysis patient care specialists: relative risk [RR] = 0.987, 95% confidence interval [CI] = 0.981–0.993; per 10-person increase in nurses who

provided hemodialysis: RR = 0.876, 95% CI = 0.833–0.921). In addition, such associations were greater in severe patients.

Conclusions Our findings suggest that hemodialysis units with high-quality, hemodialysis-specialized human resources could positively affect the outcomes of ESRD outpatients. Based on our findings, health policymakers and professionals should implement strategies for the optimal management of patients with CKD.

Keywords: chronic kidney disease; health outcome; health policy; healthcare quality assessment; hemodialysis

Strengths and limitations of this study

- Our results may prove useful for designing an effective strategy for managing CKD patients receiving hemodialysis.
- This study reflects the variety and severity of each patient and the medical institution situation.
- We were not able to include other factors that could affect outcome variables in this study as the data used were secondary data based on the NHI claim data.
- We could not identify whether each patient actually received treatment from specific human resources in each hemodialysis unit.

Introduction

As the overall health status of South Koreans has improved due to economic and health technology development during the late 20th century, the elderly population has grown, and South Korea is expected to become an aged society [1]. Naturally, health problems related to aging, such as chronic diseases, have become more prevalent compared to past centuries, leading to a gradual increase in the utilization of healthcare due to diabetes and hypertension, as well as problems related to such diseases (hypertension: 27.3% and diabetes: 7.7% among those >30 years of age in 2013) [2]. One of these related diseases is chronic kidney disease (CKD), which is defined as a progressive loss of kidney function and generally causes neurological, cardiovascular, and digestive symptoms, as well as anemia or hemorrhage, and in severe cases, death [3].

Patients with CKD receive medical services for preventing comorbid conditions and progression of CKD, including hemodialysis, peritoneal dialysis, and kidney transplantation, based upon the severity of their CKD [4-6]. Hemodialysis is a common treatment for severe cases of CKD. According to reports by the Health Insurance Review and Assessment Service (HIRA), the number of patients who underwent hemodialysis and the associated average medical cost due to hemodialysis have rapidly increased (56,896 patients in 2009 to 69,837 in 2013; 1.1 billion US dollars in 2009 to 1.4 billion US dollars in 2013) [7].

Previous studies have found that several factors, such as workload, hemodialysis-unit human resources, and unit characteristics could reduce the quality of care in managing patients with CKD [8 9]. Additionally, as the number of patients receiving hemodialysis increases, the quality of care in providing hemodialysis for CKD is expected to decrease due

to increasing workload. Although the South Korean government introduced healthcare quality assessment for hemodialysis unit resources to improve the quality of care when providing hemodialysis for patients with CKD after 2009, few studies have examined the relationship between hemodialysis unit resources and the quality of hemodialysis care after the introduction of healthcare quality assessment [10]. Therefore, concerns remain with respect to optimal care and reduction in the quality of hemodialysis due to hospital competition and overcrowding. We thus focused only on diagnosed end-stage renal disease (ESRD) patients who received hemodialysis and investigated which factors, including human resources, in each hemodialysis unit were associated with hospitalization due to ESRD as indicators for quality of care. The results of this study provide important information regarding healthcare quality assessment for hemodialysis and may aid in providing solutions for possible future problems related to the care of patients with ESRD.

Materials and methods

Data source and study population

We used two datasets from the National Health Insurance (NHI) claim data. The first dataset was claim data for 53,583 patients previously diagnosed with CKD (International Classification of Diseases [ICD]-10: N18) who received hemodialysis at medical institutions during October 2013–September 2014. Given that South Korea introduced the NHI after 1989, these patients could be identified based on the electronic data interchange (EDI) claim code that was provided during reimbursement for healthcare services. The second dataset included claim data regarding medical institution utilization due to CKD during October

2008–September 2013 and claim data regarding hospitalization due to CKD during October 2012–September 2013; this dataset reflected the severity and duration of illness in patients with CKD receiving hemodialysis. These two datasets were merged for the final analysis to investigate the association between factors including human and medical resources in each hemodialysis unit and hospitalization. We then excluded patients diagnosed with CKD stages 1–4 to reduce variation between patients and included only patients diagnosed with ESRD (ICD-10-CM: N18.6). Patients with illness durations of less than 1 year were also excluded to remove the possibility of including hospitalization due to arteriovenous fistula formation for hemodialysis rather than to the worsening status of the patient. In addition, we excluded hospitals that did not meet the criteria for hemodialysis machines for hepatitis B patients, as most hospitals met such criteria (unsatisfied: 2 hospitals). Ultimately, 4,751,047 outpatient cases of 40,543 patients were included for analysis. The unit of analysis was outpatient cases due to hemodialysis. As this study used secondary data from the NHI claim data, the requirement of informed consent was waived in the study, as the patient`s information was anonymized and de-identified prior to analysis.

Variables

The outcome variable used in this study was whether patients who were previously diagnosed with ESRD were hospitalized by ESRD based on major diagnosis after receiving outpatient care due to hemodialysis. If a patient with ESRD was hospitalized after specific outpatient care for hemodialysis, we assumed that this outpatient care caused the

hospitalization due to the worsening status of the patient with ESRD receiving hemodialysis treatment [11 12].

The exposures of interest in this study were the human resources at each medical institution, listed as follows: the total number of doctors who provided hemodialysis, the proportion of hemodialysis patient care specialists, the total number of nurses who provided hemodialysis, and the proportion of nurses experienced in hemodialysis. The total number of doctors or nurses was defined as the actual number of doctors or nurses who provided hemodialysis services for patients with ESRD. The hemodialysis patient care specialists were defined as follows: 1) specialists who were trained as nephrologists among internal medicine or pediatric specialists; 2) specialists who were trained in hemodialysis for more than 1 year after training as internal medicine or pediatric specialists; 3) internal medicine or pediatric specialists who had experience in caring for patients with hemodialysis more for than 3 years. The proportion of hemodialysis patient care specialists was defined as the proportion of such specialists among the total number of doctors who provided the hemodialysis.

We also adjusted for patient and hemodialysis-unit characteristics when analyzing the relationship between human resources and hospitalization after hemodialysis. The included patient characteristics were as follows: age, sex, type of insurance coverage, experience of pre-hospitalization within 1 year, duration of illness, and Charlson Comorbidity Index (CCI). Age was classified as ≤49 years, 50–59 years, 60–69 years, and ≥70 years. Two types of insurance coverage were considered, as defined by NHI: coverage for the general population and coverage for beneficiaries of Medical Aid (low-income, disabled, and elderly patients, who are all provided with free inpatient and outpatient care by the government). Therefore, the type of insurance coverage could represent the socioeconomic status of each inpatient.

Pre-hospitalization within 1 year was defined as whether a patient was hospitalized due to ESRD during October 2012–September 2013 to reflect the severity of each patient who was previously diagnosed with ESRD. The duration of illness was defined as the period from the first diagnosis of ESRD and was measured in years. We assumed that patients with a shorter duration of illness could not easily manage their status or were relatively more unstable [13 14]. CCI was calculated using all comorbid conditions except CKD upon hospitalization. The data used in this study included the information for a maximum of 10 comorbidities excluding major diagnoses. This information was collected from previous outpatient or inpatient care or their comorbidities when each patient visited the hospital. These comorbid symptoms were weighted and scored with additional points added to consider comorbidities that could affect the outcomes of ESRD patients.

The included hemodialysis-unit characteristics (excluding human resources) included the type of medical institution, presence of a nephrologist, hemodialysis volume per doctor, number of beds, emergency equipment in the hemodialysis unit, fulfillment rate of criteria for duration of water analysis, number of hemodialysis machines, and proportion of medical cost due to CKD. Medical institutions were classified as “general hospital” or “clinic or hospital”. The variable for emergency equipment in the hemodialysis unit merely indicated the presence of emergency equipment in the unit. The fulfillment rate of criteria for the duration of water analysis was based on whether each hemodialysis unit met the criteria for the frequency of the water analysis. The proportion of medical cost due to CKD was out of the total medical cost of each hemodialysis unit and was included to reflect the expertise in managing CKD patients in each hemodialysis unit.

Statistical analysis

We examined the distribution of each categorical variable by examining their frequencies and percentages and then performed χ^2 tests to investigate their association with hospitalization after hemodialysis in patients diagnosed with ESRD. In addition, we performed an analysis of variance (ANOVA) to compare the average values and standard deviations for continuous variables. In order to investigate the relationship between human resources in a hemodialysis unit and the risk of hospitalization after hemodialysis in patients with ESRD, we performed a Poisson regression analysis using a generalized estimating equation (GEE) model. GEE models with link logit functions that included both patient and hospital characteristics were analyzed, as the data used in this study were hierarchically structured and had binary outcome variables. Additionally, to examine the differences in the risk of hospitalization, we performed subgroup analyses, adjusting both patient and hospital characteristics by the presence of a nephrologist, duration of illness, and CCI. All statistical analyses were performed using SAS statistical software, version 9.2.

Results

The data used in this analysis comprised 4,751,047 outpatient cases of 40,543 patients. Table 1 shows the univariate associations between various independent variables including patient and hemodialysis unit characteristics and hospitalization due to ESRD after hemodialysis. Among 4,751,047 outpatient cases, 27,997 (0.59%) were hospitalized due to ESRD during the study period. Those in the elderly group were more frequently hospitalized after hemodialysis than all other age groups. Outpatient cases among those with Medical Aid

also more frequently involved hospitalization than other cases (NHI: 0.57%, Medical Aid: 0.65%), and outpatient cases among those with pre-hospitalization history within 1 year more frequently involved hospitalization than other cases (yes: 0.89%, no: 0.41%). In addition, patients with a shorter duration of illness were more frequently hospitalized after hemodialysis than those with a longer duration of illness. Regarding hemodialysis-unit characteristics, cases in general hospitals more frequently involved hospitalization due to ESRD than cases in clinics or hospitals. Furthermore, cases in hemodialysis units with a nephrologist more frequently involved hospitalization than cases in hemodialysis units without a nephrologist. The average number of total doctors in each hemodialysis unit was higher in hospitalization cases, whereas the average number of total nurses, the proportion of hemodialysis patient care specialists, and the proportion of nurses with hemodialysis experience were lower in hospitalization cases. The average values of hemodialysis volume per doctor were also lower in hospitalization cases. In addition, the average value for the proportion of medical cost due to CKD was lower in hospitalization cases (Table 1).

Table 2 shows the results of the Poisson regression analysis using the GEE model to investigate the relationship between human resources and risk of hospitalization due to ESRD. The age of the patient correlated with the risk of hospitalization due to ESRD. Additionally, an analysis by type of insurance coverage indicated that outpatient cases of Medical Aid beneficiaries were associated with the risk of hospitalization due to ESRD more so than other types of insurance coverage (relative risk [RR]: 1.334, 95% confidence interval [CI]: 1.281–1.389; ref. = NHI). In addition, patients who experienced pre-hospitalization within 1 year were associated with the risk of hospitalization (RR: 1.837, 95% CI: 1.773–1.903). CCI also tended to increase with the risk of hospitalization due to ESRD, although this correlation was

not statistically significant. Regarding hemodialysis-unit characteristics, a higher proportion of hemodialysis patient care specialists and a higher number of total nurses who provided hemodialysis were inversely associated with the risk of hospitalization (proportion of hemodialysis patient care specialists, per 10% increase, RR: 0.987, 95% CI: 0.981–0.993; number of total nurses who provided hemodialysis, RR: 0.876, 95% CI: 0.833–0.921). A higher proportion of medical cost due to CKD among total medical costs in each hemodialysis unit was inversely associated with the risk of hospitalization (RR: 0.924, 95% CI: 0.915–0.933; Table 2).

We also performed a subgroup analysis to examine differences in relation to the risk of hospitalization by duration of illness, CCI, and presence of a nephrologist at the hemodialysis unit. A higher proportion of hemodialysis patient care specialists was more inversely associated with the risk of hospitalization in the presence of a nephrologist at the hemodialysis unit; however, a higher number of total nurses was more inversely associated with the outcome variable in the absence of a nephrologist at the hemodialysis unit. By duration of illness, a higher proportion of hemodialysis patient care specialists and a higher number of total nurses who provided hemodialysis were inversely associated with the risk of hospitalization in both groups, and the magnitude also similar. Similar results were also obtained in the subgroup analysis by CCI, although a higher number of nurses was more inversely associated with the risk of hospitalization in cases with a CCI of more than 3 (Table 3).

Discussion

Since the late 20th century, new problems related to chronic diseases have rapidly emerged in South Korea. The prevalence of hypertension and diabetes, along with their associated diseases such as CKD, has gradually increased [15 16]. Concerns regarding the quality of care in managing CKD patients have been raised, and to solve and prevent these issues, the South Korean government introduced healthcare quality assessment for human and medical resources regarding hemodialysis [10]. Nevertheless, the reduction of quality of care and the worsening status of patients diagnosed with CKD continue to be debated. Therefore, we set out to investigate the relationship between hospital resources, particularly human resources, and the risk of hospitalization in patients with ESRD, which was assumed to be indicative of worsening patient status due to a reduction in quality of care.

Our findings suggest that outpatient care for hemodialysis at hemodialysis units with superior human resources, such as a higher proportion of hemodialysis patient care specialists and a higher total number of nurses who provide hemodialysis, were positively associated with better health outcomes in managing CKD patients needing hemodialysis. Although previous studies show similar results to those reported in this study, such as better outcomes being associated with better hemodialysis unit resources, ours is one of only a small number of studies conducted after the introduction of healthcare quality assessment [17-19].

In South Korea, HIRA has evaluated the structure, process, and outcome indicators of hemodialysis for each hemodialysis unit through healthcare quality assessment, and has provided adjustment payments to medical institutions that placed in the upper 10% or were of lower quality based on the evaluation results from 2009. Given the positive impact of superior human resources on patient outcomes as shown in our study, our findings provide helpful information for healthcare quality assessment of hemodialysis due to CKD. However,

we found that the total number of nurses who provided hemodialysis had a positive association with patient outcomes in this study, despite its exclusion from the evaluation criteria used in healthcare quality assessment. Therefore, based on our results, health policymakers should consider these criteria in healthcare quality assessment, as well as the weight of each factor during evaluation. In addition, vulnerable patient groups, such as those receiving Medical Aid and the elderly, were negatively associated with healthcare outcomes after hemodialysis due to ESRD, suggesting an imbalance between the ability to pay and copayment of healthcare services [20]. Similarly, healthcare professionals also assert a need to relax copayment for vulnerable populations [21]. Thus, support for vulnerable populations should be afforded careful consideration by health policymakers. There was also an inverse association between the proportion of medical cost due to CKD and the risk of hospitalization, which may have been due to the specialty differences of each medical institution. Similar results were obtained in previous studies, suggesting a positive function for specialty hospitals in South Korea [22]. Therefore, healthcare professionals should consider increasing their specialties, and policymakers should consider designating additional specialty hospitals for hemodialysis.

Our subgroup analysis also showed interesting results related to efficiency issues. There were several differences in the relationship between human resources and the risk of hospitalization after hemodialysis due to ESRD. The positive impact of better human resources was greater in patients with a more severe condition, as evidenced by CCI. Thus, the worsening status of a severely ill patient could be more effectively managed by better hemodialysis-unit characteristics, such as better staffing. However, the role of each human resource differed at each hemodialysis unit on subgroup analyses according to the presence of

a nephrologist. These results suggest that a hemodialysis patient care specialist could be a viable alternative if a hemodialysis unit does not have a nephrologist. Therefore, the importance of professional manpower is also effectively evaluated in establishing a health policy regarding the management of CKD patients [23].

These findings have many strengths compared to previous studies. First, the data used in this study were NHI claim data, which included all ESRD patients in South Korea who received hemodialysis during a 1-year period. Thus, our findings have external validity and would likely be helpful in establishing evidence-based health policies related to CKD. Second, to the best of our knowledge, ours is the first South Korean study to investigate the relationship between human resources, such as hemodialysis patient care specialists and nurses experienced in hemodialysis, and the risk of hospitalization as indicators of health outcomes in ESRD patients receiving hemodialysis after the introduction of healthcare quality assessment for hemodialysis. Therefore, our results may prove useful for designing an effective strategy for managing CKD patients receiving hemodialysis. Third, we included both patient and hemodialysis unit characteristic variables in this study. Therefore, this study reflects the variety and severity of each patient and the medical institution situation, reducing the limitations of secondary data.

Our study also had several limitations. First, in managing patients with ESRD who needed hemodialysis, there are many factors, including the type of vascular access, laboratory data (e.g., serum albumin, hemoglobin), adherence to medical therapy (particularly hemodialysis sessions), more detailed quality indicators, and clinical conditions, that can also affected the outcomes of patients with CKD according to previous studies [24-27]. However, we were unable to include these factors in this study, as the data used were secondary data from

the NHI claim data. In addition, detailed information, such as procedures or medications provided to patients with hemodialysis was not included in this study. Moreover, due to the nature of the claim data, we could not identify whether hospitalization was due to hemodialysis, as each hospitalization was recorded based on the major diagnosis. Therefore, although we assumed that a patient who received hemodialysis progressed to hospitalization due to ESRD, this hospitalization might have been caused by a worsening status after hemodialysis. Therefore, more detailed studies are needed. Second, the study period was relatively short (1 year), and we excluded patients with an illness duration of less than 1 year, as patients in the early stages of ESRD could have been hospitalized due to arteriovenous fistula formation from hemodialysis. These problems arose from difficulties in accessing patient information due to primarily ethical issues, as we needed to effectively extract patient information samples from the NHI data. Unfortunately, we were unable to obtain such details. Therefore, to avoid including uncertain causes of hospitalization (e.g., worsening status, arteriovenous fistula formation), we excluded these patients from this study. Third, we considered human resources as independent variables of major interest in this study; however, we could not identify the specific human resources used in the treatment of each patient at each hemodialysis unit due to data limitations. Fourth, to reflect the hospital and patient characteristics in this study, we included variables such as structural characteristics and severity indicators of each patient. Nevertheless, there were several other factors that could have affected the risk of hospitalization. However, we were unable to consider more detailed variables due to data limitations. Finally, in South Korea, the criteria for physicians who were permitted to provide hemodialysis contrasted with the regulations of certain other countries

that permit only nephrologists to perform hemodialysis. Therefore, the relevance of our findings may be limited to South Korea and may not be generalizable to other countries.

Despite the above limitations, our findings suggest that better human resources, such as specialists and nurses experienced in hemodialysis, could positively affect outcomes in patients who receive hemodialysis. In particular, these associations were greater in patients in a clinically vulnerable population, and the role of human resources differed depending upon hemodialysis-unit characteristics, such as the severity of patients. However, improving hospital staffing to reduce the risk of hospitalization in such patients would not be an optimal alternative in terms of cost effectiveness, even if there were many concerns about medical costs related to CKD. Therefore, more detailed studies are needed in the future. Based on these findings and further studies, health policymakers and healthcare professionals should establish an effective health policy for the appropriate management of patients needing hemodialysis due to CKD.

Conclusions

Our findings suggest that outpatient care for hemodialysis at a hemodialysis unit with superior human resources, such as a higher proportion of hemodialysis patient care specialists and a higher number of total nurses who provide hemodialysis, is positively associated with better health outcomes in the management of patients with ESRD receiving hemodialysis. Based on our findings, health policymakers and professionals should endeavor to implement strategies for the optimal management of patients with CKD.

Authors' Contributions

H.H.C. and K.T.H. designed the study, performed the research and statistical analyses, and wrote the manuscript. K.T.H., J.M.N., K.T.M., and E.C.P. contributed to the Discussion section and reviewed and edited the manuscript. E.C.P. is the guarantor of this work and, as such, has full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. The English in this document has been checked by at least two professional editors, both native English speakers. In addition, W.K. provided re-editing services for our manuscript to improve the quality of the scientific writing.

Competing interests

The authors report no conflicts of interest in this work.

Funding statement

There is no funding source.

Data sharing statement

No additional data are available.

References

1. Kim EY, Kim Cy. Who Wants to Enter a Long-Term Care Facility in a Rapidly Aging Non-Western Society? Attitudes of Older Koreans Toward Long-Term Care Facilities. J Am Geriatr Soc 2004;**52**(12):2114-19.
2. Korea Centers for Disease Control and Prevention. Korea National Health and Nutrition Examination Survey, 2013.
3. Levey AS, Coresh J. Chronic kidney disease. Lancet 2012;**379**(9811):165-80.
4. Wyld M, Lisa Morton R, Hayen A, et al. A systematic review and meta-analysis of utility-based quality of life in chronic kidney disease treatments. PLoS Med 2012;**9**(9):1435.
5. Levey AS, Coresh J, Balk E, et al. National Kidney Foundation practice guidelines for chronic kidney disease: evaluation, classification, and stratification. Ann Intern Med 2003;**139**(2):137-47.
6. Kim H, Kim KH, Park K, et al. A population-based approach indicates an overall higher patient mortality with peritoneal dialysis compared to hemodialysis in Korea. Kidney Int 2014;**86**(5):991-1000.
7. Health Insurance Review & Assessment Service. Statistics for diseases 2009-13.
8. Argentero P, Dell'Olivo B, Santa Ferretti M, et al. Staff burnout and patient satisfaction with the quality of dialysis care. Am J Kidney Dis 2008;**51**(1):80-92.
9. Klersy C, Callegari A, Martinelli V, et al. Burnout in health care providers of dialysis service in Northern Italy—a multicentre study. Nephrol Dial Transplant 2007;**22**(8):2283-90.
10. Kim SM, Jang WM, Ahn HA, et al. Korean National Health Insurance value incentive program: achievements and future directions. J Prev Med Public Health 2012;**45**(3):148.
11. Go AS, Chertow GM, Fan D, et al. Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. N Engl J Med 2004;**351**(13):1296-305.

12. Forman DE, Butler J, Wang Y, et al. Incidence, predictors at admission, and impact of worsening renal function among patients hospitalized with heart failure. J Am Coll Cardiol 2004;**43**(1):61-67.
13. Jungers P, Massy ZA, Nguyen-Khoa T, et al. Longer duration of predialysis nephrological care is associated with improved long-term survival of dialysis patients. Nephrol Dial Transplant 2001;**16**(12):2357-64.
14. Termorshuizen F, Korevaar JC, Dekker FW, et al. Hemodialysis and peritoneal dialysis: comparison of adjusted mortality rates according to the duration of dialysis: analysis of The Netherlands Cooperative Study on the Adequacy of Dialysis 2. J Am Soc Nephrol 2003;**14**(11):2851-60.
15. Ayodele OE, Alebiosu CO. Burden of chronic kidney disease: an international perspective. Adv Chronic Kidney Dis 2010;**17**(3):215-24.
16. Couser WG, Remuzzi G, Mendis S, et al. The contribution of chronic kidney disease to the global burden of major noncommunicable diseases. Kidney Int 2011;**80**(12):1258-70.
17. Needleman J, Buerhaus P, Mattke S, et al. Nurse-staffing levels and the quality of care in hospitals. N Engl J Med 2002;**346**(22):1715-22.
18. Thomas-Hawkins C, Flynn L, Clarke SP. Relationships between registered nurse staffing, processes of nursing care, and nurse-reported patient outcomes in chronic hemodialysis units. Nephrology nursing journal: journal of the American Nephrology Nurses' Association 2008;**35**(2):123.
19. Gardner JK, Thomas-Hawkins C, Fogg L, et al. The relationship between nurses' perceptions of the hemodialysis unit work environment and nurse turnover, patient satisfaction, and hospitalizations. Nephrol Nurs J 2007;**34**(3):271.
20. Choi JW, Park E-C, Chun S-Y, et al. Health care utilization and costs among medical-aid enrollees, the poor not enrolled in medical-aid, and the near poor in South Korea. Int J Equity Health 2015;**14**(1):128.
21. Kim J-H, Lee K-S, Yoo K-B, et al. The Differences in Health Care Utilization between Medical Aid and Health Insurance: A Longitudinal Study Using Propensity Score Matching. PLoS One 2015;**10**(3):e0119939.
22. Kim SJ, Park E-C, Jang SI, et al. An analysis of the inpatient charge and length of stay for patients with joint diseases in Korea: specialty versus small general hospitals. Health Policy (New York) 2013;**113**(1):93-99.

23. Mandel SR, Martin PL, Blumoff RL, et al. Vascular Access in a University Transplant and Dialysis Program: Results, Costs, and Manpower Implications. Arch Surg 1977;**112**(11):1375-80.

24. Hsu C, Ordonez J, Chertow G, et al. The risk of acute renal failure in patients with chronic kidney disease. Kidney Int 2008;**74**(1):101-07.

25. Lo LJ, Go AS, Chertow GM, et al. Dialysis-requiring acute renal failure increases the risk of progressive chronic kidney disease. Kidney Int 2009;**76**(8):893-99.

26. Tonelli M, Wiebe N, Culleton B, et al. Chronic kidney disease and mortality risk: a systematic review. J Am Soc Nephrol 2006;**17**(7):2034-47.

27. Chawla LS, Amdur RL, Amodeo S, et al. The severity of acute kidney injury predicts progression to chronic kidney disease. Kidney Int 2011;**79**(12):1361-69.

Table 1. General characteristics of the study population and hemodialysis units by hospitalization after hemodialysis

Variables	Hospitalization after hemodialysis (N=4,751,047)				P-value
	Yes		No		
	N/Mean	%/SD	N/Mean	%/SD	
Patient characteristics					
Age (years)					
≤49	4,124	0.41	1,011,407	99.59	<.0001
50–59	6,743	0.52	1,278,756	99.48	
60–69	7,889	0.63	1,241,225	99.37	
≥70	9,241	0.77	1,191,662	99.23	
Sex					
Male	15,815	0.58	2,719,129	99.42	0.0003
Female	12,182	0.60	2,003,921	99.40	
Type of insurance coverage					
NHI	20,734	0.57	3,621,256	99.43	<.0001
Medical Aid	7,263	0.65	1,101,794	99.35	
Experience of pre-hospitalization during 1 year					
Yes	15,647	0.89	1,743,611	99.11	<.0001
No	12,350	0.41	2,979,439	99.59	
Duration of illness (years)					
2–3	2,816	0.73	381,554	99.27	<.0001
3–4	3,624	0.68	529,343	99.32	
4–5	3,154	0.65	483,078	99.35	
5–6	3,806	0.65	581,142	99.35	
>6	14,597	0.53	2,747,933	99.47	
CCI					
0	3,351	0.42	797,328	99.58	<.0001
1, 2	12,579	0.58	2,173,291	99.42	
3, 4	9,824	0.70	1,385,868	99.30	
5+	2,243	0.61	366,563	99.39	
Hemodialysis-unit characteristics					
Type of medical institution					
General hospital (N=234)	15,137	0.82	1,825,112	99.18	<.0001
Clinic or hospital (N=395)	12,860	0.44	2,897,938	99.56	
Presence of nephrologist					
Yes (N=114)	8,815	0.79	1,102,400	99.21	<.0001
No (N=515)	19,182	0.53	3,620,650	99.47	
Total number of doctors who provided hemodialysis	1.99	±1.57	1.83	±1.40	<.0001
Proportion of hemodialysis patient care specialists	83.59	±33.80	84.10	±33.09	0.0107
Total number of nurses who provided hemodialysis	10.84	±6.85	11.10	±7.04	<.0001
Proportion of nurses experienced in hemodialysis	74.53	±17.09	75.22	±16.65	<.0001
Volume of hemodialysis per doctor	1.77	±0.97	1.97	±1.06	<.0001
Number of beds	330.98	±382.58	246.18	±375.48	<.0001
Emergency equipment in hemodialysis unit					
Yes (N=573)	26,483	0.59	4,469,487	99.41	0.1794
No (N=56)	1,514	0.59	253,563	99.41	
Fulfillment rate of criteria for duration of water analysis	90.74	±19.81	90.31	±19.93	0.0004
Number of hemodialysis machines	34.40	±18.18	34.36	±18.70	0.6967
Proportion of medical cost due to CKD	37.85	±38.61	53.05	±40.71	<.0001
Total	27,997	0.59	4,723,050	99.41	

SD, standard deviation; NHI, National Health Insurance; CKD, chronic kidney disease; CCI, Charlson Comorbidity Index

Table 2. Risk of hospitalization after hemodialysis by patient and hemodialysis-unit characteristics

Variables	Hospitalization after hemodialysis			
	RR	95% CI		P-value
Patient characteristics				
Age (years)				
≤49	1.000	-	-	-
50–59	1.205	1.090	1.332	0.0003
60–69	1.455	1.317	1.608	<.0001
≥70	1.732	1.560	1.921	<.0001
Sex				
Male	1.000	0.966	1.035	0.981
Female	1.000	-	-	
Type of insurance coverage				
NHI	1.000	-	-	-
Medical Aid	1.334	1.281	1.389	<.0001
Experience of pre-hospitalization within 1 year				
Yes	1.837	1.773	1.903	<.0001
No	1.000	-	-	-
Duration of illness (years)				
2–3	1.000	-	-	-
3–4	0.983	0.918	1.052	0.6158
4–5	0.987	0.917	1.063	0.7342
5–6	1.018	0.948	1.094	0.6185
>6	0.911	0.860	0.965	0.0016
CCI				
0	1.000	-	-	-
1, 2	1.058	0.955	1.173	0.2811
3, 4	1.065	0.956	1.186	0.2549
5+	1.104	0.982	1.241	0.0981
Hemodialysis characteristics				
Type of medical institution				
General hospital (N=234)	1.000	-	-	-
Clinic or hospital (N=395)	0.940	0.869	1.017	0.1220
Presence of nephrologist				
Yes (N=114)	0.982	0.936	1.029	0.4429
No (N=515)	1.000	-	-	
Total number of doctors who provided hemodialysis (per 10-doctor increase)	1.001	0.973	1.030	0.9541
Proportion of hemodialysis patient care specialists (per 10% increase)	0.987	0.981	0.993	<.0001
Total number of nurses who provided hemodialysis (per 10-nurse increase)	0.876	0.833	0.921	<.0001
Proportion of nurses experienced in hemodialysis (per 10% increase)	0.993	0.983	1.003	0.1576
Volume of hemodialysis per doctor	0.963	0.936	0.992	0.0115
Number of beds (per 10-bed increase)	0.999	0.998	1.000	0.1065
Emergency equipment in hemodialysis unit				
Yes (N=573)	1.000	-	-	-
No (N=56)	0.930	0.856	1.011	0.0882
Fulfillment rate of criteria for duration of water analysis (per 10% increase)	0.978	0.969	0.987	<.0001
Number of hemodialysis machines (per 10-machine increase)	1.046	1.029	1.063	<.0001
Proportion of medical cost due to CKD (per 10%)	0.924	0.915	0.933	<.0001

RR, relative risk; CI, confidence interval; NHI, National Health Insurance; CKD, chronic kidney disease; CCI, Charlson Comorbidity Index

Table 3. Subgroup analysis by presence of nephrologist, duration of illness, and CCI*

Subgroup		Variables	RR	P-value
Presence of nephrologist	Yes	Total number of doctors who provided hemodialysis (per 10-doctor increase)	1.023	0.2614
		Proportion of hemodialysis patient care specialists (per 10% increase)	0.970	0.0062
		Total number of nurses who provided hemodialysis (per 10-nurse increase)	0.901	0.0045
		Proportion of nurses experienced in hemodialysis (per 10% increase)	0.991	0.3602
	No	Total number of doctors who provided hemodialysis (per 10-doctor increase)	0.980	0.3125
		Proportion of hemodialysis patient care specialists (per 10% increase)	0.989	0.0005
		Total number of nurses who provided hemodialysis (per 10-nurse increase)	0.864	<.0001
		Proportion of nurses experienced in hemodialysis (per 10% increase)	0.994	0.3191
Duration of illness (years)	≤5	Total number of doctors who provided hemodialysis (per 10-doctor increase)	1.016	0.4756
		Proportion of hemodialysis patient care specialists (per 10% increase)	0.986	0.0016
		Total number of nurses who provided hemodialysis (per 10-nurse increase)	0.880	0.0009
		Proportion of nurses experienced in hemodialysis (per 10% increase)	0.996	0.5596
	6+	Total number of doctors who provided hemodialysis (per 10-doctor increase)	0.986	0.4495
		Proportion of hemodialysis patient care specialists (per 10% increase)	0.989	0.0078
		Total number of nurses who provided hemodialysis (per 10-nurse increase)	0.879	0.0002
		Proportion of nurses experienced in hemodialysis (per 10% increase)	0.990	0.1702
CCI	0,1,2	Total number of doctors who provided hemodialysis (per 10-doctor increase)	1.008	0.6615
		Proportion of hemodialysis patient care specialists (per 10% increase)	0.987	0.0021
		Total number of nurses who provided hemodialysis (per 10-nurse increase)	0.889	0.0003
		Proportion of nurses experienced in hemodialysis (per 10% increase)	0.993	0.3201
	3,4	Total number of doctors who provided hemodialysis (per 10-doctor increase)	0.998	0.9370
		Proportion of hemodialysis patient care specialists (per 10% increase)	0.987	0.0036
		Total number of nurses who provided hemodialysis (per 10-nurse increase)	0.856	<.0001
		Proportion of nurses experienced in hemodialysis (per 10% increase)	0.989	0.1336

*Table 3 shows the results of subgroup analyses of the relationship between human resources and the risk of hospitalization according to the presence of a nephrologist, duration of illness, and CCI. In this analysis, we adjusted variables such as age, sex, type of insurance coverage, experience of pre-hospitalization within 1 year, duration of illness, Charlson Comorbidity Index (CCI), type of medical institution, presence of a nephrologist, hemodialysis volume per doctor, number of beds, emergency equipment in the hemodialysis unit, fulfillment rate of criteria for duration of water analysis, number of hemodialysis machines, and proportion of medical cost due to CKD. We marked the results with statistically significant values using shadowing. CCI, Charlson Comorbidity Index; RR, relative risk; CI, confidence interval

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3-5
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	6-7
Methods			
Study design	4	Present key elements of study design early in the paper	7-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	7-8
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	None
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*7-9*
Bias	9	Describe any efforts to address potential sources of bias	8-10
Study size	10	Explain how the study size was arrived at	7-8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11
		(*b*) Describe any methods used to examine subgroups and interactions	11
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, explain how loss to follow-up was addressed	None
		(*e*) Describe any sensitivity analyses	11
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11-12
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	None
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-12
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) Summarise follow-up time (eg, average and total amount)	11-12
Outcome data	15*	Report numbers of outcome events or summary measures over time	11-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-13
		(*b*) Report category boundaries when continuous variables were categorized	9-10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	None
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	13
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-15
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	16-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Correction: *Association between human resources and risk of hospitalisation in end-stage renal disease outpatients receiving haemodialysis: a longitudinal cohort study using claim data during 2013–2014*

Choi H-H, Han K-T, Nam CM, *et al*. Association between human resources and risk of hospitalisation in end-stage renal disease outpatients receiving haemodialysis: a longitudinal cohort study using claim data during 2013–2014. *BMJ Open* 2016;6:e011319. The following statement should be included in this paper: H-HC and K-TH contributed equally to this work and should be considered co-first authors.

BMJ Open 2016;**6**:e011319corr1. doi:10.1136/bmjopen-2016-011319corr1